THE REPUBLIC OF THE UNION OF MYANMAR
MINISTRY OF NATURAL RESOURCES AND
ENVIRONMENTAL CONSERVATION

PROJECT
FOR
CAPACITY DEVELOPMENT
IN
BASIC WATER ENVIRONMENT
MANAGEMENT AND EIA SYSTEM
IN
THE REPUBLIC OF THE UNION OF MYANMAR

FINAL REPORT
OF
WATER ENVIRONMENT MANAGEMENT
COMPONENT

VOLUME NO.2

JUNE 2018

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIPPON KOEI CO., LTD.

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MINISTRY OF NATURAL RESOURCES AND
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Inspection Manual

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

INSPECTION MANUAL

FINAL VERSION

June 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT, MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION

YANGON CITY DEVELOPMENT COMMITTEE

MANDALAY CITY DEVELOPMENT COMMITTEE

JICA EXPERT TEAM

PREFACE

This inspection manual was developed as part of the outputs of the bilateral technical cooperation project between Myanmar and Japan entitled "Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar (hereinafter referred to as "the Project"). The project has the aim to support and enhance capacities of Ministry of Natural Resources and Environmental Conservation (MONREC) and other organizations concerned to manage water environment and to implement EIA reviews. Among the six outputs of the project, this manual was produced to fulfill the goal of Output 1 "inspection procedure is standardized". We sincerely hope that this manual helps each organization develop good standard practice for effective environmental inspection.

JICA Expert Team

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1 BACKGROUND

1.1 BACKGROUND

Table 1-1 summarizes some of major industrial disasters in the world. There are many examples of such disasters. Once occurred, they inflict devastating damages to the environment and the societies, and responsibilities of the firm that caused the disaster as well as the environmental authority would become focus of scrutiny. Nobody can deny the possibility that such disasters could happen in Myanmar. Many factories in Myanmar are not taking adequate environmental measures right now, and areas downstream of some factories are already polluted by discharged wastewater and emitted gas.

Table 1-1 Major Environmental Disasters in the World

Name of Incident	Country	Year	Summary
Minamata disease	Japan	1950s-70s	Mercury discharged from a fertilizer/chemical factory caused poisoning to those who consumed contaminated seafood. Over 2,000 people were officially recognized as victims and more than1,650 people died.
Itai-itai disease	Japan	1910s-70s	Mining wastewater contaminated downstream agricultural area and caused cadmium poisoning to those who ate rice and other agricultural products. About 200 people were officially recognized as victims and died.
Love Canal	US	1940s-70s	A hazardous industrial waste dump site in 1940s and 50s was redeveloped as a residential – school area, resulted in health impacts, such as birth defects and cancers, to many residents in 1970s due to dioxin and other hazardous substances. Federal Government evacuated about 800 families.
Seveso disaster	Italy	1976	A small chemical plant exploded, and about 40,000 people were exposed to toxic chemicals, such as dioxins, which caused serious long-term health problems.
Bohpal disaster	India	1984	Toxic gas leaked from a pesticide factory, exposing over 500,000 people to methyl isocyanate and other toxic chemicals. As many as 4,000 or more people died due to the disaster.

Source: JICA Expert Team

In order to prevent such disasters, roles of inspection officers are vitally important – they are the front-line officers who regularly visit factories to check environmental violations and spot signs of problems. However, it is also true that tasks of the officers are daunting because environmental issues in each factory are generally very complex, and available information is often very scarce to make judgement about potential risks with confidence. If the judgement is left to each officer, it becomes difficult to control quality of inspection activities. This is why officers have to be trained in systematic manner, and inspection is implemented methodically, in accordance with the standard practice of the organization.

1.2 OBJECTIVES

This manual was developed to support officers of ECD, YCDC and MCDC in enforcing pollution control laws in Myanmar, namely Environmental Conservation Law (2012), Law on Private Enterprise (1990), YCDC Law (2013), MCDC Law as well as their sub-laws and regulations. The objectives of the manual are:

- To standardize inspection procedures so that officers in charge of inspection can minimize undetected serious pollution problems
- To provide officers with general information on current laws and regulations pertinent to inspection activities
- To provide officers with basic information on pollution control measures in typical industrial sectors in Myanmar
- To provide sources of more detailed information on environmental management

1.3 TARGET AND USE OF MANUAL

1.3.1 Target

The main target of the manual is novice officers of ECD, YCDC and MCDC with limited experiences in inspection activities.

1.3.2 Use of Manual

Officers inspecting factories of manufacturing firms shall use this manual until they become familiar with the procedures of inspection and competent in implementing inspection. To facilitate the learning, officers are encouraged to use the checklist given in Appendix 1 of this manual.

A supervising officer shall use this manual to train his/her staff and to check their performance so that the staff can implement inspection in accordance with the standard practice of the organization.

1.4 LIMITATIONS OF THIS MANUAL

Officers who use this manual should be aware of the following limitations of this manual.

1.4.1 Legal Limitation

This manual is an internal document of ECD, YCDC and MCDC. It is not a legal document, and officers shall not use this document as the legal-basis of their actions. Their activities should be implemented according to officially enacted laws and regulations in Myanmar, especially when the officers are intervening in activities of private firms as part of their duties.

Officers should also be aware that environmental laws and regulations in Myanmar are still largely under development, and detailed legal requirements that firms have to fulfill, such as procedural requirements (e.g., reporting) and technical requirements (e.g., discharge standard), are yet to be clearly set. Similarly, other laws and regulations, such as those pertaining to management of industrial zones, judicial procedures for environmental litigation, responsibilities of different authorities in pollution control, etc., require further development. Relevant organizations are strongly encouraged to officially establish the detailed laws and regulations as soon as possible so that inspection officers can carry out their duties with confidence.

1.4.2 Limitation in Depth of Coverage

This manual was designed to be concise so that an officer can carry it with him/her all the time, even during on-site work. It was not intended to be a detailed reference book, and the depth of coverage of each topic was kept minimal.

If an officer needs detailed explanation about inspection procedures in their organization, he/she should talk to their superior. Also, there are a number of international handbooks and guidelines on environmental inspection which are highly useful for officers, such as inspection manuals of Ministry of Environment Japan (2006), USEPA (2002), OECD (2004), Environment Canada (2006) and IMPEL (1999) (please see the reference section). Although the context and underlying laws are not the same in Myanmar, these manuals were developed based on decades of experiences in enforcing similar environmental regulations in other countries, and there are many things officers can learn from these manuals.

1.4.3 Limitation in Coverage of Broad Environmental Issues

In implementing inspection, officers have to cover broad environmental issues, such as water pollution, air pollution, noise, odor, solid waste, hazardous substances, conservation of resources, preparedness against environmental accidents, etc. Among these issues, this manual, especially Appendix 2, focuses on water pollution, because the focus of this project is wastewater management.

Officers should also realize that environmental issues vary significantly from sector to sector, and they should become familiar with environmental issues of each sector. IFC’s Environmental, Health, and Safety (EHS) Guidelines (2007), which cover over 60 sectors in the fields of agribusiness/food production, chemicals, forestry, general manufacturing, infrastructure, mining, oil and gas, and power, are good starting point to study environmental issues of different industrial sectors.

2 LEGAL SYSTEMS

2.1 INTRODUCTION

Myanmar has traditional mechanism of resolving disputes based on local coordination and arbitration. This mechanism remains to be important today in resolving environmental disputes. Nevertheless, such mechanism demands significant administrative coordination and constant attention of local decision makers. Also, decisions become highly case-dependent and unpredictable – not ideal for investors and businesses who try to minimize risks in decision. Moreover, it is usually a reactive mechanism based on complaint, and not very effective in preventing pollution before it occurs.

Thus, the government is trying to strengthen rule of law in environmental management. Under the rule of law, decision is made based on specific and transparent environmental law(s) and regulations that stipulate what regulated communities, such as factories, should or should not do.

However, environmental laws in Myanmar are still under development. Hence, inspection officers should be intimately familiar with provisions of such laws and regulations as well as limitations of current legal framework and how to deal with regulated communities in this period of transition.

2.2 CONSTITUTION OF THE UNION OF MYANMAR

Constitution of Myanmar (2008), which is the supreme law of Myanmar, stipulates that the Union has the responsibility to protect and conserve natural environment, and every citizen has the duty to assist the Union in carrying out environmental conservation.

Table 2-1 Environmental Conservation in Constitution of Myanmar

Level	Law and Regulation	Relevance
Constitution	Constitution (2008)	- Chapter I, Basic Principles of the Union, Article 45 mentions that the Union shall protect and conserve natural environment. - Chapter VIII, Citizen, Fundamental Rights and Duties of the Citizens, Article 390 stipulates that every citizen has the duty to assist the Union in carrying out environmental conservation.

Source: JICA Expert Team based on Constitution (2008)

2.3 LAW ON ENVIRONMENTAL CONSERVATION

Table 2-2 summarizes the Law on Environmental Conservation (2012), its rules and related regulations. Law on Environmental Conservation (2012) is arguably the most important law concerning environmental conservation in Myanmar. Under the current framework, EIA and Prior Permission are the main legal instruments to control industrial activities. Detailed regulatory requirements under these instruments are still under development, but it is noteworthy that National Environmental Quality (Emission) Guidelines (EQEG, 2015) and Environmental Impact Assessment Procedures (2015) were officially issued in December 2015 paving ways to require firms to take environmental measures within the framework of EIA procedures.

Table 2-2 Law on Environmental Conservation (2012), Its Rules and Related Regulations

Level	Law and Regulation	Relevance
National	Law on Environmental Conservation (Law No. 9/2012)	- Chapter VII (Environmental Conservation) stipulates that businesses which cause pollution are required to install on-site facility in order to monitor, control, manage, reduce or eliminate environmental pollution. - Chapter VII also stipulates that a person or organization operating business in the industrial estate to contribute the stipulated cash or in kind for environmental conservation. - Other articles pertinent to industrial pollution control include discharge/emission standards in Chapter VI, prior permission for industrial operation in Chapter X, and environmental emergency in Chapter V.
	Environmental Conservation Rules (2014)	- In relation to the Environmental Conservation Law (2012), the roles and responsibilities of Environmental Conservation Committee, MOECAF and other governmental organizations are described in the Environmental Conservation Rules (2014).
	National Environmental Quality (Emission) Guidelines (2015)	- These guidelines were officially issued in 2015. - Annex 1 sets out the general and sector-specific guideline values, which are considered to be achievable in new facilities by existing technology at reasonable costs. These values are based primarily on International Finance Corporation (IFC) Environmental Health and Safety (EHS) Guidelines. - The guidelines are applicable to new projects subject to EIA Procedure. As for existing projects, less stringent levels or measures may be adopted at the discretion of MOECAF. - A new national effluent standard is already in discussion, and the guidelines are expected to be succeeded by the standard in near future.
	Environmental Impact Assessment Procedure (2015)	- All Projects and expansion of Projects having the potential to cause Adverse Impacts, are required to undertake IEE or EIA or to develop an EMP, and to obtain an ECC in accordance with this Procedure. - According to Chapter II of the procedure, any existing projects are also required to undertake environmental compliance audit, develop IEE, EIA or EMP and obtain ECC.MOECAF has the right to conduct monitoring and inspection regarding the requirements of Environmental Management Plan (EMP) or other requirements in Environmental Compliance Certificate (ECC).

Source: JICA Expert Team based on relevant laws and regulations

(1) *EIA and IEE*

Projects that require EIA and IEE are stipulated in the EIA Procedures (2015). For those firms that require EIA and IEE, it is possible to incorporate environmental requirements into Environmental Management Plan (EMP) of each firm and then to the conditions of Environmental Compliance Certificate (ECC) to be issued by MONREC. Emission/discharge limitation based on EQEG (2015), which lists suggested permissible values for emission of air, wastewater discharge, noise and vibration, is a good example of such environmental requirements. Please note that EQEG are merely guidelines, and their requirements are not legally-binding by themselves. However, if the requirement is incorporated into the conditions of ECC, it becomes binding. Aside from emission standards, broader environmental measures and considerations should be incorporated into the ECC. Examples of such requirements include, but not limited to cleaner production, resource conservation, 3R, management of hazardous substances, environmental monitoring, adoption of environmental management systems (EMS) and corporate social responsibility (CSR), etc., because such requirements could achieve more comprehensive improvement in environmental performance.

If the firm is operating under EIA procedures, the task of an ECD officer is to check if the conditions of the EMP and ECC are being satisfied during the construction and operation phases of the project. Hence, the officer should be fully familiar with the conditions of EMP and ECC in implementing the inspection.

(2) *Prior Permission*

Prior Permission is another mechanism that could be used to control manufacturing industries. Any firms that fall under the categories stipulated in Section 21 of the ECL and Section 62 of the Rules, which include both new and existing firms, are required to obtain a Prior Permission from MONREC. The permission is supposed to prescribe terms and conditions to be followed by the firm, and in the future, the conditions of the permission become the subject of inspection activities. Small-scaled private firms not included in these categories are supposed to obtain an agreement with ECD regarding whether or not the firm would affect the environment, as stipulated in Article 68 of the Rules.

(3) *Inspection Form*

ECD has a standardized inspection form, which is being used by the central ECD as well as regional ECD offices.

2.4 Law on Private Enterprise

Law on Private Enterprise (1990), which is administered by Ministry of Industry, is another important legislation that controls environmental performance of private firms, including manufacturing firms at the central level. There is Standing Order No.3 (1995), Water and Air Pollution Control Plan, which defines requirements to firms. Those firms regulated under this law are required to register its activities with DISI of MOI. Environmental control is a duty of Industrial Environmental Inspection Sub-department of DISI. MOI can strip its registration if the firm does not conform to the requirements of the law.

Table 2-3 Law on Private Enterprise (1990), Its Procedure (YEAR) and Standing Order No.3 (1995)

Level	Law and Regulation	Relevance
National	Law on Private Enterprise (1990)	- Chapter V describes the duties of powers of supervisory body in the States and Divisions in recommending for grant of registration of a private industry considering “no cause of being injurious to the health of the public residing in the vicinity” and “no cause of being a nuisance to the environment and not cause of there being any pollution”.

Level	Law and Regulation	Relevance
	Procedure of Law on Private Enterprise (YEAR)	- Chapter 7 of the procedure empowers relevant officers to carry out inspection.
	Standing Order No.3 of Ministry of Industry (1), Water and Air Pollution Control Plan (1995)	- This standing order requires factories to adopt uniform preparatory measures beforehand for the prevention of pollution and destruction of the environment. - Chapter III of the standing order is devoted to water pollution control, requiring factories to report monitoring result of wastewater, to set time frame for treatment of wastewater, and to complete the installation of the facility. - Similarly, Chapter IV stipulates requirements for air pollution control. - Annexure (C) provides a sample specification of allowable waste effluent standard.

Source: JICA Expert Team based on relevant laws and regulations

ECD of MONREC has been supporting enforcement of this law by providing DISI with ECD’s diagnosis/judgement about environmental performance of factories based on the results of ECD’s inspection.

2.5 YCDC LAW

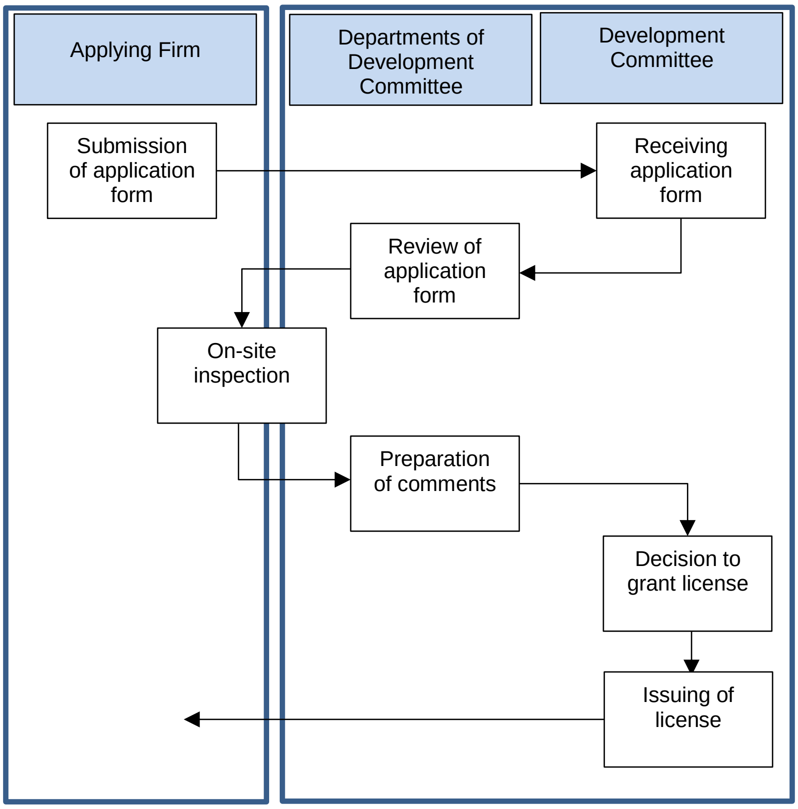
YCDC law requires factories to take environmental measures, and PCCD is the main department in YCDC in charge of industrial pollution control.

Table 2-4 Law of YCDC (2013)

Level	Law and Regulation	Relevance
Development Committees	Law of Yangon City Development Committee (2013)	- Article 62 of the Law of Yangon City Development Committee (2013) stipulates that no one is allowed to discharge wastewater from any factory, industry and enterprise into the drainages and rivers without treating it in accordance with the standard set by the committee.
	Bylaw of Yangon City Development Committee (2015)	- YCDC has been drafting a bylaw to manage environmental issues, but currently there is no officially-enacted bylaw.

Source: JICA Expert Team based on relevant laws and regulations

A business license is the main tool of YCDC to ensure firms to follow the law of the development committee. It is a general business license to be renewed every year, and it covers not only environmental requirements, but also other requirements. The licensing process starts with submission of application document by the firm, review of the document by different departments of the development committee, on-site inspection, preparation of comments, decision by committee, and issuing of the license (see Figure 3-1).



Source: JICA Expert Team

Figure 2-1 Licensing and Inspection

PCCD has an inspection form, and it has been requesting applying firms to fill out the form and return it to PCCD. Those industries that discharge wastewater are supposed to get its wastewater analyzed, and the certified result is submitted directly to PCCD.

2.6 MCDC LAW

MCDC Law (2014) is similar to YCDC Law (2013) and it requires firms to treat its wastewater. In MCDC, CD is responsible for inspecting and issuing business license, while industrial wastewater issues are handled by WSD.

Table 2-5 Law of MCDC (2014)

Level	Law and Regulation	Relevance
Development Committee	Law of Mandalay City Development Committee (2014)	- Chapter 24 of the Law of Mandalay City Development Committee (2014) stipulates the following prohibitions: ➢ Everybody must throw away the trash from factory, constructions, business, the wastes from hospital, clinic and dangerous wastes, electronic wastes, and other disgusting

Level	Law and Regulation	Relevance
		things at the specified place by committee except at the trash can, trash lake and the place to be trashed ➢ No one must throw away or pour out the trash from floor or buildings or other disgusting things to the gutters or public roads or the fences owned by someone ➢ No one must not dispose or discharge the waste water from factory/ workshop and business without undertaking to clean in accordance with the specifications specified by committee to the gutters, rivers, and agriculture lands. ➢ No one must not emit the smokes to the atmosphere that cause air pollution from factory/workshop and business without undertaking to clean in accordance with the specifications specified by committee ➢ No one must not against the instructions of recycling committee concerning to be disposed wastes
	Bylaw of Mandalay City Development Committee, activities of CD (2009)	- Chapter 2 of Environmental Conservation and Cleansing Bylaw of MCDC (2009) states that MCDC shall take action against anyone/ anything that cause environmental damage/ degradation/ and destruction.

Source: JICA Expert Team based on relevant laws and regulations

2.7 Legal Responsibilities of Factories and Environmental Authorities

To properly enforce environmental regulations and to avoid infringement of related laws and regulations, officers should be fully aware of responsibilities of factories, responsibilities of environmental authorities, and related issues in implementing environmental control activities under less than perfect legal framework of environmental laws and regulations in today’s Myanmar.

(1) *Rights and Environmental Obligations of Factories*

Detailed explanation about rights of regulated communities is beyond the scope of this manual, but enforcement of environmental regulation could potentially result in unwanted consequences, such as shut down of factories and subsequent layoff of many workers. Officers should always be aware of the rights of the regulated communities, and act responsibly. Chapter VIII of the Constitution guarantees citizens right to conduct business freely, the right to ownership, the equal opportunity in carrying out business, etc.

With regard to obligations of regulated communities, the Constitution, Environmental Conservation Law (2012), Law on Private Enterprise (1990), YCDC Law (2013) and MCDC (2014) all clearly require factories to be environmentally-responsible, as explained above. However, when it comes to details of legal obligations, things are not clear.

In principle, all major factories, including both planned and existing ones, are required to obtain ECC from MONREC in accordance with EIA Procedures (2015), and adhere to the conditions of ECC. Nevertheless, most factories are yet to obtain ECCs. Hence, as of October 2017, what is legally permitted and what is prohibited are not clear for most factories. As for business license/registration, most factories already have a license and registration from YCDC/MCDC and DISI, but environmental requirements for licensing/registration are not clearly defined in relevant laws and regulations. Therefore, officers should be aware that specific legal obligations of factories are generally not well defined beyond the general requirement, unless such requirements are specifically articulated in other documents, such as ECC, licensing conditions or an administrative order specific to the factory that are legally valid.

Officers should also be aware that there are other laws and regulations that control factories, such as those related to investment, construction, occupational health and emergency. In principle, one should not violate such laws and regulations, as one should not violate environmental laws and regulations.

(2) *Responsibilities of Environmental Authorities*

MONREC is given the authority to control pollution based on Environmental Conservation Law (2012). If ECD failed to exercise this authority to control pollution, and as the result a serious environmental damage occurred, ECD might be held responsible for its “inaction”. Similarly, ECD is legally charged to enforce the regulations under Environmental Conservation Law (2012). Thus, if regulations were not enforced and many factories ignore the regulation, competency of ECD may be questioned although ECD may not have enough administrative resources for enforcement.

Another important point is that officers are not authorized to go beyond the limit of law. For example, if his/her instruction to a factory is not consistent with requirement of any law or regulation, he/she may be held responsible even his/her instruction appears to be reasonable. He/she should not abuse the authority.

The same can be said about responsibilities of YCDC, MCDC, DISI, and other authorities.

The issue of overlapping responsibilities among different organizations also requires some attention. In principle, officers of ECD are expected to enforce Environmental Conservation Law (2012), while officers of YCDC are to enforce YCDC Law (2013), officers of DISI to enforce Law on Private Enterprise (2014), and so forth. The problem is that they all have environmental components in their laws, and this could result in different organizations imposing different environmental requirements to the same factory. It is hoped that in the near future legal requirements under each law are clarified and demarcation of responsibilities are clarified. In the meantime, officers are expected to regularly coordinate with officers of other organizations.

(3) *How to Work with Factories*

As explained above, environmental laws and regulations are new, far from perfect, and they are yet to be contested, challenged, scrutinized and revised. So, how frontline officers should work with factories under the imperfect legal system? Here are some suggestions:

- Officers should thoroughly study laws and regulations he/she enforces. Carry legal booklet whenever he/she meets regulated communities, and always check specifically how law and regulations are defined.

- Officers should also be aware of the existence of other documents issued by his/her organization, such as ECC, licensing conditions, administrative order, etc.

- Whenever in question, always seek advices from his/her superior and other professionals in his/her organization. To support officers, ECD should organize regular training about environmental laws and enforcement.

Officers should also be aware that Environmental Conservation Law (2012) is not the only legal instrument to control pollution. If the problem involves damage to property, livelihood or health of local people, or if the problem is serious and intentional, it may be considered as a civil or criminal case.

3 INSPECTION PROCEDURES

3.1 INTRODUCTION

3.1.1 Types of Inspection

This chapter explains the typical inspection procedures. In Myanmar, at least two types of environmental inspection activities are being conducted:

- Inspection for licensing and registration
- Inspection to resolve environmental problems that have already occurred.

(1) *Inspection for Licensing and Registration*

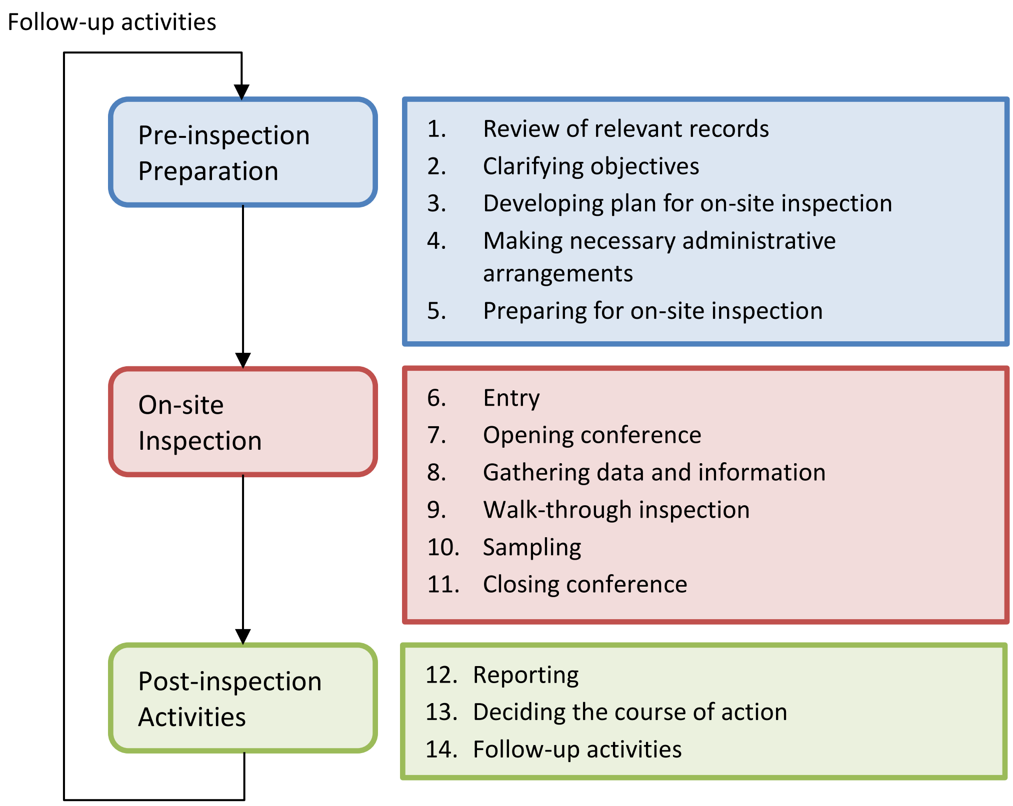
This type of inspection is implemented to evaluate whether the conditions of the target firm is acceptable for issuing a business license under YCDC Law (2013) or MCDC Law (2014) or for registering the firm under the Private Enterprise Law (1990). Law on Environmental Conservation (2012) also has a number of similar administrative tools, such as EIA and prior permission. These tools have the potential to "prevent" pollution problems, rather than to resolve ones that have already occurred. Hence, officers involved in licensing and registration need capacities to diagnose environmental problems before they occur.

(2) *Inspection for Resolving Existing Environmental Problem*

In addition to inspection for licensing and registration, inspection is also conducted to resolve an environmental problem that has already occurred. This type of inspection is often triggered by a complaint by local resident, which is usually sent to local government or local environmental authority. The processes of inspection are similar to those of inspection for business license and registration. However, this type of inspection is different from the inspection for licensing and registration as its goal is to investigate the extent and cause of pollution, and to suggest measures to contain or clean up pollution. Because of its reactive nature, it is sometimes called "reactive inspection".

3.1.2 Inspection Procedures

Figure 3-1 summarizes general inspection procedures. Inspection is usually implemented in three stages, namely i) pre-inspection preparation stage, ii) on-site inspection stage, and iii) post-inspection stage, and within each stage, there are a number of tasks. In this manual, they are categorized into 14 specific tasks.



Source: JICA Expert Team

Figure 3-1 Inspection Procedures

3.2 Pre-inspection Preparation

Successful inspection is largely determined by how well the officers are prepared for inspection activities before they head out to the site.

3.2.1 Review of relevant records

Before the site work, the officers should review all key documents about the target firm, and becomes familiar with the issues of the firm. Examples of such documents often available in Myanmar include, but not limited to:

- Application form for license/registration submitted by the firm
- Inspection form submitted by the firm
- EMP and ECC based on EIA regulation
- Historical records of inspection and environmental compliance

- Official order for inspection from relevant authority
- Certification/registration document of the firm
- Technical document from the firm
- Complaints about the firm
- Other documents

The inspecting officers should also talk to their colleagues who are familiar with the firm about the known environmental and management issues.

3.2.2 Clarifying Objectives

The next step is to clarify the objectives of inspection, i.e., what has to be achieved through the inspection. Examples of objectives are to:

- Evaluate whether the environmental performance of the target firm is acceptable for granting business license or registration
- Collect relevant data and information necessary for other administrative procedures
- Confirm whether the firm has fulfilled the requirements of EMP, ECC, or administrative order/guidance given in the past.
- Gather evidence to be used in administrative/legal action against the firm
- Investigate the extent of pollution
- Gather data and information in order to provide technical guidance to the firm

3.2.3 Developing the Plan for On-site Work

Once the objective is set, the next step is to develop a plan for the on-site work by clarifying the tasks, procedures, resources, and schedule of the inspection, and make necessary preparation according to the plan.

Table 3-1 Items to Be Clarified in Plan for Inspection

Category	Items to be clarified
Objectives	– What is the purpose of the inspection? What is to be accomplished?
Tasks	– What records, files, licenses, regulations will be checked? − What co-ordination with laboratories, other governmental or local authorities is required? − What information must be collected? − What samples will be taken and/or tests will be conducted?
Procedures	– Announced or unannounced inspection? − What specific company processes will be inspected? − What procedure will be used? − What are responsibilities of each member of the team? − How will the reporting be organized

Resources	–What personnel will be required? − What equipment will be required? − What laboratory analysis will be required? − What findings will be required for travel or other expenses?
Schedule	– What will be the time requirements and order of inspection activities? − What will be milestones? What is essential/what is optional? − Is any follow-up to be anticipated

Source: IMPEL, 1999

In principle, on-site inspection should be carried out by multiple officers because there could be aggressive or immoral people at the site who try to intimidate or corrupt officers. Also, there is a possibility of accident during inspection.

3.2.4 Making Necessary Administrative Arrangement

In Myanmar, most on-site inspection activities are conducted by notifying the target firm about the inspection prior to the inspection. Thus, the arrangement with the target firm, and the industrial zone management committee, should be done if it is required. If collection of data and information is the main objective of the inspection, this is a good opportunity to request the target firm to prepare such documents. When serious problem is suspected or sampling is required, however, it is an option to implement inspection without prior-notification so that the regular condition of the firm can be inspected. This decision should be done by the superior officer.

In addition, arrangements with other relevant organizations may be needed, especially when the inspection is carried out jointly.

3.2.5 Preparing for on-site inspection

(1) *Preparation*

Based on the plan, officers should make necessary preparation for the on-site inspection.

First, the officers should carry out further review of available data and information considering the objectives of the on-site inspection. This way, officers can focus on important tasks and might be able to avoid spending time at the site to collect documents which are already available in the office.

Before visiting the firm, the officers have to make sure that they have all the necessary documents and equipment for the inspection. Examples of such documents and equipment are:

- Official letter explaining the purpose of the inspection
- Laws and regulations which are basis of the inspection
- Most recent inspection form
- EMP and ECC

- Document explaining requirement the firm should fulfill, such as an administrative order
- Notebook and recording equipment (pens, notebook, camera, camcorder, voice recorder, etc.)
- Sampling equipment (portable water quality analyzer, reagents, tape measure, sampling bottles, marker for labeling sample bottles, water sampler, clean water for washing hands, others)
- Safety gear (gloves, masks, safety shoes, helmet, flashlight, others)

Inspection is an official work. The officers should be properly dressed and carry a credential.

- Official Uniform
- Credential/ID

(2) *On-site safety*

The site can pose various risks to the officers as well as the workers at the site. Typical hazards are listed in Table 3-2. Before going to the site, the officers should consider possibilities of such hazards specific to the site, prepare safety gear, such as gloves and helmet, to minimize exposure, and take every precaution to avoid exposure to hazard at the site.

Table 3-2 Different Types of Hazards at the Site

Type of Hazard	Remarks
Chemical	The target firm might produce, use or store toxic/hazardous chemicals that may be dangerous to the inspection officer as well as the workers. The officer may be exposed to such chemicals by accidentally touching, inhaling or ingesting them during the on-site activity. Do not touch suspicious materials, e.g., leaked liquid, chemical drums, packages of chemicals, etc. Also, avoid going into confined spaces, such as a sewer or a tank, because there is a risk of oxygen deficiency or toxic gas.
Fire and Explosion	There could be fire or explosion during on-site activity. Be particularly careful around flammable and explosive materials. An officer himself/herself could start a fire or explosion, for example by smoking a cigarette.
Biological	An officer should be aware of risks of infection in particular around food and water sources, rest rooms and washing facilities. Guard dogs, snakes, insects, and aggressive people are other examples of biological hazard.
Physical	Physical risks include overhead hazard (e.g., crane, falling objects), collapsing walls, slippery floor, sharp objects, moving machines, water hazard (e.g., ponds and reservoirs), etc. Excessive heat that could cause burning (e.g., steam pipes, boiler) or heat exhaustion/stroke is another type of physical risks. Also, watch out for electric line.

Source: JET based on USEPA (2002), OECD (2004), and IMPEL (1999)

At the beginning of the on-site work, make sure to ask people at the firm about possible hazards because it is often difficult to judge site safety without in-depth knowledge about the site. To avoid all kinds of hazards, it is very important to anticipate hazards, be prepared, and work in pairs or teams. If the site appears to be not safe, stop the work, contact the superior immediately, and leave the site.

3.3 ON-SITE INSPECTION

3.3.1 Entry

The main problem officers would encounter during entry is a denied entry. To avoid this, the officers should:

- Enter through the main gate or reception area
- Locate the person-in-charge
- Identify yourself with credentials to person-in-charge
- Explain the legal basis and the scope of the inspection
- Visit the facility at a reasonable hour unless the inspection is for emergency response

Be nice, kind, fair and act professionally. Most of all, be safe. If entry is denied, contact the superior immediately, and also notify the person-in-charge that the action has resulted in denial of inspection. The officers might encounter aggressive people who try to intimidate officers. Stay calm, professional and objective. If they become violent, leave the site immediately and seek the support of the superior or the local police.

3.3.2 Opening Conference

Before starting the on-site inspection, an opening conference should be held in order to explain the purpose, methodology and required time and arrangement for the inspection to the people of the firm, and also to learn who are responsible for different processes of industrial operation. Typical agenda for opening conference include the following items:

- Introduction of personnel involved (meeting participants);
- Explanation of his authority to inspect the facility;
- Objectives and scope of inspection, together with any brief, explanatory review of past compliance and enforcement history;
- Plan and schedule for inspection;
- Any limitations, constraints, or exceptions;
- Administrative arrangements;
- Arrangements for covering matters that involve confidential business information;
- Arrangements for the closing meeting;
- Questions.

If there is an urgent concern in the field (e.g., illegal discharging of wastewater), or if an important sample is to be taken, the officers are advised to explain the situation to the person-in-charge, forego the conference and rush to the site immediately in order to catch illegal activities or to take a representative sample.

3.3.3 Gathering Data and Information

According to the plan for the on-site work, the officers should gather required data and information from the firm. Examples of data and information include, but not limited to:

- Data and information the target company did not furnish in the inspection form
- Information on manufacturing process and the layout of the factory, which are essential in conducting an inspection
- Names and titles of key personnel
- Records of environmental measures implemented by the firm
- Information on how environmental accident occurred and how the firm responded, if the accident has already occurred
- Others

The officers should be aware that these data and information might become necessary to take a further administrative action against a serious polluter, and if they are not collected in time, it could delay the action and result in further pollution of the environment. To avoid forgetting to collect important data and information during inspection, the officers should write down important questions and items when they develop the plan, i.e., before coming to the site. In asking questions, consider how the data and information may be used in the subsequent stages of inspection. Try to cover “Who”, “What”, “Where”, “Why”, “When” and “How”. Sometime exact name of the person or the exact time the person took an action (e.g., discharged wastewater) becomes important.

It is likely that the firm does not have the data and information in readily available form. Thus, if notification is made prior to inspection, the officers should request the firm to prepare the information in advance. This is not the case if un-announced inspection is implemented.

The collected data and information should be properly filed in accordance with the protocol of the organization, perhaps in a folder designated for the firm, so that they are always available not only to the officer who inspected the site, but also to other officers for administrative work. The officers should also be aware of the confidentiality of data and information. The data and information should be kept safely at the office, and should not be disclosed to the third party without authorization of the superior.

3.3.4 Walk-through Inspection

In this process, the officers should walk through the site to check the general conditions of the factory. The route may be set considering the process lines, waste streams, or any other criteria. The officers should trace the route on the layout of the facility so that he/she does not miss any important areas or facilities.

In compliance inspection, officers are expected to thoroughly check if the target factory is meeting detailed regulatory requirements by examining, for example, condition of effluent treatment facility and consistency of the environmental management at the site with the declared information. Because detailed regulatory requirements are yet to be clearly set in Myanmar, it is somewhat difficult to determine when the firm is in violation of the regulation. Nevertheless, the goal is to prevent unacceptable pollution, and the officers shall make every effort to record activities/conditions of the factory that could possibly result in such pollution. In countries where regulatory requirements are already clearly specified, it is more straightforward to determine environmental violation. In Japan, for example, items summarized in Table 3-3 are to be inspected in accordance with requirements of the Water Pollution Control Act (1970). While the laws and regulations in Japan are different, these are examples of important items to be inspected in Myanmar.

Table 3-3 Examples of Inspection Items According to Water Pollution Control Act (1970) in Japan

Category	Examples of Requirements	Inspection Items
Registration of Regulated Facility	- Firm that has regulated sector-specific facility (facility that discharges wastewater or use/store hazardous substances) has to submit application documents (detailed specification of facility, wastewater treatment, etc.) and get the facility registered by the prefectural government. - Requirements for emergency situation	- Comparison of conditions of the firm against registered information - Condition of wastewater discharge - Manufacturing process - Main and auxiliary raw materials, etc.
Wastewater Treatment Facility	- In the registration documents, regulated firm has to describe method of wastewater treatment, pollution level, volume, chemical usage, etc. - Wastewater should satisfy the discharge standard - In some areas, pollution loads of some pollutants, in addition to concentrations, are regulated.	- Comparison of conditions of the facility against registered information - Operation condition of the facility - Use of chemicals for treatment - Conditions of devices to control wastewater - Condition of the treated wastewater - Condition of sludge - Condition of bookkeeping
Outfall, Discharge Route, Soakaway	- In the registration document, regulated firm has to describe discharge routes and locations of outfalls. - Wastewater should satisfy the discharge standard	- Sampling of wastewater - Comparison of conditions of the facility against registered information - Condition of the discharge route - Condition of outfall and surrounding area
Environmental Management	- Regulated firm has to assign supervisor/manager in charge of pollution control and certified pollution control expert based on Act on Improvement of Pollution Prevention Systems in Specified Factories (1971)	- Organization for pollution control - Coordination between environmental department and manufacturing department
Groundwater (soil)	- Firm that uses/stores hazardous substances has to meet technical and monitoring requirements	- Condition of groundwater well - Sampling of groundwater
Self-monitoring	- Regulated firm has to monitor its wastewater	- Log book of monitoring record - Certificate of analysis - Internal procedure for self-monitoring data - Maintenance and calibration of monitoring devices

Source: JET based on Ministry of Environment Japan (2006).

3.3.5 Sampling

This section discusses key aspects of taking representative samples as part of inspection activities. The section focuses on wastewater sampling, but important points are the same for sampling of air, soil, solid waste, noise, odor, etc. Take extra precautions during sampling because the site may be slippery, contaminated or poorly constructed, and there is a risk that the officer might get seriously hurt by falling into a wastewater tank, touching burning surface of a boiler, being exposed to toxic substance, or suffer from heat exhaustion.

Table 3-4 Issues to Consider When Taking Wastwater Sample

Aspect	Remark
Timing	- Volume and quality of industrial wastewater usually exhibit hourly, daily and longer-term fluctuation depending on stage of production process as well as change in production strategy in response to the market. Thus, the officer should consider operation status of the factory when taking wastewater sample. - Some operators of facilities, in fear of getting caught in discharging concentrated wastewater, try to interfere with sampling by altering the operation (e.g., start washing the floor) or by stopping the wastewater treatment. This is why it is better to take sample un-announced and at the beginning of on-site work. - According to National Environmental Quality (Emission) Guidelines (2015), the wastewater should satisfy the guideline at least 95% of operating time.
Location	- The sampling location should be set in accordance with the NEQEG or other regulation. If the point of compliance is specified in the project EMP or ECC, the point of compliance becomes the sampling points. Otherwise, the treated wastewater before dilution (e.g., by storm water) is the target of sampling. - In some factories, a wastewater line is connected to rainwater drainage, and during rainy season, wastewater may be diluted significantly at the outfall. Also, there could be a bypass line that discharges wastewater to another route. Hence, the officer should examine the wastewater routes, and make the best effort to collect a representative sample. - Bring good sampling equipment (e.g., a dipper with long handle and bucket) in order to take samples safely.
Quality Control	- Even a carefully collected sample is useless unless it is properly pre-treated, transported, stored and analyzed. Thus, the officer should coordinate with the laboratory about how to ensure analytical reliability. - Examples of typical problems include contaminated sampling bottle (e.g., bottle was not washed or washed with detergent that contains pollutant), and chemical/biological transformation during transportation and storage was not minimized (e.g., not fixing the sample by adding chemical additives, not keeping the sample in cooler box or refrigerator, and not getting the sample analyzed in time). - The laboratory also has to practice proper quality control procedures, and the officer should ask the laboratory how it would minimize analytical error. The officer should be aware that, depending on the parameter, an error is easily as large as 20 to 100% or even larger.

Source: JICA Expert Team

For details of sampling, please see, e.g., Environmental Canada (2005).

3.3.6 Evidence

It is important for officers to conduct inspection and to document the findings in such way that the results of their inspection can be used as evidence to evaluate, often by a third party (e.g., superior officers, development committee or judicial court), whether the target factory/firm is in violation of administrative requirement or the activity of the factory is the direct cause of pollution. Thus, officers should know what findings and document may be considered a valid evidence.

In formal environmental litigation, only an evidence that satisfies a set of judicial rules, often known as the rules of evidence, is admissible in court. First, evidence has to be authentic – unreliable data and information are scrutinized and refuted as evidence. Also, an evidence should be relevant in establishing the fact, such as violation of regulatory requirement. In this regard, facts (not the opinions of officers) and direct observation of facts are generally preferred over circumstantial evidence. Therefore, collecting direct evidence that establishes the fact, such as photos of pollution plumes or dead fish or reports of chemical analysis, is a priority for the officer. If direct evidence is not sufficient, the court has to rely on circumstantial evidence, which is often technical, and makes the judgement more difficult.

In dealing with serious environmental cases, the officer should consult his/her superior about what evidence is to be collected and how. Poorly conducted inspection could not only fail to contribute to resolving the case, but could even hurt it.

3.3.7 Closing Conference

At the end of an on-site work, a closing conference should be organized to explain the findings and the next course of actions to the firm. A typical agenda for a closing meeting is as follows:

- Introduction of personnel, if different from opening meeting
- Thanks for co-operation, administrative arrangements, etc.
- Summary of objectives for inspection, with any modifications that might have been made during its conduct
- Summary of general findings
- Indication of preliminary evaluation of any non-compliance found
- Indication of any corrective actions required, and of any other follow-up activity, that will be formally notified by letter in due course
- Issue of any formal instruction or order in the case of a significant risk being found, and depending on the law and officer’s powers
- Questions

3.3.8 Emergency Response (Optional)

The procedures above are applicable to most inspection activities, but when a reactive inspection is made because of an environmental accident, the officer should consider how to determine the extent and character of the incident as quickly as possible. If the officer encountered an environmental accident, he/she should inform the superior immediately by calling him/her. Also, if there is a fire or public emergency, he/she should coordination with the fire department or other departments.

In cases of more limited or local incidents, the following procedure may be followed (OECD, 2004):

- The officer should ask for the responsible site representative. In most cases this person is known from previous visits or from previous correspondence with the company;
- The officer should explain the purpose of the inspection;
- The officer should question the site representative and other site operators/staff as necessary to establish the exact details of on-site operations and potential problems that have resulted in the incident. Also, the installation’s fire brigade and/or Environment, Health and Safety department may be involved;
- If the incident is more serious, the officer should be accompanied by a colleague in order that corroborated legal evidence may be collected if necessary, and any staff being questioned should be given the caution that any information given may be used in evidence in court;
- The officer should check all relevant areas of the installation and the neighboring area unless the incident has resulted in conditions which are unsafe;
- The officer must follow the site safety requirements;
- The site representative should be given the opportunity to accompany the officer on the inspection;
- Where appropriate, the officer (or any other authorized person) should take samples, if necessary, in accordance with the legal procedures for use as evidence;
- The officer should write down all statements made by the site staff and if appropriate take photographs or video recordings as information or as evidence;
- Where appropriate, the officer should give information and advice to the site operator regarding action that may stop an ongoing incident, prevent a recurrence, or remedy damage caused. In some circumstances, depending on his or her legal powers, the officer may strongly recommend or insist that certain action is taken to stop an incident and/or prevent further pollution;
- Before leaving the site, the officer should ensure that the site representative is aware of any further action that is required by the operator, and that the officer’s course of further action is clear.
- Effective follow-up of such a visit is important in order to assess the operator’s response to any instructions or guidance from the officer.

It is very important to collect environmental evidence right away as it becomes difficult to obtain the evidence as time passes. The officer should also be aware that his/her record of the accident will become an important official record about the case. Follow the following recommendations in gathering the evidence.

Table 3-5 Suggestions for Collecting Evidence

Environmental and biological samples	- Collecting the samples right away and get them analyzed at a reliable laboratory. - Take the photos of sampling.

	- Be able to account for the location of samples from the time of sampling to delivery to the laboratory (chain of custody) - Minimize the time from sampling to delivery to the laboratory
Official notebook	- The record might become an official evidence. Thus, use an official notebook if available. - Keep the notebook safe at all time.
Site photos and videos	- Take photos and videos of the site. - Make sure that the setting of the time in the camera is correct. Activate the geo-tag.
Witness statements	- If possible, obtain witness statements. Get the name and signature of the witness. - If possible, record the interview electronically (audio or video)
Documentation	- Prepare hard copies of the evidence, and keep them in the file. - Make copies of the evidence.

Source: JET based on HCCREMS, Guideline Evidence Gathering, 2012.

3.4 POST-INSPECTION ACTIVITIES

3.4.1 Reporting

After the inspection, the officer has to write an inspection report that describes the findings and the results of the on-site inspection. Some tips for reporting are:

- Clearly mention who did what, when, where, how and to whom. Use active voice rather than passive voice.
- Write in logical order, such as the order of on-site inspection works, so that it is easy to follow.
- Make the report easy to read and understand. Use headings.
- Avoid being too formal or technical unless you are required to write a technical report.
- Write an executive summary if the report is long.

With respect to format, the officer should follow the protocol of the organization. ECD, YCDC, MCDC and DISI have standard report formats. If the format is not clear, the officers may use the following format:

Table 3-6 Sections and Contents of Typical Inspection Report

Section	Contents
Heading:	This should include the type of inspection, site or activity name, and the date of the inspection.
Facility Address:	Corporate or head office address where all official correspondence should go.
Site Address:	Exact geographic location of the site, especially if different from the Facility Address.
Site Contacts:	Name, position or title, and telephone number.
Inspection Team:	Name, position or title, and telephone number.
Site History:	This may include the compliance history, and the history of the facility site location, processes and ownership. There should also be a brief description of the present operation.

Inspection Time/Date:	The hour, day and year of the inspection.
Opening Conference:	To whom did you show your credentials? Who was present, and what were their titles or positions; what was discussed; were there specific arrangements? You should describe if entry was granted or denied, special conditions, problems or restrictions.
Field Inspection:	This is a narrative of the field inspection, events and observations. Where did you go? What did you do? What did you see?
Record Inspection:	What records were reviewed? What records were copied and taken? Where were the records kept and who was in charge of them? What selection method was used to review records?
Closing Conference:	Who was present? What was discussed? Did you request further information, from whom and by what date?
Samples:	What samples were taken, where, when, and of what? Attach copies of all supporting documentation and chain of custody. You should also include a discussion of the time, method of packaging, transporting to, and receiving samples at the lab.
Compliance Concerns:	State as your opinion only. Regulations may be cited in the report or may be cited in an "enforcement confidential" memorandum of transmittal to the program office or counsel. Some attorneys have strong feelings against the inspector drawing any enforcement conclusions at all, because it may complicate or limit the agency's discretionary powers.
Attachments:	List and identify all notes, documents, photographs, notices, and documentation. This may be done in the inspection narrative itself or in an index of attachments.
Date and Signature:	It is your report, so sign it!

Source: USEPA, 2002

3.4.2 Deciding the Course of Action

Based on the results of the inspection, the organization has to make the decision about what action should be taken about the firm in accordance with relevant laws and regulation. The decision is based on numerous factors, such as severity of violation, nature of violation, history of violation, environmental and social impact, etc. The action to be taken by the organization is largely based on relevant administrative law, such as Law on Environmental Conservation (2012), YCDC Law (2014), MCDC Law (2014) or Law on Private Enterprise (1990), and examples of action include:

- Issuing a warning letter
- Ordering improvement of environmental performance
- Ordering urgent measure to control pollution
- Suspending the license

However, if the problem is serious involving civil or criminal offence or repeated administrative violation, formal litigation in court should be considered.

How to make the decision is beyond the scope of this manual, as it depends on specific circumstance of the case. Nevertheless, it is very important to be fair and consistent about the decision. Otherwise the firms in the area might start to distrust the decisions of the organization and the inspection work.

3.4.3 Follow-up Activities

Once the decision is made, the organization should take the official action within its legal competence, such as issuing a warning letter to the firm or issuing a recommendation letter to relevant organization. Then, the organization should follow up on the action, and if necessary, carry out the next inspection to confirm the firm has complied with the decision.

Also, the organization should develop a regular report of inspection activities, such as an annual report summarizing the results of inspection activities carried out within the period. Such report is highly useful in analyzing situations of various firms in the area, effectiveness of inspection, and consistency of actions by the organization.

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APPENDIX

Appendix 1: Inspection Check List

APPENDIX 1 INSPECTION CHECKLIST

INSPECTION CHECKLIST (DRAFT)

Name of Officer	
Inspection No.	
Name and Address of Firm (Head Office)	Name: Address: Phone No.: Contact Person:
Name and Address of Factory of the Firm (factory inspected)	Name: Address: Phone No.: Contact Person:

No.	Question	Yes	No
Before on-site inspection Date (DD/MM/YR):			
1	Specifically, what are you trying to achieve in the on-site inspection (e.g., a regular walkthrough inspection for granting business license, collecting a document from the factory, taking emission/effluent sample, discussing how to resolve a complaint, etc.)? Write down the exact goal of the inspection below. If you are aware of the goal, tick the “Yes”, otherwise “No”. ( )	☐	☐
2	Which documents have you reviewed before on-site inspection?		
	- Completed inspection form submitted by the firm	☐	☐
	- EIA and EMP based on EIA	☐	☐
	- Historical records of inspection and environmental compliance	☐	☐

	- Official order for inspection from relevant authority	☐	☐
	- Certification/registration document of the firm	☐	☐
	- Technical document from the factory	☐	☐
	- Complaints about the factory/firm	☐	☐
	-	☐	☐
	- Other documents ( )		
3	Do you have the following documents and equipment for inspection?		
	- Official letter explaining the purpose of the inspection	☐	☐
	- Laws and regulations which are basis of the inspection	☐	☐
	- Most recent inspection form	☐	☐
	- EMP and ECC	☐	☐
	- Document explaining requirement the firm should fulfill, such as an administrative order	☐	☐
	- Notebook and recording equipment (pens, notebook, camera, camcorder, voice recorder, etc.)	☐	☐
	- Sampling equipment (portable water quality analyzer, reagents, tape measure, sampling bottles, marker for labeling sample bottles, water sampler, clean water for washing hands, others)	☐	☐
4	Are you properly dressed for on-site inspection?		
	- Official Uniform	☐	☐
	- Credential/ID	☐	☐
	- Safety gear (gloves, masks, safety shoes, helmet, flashlight, others)	☐	☐
During the on-site inspection Date (DD/MM/YR):			
5	- Have you made an official introduction to the representative of the factory?	☐	☐
6	- Have you had an opening conference and explained the objectives and steps of the inspection?	☐	☐
7	- Were the representative of the factory and competent technical staff present?	☐	☐
8	- Have you checked the general operational condition of the factory (cleanliness, odor, noise, safety, condition/discoloration of floor, etc.)? If you noted anything unusual, please write them down (	☐	☐

	)	
9	How was the condition of the wastewater stream? - Were the sources and the usage of water the same as declared in the inspection form? - Does the factory regularly measure the flow rate? - Does the factory separate rainwater from entering wastewater stream? - Does the factory minimize water usage (e.g., recycling)? - Was the wastewater from manufacturing process mixed with wastewater from the office building (e.g., toilet, canteen)? - Were there any wastewater lines bypassing the treatment? - Were the conditions of all outfalls acceptable? - If you note something unusual about the wastewater stream, record them below ( )	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
10	How was the condition of the wastewater treatment facility? - Does the factory have a treatment facility? - Was the primary treatment facility (e.g., screen, settling tank or oil separator) well maintained? - Was the secondary treatment facility (e.g., activated sludge, septic tank or other biological treatment facility) well maintained (e.g., no excessive scum, overflow, strong odor)? - Did the treated water look clean and meet the effluent requirement? - Other major findings? ( )	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
11	How was the condition of solid waste? - Was the industrial solid waste separated from other domestic solid waste? - Was the factory reusing/recycling byproduct and sub-product as much as they can? - (Type of waste/ Amount) - (Harmful waste) - Was the solid waste properly collected and disposed of?	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

	- Was the sludge from the manufacturing and wastewater treatment processes disposed of properly? - (Store room) - (Discharge place)	
12	How was the management of toxic substances (e.g., chromium in leather tanning)? - Was the manufacturing line that uses a toxic substance separated from the rest of the manufacturing lines? - Were the sludge and other waste containing hazardous substance disposed of properly? - (Storage)	☐ ☐ ☐ ☐
13	- Have you collected a representative wastewater or sludge sample from the factory?	☐ ☐
14	What data and information have you collected and what were not available? - What data and information were collected? ( ) - What data and information you had intended to collect during the inspection were not available and why? ( )	☐ ☐ ☐ ☐
15	- Have you recorded the findings using notebook, camera, camcorder, voice recorder, etc.?	☐ ☐
16	In the closing conference, have you made the following? - Confirmed major findings with the representative of the factory? - Explained the next course of action?	☐ ☐ ☐ ☐

	- Prepared a short report, and obtained counter signature of the representative of the factory?	☐	☐
After the on-site inspection Date (DD/MM/YR):			
17	- Have you prepared and submitted the inspection report	☐	☐
18	- Have you discussed the results of the inspection and the next course of action with your superior?	☐	☐
19	- What was the conclusion of the inspection? ( )	☐	☐
20	What follow-up actions are required? - Are follow-up actions required? - If required, what actions are required? (Required follow-up actions:) (When and by whom:)	 ☐ ☐	 ☐ ☐
Any comments on inspection			

End of document

Appendix 7:

Criteria for Selecting Sampling Points, Time and Parameters

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

CRITERIA FOR SELECTING SAMPLING POINTS, TIME AND PARAMETERS

FINAL VERSION

JUNE 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT, MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION

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TABLE OF CONTENT

1 Introduction

This document was prepared to present a criteria for selecting sampling points, sampling time, and measurement parameters in the water quality survey under the Project for Capacity Development in Basic Water Environment Management and EIA System (hereinafter referred to as "the Project"). The criteria were used to design the plans of water quality surveys.

After the criteria were firstly prepared for 1st water quality survey, the original criteria have been slightly revised in the course of the Project implementation, considering changes in site situations, result of past water quality surveys and so on, though they proved to be reasonable as a whole. The additional revision was made before 4th water quality survey based on the experience from 1st to 3rd surveys. The updated criteria was used for 4th and 5th water quality surveys.

2 Criteria

2.1 Original Criteria

The original criteria were prepared for each pilot area for water quality survey, namely Hlaing River basin and Doke Hta Waddy River basin, based on the fact and observation of geographical conditions, hydrological condition, expected water quality, water usage, pollution sources, land use and so forth. The developed criteria are shown in the table below, which was used for 1st water quality survey.

Table 2-1 Original Criteria for Selecting Sampling Points, Sampling Time, and Measurement Parameters, etc.

Item	Important Points to Consider	Criteria for selection	
		Hlaing River Basin	Doke Hta Waddy River Basin
Sampling Point	Locations of pollution sources, water usage, change in water quality and flow rate etc.	- Pollution control point: major routes of pollution (e.g., channels from factories) and downstream locations in the river after sufficient mixing of wastewater and river water - Baseline point: upstream and downstream of confluent point, as well as the lowest point in the watershed	- Pollution control point: major routes of pollution (e.g., channels from factories) and downstream locations in the river after sufficient mixing of wastewater and river water - Water usage control point: upstream of water intake - Baseline point: upstream and downstream of confluent point as well as the lowest point in the watershed
Sampling Time/ Frequency	Seasonal fluctuation (e.g., rainy /dry season), tidal fluctuation, other characteristics	- Precipitation and river discharge: dry and rainy seasons - Tide: in tidal area, low tide and high tide on spring tide day. - Stability of water quality: on a day after several days of good weather	- Precipitation and river discharge: dry and rainy seasons - Stability of water quality: on a day after several days of good weather

Item	Important Points to Consider	Criteria for selection	
		Hlaing River Basin	Doke Hta Waddy River Basin
Parameters	Parameters to characterize river waters and industrial wastewaters	- Relevant standards: Key parameters to monitor river water quality with reference to Japanese environmental standard - Pollution sources: Discharge standard and main pollutants in the effluent - In addition, existing water quality data, analytical capacity of laboratory, and other factors also shall be considered.	

Source: JICA Expert Team

2.2 Additional Considerations for Criteria

These criteria, which were presented in the previous section proved to be reasonable. Nevertheless, considering the results of the past water quality surveys in the Period 1 (June 2015 – April 2017) and updated site-related information, the criteria needed to be slightly revised and updated before starting the Period 2 (June 2017 – June 2018). Table 2-2 shows the additional considerations to update the criteria based on findings from 1st to 3rd surveys.

Table 2-2 Additional Considerations for Criteria for Selecting Sampling Points, Sampling Time, Measurement Parameters, etc. after 1st to 3rd Water Quality Survey

Item	Additional Considerations to Update the Criteria Based on Findings in 1st – 3rd Water Quality Survey
Hlaing River basin	
Sampling Point	• The trend of water quality from upstream to downstream of Haling River was not clear. This is due to the difficulty in detecting the difference of water quality among the sampling locations, which is inherently small because the river water flow is significant. The difference can be easily masked by analytical uncertainty. • In order to examine the impact of industrial wastewater, it is better to include another sampling location(s) targeting a basin of a creek draining wastewater from an industrial zone to Hlaing River or Pan Haling River, rather than setting many sampling locations in the main stream of Hlaing River. Thus, the sampling points in Hlaing River will be decreased and the other sampling points will be added to the sub-stream in Shwe Pyi Thar IZ and Hlaing Tharyar IZ. • In order to confirm the water quality of Hlaing River before affected by domestic and industrial wastewater from the urban areas of Yangon city, new sampling point in further up-stream of Hlaing River need be added in Hlaing River basin.
Sampling Time/ Frequency	• The concentrations of BOD and COD vary depending on the depth of sampling. This phenomenon seems related to the impact of saline water intrusion. It seems the water quality is worse during ebb tide, rather than during rising tide.
Parameters	• While the basic parameters should be monitored at every sampling location, selection of parameters should be optimized carefully considering the goal of the monitoring.
Doke Hta Waddy River basin	
Sampling Point	• The data did not indicate significant pollution of Doke Hta Waddy River downstream of discharge point of 10-inch-diameter line after wastewater was mixed well with the river water. The sampling points in Doke Hta Waddy River can be decreased, for example from 4 points to 3 points. • In order to investigate pollution load of organic matter and nutrients to Thaung Tha Man Lake from agricultural activities in the upper basin, new sampling points in the further upper stream of Pan Yan Taw Creek need be added in Doke Hta Waddy River basin.
Sampling Time/ Frequency	• The water level of Doke Hta Waddy River fluctuates depending on the operation of the hydro power plant in the upper stream of Doke Hta Wadddy River.
Sampling Location	• The water quality at the U Shwe Thaung Bridge, where the creek flows into Thaung Tha Man Lake, was low. More sampling points in the upper stream area are needed to examine impact of pollution sources.

Source: JICA Expert Team

2.3 Finalized Criteria

Based on the additional considerations from 1st to 3rd water quality surveys, the criteria were updated and finalized as shown in the table below. Here the tide effect on water quality in different sampling time in the Hlaing River Basin is not clear, since in the past surveys, it was difficult to reveal the full picture of fluctuation of water quality impacted by tide. The times of spring tide and ebb tide were tentatively suggested for the sampling times, aiming to monitor the worst water quality based on the past surveys' result. This finalized criteria was used for designing the 4th and 5th water quality surveys.

Table 2-3 Updated Criteria for Selecting Sampling Points, Sampling Time, Measurement Parameters, etc.

Item	Important Points to Consider	Criteria for selection	
		Hlaing River Basin	Doke Hta Waddy River Basin
Sampling Point	Locations of pollution sources, water usage, change in water quality and flow rate etc.	- Pollution control point: major routes of pollution (e.g., channels from factories) and downstream locations in the river after sufficient mixing of wastewater and river water - Water usage control point: upstream of (future) water intake - Baseline point: upstream and downstream of confluent point, as well as the lowest point in the watershed	- Pollution control point: major routes of pollution (e.g., channels from factories) and downstream locations in the river after sufficient mixing of wastewater and river water - Water usage control point: upstream of water intake - Baseline point: upstream and downstream of confluent point as well as the lowest point in the watershed
Sampling Time/ Frequency	Seasonal fluctuation (e.g., rainy /dry season), tidal fluctuation, other characteristics	- Precipitation and river discharge: dry and rainy seasons - Tide: the time of spring tide and ebb tide in tidal area - Stability of water quality: on a day after several days of good weather (dry season)	- Precipitation and river discharge: dry and rainy seasons - Stability of water quality: on a day after several days of good weather (dry season)
Parameters	Parameters to characterize river waters and industrial wastewaters	- Relevant standards: Key parameters to monitor river water quality with reference to Japanese environmental standard, which will be replaced with the Myanmar Environmental Quality Standard after it is specified in the future. - Pollution sources: Discharge standard and main pollutants in the effluent In addition, existing water quality data, analytical capacity of laboratory, and other factors also shall be considered.	

Note: The underlined sections show the update information.

Source: JICA Expert Team

Appendix 8:

Water Quality Survey Plan

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY PLAN

FINAL VERSION

JUNE 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT, MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION

YANGON CITY DEVELOPMENT COMMITTEE

MANDALAY CITY DEVELOPMENT COMMITTEE

JICA EXPERT TEAM

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1 Introduction

This technical document summarizes the water quality survey plan for the Project for Capacity Development in Basic Water Environment Management and EIA System (hereafter referred to as "the Project)", in which the water quality survey in the Hlaing River basin in Yangon and the Doke Hta Waddy River basin in Mandalay was conducted as a pilot study.

The preliminary water quality survey plan was prepared in later 2015. It was slightly modified during 2^{nd}– 3^{rd} surveys and updated for 4^{th} and 5^{th} water quality surveys, based on the past water quality survey results, the discussions with counterpart (C/P) organizations of the Project and changes in conditions of sampling sites. It should be noted that the surveys were conducted based on the survey plan but necessary slight changes were made in actual survey works depending on site conditions or other inevitable reasons in the field.

2 Outline of Water Quality Survey

The water quality survey of this Project had two pilot study areas, namely Hlaing River basin in Yangon and Doke Hta Waddy River in Mandalay. The water quality survey was initially planned for both rainy season and dry season in each target basin in two years during the project period, but eventually conducted in total five times.

3 Development of Objective of Water Quality Survey

Preparation of water quality survey plan started with setting the objectives of survey in late 2015. First, related data and information were collected (see Section 3.1 below) and then survey objectives were identified (see Section 3.2 below).

3.1 Collected data and information

3.1.1 Currently-used guideline or criteria to evaluate the water quality

The environmental water quality standard was not yet issued. One of the common reference standard in Myanmar as of 2015 was the WHO standard. It was applied not only to the drinking water sources, but also to other types of monitoring, such as the water quality survey of Hlaing River by University of Public Health and YCDC.

Regarding the guideline for industrial wastewater quality, YCDC generally referred to locally available interim guideline values, such as the draft industrial wastewater quality standards proposed by MOST/MOECAF[1]. Likewise, MCDC referred to the guideline values for some specific

[1] MOECAF was restructured as Ministry of Natural Resources and Environmental Conservation (MONREC) in 2016.

parameters such as COD level indicated in MOI regulations (MOI, Allowable Effluent Standard, 1995).

In December 2015, the new regulations specifying the reference criteria of effluent, National Environmental Quality (Emission) Guidelines, was issued by MONREC where general guideline values for wastewater, storm water runoff, effluent and sanitary discharges and industry-specific guidelines of effluent levels for each development sector are suggested.

3.1.2 Baseline Data in the Hlaing River Basin

In order to develop the monitoring plan, information on climate, hydrology, pollution sources and other relevant characteristics of the target river basins was collected from various sources at the beginning of the Project.

The Hlaing River runs through the western part of Yangon City, joins with Pan Hlaing River, becomes the Yangon River, and drains to Andaman Sea. The spatial and temporal fluctuations of the flow of Hlaing River, which is significantly affected by the tide, have not been investigated. The water quality at several sampling points in the Hlaing River basin was investigated by University of Public Health and YCDC in 2013. In terms of BOD, COD, nitrate, arsenic, lead and iron, the river water quality was not significantly worse compared with environmental water quality guideline values used in other countries, except for the extremely low level of DO. The reason for the low DO was to be examined. On the other hand, the water quality of drainage channels receiving discharges from factories seemed deteriorated, but the impact of pollution sources on the water quality of Hlaing River had not been studied yet. Other related information as of preparation of 1st water quality survey plan is summarized in Table below and pictures in the basin are shown in Figure below.

Table 3.1-1 Available Information on Water Quality Survey for Hlaing River Basin

Category		Summary
Meteorology		- The highest precipitation (approx. 600 mm/month) is observed in July while it hardly rains in the dry season especially from Nov to Mar. (JICA, Final Report of The Project for the Strategic Urban Development Plan of the Greater Yangon, 2013)
Hydrology	River information	- To be confirmed with Department of Meteorology and Hydrology
	Tidal information	- The tidal observation has not been carried out by MPA (Myanmar Port Authority) lately. The available past data at Yangon port up to 1936 showed the highest high water level (HHWL) was +6.74 m and mean water level (MWL) was +3.121 m in Yangon River at Yangon Port station. (JICA, Final Report of The Project for the Strategic Urban Development Plan of the Greater Yangon, 2013) - The salt water intrusion has been observed along Hlaing River, however the spatial distribution of brackish water and its fluctuation are unknown.
Pollution Source		- Several industrial zones (IZs) including Shwe Phi Thar IZ, Shwe Linban IZ and Hlaing Tharyar IZ are located along the river. The effluent from

	factories such as battery, alcohol, and seafood factories, seems to deteriorate the surface water quality in drainage channels. Domestic sewage is also directly discharged to the Hlaing River. - The detailed information on factories is being collected in Output 3(Database).
Past water quality data	- In total 10 river water samples and 20 wastewater samples were analyzed in 2013 for 11 analytical parameters. The level of COD of river in not high, and varied from 9 to 25 mg/L. The water quality deteriorated from upstream to downstream. The DO level was extremely low (0 – 2.0 mg/L). (University of Public Health and YCDC, Water quality assessment of Hlaing River Near Industrial Zone, Yangon, 2013) - It seems the wastewaters from factories flow into the channels and its adverse effect on water quality is obvious. However, concentrations of many pollutants as well as their main source are not clear.
Water use	- The Hlaing River serves for flood control, river transportation and fisheries.

Note: This table is based on the information collected before 1st water quality survey.
Source: JICA Expert Team

Hlaing River

Sub-stream of Hlaing River discharging from Shwe Pyi Thar IZ

Source: JICA Expert Team

Figure 3.1-1 Photos of Hlaing River Basin

3.1.3 Baseline Data in Doke Hta Waddy River Basin

The Doke Hta Waddy River flows from east to west in the south of Mandalay City and joins Ayeyarwaddy River. There is a large industrial zone (three zones) in Pyi Gyi Tagon Township discharging the wastewater to the south toward Doke Hta Waddy River and to the west toward Taung Tha Man Lake. As for the south-bound flow, the two ponds, namely Myauk Inn (north lake) and Taung Inn (south lake) located between the industrial zone and Doke Hta Waddy River were serving as the natural receiver and buffer of pollution load from the factories as of 2015. Hence, the water quality of Doke Hta Waddy River, which has been monitored weekly by WSD of MCDC for the purpose of future use for water supply, seemed reasonably good. On the other hand, the pollution load from the factories and sewage in the area is affecting Taung Tha Man Lake located in the west of the industrial zone. The Taung Tha Man Lake is famous as a tourist destination in Amarapura (former capital of Myanmar), and is rich in fishery resources. As the Taung Tha Man Lake suffered major fish kill incidents in April-May and September-October, 2015 presumably due to the pollution load from factories, WSD/MCDC started to check the water quality in Taung Tha Man Lake and surrounding channels periodically. Other related information is summarized in Table below and pictures in the basin are shown in Figure below.

Table 3.1-2 Available Information on Water Quality Survey for Doke Hta Waddy River Basin

Category	Summary
Meteorology	- High precipitation (more than 100 mm/month) is observed in the rainy season from May to October while it hardly rains in the dry season especially from Dec. to Mar.(www.weather-and-climate.com) - The detailed data is being collected from Department of Meteorology and Hydrology
Hydrology	- The river water level in Ayeyarwaddy River varied from 3.6 m to 11.5 m in 2014. According to the 13-years monitoring data available from MCDC, the minimum river water level is observed in May, June or December and maximum level is in July, August or September. - The data in Doke Hta Waddy River is to be confirmed with Department of Meteorology and Hydrology.
Pollution Source	- The wastewater from the industrial zone in Pyi Gyi Tagon Township is discharged to Doke Hta Waddy River basin through the 12,000 feet and 10- inch-diameter pipeline. The pipeline has been constructed in order to reduce the pollution load in Pa Yan Taw Creek and intend to be connected to the wastewater treatment plant to be constructed. - The surrounding factories are allowed to discharge wastewater only in the night time. - The detailed information on factories is being collected in Output 3(Database).
Past water quality data	- WSD/MCDC has been monitoring water quality of Doke Hta Waddy River weekly for 15 analytical parameters as a potential source of supplied water (e.g., BOD varies from 3.5 to 5.3) (MCDC, from Mar. 2014 to Mar. 2015) - The water temperature, pH, color, DO, BOD and COD in Taung Tha Man Lake and a connected channel have been monitored by WSD/MCDC. Concentrations of COD (48 mg/L - more than 150 mg/L) and BOD (19 – 98 mg/L) are rather high. (MCDC, Oct. 2015) - Many dead fishes were found in the coast line of north Taung Tha Man Lake in April and September 2015, and it is suspected that it was caused by low level of oxygen and pollution load from factories. - Some data of wastewater quality discharged from factories have been collected. - Water quality of Ayeyarwaddy River is monitored by Ministry of Transportation.
Water use	- MCDC plans to use the Doke Hta Waddy River as an additional source of supplied water in the near future. - The upstream of Doke Hata Waddy River is used for hydropower plant. - The other key uses are irrigation, flood control and artisanal fisheries.

Note: This table is based on the information collected before 1st water quality survey.
Source: JICA Expert Team

Doke Hta Waddy River

Taung Tha Man Lake

Source: JICA Expert Team

Figure 3.1-2 Photos of Doke Hta Waddy River Basin

3.2 Identified Objectives

Based on the collected information and data, any problems and possible concerns were discussed with the counterpart organizations before the 1st water quality survey. The discussion raised the study questions and set the objectives of the survey as shown in the table below. Among others, the main objectives of the water quality survey are to confirm the pollution statuses in the target river basins and to examine the impacts of industrial wastewaters on Hlaing River and Doke Hta Waddy River.

Table 3.2-1 Objectives of Water Quality Survey (As of later 2015)

Items to be Considered	Hlaing River basin	Doke Hta Waddy River basin
Current problems and suspected mechanism	1) The industrial zones located and other human activities along the Hlaing River and Pan Hlaing River might pollute the river water. 2) However, there is no reliable data on level and type of contaminants.	1) The 10-inch diameter pipe line discharged the polluted wastewater from Pyi Gyi Tagon to Doke Hta Waddy River. However, the pollution impact is a big concern for the surrounding area. 2) Mass fish kills incident occurred in Taung Tha Man Lake in 2015, and it was likely to be caused by hypoxic water and pollution load from factories.
Study Questions	1) What is the current status of water quality in the Hlaing River basin? 2) Is the water quality in the Hlaing River deteriorated because of the industrial wastewater in the river basin? 3) How significant is the impact on water quality in the Hlaing River by the industrial zones located along the river?	1) How significant is the impact on water quality in the Doke Hta Waddy River by the wastewater discharged from Pyi Gyi Tagon? 2) What is the current status and problems of water quality in Taung Tha Man Lake?
Objectives	1) To confirm the pollution levels in the Hlaing River and Pan Hlaing River. 2) To investigate spatial destruction of pollution in Hlaing River 3) To investigate pollution impact from IZs to Hlaing River	1) To investigate pollution impact from the discharged wastewater to Doke Hta Waddy River 2) To identify the pollution level of Taung Tha Man Lake 3) To investigate the suspected pollution path to the Taung Tha Man Lake

Source: JICA Expert Team

4 Summary of Water Quality Survey Plan

4.1 Preliminary Water Quality Survey Plan

Based on the results of discussions with C/Ps, including the workshops for Output 2 held in MCDC and YCDC, as well as the results of reconnaissance surveys and collected background information, the survey plans were developed outlining the sampling locations, sampling times and parameters for each pilot basin. Those survey items were determined according to the draft criteria for selecting sampling points, sampling time and measurement parameters, which is presented in the other technical document under the Project, namely "Criteria for selecting sampling points, sampling time and measurement parameters "(June 2018).

The preliminary survey plan in draft, that is shown in the tables below was prepared before the 1st water quality survey.

Table 4.1-1 Preliminary Water Quality Survey Plan for Hlaing River Basin (Draft)

Item	Details
Sampling point	- In total 10 samples per each sampling time - Surface water only [1st and 2nd sampling] - 1 point at upstream of Hlaing River - 1 point before confluence with Pan Hlaing River - 3 points in the crossing line at downstream of the confluence point - 1 point from channel - 2 points between Shwe Pyi Thar industrial zone and near the Bayintnaung Bridge. - 2 points (downstream and upstream) from Pan Hlaing River [3rd- 4th sampling]: Basically same as one of 1st and 2nd sampling but can be revised as needed
Sampling Time	[Season] - 1st sampling: Around spring tide in Feb, 2016 - 2nd sampling: June 2016 - 3rd sampling: Feb 2017 - 4th sampling: June 2017 [Time] - Low tide (time from low to high tide) - High tide only for on-site measurement at representative points (uppermost and lowermost)
Measurement parameters *	[for every time sampling (1st – 4th sampling)] - pH/EC/Salinity/Turbidity/Water temperature/ORP - Flow rate and water depth - TSS, TDS, BOD, COD, Color and Odor, Oil and grease, Total phosphorus, Total nitrogen, Total Coliform [for total 16 samples for each parameter (c.f. every sampling points for 2nd and 3rd sampling]* - Cyanide (as HCN), Phenols, Phosphate (PO_4^-), NH_3-N, NO_3-N, NO_2-N, Zinc (Zn), Total chromium (T-Cr), Chromium (Hexavalent), Arsenic (As), Copper (Cu), Total Mercury (Hg), Cadmium (Cd), Lead (Pb), Iron (Fe), Manganese(Mn) [for total two samples (c.f. two points at 3rd sampling)] - Total organic chlorine pesticide, Total organic phosphorus pesticide, PCB

Note: This is the preliminary survey plan as of 1st water quality survey.

Source: JICA Expert Team

Table 4.1-2 Preliminary Water Quality Survey Plan for Doke Hta Waddy River Basin (Draft)

Item	Result of selection
Sampling point	- In total 10 samples per each sampling time - Surface water only [1st and 2nd sampling] - Doke Hta Waddy River: 4 points - Pollution flow path from the outlet of wastewater pipeline to Doke Hta Waddy: 2 points - Thang Tha Man lake : 2 points - Pollution flow path to Thang Tha Man lake : 2 points [3rd- 4th sampling]: Basically same as one of 1st and 2nd sampling but can be revised as needed
Sampling Time	- 1st sampling: in Feb, 2016 - 2nd sampling: June-July 2016 - 3rd sampling: Feb 2017 - 4th sampling: June 2017
Measurement parameters	[for every time sampling (1st – 4th sampling)] - pH/EC/Salinity/Turbidity/Water temperature/ORP - Flow rate and water depth - TSS, TDS, BOD, COD, Color and Odor, Oil and grease, Total phosphorus, Total nitrogen, Total Coliform [for total 16 samples for each parameter (c.f. every sampling points for 2nd and 3rd sampling] - Cyanide, Phenols, Phosphate (PO_4^-), NH_3-N, NO_3-N, NO_2-N, Zinc (Zn), Total chromium (T-Cr), Chromium (Hexavalent), Arsenic (As), Copper (Cu), Total Mercury (Hg), Cadmium (Cd), Lead (Pb), Iron (Fe), Manganese(Mn) [for total two samples (c.f. two points at 3rd sampling)] - Total organic chlorine pesticide, Total organic phosphorus pesticide, PCB

Note: This is the preliminary survey plan as of 1st water quality survey.
Source: JICA Expert Team

4.2 Revised Plan for 2nd Water Quality Survey

The 2nd water quality survey plan needed to be revised reflecting the experience of the 1st water quality survey as shown in the table below (Also see Section 2.2 of the Criteria for selecting sampling points, sampling time and measurement parameters (JICA Expert Team, June 2018)).

Table 4-3 Additional Considerations for Criteria for Selecting Sampling Points, Sampling Time, Measurement Parameters, etc. for 2nd Water Quality Survey

Item	Considerations in 2nd Water Quality Survey Plan Based on Findings in 1st Water Quality Survey
Hlaing River basin	
Sampling Point	• The trend of water quality from upstream to downstream of Haling River was not clear. This is due to the difficulty in detecting the difference of water quality among the sampling locations, which is inherently small because the river water flow is significant. The difference can be easily masked by analytical uncertainty. • In order to examine the impact of industrial wastewater, it is better to include another sampling location(s) targeting a basin of a creek draining wastewater from an industrial zone to the Hlaing River or Pan Haling River, rather than setting many sampling locations in the main stream of Hlaing River. Thus, the sampling points in the Hlaing River will be decreased and the other sampling points will be added to the sub-stream in Shwe Pyi Thar IZ and Hlaing Tharyar IZ.
Sampling Time/ Frequency	• The concentrations of BOD and COD vary depending on the depth of sampling. This phenomenon seems related to the impact of saline water intrusion. It seems the water quality is worse during ebb tide, rather than during rising tide.
Parameters	• While the basic parameters should be monitored at every sampling location, selection of parameters should be optimized carefully considering the goal of the monitoring.
Doke Hta Waddy River basin	
Sampling Point	• The data did not indicate significant pollution of Doke Hta Waddy River downstream of discharge point of 10-inch-diameter line after wastewater was mixed well with the river water. The sampling points in Doke Hta Waddy River can be decreased, for example from 4 points to 3 points.
Sampling Time/ Frequency	• The water level of Doke Hta Waddy River fluctuates depending on the operation of the hydro power plant in the upper stream of Doke Hta Wadddy River.
Sampling Location	• The water quality at the U Shwe Thaung Bridge, where the creek flows into Taung Tha Man Lake, was low. More sampling points in the upper stream area are needed to examine impact of pollution sources.

Source: JICA Expert Team

Based on these considerations, the 2nd water quality survey plan were prepared as shown in the tables below.

Table 4.2-4 Summary of 2nd Water Quality Survey Plan for Hlaing River Basin

Item	Result of selection
Sampling point	In total 10 samples ➢ 1 point at upstream of Hlaing River ➢ 1 point before confluence with Pan Hlaing River ➢ 1 point at downstream of the confluence point ➢ 3 points from channels in Shwe Pyi Thar IZ ➢ 2 points from channels in Hlaing Tharyar IZ ➢ 2 points (downstream and upstream) from Pan Hlaing River - Surface water basically - Additional samples in depth at middle and bottom layer as needed
Sampling Time	[Season] - June – July, 2016 [Time] - At the time of ebb tide, high tide and low tide at representative point(s), as needed

Item	Result of selection
Measurement parameters	[All points] - Water depth, pH, EC, salinity, turbidity, water temperature, ORP [Basic points] - Flow rate, TSS, TDS, BOD, COD, oil and grease, total coliform [Representative points] - Total phosphorus, total nitrogen, cyanide, phenols, phosphate (PO_4^-), ammonia nitrogen(NH_3-N), nitrate nitrogen(NO_3-N), nitrite nitrogen (NO_2-N), zinc (Zn), total chromium (T-Cr), chromium (hexavalent), arsenic (As), copper (Cu), total mercury (Hg), cadmium (Cd), lead (Pb), as needed Note) Color, odor, iron and manganese are deleted due to less importance and the measurement point of total nitrogen and total phosphorus are decreased from the preliminary plan. [Only one or two points] - Total organic chlorine pesticide, Total organic phosphorus pesticide, PCB. In addition, the sediment quality in Haling River will be measured, as needed.

Source: JICA Expert Team

Table 4.2-5 Summary of 2nd Water Quality Survey Plan for Doke Hta Waddy River Basin

Item	Result of selection
Sampling point	In total 10 samples and some additional samples - Doke Hta Waddy River: 3 points - Wastewater pipeline discharging to Doke Hta Waddy: 1 points - Taung Tha Man Lake : 2 – 3 points - Pollution flow path to Taung Tha Man Lake : 4 -5 points Surface water basically
Sampling Time	- June – July, 2016
Measurement parameters	[All points] - Water depth, pH, EC, salinity, turbidity, water temperature, ORP [Basic points] - Flow rate, TSS, TDS, BOD, COD, oil and grease, total coliform [Representative points] - Total phosphorus, total nitrogen, cyanide, phenols, phosphate (PO_4^-), ammonia nitrogen(NH_3-N), nitrate nitrogen(NO_3-N), nitrite nitrogen (NO_2-N), zinc (Zn), total chromium (T-Cr), chromium (hexavalent), arsenic (As), copper (Cu), total mercury (Hg), cadmium (Cd), lead (Pb), as needed Note) Color, odor, iron and manganese are deleted due to less importance and the measurement point of total nitrogen and total phosphorus are decreased from the preliminary plan. [Only one or two points as needed] - Total organic chlorine pesticide, Total organic phosphorus pesticide, PCB. In addition, the sediment quality in Taung Tha Man Lake will be measured, as needed.

Source: JICA Expert Team

4.3 Revised Plan for 3rd Water Quality Survey

The 3rd water quality survey was planned basically following the 2nd water quality survey plan. However, based on the additional considerations shown below, it was slightly improved to add one more sampling point in the Hlaing River basin and three sampling points in Doke Hta Waddy River.

Table 4-6 Additional Considerations for Criteria for Selecting Sampling Points for 3rd Water Quality Survey

Item	Considerations in 3rd Water Quality Survey Plan Based on Findings in Past Water Quality Surveys
Hlaing River basin	
Sampling Point	• In order to confirm the water quality of Hlaing River before affected by domestic and industrial wastewater from the urban areas of Yangon city, new sampling point in further up-stream of Hlaing River need be added in Hlaing River basin.
Doke Hta Waddy River basin	
Sampling Point	• In order to investigate pollution load of organic matter and nutrients to Taung Tha Man Lake from agricultural activities in the upper basin, new sampling points in the further upper stream of Pan Yan Taw Creek need be added in Doke Hta Waddy River basin.

Source: JICA Expert Team

4.4 Finalized Plan for 4th and 5th Water Quality Surveys

In the beginning of the Period 2 (June 2017 to June 2018) of Project after 1st-3rd surveys were completed, C/Ps and JICA Expert Team discussed the necessity of further revisions based on the past survey results as well as other information, and agreed to develop the following plan for the Period 2.

- In addition to the 4th survey, the 5th survey is to be implemented in February 2018 to obtain reliable data in the Period 2 for both rainy and dry seasons, since some survey results in the Period 1 seemed to have analytical errors. Please see the details in other technical document prepared under the Project, “Water Quality Survey Report”.
- In the Hlaing River basin, the sampling point of “Wataya” was newly added in the Hlaing River in the upstream of Wataya IZ, which is a possible water intake point for Hlawga Lake.
- In the Doke Hta Waddy River basin, two sampling points were added at the intake point of Ayeyarwady River and Shwe Khin Creek in order to check the pollution impact from agricultural farm upstream.
- Phosphate, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen were removed from the measurement parameters because, it was not clear which laboratories in Myanmar or neighboring countries could provide reliable measurement of these parameters based on the experiences in the Period 1, and also it was difficult to preserve water samples property for these parameters until it is transported to Japanese laboratories.
- The measurement parameters for pesticides were selected based on the suggestions from Pesticide Analytical Laboratory under MOALI, draft National Drinking Water Quality Standards in Myanmar (MOHS), availability of analysis at laboratory, and so on.

The survey plan was finally optimized as presented in the following tables at the beginning of the Period 2 and provided to the 4th and 5th surveys.

Table 4.4-1 Summary of 4th and 5th Water Quality Survey Plan for Hlaing River Basin

Item	Contents
Sampling point	- Hlaing River: 4 points, depending on the survey time - Channels in Shwe Pyi Thar IZ: 3 points - Pan Hlaing River: 2 points - Kokkowa River: 1 point
Sampling Time	[Season] - 4th survey: rainy season in 2017 - 5th survey: dry season in 2018 [Time] - At the time of ebb tide near spring-tide day as much as possible
Measurement parameters	[All points] - pH, EC, DO, TDS, salinity, turbidity, water temperature, ORP [Basic points] - Flow rate (if available), TSS, BOD, COD, oil and grease, total coliform [Representative points] - Total phosphorus, total nitrogen, cyanide, phenols, zinc, total chromium, hexavalent chromium, arsenic, total mercury, cadmium, and lead [Only one or two points] - Pesticides* and PCB

* Aldrin, atrazine, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endosulfan, endosulfan sulfate, endrin, HCH-alpha (benzene hexachloride-alpha), HCH-beta, HCH-delta, HCH-gamma(Lindane), alachlor, diazinon, chlorpyrifos, dimethoate and imidacloprid for 4th and 5th surveys
Source: JET

Table 4.4-2 Summary of 4th and 5th Water Quality Survey Plan for Doke Hta Waddy River Basin

Item	Contents
Sampling point	- Doke Hta Waddy River: 3 points - Wastewater pipeline discharging to Doke Hta Waddy: 1 points - Taung Tha Man Lake: 2 points - Flow path to Taung Tha Man Lake :7 points depending on the survey time - Ayeyarwaddy River: 1 points, depending on the survey time - Shwe Kyin Creek: 1point, depending on the survey time
Sampling Time	- 4th survey: rainy season in 2017 - 5th survey: dry season in 2018
Measurement parameters	[All points] - pH, EC, DO, TDS, salinity, turbidity, water temperature, ORP [Basic points] - Flow rate (if available), TSS, BOD, COD, oil and grease, total coliform [Representative points] - Total phosphorus, total nitrogen, cyanide, phenols, zinc, total chromium, hexavalent chromium, arsenic, total mercury, cadmium, and lead [Only one or two points] - Pesticides* and PCB

* Aldrin, atrazine, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endosulfan, endosulfan sulfate, endrin, HCH-alpha (benzene hexachloride-alpha), HCH-beta, HCH-delta, HCH-gamma(Lindane), alachlor, diazinon, chlorpyrifos, dimethoate and imidacloprid for 4th and 5th surveys
Source: JET

Appendix 9:

Water Quality Survey Manual

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY MANUAL

FINAL VERSION

JUNE 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT, MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION

YANGON CITY DEVELOPMENT COMMITTEE

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1 INTRODUCTION

1.1 Background

A water quality survey should be implemented by a systematic methodology based on a specific guidelines and instruction in order to provide useful data for the survey objective. This Water Quality Survey Manual is developed in order to provide the national/local government officers with the comprehensive knowledge and skills to undertake and/or supervise the water quality survey for environmental management.

The Water Quality Survey Manual was originally prepared under the Project for Capacity Development in Basic Water Environment Management and EIA System (hereinafter referred to as "the Project") to be utilized for conducting pilot water quality surveys. However, this manual aims to deliver a standard methodology that is widely applied to general surface water quality survey in terms of environmental conservation and monitoring in Myanmar.

1.2 Regulatory Bases

The Environmental Conservation Law (Law No.9, 2012) specifies the duties and powers of Ministry of Natural Resources and Environmental Conservation (MONREC) for planning, implementing and monitoring of environmental conservation program in Article 7. Article 13 of Environmental Conservation Law mentions that MONREC shall maintain a comprehensive monitoring system and implementation of necessary matters by MONREC itself or in coordination with relevant parties, relating to environmental pollution. Besides, the Environmental Conservation Rules (Notification No.50, 2014) states Environmental Conservation Department may conduct necessary special inspections and investigations at necessary time and place to enable to stipulate environmental quality standards, though environmental quality standards in Myanmar are under development. These regulations provide MONREC with the authority to monitor the water quality for conservation, pollution control and establishment of environmental quality standards. However, the detailed regulation and administrative instruction which clarify concrete measures as well as responsibility and execution organization of environmental water monitoring has not been laid down yet. Since it is essential that national and local governments monitor the water quality of public water and obtain spatial and historical data for making administrative decisions, the development of such detailed regulations has been expected for securing sound water environment.

On the other hand, a regulation or guideline to specify an official methodology and procedure of water quality survey also has not yet been formulated since the water quality monitoring framework is under development in Myanmar. Currently most surveys in Myanmar are conducted by the generally recognized method or customary practice depending on the available resources in terms of capable surveyors, monitoring equipment, chemical analysis laboratories, and security of access to the survey site etc.

1.3 Objective and Target of the Water Quality Survey Manual

This Water Quality Survey Manual targets at the following users:

- Administrative staff at technical level of national/local government in charge of water environmental conservation and water pollution control
- Those who supervise and/or carry out the water quality survey

It is crucial for those parties to improve their capacities for planning and conducting a water quality survey that provides information essential for making administrative decision and obtaining reliable water quality data. Considering the necessity and current capability in Myanmar, this manual is prepared for the following objectives and is designed with procedures that are easily followed and checked.

- To provide consistent protocols and method for water quality survey
- To assist in collection of reliable and precise data in water quality survey

This manual also focuses on the freshwater and brackish water in public water bodies such as rivers, creeks, channels, lakes and reservoirs.

1.4 Overall Procedure of Water Quality Survey

The water quality survey has several procedures as listed below.

- Survey planning
- Sampling
- Chemical and physical analysis at laboratory
- Data analysis and reporting

The Water Quality Survey Manual is expected to guide all procedures so as to cover the entire cycle of environmental monitoring. The technical knowledge and skills are delivered by OJT-based activities and/or lecture organized by JICA Expert Team during the course of the Project. In the Project, the following activities compose the water quality survey.

- The water quality survey plan is developed for target area.

- The water quality survey is implemented by an outsourced contractor and supervised by national and/or local governmental staff.
- Water samples are analyzed by outsourced laboratories.
- The water quality survey report is prepared based on the verified results.

This manual follows the framework of these activities and the contents in this manual are shown in the table below.

Table 1.4-1 Contents of Water Quality Survey Manual

No.	Topics	Main contents	Remarks
1	Survey planning	• Objective of water environmental monitoring • Design of monitoring plan	See Chapter 2
2	Survey	• Sampling method • On-site measurement method • Sample preservation and transportation	See Chapter 3
3	Reporting	• Contents of water quality survey report • Data interpretation • Data presentation	See Chapter 4
4	Quality control	• Data checking and validation	See Chapter 5

Source: JICA Expert Team

2 DEVELOPMENT OF WATER QUALTIY SURVEY PLAN

2.1 Objective of Water Quality Survey

The water quality survey is conducted for steady management of water quality in public water bodies including river, lakes, water reservoirs, etc. In order to get the sufficient and necessary results from the survey, it is crucial to clarify and appreciate the specific objectives of water quality survey. All surveys should be planned and implemented in accordance with the specific objectives. The objectives to be considered follow the flow chart below.

State the Problem

1) What is the current problem?

Describe the problem as it is currently understood by briefly summarizing existing information.

Example;

- ✓ Deterioration of water quality in river
- ✓ Fish kill incidents in lake

2) What is the mechanism of the problem?

Describe the conditions or circumstances that are causing the problem.

Example;

- ✓ The most likely pollution source is a chicken farm located one mile up-river from the Beach. It is known that high rainfall can flush the coliform from their source (e.g., chicken wastes) into the river, thereby increasing the concentration of coliform in river water.

Identify the objective of water quality survey

1) What is the principal study question?

Identify the principal study question based on the stated problem.

Example;

- ✓ Is pollution from the site contributing to surface water degradation？
- ✓ Does the concentration of contaminants in river water exceed acceptable levels?
- ✓ Does a contaminant pose a human health or ecological risk?
- ✓ How do the background contaminant concentrations vary over space and time?

2) What objective should be established?

Set a goal for water quality survey to answer the raised study question.

Example;

- ✓ To assess the current conditions of surface water quality in the target area
- ✓ To assess the pollution level or load in water environment
- ✓ To assess the changes in water quality over time and space
- ✓ To identify the prioritized area with serious pollution source
- ✓ To check the suitability of applicable environmental standards or guideline
- ✓ To follow a regulatory requirement of environmental management

Source: JICA Expert Team

Figure 2.1-1 Flow Chart to Develop an Objective(s) of Survey

In order to set the appropriate objectives, the following information needs to be firstly checked or obtained to reveal the necessity of survey.

- Regulatory basis of water quality survey including the environmental standard or guideline value that should be applied to the target area
- Water management strategy or plan in the target area or at the national level
- Facts or possible concerns in terms of water environmental management in the target area
- Any other necessities of water quality survey

Especially in the course of examination of problems on water quality management and identification of the objectives of survey, the following baseline data in the targeted area or river basin needs to be collected.

Table 2.1-1 Data and Information to be Collected

No.	Factors	Necessary Information and Data
1	Hydrological information	Topography, river structure, river flow (discharge, water level, velocity), rainfall, tidal cycle and tidal area
2	Water quality	Past water quality monitoring data
3	Water use condition	Irrigation, domestic, and industrial water uses, recreation activity, aquaculture and fishery
4	Pollution sources	Factories, mining areas, craft villages, hospitals and solid waste dumping sites, aquatic farm etc.
5	Land use	Forestry and mangrove, grassland and shrub, paddy field, agricultural field, urban area, aquatic

Source: JICA Expert Team for The Project for Strengthening Capacity of Water Environmental Management in Vietnam, Handbook for Improving monitoring performance, May 2013

The surface water quality depends on natural conditions such as geological, meteorological, hydrological and biological conditions and varies with seasonal difference in weather, precipitation and flow rate. In addition, the water quality can be significantly affected by human activities. Such characteristics of the target water area should be well studies prior to develop details of a survey plan. The main factors of water quality survey, namely sampling points, sampling time and monitoring parameters, should be selected considering such conditions in the target water area under the objectives of survey.

The following sections from 2.2 to 2.4 describes fundamental viewpoints to select those three factor of survey plan.

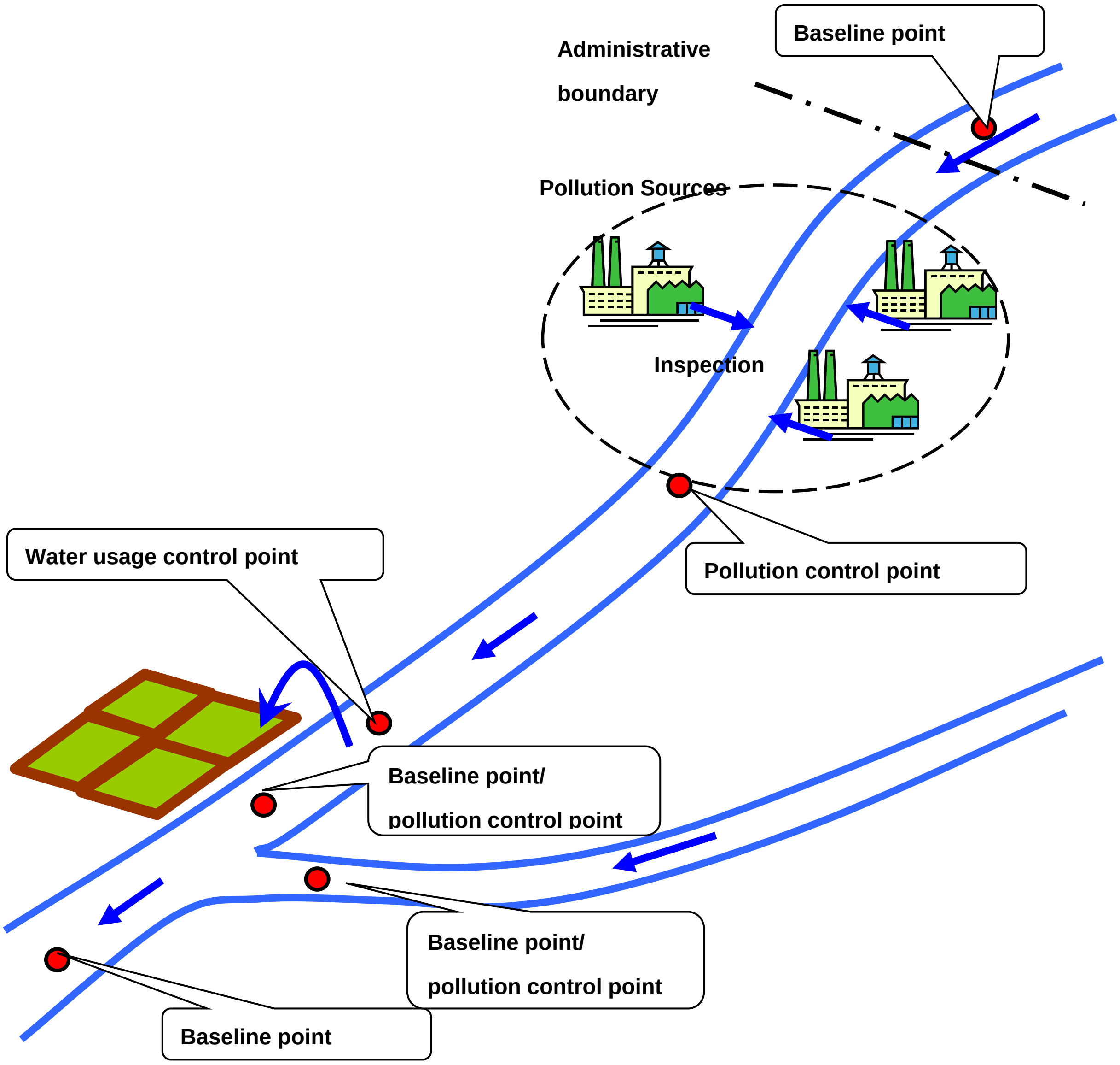
2.2 Selection of Survey Points

The survey points are basically determined from the following viewpoints, and an example is illustrated in the figure below.

- <u>Baseline environmental monitoring locations (baseline locations)</u>
  Temporal and spatial trend of water quality data are obtained at baseline locations, where same general monitoring parameters should be measured at specified locations for long

term period.

- Monitoring locations for water usage control (water usage control locations)
  Suitability of water quality for a particular water usage such as intake for water supply or agricultural water should be checked at water usage control locations.
- Monitoring locations for pollution control (pollution control locations)
  Impacts by pollution sources such as industrial factories, mines and waste disposal sites should be investigated at pollution control locations.



Source: JICA Expert Team for The Project for Strengthening Capacity of Water Environmental Management in Vietnam, Handbook for Improving monitoring performance, May 2013

Figure 2.2-1 Flow Chart to Develop an Objective(s) of Survey

Considering these three types of monitoring points, the basic criteria for selecting sampling locations are listed in the Table below.

Table 2.2-1 Basic Criteria for Selecting Sampling Locations

Category	General Criteria for Baseline Monitoring Locations	Specific Criteria for Water Usage Control Locations	Specific Criteria for Pollution Control Locations
Rivers	• Main river upstream of the confluence • Main river upstream of confluence with tributaries, its tributaries upstream of confluence and other site downstream where the waters are well mixed. • A site close to the mouth of a river • Inflow and outflow of water reservoir or lakes • Upstream and downstream of inflow with difference characteristics of water quality	• Important site for specific water utilization	• Effluent to a river as well as upstream and downstream of inflow of effluent
Lakes/Ponds	• Center of lakes/ponds • Outflow to rivers downstream • Inflow from rivers upstream	• Important site for specific water utilization	• Effluent to a river as well as downstream of inflow of effluent

Source: Prepared by JICA Expert Team with reference to Text Book for Sampling for Environmental Monitoring (Overseas Environmental Cooperation Center- Japan, March 2000)

After the monitoring locations are selected, the exact sampling points and depth should be decided with due consideration for site-specific conditions and objectives of survey.

- <u>River</u>

It is considered that the water quality at the point of maximum-depth in the cross-section of stream is representative of the water quality in the stream. However, since it takes too much time and effort to find such point, generally the surface water is taken in the center of flow or area where the water flows fastest. In case that water quality differs depending on its depth and position in the cross-sectional direction of the river, water samples should be taken at various positions for analysis of individual or mixed samples accordingly. The difference in water quality in the depth direction in the brackish river also should be taken into consideration to select the appropriate sampling point depending on the dynamic features of water. (Overseas Environmental Cooperation Center, Japan, 2000)

- <u>Lakes/Ponds</u>

The differences in water quality at different water depth in lakes/ponds need be taken into consideration. The sampling depth has the following options.

- Single point

Take the surface water.

- Two points in the different depth

Take the surface and bottom layer waters.

- Vertical distribution of water quality

Measure the vertical distribution of water temperature, pH, electrical conductivity, and dissolved oxygen, and sample water in at least three water depth.

- Specific depth for water utilization purpose

Take a sample at the specific depth of intake point for water utilization such as a water supply, water for agriculture, etc.

2.3 Selection of Survey Time

Water quality may vary over time because of time-related phenomena such as weather conditions, seasons, or human-related activity patterns. Sampling time and frequency should be decided with consideration for seasonal fluctuation of river water flow, rainfall and water usage as well as tidal fluctuation of water flow.

The basic criteria and factors for selecting sampling time are listed in Table below.

Table 2.3-1 Key Criteria or Factors or Criteria for Selecting Survey Time

Category	Key Criteria for Selecting Survey Period	Key Factors for Selecting Survey Frequency
Common	• Select a day with stable water quality after a spell of relatively good weather to determine the general condition of the water quality	• Rainfall Pattern At least monitoring in the dry season and the rainy season should be set considering the difference of rainfall pattern • Resources for monitoring Survey frequency depends on the available resources and situation of responsible organization; budget, importance, human resources, equipment and so on.
Rivers	• Periodically collect regular water samples when carrying out consecutive surveys throughout the year. • Select the survey period in accordance with the water utilization status when carrying out a water quality survey for water utilization.	• River water flow Fluctuation of water flow affects water quality.
Lakes/Ponds	• Conduct surveys in each season to determine the general condition of the water quality • Stagnation period must be considered important when examining eutrophication • When the effects on water temperature and turbidity in manmade lakes with dam are considered important, surveys are also conducted on related rivers including the season when they are swollen.	• Water level Fluctuation of water level affects water quality as well.

Source: Prepared by JICA Expert Team with reference to Text Book for Sampling for Environmental Monitoring (Overseas Environmental Cooperation Center- Japan, March 2000) and Handbook for Improving monitoring performance (JIICA Expert Team for The Project for Strengthening Capacity of Water Environmental Management in Vietnam, May 2013)

2.4 Selection of Measurement Parameters

Monitoring parameters to be measured should in principle be decided in accordance with an applicable environmental standard and guideline. The other measurement parameters can be added as needed considering suspected pollutants and site-specific conditions.

In case of Myanmar, since water environmental standard has not yet been established as of January 2017, the measurement parameters are selected based on the reference standard or guideline value such as National Environmental Quality (Emission) Guideline (MONREC, 2015) and other neighborhood countries' standards.

The typical measurement parameters for water quality survey are listed in the table below. Some parameters are measured in situ as shown in Table 2.4-2.

Once the national environmental standard is specified in Myanmar, which is under preparation led by ECD/MONREC, the measurement parameters should be reviewed and updated accordingly.

Table 2.4-1 Typical Measurement Parameters for Water Quality Survey

Category	Parameter
Basic parameter	• Temperature, • pH • Conductivity • Total Suspended Solids (TSS) • Total Dissolved Solids (TDS) • Turbidity • BOD • COD • TDS
Nutrients	• Total nitrogen • Ammonium nitrogen • Nitrite nitrogen • Nitrate nitrogen • Total phosphorus • Phosphate
Heavy metals	• Cadmium • Arsenic • Lead • Cupper • Zinc • Total Chromium • Hexavalent chromium • Mercury • Iron • Manganese
Bacteria	• Total Coliform • E. Coli
Others	• Fluoride • Sulfate • Sulfide

Category	Parameter
	• Cyanide • Phenols • Oil and Grease

Source: JICA Expert Team

Table 2.4-2 On-site Measurement Parameter

Category	Parameter	Note
On-site measurement	• Water temperature	Must be measured on site
	• Air temperature	Generally to be measured
	• pH	To be measured on site or/and at laboratory immediately
	• Electrical Conductivity	To be measured on site or/and at laboratory immediately
	• DO	To be measured on site or at laboratory with chemical preservation
	• Turbidity	To be measured on site or at laboratory
	• Water depth	As needed
	• Flow rate	As needed

Source: JICA Expert Team

3 WATER SAMPLING AND ON-SITE MEASUREMENT

3.1 Preparation

It is important to make enough preparation before the survey in order to collect samples to achieve the survey objectives. The main necessary preparation is listed below, but should be adjusted to each survey and site conditions. It also should be checked during a site visit in advance.

- Prepare equipment and tools for survey work (See Section 3.1.1)
- Prepare sample containers (See Section 3.1.2)
- Calibrate the instrument(s) (See Section 3.1.3)

Necessary permission for surveyors to enter the survey site should be obtained from relevant authorities prior to the survey.

3.1.1 Equipment and Tools

The basic equipment and apparatus to be prepared for the survey are listed in the table below.

Table 3.1-1 Necessary Equipment and Apparatus for Water Quality Survey

No	Categorized Activities	Equipment and Apparatus	Note
1	On-site Measurement	Mobile water quality meter	• pH meter, EC meter, DO meter and/or multi water quality meter • Make a necessary calibration before the measurement (See Section 3.1.3)
		Thermometer	For measurement of air quality temperature
		Water flow velocity meter	For water flow velocity measurement
		GPS	To identify and record the survey location
2	Water Sampling	Water sampler	-

No	Categorized Activities	Equipment and Apparatus	Note
		Bucket	-
		Plastic jug	-
		Beaker with handle	-
		Rope	As needed
		Weight block	As needed
		Measurement tape	-
		Sample container	-
		Sample labels	-
		Colored tape	-
		Scissors	-
		Deionized Water	-
3	Data Recording	Data record sheet	-
		Pen	-
		Marker pen	-
		Stop-watch	-
		Camera	-
4	Safety Equipment	Life jackets	-
		Leather boots	-
		Helmet	-
		Flash light	As needed
		Mosquito repellent	-
		Masks and gloves	-
5	Sample storage and transportation	Ice box	-
		Ice cube	-

Source: JICA Expert Team

3.1.2 Sample Containers

Normally, polyethylene or colorless glass bottles with ground stoppers are used as sample containers. Samples should not be contaminated and there should not be any losses of target components. So, a container must be made of a quality material and a cap should be closed properly. Before being used, it should be washed and rinsed carefully. Rubber and cork stoppers must not be used to avoid contamination of a sample. An amber-colored bottle which blocks light should be used for samples containing components that are liable to photochemical or photolysis reactions such as agricultural chemicals, organic chemical components, and nitrite ions. The bottles should be wrapped with shade paper or put in a shade bag and placed in a cool box for transport to a laboratory. Measurements should be carried out as soon as possible in a laboratory. (Overseas Environmental Cooperation Center, Japan, 2000)

The required volume of sample water depends on analytic methods and concentration of target components. It should be preliminary checked with the laboratory to which the samples will be delivered, although the reference sample volume is indicated in Table 3.3.1.

3.1.3 Calibration of Instruments

Prior to going to the field for survey, instruments for measurement water quality in situ, such as pH meter and DO meter, should be calibrated in the laboratory or office, in accordance with the method specified by the user’s manual of instrument.

3.2 Sampling Method

3.2.1 Standard Method of Water Quality Sampling

The sampling work should comply with the standard procedure to be applied to the survey, such as relevant internationally standards (see the Table below) to be adopted or official methodology specified by the authorities or the client.

Table 3.2-1 Representative Official Sampling Methodology

No	Sample Type	Method
1	Sampling from rivers and stream	ISO 5667-6:2016 American Public Health Association, American Water Works Association, and Water Environment Federation, Standard methods for the examination of water and wastewater, 1060 B
2	Sampling from lakes, natural and man-made	ISO 5667-4:2016
3	Sampling of wastewater	ISO 5667-10:2015
4	Samples for microbiological analysis	ISO 19458:2006

Source: JICA Expert Team

3.2.2 Water Sampler

The most suitable water sampler should be used depending on the target of water sample, field status and survey objective. Typical used water samplers are listed as follows.

- Sampling by sample vessels
  Taking a sample water directly to the container is the easiest and desirable way to avoid contamination.
- Bucket or dipper
  Polyethylene-made buckets or dipper is often used. A rope can be attached to the bucket if needed.
- Vandorn water sampler
  A Vandorn water sampler is used to take water at different depth as the lid of water container can be closed at the desired water depth and opened after the surveyor retrieves the container. For example. It can take bottom layer water in lakes.

3.2.3 Procedure of Sampling

The general procedures for sampling are as follows. Please see the detailed procedure in a water quality sampling manual (see Appendix 1).

1) Take a water sample at the desired point by using a sampler apparatus
2) Rinse a sampler with sample water more than 3 times
3) Take another water sample
4) Rinse a sample container with sample water more than 3 times
5) Fill a sample container with water sampler and close the lid
6) Measure on-site measurement parameters (see Section 3. 4)
7) Take photograph during the sampling process.
8) Make a label of sample container with name of sampling points, date and time of sampling and other necessary information (see Section 3.2.4)
9) Fill out a field note (see Section 3.2.5)

3.2.4 Sample Label

The labels for sample container should include the following information.

- Name of project or study, as appropriate.
- Name of sampling points
- Sampling date and time
- Measurement parameter if it should be clarified in the sample container
- Chemical added to sample for preservation, if any

3.2.5 Field Note

The field note will provide the necessary and useful information to evaluate the water quality data. The following information is to be recorded.

- Name of sampling points
- Coordinates of sampling points, if recorded
- Sampling date and time
- Weather
- Result of on-site water quality measurement
- Result of water flow measurement, if measured
- Site condition and findings to be noted

3.3 Sample Preservation and transportation

3.3.1 Sample Preservation

As a general rule, collected samples have to be stored in accordance with the method officially specified for each parameter. The table below shows the standard methods based on JIS (Japanese Industrial Standards). The sample for the other parameters should be stored in a cool and dark place between zero and ten degrees centigrade.

Table 3.3-1 Preservation of Sample Water

Test Parameter	Water Sample Bottle	Example of required water sample volume (ml)	Required Method for Preparation
Smell	G	500	Fill a glass bottle with a ground stopper, store it in a cool, dark place at 4° C, and conduct measurements as soon as possible.
Color	G	200	Measurements should be conducted immediately as it is easily changed due to physical and biochemical reactions.
Turbidity	P, G	200	Store it in a cool, dark place at 4° C and carry out measurements within 24 hours. Vigorously shake it before measurements.
Alkalinity and acidity	P, G (B)	200	Fill the bottle, tightly close the lid, store it at 4° C and carry out measurements within 24 hours. Do not stir the sample or leave it in contact with the air to avoid any reactions such as with carbonic acid.
Suspended solids (SS), Total dissolved solids (TDS)	P, G (B)	500	Quickly filter, separate and measure. TDS and TR increase if stored in a soft glass bottle. When iron or manganese is included, close the lid tightly to avoid any exposure to the air, and store it in a dark place at 10° C or lower (but without freezing).
BOD	P, G	1000	Store it in a cool, dark place at between 0° C and 10° C. Testing should be carried out as soon as possible.
COD	P, G	100	Store it in a cool, dark place at between 0° C and 10° C. Measurements should be carried out as soon as possible.
TOC (Total Organic Carbon), Total Oxygen Demand (TOD)	G (amber colored), P	100	Store it in a cool, dark place at 10° C or lower.
Oil and grease	G (S, Wide-mouthed bottle)	5L – 10L	Fill a wide-mouthed bottle with a ground stopper, which has been sufficiently rinsed with N-hexane, with the water sample leaving sufficient space at the top. Use the whole amount for measurement and do not transfer or separate it. If it must be stored or transported, add methyl orange indicator, then add hydrochloric acid (1+1) until the sample water turns red, and close it tightly.
Carbon tetrachloride extracts	G (S, wide-mouthed bottle)	1000	Treat in the same manner as hexane extracts
Phenols	G	500	Add phosphoric acid until the pH = 4. Add copper (II) sulfate pentahydrate (1g) per liter of sample, shake it and store it in a cool, dark place at between 0° C and 10° C.
Nitrite ions	P, G	100	Store it in a cool, dark place at between 0° C and 10° C. Measurements should be carried out as soon as possible. If it is stored for around three days, add 1ml chloroform per liter of sample and store it in a cool, dark place at between 0° C and 10° C. Immediate measurements should be carried out when ion chromatography is used without being stored.
Nitrate ions	P, G	100	Measure immediately. If this is not possible, add hydrochloric or sulfuric acid to the sample until the pH = 2-3, and store it in a cool, dark place at between 0° C and

Test Parameter	Water Sample Bottle	Example of required water sample volume (ml)	Required Method for Preparation
			10° C. Immediate measurements should be carried out when ion chromatography is used without being stored.
Ammonium ion	P, G	500	Measure immediately as it is easily changed. If this is not possible, store it in the same way as nitrate ions.
Phosphorus Compounds	G (A)	100	When fractional determination is carried out per phosphorus type, filter the sample water immediately after collecting it in accordance with the targeted. Add approximately 5ml of chloroform per liter of the sample while it is neutral, and store it in a cool, dark place at between 0° C and 10° C. Under such conditions, it can be saved for 1-2 days.
Total phosphorus (T-P)	G (A)	100	These can preserved by adding sulfuric or nitric acid until the pH = around 2.
Dissolved phosphorus	G (A)	100	Filter the sample water using 0.45mm or No. 5C filter paper immediately after collection, add approximately 5ml of chloroform per liter of the sample and store it in a cool, dark place at between 0° C and 10° C. Under such conditions, it can be saved for 1-2 days.
Phosphate ion	G (A)	100	As above
Dissolved oxygen	G (BOD bottle)	100 -300	Measure immediately after the water is sampled, or carry out on-site preparation of the sample for preservation, store it in a cool, dark place at between 0° C and 10° C after closing it tightly, and measure it as soon as possible.
Residual chlorine	G	100	Measure immediately after the water is sampled. It can not be stored.
Cyanogen compounds	P, G	500	Add sodium hydroxide solution (20W/V%) until the pH = about 12 and store it. If oxidized substances such as residual chlorine exist, add L-ascorbic acid for reduction, and change the pH to about 12.
Sulfur compounds	P, G	200	These are classified per type, such as sulfide ions, sulfurous acid ions, and sulfate ions, etc. The processing and storage methods differ according to the analysis method that will be adopted.

G: Glass bottles, P: Poly bottles
(A): washed with acid, (B): borosilicate glass, (S): washed with organic solvent for the parameters sensitive to photochemical reactions, samples should be kept in amber-colored glass bottles or covered with black boxes.

Source: Handbook for Improving monitoring performance (JICA Expert Team for The Project for Strengthening Capacity of Water Environmental Management in Vietnam, May 2013) and revised by JICA Expert Team

3.3.2 Sample Transportation

Samples should be transported in transit containers with appropriate packing to avoid bottle breakage. Effects of light and heat should be avoided because sample quality can be changed quickly due to chemical reaction, and uptake by micro-organisms. Water samples should be kept at around 4°C during transportation.

3.3.3 Chain of Custody

When the samples are delivered from a survey team to the laboratory, details of handover should be recorded on a Chain of Custody form in order to make sure traceability of samples. The Chain of Custody form should contain the detailed information of samples and analysis such as a sampling date, name of sampling location, number of samples, analysis parameters in laboratory, date and time of delivery as the example form is shown in Attachment 2.

3.4 On-site Water Quality Measurement

On-site water quality measurement should be conducted immediately after or during the sampling work. Though a detailed measurement methodology can be found in each instrument manual, the general procedure is presented in the table below. It is crucial to calibrate the equipment before field survey in order to secure the accuracy of measurement data.

Table 3.4-1 General Procedure of On-site Water Quality Measurement

Test Parameter	General Method
pH	- At each station, turn the meter on and place the probe into the water column. - Obtain the pH reading for each station. Wait until the meter reading stabilizes before reading and recording the pH and the temperature. - Record the pH on the data sheet. - Rinse the probe with distilled water. - Turn the pH meter off. Be careful to handle the probe carefully so as not to damage it while in the field. - If direct access to the water surface with the pH meter is not possible measure the pH in a sub-sample of the main sample. ON NO ACCOUNT measure directly in the main sample or return the sub-sample to the main sample container.
Conductivity	- Turn the conductivity meter on and place the probe into the water column and stir with the probe. - Wait until the meter stabilizes to obtain the reading for conductivity. The meter should be in the "Conductivity Mode". - Record the conductivity reading on the data sheet. - Rinse the probe with distilled water. - Turn off the conductivity meter and be careful when handling the meter and probe so as not to damage it while in the field.
Air Temperature	- Measure the air temperature by the stick shape thermometer.(at Good ventilation, 1.2-1.5 m height from the ground, Avoid direct sunlight). - Record the results recorded for temperature on the data sheet.
Water Temperature	- Insert a thermometer in sample immediately after sampling or insert a thermometer in water in the direct spot, and measure the water temperature - Record the results recorded for temperature on the data sheet. - Water temperature is required during data processing for temperature correction of pH, conductivity, Dissolved oxygen saturation level and concentration of free Ammonia.
Dissolved Oxygen	- At each station, turn the meter on and place the probe into the water column and stir with the probe. - Adjust the salinity compensation switch to the measured salinity. - Allow sufficient time for the probe to stabilize before sampling the dissolved oxygen. - Record the readings for both concentration and percentage saturation. - Rinse the probe with distilled water. - Turn off the instrument and handle the probe carefully so as not to damage it while in the field.

Source: CHEHALIS RIVER COUNCIL, http://www.crcwater.org/wqmanual.html

3.5 Water Flow Measurement

The flow rate in an open channel such as a river or creek can be measured by the several methods: timed gravimetric flow method, tracer-dilution method, area-velocity measurement method, Acoustic Doppler Current Profiler (ADCP) method, etc. The following two methods are guides for general environmental water quality survey, which can be easily done.

1) Measure the cross-section area and water velocity
2) Measure water discharge by bucket method in case of small effluent discharge channel

A water flow rate data can be used to estimate a pollution load, which is calculated by the following formula.

Pollution load [kg/day] = Concentration of pollutants [mg/L]

x Flow volume of discharged water [m^3/day] / 1000

The principal and summarized methodologies of low measurement are described below while the detailed procedure for using the water flow velocity meter is described as a SOP (Standard Operation Procedure) for river flow rate measurement (see Appendix 3).

3.5.1 Measurement of cross-section area and water velocity

The flow rate is calculated by the following formula:

$$\mathrm{Q} = q_1 + q_2 + \cdots + q_{n-2} + q_{n-2} + q_n$$

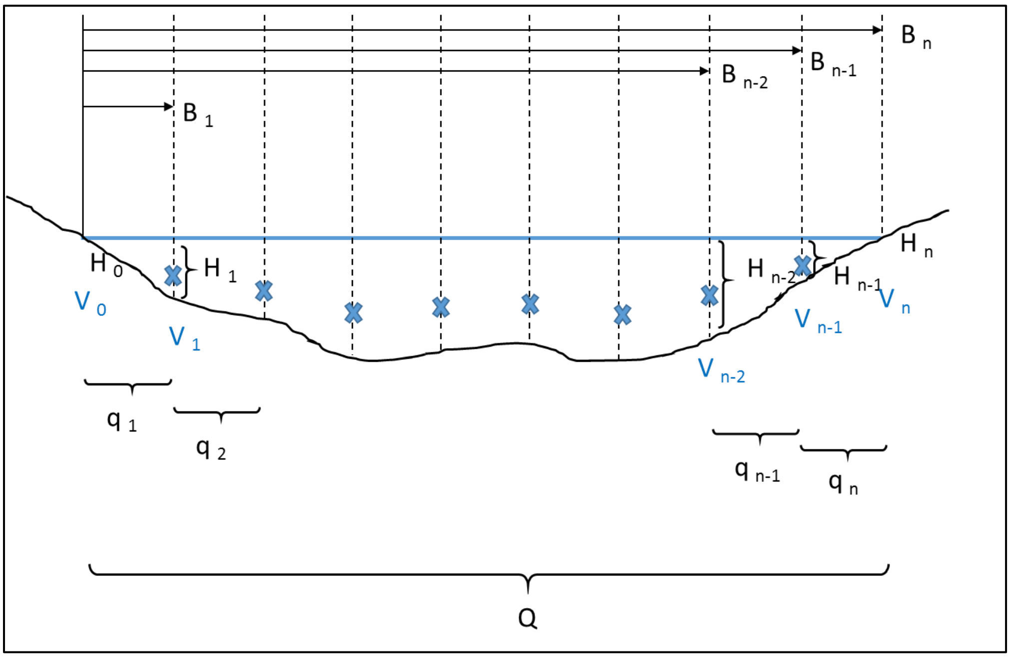
$$q_{n-1} = (B_{n-1} - B_{n-2}) \times \frac{(H_{n-2} + H_{n-1})}{2} \times \frac{(V_{n-1} + V_{n-2})}{2}$$

Wherein, n >0
Q: Total flow rate (m^3/s)
q: Flow rate in each zone (m^3/s)
B: Horizontal distance from the starting point of measurement (m)
H: Water depth (m)
V: Flow velocity (m/s)

The cross-section area of target flow and flow velocity can be measured to calculate the total flow rate by the following procedure.

1) Divide the cross-section area of river into several zones (see the figure below)
2) Estimate a cross-section area by measuring the width and water depth for each zone
3) Measure the water flow velocity and take an average of water flow velocity for each zone

4) Multiply the cross-section area by water flow velocity and get a flow rate for each zone
5) Add the flow rate of each zone and get a total flow rate



Q: Total flow rate (m3/s), q: Flow rate in each zone (m3/s), B: Horizontal distance from the starting point of measurement (m), H: Water depth (m), V: Flow velocity (m/s)

Source: JICA Expert Team

Figure 3.5-1 Measurement of cross-section area and water velocity

3.5.2 Measurement of water discharge by bucket method

In case of measuring a water discharge of small channel or stream, it is useful to use bucket method. This method can only be used if the whole flow can be directed into the bucket. Procedure for bucket method is as follows.

1) Collect an effluent with a bucket or a plastic bag.
2) Press a stop watch at the same time and measure the time till a bucket becomes full.
3) Repeat this several times and calculate the average and standard deviation.

$$Q = \frac{v}{t}$$

Where:

Q =Flow rate (m^3/sec)

V = volume of the bucket (m^3)

T =time taken to fill the bucket (sec)

4 Reporting

The water quality survey (WQS) report shall be prepared for each water quality survey or a series of surveys after receiving the survey results from the laboratory and on-site measurement. The WQS report should provide the valuable conclusion to the decision makers or target readers. Depending upon survey objectives, the WQS report can be prepared to describe the following facts;

(i) Results of on-site measurements and laboratory analysis of field samples

(ii) Data analysis of results to indicate compliance with standards or variation over time or space

(iii) Results of an investigation into a pollution incident or/and regular monitoring

This chapter will provide the basic know-how to prepare the WQS, starting with a content and description of report in section 4.4 and 4.2, followed by a guidance of how to interpret and present the result in section 4.3 and 4.4.

4.1 Content of WQS Report

The WQS report is composed of the following contents;

4.1.1 Main Title Page (Cover Page)

The main title page describes the title of the page, name of the project, month/year, and organization/department which prepares the WQS report.

4.1.2 Executive Summary

The executive summary contains the purpose of the report, the survey information, key findings, and conclusions. It should not be a re-statement of the conclusions and it should not be more than ten percent of the main report.

4.1.3 Table of Content (TOC)/ List of Table/ List of Figures

The table of contents shows the relationship between sections and within sections in the WQS report, and to list chapter, sub-sections with respective page numbers. Table of contents assists the readers to get a schematic overview of the structure and contents of the WQS report. Similarly, list of tables and list of figures are also useful indicators of the WQS report.

4.1.4 Body of Report

This is main part of the WQS report, where the main work of the water quality survey can be described. It is composed of Introduction, Survey/Sampling Summary, and Results & Discussion, Conclusion. The detail of the description of those components is discussed in section 4.2.

4.1.5 Appendices

In the Appendices of WQS report, typical information such as details of field and laboratory results, laboratory analytical procedures, figures, fables and drawings with larger page size, survey photographs, and supporting information is illustrated.

4.1.6 References

If the WQS report refers any documents/ books/ reports, the references are included in the WQS report. Normally, the references enable the reader to read for themselves the information from external documents that have been used to support the discussions, conclusion or recommendations in the body of the WQS report.

4.2 Description of Body of Report

4.2.1 Introduction

(a) Background

In the introduction of the WQS Report, the previous water quality in the target area/river/lake and also, the status of water quality either improving or deteriorating should be briefly explained with maps. If the survey is conducted under regular monitoring program/ certain project, it should briefly describe the origin of the monitoring plan/ certain project. The pollution sources; (i) Point sources such as industrial wastewater, domestic wastewater, animal husbandry wastewater, and others (hotel, mining, hospital, supermarket, golf course, etc.) and (ii) Non-point sources such as agricultural area, urban area, bare area, forest area, should be clarified for target area. Also, the conditions of water use from target river/lake (domestic, agriculture, industry, fishery, recreation, and etc.), hydrological pattern (water discharge, rainfall, etc.), brackish water area (tidal level pattern, salinity, EC, Chlorine, Iron, etc.) should be described if any. In addition, the main causes of pollution if any and impacts on river/lake water usage should be described.

(b) Objectives

The objectives of the water quality survey should be set clearly as discussed in section 2.1 of this manual. The defined objectives should be described in this part of the WQS report.

(c) Legal Basis of Water Quality Survey

The available rules and regulations related to environmental and water environment (National, Regional, Departmental, etc.) in Myanmar should be mentioned. The available water quality standards (National, Regional, International) should be introduced. The specific legal basis for conducting each water quality survey should be described if any.

4.2.2 Survey/Sampling Summary

(a) Role and Responsibility of Survey Team

When one water quality survey is planned to conduct, the role and responsibility of survey team is clarified. The role and responsibility of each member is expressed under this section.

(b) Sampling points and Sampling Schedule

In the target area, the sampling points should be plotted on the map (GIS map etc.) with simple legend. The sampling schedule should be displayed with the reasons.

(c) Survey Parameters and its target levels

The parameters which will be analyzed under the proposed survey with target levels are declared. The target levels mean the standard/guideline values to be complied with. It is important to select the proper standard/guideline values depending on the objectives/status of the target survey area/river/lake.

(d) Sampling and Measurement Methods

The methodology for sampling activity, measurement method at laboratory and in-situ condition, and quality control method are expressed. The photos of sampling activities are demonstrated. The sampling methodology (e.g. depth of water, sample mixing, number of samples, etc.), if necessary, at each sampling point is described. Both the methodology used in the laboratory for each parameter and at in-situ measurement, if any, are also summarized.

4.2.3 Results & Discussion

(a) Results

The results of each parameter are presented under each sub-section using tables, figures, and maps to convey the findings of the survey. Basically, the results of each parameter for all survey points are checked whether under compliance with target level’s values or not. Moreover, the results are analyzed by considering the water quality variation over time and space, generally in relation to the relevant water quality standard/target levels. On the other hand, using data/statically analysis, the comparisons between stations, over time (seasonal conditions/yearly), conditional changes or with the standard/target level are made because it can statically support the conclusion and recommendations to be credible. For ease of reading it is preferable to divide the results and discussion into subsections with the first level of division at the geographical level and then by parameter/determinant, for example as shown below.

3.3 Result in Yangon *3.3.1 BOD* *3.3.2 Inorganic Nitrogen* *A Ammonia* *B Nitrate*

Source: JICA Expert Team

Figure 4.2-1 Example of Dividing Subsections

(c) Discussion

The discussion on the observations of the survey results is done accordingly with the objectives of each survey report. Whenever making the opinions/suggestion/ assumption, it is very important to consider not only the results but also the several conditions (e.g., locations/status of target area during the survey period/special activities or events near target area during the survey period, etc.). It is required to find out the possible reasons with facts and figure, if possible, in order to explain the obtained results.

4.2.4 Conclusion and Recommendations

Conclusion includes the summary of important findings and comprehensive message obtaining from the survey report. The conclusions must be based on facts that have been presented in the previous sections of the report. It is noted that conclusion is not the repetitive description of the discussion and new idea should not be introduced in conclusion part.

The inclusion of a recommendations depends on the purpose of the report. When the recommendations are proposed, the benefits of implementing the recommendations should be clearly set out and supported by facts and conclusions presented by the survey report, if necessary, with a realistic cost/benefit analysis.

4.3 Data Check and Data Interpretation

Prior to the writing of the results section, the obtained results can be cross-checked by the writers, themselves. For example, the unit consistency of the result of each parameter is one of the important point to be checked. It also should be checked if the data such as name of samples, analysis parameters, analysis date are correct or not. Moreover, the reliability of obtained values of BOD, COD, and TOC can be checked by the BOD/COD ratio (e.g., >0.5 or greater in some cases), and BOD/TOC ratio (e.g., >1). The data check is one of the component of quality control process. Please see the detailed procedure in Section 5.1.

The obtained results/data from laboratory analysis, and in-situ measurement are interpreted in accordance with the objectives, after those data is validated. The common method for data interpretation is shown in the following table.

Table 4.3-1 Common Method for Data Interpretation

Objectives of survey	Way of Data Interpretation
(1) Identification of area with serious pollution source	- Making the map overlapping the pollution sources - Check trend of water quality from up-stream to downstream
(2) Confirmation on suitability on water usage	- Compare with environmental standards
(3) Grasp of baseline	- Compare with the environmental standards - Check trend of water quality from up-stream to downstream
(4) Evaluation of effectiveness of countermeasures	- Check historical change of water quality

Source: JICA Expert Team

4.4 Data Presentation

4.4.1 Figures, Graphs and Tables etc.

Figures and graphs are valuable tools when presenting information. Complex results can be presented in a more understandable form and can represent many pages of numbers in a clear and simple way. However, it is important that they are used carefully.

Most technical reports use figures and tables for the presentation of data, the form and quality of the figures and tables are important in determining the readability of the report. Only use figures and tables that add value to the report. Present the data as simply and straightforwardly as possible. Present data in the text, in a figure or in a table never in more than one way. It is acceptable to include detailed data in a table in an appendix and in a summary figure in the main body of the text.

Before beginning to write the report, identify the data to include. Even the most carefully prepared survey works generate more data than are needed for the report. However, it is required to use only data that are directly relevant to the report. Once the data to be included have been selected decide how they can best be presented; tabulated or plotted? This is determined by the needs of the reader. If it is necessary to know exact values, tabulate the results. If relative trends are more important, use graphs.

(a) Figures

Figures used in technical reports fall into three types, graphs, drawings, and photographs. It is better to prepare figures taking into account their appearance in the final printed document. Clearly the size of the printed figure including the legend cannot exceed the dimensions of the report image area. If there are a many large figures associated with the report they can be presented as an appendix. All figures must have legends. If a figure has parts (a), (b), (c), etc., it must have corresponding sub-legends. It is noted to use similar wording in the legends of related figures.

(b) Graphs

Graphs should be clear and simple and comply with the following guidelines:

a) Use few data curves as possible. It is usually best to have no more than six types of lines or data points on a graph
b) Avoid interweaving or unrelated curves.
c) As few words as possible should be inserted directly on the figure.
d) Explanations and conditions should be added to the legends or placed in the text.
e) Clearly label what is plotted on each axis and the units used.. For ease in interpolation divide scales into logical, consistent increments.
f) Label main and auxiliary scales with a word description and its unit. For example, “Dissolved Oxygen Concentration (mg/l)” is more descriptive than "Oxygen"..
g) Avoid un-necessary trailing zeros when labeling scales.
h) Decide whether graphs will be in colour or black and white and chose markers and lines appropriately.
i) Use the same data symbols and lines to represent the same conditions consistently throughout the graphs of the report. .

(c) Drawings

When including drawings or maps to illustrate sampling locations, pollution sources or sensitive receivers using GIS/ Google earth (if it is acceptable) keep them simple and comply with the following guidelines:

a) Include only those features in the drawing that are essential for the readers' understanding. Avoid unnecessary detail.
b) Decide whether drawings will be in colour or black and white and prepare the drawing accordingly.
c) Avoid un-necessary shading and rendering on the drawing.

(d) Photographs

The need for high quality color printing should be considered carefully because it greatly increases printing costs. Photographs that are clear when seen in color, in many cases, will lose much of their value when printed in black and white. Include some object or scale in the photograph to help the readers to judge the size of the objects shown. The file size of the photographs should be careful to be less with good photo quality.

(e) Tables

Tables should be as brief and simple as possible. Otherwise the reader may not spend time studying the concentrated columns of figures. If the information in the table can be put into words it is better to do so.

Tables are numbered in the order in which they are mentioned using Arabic numerals. Similar data at different conditions are organized into parts (a), (b), (c), etc. of the same table with subtitles. Numbered tables must have title. Numbers that are to be compared should be placed in columns. See the example and explanation below.

Table 1. Statistics for BOD, TSS and COD in the Hlaing river in September 2017

Location name*	BOD (mg/L)	Total Suspended Solids (TSS) (mg/L)	COD Cr (mg/L)	← Column titles
H1	1.16	390	14	← Table Body
H3	1.80	440	14	
H5	1.26	330	10	

Note: * is the sample taken from the center of the river ← Footnotes

Source: JICA Expert Team ← Source Notes

Source: JICA Expert Team

Figure 4.4-1 Example of Table

Table caption: The main heading must describe the contents of the table and indicate the purpose of the table. The format of the title is generally bold sentence case.

Column titles: The vertical heading and subheadings of the columns are known as column titles. Generally, only the first letter of the box head is in capital letters and the remaining words are in lower case. It is normal to use the columns for variables whose values vary – such as values measured or calculated

Row titles The horizontal headings and sub heading of the row are the row captions. As in the case of the column titles the caption is in capital letters and the remaining words are in lower case. Rows are used for variables whose values do not change such as sampling locations and years.

The Body: the main part of the table that contains the numerical information classified with reference to the row and column captions.

Foot Notes: appear immediately below the body of the table providing explanation of a caption or values within the body of the table.

Source Notes: are given at the end of the table indicating the source of information that has been provided by a third party. It includes the information about compiling agency, publication etc.

Lines: Lines dividing the table into part should be used carefully and consistently through the report. The lines, together with spacing should be used to guide the eye of the reader through the table so that they see what you want them to see.

4.4.2 Placement of tables and diagrams

Graphs, summary tables, figures and diagrams should be used in the results and discussion section. Complex tables of raw data should be placed in an Appendix.

Tables, figures and graphs should be:

a) Numbered sequentially
b) Labelled clearly and
c) Positioned as close to the associated text as possible, usually following the first reference to them.

(a) References to Figures and Tables

Tables of data are quite clearly referred to as tables. For drawings, maps, graphs, figures and photographs, it can be referred to as figures although it can be other naming schemes.

It is required to make specific reference to each figure, graph and table in the paragraph. Do not assume that the reader will make the necessary connection between the text and the figure or table. A direction look at each figure and table is required.

Refer to each figure, or table in the text by its number. When referring to tables and figures, phrases such as the following can be used:

- 'As shown in Table I below, pH values were between 7.8 and 8.4'
- 'Mean concentrations of Nitrate-nitrogen are shown in Table 2.2'
- 'During the year the measured BOD concentrations frequently exceeded 8mg/l (Figure 3.1).

(b) Numbering and Labeling

If there are a large number of tables and figures in a report the placing of additional ones into the early sections of the report will require complete re-numbering of all of the following tables and figures. It is more convenient to include the section number as part of the table of figure number. For example the fourth table in section six of the report will be numbered **Table 6.4.**

Any changes in sections one to five will have no effect on the table number. As a general rule, labels for tables are placed above the table and labels for figures below the figure. All tables and figures should be labeled, even if the report contains only one.

It is better to keep labels brief but informative. Explanatory notes, if they are needed, can be placed as footnotes under the table or figure. MS Word provides tools for automatically numbering labels for tables and figures which will automatically renumber if new tables or figures are inserted or are moved to different places in the report. In the same way that numbered chapter and section headings can be automatically collated into a table of contents lists of figures and tables can be inserted in the table of contents section of the report. The tool is accessed through the "Insert/Captions" dropdown menu in MS Word and the creation of the list through the "Insert/Index and Tables" menu.

(c) Figures and Tables in Appendices

It is required to number figures and tables in appendices according to the appendix in which they appear. For example in Appendix A you would have **Figure A1**, **Table A1**. A list of the figures and tables contained in each appendix should either be part of or follow the ToC for the Appendix, not following the ToC for the main report.

5 Quality Control

5.1 Validation of Survey Result

The chemical and physical analysis result sent from laboratories need to be carefully checked and reviewed. In this procedure, any outliers and anomalous data should be found.

In the test report from laboratories, the following contents need to be clarified.

- Name and address of laboratory, and location where analysis were carried out if different from an address of laboratory
- Test methods used
- Test results with units of measurement
- Limits of detection or limits of reporting for each parameter
- Name, function and signature or equivalent of person authorizing a test report to whom any questions relating to the report should be communicated.

The Table below is given as checkpoints and key notes for judging validity of the analysis results which are reported by an external contracted laboratory.

Table 5.1-1 Checkpoints of Laboratories Result

Topics	Checkpoints	Note
Analysis result		
Proper recording	- Are sample names, analysis parameter and other basic information on sample correct?	- Check the field note and other related document
	- Are the description of analysis parameter name correct, especially for nitrogen/phosphorus?	- Note the difference between ammonia and ammonia nitrogen, nitrite and nitrite nitrogen, as well as nitrate and nitrate nitrogen. - e.g. Conversion of nitrogen Nitrate nitrogen (NO3-N) and nitric acid ion (NO3) are sometimes listed in a same line. The result needs be converted from NO3 to NO3-N as needed when compared with a standard value.
	- Is the unit of result correct?	- e.g. Unit inconsistency of conductivity Conductivity can be expressed in a number of units (mS/m, µS/cm, S/m). Relations among units are “1S/m＝1,000 mS/m = 10,000 µS/cm”.
	- Is the Limit of Detection or other limit mentioned in a proper manner?	- The limit of detection/measurement should be clarified. The result cannot be 0 mg/L.
	- Is the significant digit is correct and proper?	- Significant figure is a digit that carry meaning contributing to its measurement resolution.
Data quality	- Is the result reasonable compared with on-site measurement result?	- Check the field note
	- Is the result exceed the environmental standard value or any other applicable target value?	- In case the result exceeds the standard value, the data should be carefully checked. Duplicate analysis or/and re-sampling is suggested as needed..
	- Is the result reasonable compared among sampling locations?	-
	- Is the result reasonable compared with data of several recent month ago and back data of several recent years?	-
	- Is the result reasonable considering physical characters of parameters?	- e.g., Nitrite nitrogen is quickly oxidized to form nitrate nitrogen. Therefore in natural waters concentrations of nitrite nitrogen are almost always less than those of nitrate nitrogen in the same sample.
	- Is the result reasonable compared between measurement parameters?	- Relation between conductivity and chloride ions - Ration between BOD and COD: In most cases, COD value is higher than BOD because COD measures the consumed oxygen by strong oxidant (dichromate ion; $Cr_2O_7^{2-}$) during the decomposition of organic matters and the oxidation of inorganic substances. On the other hand, BOD measures only organic matters which can be degraded by microorganism. - Ration between total nitrogen and total phosphorus: generally stable at same monitoring location - Total nitrogen should be higher than a total of ammonia nitrogen, nitrite nitrogen and nitrate nitrogen. - Nitrite nitrogen has a lower concentration in aerobic state. - Total phosphorus should be higher than phosphonate. - Total chromium should be higher than hexavalent chromium and trivalent chromium. - Evaluation of cation and anion balance
	Further detailed checkpoints for laboratory if needed;	- Measures for prevention of contamination (e.g., purity of water used for analysis, storage condition of glassware) - Analysis date and sample storage condition - Calibration of instrument

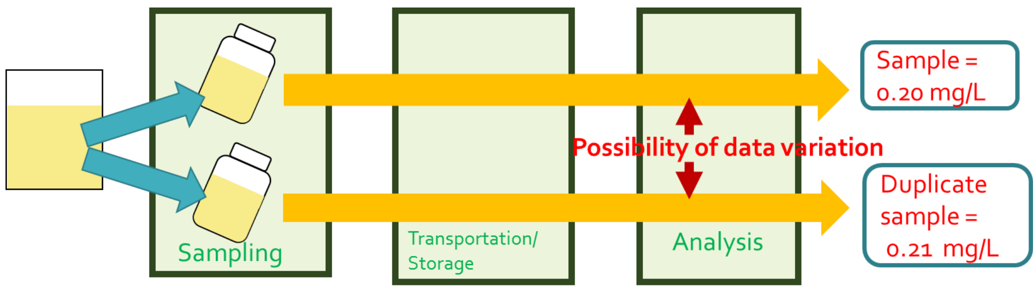
Topics	Checkpoints	Note
		- Linearity and range of calibration curve - Measures for interference (e.g., chloride interference in the determination of COD) - Calculation check(e.g., dilution factor) - Detailed procedure of analytical method (e.g., SOP) - Other QC procedure
QC(Quality Control) samples		
Blank sample	- Does the quality-control sample such as a blank sample or duplicate sample provide an acceptable result?	- See Section 5.1.2 for details
Duplicate sample	- ditto	- See Section 5.1.2 for details

Source: JICA Expert Team

5.2 Quality Control Samples

Quality Control (QC) sample is a sample intended to measure the precision of the whole sampling and analysis procedure.

- **Blank sample**: Blank samples are collected and analyzed to ensure that environmental samples have not been contaminated during the data-collection process, for example from the sampling time to the instrumental analysis time, or from the sampling preparation time to the sample analysis time. The distilled or purified water that does not contain the target analytical parameter can be used to measure a travel blank.
- **Duplicate sample**: This is a sample which was collected with the target sample at same point and time. It shall be analyzed in the same way as another sample in parallel and provide precision of monitoring (See below figure).



Source: JICA Expert Team

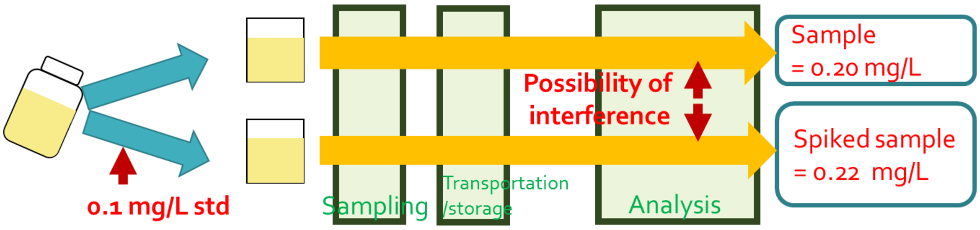
Figure 5.2-1 Procedure of Duplicate Sample Test

The difference between two samples can be calculated by the following formula.

$$\text{Difference (\%)} = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100(\%)$$

The difference usually should be within a range of 0 – 15 or 20%, generally but depending on the method and parameters, etc.

- **<u>Spike sample</u>**: This is prepared by adding a known amount of a reference or standard sample to a single water sample. Recovery rate reveals systematic errors (bias) in an analytical method, which can arise from matrix interference or other reasons. (see below figure)



Source: JICA Expert Team

Figure 5.2-2 Procedure of Spike Sample Test

The accuracy can be evaluated using recovery rate to be calculated by the following formula.

$$\text{Revovery rate (\%)} = \frac{(X_{spike} - X_{sample})}{\text{spiked amount}} \times 100(\%)$$

Where, X spike: Result of spike sample, X sample; Result of sample

The recovery rate should be generally within a range of 85 (80) – 115 (120) % depending on the method, parameter, etc.

References

- Overseas Environmental Cooperation Center, Japan, Text Book for Sampling for Environmental Monitoring, March 2000
- JICA Expert Team for The Project for Strengthening Capacity of Water Environmental Management in Vietnam, Handbook for Improving monitoring performance, May 2013

Appendices

Appendix 1 Surface water sampling manual

Appendix 2 Form of Chain of Custody

Appendix 3 SOP for river flow rate measurement

Appendix 1 Surface water sampling manual

Surface water sampling manual

1. General Information

1.1 Purpose

This SOP addresses the process for sampling with the main objective to obtain representative samples for water quality survey.

1.2 Scope and Application

This SOP applies to a sampling work for taking an environmental surface water sample, such as river water and lake water, as well as an industrial or domestic wastewater in a channel and creek.

2. Procedural Precautions

2.1 Pre-sampling Activities and Checks

This section includes the activities and precautions to be done prior to leaving the office for water sampling.

2.1.1 Equipment and Instruments for Surface-water Sampling

The necessary equipment for surface-water sample collection are tabulated below. This table can be used by field staff as a general check-off list to ensure that all needed items are taken to the field each work day.

No	Category	Equipment and Instruments	Note
1	Measurement Devices	On-site water quality meter	e.g. Horiba U52 Water Quality Meter
		GPS	
		Extra batteries for above equipment	
		Other equipment or devices as appropriate	As needed (e.g., water depth meter)
2	Water Sampling Stuffs	Sample bottle	
		Water Sampler	
		Bucket	
		Plastic jug	
		Beaker with handle	
		Rope	

		Weight block (in case of turbulent flow or large depth)	
		Measurement tape	
		Sample containers/ plastic bottles	
		Scissors	
		Deionized Water	
4	Data Recording	Field Data Record Sheet	
		Marker pen & pen	
		Colored tape & clear tape	
		Stop-watch	
		Camera	
		Sample container labels	
5	Safety Equipment	Life jackets	
		First Aid Kit	
		Leather boots	
		Helmet/ hard hats	
		Flash light	As needed
		Mosquito repellent	
		Masks and gloves	
6	Storage of Samples	Ice box and ice tubes	
		Chemical preservations if necessary	
7	Necessary Documents	Map showing sample site location with coordinates	
		Tide Table (if the site location has tidal effects)	
8	Personal Gears and other stuffs	Drinking Water	
		Trash bags	
		Sunglasses, sunscreen	
		Extra clothing	As needed

Source: JICA Expert Team

2.1.2 Sample Volume and Preparation of Sample Containers

The size of the final sample is an important consideration. This must be more than required volume for all the tests to be made. Before site sampling, contact laboratories where the samples are to be analyzed for the necessary amount (volume) of samples to cover for all parameters.

Type and materials of necessary sample bottles depend on analysis parameter and should be checked in advance. Polyethylene containers are generally used as sample bottles except for the case requiring a special container.

Sometimes, containers provided from the laboratory should be used. Those sample bottles must not be contaminated and be stored in the clean equipment room.

2.1.3 Instrument Calibration and Maintenance

Maintain, calibrate and operate the meter in accordance with the manufacturer's instructions. Record all calibration, use, and repair and maintenance information in the logbook. This must be done before going to the site for sampling.

2.1.4 Selection of Sample Types

Grab Sample – A grab sample is defined as an individual sample collected over a period of time not exceeding 15 minutes. Grab samples represent only the condition that exists at the time the sample is collected (US EPA 1977).

Composite Sample – A sample in one container comprised of several sub-samples collected over an extended period of time, usually 24 hours. Typically time proportioned, but may be flow proportioned in special circumstances. All composite samples should be identified as to the method of sampling collection, duration of composite (e.g. 24 hours), and frequency of the sampling (e.g. every 2 hours).

Grab samples are appropriate for characterization of a stream at a particular time, to provide information about minimum and maximum concentrations, to allow for the collection of variable sample volume.

Composite samples are required when a widely variable flow, or parameter concentration, is being sampled and "average" concentrations, or loadings, are desired.

2.1.5 Pre-arrangement and Co-ordination

The following arrangement and coordination should be done prior to site visit.

- To ensure access to sites on restricted or private land
- Institutional co-ordination, for example, for travel arrangements or sample transport
- To notify laboratories of expected date and time of sample arrival.

2.1.6 Weather and Site Condition

Before leaving the office, field technicians or samplers should check any available sources of information on local weather conditions. If the sampling point is in a river or stream which has tidal effects (e.g. Hlaing River and Pan Hlaing River), impact of sea water on water quality should also be considered. In such case, tidal condition should also be checked before going to the site.

2.1.7 Health and Safety

Water quality monitoring supervisor or management-level officer should outline and provide site-specific health and safety guidelines to field technicians (samplers) before beginning their works.
The samplers must have adequate protection gear including personal protective clothing. They must wear gloves, as protection against chemical and/or bacteriological hazards depending on the sample type. When in a boat, personal floatation devices (life-jackets) shall be worn at all times. Other protective measures shall be taken in accordance with the site-specific health and safety guidelines.

3. Procedures for Sample Collection and On-site Measurement

3.1 Site Arrival

The first step in sampling procedures, once the samplers have arrived at the site, is the identification of the site. The sites are identified based upon written descriptions, photographs, and maps located in the pre-printed documents, or by GPS location. Special care must be taken for site location as the proper identification of the site is a critical step in the sampling process.

3.2 Sample Collection

All field parameter data and water quality samples should be collected upstream of bridges or other permanent structures. Sediments and other types of debris can accumulate around bridge abutments and influence the data being collected.

Samplers should wear gloves during the collection of all samples. Sample collection should be done in an area located out of direct sunlight and wind.

Unfiltered samples shall be collected by the beaker with a handle or by the bucket or by the water sampler if water level cannot be reached by beaker. Prior to collecting unfiltered samples, fill each bottle partially with sample source water directly from the source (river, stream or lake) or from the water sampler, replace lid, and shake gently to rinse. Pour out rinse water and fill all unfiltered bottles directly from the sampler or bucket without leaving bubbles in each bottle.

If collecting samples from a surface water system with high flow, weight blocks should be attached to the water sampler and the water quality meter (e.g. Horiba U52) to keep equipment stable.

In case of sample collection with direct dipping of bottles into flowing water, the sampler will stand in the center of the stream, downstream of where the sample will be collected (i.e. stand with flow coming toward you and dip bottles ahead of where you are standing).

Generally, there are two methods of collecting samples: by using a water sampler or by dip-grab methods.

Dip-grab samples are collected by submersing a bottle neck-first into the water to the appropriate depth (normally this will be elbow depth for a 0.5 meter sample collection). The sampler will stand in the center of the stream, downstream of where the sample will be collected. This will reduce the probability of introducing suspended sediments to the sample bottles. Only unfiltered bottles will be collected using this method. First, allow bottle to fill partially with water, bring the bottle back to the surface, replace the cap, shake bottle gently to rinse, and pour water downstream or away from sample location. Then, fill the bottle without leaving bubbles in the containers.

Finally, the time, date, code of sampling location and other necessary information shall be recorded on pre-printed container labels. All samples must be stored immediately in the cool box already filled with ice tubes.

3.3 Recording Field Observations and Measurement

The first step in field data collection for surface water projects is to record general information such as weather, date and time of sampling, location name and general observations. Detailed field measurement parameter values and other details shall be noted down on the field data record form. The following field form (Fig.3.1) can be studied as an example.

Field data collection (on-site measurement) can be done with hand-held water quality meter such as Horiba U-50 and Hanna EC/pH meter. Profile readings (surface, middle, bottom) are usually collected if the total depth is greater than 1.5 meters. Bottom samples should be collected at the profile of 0.5 meter above river bed so as to prevent sediments included in the sample water.

Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Field Form for Sampling and On-site Measurement

Ver.3

Date: ____________ Recorded by: ____________

Weather: ____________ Air temp. ____________

Location name: ____________

Coordinate: ____________

Observations: ____________

____

Sampling location*: ☐Right, ☐Center, ☐ Left Sampling Time: ____________

* facing toward downstream Sampling method: ____________

Sampling depth: ____________

Field Measurements:

Parameter	Unit	Parameter	Unit
Time		DO	[ ]
Air temp.	[°C]	TDS*	[ ]
Water temp.	[°C]	Salinity*	[ ]
pH	[-]	Sea water specific gravity*	[ ]
pH(mv)	[mv]	Color**	
ORP	[ ]	*conductivity conversion	
Conductivity	[ ]	**by obrservation	
Turbidity	[ ]		

Others: ____________

____

____

Source: JICA Expert Team

Fig. 3.1 Sample Field Form for Sampling and On-site Measurement

Following field parameter data collection, on-site measurement meters should be turned off to save battery power, and stored in the protective case.

3.4 Duplicate Sample Collection

Duplicate sample means a sample collected at one location where not only regular sample is collected but one more sample of the same volume is also collected. As needed duplicate samples are collected to check data-bias, and the accuracy and performance of the laboratory where the samples are analyzed. The sample container or bottle should be left unmarked, and the collection point of the duplicate sample shall be recorded by field technicians or samplers.

3.5 Post Sampling Procedures

Following the completion of the sampling procedure, the equipment and instruments shall be thoroughly cleaned with fresh water, and special equipment, such as Horiba U-52 and Hanna pH/EC meter, must be rinsed with deionized water. Take pictures as necessary. The sampling site needs to be picked-up including the removal of all trash.

4. Final Paperwork and Sample Shipment

Upon returning to the office at the end of the day, the samples need to be prepared for shipment to respective laboratories, and the appropriate paperwork printed and stored. Shipment should be started as soon as possible.

5. References

UNEP/WHO, “Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater”, 1996

Southwest Florida Water Management District, “Standard Operating Procedures for the Collection of Water Quality & Biological Sample”, August 2009

John R. Kasich, Governor, Mary Taylor, Lt. Governor, Scott J. Nally, “Director Surface Water Field Sampling Manual”, Jan 2015

Note: This form will be prepared for each laboratory to be outsourced.

Form of Chain of Custody (1/2) -From the site to the laboratory-

Name of laboratory: ____________________

Ver.1

Project name: ____________________ Project site: ____________________

The following information shall be filled out by a sampler.

No.	Sample name	Sampling date/time		Sample type	Number of containers						Analysis parameter requested														Sample condition		Other note
		Date	Time	Water, Soil, Sediment	500 mL bottle	1L bottle	2 L bottle	Other ( )	Other ( )	Total Q'ty															F(Filtered) /U(Unfiltered)	R(Refrigerated) /N (Not refrigerated)	
1				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
2				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
3				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
4				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
5				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
6				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
7				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
8				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
9				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
10				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
11				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
12				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
13				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
14				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	
15				W □/ Soil □ Sed □							□	□	□	□	□	□	□	□	□	□	□	□	□	□	F □ / U □	R □ / N □	

Note; ____________________

Name of sampler: ____________________ (signature)

The following information shall be filled out by a sampler.

Sample arrival at lab: (Date) (Time) ____________________ **Received by:** ____________________ (signature)

Note: This form will be prepared for each laboratory to be outsourced.

Form of Chain of Custody (2/2) -In the process of laboratory-

Name of laboratory: ______________________ Ver.1

Project name: ______________________ Project site: ______________________

The following information shall be filled out by a person in charge of from laboratory or by a sample collector with the confirmation of laboratory.

No.	Analysis Parameter	Analysis date or period		Sample preservation		Sample used for analysis		Analysis method		Note
		From	To	Refrigerated(R) or Not refrigerated(N)	Treated by chemicals: Yes (please specify) or No	Agitated sample (A) or Supernatant (S)	Filtered (please specify the pore size of filter) or unfiltered	Name of method	Name of instrument used	
1				R □ / N □	Y □ ( ) / N □	A □ / S □ / Others ( )	F □ ( ) / U □			
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

Note: If any specific information in this form is described in a test result report or any other documents issued by the laboratory, it can be referred to.

Recorded by or confirmed by (from lab): ______________________ (signature) (Date)

Appendix 3 SOP for river flow rate measurement

SOP for river flow rate measurement

1. Measurement method

Method using an electromagnetic flow velocity meter

2. Equipment

Prepare the following equipment:
- Electromagnetic flow velocity meter
- Measurement tape
- Field note

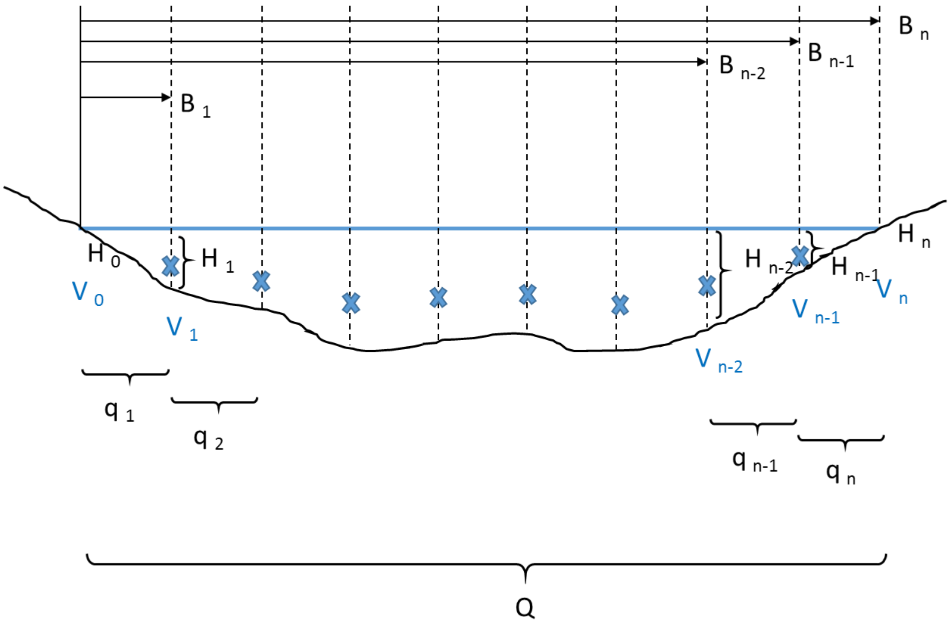
3. Principles

1) Divide the cross-section area of river into 5-20 sections (see the reference below to decide the number of section)

Width of Water Surface (m)	Distance between B_n and B_{n-1} (width of each zone) for water depth measurement (m)	Distance between B_n and B_{n-1} (width of each zone) for water velocity measurement (m)
= or < 10	10 – 15 % of width of water surface	10 – 15 % of width of water surface
10 – 20	1	2
20 – 40	2	4
40 – 60	3	6
60 – 80	4	8
80 – 1000	5	10
100 – 150	6	12
150 – 200	10	20
> 200	15	30

Source: Ministry of Construction in Japan, Draft technical standard method for river and sand control, 1997

2) Estimate a cross-section area by measuring the width and water depth for each zone
3) Measure the water flow velocity and take an average of water flow velocity for each zone
4) Multiply the cross-section area by water flow velocity and get a flow rate for each zone
5) Add the flow rate of each zone and get a total flow rate



Q: Total flow rate (m3/s), q: Flow rate in each zone (m3/s), B: Horizontal distance from the starting point of measurement (m), H: Water depth (m), V: Flow velocity (m/s)

Source: JICA Expert Team

Figure: Water Flow Rate Measurement Method

4. Preparation

1) Set the water velocity meter. (Ref. calculation time is 20 seconds or as appropriate)
2) Check the site condition. The following points should generally be considered when selecting the location to measure flow velocity.
   a) Stream should flow through single channel.
   b) Water should flow several times further than the river width (normally four times) in a straight line both up- and downstream, and there should not be a big difference in the cross section or inclination of the riverbed.
   c) Poor condition riverbeds such as those with irregularly placed rocks and stones should not be selected.
   d) Water streams should not be too fast or slow.
   e) There should not be any whirlpools, backward flow, or stagnation.

5. Measurement procedure
1) Measure the width of river
2) Decide the width of divided zone and set the point of Bo, B1,…., Bn.
3) Measure the water depth at Bo, B1, …, Bn (= H0, H1, …., Hn)

4) Measure the water velocity at Bo, B1, …, Bn (= V0, V1, …., Vn)

   In principle, hold the sensor at a depth of 60% from the water surface if the total water depth is not more than 40 cm. If the water depth is 40 cm or more, take measurements at the two points of 20% and 80% from the water surface and get the average velocity.

5) In general, take measurements twice and get the average.
   e.g. From the left river bank to the right river bank – and vice versa

6. Calculation

Calculate the total flow rate (Q) by the following formula.

$$\mathrm{Q} = q_1 + q_2 + \cdots + q_{n-2} + q_{n-2} + q_n$$

$$q_{n-1} = (B_{n-1} - B_{n-2}) \times \frac{(H_{n-2} - H_{n-1})}{2} \times \frac{(V_{n-1} + V_{n-2})}{2}$$

Wherein, n >0
Q: Total flow rate (m3/s)
q: Flow rate in each zone (m3/s)
B: Horizontal distance from the starting point of measurement (m)
H: Water depth (m)
V: Flow velocity (m/s)

Example of field form

Field Form for Water Flow Measurement

Page No.

Name of point:

Measurement date and time:

Method/Equipment used: Electromagnetic current meter

Distance		Water Depth		Water Velocity					Water Flow [m3/s]	Total water flow [m3/s]
No.	[m]	No.	[m]	No.	$V_{0.6}$ or Average($V_{0.2}$, $V_{0.8}$) [m/s]	$V_{0.2}$ [m/s]	$V_{0.8}$ [m/s]	Memo		
B0		H0		V0					-	
B1		H1		V1					0	
B2		H2		V2					0	
B3		H3		V3					0	
B4		H4		V4					0	
B5		H5		V5					0	
B6		H6		V6					0	
B7		H7		V7					0	
B8		H8		V8					0	
B9		H9		V9					0	
B10		H10		V10					0	0
B11									0	
B12									0	
B13									0	
B14									0	
B15									0	
B16									0	
B17									0	
B18									0	
B19									0	
B20									0	

In case that water depth is not more than 40 cm, measure

V0.2: Velocity at 20 % of water depth from the surface water

In case that water depth is more than 40 cm, measure

V0.6: Velocity at 60 % of water depth from the surface water

V0.8: Velocity at 80 % of water depth from the surface water

End

Appendix 10:

Water Quality Survey Reports

The water quality survey reports were prepared by technical staff of C/P organizations participated in the water quality surveys, namely, ECD Yangon, YCDC-PCD, YCDC-WSD, ECD Mandalay and MCDC-WSD, as one of the capacity development activities under output2: water quality survey. Each organization prepared its own report according to the responsibilities of the organization and the survey objectives. ECD Yangon, YCDC-PCD and YCDC-WSD prepared the survey report of the Hlaing River basin and ECD Mandalay and MCDC-WSD prepared the survey report of the Doke Hta Waddy River basin. Another water quality survey report was prepared by the JICA Expert Team to complete all necessary descriptions of the surveys in both target areas. Thus, Appendix 10 is composed of the folliwng six reports as follows.

Appendix 10-1: Water quality Survey Report prepared by JET and C/P Organizations
Appendix 10-2: Water quality Survey Report prepared by ECD Yangon (only in CD-R)
Appendix 10-3: Water quality Survey Report prepared by YCDC-PCCD (only in CD-R)
Appendix 10-4: Water quality Survey Report prepared by YCDC-WSD (only in CD-R)
Appendix 10-5: Water quality Survey Report prepared by ECD Mandalay (only in CD-R)
Appendix 10-6: Water quality Survey Report prepared by MCDC-WSD (only in CD-R)

Appendix 10-1:

Water Quality Survey Report prepared by JET and C/P Organizations

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY REPORT

JUNE 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT, MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION

YANGON CITY DEVELOPMENT COMMITTEE

MANDALAY CITY DEVELOPMENT COMMITTEE

JICA EXPERT TEAM

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* Appendix 4 is available only in electric form in CD-R

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LIST OF FIGURES

ABBREVIATIONS

BOD	Biochemical Oxygen Demand
C/P	Counterpart
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EC	Electrical Conductivity
ECD	Environmental Conservation Department
ECL	Environmental Conservation Law
EIA	Environmental Impact Assessment
IZ	Industrial Zone
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
MCDC	Mandalay City Development Committee
MOH	Ministry of Health
MOHS	Ministry of Health and Sports
MONREC	Ministry of Natural Resources and Environmental Conservation
ORP	Oxidation Reduction Potential
PCB	Poly Chlorinated Biphenyl
PCCD	Pollution Control and Cleansing Department
SS	Suspended Solid
TDS	Total Dissolved Solid
T-N	Total nitrogen
T-P	Total phosphorus
WSD	Water and Sanitation Department
YCDC	Yangon City Development Committee

EXECUTIVE SUMMARY

1. Introduction

The water quality survey targeting the Hlaing River basin and the Doke Hta Waddy River basin was conducted as one of activities of the Project for Capacity Development in Basic Water Environment Management and EIA System (hereinafter referred to as "the Project"). This report summarizes the water quality survey results which are to be utilized to interpret the water quality status in the target areas and develop the pollution control measures.

2. Purpose of water quality survey

The main objectives of the water quality survey were set to confirm the pollution status in the target river basins and to examine the impact of industrial wastewater on the Hlaing River in Yangon and the Doke Hta Waddy River in Mandalay.

The survey objectives specific to the Hlaing River Basin were established as follows.

1) To confirm the water quality in the Hlaing River and Pan Hlaing River
2) To investigate spatial distribution of pollution in the flow direction in the Hlaing River
3) To investigate seasonal changes of water quality
4) To investigate the pollution impact from Industrial wastewater to the Hlaing River

The survey objectives specific to the Doke Hta Waddy River Basin were established as follows.

1) To investigate the pollution impact from industrial wastewater to the Doke Hta Waddy River
2) To confirm the pollution status in Taung Tha Man Lake
3) To investigate the main pollution path to Taung Tha Man Lake

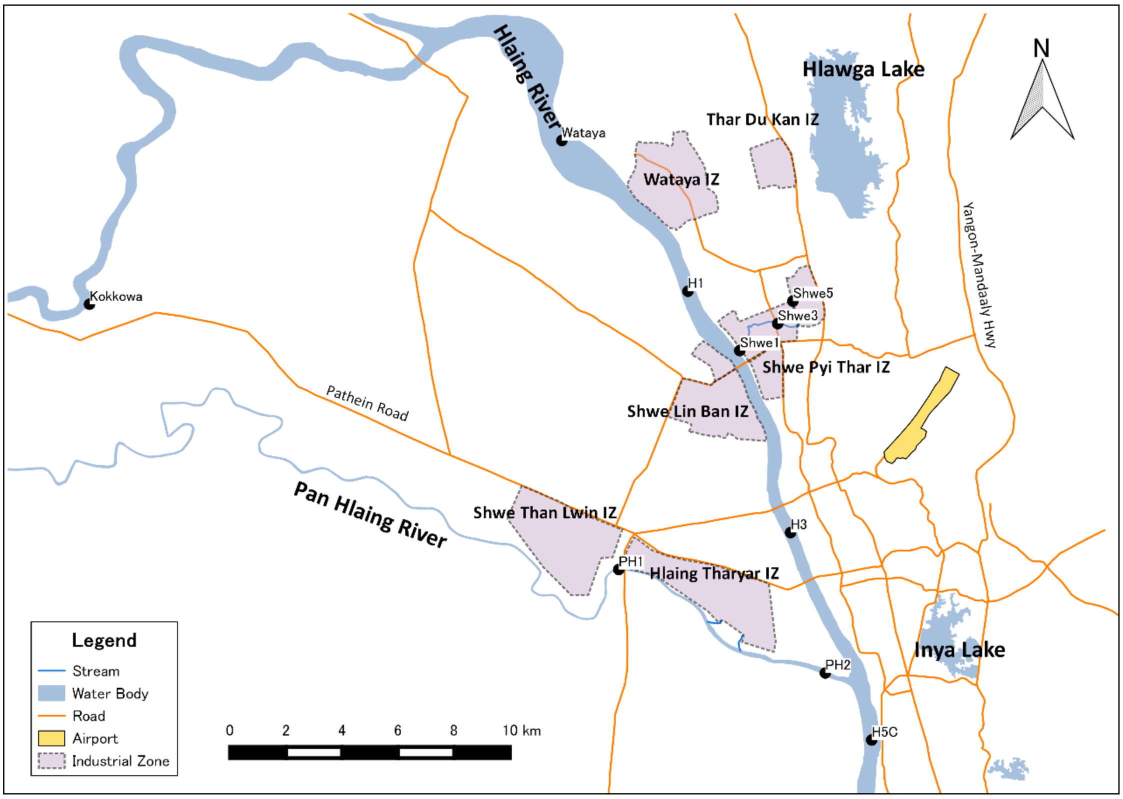
3. Outline of water quality survey

The surveys were implemented in total five times in the dry season and rainy season from 2016 to 2018. The overall schedule and scope of surveys are described in the table below. This Water Quality Survey Report summarized the results from 4th and 5th water quality surveys. The sampling points of the surveys are shown in the Figure ES-1 an Figure ES-2. Main counterpart (C/P) organizations for conducting the survey are Environmental Conservation Department (ECD) of Ministry of Natural Resources and Environmental Conservation (MONREC), Yangon City Development Committee (YCDC) and Mandalay City Development Committee (MCDC). The fieldwork of surveys was outsourced to the local environmental consulting company under management of JICA Expert Team and supervised by C/Ps.

Table 1 Components of Water Quality Survey

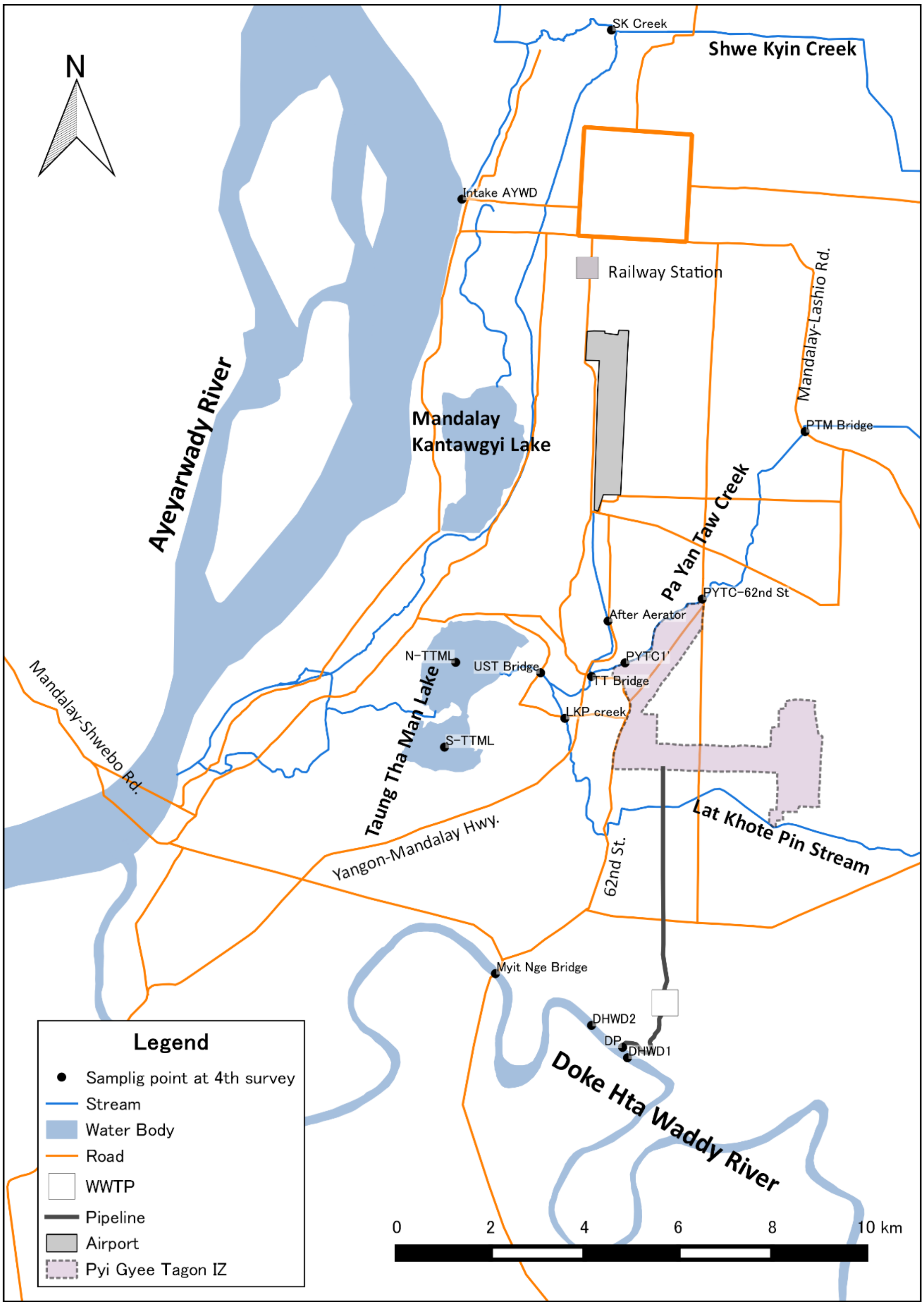
Category		Period 1 (2016 – early 2017)	Period 2 (late 2017 – early 2018)
Period		- 1st survey: Feb 2016 (dry season) - 2nd survey: Jun 2016 (rainy season) - 3rd survey: Jan - Feb 2017 (dry season)	- 4th survey: Sep - Oct 2017(rainy season) - 5th survey: Feb 2018 (dry season)
Scope	Hlaing River Basin	- 9-10 sampling points - 8 on-site-measurement parameters - 29 measurement parameters for lab analysis at max.	- 10 sampling points - 8 on-site-measurement parameters - 35 measurement parameters for lab analysis at max.
	Doke Hta Waddy River Basin	- 10-14 sampling points - 8 on-site-measurement parameters - 29 measurement parameters for lab analysis at max.	- 15 sampling points - 8 on-site-measurement parameters - 35 measurement parameters for lab analysis at max.

Source: JICA Expert Team



Source: JET

Figure ES-1 Main Sampling Points of Water Quality Surveys in the Hlaing River Basin



Source: JET

Figure ES-1 Main Sampling Points of Water Quality Surveys in the Doke Hta Waddy River Basin

4. Findings from water quality survey in the Hlaing River basin

The main findings from the surveys in the Hlaing River basin are desctibed below.

(1) Water quality in the Hlaing River and the Pan Hlaing River

The levels of organic pollution in the Hlaing River did not appear to be very high in the rainy season, though the river water was highly turbid and had localized pollution due to discharged wastewater from various source. The water quality was obviously deteriorated in the dry season. However, the water quality for most parameters in the Hlaing River is considered to be acceptable for conservation of aquatic life, irrigation, and water transportation. The elevated level of toxic pollutants was not confirmed in the Hlaing River within the scope of survey.

One concern is a hypoxic water area with higher COD and suspended solid was observed at some points downstream in the dry season. It is important to check how the hypoxic water is formulated and how it moves forward or downward in the river by obtaining more monitoring data including the water quality in different-depth points and in other tide condition.

(2) Spatial distribution of pollution in the flow direction of Hlaing River

The result did not show the marked deterioration of surface water quality in the flow direction of the Hlaing River and Pan Hlaing River in the rainy season. In the dry season, the COD level increased from middle stream to downstream in the survey area, while there was no significant difference in BOD level among the locations. This implies that the high COD in the dry season in the downstream area was largely due to organic matter associated with suspended solid in the water and not soluble organic substance. More monitoring data is required to identify the spatial and temporal changes of surface water quality in the Hlaing River.

(3) Pollution impact from industrial wastewater to the Hlaing River

One small creek flowing through the Shwe Phy That IZ to the Hlaing River was selected as a target creek in IZ to be investigated. In the creek, the water quality was significantly deteriorated by industrial wastewater when the highly-polluted industrial wastewater was discharged from factories to the creek. The water pollution was indicated by low DO as well as high concentrations of COD, BOD, oil and grease, nutrients and others. The pollution impact on the Hlaing River by this creek seemed limited currently because a large amount of water flow in the Hlaing River could alleviate such impact by dilution of pollutants at this moment. However, dilution capacity in the river is limited or even reduced in the dry season and the environmental risk in the main river could be higher. The regular water quality monitoring is required to clarify the water quality status and mechanism of distribution of water pollution.

5. Findings from water quality survey in the Doke Hta Waddy River basin

The water quality in the Doke Hta Waddy River basin was evaluated as shown below

(1) Pollution impact from the discharged wastewater to the Doke Hta Waddy River

The Doke Hta Wady River maintains adequate water quality for domestic water supply with simple treatment facility. The water quality did not dramatically vary by season or points. No elevated levels of toxic substances were confirmed at present.

In 2016, the wastewater discharged from 10-inch pipeline contained high concentrations of pollutants that included oil and grease, phenols and hexavalent chromium in addition to organic materials and nutrients, which was higher than the guideline values applied to wastewater (general application, Environmental Quality (Emission) Guidelines, 2015). The pollution impact on water quality in the River by the 10-inch pipeline wastewater was limited because of the large dilution capacity of the river. After regional government enforced several measures such as an order of tentative shut-down of distilleries, the pollution load was reduced. However the wastewater still contains organic and nutrients pollutants as well as oil and grease and phenols etc.

(2) Pollution level of Taung Tha Man Lake

The water quality in Taung Tha Man Lake is characterized as eutrophic represented by high COD and nutrients as well as relatively low DO. When the lake water level was quite lower in the dry season, especially the water in the northern lake was hypereutrophic, receiving the wastewater from the inflowing creeks. The eutrophication mechanism in the lake is complicated and not clear. Since the water quality in the lake has changed or fluctuated dramatically over time, continuous and wider scope of monitoring will be necessary to examine the mechanism of water pollution in the lake that caused eutrophication and the mass fish death events in the past.

(3) Pollution path to Taung Tha Man Lake

The creek running through U Shwe Taung Bridge is one of the most important routes of pollutants to reach Taung Tha Man Lake. The water quality was characterized by low DO and high organic contamination, polluted by both domestic wastewater and industrial wastewater. The pollution load from faming land seemed limited, but needs to be investigated in another farming season.

The survey found that highest pollution load of organic material and nutrients came from Pa Yan Taw creek among three creeks reaching U Shwe Taung Bridge except T-N in the dry season. Deterioration of water quality in creeks was significant in the dry season. It is considered that these pollution load from upper basin of lake has led to accumulation of nutrients in the lake, resulting in the eutrophication in the Taung Tha Man Lake.

6. Conclusions

The surface water quality in main rivers and creeks was investigated in the Hlaing River basin and Doke Hta Waddy River basin in order to investigate the impact from industrial wastewater. The Hlaing River receives domestic wastewater and industrial wastewater from the river basin of Yangon City. Although the Doke Hta Waddy River is not located in the urban area, the industrial wastewater is directly discharged to the river. The surveys confirmed that the Hlaing River and Doke Hta Waddy River still maintains the water quality desirable for each water as far as the receiver water bodies have a certain level of water flow. On the other hand, the survey results pointed out several issues and concerns on surface water quality in target areas. First, the Hlaing River or/and Pan Hlaing River could have a localized dysoxic water area in the brackish water area. It is generally formulated associated with hydrological behavior of brackish water area and depending on the organic pollution level. In case of such dysoxic environment, the river water quality is not suitable especially in terms of conservation of aquatic life. Secondly, Taung Tha Man Lake represented the case and behavior of eutrophication in the enclosed water area where the high pollution load from the upstream basin inflows. The lake still has a potential risk of fish kill incidents if hypoxic condition is exacerbated.

The pollution in the surface water in target area was mainly concerned with the organic pollutions and nutrients at present. Elevated level of toxic substances was not observed within the scope of survey. However, the environmental risk in the surface water could be higher as more factories in the wider area of industrial sector invest to IZ. It is crucial to develop the regular water quality monitoring program in Myanmar in the near future to figure out the water environmental status and enforce the appropriate measures necessary for environmental conservation.

7. Recommendations

(1) Improvement of monitoring data quality in Myanmar

The quality control of survey data was a big challenge in the first half of the Project. The validation process of analytical data revealed that the analytical result has much variation among local laboratories. The capacity improvement of laboratories in Myanmar is one of the key challenges to acquire reliable data. Technical guidance to environmental analysis laboratories should be provided. The required measures include the standardization of environmental analytical methods of laboratories, establishment of accrediation system of laboratories, etc.

(2) Development of proper water environmental standard

National Enivironmental Quality Standards is under the development of ECD(Environmental Conservation Department)/MONREC(Ministry of Natural Resources and Environmental Conservation). The surface water qualtiy standard should have proper criteria that is adequate for characterization and water usage, etc. of each water body. It is recommended to utilize the monitoring data acquried from Water Qualiry Sureys in this Project for examination to establish a propoer surface water qualtiy standard in Myanmar.

(3) Regular surface water monitoring in wider scope

The spatial and temporal changes of surface water quality in targeted water bodies are not clear in detail. More sampling frequency to acquire at least monthly data for representative points and parameters is necessary in terms of environmental water quality monitoring. The monitoring is required not only to investigate the current water quality but also to predict the change in water environment and to predict the impact by any environmental changes including increased industrial activity. It is suggested that regular water quality montioring be planned, conducted and reported by responsible authorities.

(4) Investigation of mechanism of water pollution in a specific target area

More monitoring data is also required to examine the mechanism of water pollution in the specific river and lake. The water status and hydorogical mechanisms in tidal area of Hlaing River are complicated and not clear. The depth-direcion survey in daily and monthly tidal cycle in differenct season is necessary to clairfy how the water quality is changed by tidal current. The eutrophication mechanism in Taung Tha Man lake also has not been investigated: how the nutients inflow to the lake, how the oxygen in the water is consumed, and how the nitrogen and phosphorus are cycled among the sediment, water, phytoplankton and other medium. It is essential to clarify these meachnisms to conserve the lake environment.

1 INTRODUCTION

1.1 Background

The water quality survey targeting the Hlaing River basin and the Doke Hta Waddy River basin was conducted as one of activities of the Project for Capacity Development in Basic Water Environment Management and EIA System (hereinafter referred to as "the Project"). The surveys were implemented in total five times in the dry season and rainy season from 2016 to 2018. The results were utilized to interpret the water quality status in the target areas and develop the pollution control measures.

1.2 Legal basis of water quality survey

Under the Constitution of the Republic of the Union of Myanmar (2008) which states in Article 45 that the Union shall protect and conserve natural environment, the Environmental Conservation Law (Law No.9, 2012) and the Environmental Conservation Rules (2013) were established as basic environmental law and rules. The Environmental Conservation Law (ECL) specifies the duties and powers of Ministry of Natural Resources and Environmental Conservation (MONREC) for planning, implementing and monitoring of environmental conservation programs in Article 7. Article 10 of ECL stipulates the environmental quality standards including the suitable surface water quality standards for the usage in rivers, streams, canals, springs, marshes, swamps, lakes, reservoirs and other inland water sources of the public. In addition, Article 13 of ECL mentions that MONREC shall maintain a comprehensive monitoring system and implementation of necessary matters by MONREC itself or in coordination with relevant parties, relating to environmental pollution. Besides, the Environmental Conservation Rules (Notification No.50, 2014) states Environmental Conservation Department may conduct necessary special inspections and investigations at necessary time and place to enable to stipulate environmental quality standards. These regulations provide MONREC with the authority to monitor the water quality for conservation, pollution control and establishment of environmental quality standards.

It is essential that national and local governments monitor the water quality of public water and obtain spatial and historical data for making administrative decisions. However, there are no laws or regulations yet that stipulate the specific mandate or responsibilities of water quality monitoring in the public water bodies. In addition, nationwide or region-wide water quality monitoring has not been conducted by national or local governments with regard to water environment conservation and management. The detailed measures of water quality survey have not been specified as well.

In general, a surface water quality survey in Myanmar is conducted by an organization that has a special interest in the water body. Such surveys include: drinking water monitoring by Ministry of Health and Sports or local governments from the viewpoint of public health; river water monitoring by a managing ministry or organization of specific river section, such as Ministry of Transportation and Communications and Ministry of Agriculture, Livestock and Irrigation; water environmental survey for specific projects, such as an EIA study for checking the basic water quality status; and other on-demand water quality survey, as shown in Table 1.2-1. Each organization conducts the survey based on internationally recognized methods or their own methods considering the purpose of the survey.

Table 1.2-1 Types of Water Quality Survey in Myanmar

No	Implementer	Example Cases
1	Government/public institution	[Periodical survey] - MOTC periodically conducts the water quality monitoring in the Ayeyarwady River. - A department in charge of water supply in the local government such as WSD/YCDC and WSD/MCDC checks the water quality of the supplied water every week. - In addition, WSD/MCDC conducts the every-week water quality monitoring in Doke Hta Waddy River as well as Thaung Tha Man Lake and channels flowing into/out from Thaung Tha Man Lake. [Demand-based survey] - MOHP in cooperation with YCDC conducted the water quality monitoring of surface water of the Hlaing River and wastewater in the surrounding area in 2014. - A joint inspection team composed of representatives from relevant ministries and organizations checked the water quality to investigate the water pollution status in Thaung Tha Man Lake and other areas in 2015.
2	Project proponent of EIA	- A water quality survey is generally conducted in a basic environmental survey of EIA/IEE in surrounding of project area or project-affected area based on the requirement of EIA Procedure (2015) and the result is evaluated according to National Environmental Quality (Emission) Guidelines (2015). - As one of example, an EIA study for a central wastewater treatment plant to be constructed nearby the Doke Hta Waddy River investigated the water quality in Doke Hta Waddy River in early 2016.
3	Others (NGO, researchers etc.)	- A NGO group in Yangon periodically carries out the water quality survey in several channels in Hlaing Thar Yar IZ to monitor the pollution impact from the industries as of 2016. - A research team from Yadanabon University conducted the water quality survey mainly in Ayeyarwaddy River and once in Thaung Tha Man Lake for their research about water resource.

Note: The table was prepared based on information collected at the beginning of Project in 2016.

Source: JICA Expert Team

1.3 Overall objectives of water quality survey

The water quality survey in the Project was implemented in order to achieve the Project purpose for water environmental management component: namely “Capacity for developing basic water pollution control measures based on obtained and interpreted information is enhanced.”. For this purpose, it is crucial to acquire reliable water quality data that will be used to develop water pollution control measures in the target pilot study areas: namely Hlaing River basin in Yangon and Doke Hta Waddy River basin in Mandalay. A main subject of the survey is the pollution impact on surface water which is caused by the wastewater from industries. In this context this water quality survey targets on the surface water in rivers, creeks and channels and wastewater discharged from industrial zones in each pilot area. The main objectives of the water quality survey are set to confirm the pollution statuses in the target river basins and to examine the impacts of industrial wastewaters on the Hlaing River and Doke Hta Waddy River. In particular, it is expected to confirm the levels of pollution by organic and toxic substances as well as fluctuation or changes of water quality by natural phenomena or human-caused reasons such as wastewater in public water area. The specific objectives for each target basin are described in Sections 2.1 and 3.1.

1.4 Outline of water quality survey

Main counterpart organizations for conducting the survey are Environmental Conservation Department (ECD) of Ministry of Natural Resources and Environmental Conservation (MONREC), Yangon City Development Committee (YCDC) and Mandalay City Development Committee (MCDC): especially,

1) ECD Yangon Region, Pollution Control and Cleansing Department (PCCD) of YCDC and Water Sanitation Department (WSD) of YCDC for the Haling River basin survey.
2) ECD Mandalay Region and Water Sanitation Department (WSD) of MCDC for the Doke Hta Waddy River basin survey.

The water quality survey was planned to be implemented in total five times for each pilot area as shown in Table 1.4-1. The survey has two pilot areas: Hlaing River basin in Yangon Region and Doke Hta Waddy River basin in Mandalay Region as mentioned above. However, it should be noted that the actual sampling points were not necessarily located in each river basin but in the other surrounding area such as the sampling points in Taung Tha Man Lake where the water quality was investigated in order to examine the pollution impact from the target industrial zone around Doke Hta Waddy River basin.

Table 1.4-1 Components of Water Quality Survey

Category		Period 1 (2016 – early 2017)	Period 2 (late 2017 – early 2018)
Period		- 1st survey: Feb 2016 (dry season) - 2nd survey: Jun 2016 (rainy season) - 3rd survey: Jan - Feb 2017 (dry season)	- 4th survey: Sep - Oct 2017(rainy season) - 5th survey: Feb 2018 (dry season)
Scope	Hlaing River Basin	- 9-10 sampling points - 8 on-site-measurement parameters - 29 measurement parameters for lab analysis at max.	- 10 sampling points - 8 on-site-measurement parameters - 35 measurement parameters for lab analysis at max.
	Doke Hta Waddy River Basin	- 10-14 sampling points - 8 on-site-measurement parameters - 29 measurement parameters for lab analysis at max.	- 15 sampling points - 8 on-site-measurement parameters - 35 measurement parameters for lab analysis at max.

Source: JICA Expert Team

In the first half of the Project period (June 2015 – April 2017), some data was not satisfactorily validated in the 1st – 3rd surveys although efforts were made to improve the data quality. The data reliability was significantly improved in the 4th and 5th surveys due to the change of policy to select the laboratories. Thus, the water quality in target river basins was evaluated based on the results of 4th and 5th surveys in the report. The results from the 1st to 3rd surveys were used as reference. The details of data validation are described in Chapter 4.

The water quality surveys have been conducted by the following procedures. The key determinants of the survey are sampling points, sampling time and measurement parameters. The criteria for selecting these determinants were examined at first as described in "Criteria for selecting sampling points, sampling time and measurement parameters" (JICA Expert Team, May 2018), which was prepared under the Project. The survey plan that specifies the exact sampling points and measurement parameters was developed based on these criteria (See the other project document, "Water Quality Survey Plan" (JICA Expert Team, May 2018)). The survey was implemented according to the survey plan, while some conditions were changed from the original plan due to the site conditions and other necessary reasons. The survey results were analyzed and evaluated with counterpart organizations as mentioned further in this report.

1.5 Outline of water quality survey report

Chapter 2 reports the survey results in the Haling River basin and Chapter 3 presents the survey results in Doke Hta Waddy River basin. Both chapters start with the survey objectives, followed by survey items, methodology, result and evaluation. Chapter 4 focuses the quality control aspect of the surveys. This report concludes with recommendations in Chapter 5.

2 WATER QUALITY SURVEY REPORT FOR HLAING RIVER BASIN

2.1 Survey objectives

The survey objectives for the Hlaing River Basin were set as follows based on the Water Quality Survey Plan (JICA Expert Team, May 2018).

1) To confirm the water quality in the Hlaing River and Pan Hlaing River.
2) To investigate spatial distribution of pollution in the Hlaing River: difference in water quality from upstream to downstream.
3) To investigate seasonal changes of water quality
4) To investigate pollution impact from Industrial Zone to the Hlaing River

2.2 Survey outline and methodology

2.2.1 Data source

As mentioned in Section 1.4, the results from 4th and 5th surveys were used to evaluate the water quality status.

2.2.2 Survey team

The fieldwork of surveys was outsourced to the local environmental consulting company under management of JICA Expert Team and supervised by C/Ps from ECD-Yangon Regional Office, PCCD-YCDC and WSD-YCDC.

2.2.3 Sampling schedule

The sampling work for Hlaing River basin was conducted by the following schedule. It was planned to target the spring tide period. The sampling time in the Hlaing River was arranged to take water samples in the ebb tide time when the water flows from upstream to downstream to check the pollution impact from the upstream river basin.

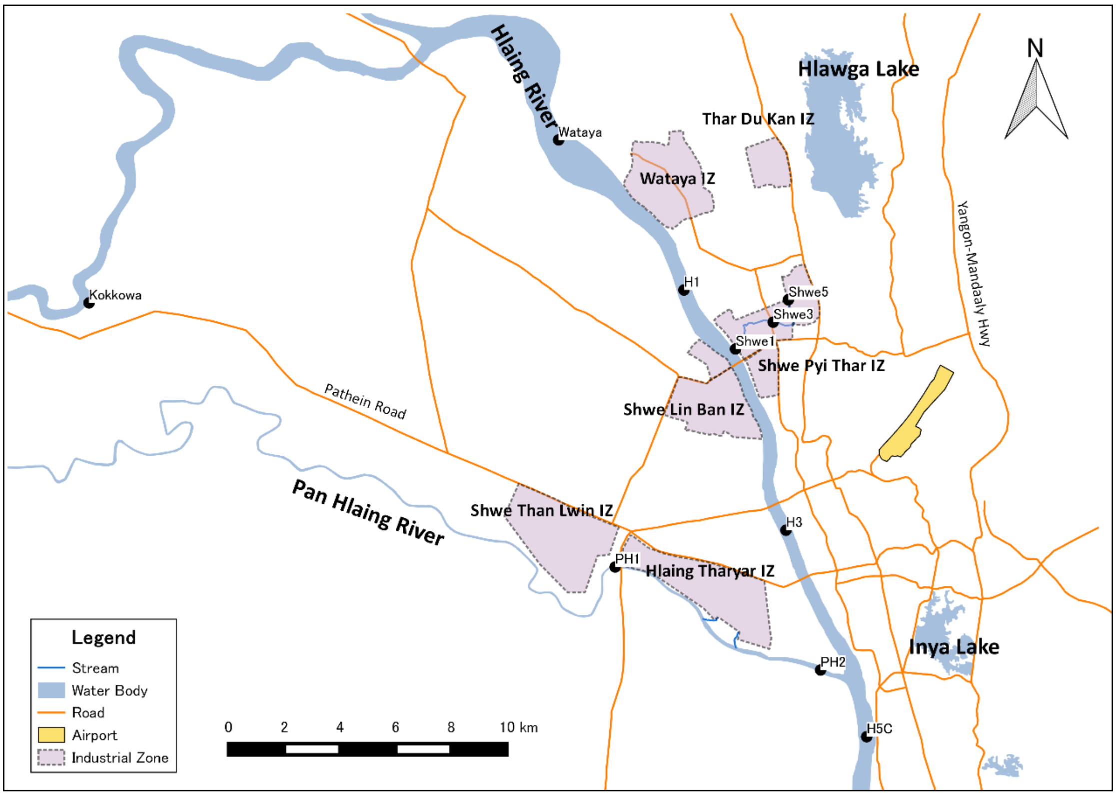
Table 2.2-1 Survey Schedule for Hlaing River Basin

Survey	Sampling Period	Notes
1st water quality survey	22-23 Feb 2016	-
2nd water quality survey	20-21 Jun 2016	-
3rd water quality survey	30 Jan–1 Feb 2017	-
4th water quality survey	18-20 Sep 2017	It rained heavily in the afternoon of 19 Sep.
5th water quality survey	19–21 Feb 2018	-

Source: JICA Expert Team

2.2.4 Sampling points

The sampling points in the Hlaing River basin are shown in the figure and table below. The points from Wataya to H5 were located from the upstream to the downstream of Hlaing River to confirm the changes in water quality in Hlaing River. Shwe-1 is mouth of the sub-stream of Hlaing River that flows through Shwe Pyi Thar IZ. Shwe-3 is the middle point and Shwe-5 is upstream in the creek. PH1 and PH2 are located respectively at upstream and downstream of Hlaing Thar Yar IZ. The sampling points of Kokkowa and Wataya were investigated as possible future intake point(s) of domestic water supply to Yangon City. The water treatment plant is planned to be constructed on the bank of the Kokkowa River, upstream of Hlaing River. WSD-YCDC is also seeking the possibility to withdraw water from Hlaing River to Hlawga Lake to prevent a drawdown of Hlawga lake in the dry season. The sampling location from 1st to 3rd surveys were slightly different from those and they were optimized in the course of past surveys.



Source: JICA Expert Team

Figure 2.2-1 Sampling Points for 4th and 5th survey in the Hlaing River Basin

Table 2.2-2 List of Sampling Points for 4th and 5th surveys in the Hlaing River Basin

No.	Abbreviated Location Name	Location Name	Latitude	Longitude
1	Wataya	Wataya-C	16.99800	96.01475
2	H1	Hlaing 1-C	16.94967	96.05700
3	H3	Hlaing 3-C	16.87228	96.09142
4	H5C	Hlaing 5-C	16.80572	96.11861
5	PH1	Pan Hlaing 1-C	16.86042	96.03381
6	PH2	Pan Hlaing 2-C	16.82722	96.10306
7	Shwe1	Shwe 1-C	16.93066	96.07438
8	Shwe3	Shwe 3-C	16.93931	96.08710
9	Shwe5	Shwe 5-C	16.94651	96.09220
10	Kokkowa	Kokkowa Intake	16.94552	95.85644

Source: JICA Expert Team

2.2.5 Measurement parameters

(1) Measurement parameters

Measurement parameters are shown in the table below. The 1st survey focused on the basic parameters to study a spatial distribution of organic pollution level. The following surveys covered more measurement parameters including heavy metals and pesticides, based on the findings from past surveys and changes in site conditions.

Table 2.2-3 Measurement Parameters for Hlaing River Basin

Points	Measurement Parameters
All points	[On site measurement] - pH, EC, DO, TDS, salinity, turbidity, water temperature, ORP [Laboratory analysis] - TSS, BOD, COD, cyanide, oil and grease, phenols (except in the 1st survey), total phosphorus and total nitrogen
Representative points	[On site measurement] - Flow rate (if available) [Laboratory analysis] - Total coliform, zinc, total chromium, hexavalent chromium, arsenic, copper, total mercury, cadmium, and lead - Phenols, color, odor, iron and manganese in the 1st survey - Phosphate(except in the 1st survey), ammonia nitrogen, nitrate nitrogen and nitrite nitrogen in the 1st – 3rd surveys - Pesticides* and PCBs for only one or two points

* Total organic chlorine pesticides and total organic phosphorus pesticides for 2nd and 3rd surveys
* Aldrin, atrazine, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endosulfan, endosulfan sulfate, endrin, HCH-alpha (benzene hexachloride-alpha), HCH-beta, HCH-delta, HCH-gamma(Lindane), alachlor, diazinon, chlorpyrifos, dimethoate and imidacloprid for 4th and 5th surveys

Source: JICA Expert Team

(2) Guideline levels

National surface water quality standard is under preparation by ECD/MONREC according to the Environmental Conservation Law (Law No.9, 2012). However, since there is no ambient water environmental quality standard in Myanmar yet, C/Ps and JET evaluated the water qualities based on some reference standards and related guidelines in Myanmar, Vietnam and Japan, considering the type and usage of water. They included: i) Vietnamese national technical regulations on surface water quality (QCVN 08-MT 2015/BTNMT), ii) Japanese environmental quality standard for water pollution in lake (Environment Agency Notification No. 59, last amended in 2016), iii) draft national drinking water quality guideline (MOH superseded by MOHS, 2014) and iv) National Environmental Quality (Emission) Guideline (MONREC, 2015) for wastewater.

2.2.6 Sampling and measurement

(1) Sampling and measurement

The representative sample water at sampling location was taken basically at the center of water flow. It could be a mixed sample taken from several points in the cross-line of river, for example, from left, center and right side of water flow, if the water flow was not homogenized. The surface water was taken at the desired point(s) by using a plastic sampling bucket and put into one plastic container. After careful homogenization in the container, the water sample was dispensed to sample bottles that were already rinsed with the sample water several times. The sample bottles were selected to be suitable for each measurement parameter. In 1st – 2nd surveys, some samples were taken from the boat directly by sample bottles, which is also general sampling method. However, the survey team decided to have homogenization process for every samples before dispensing since some samples had extremely high turbidity.

The collected water samples were preserved in cool temperature to be delivered to laboratories. Sample preservation was taken as needed to prevent reduction or loss of target analytes with adding chemicals specific to target measurement parameters such as acid or base according to the applied analytical methodology. The sampling photos are shown in Figure 2.2-2.

Sampling from a boat

Sampling from a bridge

Sample Homogenization

Sample Preservation

Source: JICA Expert Team

Figure 2.2-2 Photos from the Water Quality Surveys

(2) On-site measurement method

Field measurement equipment is listed in the table below. pH, EC, DO and some other measurement parameters were analyzed by on-site water quality meter. Field measurement equipment is listed in Table 2.2-4 and photos of on-site measurement shown in Figure 2.2-3.

Table 2.2-4 Field Measurement Equipment

Parameter	Model Name	Manufacture
pH, DO, conductivity (EC), salinity, TDS, water temperature, turbidity, ORP	U52G Multi-Parameter Water Quality Meter	Horiba
Water velocity*	Digital current meterUC-200v (for Hlaing River basin survey)	Tamaya
	Handheld 1-D electro-magnetic current meter AEM1-DA (for Doke Hta Waddy River basin survey)	JFE Afvantech Co., Ltd.
	Global water flow probe FP111	Global Water

* Water velocity data was provided to calculate the water flow data.

Source: JICA Expert Team

On-site water quality measurement

Water flow rate measurement

Source: JICA Expert Team

Figure 2.2-3 Photographs from On-site Measurement

(3) Water flow measurement method

A water flow rate is investigated to estimate the pollution load, which is calculated by the following formula.

Pollution load [kg/day] = Concentration of pollutants [mg/L]
x Flow volume of discharged water [m^3/day] / 1000

Water flow rates at representative sites were calculated by the following methods.

1) Area-velocity measurement method

$$\mathrm{Q} = q_1 + q_2 + \cdots + q_{n-2} + q_{n-2} + q_n$$

$$q_{n-1} = (B_{n-1} - B_{n-2}) \times \frac{(H_{n-2} + H_{n-1})}{2} \times \frac{(V_{n-1} + V_{n-2})}{2}$$

Wherein, n >0
Q: Total flow rate (m^3/s)
q: Flow rate in each zone (m^3/s)
B: Horizontal distance from the starting point of measurement (m)
H: Water depth (m)
V: Flow velocity (m/s)

2) Bucket and stopwatch method

$$Q = \frac{v}{t}$$

Where:
Q =Flow rate (m^3/sec)

V = volume of the bucket (m^3)

T =time taken to fill the bucket (sec)

3) Float method

V = L / T

Where

V = Flow velocity (m/s)

L = Travel distance (m)

T = Travel time (s)

Q = f x V x A

Q = Flow rate (m^3/s)

f = Correction factor (-)

A = Cross-sectional area (m^2)

(4) Laboratory analysis method

The samples transported to laboratories in 4th and 5th surveys were analyzed by the following methods.

Table 2.2-5 Analytical Method at Laboratories

No.	Parameter	Method	Name of laboratory	Note
Laboratory analysis in Myanmar				
1	BOD	Membrane electrode method (SM 2012:5210 B and 4500-O G)	REM-UAE Laboratory and Consultant Co., Ltd.	4th survey in the Doke Hta Waddy River basin
		Respirometric method (HACH Method 10099)	DOWA Eco-system–Myanmar Co., Ltd. for survey in Hlaing River basin	Except the 4th survey in the Doke Hta Waddy River basin
2	Total Coliform	Multiple tube fermentation technique (SM 2012:9221 B)	REM-UAE Laboratory and Consultant Co., Ltd. for survey in Doke Hta Waddy River basin	4th survey in the Doke Hta Waddy River basin
		Standard total coliform fermentation method (APHA 9221 B)	DOWA Eco-system–Myanmar Co., Ltd. for survey in Hlaing River basin	Except the 4th survey in the Doke Hta Waddy River basin
Laboratory analysis in Japan (except pesticides)				
3	Total Suspended Solids (TSS)	Environment Agency Notification No. 59, 1971, Appendix, Table 9	OSUMI Co., Ltd.	-
4	COD Cr	JIS K0102 (2016) 20.1	OSUMI Co., Ltd.	-
5	Cyanide(total)	JIS K0102 (2016) 38.1.2 and 38.3	OSUMI Co., Ltd.	-
6	Oil and grease	Standard Method 5520 B	OSUMI Co., Ltd.	-

No.	Parameter	Method	Name of laboratory	Note
7	Phenols	JIS K0102(2016) 28.1.1 and 28.1.2	OSUMI Co., Ltd.	-
8	Total phosphorus (T-P)	JIS K0102(2016) 46.3.1	OSUMI Co., Ltd.	-
9	Total nitrogen (T-N)	JIS K0102(2016) 45.2	OSUMI Co., Ltd.	-
10	Zinc (Zn)	JIS K0102(2016) 53.3	OSUMI Co., Ltd.	-
11	Total chromium (T-Cr)	JIS K0102(2016) 65.1.4	OSUMI Co., Ltd.	-
12	Chromium (Hexavalent)	JIS K0102(2016) 65.2.1	OSUMI Co., Ltd.	-
13	Arsenic (As)	JIS K0102(2016) 61.4	OSUMI Co., Ltd.	-
14	Copper (Cu)	JIS K0102(2016) 52.4	OSUMI Co., Ltd.	-
15	Total Mercury (Hg)	Environment Agency Notification No.59, 1971, Appendix, table 1	OSUMI Co., Ltd.	-
16	Cadmium (Cd)	JIS K0102(2016) 55.4	OSUMI Co., Ltd.	-
17	Lead (Pb)	JIS K0102(2016) 54.4	OSUMI Co., Ltd.	-
18	Pesticides	See below	OSUMI Co., Ltd.	-
19	PCBs	Environment Agency Notification No.59, 1971, Appendix, table 3	OSUMI Co., Ltd.	-
Laboratory analysis in Japan (pesticides)				
1	Aldrin	GC-MS *	Nihon Ecotech Co., Ltd.	-
2	Atrazine	GC-MS *	Nihon Ecotech Co., Ltd.	-
3	4,4'-DDD	GC-MS *	Nihon Ecotech Co., Ltd.	-
4	4,4'-DDE	GC-MS *	Nihon Ecotech Co., Ltd.	-
5	4,4'-DDT	GC-MS *	Nihon Ecotech Co., Ltd.	-
6	Endosulfan	GC-MS *	Nihon Ecotech Co., Ltd.	-
7	Endosulfan sulfate	GC-MS *	Nihon Ecotech Co., Ltd.	-
8	Endrin	GC-MS *	Nihon Ecotech Co., Ltd.	-
9	HCH-alpha (benzene hexachloride-alpha)(alpha-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.	-
10	HCH-beta(beta-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.	-
11	HCH-delta(delta-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.	-
12	HCH-gamma(Lindane)(ganma-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.	-
13	Alachlor	GC-MS *	Nihon Ecotech Co., Ltd.	-
14	Diazinon	GC-MS *	Nihon Ecotech Co., Ltd.	-
15	Chlorpyrifos	GC-MS *	Nihon Ecotech Co., Ltd.	-
16	Dimethoate	LC-MS/MS *	Nihon Ecotech Co., Ltd.	-
17	Imidacloprid	GC-MS *	Nihon Ecotech Co., Ltd.	-

*Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017"

Source: JICA Expert Team

(5) Quality control method

The data quality was checked according to the Water Quality Survey Manual (JICA Expert Team, May 2018). As one of quality control methods, duplicate samples were taken in order to measure the precision of the whole sampling and analysis procedure. This is a sample which was collected with the target sample at same point and time. It is to be analyzed in the same way as another sample in parallel and provide precision of monitoring.

2.3 Result and Discussion

2.3.1 Water quality results

The water quality survey results were firstly evaluated with respect to each analytes compared with the surface water quality guideline of Vietnam for surface water quality (QCVN 08-MT 2015/BTNMT). The water quality guideline value of Vietnam is specified for water usage. Tentatively in the surveys, the purpose of water usage in each water body was considered to be: i) domestic water supply with treatment and conservation of aquatic life for sampling points of Wataya and Kokkowa, and ii) domestic supply water transportation and other purposes with demand for low-quality water for other sampling points. The results area listed in Table 2.3-1 - Table 2.3-5.

(1) pH

The pH level is neutral in target rivers within the desirable range between 6 and 8.5. On the other hand, in the creek that flows through the Shwe Pyi Thar IZ to the Hlaing River, the pH level was decreased to around pH 5 and showed mild acidity in the 5th survey (dry season).

(2) DO

The water contained enough dissolved oxygen necessary for aquatic life in the 4th survey (rainy season). However, in the 5th survey, the DO values were decreased to less than 1 or 2 mg/L: dysoxic level in PH1 and the creek in Shwe Pyi Thar IZ, where the higher BOD and COD were observed. It implied the following possibility; the oxidation rate of organic matter by bacteria was greater than the supply of dissolved oxygen and the high amounts of organic matter would cause the dysoxic status.

(3) BOD and COD

BOD and COD represent the organic substances in the water. Those values in the 4th survey (rainy season) satisfied the target water quality level desirable for each water usages. For example in the Hlaing River, BOD was less than 3 mg/L and COD was less than 14 mg/L, which is appropriate for water transportation, irrigation and conservation of aquatic life and even for domestic water supply with ordinary treatment. The level of organic pollution in rivers did not appear to be high though the impact of localized pollution such as a pollution plume from discharged wastewater or oil leakage from ships would be a concern.

On the other hand in the 5th survey (dry season), most sampling points except Kokkowa did not satisfy the target water quality level of BOD or/and COD and showed the deterioration of water quality. For example at the H3 and H5 in the downstream of Hlaing River, COD level increased to more than 50 mg/L.

(4) Total coliform

At Kokkowa, total coliform level was adequate for domestic water supply in the both 4th and 5th surveys. In the Hlaing River, Pan Hlaing River and creek in Shwe Pyi Thar IZ, total coliform level was more than 10, 000 MPN/100ml except at Wataya in the 5th survey, which indicated these water body is presumably contaminated by sewage, livestock wastewater and other pollution sources.

The parameter of total coliform is generally used as an indicator of the sanitary condition of environmental water and is used for an environmental water quality standard. Total coliform includes various species of bacteria not only derived from human or animal waste, but also from other sources. Testing for E coliform or/and fecal coliform should be added if the public health rick such as contamination by feces needs to be checked.

(5) TSS

High levels of suspended solids were observed in the targeted water area except at the most-upper point of creek in Shwe Pyi Thar IZ. The river water flowing for long distance from upper direction to Yangon City seems to be originally significantly turbid.

In February 2018, TSS level increased to more than 1, 000 mg/L in the downstream of Haling River and Pan Hlaing River, namely H3, H5, PH1 and PH2. The river water of PH1 was extremely muddy.

(6) Total cyanides

Cyanides were not detected at any points.

(7) Oil and grease

While oil and grease were not detected except at upper stream of creek in Shwe Pyi Thar IZ (Shwe5) in September 2017, moderate levels of oil and grease were observed at every point in February 2018.

(8) Phenols

1.1 mg/L of phenols at maximum was detected only in the creek in Shwe Pyi Thar IZ in February 2017. It was not detected at other rivers.

(9) Nutrients

Total phosphorus level ranged between 0.16 and 0.19 mg/L in September 2017 and between 0.15 and 0.32 mg/L in February 2018. Total nitrogen level ranged between 1.0 and 1.2 mg/L in September 2017 and between 0.64 and 1.2 mg/L in February 2018.

In general, nitrate, nitrite and ammonia among various forms of nitrogen and phosphate as one of phosphorus forms are important determinants to evaluate the environmental water quality in rivers. However, these specific forms were not surveyed in 4th and 5th surveys. The reason was firstly because the analytical precision for these parameters in local laboratories were not good enough. Secondly, the samples for these parameters could not be preserved appropriately for long time necessary for transportation to other countries' laboratory since the concentration of each form substance can be easily changed due to oxidation or reductive reaction, biological degradation and any other reasons. Reliable analysis is a challenge currently in Myanmar but expected to be available in the near future to get the reliable data of nitrate, nitrite and ammonia as well as phosphate for environmental water sample.

In February 2018, total nitrogen and total phosphorus levels in the creek in Shwe Pyi Thar IZ were quite high: 9.7 mg/L of total nitrogen and 140 mg/L of total phosphorus at maximum. It was mainly caused by the wastewater from distilleries.

(10) Heavy metals

In September 2017, heavy metals level was less than the reference water quality guideline value for usage of domestic water supply. In February 2018, some heavy metal parameters showed slightly higher concentration apparently due to higher level of suspended solids. Total chromium result (0.11 mg/L) at Wataya as well as lead result at Wataya (0.024 mg/L) and PH2 (0.058 mg/L) were slightly higher than desirable water quality level for water usage according to the reference standard value of Vietnam. However, it was hypothesized that the origin is from natural heavy metals in the ground and not caused by human activities at industries. As a whole, it was considered that no elevated level of heavy metals were detected.

(11) PCBs

No PCBs was detected in Wataya.

(12) Pesticides

No pesticides was detected within the 17 pesticides parameters in Wataya and Kokkowa.

Table 2.3-1 Results of 4th Survey in Hlaing River Basin (1)

No.	Location Name	pH	DO	BOD	Total Coliform	TSS	COD Cr	Total Cyanide	Oil and grease	Phenols
		-	mg/L	mg/L	MPN/100 ml	mg/L	mg/L	mg/L	mg/L	mg/L
1	Wataya	7.61	6.67	2.30	35000	420	11	< 0.1	< 1	< 0.005
2	H1	7.23	6.60	1.16	-	390	14	< 0.1	< 1	< 0.005
3	H3	7.62	8.92	1.80	-	440	14	< 0.1	< 1	< 0.005
4	H5	7.69	6.71	1.26	92000	330	10	< 0.1	< 1	< 0.005
5	PH1	7.15	4.69	1.57	-	230	14	< 0.1	< 1	< 0.005
6	PH2	7.43	5.30	0.72	54000	290	12	< 0.1	< 1	< 0.005
7	Shwe1	7.36	7.16	5.41	>160,000	180	19	< 0.1	< 1	< 0.005
8	Shwe3	7.00	8.84	5.94	>160,000	27	22	< 0.1	< 1	< 0.005
9	Shwe5	7.15	4.46	32.07	>160,000	25	44	< 0.1	1.3	< 0.005
10	Kokkowa	7.89	6.68	3.72	4600	120	8.3	< 0.1	< 1	< 0.005
Comparison with Vietnamese Environmental Standard for reference										
A1	For domestic water supply	6 - 8.5	≥6	4	2500	20	10	0.05	0.3	0.005
A2	For domestic water supply with treatment and conservation of aquatic lives	6 - 8.5	≥5	6	5000	30	15	0.05	0.5	0.005
B1	For irrigation	5.5 - 9	≥4	15	7500	50	30	0.05	1	0.01
B2	For water transportation and other purposes with demand for low-quality water	5.5 - 9	≥2	25	10000	100	50	0.05	1	0.02
Less than B2		<5.5, >9	<2	>25	>10000	>100	>50	>0.05	>1	>0.02

Source: JICA Expert Team

Table 2.3-2 Results of 4th Survey in Hlaing River Basin (2)

No.	Location Name	T-P	T-N	Zn	T-Cr	Cr 6+	As	Cu	T-Hg	Cd	Pb	PCBs
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	Wataya	0.16	1.0	0.054	0.048	< 0.005	0.0026	0.017	< 0.0005	< 0.001	0.0097	< 0.0005
2	H1	0.19	1.1	0.060	0.048	< 0.005	0.0028	0.019	< 0.0005	< 0.001	0.0098	-
3	H3	0.16	1.2	-	-	-	-	-	-	-	-	-
4	H5	0.14	1.1	0.049	0.038	< 0.005	0.0030	0.016	< 0.0005	< 0.001	0.0083	-
5	PH1	0.18	1.4	-	-	-	-	-	-	-	-	-
6	PH2	0.13	0.83	0.040	0.038	< 0.005	0.0020	0.020	< 0.0005	< 0.001	0.0070	-
7	Shwe1	0.18	1.3	0.032	0.024	< 0.005	0.0019	0.013	< 0.0005	< 0.001	< 0.005	-
8	Shwe3	0.22	2.0	0.021	< 0.005	< 0.005	0.0012	< 0.005	< 0.0005	< 0.001	< 0.005	-
9	Shwe5	0.65	4.9	0.042	0.010	< 0.005	0.0033	0.014	< 0.0005	< 0.001	< 0.005	-
10	Kokkowa	0.089	0.71	0.029	0.019	< 0.005	0.0016	0.010	< 0.0005	< 0.001	< 0.005	-
Comparison with Vietnamese Environmental Standard for reference												
A1	For domestic water supply	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	0.5	0.05	0.01	0.01	0.1	0.001	0.005	0.02	-
A2	For domestic water supply with treatment and conservation of aquatic lives	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.0	0.1	0.02	0.02	0.2	0.001	0.005	0.02	-
B1	For irrigation	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.5	0.5	0.04	0.05	0.5	0.001	0.01	0.05	-
B2	For water transportation and other purposes with demand for low-quality water	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	2	1	0.05	0.1	1	0.002	0.01	0.05	-
Less than B2		-	-	>2	>1	>0.05	>0.1	>1	>0.002	>0.01	>0.05	-

Source: JICA Expert Team

Table 2.3-3 Results of 5th Survey in Hlaing River Basin (1)

No.	Location Name	pH	DO	BOD	Total Coliform	TSS	COD Cr	Total Cyanide	Oil and grease	Phenols
		-	mg/L	mg/L	MPN/100 ml	mg/L	mg/L	mg/L	mg/L	mg/L
1	Wataya	8.21	6.9	3.7	610	980	25	< 0.1	1.2	< 0.005
2	H1	8.14	6.54	2.82	-	250	20	< 0.1	1.6	< 0.005
3	H3	8.34	5.46	2.44	-	1,200	61	< 0.1	1.3	< 0.005
4	H5	8.14	5.33	2.91	54,000	1,400	71	< 0.1	2.2	< 0.005
5	PH1	7.95	0.74	44.61	-	98,000	3,400	< 0.1	2.0	< 0.005
6	PH2	8.02	5.12	3.8	35,000	1,800	63	< 0.1	1.5	< 0.005
7	Shwe1	5.66	0.54	267.57	>160,000	2,400	4,900	< 0.1	4.8	1.1
8	Shwe3	4.98	1.91	264.37	>160,000	280	5,700	< 0.1	3.5	0.10
9	Shwe5	6.72	0.54	133.97	>160,000	12	230	< 0.1	2.1	0.021
10	Kokkowa	8.35	7.01	5.73	930	60	5.2	< 0.1	1.9	< 0.005
Comparison with Vietnamese Environmental Standard for reference (QCVN08:2015)										
A1	For domestic water supply	6 - 8.5	≥6	4	2,500	20	10	0.05	0.3	0.005
A2	For domestic water supply with treatment and conservation of aquatic lives	6 - 8.5	≥5	6	5,000	30	15	0.05	0.5	0.005
B1	For irrigation	5.5 - 9	≥4	15	7,500	50	30	0.05	1	0.01
B2	For water transportation and other purposes with demand for low-quality water	5.5 - 9	≥2	25	10,000	100	50	0.05	1	0.02
Less than B2		<5.5, >9	<2	>25	>10,000	>100	>50	>0.05	>1	>0.02

Source: JICA Expert Team

Table 2.3-4 Results of 5th Survey in Hlaing River Basin (2)

No.	Location Name	T-P	T-N	Zn	T-Cr	Cr 6+	As	Cu	T-Hg	Cd	Pb	PCBs
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	Wataya	0.19	0.92	0.13	0.11	< 0.005	0.011	0.045	< 0.0005	< 0.001	0.024	< 0.0005
2	H1	0.29	0.64	0.052	0.034	< 0.005	0.0051	0.014	< 0.0005	< 0.001	0.0066	-
3	H3	0.15	1.4	-	-	-	-	-	-	-	-	-
4	H5	0.32	1.2	0.21	0.17	< 0.005	0.024	0.071	< 0.0005	< 0.001	0.039	-
5	PH1	0.42	92	-	-	-	-	-	-	-	-	-
6	PH2	0.33	1.6	0.28	0.24	< 0.005	0.031	0.096	< 0.0005	< 0.001	0.058	-
7	Shwe1	9.7	130	0.46	0.24	< 0.005	0.038	0.18	< 0.0005	< 0.001	0.066	-
8	Shwe3	6.5	140	0.16	0.014	< 0.005	0.003	0.045	< 0.0005	< 0.001	< 0.005	-
9	Shwe5	1.4	19	0.022	< 0.005	< 0.005	0.0038	0.10	< 0.0005	< 0.001	< 0.005	-
10	Kokkowa	0.074	0.16	0.014	0.01	< 0.005	0.0015	0.0054	< 0.0005	< 0.001	< 0.005	-
Comparison with Vietnamese Environmental Standard for reference(QCVN08:2015)												
A1	For domestic water supply	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	0.5	0.05	0.01	0.01	0.1	0.001	0.005	0.02	-
A2	For domestic water supply with treatment and conservation of aquatic lives	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.0	0.1	0.02	0.02	0.2	0.001	0.005	0.02	-
B1	For irrigation	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.5	0.5	0.04	0.05	0.5	0.001	0.01	0.05	-
B2	For water transportation and other purposes with demand for low-quality water	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	2	1	0.05	0.1	1	0.002	0.01	0.05	-
Less than B2		-	-	>2	>1	>0.05	>0.1	>1	>0.002	>0.01	>0.05	-

Source: JICA Expert Team

Table 2.3-5 Results of Pesticides in Hlaing River Basin

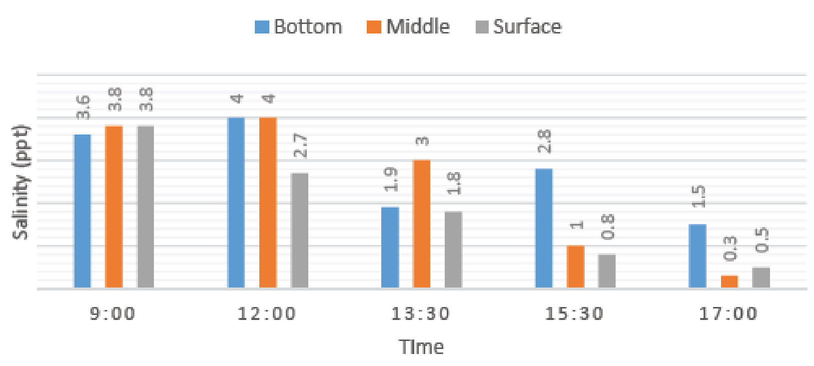
mg/L

No.	Parameter	Oct 2017		Feb 2018	
		Wataya	Kokkowa	Wataya	Kokkowa
1	Aldrin	< 0.0005	< 0.0005	< 0.0005	< 0.0005
2	Atrazine	< 0.0005	< 0.0005	< 0.0005	< 0.0005
3	4,4'-DDD	< 0.0005	< 0.0005	< 0.0005	< 0.0005
4	4,4'-DDE	< 0.0005	< 0.0005	< 0.0005	< 0.0005
5	4,4'-DDT	< 0.0005	< 0.0005	< 0.0005	< 0.0005
6	Endosulfan	< 0.0005	< 0.0005	< 0.0005	< 0.0005
7	Endosulfan sulfate	< 0.0005	< 0.0005	< 0.0005	< 0.0005
8	Endrin	< 0.0005	< 0.0005	< 0.0005	< 0.0005
9	HCH-alpha (benzene hexachloride-alpha)(alpha-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
10	HCH-beta(beta-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
11	HCH-delta(delta-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
12	HCH-gamma(Lindane)(ganma-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
13	Alachlor	< 0.0005	< 0.0005	< 0.0005	< 0.0005
14	Diazinon	< 0.0005	< 0.0005	< 0.0005	< 0.0005
15	Chlorpyrifos	< 0.0005	< 0.0005	< 0.0005	< 0.0005
16	Dimethoate	< 0.0005	< 0.0005	< 0.0005	< 0.0005
17	Imidacloprid	< 0.0005	< 0.0005	< 0.0005	< 0.0005

Source: JICA Expert Team

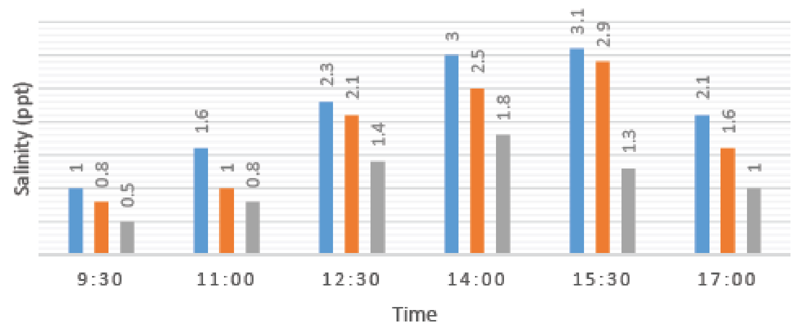
2.3.2 Hydrological conditions

At the Monkey Point, which is located downstream of survey area and a confluence point of Hlaing River and Bago River, the average difference of water level between high tide and low tide is 5.13 m. And the flow rate of ebb current in Yangon is 2 m/s – 3 m/s in the spring tide (JICA et al., 2015). Although there is no available hydrologic data such as water flow and water level in the survey area of Hlaing River, apparently the survey points in the Hlaing River also have several meters difference between high tide and low tide. From Wataya to H5 in the Hlaing River, PH1 and PH2 in the Pan Hlaing River and Shwe1 in the creek are considered to be the brackish water area and Kokkowa point is considered as a tidal reach area. The salt water wedge observed by the tide survey of JET in the Hlaing River in March 2016 are shown in Figure 2.3-1.



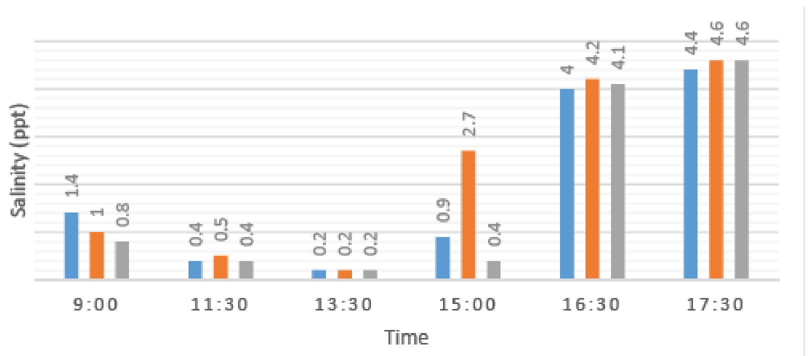
↑High tide Low tide↑

2 March 2016
(neap tide)



↑Low tide ↑High tide

4 March 2016
(half tide)



↑Low tide High tide↑

9 March 2016
(spring tide)

Location: H5-C (down-most point of Hlaing River)

Source: JICA Expert Team

Figure 2.3-1 Changes in Salinity with Daily-Tide Cycle

2.3.3 Evaluation of Water Quality

The water quality survey in the Hlaing River basin was evaluated for each survey paurpose as shown below.

(1) Pollution levels in the Hlaing River and Pan Hlaing River

As represented by Table 2.3-6 summarizing the organic pollution level in each water area, except for TSS (Total Suspended Solid) and total coliform, the water quality in the Hlaing River and Pan Hlaing River in the rainy season (September 2017) was acceptable for conservation of aquatic life, irrigation and water transportation according to the Vietnamese surface water quality guideline values. In the dry season (February 2018), the water quality was deteriorated as indicated by high COD at some points and slight oil and grease at all sampling points. Only the upstream area of Hlaing River (upstream of Shwe Pyi Thar Bridge) still kept the good water quality desirable for irrigation and water transportation except for the above-mentioned TSS, total coliform and oil and grease.

In the middle-stream of the Pan Hlaing River (upstream of Hlaing Bridge), the river water was extremely muddy in February 2018 resulting in very low DO and high BOD and COD (Figure 2.3-2), presumably due to the effect of sediment in the water stirred by a surging tide flow or other reasons. There was a dam appeared around 3.5 km upstream of PH2 and it seems to interfere with the flowing current in the Pan Haling River. The reason of hypoxic water area is exactly not clear. In some cases in other tidal river, the hypoxic water mass in the lower water column layer is observed and can be one of the general water quality issue. Thus, it will be important to check how the hypoxic water is formulated and how it is moved forward or downward affected by saltwater instruction in the river by obtaining more monitoring data including the water quality in different depth and in other tide conditions.

The results in these rivers did not exhibit levels of toxic pollutants harmful to human health. Only slight lead (0.058 mg/L) was detected in downstream area in the Pan Hlaing River in February 2018, but it is considered to be originally contained in the natural sediment.

Table 2.3-6 Classification of BOD and COD Levels in the Hlaing River Basin

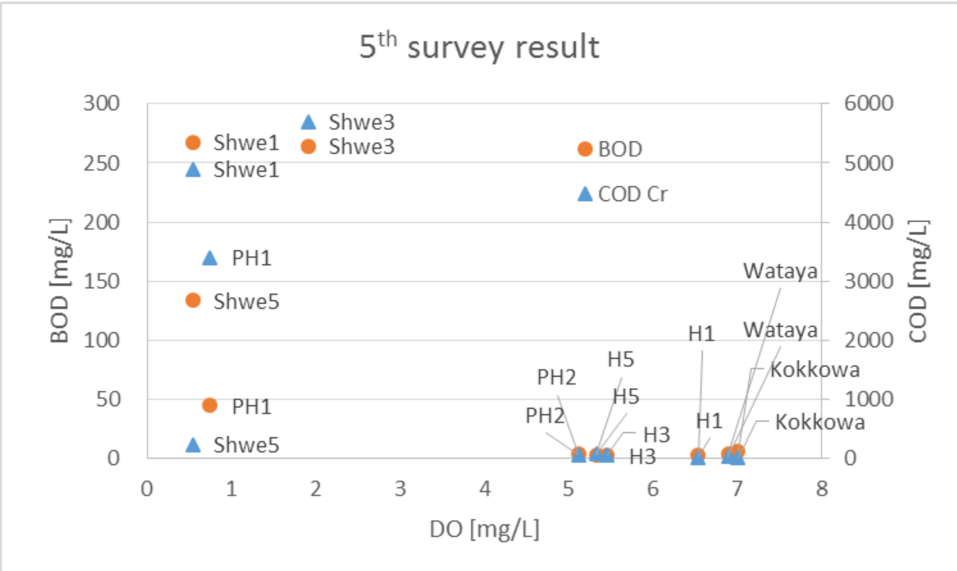
Unit: mg/L

Target		BOD						COD					
		Rainy Season(Sep 2017)			Dry Season(Feb 2018)			Rainy Season(Sep 2017)			Dry Season(Feb 2018)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
River	Hlaing River	1.2	2.3	1.6	2.4	3.7	3.0	10	14	12	20	71	44
	Pan Hlaing River	0.7	1.6	1.1	3.8	44.6	24.2	12	14	13	63	3400	1732
	Kokkowa River		3.7			5.7			8.3			5.2	
Creek	Creek in Shwe Pyi Tar IZ	5.4	32	14	134	268	222	19	44	28	230	5700	3610

Vietnamese Environmental Standard(QCVN08:2015) for reference

Water Usage		BOD	COD
A1	For domestic water supply	4	10
A2	For domestic water supply with treatment and conservation of aquatic lives	6	15
B1	For irrigation	15	30
B2	For water transportation and other purposes with demand for low-quality water	25	50
Less than B2		>25	>50

Source: JICA Expert Team

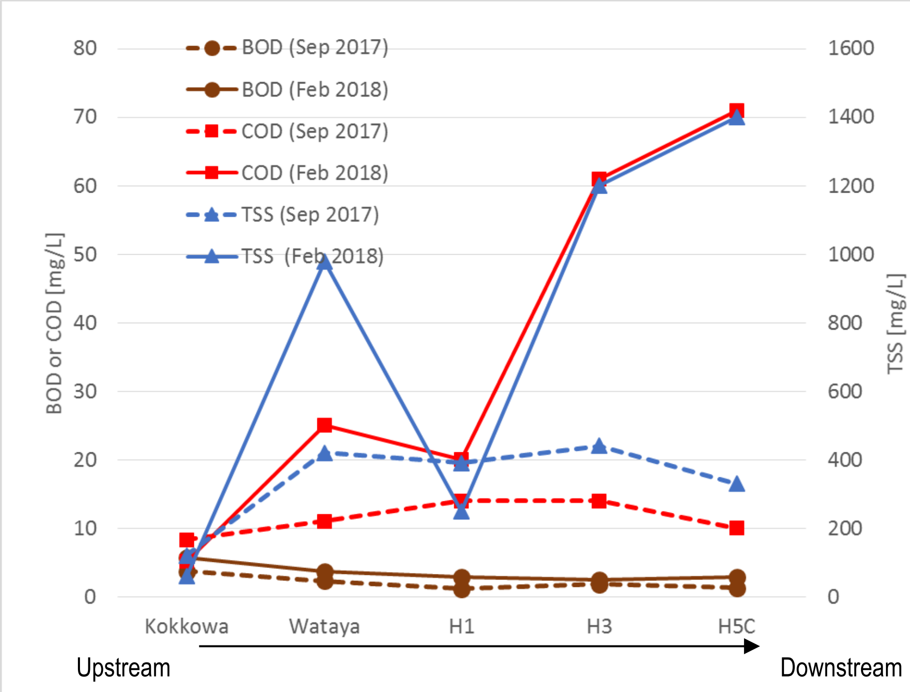


Source: JICA Expert Team

Figure 2.3-2 DO vs BOD and COD in the 5th survey

(2) Spatial distribution of pollution in the Hlaing River: difference in water quality from upstream to downstream

The result did not show marked deterioration of surface water quality in the flow direction of Hlaing River and Pan Hlaing River in the rainy season. In the dry season, the COD level increased from upper-stream to downstream while there was no significant difference in BOD level among the locations (see Figure 2.3-3). This implies that the high COD in the dry season in the downstream area was largely due to organic matter associated with suspended solid in the water and not soluble organic substance. The spatial and temporal changes of surface water quality in the Hlaing River need to be investigated.

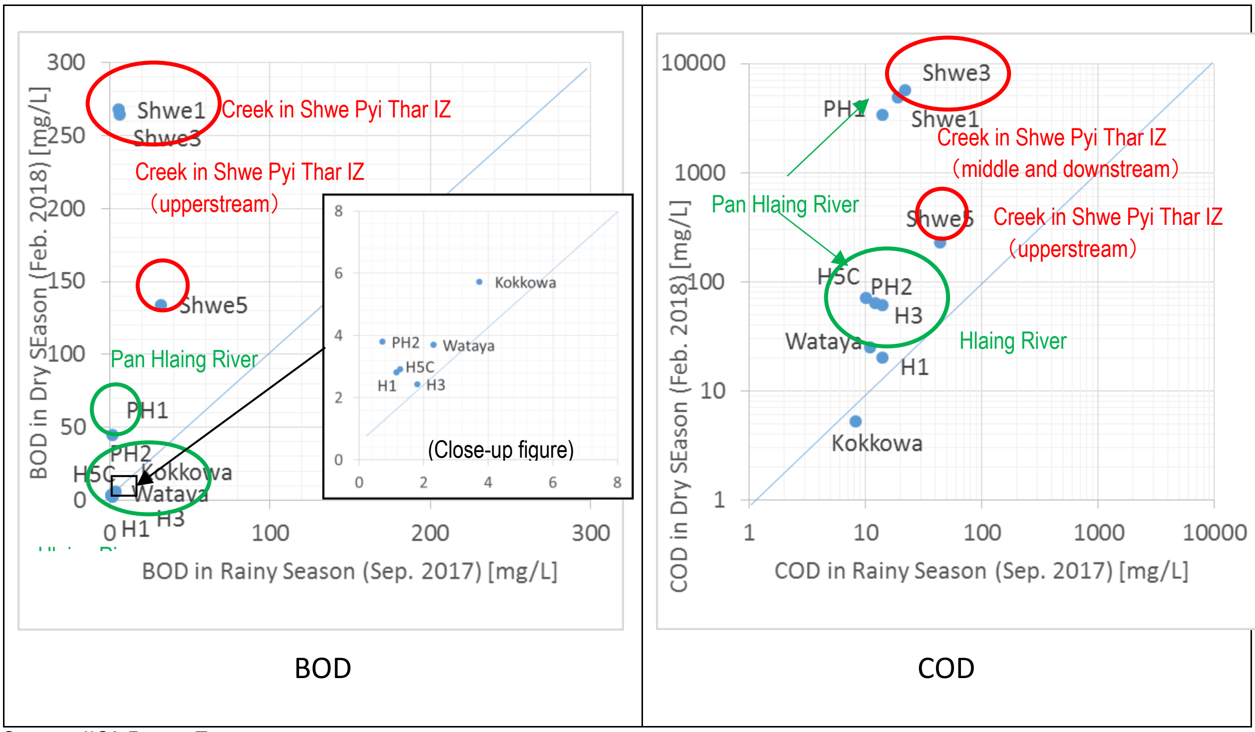


Source: JICA Expert Team

Figure 2.3-3 Water Quality Distribution in the Hlaing River

(3) Seasonal changes of water quality

The concentration of pollutants in the dry season was higher than one in the rainy season for most sampling points and for most parameters as represented by BOD and COD (see Figure 2.3-4). It indicated that in the rainy season the storm water diluted such pollutants and alleviated the pollution impact in the river. On the other hand, it can be considered that the pollution impact of industrial wastewater and domestic wastewater from the basin could be bigger when the water flow is lower, making it difficult to fully maintain the desired water quality in the Hlaing River in the dry season.



Source: JICA Expert Team

Figure 2.3-4 Water Quality Changes between Rainy Season and Dry Season (Hlaing River Basin)

(4) Pollution impact from IZs to the Hlaing River

In the creek that flows through the Shwe Pyi Thar IZ to the Hlaing River, the water quality in the past surveys until February 2017 was significantly worse due to inflow of wastewater, which was indicated by low DO as well as several hundreds mg/L of BOD add COD as well as high concentrations of oil and grease, nutrients, phenol and others.

The water quality of this creek was improved in September 2017 probably because the operation of distilleries along the creek was suspended. This order was given by Yangon Region Government to six distilleries in the IZ in July or August 2017. However, after the new pipeline from distilleries was constructed in the creek, the water quality again deteriorated. The creek water in the vicinity of discharging point indicted 263 mg-BOD/L and 5,700 mg-COD/L as well as lower DO and higher nutrients, oil and grease and others as shown in Figure 2.3-5. The water quality in the creek hinges on the impact of wastewater from these factories. It is important to continue to monitor the wastewater from these pollution sources, which could improve or deteriorate depending on the factories' operation and performance of wastewater treatment.

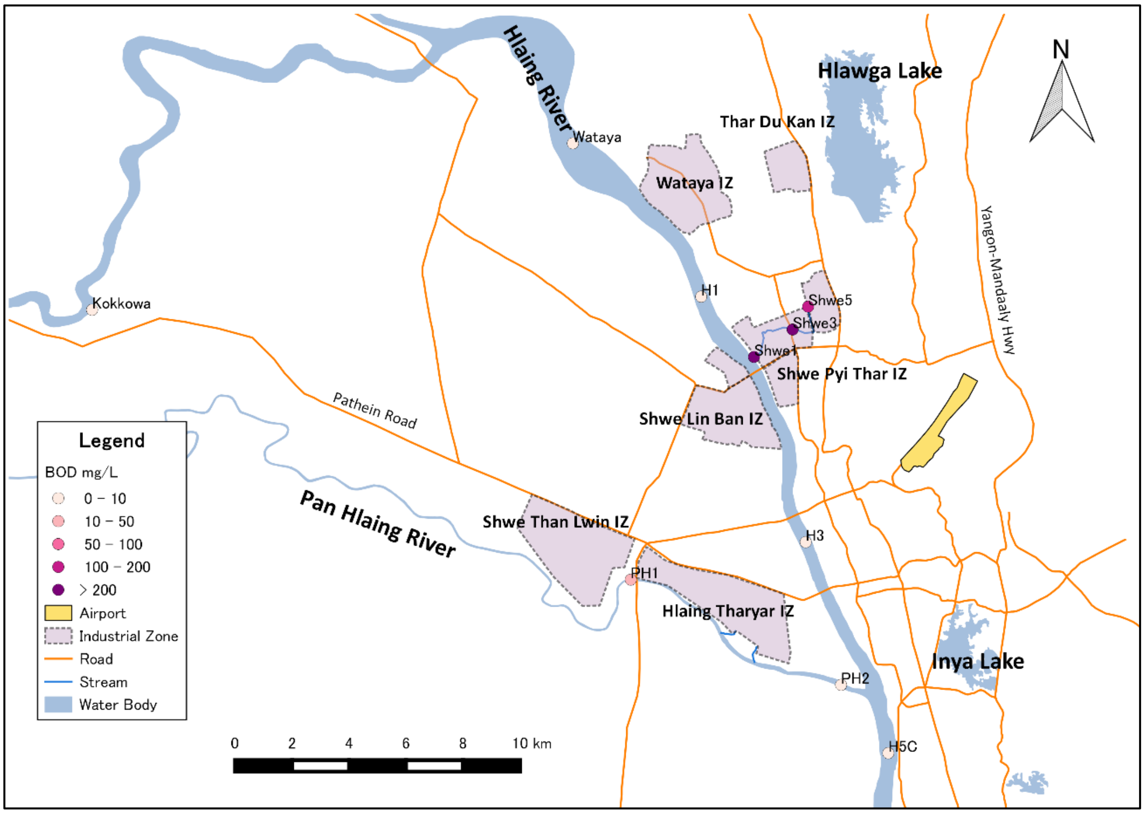
There was not enough data to assure to say there is a significant water deterioration in the downstream compared with upstream among sampling points except for COD and TSS (see BOD distribution in Figure 2.3-5 for example). Overall, the pollution impact on the Hlaing River by this creek seemed limited currently because a large amount of water flow in the main stream can alleviate such impact by dilution of pollutants. However, dilution capacity in the river is limited or even reduced in the dry season and the environmental risk in the main river could be higher.

Pollution plume from a pipeline discharging the wastewater in the creek in Shwe Pyi Tar IZ(downstream of Shwe-3)

Brown-colored water flow in the creek to the Hlaing River (downstream of Shwe-1)

Source: JICA Expert Team

Figure 2.3-5 Pollution Plume in the Creek of Shwe Pyi Thar IZ



Source: JICA Expert Team

Figure 2.3-6 BOD Distribution in the Hlaing River in Feb 2018

(5) Water quality for future domestic water supply at the Kokkowa River and Wataya

The sampling points of Kokkowa and Wataya were investigated as possible future intake points of domestic water supply to Yangon City. Judging from the results, the water quality at Kokkowa and Wataya in the rainy season seem good enough for water supply for domestic water supply if the water is treated at a water treatment facility using filters and other ordinary means. It satisfied the draft national drinking water guideline value (MOH superseded by MOHS, 2014) with respect to the measured parameters except turbidity at both sampling points in September 2017 and February 2018 as well as total chromium and lead at Wataya point in February 2018 (see Table 2.3-7). It was hypothesized that chromium and lead, whose concentrations were not very high, were contained in the suspended sediment and are of natural origin. Whether they can be removed during water treatment or not should be confirmed. The pesticides were not detected in the surveys both in September 2017 and February 2018, but need to be investigated in other seasons including the farming season.

Although the survey results did not reveal a specific environmental risk, there are some potential pollution sources along the Hlaing River in the surrounding of Wataya. The water samples in these surveys were taken in the spring tide time and when the water was flowing downward after high-tide. However, the pollution level might change in a farming season, or when the water flows upward after low-tide.

However, it should be noted that these surveys were conducted as part of environmental monitoring under the water environmental management project, and the results do not guarantee safety of waters for drinking and other purposes. The measurement parameter in these surveys was limited and did not cover all the guideline values. Thus it is crucial to continue to check the water quality throughout the year for wider range of parameters and with continuous monitoring in one tide cycle per day and between spring tide and neap tide.

Table 2.3-7 Comparison with Draft Drinking Water Quality Standard for Possible Domestic Water Supply (Hlaing River Basin)

Parameter	Unit	Kokkowa		Wataya		MOH Draft National Drinking Water Quality Std(2014)
		Sep 2017	Feb 2018	Sep 2017	Feb 2018	
pH	-	7.89	8.35	7.61	8.21	6.5 - 8.5
Turbidity	NTU	545	169	618	>1000	5
TDS	mg/L	66	140	81	156	1000
Cyanide(total)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	0.07
Zinc (Zn)	mg/L	0.029	0.014	0.054	0.13	3
Total chromium (T-Cr)	mg/L	0.019	0.010	0.048	0.11	0.05
Arsenic (As)	mg/L	0.0016	0.0015	0.0026	0.011	0.05
Copper (Cu)	mg/L	0.010	0.0054	0.017	0.045	2
Total Mercury (Hg)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.001
Cadmium (Cd)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.003
Lead (Pb)	mg/L	< 0.005	< 0.005	0.0097	0.024	0.01
Pesticides (total 17 paramete	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	Specified for some parameters respectively

: Satisfied with reference standard
: Not satisfied with reference standard

Source: JICA Expert Team

2.4 Conclusions in Hlaing River basin survey

The water quality survey in the Hlaing River basin conclusions are described below and the recommendations from surveys are summarized in Section 5.2.

(1) Pollution level in the Hlaing River

The water quality in the Hlaing River was acceptable for conservation of aquatic life, irrigation and water transportation for most parameters. The water quality was deteriorated in the dry season. No harmful levels of toxic substance in the water environment was detected.

One concern is the hypoxic water area with higher COD and suspended solid observed at some points. It will be important to check how the hypoxic water is formulated and how it is moved forward or downward, settled or flocculated in the river by obtaining more monitoring data including the water quality in the different depth and in other tide condition.

(2) Spatial distribution of water quality

No clear deterioration from upstream to downstream was observed in the rainy season. COD increased in the downstream in the dry season but BOD was not increased and the mechanism is not exactly clear.

(3) Seasonal changes of water quality

The water quality at most points was worse in dry season than in rainy season. It was considered that in the rainy season the larger volume of river water diluted discharged pollutants and alleviated the pollution impact.

(4) Pollution impact from IZ

The creek in Shwe Pyi Thar IZ was highly polluted when it receives the wastewater with high pollution load from distilleries. Apparently not so high impact to the Hlaing River was observed within the scope of survey. The reason is that a large amount of water flow in the main stream can alleviate such impact by dilution of pollutants. However, dilution capacity in the river is limited or even reduced in the dry season and the environmental risk in the main river could be higher. The water quality status and mechanism of distribution of water pollution need to be further clarified.

3 WATER QUALITY SURVEY REPORTT IN DOKE HTA WADDY RIVER BASIN

3.1 Survey objectives

The survey objectives for the Doke Hta Waddy River Basin were set as follows based on the Water Quality Survey Plan (JICA Expert Team, May 2018).

1) To investigate pollution impact from discharged wastewater to Doke Hta Waddy River
2) To confirm the pollution level of Taung Tha Man Lake
3) To investigate the main pollution path to the Taung Tha Man Lake

3.2 Survey outline and methodology

3.2.1 Data source

As mentioned in Section 1.4, the results from 4th and 5th surveys were mainly provided to evaluate the water quality status.

3.2.2 Survey team

The fieldwork of surveys was outsourced to the local environmental consulting company under management of JICA Expert Team and supervised by C/Ps from ECD-Mandalay Regional Office and WSD-MCDC.

3.2.3 Sampling schedule

The sampling work for the Doke Hta Waddy River was conducted by the following schedule. In the 2nd survey, the sampling at the Doke Hta Waddy River was conducted at the night time when the water quality was worse since the factories are allowed to discharge their wastewater from 7 pm to 6 am into 10-inch pipeline.

Table 3.2-1 Survey Schedule for the Doke Hta Waddy River Basin

Title	Survey Date	Note
1st water quality survey	17, 18 and 25(re-sampling) Feb 2016	Since the survey team found the sample volume was not enough for analysis after the survey, they went to the site again to retake the samples on 25th February.
2nd water quality survey	27-28 Jun 2016	The samples of Doke Hta Waddy River were taken at night time.
3rd water quality survey	23-24 Jan 2017	-
4th water quality survey	2-3 Oct 2017	
5th water quality survey	26–27 Feb 2018	

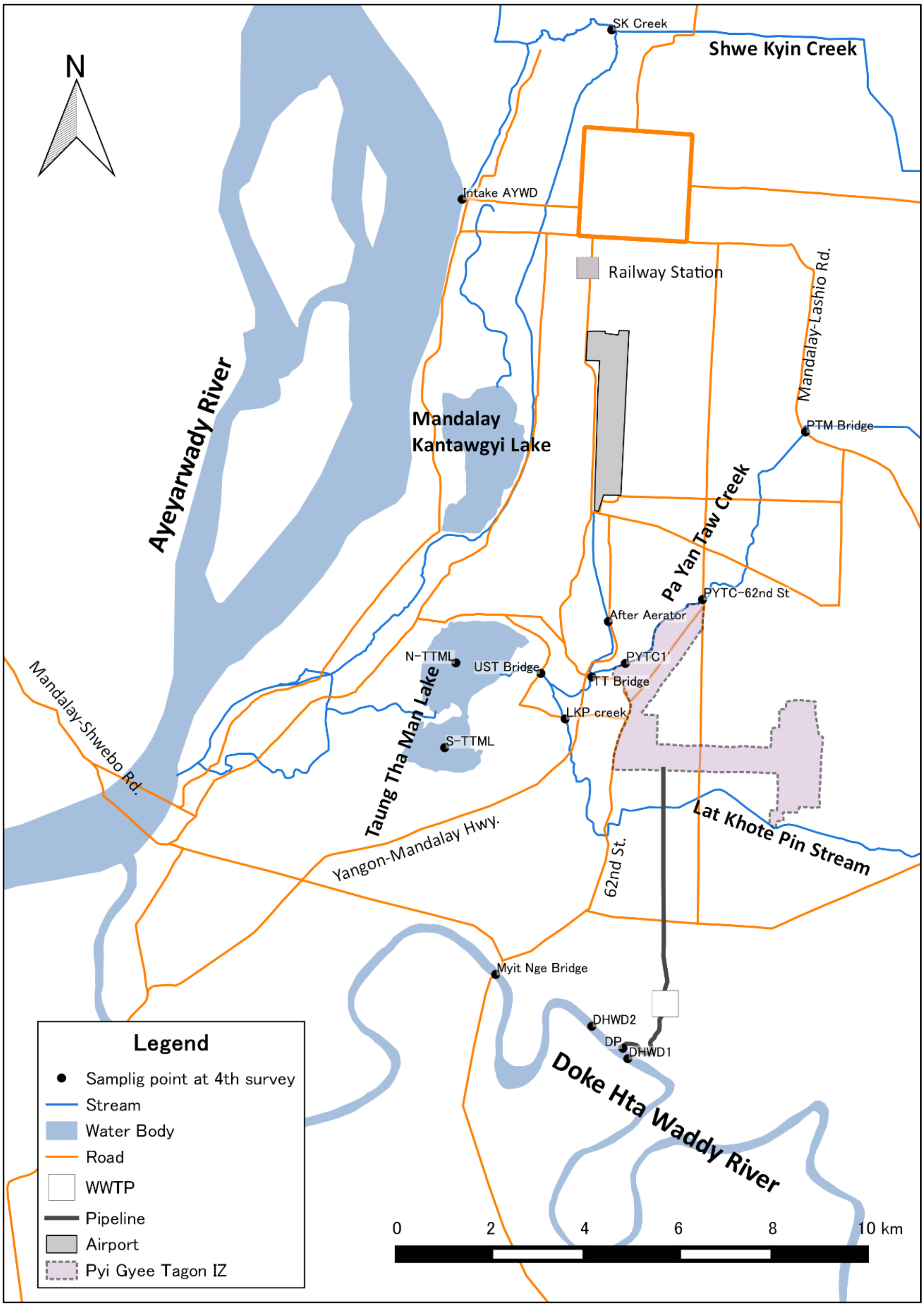
Source: JICA Expert Team

3.2.4 Sampling points

The sampling points in the Doke Hta Waddy River basin are shown in the map and table below. In order to confirm the pollution impact from the wastewater discharging from industrial factories to the Doke Hta Waddy River, the discharged wastewater from 10-inch pipeline(DP), the upstream of discharging point (DHWD 1) and several points in the downstream of discharging point (DHWD-2 – DHWD 4) were arranged. The end of 10-inch pipe was submerged under the water from the 4th survey because the water level is high in the rainy season and the pipeline was extended at the time of 5th survey. Thus the water was taken from the pollution plume nearby the end of the pipe.

The Taung Tha Man Lake has two sampling points at northern point and southern point in the lake. The main water flow path to Taung Tha Man Lake is the Pa Yan Taw Creek, Columbo Creek and Lat Khote Pin Stream that are combined to flow into the lake through the U Shwe Thaung Bridge. The survey sites cover the representative points of each creek. Pa Taw Muu bridge, upstream of Pa Yan Taw Creek was investigated to check the pollution status in the water coming from agricultural land in the east part of Mandalay city.

Intake point of the Ayeyarwaddy River is used for MCDC’s domestic water supply. The Shwe Kyin Creek is the sampling point to check the water pollution from upstream farming land in the creek flowing to the intake point of the Ayeyarwaddy River. The sampling location from 1st to 3rd surveys were slightly different from those and they were optimized in the course of past surveys.



Source: JICA Expert Team

Figure 3.2-1 Sampling Points in the Doke Hta Waddy River Basin

Table 3.2-2 List of Sampling Points for 4th and 5th surveys in the Doke Hta Waddy River Basin

No.	Abbreviated Location Name	Location Name	Latitude	Longitude
1	DHWD1	Doke Hta Waddy 1	21.8260	96.0945
2	DHWD2	Doke Hta Waddy 2	21.8322	96.0871
3	Myit Nge Bridge	Myit Nge Bridge	21.8421	96.0673
4	DP	Discharge Point	21.8280	96.0935
5	LKP creek	Lat Khoke Pin Creek	21.8909	96.0816
6	UST Bridge	U Shwe Taung Bridge	21.8996	96.0766
7	TT Bridge	Tagon Taing Bridge	21.8989	96.0871
8	PYTC-62nd St	PYTC-62nd St	21.9137	96.1099
9	PYTC1'	Pa Yan Taw Creek 1'	21.9015	96.0940
10	After Aerator	After Aerator	21.9095	96.0905
11	N-TTML	North of Taung Tha Man Lake	21.9016	96.0591
12	S-TTML	South of Taung Tha Man Lake	21.8854	96.0568
13	PTM Bridge	Paw Taw Muu Bridge	21.9457	96.1311
14	SK Creek	Shwe Kyin Creek	22.0224	96.0912
15	Intake AYWD	Intake point of the Ayeyarwaddy River	21.9901	96.0604

Source: JICA Expert Team

3.2.5 Measurement parameters

(1) Measurement parameters

The total number of water samples and measurement parameters for water quality surveys are shown in table 3.2-3 below. The 1st survey focused on the basic parameters to study a spatial destruction of organic pollution level. The following surveys covered more measurement parameters including the heavy metals and pesticides and reflected the findings from past surveys and changes in site conditions.

Table 3.2-3 Measurement Parameters for the Doke Hta Wady River Basin

Points	Measurement Parameters
All points	[On site measurement] - pH, EC, DO, TDS, salinity, turbidity, water temperature, ORP [Laboratory analysis] - TSS, BOD, COD,
Representative points	[On site measurement] - Flow rate (if available) [Laboratory analysis] - Cyanide, oil and grease, phenols, total phosphorus, and total nitrogen, total coliform, zinc, total chromium, hexavalent chromium, arsenic, copper, total mercury, cadmium, and lead - Color, odor, iron and manganese in the 1st survey - Phosphate, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen in the 1st – 3rd surveys - Pesticides* and PCBs for only one or two points

* Total organic chlorine pesticides and total organic phosphorus pesticides for 2ndand 3rd surveys
* Aldrin, atrazine, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endosulfan, endosulfan sulfate, endrin, HCH-alpha (benzene hexachloride-alpha), HCH-beta, HCH-delta, HCH-gamma(Lindane), alachlor, diazinon, chlorpyrifos, dimethoate and imidacloprid for 4th and 5th surveys

Source: JICA Expert Team

(2) Guideline levels

Since there is no ambient water environmental quality standard in Myanmar yet, C/Ps and JET evaluated the water qualities based on some reference standards and related guidelines in Myanmar, Vietnam and Japan, considering the type and usage of water. They included: i) Vietnamese national technical regulations on surface water quality (QCVN 08-MT 2015/BTNMT), ii) Japanese environmental quality standard for water pollution in lake (Environment Agency Notification No. 59, last amended in 2016), iii) draft national drinking water quality guideline (MOH superseded by MOHS, 2014) and iv) National Environmental Quality (Emission) Guideline (MONREC, 2015) for wastewater.

3.2.6 Sampling and measurement

The sampling method is the same as described in section 2.2.6.

3.3 Result and discussion

3.3.1 Water quality results

The water quality survey result in rivers were firstly evaluated with respect to each analyte compared with the surface water quality guideline of Vietnam for surface water (QCVN 08-MT 2015/BTNMT). The lake water was compared with the Japanese Environmental Standard for lake. A water quality guideline/standard value is generally specified for water usage. Tentatively in this Project surveys, the purpose of water usage in the Ayeyarwaddy River and Doke Hta Waddy River was considered to be “domestic water supply with treatment and conservation of aquatic life”. Taung Tha Man Lake was considered to be used for “Fishery for smelt etc., industrial water, agricultural water, and conservation of the environment”. As for the creeks of sampling points, although it is difficult to determine the water usage, the desired water quality level would be for “domestic water supply with treatment and conservation of aquatic life” because these creeks flow into Taung Tha Man Lake that is rich with aquatic life. The list of results area shown in Table 3.3-1 - Table 3.3-6.

(1) pH

The pH level was neutral in target rivers within the desirable range between 6 and 8.5 except at northern Taung Tha Man Lake, where the pH is slightly high between pH 8.5 and pH 9 in day time.

(2) DO

In Oct 2017, the DO level except at DP was more than 5 mg/L, which is enough for aquatic life. However, in Feb 2018, it was decreased at most points except in the Doke Hta Waddy River and Ayeyarwaddy River. Especially, it was less than 3 mg/L at U Shwe Taung Bridge and Northern Taung Tha Man Lake. It indicated the disoxic condition in the enclosed area of northern Lake, which would adversely affect to aquatic life.

(3) BOD and COD

In the Doke Hta Waddy River and Ayeyarwaddy River, BOD and COD levels were low enough in both October 2017 and February 2018 in terms of water usage for domestic water supply with treatment and conservation of aquatic life. The organic pollution level in Taung Tha Man Lake was moderate in rainy season, but got worse in the dry season. In the northern lake in Feb 2018, COD level increased to 280 mg/L. The higher organic matters were observed in the water flow path to the lake such as U Shwe Taung Bridge and Tagon Taing Bridge, where the COD level was more than 20 times of reference acceptable level.

It is noted that BOD concentration was higher than COD at several points in Feb 2018, while in general COD is more than BOD because the COD is measured by stronger chemical oxidation reaction and consuming more oxygen. The difference was larger in after-aeration of Columbo creek, Shwe Khin Creek and so forth. Higher BOD than true value could occur when the oxygen is consumed by nitrification and counted as BOD. The reason causing higher BOD needs to be checked.

(4) Total coliform

Total coliform value was higher than the desirable water quality level or even more than 10,000 MPN/100ml, except in the Doke Hta Waddy River in February 2018. This indicated that these water bodies is presumably contaminated by sewage, livestock wastewater and other pollution source.

The parameter of total coliform is generally used as an indicator of sanitary condition of environmental water and used for an environmental water quality standard. Total coliform includes various species of bacteria not only derived from human or animal waste, but also from other sources. Testing for E coliform or/and fecal coliform should be added if the public health rick such as contamination by feces needs to be checked.

(5) TSS

In the Doke Hta Waddy River, TSS was low enough for domestic water supply. Compared by seasons, it was higher in October 2017 than in February 2018. In the other surface water area, the highest value was 68 mg/L in October 2017 and 260 mg/L in February 2018 in Pa Yan Taw Creek. Although several points did not satisfy the desirable level (30 mg/L), the overall result was much lower than Hlaing River basin.

(6) Total cyanides

Total cyanide was not detected at any points in both 4th and 5th surveys.

(7) Oil and grease and phenols

The Discharging Point (DP) sample contained a slight amount of oil and grease and phenols, while the upstream river water did not include them. This means the wastewater from 10-inch pipeline contained some amount of oil and grease and phenols, while they seemed to be diluted in the river and were not detected in the downstream point (Myint Nge Bridge). Oil and grease and phenols were also detected in the creeks flowing to Taugn Tha Man Lake with higher level than desirable water quality at several points in Feb 2018.

(8) Nutrients

The total phosphorus and total nitrogen in the lake was compared with the Japanese Environmental Standard for lakes. The results shows nutrient levels in both seasons exceeded the acceptable range for prevention of eutrophication of lake (see Table 3.3-5). Highest level was observed in the northern lake in Feb 2018: 4.3 mg/L of total phosphorus and 25 mg/L of total nitrogen. The higher nutrients level were also detected from the creeks upstream of the lake: 4 mg /L of total phosphorus and 37 mg/L of total nitrogen at the highest in Tagon Taing Bridge.

On the other hand in rivers, in general, nitrate, nitrite and ammonia among various forms of nitrogen and phosphate as one of phosphorus forms are important determinants to evaluate the environmental river water quality. However, these specific forms were not surveyed in 4th and 5th surveys as explained in Section 3.3.1 (9). A reference of nitrite, nitrate and phosphate data was made to other monitoring data obtained by Mandalay Urban Services Improvement Project. Those consecrations in Doke Hta Waddy River in June 2016 was within the range of surface water quality guideline for domestic water supply in Vietnam (QCVN 08-MT 2015/BTNMT).

(9) Heavy metals

The measurement parameters for heavy metals included zinc, total chromium, hexavalent chromium, arsenic, cupper, total mercury, cadmium and lead. No elevated level of heavy metals was observed. Slight level of total chromium was detected in PYRC-1'. However, hexavalent chromium harmful to human health was not detected.

(10) PCBs

No PCBs was detected at the survey point: the intake point of domestic water supply in the Ayeyarwaddy River.

(11) Pesticides

No pesticides were detected at the survey point: upper point in Doke Hta Waddy River and intake point of Ayeyarwaddy River.

Table 3.3-1 Results of 4th survey in Doke Hta Waddy River Basin (1)

No.	Location Name	pH	DO	BOD	Total Coliform	TSS	COD Cr	Total Cyanide	Oil and grease	Phenols
		-	mg/L	mg/L	MPN/100ml	mg/L	mg/L	mg/L	mg/L	mg/L
1	DHWD1	8.40	7.73	5.4	92,000	14	5.3	< 0.1	< 1	< 0.005
2	DHWD2	8.30	6.21	4.5	-	16	6.0	-	-	-
3	Myint Nge Bridge	7.96	7.78	1.1	160,000	22	4.2	< 0.1	< 1	< 0.005
4	DP*	7.59	4.82	11.0	> 160,000	86	150	< 0.1	9.1	0.012
5	LKP Stream	8.03	6.57	2.7	35,000	7.8	17	< 0.1	< 1	< 0.005
6	UST Bridge	7.77	6.70	5.6	> 160,000	22	31	< 0.1	< 1	< 0.005
7	TT Bridge	7.46	5.11	4.8	-	28	34	< 0.1	< 1	< 0.005
8	PYTC-62nd Str.	7.86	6.31	2.3	-	68	23	< 0.1	< 1	< 0.005
9	PYTC-1'	7.82	8.89	5.1	> 160,000	36	32	< 0.1	< 1	< 0.005
10	After-aeration	7.93	5.36	3.9	160,000	28	70	< 0.1	< 1	0.0086
11	N-TTML	8.18	5.12	6.0	17,000	15	28	< 0.1	< 1	< 0.005
12	S-TTML	8.56	6.43	5.4	24,000	14	28	< 0.1	< 1	< 0.005
13	PTM Bridge	7.56	7.38	6.6	-	44	14	-	-	-
14	SK Creek	8.02	8.52	1.6	-	62	15	-	-	-
15	Intake AYWD	7.88	7.68	5.4	92,000	45	11	< 0.1	< 1	< 0.005
Comparison with Vietnamese Environmental Standard for reference										
A1	For domestic water supply	6 - 8.5	≥6	4	2500	20	10	0.05	0.3	0.005
A2	For domestic water supply with treatment and conservation of aquatic lives	6 - 8.5	≥5	6	5000	30	15	0.05	0.5	0.005
B1	For irrigation	5.5 - 9	≥4	15	7500	50	30	0.05	1	0.01
B2	For water transportation and other purposes with demand for low-quality water	5.5 - 9	≥2	25	10000	100	50	0.05	1	0.02
Less than B2		<5.5, >9	<2	>25	>10000	>100	>50	>0.05	>1	>0.02

Source: JICA Expert Team

Table 3.3-2 Results of 4th survey in the Doke Hta Waddy River Basin (2)

No.	Location Name	T-P	T-N	Zn	T-Cr	Cr 6+	As	Cu	T-Hg	Cd	Pb	PCBs
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	DHWD1	< 0.06	0.30	0.0081	0.0058	< 0.005	0.0016	< 0.005	< 0.0005	< 0.001	< 0.005	-
2	DHWD2	-	-	-	-	-	-	-	-	-	-	-
3	Myint Nge Bridge	< 0.06	0.34	0.0098	< 0.005	< 0.005	0.0019	< 0.005	< 0.0005	< 0.001	< 0.005	-
4	DP*	0.32	2.8	0.014	0.0050	< 0.005	0.0033	0.016	< 0.0005	< 0.001	0.0056	-
5	LKP Stream	0.10	0.60	0.010	< 0.005	< 0.005	0.0040	< 0.005	< 0.0005	< 0.001	< 0.005	-
6	UST Bridge	0.31	2.0	0.016	0.011	< 0.005	0.0041	0.0097	< 0.0005	< 0.001	0.0051	-
7	TT Bridge	0.39	3.0	0.0096	< 0.005	< 0.005	0.0034	< 0.005	< 0.0005	< 0.001	< 0.005	-
8	PYTC-62nd Str.	0.28	2.1	0.014	0.0054	< 0.005	0.0032	< 0.005	< 0.0005	< 0.001	< 0.005	-
9	PYTC-1'	0.31	2.1	0.011	0.0054	< 0.005	0.0035	< 0.005	< 0.0005	< 0.001	< 0.005	-
10	After-aeration	2.7	18	0.018	0.0050	< 0.005	0.0041	< 0.005	< 0.0005	< 0.001	< 0.005	-
11	N-TTML	0.38	2.0	0.0074	< 0.005	< 0.005	0.0037	< 0.005	< 0.0005	< 0.001	< 0.005	-
12	S-TTML	0.36	1.7	0.0050	< 0.005	< 0.005	0.0042	< 0.005	< 0.0005	< 0.001	< 0.005	-
13	PTM Bridge	0.063	0.63	-	-	-	-	-	-	-	-	-
14	SK Creek	0.20	1.2	-	-	-	-	-	-	-	-	-
15	Intake AYWD	0.077	0.51	0.0087	0.0056	< 0.005	0.0017	< 0.005	< 0.0005	< 0.001	< 0.005	< 0.0005
A1	For domestic water supply	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	0.5	0.05	0.01	0.01	0.1	0.001	0.005	0.02	-
A2	For domestic water supply with treatment and conservation of aquatic lives	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.0	0.1	0.02	0.02	0.2	0.001	0.005	0.02	-
B1	For irrigation	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.5	0.5	0.04	0.05	0.5	0.001	0.01	0.05	-
B2	For water transportation and other purposes with demand for low-quality water	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	2	1	0.05	0.1	1	0.002	0.01	0.05	-
Less than B2		-	-	>2	>1	>0.05	>0.1	>1	>0.002	>0.01	>0.05	-

Source: JICA Expert Team

Table 3.3-3 Results of 5th survey in the Doke Hta Waddy River Basin (1)

No.	Location Name	pH	DO	BOD	Total Coliform	TSS	COD Cr	Total Cyanide	Oil and grease	Phenols
		-	mg/L	mg/L	MPN/100ml	mg/L	mg/L	mg/L	mg/L	mg/L
1	DHWD1	8.15	6.6	4.74	610	4	5.2	< 0.1	< 1	< 0.005
2	DHWD2	7.02	5.0	5.65	-	< 4	2.8	-	-	-
3	Myint Nge Bridge	8.07	6.9	4.72	1,400	5.8	2.9	< 0.1	< 1	< 0.005
4	DP*	6.89	5.5	175.9	>160,000	79	660	< 0.1	2.4	0.021
5	LKP Stream	8.03	6.8	80.7	>160,000	38	63	< 0.1	1.2	0.0053
6	UST Bridge	6.80	2.5	348.38	>160,000	91	370	< 0.1	6.3	0.14
7	TT Bridge	6.71	5.5	354.14	-	260	540	< 0.1	9.6	0.057
8	PYTC-62nd Str.	7.65	4.7	63.58	>160,000	15	42	< 0.1	< 1	< 0.005
9	PYTC-1'	7.13	4.8	347.1	>160,000	82	370	< 0.1	7.9	0.025
10	After-aeration	7.55	3.9	239.58	>160,000	13	60	< 0.1	2.5	0.0091
11	N-TTML	7.47	2.9	356.7	>160,000	51	280	< 0.1	< 1	0.050
12	S-TTML	8.74	4.7	22.62	24,000	130	130	< 0.1	< 1	< 0.005
13	PTM Bridge	7.70	5.0	9.76	-	89	21	-	-	-
14	SK Creek	7.57	6.1	86.78	-	58	20	-	-	-
15	Intake AYWD	8.06	9.2	4.74	35,000	50	4.4	< 0.1	< 1	< 0.005
Comparison with Vietnamese Environmental Standard for reference(QCVN08:2015)										
A1	For domestic water supply	6 - 8.5	≥6	4	2500	20	10	0.05	0.3	0.005
A2	For domestic water supply with treatment and conservation of aquatic lives	6 - 8.5	≥5	6	5000	30	15	0.05	0.5	0.005
B1	For irrigation	5.5 - 9	≥4	15	7500	50	30	0.05	1	0.01
B2	For water transportation and other purposes with demand for low-quality water	5.5 - 9	≥2	25	10,000	100	50	0.05	1	0.02
Less than B2		<5.5, >9	<2	>25	>10,000	>100	>50	>0.05	>1	>0.02

Source: JICA Expert Team

Table 3.3-4 Results of 5th survey in the Doke Hta Waddy River Basin (2)

No.	Location Name	T-P	T-N	Zn	T-Cr	Cr 6+	As	Cu	T-Hg	Cd	Pb	PCBs
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	DHWD1	< 0.06	0.3	< 0.005	< 0.005	< 0.005	0.0023	< 0.005	< 0.0005	< 0.001	< 0.005	-
2	DHWD2	-	-	-	-	-	-	-	-	-	-	-
3	Myint Nge Bridge	< 0.06	< 0.25	< 0.005	< 0.005	< 0.005	0.0022	< 0.005	< 0.0005	< 0.001	< 0.005	-
4	DP*	1.3	20	0.048	< 0.005	< 0.005	0.0032	0.0098	< 0.0005	< 0.001	0.005	-
5	LKP Stream	1.3	5.1	0.017	< 0.005	< 0.005	0.0091	< 0.005	< 0.0005	< 0.001	< 0.005	-
6	UST Bridge	3.1	24	0.065	0.0052	< 0.005	0.0056	0.012	< 0.0005	< 0.001	0.0064	-
7	TT Bridge	4.0	37	0.12	0.018	< 0.005	0.0074	0.032	< 0.0005	< 0.001	0.013	-
8	PYTC-62nd Str.	2.1	14	0.0098	< 0.005	< 0.005	0.0039	< 0.005	< 0.0005	< 0.001	< 0.005	-
9	PYTC-1'	2.5	17	0.047	0.0056	< 0.005	0.0064	0.025	< 0.0005	< 0.001	0.0058	-
10	After-aeration	3.1	30	0.011	< 0.005	< 0.005	0.0043	< 0.005	< 0.0005	< 0.001	< 0.005	-
11	N-TTML	4.3	25	0.0072	< 0.005	< 0.005	0.0048	< 0.005	< 0.0005	< 0.001	< 0.005	-
12	S-TTML	1.7	9.2	0.014	< 0.005	< 0.005	0.01	< 0.005	< 0.0005	< 0.001	0.012	-
13	PTM Bridge	0.15	1.4	-	-	-	-	-	-	-	-	-
14	SK Creek	0.37	2.0	-	-	-	-	-	-	-	-	-
15	Intake AYWD	0.12	1.3	0.0078	< 0.005	< 0.005	0.0013	0.014	< 0.0005	< 0.001	< 0.005	< 0.0005
Comparison with Vietnamese Environmental Standard for reference(QCVN08:2015)												
A1	For domestic water supply	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	0.5	0.05	0.01	0.01	0.1	0.001	0.005	0.02	-
A2	For domestic water supply with treatment and conservation of aquatic lives	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.0	0.1	0.02	0.02	0.2	0.001	0.005	0.02	-
B1	For irrigation	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	1.5	0.5	0.04	0.05	0.5	0.001	0.01	0.05	-
B2	For water transportation and other purposes with demand for low-quality water	Specified as PO_4^{3-}	Specified as NO2- and NO3- respectively	2	1	0.05	0.1	1	0.002	0.01	0.05	-
Less than B2		-	-	>2	>1	>0.05	>0.1	>1	>0.002	>0.01	>0.05	-

Source: JICA Expert Team

Table 3.3-5 Nutrients Level in Taung Tha Man Lake

mg/L

Location Name		Total Phosphorus		Total Nitrogen	
		Oct 2017	Feb 2018	Oct 2017	Feb 2018
N-TTML		0.38	4.3	2.0	25
S-TTML		0.36	1.7	1.7	9.2
Comparison with Japanese Environmental Standard (lake) for reference					
I	Conservation of natural environment	0.005 mg/L or less		0.1 mg/L or less	
II	Water supply for purify water using filters and other simple means, fishery for salmon/troun, sweetfish, bathing etc.	0.01 mg/L or less		0.2 mg/L or less	
III	Water supply for purify water using pre-treatment and other advanced methods	0.03 mg/L or less		0.4 mg/L or less	
IV	Fishery for smelt etc.	0.05 mg/L or less		0.6 mg/L or less	
V	Fishery for smelt etc., industrial water, agricultural water, and conservation of the environment	0.1 mg/L or less		1 mg/L or less	
Remarks	1 Standard values are based on daily average values. 2 Standard values for total phosphorous are not applicable to water for agricultural use.				

Source: JICA Expert Team

Table 3.3-6 Results of Pesticides in the Doke Hta Waddy River Basin

mg/L

No.	Parameter	Sep 2017		Feb 2018	
		DHWD1	Intake AYWD	DHWD1	Intake AYWD
1	Aldrin	< 0.0005	< 0.0005	< 0.0005	< 0.0005
2	Atrazine	< 0.0005	< 0.0005	< 0.0005	< 0.0005
3	4,4'-DDD	< 0.0005	< 0.0005	< 0.0005	< 0.0005
4	4,4'-DDE	< 0.0005	< 0.0005	< 0.0005	< 0.0005
5	4,4'-DDT	< 0.0005	< 0.0005	< 0.0005	< 0.0005
6	Endosulfan	< 0.0005	< 0.0005	< 0.0005	< 0.0005
7	Endosulfan sulfate	< 0.0005	< 0.0005	< 0.0005	< 0.0005
8	Endrin	< 0.0005	< 0.0005	< 0.0005	< 0.0005
9	HCH-alpha (benzene hexachloride-alpha)(alpha-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
10	HCH-beta(beta-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
11	HCH-delta(delta-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
12	HCH-gamma(Lindane)(ganma-BHC)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
13	Alachlor	< 0.0005	< 0.0005	< 0.0005	< 0.0005
14	Diazinon	< 0.0005	< 0.0005	< 0.0005	< 0.0005
15	Chlorpyrifos	< 0.0005	< 0.0005	< 0.0005	< 0.0005
16	Dimethoate	< 0.0005	< 0.0005	< 0.0005	< 0.0005
17	Imidacloprid	< 0.0005	< 0.0005	< 0.0005	< 0.0005

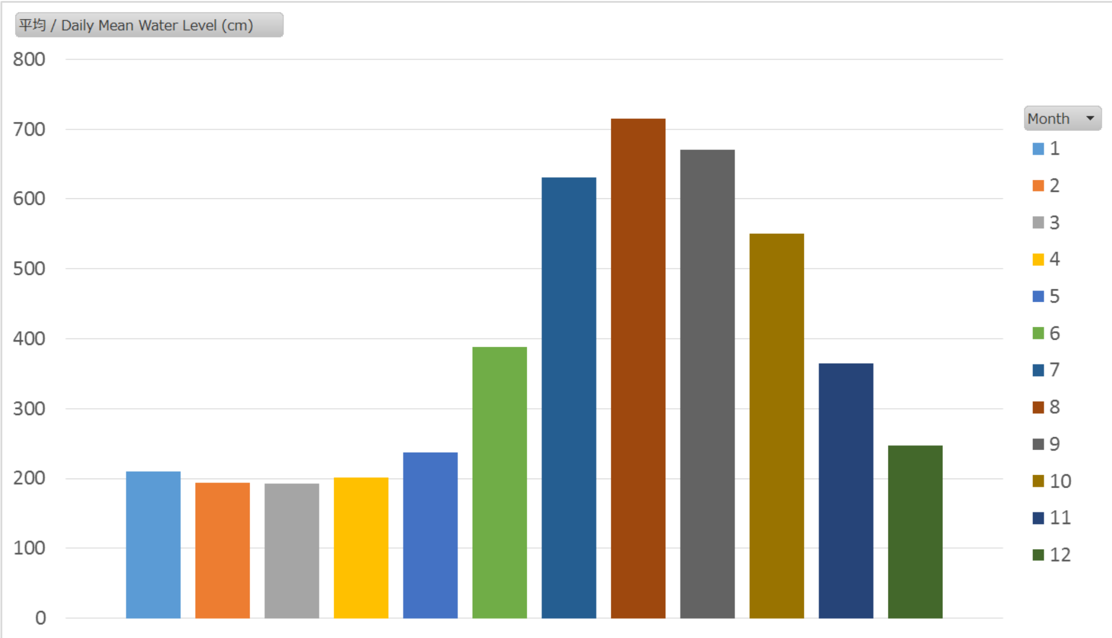
Source: JICA Expert Team

3.3.2 Hydrological conditions

The water level data of the Doke Hta Waddy River is available from Department of Meteorology and Hydrology (DMH). The water level is lower from December to May and higher from July to October (Figure 3.3-1). In a daily cycle, the water level is also fluctuated depending on water amount discharged from the upstream dam, Yeywa Dam. In the surveys, the flow rate was estimated by the flow measurement survey as 560 m3/s in Oct 2017 and 180 m3/day in Feb 2018.

The water level data at Taung Tha Man Lake was not available but it also changes with seasons and the water depth in dry season is decreased to less than 1 m. The water area is totally enclosed when the water level is lowest.

As for the creek flowing to Taung Tha Man Lake, the water flow at Tagon Taing Bridge was measured as 6.8 m^3/s in October 2017 and 2.8 m^3/day in February 2018. However, no water flow was observed in U Shwe Taung Bridge and Let Khot Pin stream in February 2018.



Source: JICA Expert Team

Figure 3.3-1 Water Level of Doke Hta Waddy River at Myitge Bridge

3.3.3 Evaluation of water quality

The water quality survey in the Doke Hta Waddy River was evaluated as discussed below.

(1) Water quality of Doke Hta Waddy River

The Doke Hta Waddy River seems to have adequate water quality for domestic water supply with water treatment facility using filters and other ordinary means. The level of organic pollution did not appear to be very high. None of the results in this project showed elevated levels of toxic substances. The water quality did not dramatically vary by season or from point to point. Table 3.3-7 shows the results of BOD and COD, and Table 3.3-8 shows the results of water qualities at future intake points compared with drinking water quality guideline value.

Compared with draft national drinking water quality standard (MOH superseded by MOHS, 2014), the upstream of Doke Hta Waddy River (DHWD1) and Intake point of Ayeyarwaddy River met with the required level except for turbidity. The water seems suitable for domestic water supply with simple water treatment system. However, it should be noted that this survey was conducted as one of environmental survey and not guarantee the safety of drinking water since the measurement parameter and monitoring frequency were limited and does not cover all necessary requirements.

Table 3.3-7 Classification of BOD and COD Levels in the Doke Hta Waddy River Basin

Unit: mg/L

Target		BOD						COD					
		Rainy Season(Sep 2017)			Dry Season(Feb 2018)			Rainy Season(Sep 2017)			Dry Season(Feb 2018)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
River	Doke Hta Waddy River	1.1	5.4	3.7	4.7	5.7	5.0	4.2	6	5.2	2.8	5.2	3.6
	Ayeyarwaddy River	5.4			4.7			11			4.4		
Lake	Taung Tha Man Lake	5.4	6.0	5.7	23	357	190	28	28	28	130	280	205
Creek	Inflow to Taung Tha Man Lake (LKP Stream, UST Bridge, Pa Yan Taw Creek, Columbo Creek)	2.3	6.6	4.4	9.8	354	206	14	70	32	21	540	209

Vietnamese Environmental Standard(QCVN08:2015) for reference

Water Usage		BOD	COD
A1	For domestic water supply	4	10
A2	For domestic water supply with treatment and conservation of aquatic lives	6	15
B1	For irrigation	15	30
B2	For water transportation and other purposes with demand for low-quality water	25	50
Less than B2		>25	>50

Source: JICA Expert Team

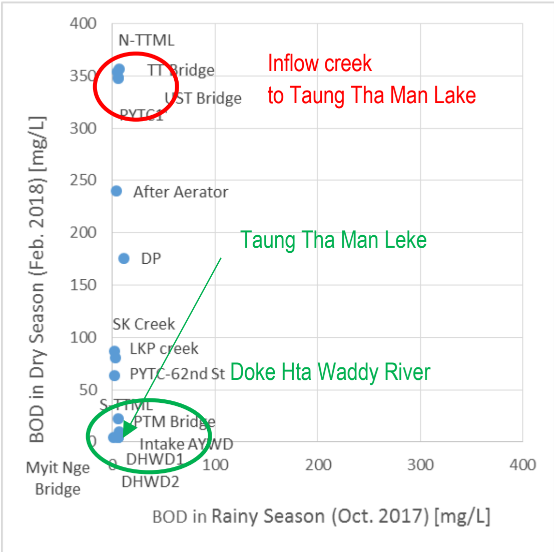
Table 3.3-8 Comparison with Draft Drinking Water Quality Standard for Existing/Possible Domestic Water Supply (Doke Hta Waddy River Basin)

Location Name	Unit	DHWD1		Intake AYWD		MOH Draft National Drinking Water Quality Std(2014)
		Sep 2017	Feb 2018	Sep 2017	Feb 2018	
pH	-	8.40	8.15	7.88	8.06	6.5 - 8.5
Turbidity	NTU	39.5	9.5	74.1	80	5
TDS	mg/L	160	0.245	133	0.101	1000
Cyanide(total)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	0.07
Zinc (Zn)	mg/L	0.0081	< 0.005	0.0087	0.0078	3
Total chromium (T-Cr)	mg/L	0.0058	< 0.005	0.0056	< 0.005	0.05
Arsenic (As)	mg/L	0.0016	0.0023	0.0017	0.0013	0.05
Copper (Cu)	mg/L	< 0.005	< 0.005	< 0.005	0.014	2
Total Mercury (Hg)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.001
Cadmium (Cd)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.003
Lead (Pb)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.01
Pesticides	mg/L		-	< 0.0005	< 0.0005	Specified for some parameters respectively

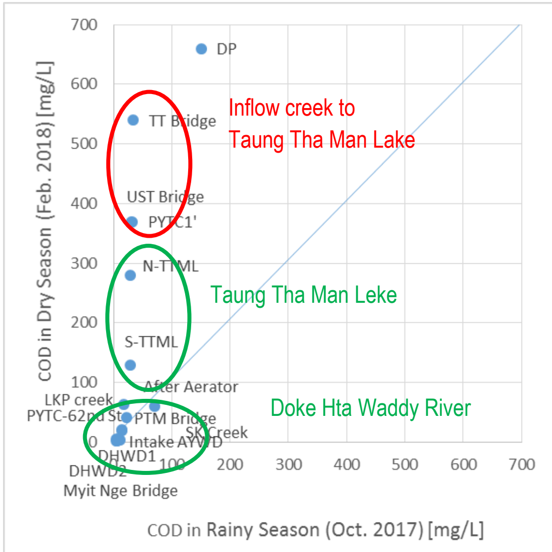
: Satisfied with reference standard
: Not satisfied with reference standard

Source: JICA Expert Team

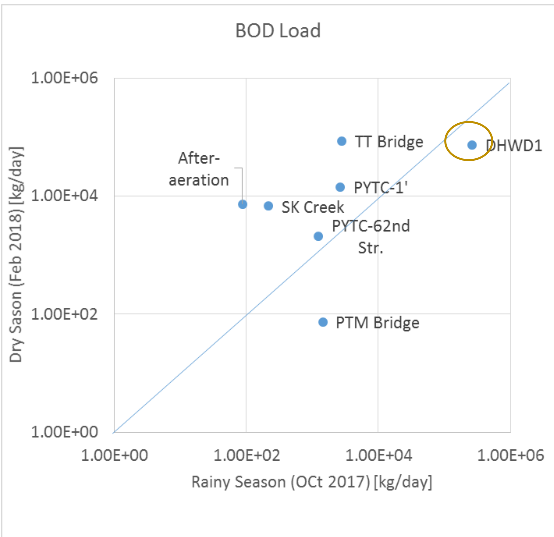
The concentrations of pollutants in the dry season was higher than those in the rainy season for most sampling points and for most parameters as shown in Figure 3.3-2. This is similar to the Hlaing River basin. On the other hand, the pollution loads of organic substances (i.e., BOD and COD) in the Doke Hta Waddy River in October 2017 seemed larger than those in February 2018. This indicated that the storm water in the rainy season flushed more organic substances with soils from the upper basin to the river, although the concentrations of organic substances is not higher because of the dilution effect.



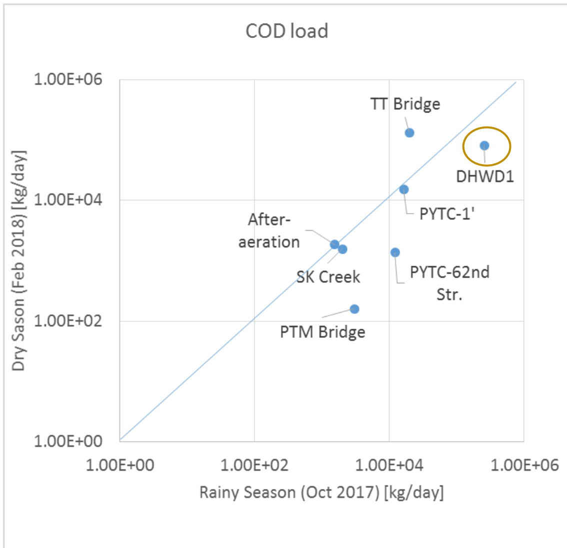
BOD Concentration



COD Concentration



BOD Load



COD Load

Source: JICA Expert Team

Figure 3.3-2 Water Quality and Pollution Load Changes between Rainy Season and Dry Season (Doke Hta Waddy River Basin)

(2) Pollution impact from industrial wastewater to Doke Hta Waddy River

The wastewater discharged from the 10-inch pipeline contained more than 10,000 mg/L of organic pollutants. The past survey result showed 18,000 mg/L of BOD and 448,000 mg/L of COD at maximum in June 2016. It also contained extremely high concentrations of pollutants that included oil and grease (906 mg/L), phenols (5.76 mg/L) and hexavalent chromium (1.1 mg/L) in addition to the nutrients. The concentrations of these pollutants were higher than the guideline values applied to general wastewater (general application, National Environmental Quality (Emission) Guidelines, 2015). However, the pollution impact of the wastewater from the 10-inch pipeline on the water quality of Doke Hta Waddy River seemed limited because of the dilution effect, though localized pollution and adverse impact such as an awful odor to residents in vicinity of the discharging point were noted.

After several distilleries in Pyi Gyi Tagon IZ shut down their operation temporarily from June – August 2017 by instructions of Mandalay Region Government and MCDC, the pollution load from the 10-pipe line seemed decreased. However, the discharging wastewater still contained organic and nutrients pollutants as well as oil and grease, phenols and other pollutants. The pollution load from the pipe line fluctuates and it could contain other hazardous substances depending on the factories' operation. Continuous monitoring is required until the centralized wastewater treatment facility is constructed and operated with the appropriate treatment capcity.

In 2016

In 2018(The end of pipe is submerged)

Source: JICA Expert Team

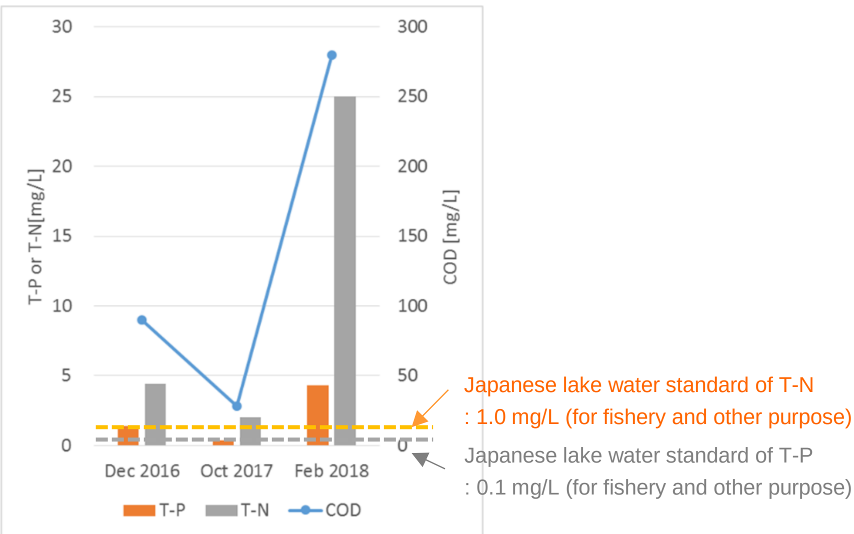
Figure 3.3-3 Photographs of Discharging `Point pf 10-inch Pipeline

(3) Pollution status in Taung Tha Man Lake

The water quality in Taung Tha Man Lake was characterized as eutrophic, which was manifested by higher phosphorus and nitrogen concentrations compared with general indicators for eutrophication: 0.01 mg/L for total phosphorus and 0.15 mg/L for total nitrogen (USEPA, 2000), relatively low DO as well as high COD and pH.

Water quality in the lake was significantly deteriorated in the dry season compared with the rainy season (Table 3.3-5). In February 2018, the nutrient level was very high (4.3 mg/L for total phosphorus and 25 mg/L of total nitrogen) in the northern lake. At that period, the water level was quite low and the water area was totally enclosed without enough water exchanges between the lake and other water bodies. In such condition, the influent nutrients are further accumulated in the lake. It will increase algae and phytoplankton and result in internal organic production, which accelerates eutrophication. There is no doubt that the lake is eutrophic, even hypereutrophic. However the eutrophication mechanism in the lake is complicated and not clear. Since the water quality in the lake has changed or fluctuated dramatically over time or with seasons, detailed monitoring to examine the mechanism of water pollution in the lake is required. All of these mechanisms should be taken into consideration in explaining the hypoxic condition of the lake, which apparently caused the massive fish die-off in the lake in 2016.

As a reference, the sediment samples were taken from Tang Tha Man Lake in February 2016 since there was a concern about accumulated heavy metals in the sediment due to water pollution. High levels of toxic heavy metals such as arsenic, cadmium, lead and mercury were not detected from the sediment at northern point of Taung Tha Man Lake. The sediment analysis result is shown in Appendix 2.



Source: JICA Expert Team

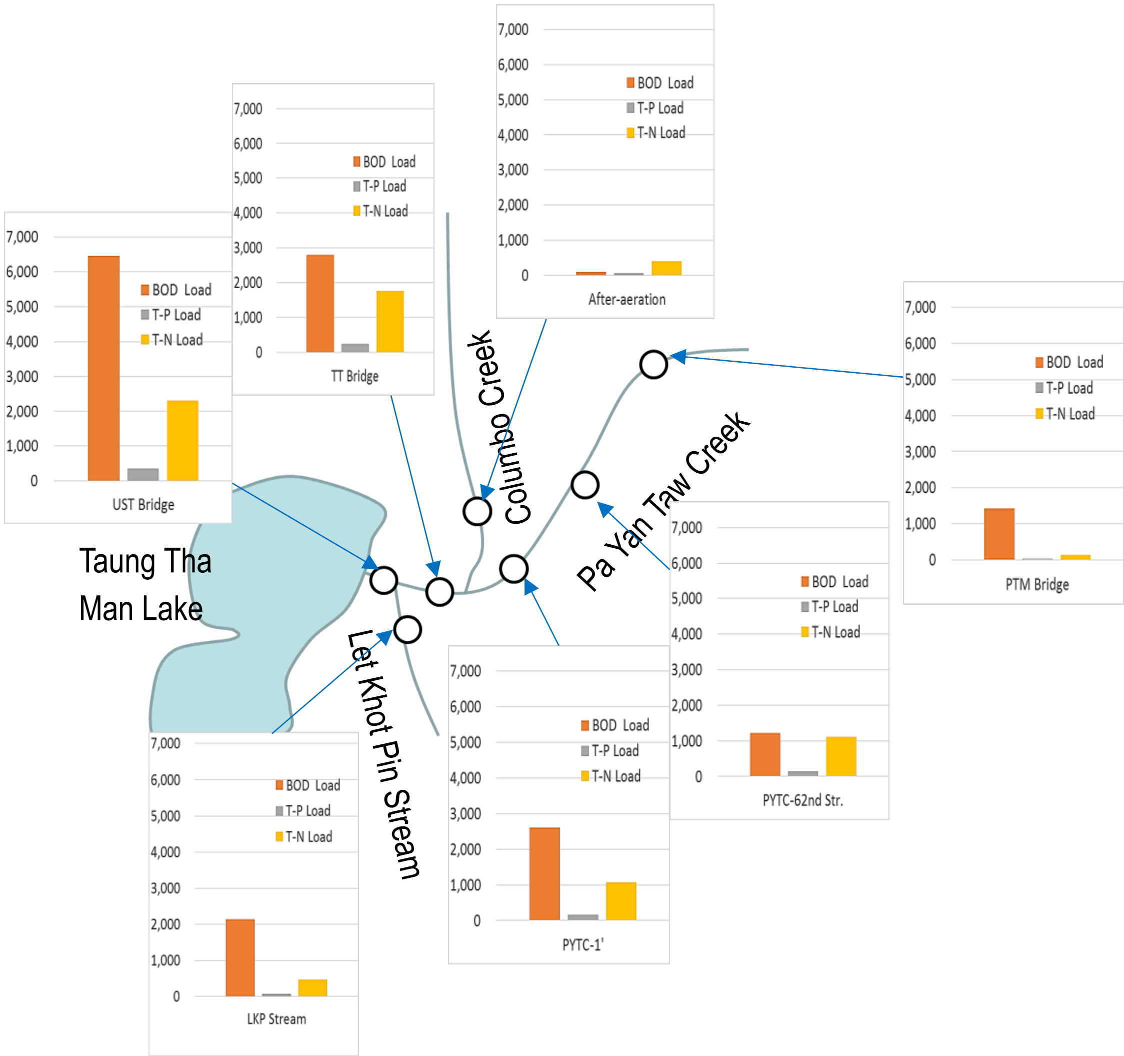
Figure 3.3-4 Water Quality Changes in Northern Taung Tha Man Lake

(4) Pollution path to Taung Tha Man Lake

The creek flowing through U Shwe Taung Bridge, which is a confluence of Pa Yan Taw creek, Let Khot Pin stream and Columbo creek, is one of the major pollution paths to Taung Tha Man Lake. Among these creeks, the pollution loads of organic material and nutrients were the highest in Pa Yan Taw creek except the total nitrogen in the dry season as shown in Figure 2.3-5. This implies that the Pa Yan Taw creek basin would have the highest priority for pollution control measures among these three creeks in order to reduce the load to Taung Tha Man Lake.

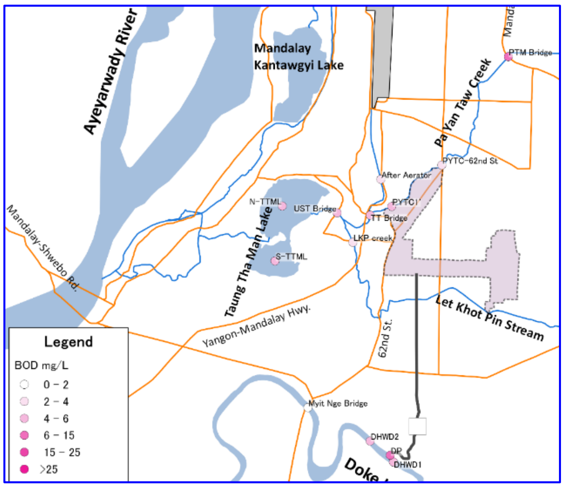
Deterioration of water quality in these creeks was obvious in the dry season. In addition to organic matter and nutrients, moderate levels of oil and grease (max. 10 mg/L) and phenols (max. 0.06 mg/L) were detected, which are considered to originate from domestic wastewater and industrial wastewater. On the other hand, no harmful levels of toxic substance to human health such heavy metals were detected. The pollution source discharging high level of organic pollutants and nutrients as well as hypoxic wastewater needs to be identified for pollution control in the basin.

Regarding the impact from agricultural land in the eastern part of survey area, the pollution load from faming land seemed limited because the most pollution load flowed into Pa Yan Taw Creek after Paw Taw Muu Bridge (PTM Bridge). On the other hand, the T-P and T-N pollution load at PTM Bridge in rainy season was higher than dry season. There is a possibility that more nutrients are discharged from agricultural land with storm water in the flood season. It needs to be further investigated targeting the busy farming season or when the outflow of agricultural pollutants with soil from farming land is peak.

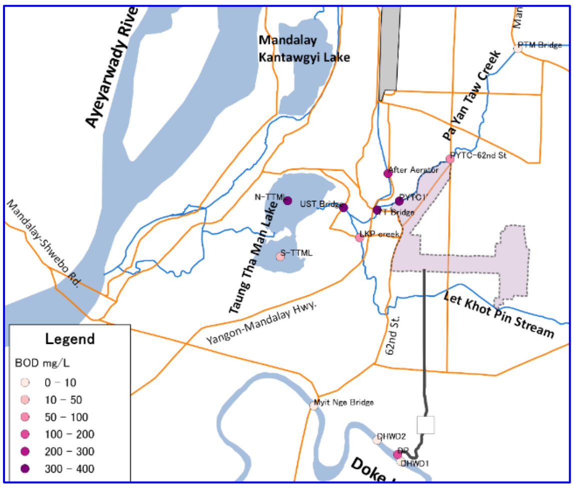


Source: JICA Expert Team

Figure 3.3-5 Pollution load from three Creeks to TTML in Oct 2017



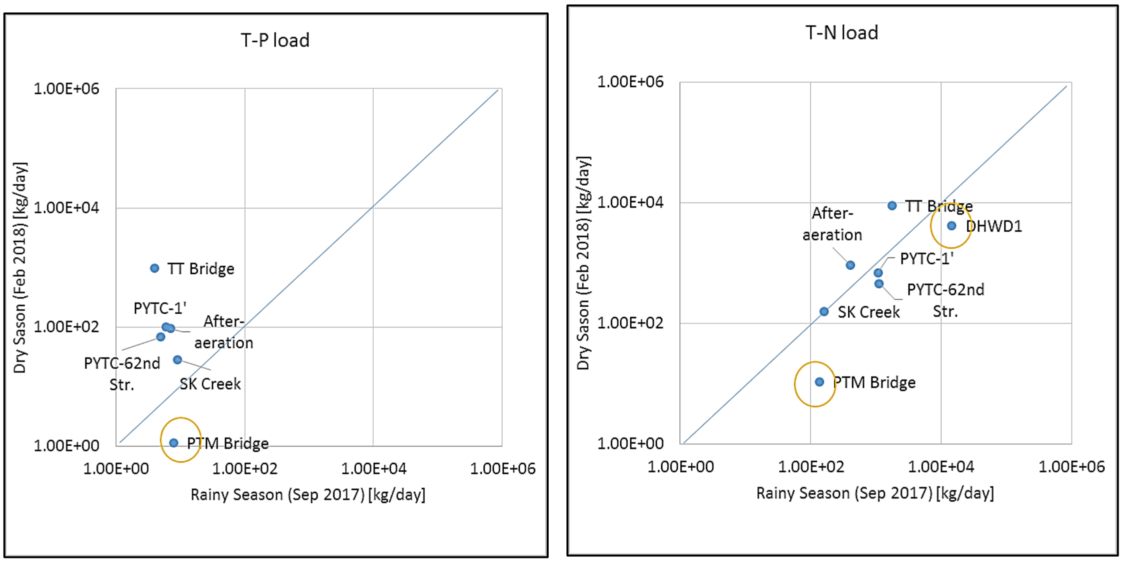
BOD in Oct 2017



BOD in Feb 2018

Source: JICA Expert Team

Figure 3.3-6 BOD in the Pollution Paths



Note: T-P load in DHWR1 was not available because the T-P concentration was less than reporting limit.

Source: JICA Expert Team

Figure 3.3-7 T-P and T-N Pollution Load in Rainy Season and Dry Season

3.4 Conclusions in Doke Hta Waddy River basin Survey

The water quality survey in the Doke Hta Waddy River basin conclusions are explained below and the recommendations from surveys are summarized in Section 5.2.

(1) Pollution Impact from IZ to Doke Hta Waddy River

The Doke Hta Wady River maintains adequate water quality for domestic water supply with simple treatment facility. The water quality did not dramatically vary by season or points. Elevated levels of toxic substances were not detected this time.

The pollution impact from 10-inch pipeline seemed limited and reduced apparently due to tentative shut-down of distilleries and other measures, but wastewater still contained organic and nutrients pollutants as well as oil and grease and phenols, etc.

(2) Pollution level of Taung Tha Man Lake

Taung Tha Man Lake showed signs of eutrophication manifested by high phosphorus, nitrogen and COD as well as lower DO. The higher pH in the northern lake also showed that increased algae and phytoplankton accelerated photosynthesis in the daytime. Chlorophyll *a* measurement will be necessary to figure out the volume of phytoplankton.

When the lake water level become lower in the dry season, especially the northern part of lake is hypereutrophic, receiving the wastewater from the inflowing creeks. Since the water quality in the lake has changed or fluctuated dramatically over time or with seasons, more monitoring data will be necessary to examine the mechanism of water pollution in the lake that caused eutrophication and the mass fish death events in the past. The lake still have a potential risk of fish kill incidents if hypoxic condition is exacerbated.

(3) Pollution path to the TTML

The creek running through U Shwe Taung Bridge is one of the most important routes of organic and nutrient pollutants to reach Taung Tha Man Lake. The water quality is characterized by very low DO and high organic contamination, polluted by both domestic wastewater and industrial wastewater.

The survey found that highest pollution loads of organic material and nutrients came from Pa Yan Taw creek among three creeks reaching U Shwe Taung Bridge except T-N in the dry season. Deterioration of water quality in creeks was significant in the dry season. It is considered that these pollution load has caused the eutrophication in Taung Tha Man Lake. On the other hand, pollution load from faming land was limited, but needs to be investigated in another farming season.

4 QUALITY CONTROL

4.1 Quality control method

In the water quality surveys of the Project, the analytical results of water quality surveys were validated based on the Water Quality Survey Manual. The validation method included the following points.

- Check any careless mistakes of result value and unit
- Check significant figures and reporting limit
- Check an analysis method
- Compare the result against reference environmental standard values or guideline values
- Check consistency with other parameters and sampling locations as well as past data considering the physical characters of measured substance and site conditions
- Check a data precision referring to a result of quality control samples, which is generally used to reveal the level of analysis error for each parameter

4.2 Validation of results

The task of water quality analysis in surveys were outsourced to local environmental analysis laboratories. In order to select laboratories at the beginning of the Project, JET visited several candidate laboratories and checked their capabilities in terms of related work experiences, methods and procedures of analysis work, quality control system, and availability of human and other resources, etc. Laboratories providing the water quality analysis services for the 1st – 3rd survey were selected for the first time in early February 2016. Their performance was evaluated at each survey time, and the laboratories were changed as needed. Although these laboratories were carefully selected with available information, C/Ps and JET found that the analytical precision and accuracy were not enough based on the examination of their performance in the 1st – 3rd surveys as explained below.

The past 1st – 3rd water quality surveys revealed various issues in data quality control. Some measured values of the outsourced laboratory did not seem to have enough reliability due to low resolution. The precision of data (especially low environmental level of COD, BOD, total nitrogen and total phosphorus) did not seem good enough to evaluate the water environmental quality. Some of the duplicate analysis results in past surveys also showed more than several dozen percentages of difference when the two same samples that were analyzed in parallel and the results compared. In addition to the precision issue, there was a possibility that measured values for some specific parameters such as COD, BOD, cadmium and lead were higher than true values. Detection of trace amount of harmful heavy metals also needed to be checked.

As a first step to solve such issues and obtain reliable results, a comparative analysis among selected laboratories was conducted for a few representative parameters and sampling points in December 2017.

4.3 Comparative analysis program

The comparative analysis program was conducted with the following objectives and targets.

- Objectives: To confirm the actual water quality levels in targeted public water bodies and to check the variation of analysis results of laboratories
- Sampling points: H1-C and H5-C in the Hlaing River, most-upstream of Doke Hta Waddy River (DHWR-1) and Northern Taung Tha Man Lake
- Measurement parameters (at most): COD, BOD, total nitrogen, total phosphorus, cadmium and lead and total mercury
- Selected laboratories: Five governmental labs in Myanmar, three private labs in Myanmar, two labs in Thailand, one lab in Japan
- Note: The results were compared to select the reliable laboratories only as internal information.

The results displayed the following facts and considerations.

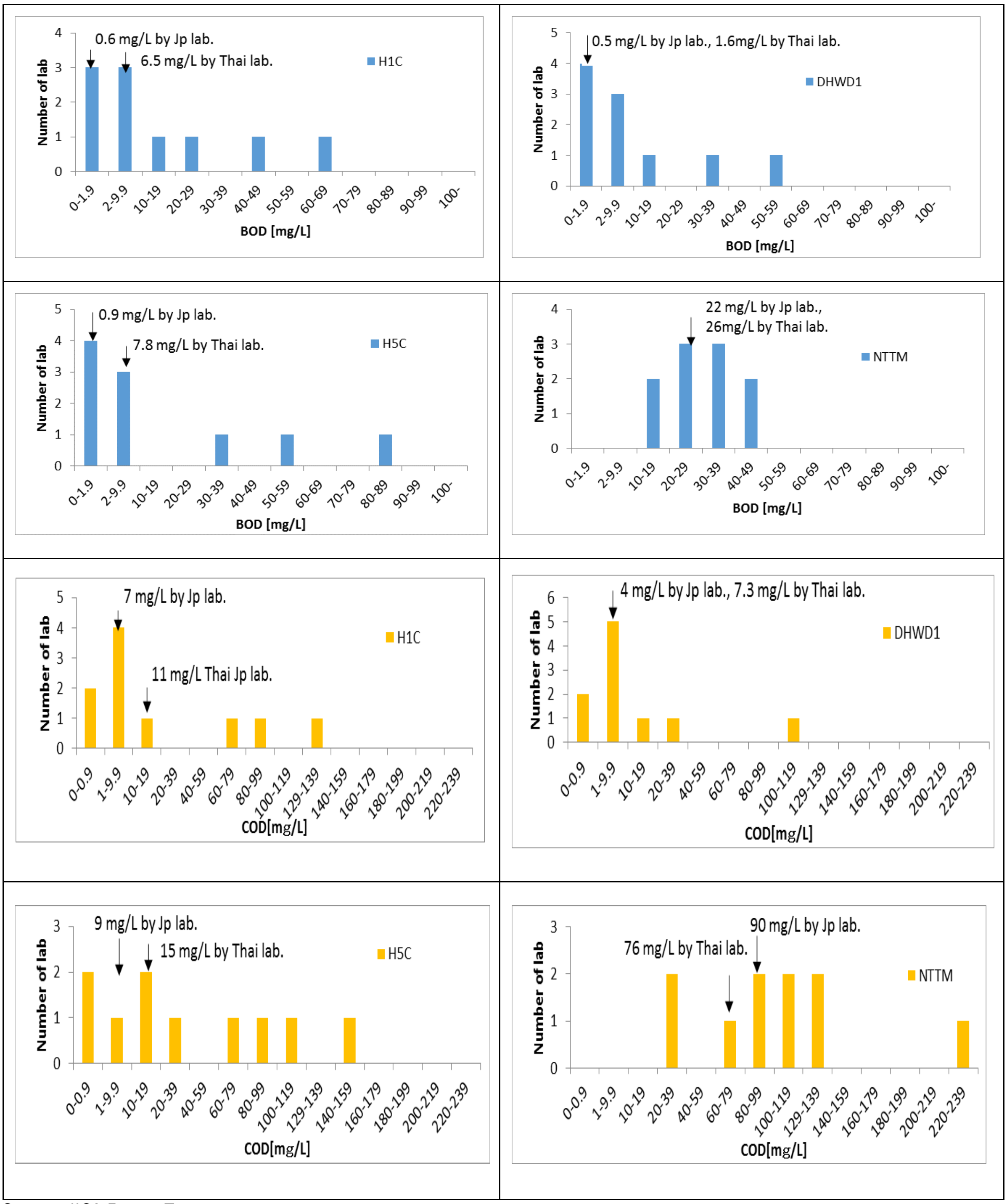
(1) Huge variation in results among Laboratories

The variation of results among laboratories was huge as shown in Figure 3.3-6. As for BOD and COD for most samples, CV (Coefficient of Variation) which describes the relative variability of data was more than 100%. The precision of chemical analysis was not good enough so that the toxic level in environmental water area cannot be determined for comparing with standard value for human health. It is considered that some past results also had margin of error of more than 50%. Under such conditions, even a slight difference of water quality in locations and sampling times cannot be evaluated.

(2) Actual water quality in target water area

The result provided by accredited laboratory in Japan were used to evaluate the actual water quality status in the targeted rivers compared with the past 1st – 2nd surveys results. It revealed the possibility in which the 1st and 2nd survey results of BOD and COD in the Doke Hta Waddy River were higher than the real values. While the result of local laboratories showed harmful heavy metals such as total mercury, they were not detected in Japan.

As a conclusion, the chemical analysis results varied significantly among the local laboratories, and it was not possible to determine any reliable local laboratories.



Source: JICA Expert Team

Figure 4.3-1 Comparative Analysis Among Laboratories

4.4 Improvement of data quality

It was quite difficult to get reliable data for ambient water quality in Myanmar. To achieve the main purpose of the survey (i.e., to acquire reliable water quality data that will be used to develop water pollution control measures in the target pilot study areas), the survey should be repeated and analysis should be outsourced to overseas labs in the second half of Project period. Based on the lessons learned in the past surveys, JET discussed with C/Ps and decided to outsource the laboratory analysis for most measurement parameters in the 4th and 5th surveys to a certificated laboratory in Japan except BOD and total coliform, which were analyzed in local laboratories in Yangon since the samples for these parameters cannot be preserved for a long time and they require immediate analysis work.

In the 4th and 5th surveys, overall, the data reliability was totally improved. The precision can be estimated by the duplicate analysis results shown in table below. The difference of duplicate samples was almost less than 20%, which was set as a tentative target value for quality control in the surveys. The bigger difference still existed for BOD, total coliform and COD at several sampling points or sampling times. Especially for total coliform, it was apparently because the growth rate of bacteria can extremely increase or decrease for short time along a logarithmic curve. However, it should be noted that the 4th and 5th survey data contains such wide range of data variation.

Table 4.4-1 Improvement of Data Quality in Surveys

No.	Parameter	Unit	4th survey			5th survey			4th survey			5th survey		
			H5	Duplicate Sample (same as H5)	Difference (%)	H5	Duplicate Sample (same as H5)	Difference (%)	DHWD1	Duplicate Sample (same as DHWD1)	Difference (%)	DHWD1	Duplicate Sample (same as DHWD1)	Difference (%)
1	BOD	mg/L	1.26	1.77	34	2.91	3.39	15	5.4	4.2	25	4.74	5.03	6
2	Total Coliform	MPN/ 100ml	92000	35000	90	54000	160000	99	92,000	54,000	52	610	680	11
3	Total Suspended Solids	mg/L	330	320	3.1	1400	1400	0	14	17	19	4.0	4.6	14
4	COD Cr	mg/L	10	12	18	71	57	22	5.3	4.6	14	5.2	3.4	42
5	Cyanide(total)	mg/L	< 0.1	< 0.1	-	< 0.1	< 0.1	-	< 0.1	< 0.1	-	< 0.1	< 0.1	-
6	Oil and grease	mg/L	< 1	< 1	-	2.2	2.2	0	< 1	< 1	-	< 1	< 1	-
7	Phenols	mg/L	< 0.005	< 0.005	-	< 0.005	< 0.005	-	< 0.005	< 0.005	-	< 0.005	< 0.005	-
8	Total phosphorus	mg/L	0.14	0.14	0.0	0.32	0.31	3	< 0.06	< 0.06	-	< 0.06	< 0.06	-
9	Total nitrogen	mg/L	1.1	1.1	0.0	1.2	1.6	29	0.30	0.27	11	0.27	< 0.25	-
10	Zinc	mg/L	0.049	0.053	7.8	0.21	0.20	5	0.0081	0.0094	15	< 0.005	< 0.005	-
11	Total chromium	mg/L	0.038	0.040	5.3	0.17	0.16	6	0.0058	0.0050	14	< 0.005	< 0.005	-
12	Chromium (Hexavalent)	mg/L	< 0.005	< 0.005	-	< 0.005	< 0.005	-	< 0.005	< 0.005	-	< 0.005	< 0.005	-
13	Arsenic	mg/L	0.0030	0.0030	0.0	0.024	0.028	15	0.0016	0.0019	17	0.0023	0.0022	4
14	Copper	mg/L	0.016	0.016	0.0	0.071	0.067	6	< 0.005	< 0.005	-	< 0.005	< 0.005	-
15	Total Mercury	mg/L	< 0.0005	< 0.0005	-	< 0.0005	< 0.0005	-	< 0.0005	< 0.0005	-	< 0.0005	< 0.0005	-
16	Cadmium	mg/L	< 0.001	< 0.001	-	< 0.001	< 0.001	-	< 0.001	< 0.001	-	< 0.001	< 0.001	-
17	Lead	mg/L	0.0083	0.0086	3.6	0.039	0.041	5	< 0.005	< 0.005	-	< 0.005	< 0.005	-

Note: More than 20% of difference is highlighted by yellow.

Source: JICA Expert Team

4.5 Recommendations for quality control

From the experience on improvement of monitoring data quality in the surveys, several measures are suggested to secure the reliability of environmental monitoring system to be developed in Myanmar as follows.

One of the reasons why there are significant variations of analysis results among local laboratories is that each laboratory applies different analysis method including simplified methods and originally-developed methods. Several advanced laboratories apply internationally-recognized and reliable analytical methods for some analytical parameters, but not for all parameters. A technical guideline for environmental water monitoring needs to be developed by a responsible government authority to ensure monitoring quality in Myanmar. Monitoring methodologies especially for analysis method should be standardized and specified for each measurement parameter.

In addition, it seemed some laboratories have difficulties in conforming to each step of a procedure and requirement specified in the original analysis method, apparently due to lack of understanding of analysis method, insufficient skill and unavailability of reagent and apparatus. It is essential to establish a wide range of QA/QC (Quality Assurance/Quality Control) system that will ensure appropriate data management in a laboratory, implementation of proficiency test and cross-check, as well as establishment of accreditation system of laboratories, such as ISO17025.

5 OVERALL CONCLUSIONS AND RECOMMENDATIONS

5.1 Overall conclusions of water quality surveys

The surface water quality in the main rivers and creeks receiving the industrial wastewater was investigated in the Hlaing River basin and Doke Hta Waddy River basin. The main surveys covered total 10 sampling points in the Hlaing River basin and 15 points in the Doke Hta Waddy River basin in rainy season and dry season from late 2017 to early 2018.

In the Hlaing River in Yangon, although the river water is highly turbid and moderately polluted by wastewater, the water quality is acceptable for conservation of aquatic life, irrigation and water transportation for most measurement parameters. However, deterioration of water quality in the dry season is obvious. The main pollutants are organic matter, nutrients and slight level of oil and grease among the surveyed parameters. One concern is the hypoxic water area with higher COD and suspended solid observed at some points. On the other hand, the creek flowing in the Shwe Pyi Thar IZ is significantly polluted when it directly receives the industrial wastewater containing high pollutants. The pollution from creek can be diluted when it flows into the Hlaing River and the pollution impact seems limited due to high dilution factor. However, as the water quality in the Hlaing River is deteriorated when the flow rate is deceased in the dry season, the Hlaing River would hardly alleviate the pollution load from various pollution source in the basin. The environmental risk in the surface water could be higher if the pollution control measures at the pollution source are not well managed.

In the Doke Hta Waddy River in Mandalay, the river maintains adequate water quality for domestic water supply with simple treatment facility. The pollution impact discharged through 10-inch pipeline from Pyi Gyi Tagon IZ seemed limited and reduced apparently due to tentative shut-down of distilleries and other measures, but wastewater still contains organic and nutrients pollutants as well as oil and grease and phenols, etc. On the other hand, another important public water body, Taung Tha Man Lake is eutrophic manifested by high phosphorus, nitrogen and COD as well as lower DO. The water quality in the lake is significantly deteriorated in the dry season. When the lake water level become quite low, the nutrients level highly exceeded the acceptable level to prevent eutrophication in the lake. Especially the northern part of lake can be hypereutrophic, receiving the wastewater from the inflowing creeks. The lake still have a potential risk of fish-kill incidents if hypoxic condition is exacerbated. Since the water quality in the lake has changed or fluctuated dramatically over time or by season, more monitoring data will be necessary to examine the mechanism of water pollution in the lake.

To date, the pollution in the surface water in the target area was mainly concerned with the organic pollutions and nutrients. The elevated level of toxic substances was not observed within the scope of survey. However, the environmental risk in the surface water could be higher as more factories set up in the wider area of industrial sector invest to IZ. It is crucial to develop a regular water quality monitoring program in Myanmar in the near future to figure out the water environmental status and enforce appropriate measures necessary for environmental conservation.

5.2 Recommendations

Based on these findings, the following recommendations were derived from Water Qualtiy Surveys.

(1) Improvement of monitoring data quality in Myanmar

The quality control of survey data was a big challenge in the first half of the Project. The validation process of analytical data revealed that the analytical results had wide variation among local laboratories. The capacity improvement of laboratories in Myanmar is one of the key challenges to acquire reliable data. Technical guidance for environmental analysis laboratories should be provided. The required measures include the standardization of environmental analytical method of laboratories, establishment of accrediation system of laboratories and so forth. In addition, it is also crucial to obtain more reliable environmental surface water quality data in a wider area in Myanmar so that the obtained data at specific site can be compared with the data of different areas or times, which will help to validate the monitoring data.

(2) Development of proper water environmental standard

National Enivironmental Quality Standards including surface water quality standard is under the development of ECD/MONREC. The surface water qualtiy standard should have a proper criteria that is adequate for characterization and water usage, etc. of each water body. It is recommended to utilize these monitoring data acquried from Water Qualiry Sureys in this Project for examination to establish a propoer surface water qualtiy standard in Myanmar.

(3) Regular surface water monitoring in wider scope

The spatial and temporal changes of surface water quality in targeted water bodies are not clear in detail. The water quality data in surveys under this Project may have been affected by specific event such as soil erosion, temporal discharged wastewater and sand excavation activities, etc. In addition, the water quality not only would have seasonal variation but also other variation on monthly or daily basis. Only two-times-per-year sampling survey cannot reveal the mechanisms and reasons for such variation. More sampling frequency to acquire at least monthly data for representative points and parameters will be required in terms of environmental water quality monitoring. The monitoring is required not only to investigate the current water quality but also to predict the change in water environment and to predict the impact by any environmental changes including increased economic activity in industries. It is suggested that regular water quality montioring be planned, conducted and reported by responsible authorities in order to enforce the necessary pollution control measures.

(4) Investigation of mechanism of water pollution in a specific target area

More monitoring data is also required to examine the mechanism of water pollution in specific rivers and lakes. The water status and hydorogical mechanism in tidal area of Hlaing River are complicated and not clear. A depth-direcion survey in daily and monthly tidal cycle in differenct season is necessary to clairfy how the water quality is changed by tidal current. The eutrophication mechanism in Taung Tha Man lake has also not been investigated for: how the nutients inflow to the lake, how the oxygen in the water is consumed and how the nitrogen and phosphorus are cycled among the sediment, water, phytoplankton and other medium. It is essencil to clarify these meachnisms to conserve the river and lake environment.

References

JICA, Nippon Koei Co., Ltd., Overseas Coastal Area Development Institute of Japan, The urgent project for rehabilitation of Yangon port and main inland water transport in the Republic of the Union of Myanmar final report, 2015

JICA Expert Team, Water Qualtiy Survey Plan for Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar, 2018

USEPA, Nutrient Criteria Technical Guidance Manual, 2000

Appendices

Appendix 1 Photo Gallery

Hlaing River Basin

	
Hlaing River	Pan Hlaing River
	
Oil Leaking in Hlaing River (nearby H-5)	Sub-stream of Hlaing River (Shwe-1)
	
Creek in Shwe Pyi Thar IZ IZ in Yangon (Shwe-5)	Pipeline discharged the wastewater in the Creek (upstream of Shwe-3)

Source: JICA Expert Team

Doke Hta Waddy River Basin

Doke Hta Waddy River

Wastewater discharged from 10-inch pipeline (DP)

Taung Tha Man Lake

Waterweed at U Shwe Taung Bridge

Aeration pump in Columbo Creek

Pa Yan Taw Creek

Source: JICA Expert Team

Appendix 2 Sediment Analysis Results

Parameter	Result		Sediment Quality Guidelines for the Protection of Aquatic life in Canada	
			Freshwater	
	N. TTM Lake	S. TTM Lake	ISQL	PEL
	mg/kg	mg/kg	mg/kg-dry weight	mg/kg-dry weight
Chromium Hexavalent	0.07	0.11	-	-
Chromium(total)	-	-	37.3	90
Arsenic	4.701	3.543	5.9	17
Cadmium	0.133	0.162	0.6	3.5
Copper	41.762	35.261	35.7	197
Iron	56,300	56,000	-	-
Lead	68.532	100.874	35	91.3
Manganese	839.935	791.891	-	-
Mercury	<0.010	<0.010	0.17	0.486
Nickel	53.617	53.746	-	-
Selenium	0.267	<0.185	-	-
Zinc	151.003	153.834	123	315

equal to or more than ISQL
equal to or more than PEL

Appendix 3 Results of Comparative Analysis Program

Parameters	Location	Myanmar Governmental Labs.								Myanmar Private Lab.			Others		Japanese Lab	CV(%)
		Lab. A	Lab. B	Lab. C	Lab. D	Lab. E	Lab. F	Lab. G	Lab. H	Lab. I	Lab. J	Lab. K	Lab. L(Myanmar and Thailand)	Lab. M（Thailand)	Lab. N	
BOD (mg/L)	H1C	14.2	-	0.5	-	47.9	-	67	-	22	<2	2.52	6	6.47	0.6	127
	H5C	0	-	0.30	-	49.7	-	80.5	-	38	<2	2.07	5.7	7.75	0.9	141
	DHWD1	35.2	-	0.10	-	52.09	-	-	3.90	12	<2	2.03	5.2	1.64	0.5	148
	NTTM	43.3	-	16.20	-	47.3	-	-	38	10	37	20.9	31.8	26.33	22	42
COD (mg/L)	H1C	0	-	3.84	-	1.9	-	97	-	64	<10	<0.7	136	10.9	7	131
	H5C	0	-	11.52	-	33.0	-	150	-	96	74	<0.7	100	14.53	9	97
	DHWD1	0	-	1.92	-	1.4	-	-	10	32	<10	<0.7	112	7.26	4	181
	NTTM	108	-	38.40	-	221.1	-	-	95	32	125	116.0	124	76.27	90	52
Total Nitrogen (mg/L)	H1C	-	-	-	-	-	-	-	-	-	<1	2	0.57	<0.05	0.51	-
	H5C	-	-	-	-	-	-	-	-	-	1.12	4.5	0.89	<0.05	0.66	-
	DHWD1	-	-	-	-	-	-	-	1.129	-	<1	0.4	0.40	<0.05	0.28	-
	NTTM	-	-	-	-	-	-	-	2.258	-	5.88	6.5	5.31	3.87	4.4	-
Total phosphorus (mg/L)	H1C	-	-	-	-	-	-	-	-	-	<0.01	0.363	0.05	0.1	0.16	-
	H5C	-	-	-	-	-	-	-	-	-	<0.01	1.240	0.05	0.11	0.13	-
	DHWD1	-	-	-	-	-	-	-	0.359	-	0.746	<0.05	0.01	<0.1	0.008	-
	NTTM	-	-	-	-	-	-	-	1.435	-	0.882	1.300	1.09	1.24	1.4	-
Cadmium (mg/L)	H1C	0.747	<0.001	0.001	-	-	-	-	-	-	-	<0.001	<0.003	<0.0005	<0.001	-
	H5C	1.003	<0.001	0.005	-	-	-	-	-	-	-	<0.001	<0.003	<0.0005	<0.001	-
	DHWD1	0.483	<0.001	0.003	-	-	-	-	-	-	-	<0.001	<0.003	<0.0005	<0.001	-
	NTTM	1.05	<0.001	0.002	-	-	-	-	-	-	-	<0.001	<0.003	<0.0005	<0.001	-
Lead (mg/L)	H1C	<0.001	0.04	0.021	0.01765	-	0.2	-	-	<0.01	-	<0.002	<0.010	<0.0005	0.005	-
	H5C	<0.001	0.05	0.032	0.02749	-	0.2	-	-	<0.01	-	<0.002	<0.010	<0.0005	0.005	-
	DHWD1	<0.001	0.04	0.029	0.01487	-	-	-	-	<0.01	-	0.008	<0.010	<0.0005	<0.005	-
	NTTM	<0.001	0.05	0.038	0.01732	-	-	-	-	<0.01	-	0.008	<0.010	<0.0005	<0.005	-
Mercury (mg/L)	H1C	2.17	-	-	-	-	-	-	-	-	-	<0.00054	<0.0002	<0.0005	<0.0005	-
	H5C	0	-	-	-	-	-	-	-	-	-	0.004	0.0035	0.0005	<0.0005	-
	DHWD1	5.751	-	-	-	-	-	-	-	-	-	<0.00054	<0.0002	<0.0005	<0.0005	-
	NTTM	8.747	-	-	-	-	-	-	-	-	-	0.001	<0.0002	<0.0005	<0.0005	-

H1C: Upstream of Hlaing River, H5C: Downstream of Hlaing River,
DHWD1: Upstream of Doke Hta Waddy River, NTTM: Northern Thaung Tha Man Lake

Appendix 4 Laboratory Test Reports

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709237
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : WTY
Sample No. : W-1709175
Waste Profile No. : -
Sampling Date : 20 September, 2017
Sampling By : Customer
Sample Received Date : 20 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	2.30	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	35000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

Approved By :

Tomoya Suzuki
Director

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709230
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : H 1 | Sampling Date : 19 September, 2017
Sample No. : W-1709145 | Sampling By : Customer
Waste Profile No. : - | Sample Received Date : 19 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	1.16	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

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GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709229
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : H 3
Sample No. : W-1709144
Waste Profile No. : -
Sampling Date : 19 September, 2017
Sampling By : Customer
Sample Received Date : 19 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	1.80	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

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Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709232
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : H 5
Sample No. : W-1709147
Waste Profile No. : -
Sampling Date : 19 September, 2017
Sampling By : Customer
Sample Received Date : 19 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	1.26	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	92000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

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Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709231
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : PH 1
Sampling Date : 19 September, 2017
Sample No. : W-1709146
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 19 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	1.57	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709233
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : PH 2
Sampling Date : 19 September, 2017
Sample No. : W-1709148
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 19 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	0.72	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	54000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709238
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : S 1
Sample No. : W-1709176
Waste Profile No. : -
Sampling Date : 20 September, 2017
Sampling By : Customer
Sample Received Date : 20 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	5.41	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709239
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : S 3
Sampling Date : 20 September, 2017
Sample No. : W-1709177
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 20 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	5.94	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709236
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : S 5
Sampling Date : 20 September, 2017
Sample No. : W-1709174
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 20 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	32.07	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709235
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Kokkowa
Sampling Date : 20 September, 2017
Sample No. : W-1709173
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 20 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	3.72	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	4600	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201709234
Revision No. : 1
Report Date : 26 September, 2017
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : UKY
Sample No. : W-1709149
Waste Profile No. : -
Sampling Date : 19 September, 2017
Sampling By : Customer
Sample Received Date : 19 September, 2017

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	1.77	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	35000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB
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ANALYSIS REPORT

PROJECT	: JICA WATER SERVEY		
CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: DHWD-1		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 3, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 10:20 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA248/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00248/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			DHWD-1
			LAA248/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	92,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	5.4
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

SM : STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, APHA, AWWA, WEF, 22nd EDITION, 2012.

Toe Toe Hlaing
(MS TOE TOE HLAING)
LABORATORY HEAD
DATE OCTOBER 30,2017

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Tel. 959 7301 3448, 959 5144005, 959 5376382
www.rem-uaeconsultant.com E-mail: contact@rem-uaeconsultant.com

ANALYSIS REPORT

PROJECT	: JICA WATER SERVEY		
CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: DHWD-2		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 3, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 11:30 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA249/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00249/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			DHWD-2
			LAA249/2017
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	4.5
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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ANALYSIS REPORT

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CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: MYINT NGE		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 3, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 02:11 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA260/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00260/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT MYINT NGE LAA260/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	160,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	1.1
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: DP		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 3, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 12:00 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA250/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00250/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			DP
			LAA250/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	> 160,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	11.0
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/ TURBID
SEDIMENT			BROWN

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ANALYSIS REPORT

PROJECT	: JICA WATER SERVEY		
CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: LKP BRIDGE		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 04:10 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA261/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00261/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			LKP BRIDGE
			LAA261/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	35,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	2.7
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: UST BRIDGE		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 04:50 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA254/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00254/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			UST BRIDGE
			LAA254/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	>160,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	5.6
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BLACK

SM : STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, APHA, AWWA, WEF, 22nd EDITION, 2012.

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ANALYSIS REPORT

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ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: TT BRIDGE		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 02:36 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA246/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00246/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT TT BRIDGE LAA246/2017
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	4.8
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BLACK

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ANALYSIS REPORT

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CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: PYTC-62nd STR		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 11:50 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA252/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00252/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			PYTC-62nd STR
			LAA252/2017
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	2.3
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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PROJECT	: JICA WATER SERVEY		
CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: PYTC-1		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 03:30 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA259/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00259/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT PYTC-1 LAA259/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	>160,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	5.1
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BLACK

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DATE OCTOBER 30,2017

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ANALYSIS REPORT

PROJECT	: JICA WATER SERVEY		
CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: N-TTML		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 3, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 04:11 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA247/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00247/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			N-TTML
			LAA247/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	17,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	6.0
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: S-TTML		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 3, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 04:40 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA255/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00255/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT S-TTML LAA255/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	24,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	5.4
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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ANALYSIS REPORT

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CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: PTM BRIDGE		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 10:40 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA258/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00258/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			PTM BRIDGE
			LAA258/2017
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	6.6
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: AFTER AERATION-2		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 12:55 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA256/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00256/2017

PARAMETER	**UNIT**	**METHOD OF ANALYSIS**	**RESULT**
			AFTERAERATION-2
			LAA256/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	>160,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	3.9
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

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PROJECT	: JICA WATER SERVEY		
CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: SK CREEK		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 2, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 09:53 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA257/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00257/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			SK CREEK
			LAA257/2017
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	1.6
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

SM : STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, APHA, AWWA, WEF, 22nd EDITION, 2012.

Toe Toe Hlaing
(MS TOE TOE HLAING)
LABORATORY HEAD
DATE OCTOBER 30,2017

- **DO NOT COPY PARTIAL OF THIS ANALYSIS REPORT WITHOUT OFFICIAL APPROVAL.**
- **REPORTED ANALYSIS REFERS TO SUBMITTED SAMPLE ONLY.**

REM-UAE LABORATORY AND CONSULTANT COMPANY LIMITED

REM-UAE Laboratory and Consultant Co., Ltd.
B702 Delta Plaza, Shwegondaing Road, Bahan, Yangon, 11201, Myanmar.
Tel. 959 7301 3448, 959 5144005, 959 5376382
www.rem-uaeconsultant.com E-mail: contact@rem-uaeconsultant.com

ANALYSIS REPORT

PROJECT : JICA WATER SERVEY

CUSTOMER NAME : SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD

ADDRESS : NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212

SAMPLING SOURCE : INTAKE AYWD

SAMPLE TYPE : SURFACE WATER

SAMPLING DATE : OCTOBER 2, 2017

SAMPLING TIME : 08:45 HOUR

SAMPLING METHOD : GRAB

SAMPLING BY : SEAM

SUBMITTAL/ RECEIPT NO. :

RECEIVED DATE : OCTOBER 4,2017

ANALYSIS DATE : OCTOBER 4-25, 2017

ANALYSIS NO. : LAA251/2017

REPORT NO. : L00251/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			INTAKE AYWD
			LAA251/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	92,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	5.4
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

SM : STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, APHA, AWWA, WEF, 22nd EDITION, 2012.

Toe Toe Hlaing
(MS TOE TOE HLAING)
LABORATORY HEAD
DATE OCTOBER 30,2017

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ANALYSIS REPORT

PROJECT	: JICA WATER SERVEY		
CUSTOMER NAME	: SOCIAL AND ENVIRONMENTAL ASSOCIATES-MYANMAR CO.,LTD		
ADDRESS	: NO.76, MYITZUTHAKA STREET, SECTOR 4, PAUK KONE. MINGALARDON TOWNSHIP, YANGON, TEL +959454017212		
SAMPLING SOURCE	: UK-M		
SAMPLE TYPE	: SURFACE WATER	**SUBMITTAL/ RECEIPT NO.**	:
SAMPLING DATE	: OCTOBER 3, 2017	**RECEIVED DATE**	: OCTOBER 4,2017
SAMPLING TIME	: 10:20 HOUR	**ANALYSIS DATE**	: OCTOBER 4-25, 2017
SAMPLING METHOD	: GRAB	**ANALYSIS NO.**	: LAA253/2017
SAMPLING BY	: SEAM	**REPORT NO.**	: L00253/2017

PARAMETER	UNIT	METHOD OF ANALYSIS	RESULT
			UK-M
			LAA253/2017
TOTAL COLIFORM BACTERIA	MPN/100 mL	MULTIPLE TUBE FERMENTATION TECHNIQUE (SM 2012:9221 B)	54,000
BIOCHEMICAL OXYGEN DEMAND	mg/L	MEMBRANE ELECTRODE METHOD (SM 2012:5210 B AND 4500-O G)	4.2
SAMPLE CONDITION			
WATER'S COLOUR/TURBID			BROWN/TURBID
SEDIMENT			BROWN

SM : STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, APHA, AWWA, WEF, 22nd EDITION, 2012.

Toe Toe Hlaing
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LABORATORY HEAD
DATE OCTOBER 30,2017

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Result of analysis

"Analysis for Output 2 in Japan"

Water of Hlaing River basin (Yangon)
Sampling Date : From 18-Sep-2017 To 20-Sep-2017

Doke Hta Waddy River basin (Mandalay)
Sampling Date : From 2-Oct-2017 To 3-Oct-2017

Analysis Report

To: NIPPON KOEI Co., Ltd.
1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN
TEL : +81-3-5276-3930 Fax : +81-3-5276-3024

No. A17I0403-1E
Date: 30-Oct-2017

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20-17,Gokanme-chou,Seya-ku,
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246-0008,Japan
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FAX : +81-45-924-1055

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 21-Sep-2017
Sample Name : No.1 Wataya
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Sep-2017
Analysis period : From 21-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	420	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	11	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.16	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.0	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.054	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.048	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0026	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.017	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0097	0.005	JIS K0102(2016) 54.4
PCBs	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 3
Remarks	Location name : Wataya			

Environmental Certified Public Measurer :
Tomoki Kotani
Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
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No. A17I0404-1E
Date: 30-Oct-2017

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 20-Sep-2017
Sample Name : No.2 H1
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 18-Sep-2017
Analysis period : From 20-Sep-2017 To 4-Oct-2017

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Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	390	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	14	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.19	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.1	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.060	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.048	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0028	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.019	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0098	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Hlaing-1-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 20-Sep-2017
Sample Name : No.3 H3
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 18-Sep-2017
Analysis period : From 20-Sep-2017 To 3-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	440	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	14	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.16	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.2	0.25	JIS K0102(2016) 45.2
		- Blank -		
Remarks	Location name : Hlaing-3-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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No. A17I0406-1E
Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 20-Sep-2017
Sample Name : No.4 H5
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 18-Sep-2017
Analysis period : From 20-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	330	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	10	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.14	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.1	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.049	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.038	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0030	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.016	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0083	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Hlaing-5-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN
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No. A17I0407-1E
Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 20-Sep-2017
Sample Name : No.5 PH1
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 18-Sep-2017
Analysis period : From 20-Sep-2017 To 3-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	230	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	14	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.18	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.4	0.25	JIS K0102(2016) 45.2
		- Blank -		
Remarks	Location name : Pan Hlaing-1-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
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No. A17I0408-1E
Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 20-Sep-2017
Sample Name : No.6 PH2
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 18-Sep-2017
Analysis period : From 20-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	290	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	12	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.13	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.83	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.040	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.038	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0020	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.020	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0070	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Pan Hlaing-2-C			

Environmental Certified Public Measurer :

Tomoki Kotani

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Analysis Report

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No. A17I0409-1E
Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 21-Sep-2017
Sample Name : No.7 Shwe1
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Sep-2017
Analysis period : From 21-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	180	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	19	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.18	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.3	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.032	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.024	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0019	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.013	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Shwe-1-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN
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No. A17I0410-1E
Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 21-Sep-2017
Sample Name : No.8 Shwe3
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Sep-2017
Analysis period : From 21-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	27	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	22	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.22	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	2.0	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.021	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0012	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Shwe-3-C			

Environmental Certified Public Measurer :

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Analysis Report

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Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 21-Sep-2017
Sample Name : No.9 Shwe5
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Sep-2017
Analysis period : From 21-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	25	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD_{Cr}	mg/L	44	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	1.3	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.65	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	4.9	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.042	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.010	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0033	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.014	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Shwe-5-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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No. A17I0412-1E
Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 21-Sep-2017
Sample Name : No.10 Kokkowa
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 20-Sep-2017
Analysis period : From 21-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	120	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	8.3	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.089	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.71	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.029	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.019	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0016	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.010	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Kokkowa			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 20-Sep-2017
Sample Name : No.11 UK-Y
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 18-Sep-2017
Analysis period : From 20-Sep-2017 To 4-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	320	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	12	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.14	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.1	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.053	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.040	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0030	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.016	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0086	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Unknown			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 21-Sep-2017
Sample Name : No.1 Wataya
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Sep-2017
Analysis period : From 21-Sep-2017 To 5-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name :Wataya (*) Method :Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

Environmental Certified Public Measurer :

Tomoki Kotani

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 21-Sep-2017
Sample Name : No.10 Kokkowa
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 20-Sep-2017
Analysis period : From 21-Sep-2017 To 5-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name : Kokkowa (*) Method : Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.1 DHWD1
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 3-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	14	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	5.3	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	< 0.06	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.30	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0081	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0058	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0016	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Upstream of the wastewater-discharging point			

Environmental Certified Public Measurer :

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Analysis Report

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No. A17J0123-1E

Date: 30-Oct-2017

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

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Sample Received : 6-Oct-2017

Sample Name : No.2 DHWD2

Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)

Sampling Date : 3-Oct-2017

Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	16	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD_{Cr}	mg/L	6.0	1	JIS K0102(2016) 20.1
		- Blank -		
Remarks	Location name : Downstream of the wastewater-discharging point			

Environmental Certified Public Measurer :

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Analysis Report

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No. A17J0124-1E
Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.3 Myint Nge Bridge
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 3-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	22	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	4.2	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	< 0.06	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.34	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0098	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0019	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Myint Nge Bridge in DHW River			

Environmental Certified Public Measurer :

Tomoki Kotani

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.4 DP
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 3-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	86	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	150	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	9.1	1	Standard Method 5520 B
Phenols	mg/L	0.012	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.32	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	2.8	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.014	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0050	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0033	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.016	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0056	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Discharging point			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.5 LKP Stream
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	7.8	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	17	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.10	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.60	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.010	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0040	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Let Khot Pin stream			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017

Sample Name : No.6 UST Bridge

Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)

Sampling Date : 2-Oct-2017

Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	22	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	31	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.31	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	2.0	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.016	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.011	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0041	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.0097	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0051	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : U shwe Taung Bridge			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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Date: 30-Oct-2017

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.7 TT Bridge
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

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Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	28	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	34	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.39	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	3.0	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0096	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0034	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Tagon Taing Bridge			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.8 PYTC-62nd Str.
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	68	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	23	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.28	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	2.1	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.014	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0054	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0032	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Pa Yan Taw Creek (on 62nd street,upstream from Pyi Gyi Tagon IZ)			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.9 PYTC-1
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	36	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	32	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.31	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	2.1	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.011	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0054	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0035	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Pa Yan Taw Creek 1 (Myo Ma Aung Myin Street)			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.10 After-aeration
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	28	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	70	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	0.0086	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	2.7	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	18	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.018	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0050	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0041	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : After-aeration in Columbo creek			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.11 N-TTML
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 3-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	15	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	28	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.38	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	2.0	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0074	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0037	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Northern Thaung Tha Man Lake			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.12 S-TTML
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 3-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	14	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	28	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.36	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.7	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0050	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0042	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Southern Thaung Tha Man Lake			

Environmental Certified Public Measurer :
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Analysis Report

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Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017

Sample Name : No.13 PTM Bridge

Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)

Sampling Date : 2-Oct-2017

Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	44	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	14	1	JIS K0102(2016) 20.1
Total phosphorus (T-P)	mg/L	0.063	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.63	0.25	JIS K0102(2016) 45.2
		- Blank -		
Remarks	Location name : Paw Taw Muu Bridge (Upstream in PYTC, after confluence)			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.14 SK Creek
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	62	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD_{Cr}	mg/L	15	1	JIS K0102(2016) 20.1
Total phosphorus (T-P)	mg/L	0.20	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.2	0.25	JIS K0102(2016) 45.2
		- Blank -		
Remarks	Location name : Shwe Kyin Creek (86street)			

Environmental Certified Public Measurer :

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Analysis Report

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Date: 30-Oct-2017

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.15 Intake AYWD
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	45	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	11	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.077	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.51	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0087	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0056	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0017	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
PCBs	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 3
Remarks	Location name : Intake point of Aye Yar Waddy River			

Environmental Certified Public Measurer :
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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017

Sample Name : No.16 UK-M

Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)

Sampling Date : 3-Oct-2017

Analysis period : From 6-Oct-2017 To 19-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	17	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	4.6	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	< 0.06	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.27	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0094	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0050	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0019	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Unknown			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN
TEL : +81-3-5276-3930 Fax : +81-3-5276-3024

No. A17J0138-1E
Date: 30-Oct-2017

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

OSUMI Co.,Ltd.
20-17,Gokanme-chou,Seya-ku,
Yokohama-city,Kanagawa
246-0008,Japan
TEL : +81-45-924-1050
FAX : +81-45-924-1055

Sample Received : 6-Oct-2017
Sample Name : No.1 DHWD1
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 3-Oct-2017
Analysis period : From 6-Oct-2017 To 24-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name :Upstream of the wastewater-discharging point (*) Method :Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

Environmental Certified Public Measurer :
Tomoki Kotani
Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
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No. A17J0139-1E
Date: 30-Oct-2017

OSUMI Co.,Ltd.
20-17,Gokanme-chou,Seya-ku,
Yokohama-city,Kanagawa
246-0008,Japan
TEL : +81-45-924-1050
FAX : +81-45-924-1055

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 6-Oct-2017
Sample Name : No.15 Intake AYWD
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 2-Oct-2017
Analysis period : From 6-Oct-2017 To 24-Oct-2017

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name : Intake point of Aye Yar Waddy River (*) Method : Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

Environmental Certified Public Measurer :
Tomoki Kotani
Tomoki Kotani

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201802151
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Wataya
Sampling Date : 20 February, 2018
Sample No. : W-1802116
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 21 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	3.70	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	610	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB
GEM

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

Approved By :

Tomoya Suzuki
Director

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201802142
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : H1
Sampling Date : 19 February, 2018
Sample No. : W-1802101
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 20 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	2.82	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Analysed By :
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Assistant supervisor

Approved By :
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Report No. : GEM-LAB-201802143
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description

Sample Name : H3
Sample No. : W-1802102
Waste Profile No. : -

Sampling Date : 19 February, 2018
Sampling By : Customer
Sample Received Date : 20 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	2.44	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

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Approved By :

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Report No. : GEM-LAB-201802145
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : H5
Sample No. : W-1802104
Waste Profile No. : -
Sampling Date : 19 February, 2018
Sampling By : Customer
Sample Received Date : 20 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	2.91	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	54000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
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Approved By :
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Report No. : GEM-LAB-201802144
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : PH1
Sampling Date : 19 February, 2018
Sample No. : W-1802103
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 20 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	44.61	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Analysed By :
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Approved By :
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Report No. : GEM-LAB-201802147
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : PH2
Sample No. : W-1802106
Waste Profile No. : -
Sampling Date : 19 February, 2018
Sampling By : Customer
Sample Received Date : 20 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	3.80	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	35000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Report No. : GEM-LAB-201802148
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Shwe-1 Sampling Date : 20 February, 2018
Sample No. : W-1802113 Sampling By : Customer
Waste Profile No. : - Sample Received Date : 21 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	267.57	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
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Approved By :
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Report No. : GEM-LAB-201802149
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Shwe-3
Sample No. : W-1802114
Waste Profile No. : -
Sampling Date : 20 February, 2018
Sampling By : Customer
Sample Received Date : 21 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	264.37	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

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Assistant supervisor

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Approved By :

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Director

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Report No. : GEM-LAB-201802150
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Shwe-5
Sample No. : W-1802115
Waste Profile No. : -
Sampling Date : 20 February, 2018
Sampling By : Customer
Sample Received Date : 21 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	133.97	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

Analysed By :
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Report No. : GEM-LAB-201802152
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Kokowa
Sample No. : W-1802117
Waste Profile No. : -
Sampling Date : 21 February, 2018
Sampling By : Customer
Sample Received Date : 21 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	5.73	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	930	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

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Analysed By :
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Approved By :
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Report No. : GEM-LAB-201802146
Revision No. : 1
Report Date : 27 February, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : UK-Y (H5) Sampling Date : 19 February, 2018
Sample No. : W-1802105 Sampling By : Customer
Waste Profile No. : - Sample Received Date : 20 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	3.39	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
Ni Ni Aye Lwin
Assistant supervisor

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Approved By :
Tomoya Suzuki
Director

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GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803016
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : DHWD-1
Sampling Date : 27 February, 2018
Sample No. : W-1802148
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	4.74	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	610	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
Ni Ni Aye Lwin
Assistant supervisor

LAB GEM

Approved By :
鈴木智也
Tomoya Suzuki
Director

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803017
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : DHWD-2
Sample No. : W-1802149
Waste Profile No. : -
Sampling Date : 27 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	5.65	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

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Approved By :

Tomoya Suzuki
Director

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803018
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Myint Nge Bridge
Sample No. : W-1802150
Waste Profile No. : -
Sampling Date : 27 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	4.72	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	1400	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

LAB GEM

Approved By :

鈴木 智也

Tomoya Suzuki
Director

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803010
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : DP
Sample No. : W-1802142
Waste Profile No. : -
Sampling Date : 27 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	175.90	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

LAB GEM

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

Approved By :

鈴木 智也

Tomoya Suzuki
Director

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803013
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : LKP Stream
Sample No. : W-1802145
Waste Profile No. : -
Sampling Date : 26 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	80.70	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

LAB GEM

Approved By :

鈴木智也

Tomoya Suzuki
Director

DOWA

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803014
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : UST Bridge — Sampling Date : 26 February, 2018
Sample No. : W-1802146 — Sampling By : Customer
Waste Profile No. : - — Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	348.38	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
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Approved By :

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803015
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : TT Bridge
Sample No. : W-1802147
Waste Profile No. : -
Sampling Date : 26 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	354.14	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
Ni Ni Aye Lwin
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Approved By :
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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803019
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : PYTC-62nd Str
Sample No. : W-1802151
Waste Profile No. : -
Sampling Date : 26 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	63.58	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

LAB GEM

Approved By :

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Report No. : GEM-LAB-201803020
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : PYTC-1
Sampling Date : 26 February, 2018
Sample No. : W-1802152
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	347.10	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
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Tomoya Suzuki
Director

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GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
Lot No. E1 ,ThilawaSEZ Zone A, Yangon Region, the Union of Myanmar
Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803021
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : After Aeration-2
Sample No. : W-1802153
Waste Profile No. : -
Sampling Date : 26 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	239.58	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803011
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : N-TTML
Sample No. : W-1802143
Waste Profile No. : -
Sampling Date : 27 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	356.70	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	> 160000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
Nd
Ni Ni Aye Lwin
Assistant supervisor

LAB GEM

Approved By :
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Tomoya Suzuki
Director

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803012
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : S-TTML
Sample No. : W-1802144
Waste Profile No. : -
Sampling Date : 27 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	22.62	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	24000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
Ni Ni Aye Lwin
Assistant supervisor

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Approved By :
Tomoya Suzuki
Director

GOLDEN DOWA ECO-SYSTEM MYANMAR CO., LTD.
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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803022
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : PTM Bridge
Sample No. : W-1802154
Waste Profile No. : -
Sampling Date : 26 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	9.76	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :
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Approved By :
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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803023
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : SK Creek
Sample No. : W-1802155
Waste Profile No. : -
Sampling Date : 26 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	86.78	0.00

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

LAB GEM

Approved By :

Tomoya Suzuki
Director

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803024
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : Intake AYWD
Sampling Date : 26 February, 2018
Sample No. : W-1802156
Sampling By : Customer
Waste Profile No. : -
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	4.74	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	35000	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

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Approved By :

鈴木智也

Tomoya Suzuki
Director

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Tel:01-2309051/ 09 796935149

Report No. : GEM-LAB-201803025
Revision No. : 1
Report Date : 8 March, 2018
Application No. : 0158-C001

Analysis Report

Client Name : Social & Environmental Associates-Myanmar
Address : No(76), Myitzuthaka Street, Sector 4, Paukkone, Mingalardon Tsp.
Project Name : JICA
Sample Description
Sample Name : UK-M
Sample No. : W-1802157
Waste Profile No. : -
Sampling Date : 27 February, 2018
Sampling By : Customer
Sample Received Date : 28 February, 2018

No.	Parameter	Method	Unit	Result	LOQ
1	BOD (5)	HACH Method 10099 (Respirometric Method)	mg/l	5.03	0.00
2	Total Coliform	APHA 9221B (Standard Total Coliform Fermentation Technique)	MPN/100ml	680	1.8

Remark : LOQ - Limit of Quantitation
APHA - American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater, 22nd edition

Analysed By :

Ni Ni Aye Lwin
Assistant supervisor

LAB
GEM

Approved By :

Tomoya Suzuki
Director

Result of analysis

"Analysis for Output 2 in Japan"

Water of Hlaing River basin (Yangon)
Sampling Date : From 19-Feb-2018 To 21-Feb-2018

Doke Hta Waddy River basin (Mandalay)
Sampling Date : From 26-Feb-2018 To 27-Feb-2018

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN
TEL : +81-3-5276-3930 Fax : +81-3-5276-3024

No. A18B0303-1E
Date: 27-Mar-2018

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

OSUMI Co.,Ltd.
20-17,Gokanme-chou,Seya-ku,
Yokohama-city,Kanagawa
246-0008,Japan
TEL : +81-45-924-1050
FAX : +81-45-924-1055

Sample Received : 22-Feb-2018
Sample Name : No.1 Wataya
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 20-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	980	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	25	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	1.2	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.19	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.92	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.13	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.11	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.011	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.045	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.024	0.005	JIS K0102(2016) 54.4
PCBs	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 3
Remarks	Location name : Wataya			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN
TEL : +81-3-5276-3930 Fax : +81-3-5276-3024

No. A18B0304-1E
Date: 27-Mar-2018

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

OSUMI Co.,Ltd.
20-17,Gokanme-chou,Seya-ku,
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TEL : +81-45-924-1050
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Sample Received : 22-Feb-2018
Sample Name : No.2 H1
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	250	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	20	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	1.6	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.29	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.64	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.052	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.034	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0051	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.014	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0066	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Hlaing-1-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**
1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN
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No. A18B0305-1E
Date: 27-Mar-2018

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TEL : +81-45-924-1050
FAX : +81-45-924-1055

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018
Sample Name : No.3 H3
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	1200	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	61	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	1.3	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.15	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.4	0.25	JIS K0102(2016) 45.4
		- Blank -		
Remarks	Location name : Hlaing-3-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

To: **NIPPON KOEI Co., Ltd.**

1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN

TEL : +81-3-5276-3930 Fax : +81-3-5276-3024

No. A18B0306-1E

Date: 27-Mar-2018

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

OSUMI Co.,Ltd.
20-17,Gokanme-chou,Seya-ku,
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TEL : +81-45-924-1050
FAX : +81-45-924-1055

Sample Received : 22-Feb-2018

Sample Name : No.4 H5

Offered Sample : Water of Hlaing River basin (Yangon)

Sampling Date : 19-Feb-2018

Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	1400	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	71	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	2.2	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.32	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.2	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.21	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.17	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.024	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.071	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.039	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Hlaing-5-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

To: NIPPON KOEI Co., Ltd.

1-14-16 Kudan-kita Chiyoda-ku, Tokyo 102-8539 JAPAN

TEL : +81-3-5276-3930 Fax : +81-3-5276-3024

No. A18B0307-1E

Date: 27-Mar-2018

OSUMI Co.,Ltd.
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TEL : +81-45-924-1050
FAX : +81-45-924-1055

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018

Sample Name : No.5 PH1

Offered Sample : Water of Hlaing River basin (Yangon)

Sampling Date : 19-Feb-2018

Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	98000	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	3400	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	2.0	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.42	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	92	0.25	JIS K0102(2016) 45.4
		- Blank -		
Remarks	Location name : Pan Hlaing-1-C			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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No. A18B0308-1E
Date: 27-Mar-2018

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018
Sample Name : No.6 PH2
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	1800	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	63	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	1.5	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.33	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.6	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.28	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.24	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.031	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.096	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.058	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Pan Hlaing-2-C			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018

Sample Name : No.7 Shwe1

Offered Sample : Water of Hlaing River basin (Yangon)

Sampling Date : 20-Feb-2018

Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	2400	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	4900	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	4.8	1	Standard Method 5520 B
Phenols	mg/L	1.1	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	9.7	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	130	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.46	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.24	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.038	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.18	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.066	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Shwe-1-C			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018
Sample Name : No.8 Shwe3
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 20-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	280	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	5700	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	3.5	1	Standard Method 5520 B
Phenols	mg/L	0.10	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	6.5	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	140	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.16	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.014	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0030	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.045	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Shwe-3-C			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018
Sample Name : No.9 Shwe5
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 20-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	12	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	230	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	2.1	1	Standard Method 5520 B
Phenols	mg/L	0.021	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	1.4	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	19	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.022	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0038	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.10	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Shwe-5-C			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018
Sample Name : No.10 Kokkowa
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 21-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	60	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	5.2	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	1.9	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.074	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.16	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.014	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.010	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0015	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.0054	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Kokkowa			

Environmental Certified Public Measurer :

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Analysis Report

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No. A18B0313-1E
Date: 27-Mar-2018

Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018
Sample Name : No.11 UK-Y
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 19-Feb-2018
Analysis period : From 22-Feb-2018 To 9-Mar-2018

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Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	1400	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	57	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	2.2	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.31	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.6	0.25	JIS K0102(2016) 45.4
Zinc (Zn)	mg/L	0.20	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.16	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.028	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.067	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.041	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Unknown			

Environmental Certified Public Measurer :

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Project Name	:	Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject	:	"Analysis for Output 2 in Japan"
Sample Received	:	22-Feb-2018
Sample Name	:	No.1 Wataya
Offered Sample	:	Water of Hlaing River basin (Yangon)
Sampling Date	:	20-Feb-2018
Analysis period	:	From 22-Feb-2018 To 12-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name :Wataya (*) Method :Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 22-Feb-2018
Sample Name : No.10 Kokkowa
Offered Sample : Water of Hlaing River basin (Yangon)
Sampling Date : 21-Feb-2018
Analysis period : From 22-Feb-2018 To 12-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name : Kokkowa (*) Method : Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.1 DHWD1
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	4.0	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	5.2	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	< 0.06	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	0.27	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	< 0.005	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0023	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Upstream of the wastewater-discharging point			

Environmental Certified Public Measurer :

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Analysis Report

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No. A18C0002-1E
Date: 27-Mar-2018

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.2 DHWD2
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	< 4	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD_{Cr}	mg/L	2.8	1	JIS K0102(2016) 20.1
		- Blank -		
Remarks	Location name : Downstream of the wastewater-discharging point			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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No. A18C0003-1E
Date: 27-Mar-2018

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.3 Myint Nge Bridge
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	5.8	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	2.9	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	< 0.06	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	< 0.25	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	< 0.005	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0022	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Myint Nge Bridge in DHW River			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.4 DP
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	79	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD_{cr}	mg/L	660	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	2.4	1	Standard Method 5520 B
Phenols	mg/L	0.021	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	1.3	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	20	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.048	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0032	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.0098	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0050	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Discharging point			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.5 LKP Stream
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	38	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	63	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	1.2	1	Standard Method 5520 B
Phenols	mg/L	0.0053	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	1.3	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	5.1	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.017	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0091	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Let Khot Pin stream			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.6 UST Bridge
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	91	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	370	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	6.3	1	Standard Method 5520 B
Phenols	mg/L	0.14	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	3.1	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	24	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.065	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0052	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0056	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.012	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0064	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : U shwe Taung Bridge			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.7 TT Bridge
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	260	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	540	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	9.6	1	Standard Method 5520 B
Phenols	mg/L	0.057	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	4.0	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	37	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.12	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.018	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0074	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.032	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.013	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Tagon Taing Bridge			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.8 PYTC-62nd Str.
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	15	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	42	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	2.1	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	14	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0098	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0039	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Pa Yan Taw Creek (on 62nd street,upstream from Pyi Gyi Tagon IZ)			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.9 PYTC-1'
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	82	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	370	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	7.9	1	Standard Method 5520 B
Phenols	mg/L	0.025	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	2.5	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	17	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.047	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	0.0056	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0064	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.025	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.0058	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Pa Yan Taw Creek 1' (Myo Ma Aung Myin Street)			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.10 After-aeration
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	13	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	60	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	2.5	1	Standard Method 5520 B
Phenols	mg/L	0.0091	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	3.1	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	30	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.011	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0043	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : After-aeration in Columbo creek			

Environmental Certified Public Measurer :

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Analysis Report

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.11 N-TTML
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

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Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	51	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	280	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	0.050	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	4.3	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	25	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0072	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0048	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Northern Thaung Tha Man Lake			

Environmental Certified Public Measurer :

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.12 S-TTML
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	130	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD_{Cr}	mg/L	130	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	1.7	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	9.2	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.014	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.010	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	0.012	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Southern Thaung Tha Man Lake			

Environmental Certified Public Measurer :

Tomoki Kotani

Tomoki Kotani

Analysis Report

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No. A18C0013-1E
Date: 27-Mar-2018

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.13 PTM Bridge
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	89	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD_{cr}	mg/L	21	1	JIS K0102(2016) 20.1
Total phosphorus (T-P)	mg/L	0.15	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.4	0.25	JIS K0102(2016) 45.2
		- Blank -		
Remarks	Location name : Paw Taw Muu Bridge (Upstream in PYTC, after confluence)			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.14 SK Creek
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	58	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	20	1	JIS K0102(2016) 20.1
Total phosphorus (T-P)	mg/L	0.37	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	2.0	0.25	JIS K0102(2016) 45.2
		- Blank -		
Remarks	Location name : End of Shwe Kyin Creek			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar

Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018

Sample Name : No.15 Intake AYWD

Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)

Sampling Date : 26-Feb-2018

Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	50	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{Cr}$	mg/L	4.4	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	0.12	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	1.3	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	0.0078	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0013	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	0.014	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
PCBs	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 3
Remarks	Location name : Intake point of Aye Yar Waddy River			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.16 UK-M
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 15-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Total Suspended Solids (TSS)	mg/L	4.6	4	Environment Agency Notification No.59, 1971, Appendix, table 9
COD $_{cr}$	mg/L	3.4	1	JIS K0102(2016) 20.1
Cyanide(total)	mg/L	< 0.1	0.1	JIS K0102(2016) 38.1.2 and 38.3
Oil and grease	mg/L	< 1	1	Standard Method 5520 B
Phenols	mg/L	< 0.005	0.005	JIS K0102(2016) 28.1.1 and 28.1.2
Total phosphorus (T-P)	mg/L	< 0.06	0.06	JIS K0102(2016) 46.3.1
Total nitrogen (T-N)	mg/L	< 0.25	0.25	JIS K0102(2016) 45.2
Zinc (Zn)	mg/L	< 0.005	0.005	JIS K0102(2016) 53.3
Total chromium (T-Cr)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.1.4
Chromium (Hexavalent)	mg/L	< 0.005	0.005	JIS K0102(2016) 65.2.1
Arsenic (As)	mg/L	0.0022	0.001	JIS K0102(2016) 61.4
Copper (Cu)	mg/L	< 0.005	0.005	JIS K0102(2016) 52.4
Total Mercury (Hg)	mg/L	< 0.0005	0.0005	Environment Agency Notification No.59, 1971, Appendix, table 1
Cadmium (Cd)	mg/L	< 0.001	0.001	JIS K0102(2016) 55.4
Lead (Pb)	mg/L	< 0.005	0.005	JIS K0102(2016) 54.4
		- Blank -		
Remarks	Location name : Unknown			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.1 DHWD1
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 27-Feb-2018
Analysis period : From 1-Mar-2018 To 14-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name : Upstream of the wastewater-discharging point (*) Method : Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

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Project Name : Project for Capacity Development Project in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar
Subject : "Analysis for Output 2 in Japan"

Sample Received : 1-Mar-2018
Sample Name : No.15 Intake AYWD
Offered Sample : Water of Doke Hta Waddy River basin (Mandalay)
Sampling Date : 26-Feb-2018
Analysis period : From 1-Mar-2018 To 14-Mar-2018

Results of analysis are certified as follows:

Item	Unit	Result	Limit of Quantification	Method
Aldrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Atrazine	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDD	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDE	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
4,4'-DDT	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endosulfan sulfate	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Endrin	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-alpha	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-beta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-delta	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
HCH-gamma(Lindane)	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Alachlor	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Diazinon	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Chlorpyrifos	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Dimethoate	mg/L	< 0.0005	0.0005	LC-MS/MS (*See "Remarks")
Imidacloprid	mg/L	< 0.0005	0.0005	GC-MS (*See "Remarks")
Remarks	Location name :Intake point of Aye Yar Waddy River (*) Method :Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017" The results was analysed by outsource Nihon Ecotech Co.,Ltd.			

Environmental Certified Public Measurer :
Tomoki Kotani
Tomoki Kotani

Appendix 10-2:

Water Quality Survey Report prepared by ECD Yangon

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY REPORT FOR HLAING RIVER BASIN

FINAL VERSION

FEBURARY 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT YANGON REGION

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DEM	Digital Elevation Model
DO	Dissolved Oxygen
ECD	Environmental Conservation Department
EIA	Environment Impact Assessment
IZ	Industrial Zone
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
MOHS	Ministry of Health and Sports
MONREC	Ministry of Natural Resources and Environmental Conservation
TSS	Total Suspended Solid
YCDC	Yangon City Development Committee
EQEG	National Environmental Quality (Emission) Guidelines

EXECUTIVE SUMMARY

i) Background and Purpose

This project is a bilateral technical cooperation project between Myanmar and Japan with the aim to support and enhance capacities of Ministry of Natural Resources and Environmental Conservation (MONREC) and other relevant organizations concerned to manage water environment and to implement Environmental Impact Assessment (EIA) reviews. There are two main components in this project; water environmental management component with four outputs and EIA component with two outputs to be achieved. This report was prepared in the activities of output2 from water environment management component, which focuses on implementation of water quality survey in the Hlaing River Basin in Yangon. This report will discuss the result data from 3rd and 4th water quality surveys in the points of Hlaing 1, Hlaing 3, Hlaing 5, and Wataya which are located along the Hlaing River. The objective of this report is to assess the conditional and seasonal changes in water quality along Hlaing River. This report aims to align the goals of the water environment with the current status of the river through the on-site measurement and laboratory analysis. It is also expected to enhance the capacity for implementing water quality survey to obtain reliable information on the river water quality in the course of surveys.

ii) Findings

Among total five times surveys conducted in the Project, 4th survey result was mainly used to evaluate the water quality in the Hlaing River and 3rd survey result was used to be compared for evaluation of seasonal changes. The 3rd water quality survey was conducted in January 2017 and 4th water quality survey was conducted in September 2017. Regarding the sampling points, in order to confirm the water quality of Hlaing River before affected by domestic and industrial wastewater from the urban area of Yangon city, the water samples were taken from several points in the Hlaing River; the upstream point of the river before receiving the wastewater from several IZs (Wataya and H1), middle-stream point (H3), and downstream nearby Kyimyin Daing (H5).

The survey objective is to assess the pollution level as well as the conditional and seasonal changes in water quality along the Hlaing River. So, four main parameters such as BOD, COD, DO and TSS were measured in four points along Hlaing River (Wataya, H1, H3 and H5). The results of all of these parameters satisfied the required water quality level in comparing with Vietnam Environmental Standard. Compared between results of 3rd

and 4th water quality surveys, the results of BOD, COD and TSS in 3rd water quality survey representing the dry season were higher than the results in 4th water quality survey representing the rainy season because of the seasonal changes in dry and raining season.

iii) Conclusions and Recommendations

According to the result of 4th water quality survey, the values of specific parameters at Wataya, H1, H3 and H5 were within the standard value of Vietnam Environmental Standard (QCVN08.2015) Class - B2 for water transportation indicating Hlaing River is not significantly polluted at present. Compared between 3rd and 4th water quality surveys, the results of BOD, COD and TSS in 3rd water quality survey (dry season) are higher than that in 4th water quality survey (rainy season). Apparently it is because the water flow rate is lower in dry season and the pollutants would concentrate in the river. To identify the conditional changes of surface water quality in Hlaing River Basin, there will be necessary to acquired more monitoring data; monthly data or at least seasonal data over the years.

Another one finding is that when duplicate samples were analyzed for quality control, the results from 3rd survey showed much variation indicating the insufficient data precision at that time. The data quality was improved in the 4th survey after changing the laboratory to the other overseas certificated laboratory. However, the potential issues on significant variation of results among local chemical analysis laboratories needs to be considered in future surveys in order to ensure precious result data. It will be a challenge of quality control of laboratories among State and Regional Environmental Conservation Departments in Myanmar. The quality improvement of laboratory capacity in Myanmar is one of the key issues to acquire the reliable data that can be found out through this project.

1 INTRODUCTION AND OBJECTIVES

1.1 Background

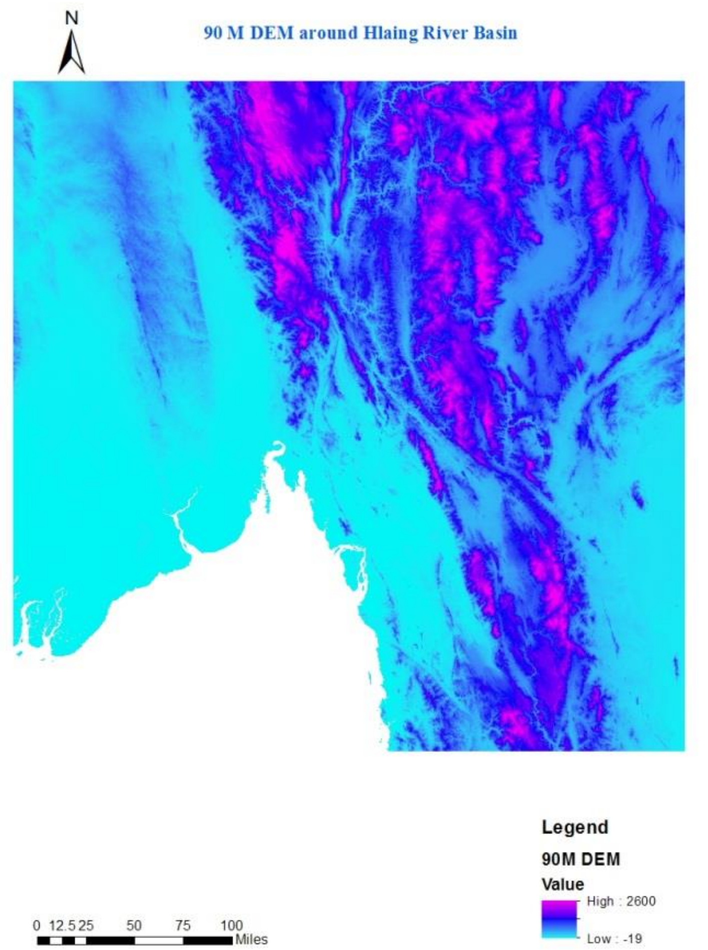
In the Hlaing River of Yangon, the problem of various manner of discharging wastewater from industrial zones is one of the most important problems to protect water quality and water environment. The wastewater discharged from industrial zones could be able to cause the changes of water quality and adverse effect on water environment in Hlaing River. Therefore, it is crucial to investigate the effects of different effluent manner in the Hlaing River. If it is investigated, the results will be useful baseline data of water environment in the Hlaing River to initiate the effective wastewater treatment system in industrial sector and baseline data.

The water quality survey in the Hlaing River basin was conducted as one of activities of the Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar (hereinafter referred to as “the Project”). The water quality survey was composed of total five-time surveys: in February 2016, June-July 2016, January 2017, September 2017 and February 2018, in order to cover the dry season and rainy season in more than two years. This water quality survey report presents the result of 3rd water quality survey and 4th water quality survey along Hlaing River Basin.

This report summarizes the survey methodology based on the actual activities and the water quality data acquired from the on-site measurement and laboratory analysis. The results will be utilized to interpret the water quality status in the target areas and develop the pollution control measures.

1.1.1 Topography

Figure 1.1-1 shows a topography map around Yangon including the Hlaing river basin using Digital Elevation Model (DEM) which only representing height information without any further definition about the surface. It can be found that Hlaing river basin is located below the sea level. The area along Yangon River, Hlaing River and Bago River is a delta area. Several industrial zones (IZs) including Shwe Pyi Thar IZ, Shwe Linban IZ and Hlaing Thar Yar IZ are located along the Hlaing river basin. The effluent from factories such as battery, alcohol and seafood factories seems to deteriorate the surface water quality in drainage channels. Domestic sewage from people living along the river and transportation vehicles is also directly discharged to the Hlaing River.



Source: prepared by ECD-YGN, based on data from USGS and CGIAR

Figure 1.1-1 Topography Map in Hlaing River Basin

1.1.2 Meteorology

Table 1.1-1 and Table 1.1-2 show monthly mean temperature and monthly rainfall in Yangon Region from 2005 to 2014. As for temperature, the hottest month in a year is April (30.5 ^{0}C) and the coldest month is January (24.7 0C), but the mean monthly temperature does not change drastically through the year. The rainfall pattern is divided into two distinctive seasons, namely rainy season (May to October) and dry season (November to April).

Table 1.1-1 Monthly Mean Temperature in Yangon (Average) Years 2005-2014

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean Temp; (^{0}C)	24.7	26.8	28.8	30.5	28.7	27.2	26.5	26.5	26.8	27.9	27.4	25.2

Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning Economic Development

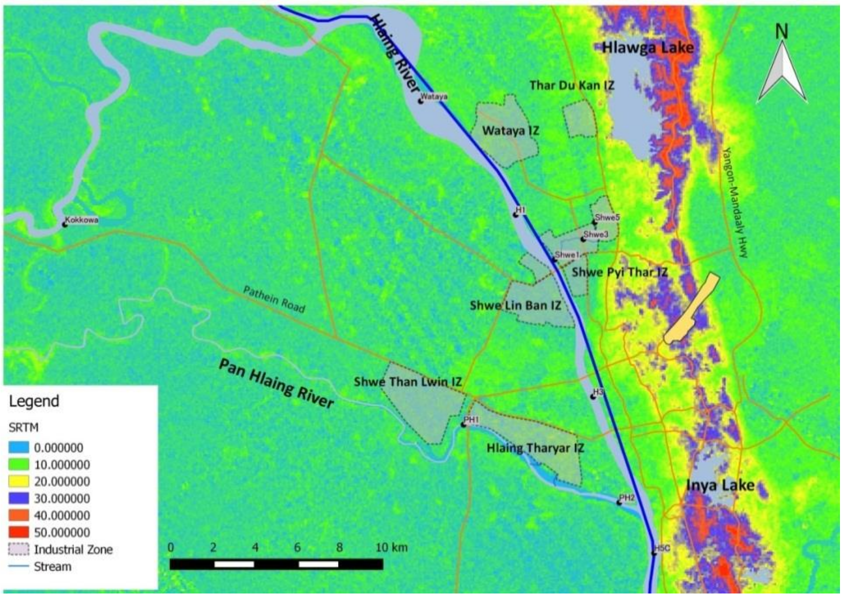
Table 1.1-2 Monthly Rainfalls in Yangon (Average), Years 2005- 2014

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall (millimeters)	6	1	20	39	375	520	671	554	480	215	50	16

Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning Economic Development

1.1.3 Hydrology

Figure 1.1-2 shows an estimate about water resource potential of the Hlaing river basin with the locations of industrial zones along the river basin. It also demonstrates water resource potential of the Hlaing river basin with the color deviation pattern. Hlaing River Basin is long in North-South direction, and the industrial zones are located in the most downstream area. At its mouth Hlaing river connects with Yangon River and drains to the Andaman Sea.



Source: prepared by ECD-YGN, based on data from USGS and CGIAR

Figure 1.1-2 Hlaing River Basin and Locations of Industrial Zones

1.2 Legal basis of water quality survey

The Constitution of the Republic of the Union of Myanmar (2008) definitely prescribes conservation for environment. In session 45, it reads that the Union shall protect and conserve natural environment. In session 390 (b), it also reads that every citizen has the duty to assist the Union in carrying out natural environment.

Myanmar has been undertaking environmental issues throughout the years. The following are Myanmar activities for environmental conservation;

1) National Environmental Policy has laid down in 1994
2) Myanmar Agenda 21 was formulated in 1995
3) Complied National Sustainable Development Strategy in 2009
4) Enacted Environmental Conservation Law in 2012
5) Environmental Conservation Rules in 2014
6) National Environmertal Quality (Emission) Guidelines (EQEG) in 2015
7) Environmental Impact Assessment in 2015

According to Environmental Conservation Law, this project is one of the output based on session 10 in Environmental Conservation Law, mentioning about that “The Ministry may, with the approval of the Union Government and the Committee, stipulate the following environmental quality standards:

(a) suitable surface water quality standards in the usage in rivers, streams, canals, springs, marshes, swamps, lakes, reservoirs and other inland water sources of the public;

(b) water quality standards for coastal and estuarine areas;

(c) underground water quality standards;

(d) atmospheric quality standards;

(e) noise and vibration standards;

(f) emissions standards;

(g) effluent standards;

(h) solid wastes standards;

(i) other environmental quality standards stipulated by the Union Government.

1.3 Water quality standard or guideline value to be applied

In this project, the following water quality standards or guideline value was referred to.

- National Environmental Quality Guideline, ECD (2015)
- National Drinking Water Quality Standard, MOH (2014)
- Environmental Standard, Vietnam (2015)
- Environmental Standard, Japan

Currently, Myanmar has already set up emission standards. However, the standards for surface water quality to assess this water quality survey results are not yet laid down.

In order to evaluate the water quality in Hlaing River in this Water Quality Survey, surface water standard from Vietnam Environmental Standard (QCVN08.2015) for water transportation (B2) was referred to. The reason is that Vietnam is included in South Asia countries and it is also developing county as Myanmar. And it is considered that the nature and condition of water body in Vietnam is not quite different from Myanmar. Table 1.3-1 describes standard values of surface water quality parameters in Vietnam for specific parameters (pH, DO, TSS, BOD and COD) that are considered to be essential for surface water quality and analyzed in this report.

Table 1.3-1 Standard values of surface water quality parameters in Vietnam

STT.	Parameters	Unit	Standard Values			
			A		B	
			A1	A2	B1	B2
1.	pH	-	6-8.5	6-8.5	5.5-9	5.5-9
2.	DO	mg/l	≥6	≥5	≥4	≥2
3.	TSS	mg/l	20	30	50	100
4.	COD	mg/l	10	15	30	50
5.	BOD	mg/l	4	6	15	25

Source: Vietnamese national technical regulations on surface water quality, QCVN 08-MT 2015/BTNMT, 2015

1.4 Survey objectives

The water quality survey along Hlaing River Basin is mainly formulated with the following objectives:

- To investigate the pollution level of Hlaing River.
- To assess the seasonal changes in water quality of Hlaing River

2 Survey Methods

2.1 Data source

This report was prepared mainly based on the on-site measurement and laboratory analysis result data of 4th water quality surveys and supplemented by 3rd survey result, which were provided by JICA Expert Team. In addition, in order to evaluate quality control of analytical or measurement precision and on-site sampling there has been used the duplicate samples from 3rd and 4th water quality surveys.

2.2 Role and responsibility of survey team

The water quality survey was mainly implemented by environmental consulting company, i.e. Environ Myanmar Co., Ltd. for until the 3rd survey and Social and Environmental Associates-Myanmar from 4th survey, as subcontractors of JICA Expert Team and managed by JICA Expert Team. The technical staff from Yangon regional office of ECD and YCDC participated the sampling activities to supervise the survey works.

2.3 Sampling schedule

The sampling works for 3rd and 4th water quality surveys in Hlaing River basin were conducted by the following schedules (Table 2.3-1) in order to know the seasonal changes in water quality along Hlaing River, it has been made a comparison between wet season and dry season from 3rd and 4th water quality survey data.

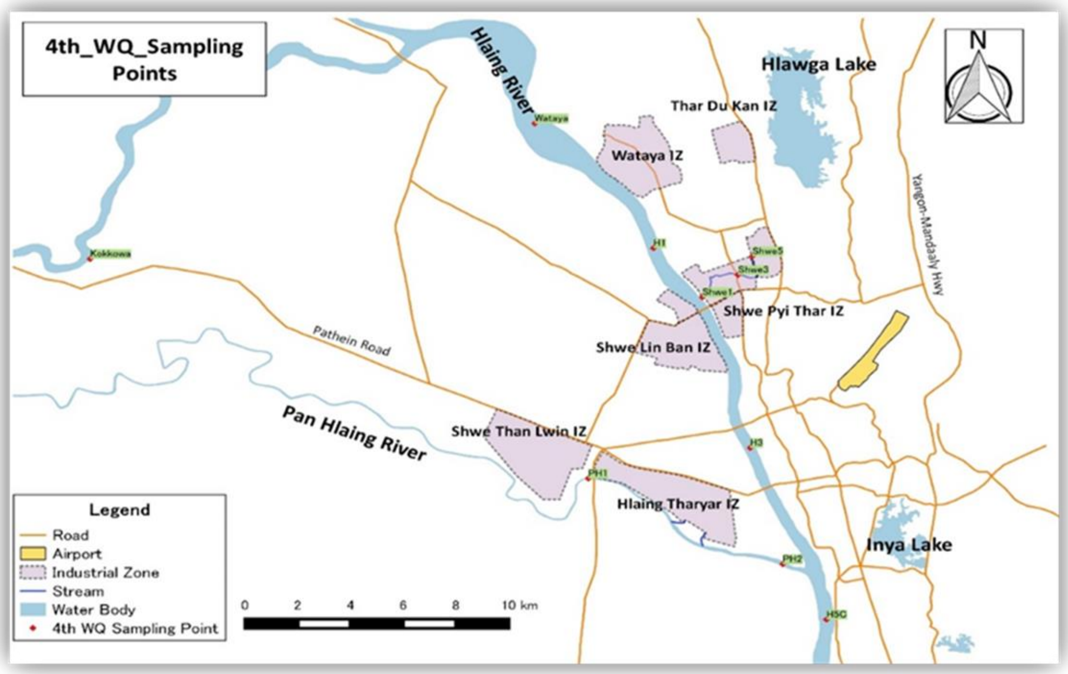
Table 2.3-1 Survey Schedules of 3rd and 4th Water Quality Surveys at Hlaing River Basin

Title	Survey Date and Location	Sampling Points	Note
3rd water quality survey	- 30th January 2017 at Hlaing River - 31st January 2017 at Hlaing River - 01st February 2017	- H1,H3,Shwe1,Shwe3, Shwe5 - H5, PH1, PH2 - Kokkowa	Tidal fluctuation was varied in time. Weather condition was dry and cold during survey.
4th water quality survey	- 18th September 2017 at Hlaing River - 19th September 2017 at Hlaing River - 20th September 2017	- H1,H3, H5, PH1, PH2 - Shwe1,Shwe3, Shwe5,Wataya - Kokkowa	Tidal fluctuation was varied in time. Weather condition was heavy rain during survey.

Source: JICA Expert Team

2.4 Sampling points

There are 10 sampling points for 4th survey along Hlaing River basin as shown in Figure 2.4-1. Among them, four points were selected for this report. Table 2.4-1 shows four sampling points along Hlaing River to be discussed in the is report; Wataya in upstream and Hlaing 1 (H1), Hlaing 3 (H3) and Hlaing 5 Center (H5C) in downstream along Hlaing River. Since the water sample from Wataya was not collected in the 3rd survey, the seasonal changes were evaluated only for remaining three points.



Source: ECD-YGN

Figure 2.4-1 Sampling points in Hlaing River Basin at 4th Water Quality Survey

Table 2.4-1 List and location of selected sampling points

Name of Sampling Point	Location		Note
	Longitude	Latitude	
Wataya	16.998	96.01475	Upstream of Hlaing river Not collected in the 3rd survey
Hlaing 1 (H1)	16.94967	96.057	Middle or ownstream of Hlaing river
Hlaing 3 (H3)	16.87228	96.09142	
Hlaing 5 Center (H5C)	16.80572	96.11861	

Source: JICA Expert Team

2.5 Survey parameter

The parameters such as water depth, pH, EC, Salinity, turbidity, water temperature, ORP and DO were measured on-site in all sampling points and the parameters like TSS, BOD, COD, cyanide, oil and grease, phenols, total phosphorus and total nitrogen were analyzed in basic points. Arsenic, copper, total mercury, cadmium, lead, total coliform were analyzed in representative points. Pesticides were analyzed in only one or two points. In this report, BOD, COD, TSS and DO will be discussed and mentioned.

2.6 Guideline levels

MOHS and MONREC issued the draft drinking water quality standard and National Environmental Emission Guideline for water. However, in Myanmar, there is no surface water quality standard. So, Vietnam Standard for surface water was used in order to compare with final results of selected parameters. The following Table 2.6-1 is Vietnam Standard for surface water.

Table 2.6-1 Vietnam standard values of selected parameters for surface water

Surface water quality standard			
No.	**Parameter**	**Unit**	**Vietnam Standard**
1.	BOD	mg/l	25
2.	COD	mg/l	50
3.	DO	mg/l	≥2
4.	TSS	mg/l	100

Source: Class B2 (for water transportation and other purposes with demand for low-quality water), Vietnamese national technical regulations on surface water quality, QCVN 08-MT 2015/BTNMT,2015

2.7 Sampling and measurement

2.7.1 Sampling method

Water samples were taken at 0.5 depth of surface water, then collected and mixed in plastic bucket in order to get homogeneous mixture. All sampling containers were rinsed by sample water three times before taking into sample bottles. Then, homogeneous sample was taken into sample bottle and sent to the laboratory. Figure 2.7-1 shows some photo of water sampling.

Source: JICA Expert Team

Figure 2.7-1 Photos of Water Sampling

2.7.2 On-site measurement method

The parameters like pH, ORP, EC, Turbidity, DO, TDS, TSS and salinity were measured on-site by using Horiba (U 52 G) Multi parameter. The following Figure 2.7-2 shows on-site measurement using Horiba (U 52G) in the Hlaing River.

Source: ECD-YGN

Figure 2.7-2 Photo of On-site Measurement Water Sampling by using Horiba (U 52 G)

2.7.3 Laboratory analysis method

BOD was analyzed by in DOWA Eco-system–Myanmar Co., Ltd. according to the method of Respirometric method (HACH Method 10099).

COD Cr was analyzed by OSUMI CO., Ltd. according to the method of Japanese Standard JIS K0102 (2016) 20.1.

TSS was analyzed by OSUMI CO., Ltd. according to the method of Environment Agency Notification No. 59, 1971, Appendix, Table 9 (Ministry of Japan).

3 Results and Discussion

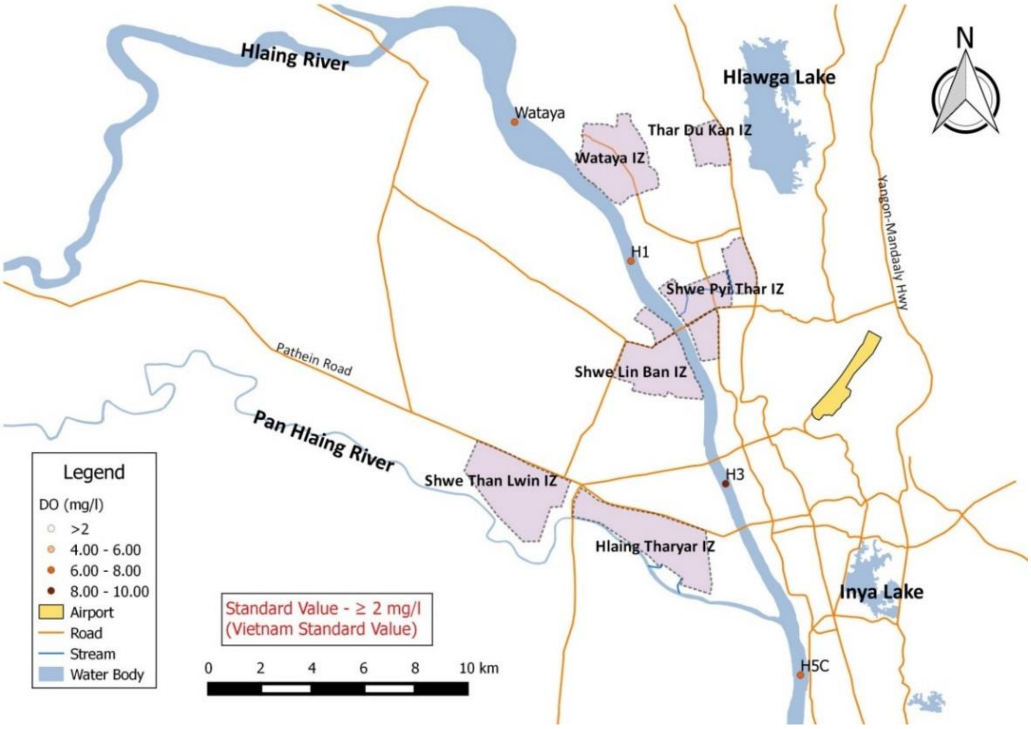
3.1 Water quality results

3.1.1 Basic parameters

The survey results of specific sampling points along Hlaing River are summarized below. Firstly the results of 4th water quality survey were evaluated with respect to the river water quality and the results between two seasons were compared to evaluate the seasonal changes. The overall data are shown in Appendix 2. While various efforts were made to control data quality, it has to be pointed out that the results presented below are not totally free from problems of data reliability especially in the 3rd survey. The data reliability will be discussed in Section 3.3.

(1) Dissolved Oxygen (DO)

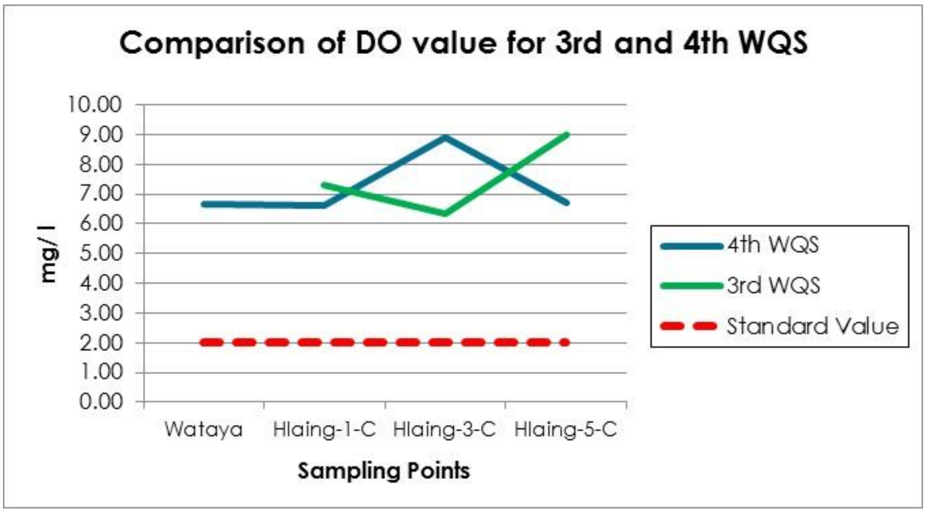
At Wataya, H1, H3 and H5 C in the 4th survey, DO levels are within the standard value of Vietnam Environmental Standard (QCVN08.2015), Class-B2 for water transportation. In Vietnam environmental standard (Class-B2), dissolve oxygen value should have equal and/or greater than 2. If DO value is under 2, aquatic life would not be able to survive. So it was found that DO level at all specific points is good enough for aquatic life to survive. Figure 3.1-1 shows DO levels at specific points in 4th survey.



Source: prepared by ECD-YGN

Figure 3.1-1 Level of DO for Specific Points of 4th Water Quality Survey in Hlaing River Basin

Figure 3.1-2 compares the DO result between 3rd survey and 4th survey, except for Wataya, since Wataya point was not surveyed in 3rd water quality survey. As mentioned above DO result is very good for three points; H1, H3 and H5 in both surveys. The value of DO meets with B2 Standard for aquatic life and transportation in Vietnam Environmental Standard (QCVN08.2015).



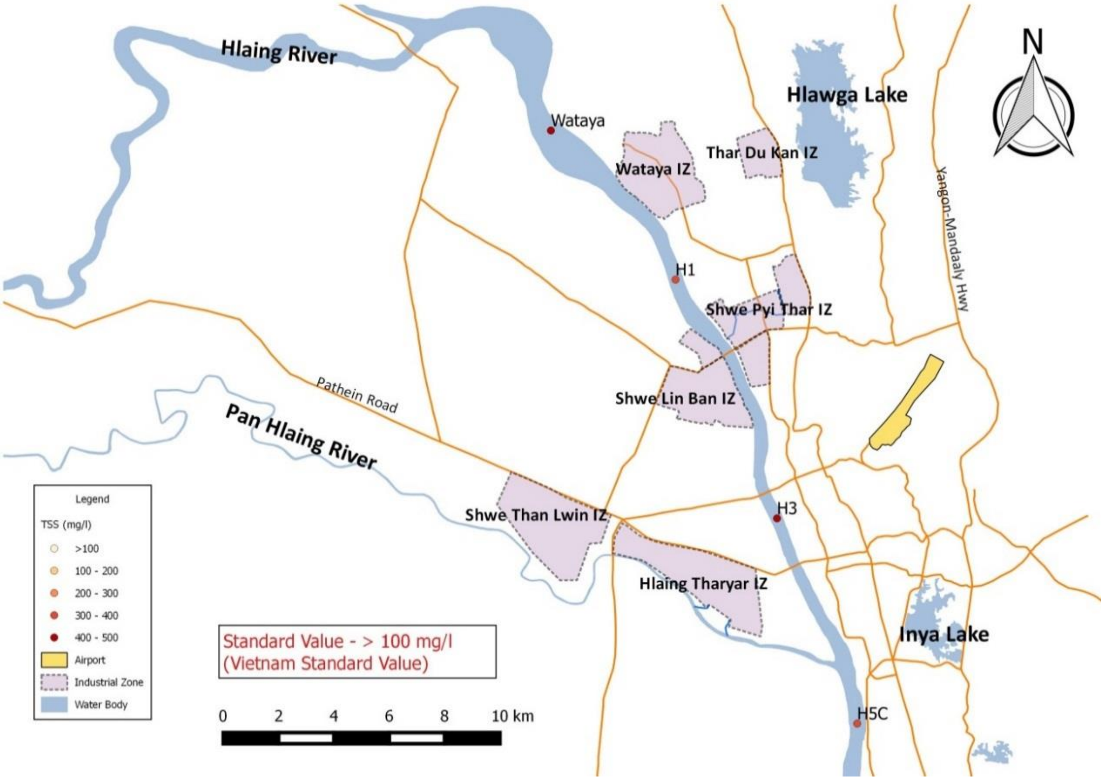
Note: Standard Value refers to Vietnamese national technical regulations on surface water quality (B2 level) (QCVNO8:2015)

Source: prepared by ECD-YGN

Figure 3.1-2 Comparison of DO for Specific Point of 3rd and 4th Water Quality Survey with Standard Value in Hlaing River Basin

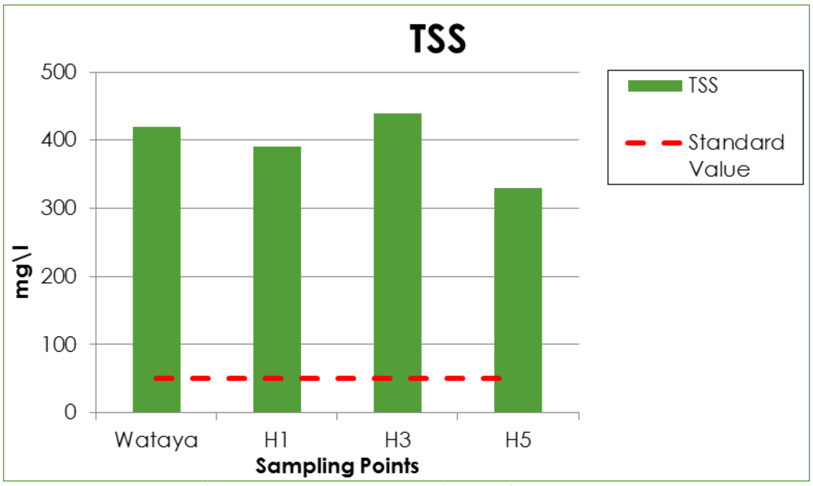
(2) Total Suspended Solid (TSS)

Figure 3.1-3 shows the levels of TSS at selected points from 4th survey. According to Figure 3.1-4, TSS values at all selected points were higher than the standard value of Vietnam Environmental Standard (QCVN08.2015) Class- B2 for water transportation.



Source: prepared by ECD-YGN

Figure 3.1-3 Level of TSS for Specific Points of 4th Water Quality Survey in Hlaing River Basin

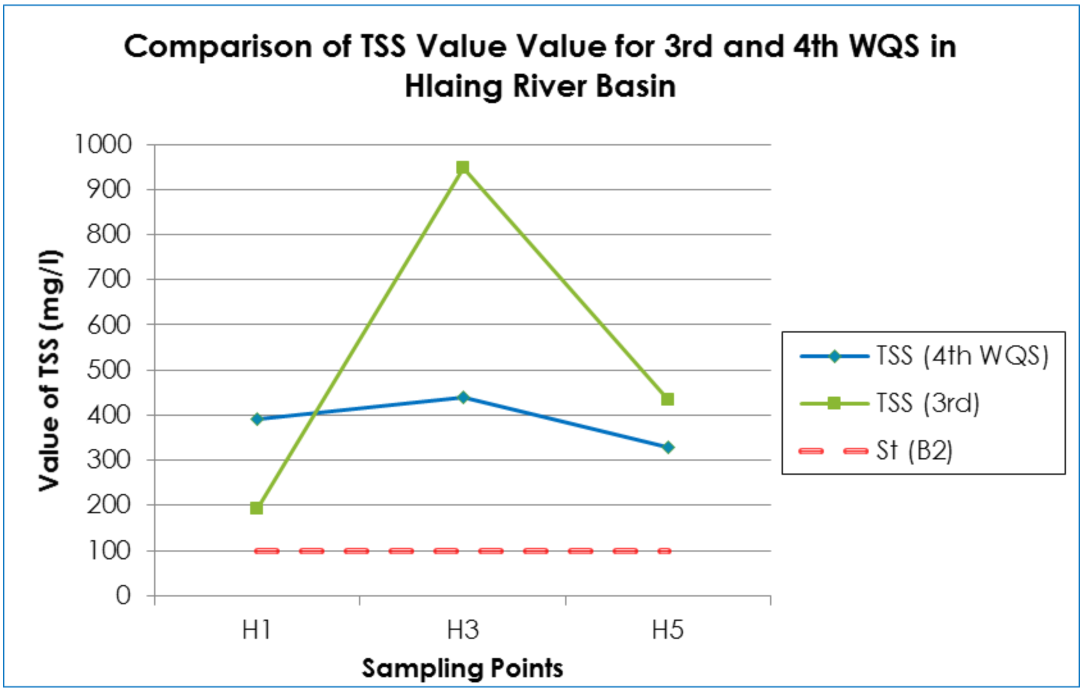


Note: Standard Value indicates a reference guideline level for surface water in Vietnam (B2 level) (QCVNO8:2015)

Source: prepared by ECD-YGN

Figure 3.1-4 Comparison of TSS for Specific Point of 4th Water Quality Survey and Standard Value in Hlaing River Basin

According to Figure 3.1-5, total suspended solid level at H3 and H4 from 4th survey was lower than that from 3rd survey. It might be that the time of 4th water quality survey was raining season, so dilution of river water could be happened with heavy rain. Due to the tide and flood, movement of soil particles from upstream might have been caused to increase in value of total suspended solids.



St (B2): Standard Value for surface water in Vietnam (B2 level) (QCVNO8:2015)

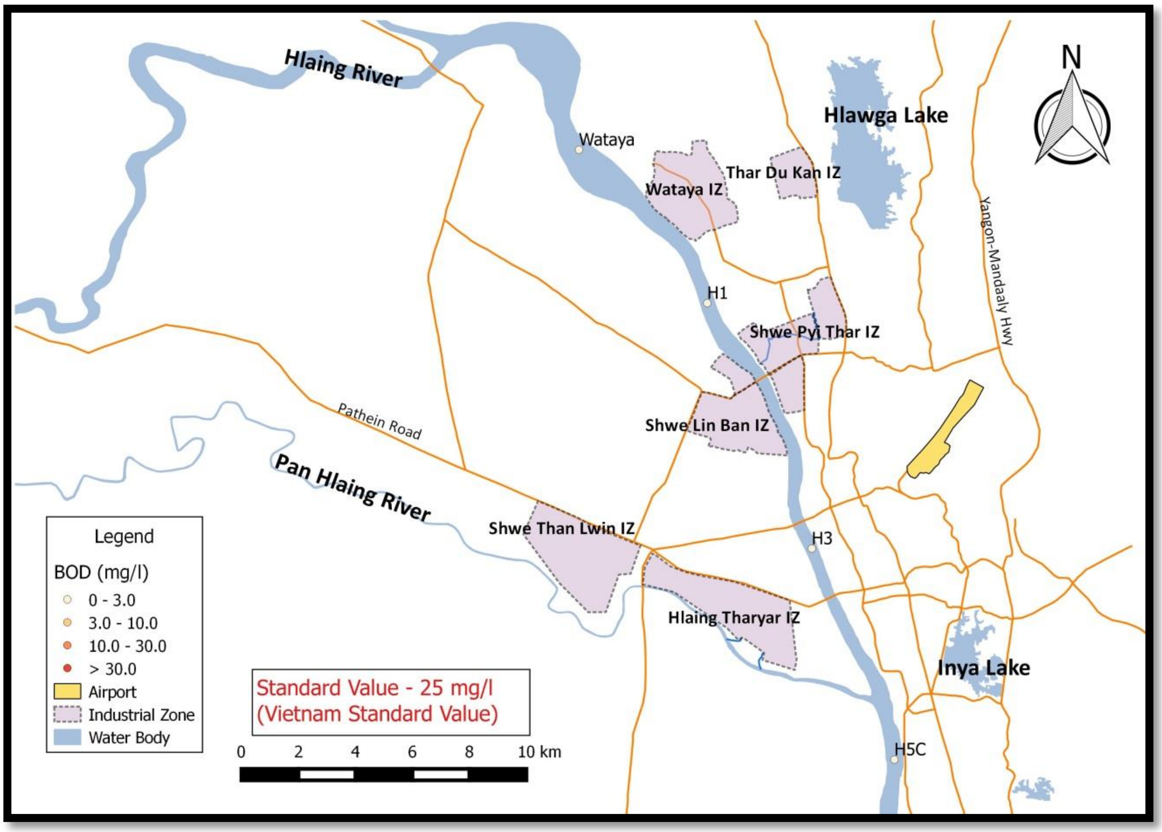
Source: prepared by ECD-YGN

Figure 3.1-5 Comparison of TSS for Specific Point of 3rd and 4th Water Quality Survey with Standard Value in Hlaing River Basin

3.1.2 Organic substances

(1) Biological Oxygen Demand (BOD)

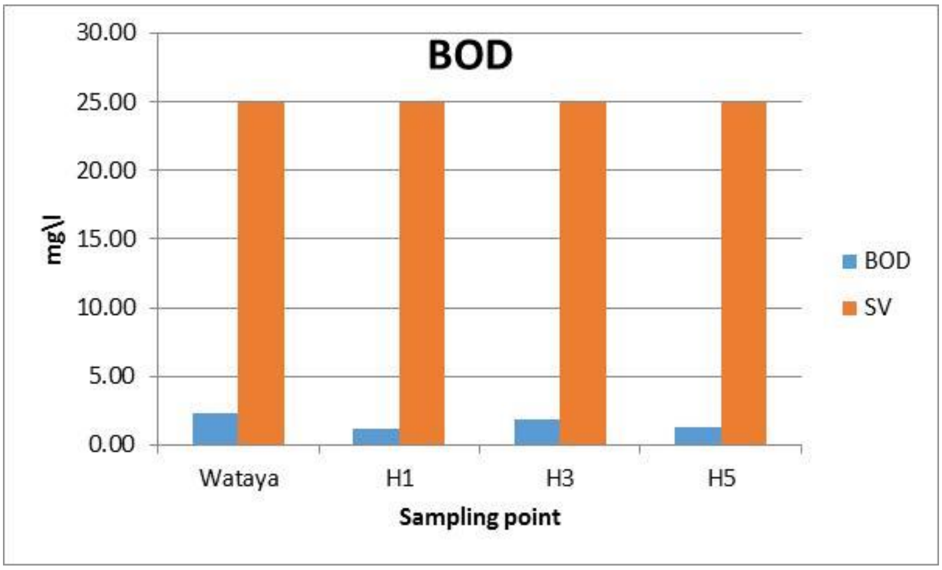
Figure 3.1-6 shows BOD levels at specific points of 4th survey along the Hlaing River. BOD concentration in specific sampling points is within the standard value of Vietnam Environmental Standard (QCVN08.2015) Class- B2 for water transportation.



Source: prepared by ECD-YGN

Figure 3.1-6 Levels of BOD at Specific Points of 4th Water Quality Survey in Hlaing River Basin

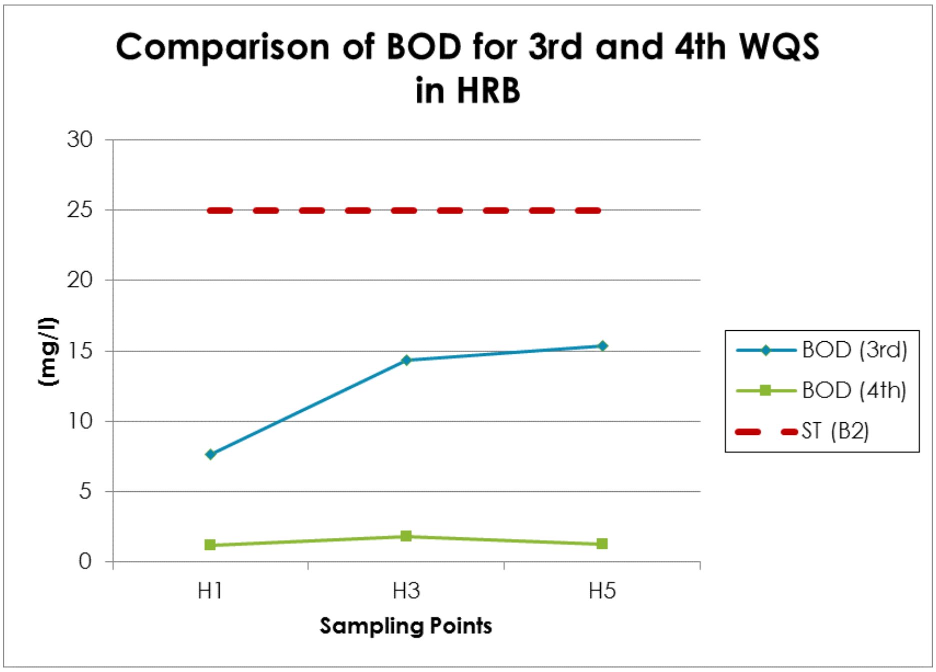
According to Figure 3.1-7, BOD value is very lower than the standard value of Vietnam Environmental Standard (QCVNO8:2015) for water transportation.



SV: Standard Value of Vietnamese national technical regulations on surface water quality (B2 level) (QCVNO8:2015)

Source: prepared by ECD-YGN

Figure 3.1-7 Comparison of BOD for Specific Point of 4th Water Quality Survey and Standard Value in Hlaing River Basin



ST: Standard Value of Vietnamese national technical regulations on surface water quality (B2 level) (QCVNO8:2015)

Source: prepared by ECD-YGN

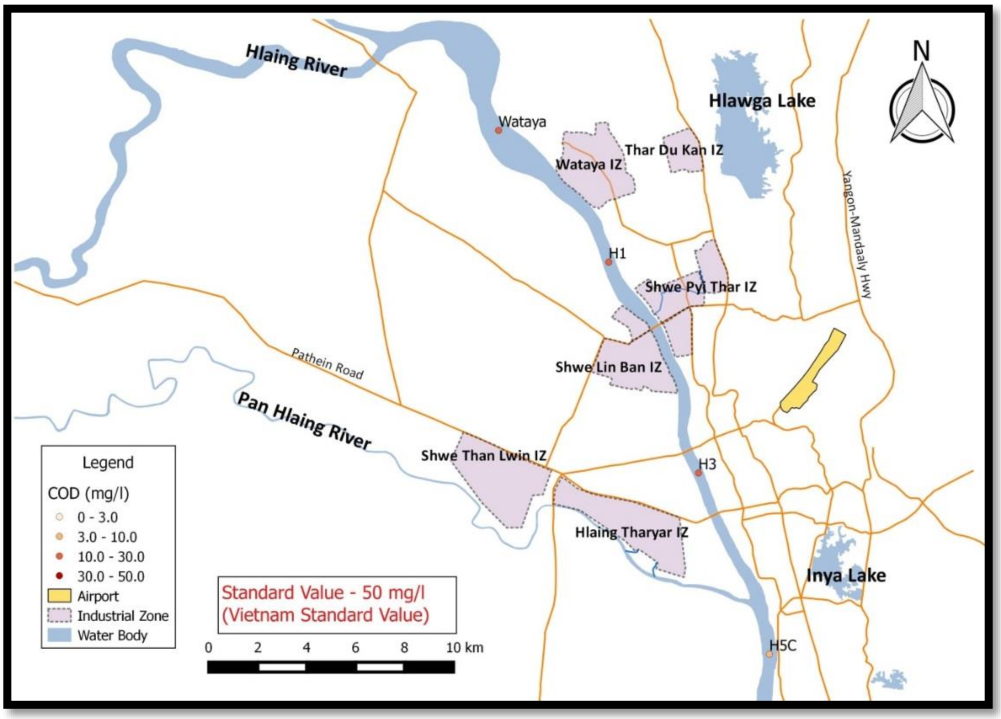
Figure 3.1-8 Comparison of BOD for Specific Point of 3rd and 4th Water Quality Survey with Standard Value in Hlaing River Basin

According to Figure 3.1-8, BOD values at H1, H3 and H5 were lower than the standard value of Vietnam Environmental Standard (QCVNO8:2015) for water transportation in 3t^h and 4^th water quality surveys. But, the result of BOD in 3^rd water quality survey was higher than the 4^th water quality survey. Because, the time of 3^rd water quality survey was dry season and the water flow rate was lower, while 4^th water quality survey time was rainy season and river water might be diluted by rainfall.

In addition, there is a possibility that the pollution load from the channel of IZ to the Hlaing River river was released and it contributed to improve the water qulity in the river. It was because that between 3^rd and 4^th surveys, the operation of six distilleries in Shwe Pyi Thar IZ was temporarily suspended, that is considered to be one of the biggest industrial pollution source in the river basin.

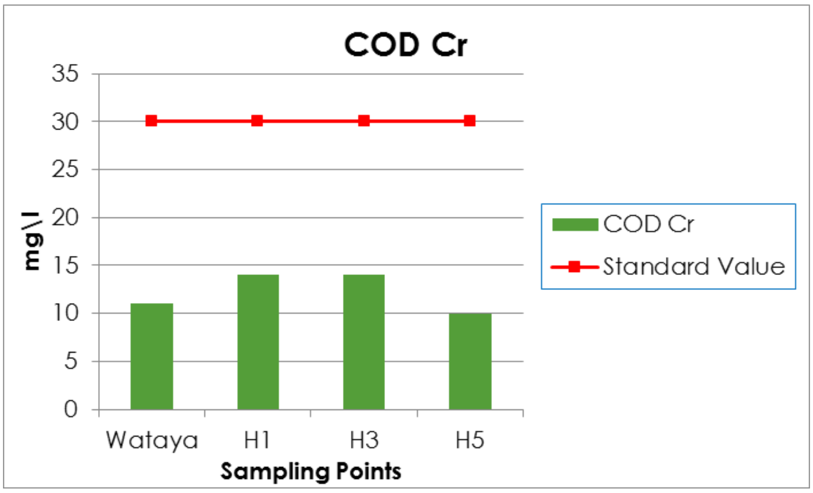
(2) Chemical Oxygen Demand (COD)

Figure 3.1-9 shows level of COD for specific points of 4^th Water Quality Survey in Hlaing River Basin.



Source: prepared by ECD-YGN

Figure 3.1-9 Level of COD for Specific Point of 4th Water Quality Survey in Hlaing River Basin

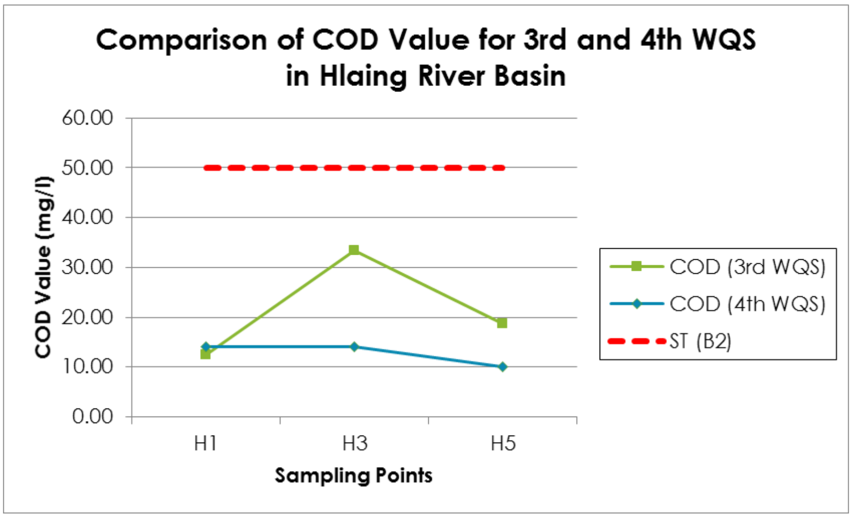


Note: Standard Value refers to Vietnamese national technical regulations on surface water quality (B2 level) (QCVNO8:2015)

Source: prepared by ECD-YGN

Figure 3.1-10 Comparison of COD for Specific Point of 4th Water Quality Survey and Standard Value in Hlaing River Basin

According to Figure 3.1-10, COD concentration in the all specific sampling points are within the standard value of Vietnam Environmental Standard (QCVN08.2015), Class-B2 for water transportation.



ST(B2): Standard Value of Vietnamese national technical regulations on surface water quality (B2 level) (QCVNO8:2015)

Source: prepared by ECD-YGN

Figure 3.1-11 Comparison of COD for Specific Point of 3rd and 4th Water Quality Survey with Standard Value in Hlaing River Basin

According to Figure 3.1-11, COD values at H1, H3 and H5 are lower than the standard value of Vietnam Environmental Standard (QCVNO8:2015) for water transportation in 3rd and 4th water quality surveys. But, the result of COD in 3rd water quality survey is higher than that in 4th water quality survey. Because the time of 3rd water quality survey was dry season and river flow was decreased. But 4th water quality survey time was rainy season and dilution might be happened by rainfall at that time. It might be the reason that the result of COD in 3rd water quality survey is higher than 4th water quality survey.

3.2 Overall Evaluation

3.2.1 Pollution level of Hlaing River

The water quality in Hlaing River basin was analyzed in order to know pollution impact from the discharged wastewater to Hlaing River and pollution level of Hlaing River. Four main parameters such as BOD, COD, DO and TSS were selected in four points along Hlaing River (Wataya, H1, H3 and H5). The results of all of these parameters are satisfied the desirable water quality in comparing with Vietnam Environmental Standard (Class-B2).

3.2.2 Seasonal changes in water quality of Hlaing River

Another survey objective is assessing the conditional and seasonal changes in water quality along Hlaing River. When the results of 3rd and 4th water quality surveys are compared, the results of BOD, COD and TSS in 3rd water quality survey are higher than that in 4th water quality survey. Apparently it is because the water flow rate is lower in dry season, and the concentration of pollutants can be higher than in rainy season.

3.3 Data Quality Control

This section will discuss the data quality in the 4th survey. In the 4th water quality survey, the analytical results of water quality survey were validated using the following check points:

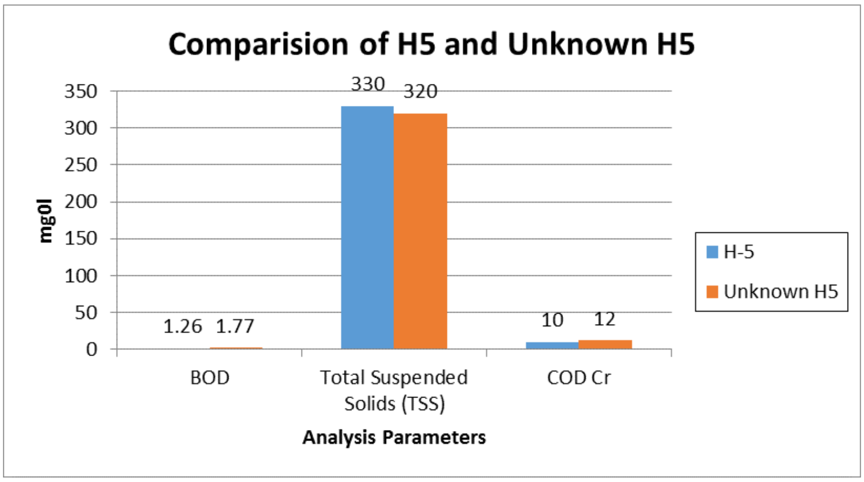
- Check any careless mistakes of result value and unit
- Check significant figures and reporting limit
- Check an analysis method
- Compare the result against reference environmental standard values or guideline values
- Check a consistency with other parameters and sampling locations as well as past data considering the physical characters of measured substance and site conditions

- Check a data precision referring to a result of quality control samples, which is generally used to reveal the level of analysis error for each parameter.

The past water quality surveys until the 3rd survey revealed various issues in implementing reliable water quality survey as listed below.

- There is a possibility that measured values for some specific parameter such as COD, BOD, cadmium and lead were higher than true values.
- Some measured values of the outsourced laboratory did not seem to have enough reliability due to low resolution. Especially the accuracy of low level COD, BOD seem good enough to evaluate the water environmental quality. Some of duplicate analysis results in past surveys also showed more than several dozen percentages of difference when the two same samples were analyzed in parallel and the results are compared. Detection of trace amount of heavy metals also needs to be checked.

Such challenges were examined and overcome after 4th survey by changing the laboratory and sending samples to overseas certificated laboratory. As one of the quality control method, a duplicate sample was collected from randomly-selected sampling point and analyzed in the same way as target sample in parallel at the laboratory to check a precision of monitoring data. Figure 3.3-1 shows difference between the actual sample (H5) and duplicate sample (Unknown H5) in the 4th survey. The results showed the difference between two samples was small enough and it is liketly to assure the good precision of these data.



Source: prepared by ECD-YGN

Figure 3.3-1 Comparison of H5 and Unknown H 5 for quality control in 4th Water Quality Survey

4 Conclusions and Recommendations

The Hlaing River and industrial zones along Hlaing River in Yangon have been selected as representative areas where impact of industrial activities on water quality of a river is evident. The Hlaing River is strongly influenced by tidal fluctuation, and there are Shwe Linban Industrial Zone, Hlaing Tharyar Industrial Zone and other Industrial Zones in its basin. A large part of industrial effluent in the area is being discharged to the river without adequate treatment.

According to the result of 4^{th} water quality survey, it was found that the values of specific parameters at the points Wataya, H1, H3 and H5 were within the standard value of Vietnam Environmental Standard (QCVN08.2015) Class- B2 for water transportation. Compared between 3rd and 4th water quality surveys, the results of BOD, COD and TSS in 3rd water quality survey (dry season) are higher than that in 4th water quality survey (rainy season). Apparently it is because the water flow rate is lower in dry season and the pollutants would concentrate in the river. To identify the conditional changes of surface water quality in details, more monitoring data such as monthly or at least seaonal data of over the year will be required.

Additionally, there will be needed to consider the significant variation among analysis in order to ensure reliable data in future analysis methods because there were different analysis results from different laboratories with different methods. It will also be a challenge of quality control of laboratories from the State and Regional Environmental Conservation Departments in Myanmar. As a result, government staffs have opportunities to implement sampling procedures and standard method of parameters not only doing to get uniform laboratory analysis but also getting to know precious environmental parameters. Therefore, better quality control is necessary for the improvement of laboratory capacity in Myanmar is one of the key issues to acquire the reliable data that can be found out through this project.

Appendix 1 Photographs

	
Hlaing River	Pan Hlaing River
	
Hlaing River Basin in Yangon (Hlaing 3)	Sub-stream of Hlaing River (Shwe-1)
	
Creek in Shwe Phy Thar IZ in Yangon (Shwe-5)	Joint Cooperation Committee Meeting at Nay Pyi Taw

Source: JICA Expert Team & ECD

Appendix 2 List of Data

A2.1 Analysis Results of 3rd Water Quality Survey

Table A.2.1-1 Results of On-site measurement

No	No	Unit	1	2	3	4
	Location name		Wataya	H1	H3	H5
			Wataya	Hlaing-1-C	Hlaing-3-C	Hlaing-5-C
	Left/Center/Right		Center	Center	Center	Center
	Sampling Date		19/9/2017	18/9/2017	18/9/2017	18/9/2017
	Sampling Time		11:16	10:10	11:05	12:01
1	DO	mg/L	-	7.3	6.34	9

Table A.2.1-2 Results of laboratory analysis

No	No	Unit	1	2	3	4
	Location name		Wataya	H1	H3	H5
			Wataya	Hlaing-1-C	Hlaing-3-C	Hlaing-5-C
	Left/Center/Right		Center	Center	Center	Center
	Sampling Date		19/9/2017	18/9/2017	18/9/2017	18/9/2017
	Sampling Time		11:16	10:10	11:05	12:01
1	BOD	mg/L	-	7.67	14.33	15.38
2	Total Suspended Solids (TSS)	mg/L	-	192.00	948.00	434.00
3	COD Cr	mg/L	-	12.50	33.34	18.76

A2.2 Analysis Results of 4th Water Quality Survey

Table A.2.2-1 Results of On-site measurement

No	No	Unit	1	2	3	4
	Location name		Wataya	H1	H3	H5
			Wataya	Hlaing-1-C	Hlaing-3-C	Hlaing-5-C
	Left/Center/Right		Center	Center	Center	Center
	Sampling Date		19/9/2017	18/9/2017	18/9/2017	18/9/2017
	Sampling Time		11:16	10:10	11:05	12:01
1	DO	mg/L	6.67	6.60	8.92	6.71

Table A.2.2-2 Results of laboratory analysis

No	No	Unit	1	2	3	4
	Location name		Wataya	H1	H3	H5
			Wataya	Hlaing-1-C	Hlaing-3-C	Hlaing-5-C
	Left/Center/Right		Center	Center	Center	Center
	Sampling Date		19/9/2017	18/9/2017	18/9/2017	18/9/2017
	Sampling Time		11:16	10:10	11:05	12:01
1	BOD	mg/L	2.30	1.16	1.80	1.26
2	Total Suspended Solids (TSS)	mg/L	420	390	440	330
3	COD Cr	mg/L	11	14	14	10

Appendix 10-3:

Water Quality Survey Report prepared by YCDC-PCCD

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY REPORT FOR HALING RIVER BASIN

FINAL VERSION

APRIL 2018

PREPARED BY:

POLLUTION CONTROL AND CLEANSING DEPARTMENT

(YANGON CITY DEVELOPMENT COMMITTEE)

Table of Content

Appendices

LIST OF TABLES

LST OF FIGURES

LST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
ORP	Oxidation Reduction Potential
DO	Dissolved Oxygen
EC	Electrical Conductivity
ECD	Environmental Conservation Department
EIA	Environment Impact Assessment
NEQEG	National Environmental Quality Emission Guidelines
IZ	Industrial Zone
JICA	Japan International Cooperation Agency
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
COD Cr	Chemical Oxygen Demand (Chromium)
T-P	Total Phosphorus
T-N	Total Nitrogen
YCDC	Yangon City Development Committee
PCCD	Pollution Control and Cleansing Department

EXECUTIVE SUMMARY

i) Purpose

The main subject of the water quality survey report is i) to access the pollution impact on surface water which would be caused by the wastewater from industries, and ii) to access the accurate information on surface water quality of the Hlaing River because Hlaing river is utilized for transportation, fishing and agriculture and domestic use from people who are dwelled along the river bank.

ii) Findings

Total five time sampling surveys were conducted. Among them, this report forcused to evaluate the results from the 3rd water qualtiy survey in January 2017 and the 4th survey in September 2018. The survey area covered from the upstream to downstream of the Hlaing River and it's substream in Shwe Pyi Thar Industrial Zone (IZ). Regarding the measurement parameter, BOD, COD, Total Suspended Solid (TSS), total nitrogen, total phosphorus and lead were selected in this report as representative paramaters to evaluate the pollution level in the surface water. The results were compared with the surface water quality standadrd in the other countries since the ambient water environmental standard has been not yet set in Myanmar. In these surveys, the Vietnamese standard for water usage of water transporation and other purposes (Class B2) was selected as a reference standard to be applied. The findings from the 3rd survey and 4th survey are summarized as follows.

1) Pollution status in the Hlaing River basin

The 4th survey result did not exceed the limit of reference environmental standard in terms of BOD and COD. Overall, the river water was not polluted seriously.

2) Impacts of industrial wastewaters on Hlaing River basin

The BOD and COD results in the sub-stream in Shwe Phy That IZ did not frequently meet the reference environmental quality standard. This sub-stream is considered to be one of the pollution path of organic substance and nutrients to the Hlaing River, which would deteriorate the Hlaing River water quality, although the pollution impact seems to be limited at present.

3) Seasonal impact on the water quality

The water quality significantly differed between the 3rd water quality survey (January 2017) and 4th water quality survey (September 2018) for most measurement parameters. Apparently, the water quality in the Hlaing River is deteriorated in the dry season, but improved in the rainy season because a larger amount of river water dilutes the pollutants.

iii) Conclusions and Recommendations

It is considered that the water quality in the Hlaing River is not polluted seriously at present. However, the survey confirmed that the sub-stream in the IZs gives a certain pollution load to the Hlaing River especially in terms of organic and nutrients pollution, which would deteriorate the Hlaing River water quality. The regular monitoring should be implemented, in order to maintain the sustainability of the Hlaing River. The pollution control measures at industries is required to prevent the discharge of wastewater without adequate treatment. Furthermore, the environmental regulations of pollution control should be strengthened although it will require some amount of cost burden.

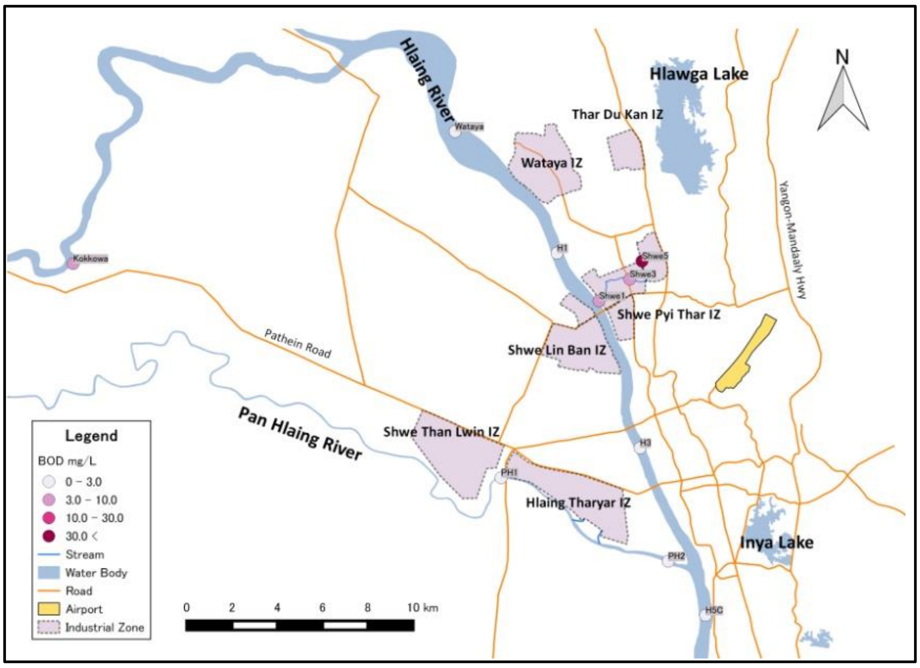
1 Introduction and Objectives

1.1 Background

In the project for Capacity Development in Basic Water Myanmar Environment Management and EIA System, there are four outputs: (1) Output 1 – Inspection, (2) Output 2 - Water quality Survey and Monitoring, (3) Output 3 – Database development and (4) Output 4 – Interpretation. This is three years project, starting in June 2015 and ending in May 2018. This report presents the results of water quality surveys which are implemented during 3 years of this project. Among the pilot study area in Yangon and Mandalay, the water quality survey in Yangon targets the Hlaing River Basin, including the Hlaing River and Pan Hlaing River.

This project was implemented cooperated with Environmental Conservation Department (ECD) under Ministry of Natural Resources and Environmental Conservation (MONREC), Pollution Control and Cleansing Department (PCCD), Water and Sanitation Department (WSD) under Yangon City Development Committee (YCDC) and JICA Expert Team.

The water quality survey is composed of total fifth time surveys: 1st survey in February 2016, 2nd survey in June-July 2016, 3rd survey in January 2017 , 4th survey in September 2017 and 5th survey in February 2018 respectively in order to cover three dry seasons and two rain seasons. This water quality survey report presents the result of 3rd and 4th water quality surveys.



Source: PCCD-YCDC

Figure 1.1-1 Map of Target Area

1.2 Legal basis of water quality survey

The YCDC Law (2013) mentions in the session 22 that " YCDC is responsible for pollution control and cleansing activities with the following obligation.

(a) Performs to control the pollution quality, based on the session 62 of prohibition in the YCDC Law (2013), specifying prohibited factors for pollution control and cleansing, and
(b) Do not discharge the wastewater from factories, industries and commercial sector to creeks and rivers without treatment by any standards YCDC.”

Now the committee is reforming the YCDC Law, which includes the amendment for industrial waste management.

On the other hand, the National Environmental Quality (Emission) Guideline (NEQEG) (MONREC, 2015) specified the guideline values for wastewater, storm water, runoff, effluent and sanitary discharges. The ambient water quality guideline has not been set yet. Thus the surface water standard from Vietnamese environmental standard (QCVN08.2015) was introduced to evaluate the water quality in the surveys. It is because that water quality in Vietnam is a neighboring country and likely to have the similar nature with Myamar’s water quality as thesame South Asian country and developing country.

1.3 Survey objectives

The surveys were implemented to confirm 1) levels of pollution by organic and toxic substances, and 2) fluctuation or changes of water quality by natural phenomena or human-caused reasons such as discharge of wastewater in the public water area. The main objectives of the water quality survey are set as follows,

(1) To confirm the pollution status in the target river basin

(2) To examine the impact of industrial wastewater on the Hlaing River basins

(3) To assess the seasonal impact on the water quality

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2 Survey Methods

2.1 Role and responsibility of survey team

The survey work was outsourced to local environmental consultant companies, namely, Environ Co., Ltd. for 3rd survey and Social and Environmental Associates Myanmar (SEAM) for 4th survey under the management of JICA Expert Team for the Project.

The technical staff from Yangon regional office of ECD and Pollution Control and Cleansing Department and Water and Sanitation Department under YCDC participated the sampling activities to supervise the survey works.

2.2 Sampling schedule

The sampling schedules are shown in Tables below.

Table 2.2-1 3rd Survey Schedule

Date	Time	Sampling Points
30.1.2017	8:00 – 16:30	H-1, H-3, Shwe-1,Shwe-3 & Shwe-5
31.1.2017	8:00 – 16:30	PH-1,PH-2 & H-5

Source: PCCD-YCDC

Table 2.2-2 4th Survey Schedule

Date	Time	Sampling Points
18.9.2017	8:00 – 16:30	H-1, H-3, H-5, PH-1 & PH-2
19.9.2017	8:00 – 16:30	Shwe-1, Shwe-3, Shwe-5 & Wataya
20.9.2017	8:00 – 14:00	Kokkowa

Source: PCCD-YCDC

2.3 Sampling points

In the 3rd water quality survey, there are total eight sampling points; five sampling points along the Hlaing River and three sampling points from the creeks flowing through Shwe Pyi Thar IZ. In the 4th water quality survey, there are ten sampling points; seven sampling points along the

Hlaing River and three samplings points from the creeks through the Shwe Pyi Thar IZ. Among these sampling points, H1, H3, Shwe 1, Shwe 3 and Shwe 5 are selected to confirm the changes in water quality in theHlaing River and Shwe Pyi Thar IZ in this report.

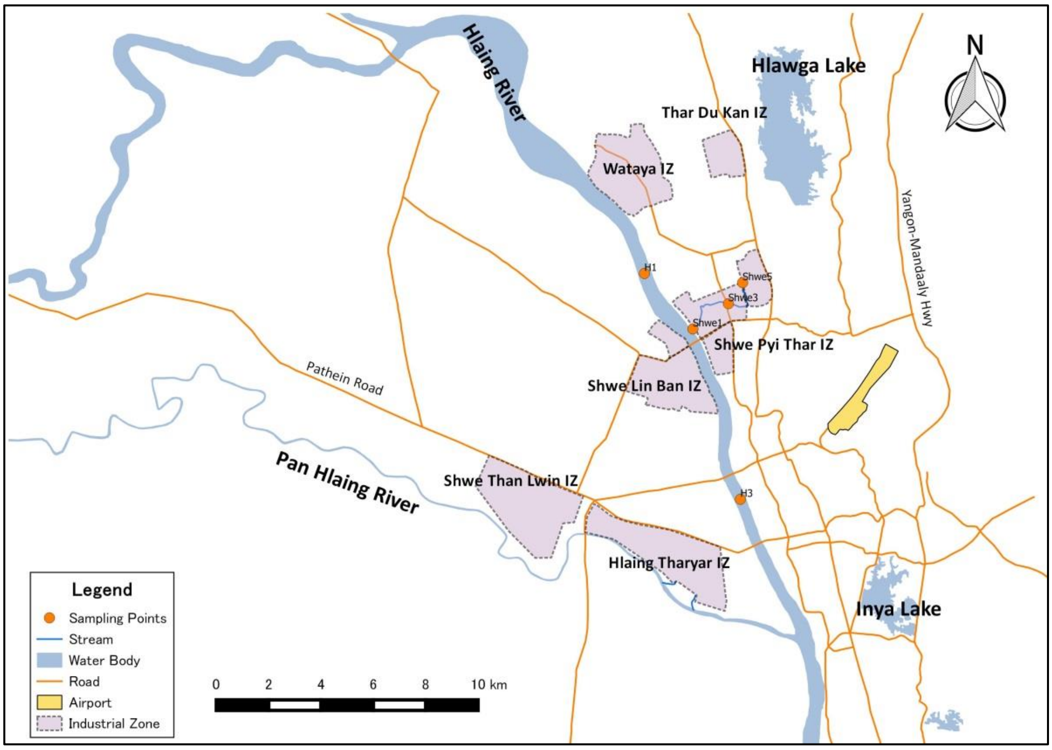


Figure 2.3-1 Sampling Points in the Hlaing River Basin

2.4 Survey parameters

The parameters for on-site measurement and laboratory analysis are listed below. Among them, COD, TSS, total nitrogen, total phosphorus and lead were selected in this report as representative paramaters to evaluate the pollution level in the surface water.

(1) On-site Measurement

- (1) Air Temperature
- (2) Water Temperature
- (3) pH
- (4) ORP
- (5) Conductivity
- (6) Turbidity
- (7) DO
- (8) TDS
- (9) Salinity

(2) Laboratory Analysis

(1) BOD

(2) Total Coliform

(3) Total Suspended Solids (TSS)

(4) COD Cr

(5) Cyanide (total)

(6) Oil and grease

(7) Phenols

(8) Total phosphorus (T-P)

(9) Total nitrogen (T-N)

(10) Zinc (Zn)

(11) Total chromium (T-Cr)

(12) Chromium (Hexavalent)

(13) Arsenic (As)

(14) Copper (Cu)

(15) Total Mercury (Hg)

(16) Cadmium (Cd)

(17) Lead (Pb)

(18) Pesticides

(19) PCBs

2.5 Sampling and measurement

2.5.1 Sampling method

The surface water was taken directly by using a plastic bucket and poured into the sampling bucket. It was then mixed to get homogeneous water before putting into sample bottles.

Sampling from a boat

Homogenization of water samples

Source: JICA Expert Team

Figure 2.5-1 Photos of Water Sampling

2.5.2 On-site measurement method

The pH, EC, DO and some other measurement parameters were analyzed for on-site measurement by using U 52-G multi-parameter water quality meter. The water flow rate at representative sites were calculated by measuring the water flow velocity, water depth and river width. Table 2.5-1 shows a list of equipment which were used for on-site measurement of 3rd survey and 4th survey.

Figure 2.5-2 Photos of On-site Measurement

Source: JICA Expert Team

Table 2.5-1 Field Measurement Equipment

No.	Manufacture	Model Name	Parameter
1	Horiba	U52G Multi-parameter Water Quality Meter	pH, DO, conductivity (EC), salinity, TDS, water temperature, turbidity, ORP
2	Tamaya	Digital current meter UC-200v	Water velocity

3	Global Water	Global water flow probe FP111	Water velocity

Source: JICA Expert Team

2.5.3 Laboratory analysis method

Table 2.5-2 shows the analysis method from respective laboratories of 3rd water quality survey and Table 2.5-3 shows the analysis method of 4th water quality survey.

Table 2.5-2 Analysis Method of 3rd Water Quality Survey

No.	Parameter	Method	Name of
1	BOD	In-house method based on Standard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 5210 B	CLT(Thailand)
2	COD Cr	In-house method based on Standard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 5220 C	CLT(Thailand)
3	Total organic chlorine	In-house method based on EPA Method 508 by GC/μ-ECD	CLT(Thailand)
4	Total organic phosphorus	In-house method based on EPA Method 507 by GC/FPD	CLT(Thailand)
5	Total nitrogen (T-N)	In-house method based on Standard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 4500-N C	CLT(Thailand)
6	Total phosphorus (T-P)	In-house method based on Standard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 4500-P J	CLT(Thailand)

Source: JICA Expert Team

Table 2.5-3 Analysis Method of 4th Water Quality Survey

No.	Parameter	Method	Name of laboratory
1	Total Suspended Solids (TSS)	Environment Agency Notification No. 59,	OSUMI CO., Ltd.
2	COD Cr	JIS K0102 (2016) 20.1	OSUMI CO., Ltd.

3	Cyanide(total)	JIS K0102 (2016) 38.1.2	OSUMI CO., Ltd.
4	Oil and grease	Standard Method 5520 B	OSUMI CO., Ltd.
5	Phenols	JIS K0102(2016) 28.1.1	OSUMI CO., Ltd.
6	Total phosphorus (T-P)	JIS K0102(2016) 46.3.1	OSUMI CO., Ltd.
7	Total nitrogen (T-N)	JIS K0102(2016) 45.2	OSUMI CO., Ltd.
8	Zinc (Zn)	JIS K0102(2016) 53.3	OSUMI CO., Ltd.
9	Total chromium (T-Cr)	JIS K0102(2016) 65.1.4	OSUMI CO., Ltd.
10	Chromium	JIS K0102(2016) 65.2.1	OSUMI CO., Ltd.
11	Arsenic (As)	JIS K0102(2016) 61.4	OSUMI CO., Ltd.
12	Copper (Cu)	JIS K0102(2016) 52.4	OSUMI CO., Ltd.
13	Total Mercury (Hg)	Environment Agency Notification	OSUMI CO., Ltd.
14	Cadmium (Cd)	JIS K0102(2016) 55.4	OSUMI CO., Ltd.
15	Lead (Pb)	JIS K0102(2016) 54.4	OSUMI CO., Ltd.
16	Pesticides	See below	OSUMI CO., Ltd.
17	PCBs	Environment Agency Notification	OSUMI CO., Ltd.
No.	Parameter (Pesticides)	Method	Name of laboratory
1	Aldrin	GC-MS	Nihon Ecotech Co., Ltd.
2	Atrazine	GC-MS	Nihon Ecotech Co., Ltd.
3	4,4'-DDD	GC-MS	Nihon Ecotech Co., Ltd.
4	4,4'-DDE	GC-MS	Nihon Ecotech Co., Ltd.
5	4,4'-DDT	GC-MS	Nihon Ecotech Co., Ltd.
6	Endosulfan	GC-MS	Nihon Ecotech Co., Ltd.
7	Endosulfan sulfate	GC-MS	Nihon Ecotech Co., Ltd.
8	Endrin	GC-MS	Nihon Ecotech Co., Ltd.
9	HCH-alpha (benzene	GC-MS	Nihon Ecotech Co., Ltd.
10	HCH-beta(beta-BHC)	GC-MS	Nihon Ecotech Co., Ltd.
11	HCH-delta(delta-BHC)	GC-MS	Nihon Ecotech Co., Ltd.
12	HCH-gamma(Lindane) (ganma-BHC)	GC-MS	Nihon Ecotech Co., Ltd.
13	Alachlor	GC-MS	Nihon Ecotech Co., Ltd.

14	Diazinon	GC-MS	Nihon Ecotech Co., Ltd.
15	Chlorpyrifos	GC-MS	Nihon Ecotech Co., Ltd.
16	Dimethoate	LC-MS/MS	Nihon Ecotech Co., Ltd.
17	Imidacloprid	GC-MS	Nihon Ecotech Co., Ltd.

Source: JICA Expert Team

3 Results and Discussion

3.1 Water quality results

The results of 3rd and 4th water quality survey are summarized below. The results were compared with the surface water quality standard in the other countries since the ambient water environmental standard has been not yet set in Myanmar. In these surveys, the Vietnamese standard for water usage of water transporation and other purposes (Class B2) was selected as a reference standard to be applied.

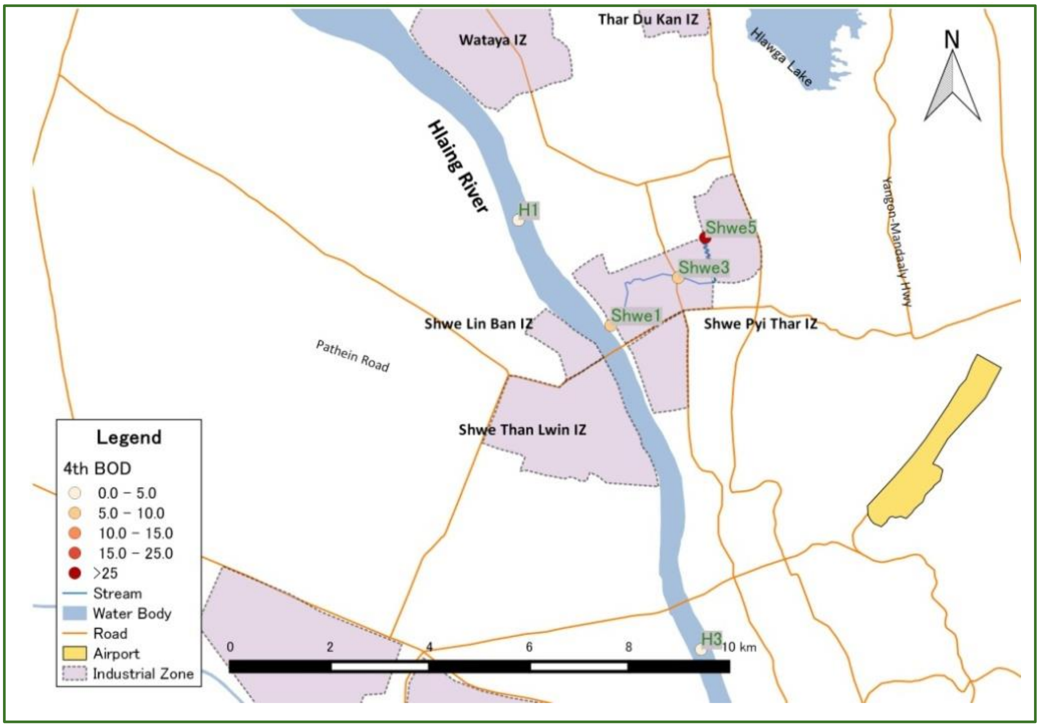
Table 3.1-1 Water Quality Results of 3rd and 4th Survey

Parameters	H-1		H-3		Shwe-1		Shwe-3		Shwe-5		Vn Std* (B2)
	Third Survey (3rd)	Fourth Survey (4th)	3rd	4th	3rd	4th	3rd	4th	3rd	4th	
BOD	7.67	1.16	14.33	1.8	745	5.41	618.75	5.94	34.38	32.07	**25**
COD Cr	12.5	14	33.34	14	823.18	19	781.5	22	37.51	44	**50**
TSS	192	390	948	440	396	180	426	27	7	25	**100**
T-P	0.55	0.19	0.56	0.16	5.87	0.18	10.54	0.22	1.34	0.65	-
T-N	0.45	1.1	0.64	1.2	0.24	1.3	2.33	2.0	<0.05	4.9	-
Lead	0.0039	0.0098	-	-	0.0061	<0.005	0.0050	<0.005	0.0090	<0.005	**0.05**

Unit: mg/L
*Vn Std: Vietnamese national technical regulations on surface water quality (B2: for water transportation and other purposes with demand for low-quality water) (QCVN 08-MT 2015/BTNMT)
Note: The red color shows the value that does not satisfy the Vietnamese Standard (B2)
Source: JICA Expert Team and

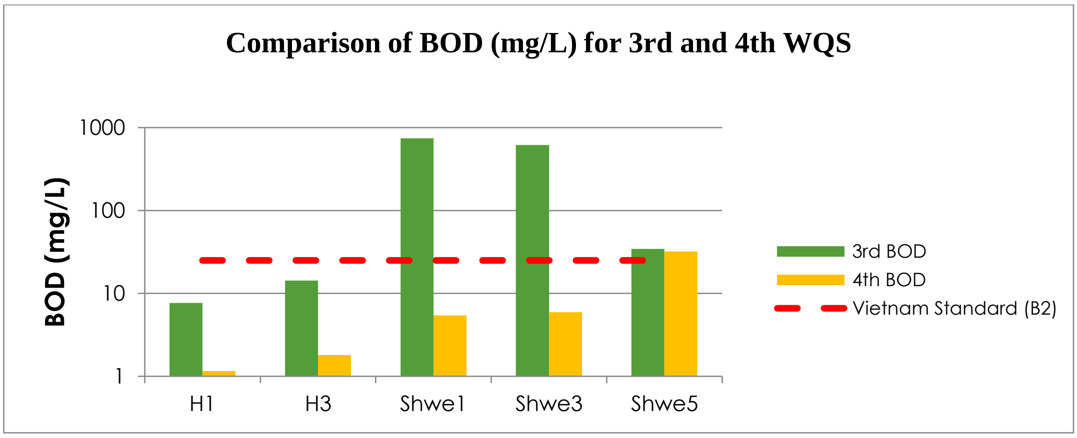
3.1.1 Biochemical Oxygen Demand (BOD)

The BOD results are shown in Figure 3.1-1 and Figure 3.1-2. BOD value of H1 and H3 are lower than the reference standard in 3rd and 4th water quality survey. BOD value of Shwe1, 3 and 5 are higher than the reference standard value in the 3rd water quality survey, indicating the organic pollution in the sub-stream of Hlaing River. The BOD values have difference by seasons; BOD in the 3rd water quality survey for dry season was higher than those in the 4th water quality survey for rainy season.



Source: PCCD-YCDC

Figure 3.1-1 Water Quality Survey Result of BOD (4th Survey)

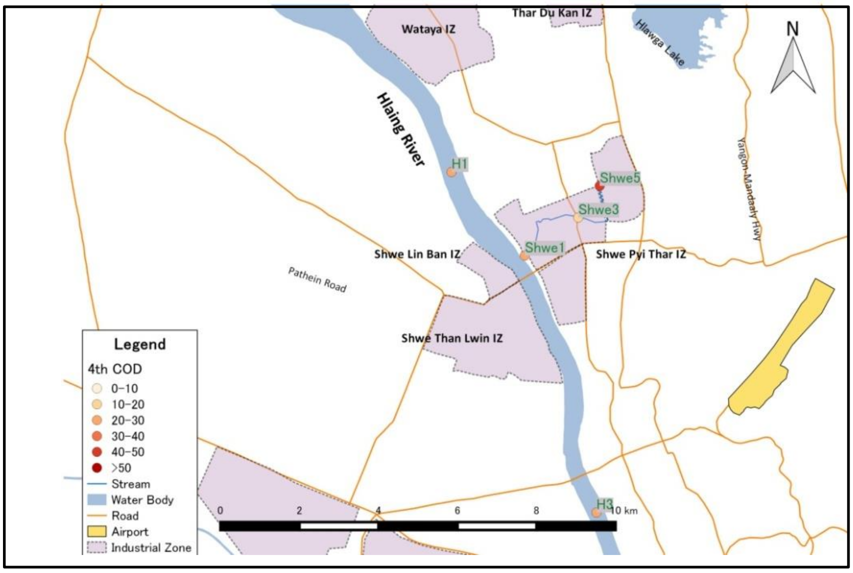


Source: PCCD-YCDC and Vietnamese national technical regulations on surface water quality (B2: for water transportation and other purposes with demand for low-quality water) (QCVN 08-MT 2015/BTNMT)

Figure 3.1-2 Comparison of BOD for 3rd and 4th Water Quality Survey with Reference Standard in the Hlaing River Basin

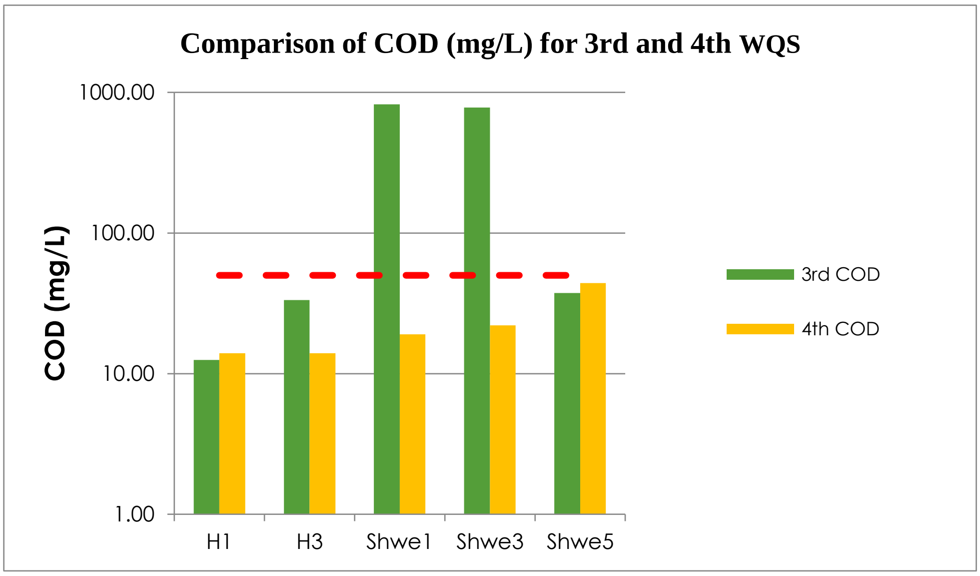
3.1.2 Chemical Oxygen Demand (COD)

The COD results are shown in Figure 3.1-3 and Figure 3.1-4. COD values are lower than the reference standard in the 4th water quality survey. In the 3rd water quality survey, H-1, H-3 and Shwe-5 are lower than the reference standard and Shwe-1 and Shwe-3 are about 16 times higher than the reference standard in the 3rd water quality survey, which indicates a certain level of organic pollution in the sub-stream of the Shwe Pyi Thar IZ.



Source: PCCD-YCDC

Figure 3.1-3 Water Quality Survey Result of COD (4th Survey)

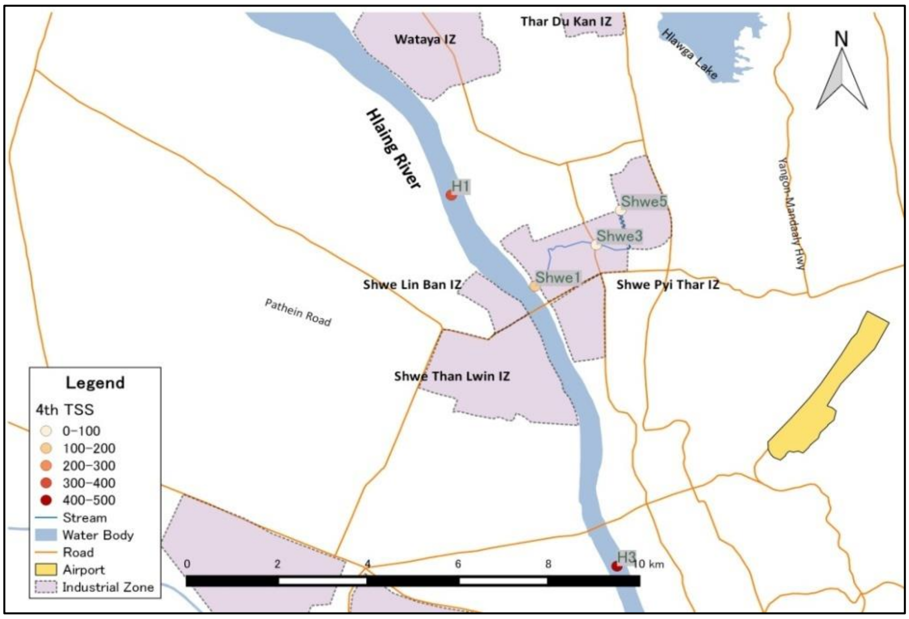


Source: PCCD-YCDC and Vietnamese national technical regulations on surface water quality (B2: for water transportation and other purposes with demand for low-quality water) (QCVN 08-MT 2015/BTNMT)

Figure 3.1-4 Comparison of COD for 3th and 4th Water Quality Survey with Reference Reference standard in the Hlaing River Basin

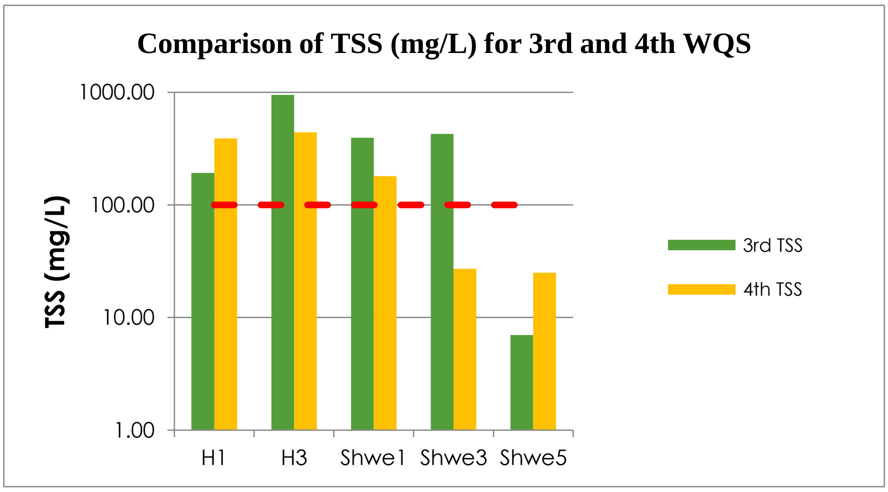
3.1.3 Total Suspended Solids (TSS)

The TSS results are shown in Figure 3.1-5 and Figure 3.1-6. The levels of TSS are higher than the reference standard at almost every points except at Shwe 5 in the 3rd water quality survey. In the 4th water quality survey, TSS values of Shwe 3 and Shwe 5 are lower than the reference standard and those values of H1, H3, and Shwe1 are higher than the reference standard. Since the time of 4th water quality survey is the raining season, it is likely that more suspended solid was contained in the river water due to the tidy and flood.



Source: PCCD-YCDC

Figure 3.1-5 Water Quality Survey Result of TSS (4th Survey)

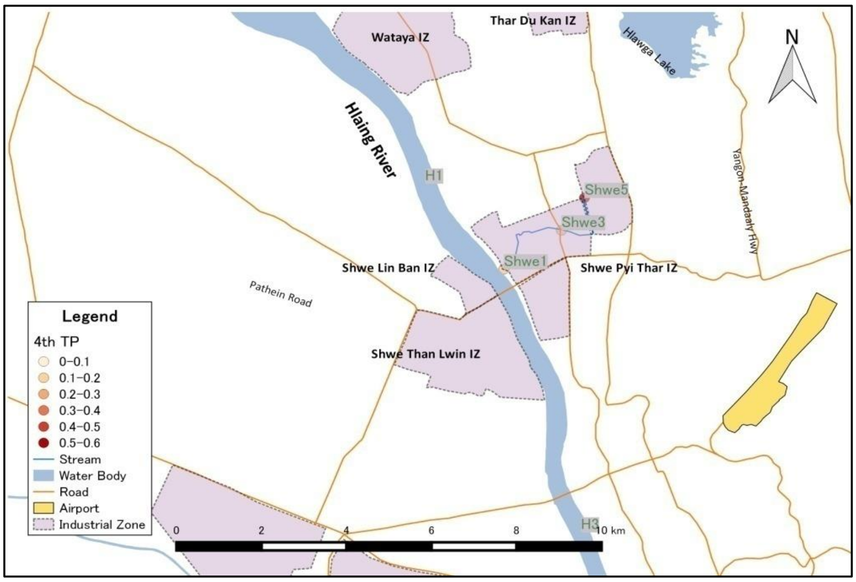


Source: PCCD-YCDC and Vietnamese national technical regulations on surface water quality (B2: for water transportation and other purposes with demand for low-quality water) (QCVN 08-MT 2015/BTNMT)

Figure 3.1-6 Comparison of TSS for 3rd and 4th Water Quality Survey with Reference Standard in the Hlaing River Basin

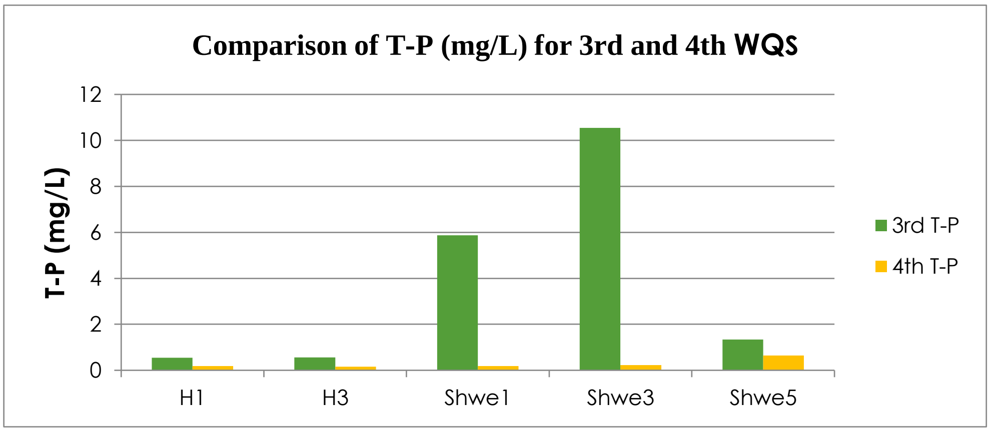
3.1.4 Total Phosphorus (T-P)

The T-P results are shown in Figure 3.1-7 and Figure 3.1-8. The values of T-P at Shwe 1 and Shwe 3 are significantly high in the 3rd water quality survey. It might be polluted by domestic water, industrial wastewater or fertilizer. In the 4th water quality survey, the T-P results are not high values at every points and did not differ by points.



Source: PCCD-YCDC

Figure 3.1-7 Water Quality Survey Result of T-P (4th Survey)

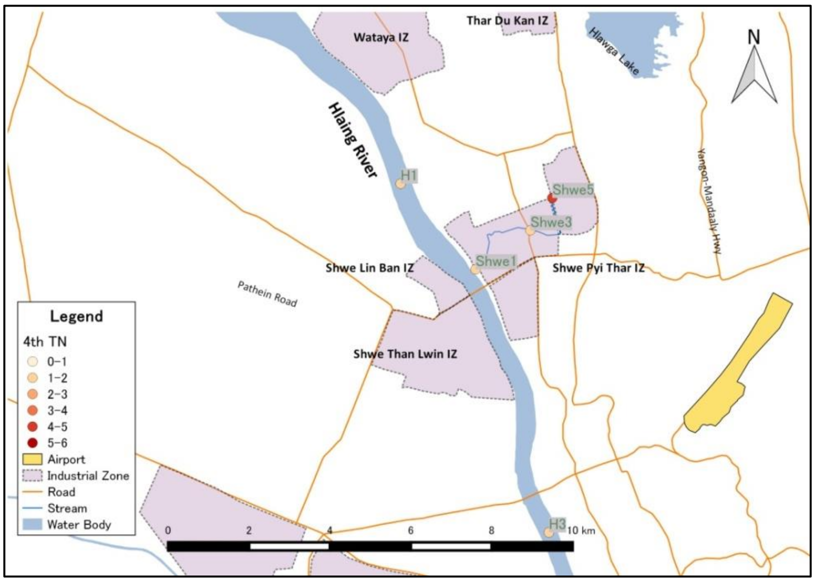


Source: PCCD-YCDC

Figure 3.1-8 Comparison of T-P for 3th and 4th Water Quality Survey in the Hlaing River Basin

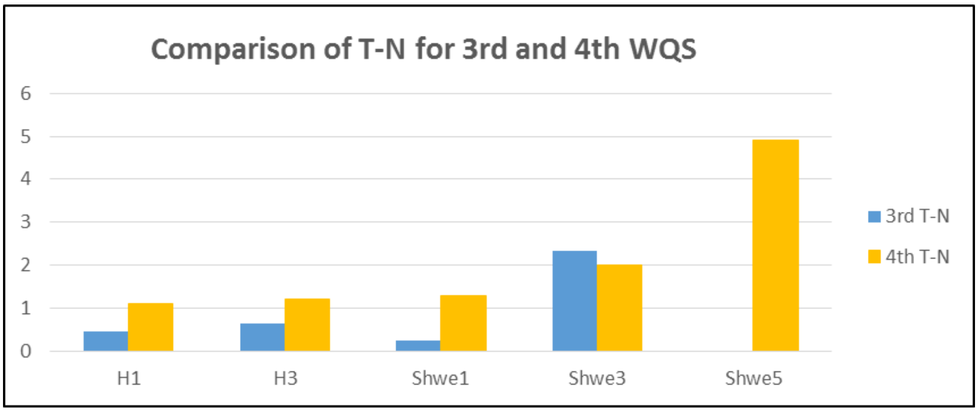
3.1.5 Total Nitrogen (T-N)

The T-N results are shown in Figure 3.1-9 and Figure 3.1-10. The T-N level in the Hlaing River ranges between 0.45 mg/L and 1.2 mg/L. On the other hand, the T–N level in the creek of Shwe Pyi Thar IZ has a wider range; between <0.05 mg/L and 4.9 mg/L. The values of T-N at H1, H3, Shwe 1 and Shwe 5 in the 3rd water quality survey are lower than those values at the same points in the 4th water quality survey. Only the value at Shwe 3 in the 3rd water quality survey is higher than in the 4th water quality survey. The results indicated that these water area would mostly polluted by domestic wastewater, industrial wastewater or fertilizer.



Source: PCCD-YCDC

Figure 3.1-9 Water Quality Survey Result of T-N (4th Survey)



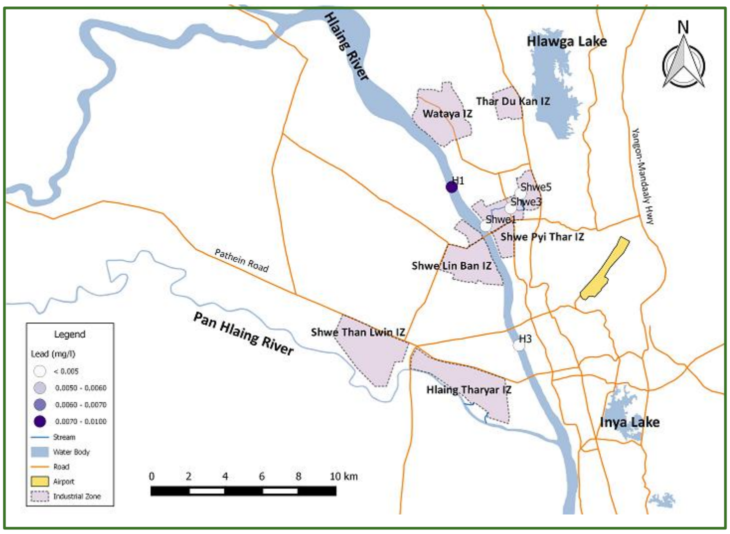
Note: The T-N at Shwe 5 in the 3rd survey was not detected (< 0.05 mg/L)

Source: PCCD-YCDC

Figure 3.1-10 Comparison of T-N for 3rd and 4th Water Quality Survey in the Hlaing River Basin

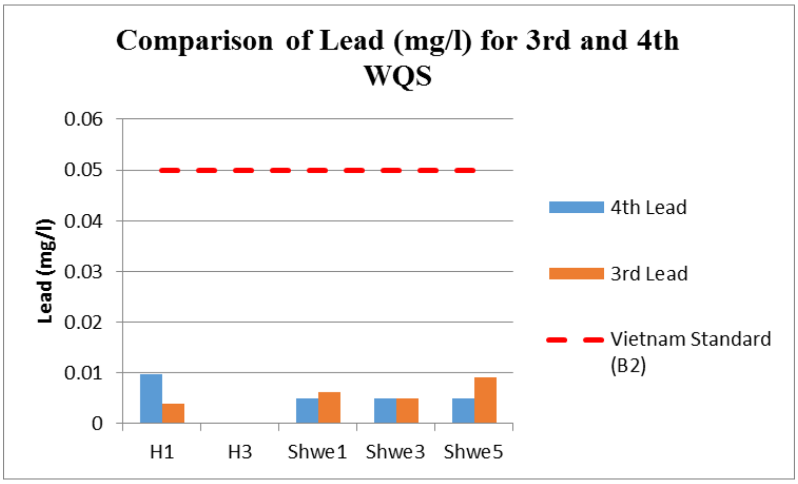
3.1.6 Lead (Pb)

The lead results are shown in Figure 3.1-11 and Figure 3.1-12, a light level of lead or was detected or it was not detected (< 0.005 mg/L) in the both of 3th and 4th water quality survey. The pollution impact of lead from battery factories are suspected in the creek of Shwe Pyi Thar IZ, but not clear in the survey result.



Source: PCCD-YCDC

Figure 3.1-11 Water Quality Survey Result of Lead (4th Survey)



Note: The values of Shwe 1, Shwe 3 and Shwe 5 in the 4th survey were less than 0.005 mg/L and presented as "not detected". The lead at H3 was not measured.
Source: PCCD-YCDC and Vietnamese national technical regulations on surface water quality (B2: for water transportation and other purposes with demand for low-quality water) (QCVN 08-MT 2015/BTNMT)

Figure 3.1-12 Comparison of Lead for 3th and 4th Water Quality Survey with Reference Standard in the Hlaing River Basin

3.2 Discussion

The pollution level of organic materials, nutrients and lead in the Hlaing River and sub-stream of Shwe Pyi Thar IZ was investigated. The evaluation of water quality results are summarized as follows.

- Regarding the organic substance indicated by BOD and COD, the water quality in the Hlaing River met the reference environmental standard (Vietnamese surface water quality standard) in the both of 3rd survey (January 2017) and 4th survey (September 2017). However, BOD and COD values in the creek of Shwe Phy Thar IZ often exceeded the reference standard.
- The nutrients, i.e., total phosphorus and total nitrogen values in the creek of Shwe Pyi Thar IZ are mostly higher than those in the Hlaing River. The nutrients level in the creek differs from point to point. It seems that there was a high pollution load to the creek between Shwe 3 (middle stream) and Shwe 5 (upstream) at the time of 3rd survey (January 2017). However, in the 4th survey (September 2017), the biggest pollution source(s) of nutrients was located at upstream of Shwe 5. The origin of nitrogen and phosphate in this area is considered as domestic wastewater or industrial wastewater. But it is hypothesized that such fluctuation or variation of pollution load could be caused by industrial pollution source. High load of nutrients would cause algal blooms and eutrophication especially in the enclosed water area including the bay which reduces the water’s oxygen content and would kill fish and other aquatic life.
- High levels of lead was not detected in the Hlaing River and sub-stream of Shwe Pyi Thar IZ.

4 Conclusions and Recommendations

4.1 Conclusions

The survey results are concluded as follows.

1) Pollution status in the Hlaing River basin

The 4th survey result did not exceed the limit of reference environmental standard in terms of BOD and COD. Overall, the river water was not polluted seriously.

2) Impacts of industrial wastewaters on Hlaing River basin

The BOD and COD results in the sub-stream in Shwe Phy That IZ did not frequently meet the reference environmental quality standard. This sub-stream is considered to be one of the pollution path of organic substance and nutrients to the Hlaing River, which would deteriorate the Hlaing River water quality, although the pollution impact seems to be limited at present.

3) Seasonal impact on the water quality

The water quality significantly differed between the 3rd water quality survey (January 2017) and 4th water quality survey (September 2018) for most measurement parameters. Apparently, the water quality in the Hlaing River is deteriorated in the dry season, but improved in the rainy season because a larger amount of river water dilutes the pollutants.

4.2 Recommendations

The survey confirmed that the sub-stream in the IZs gives a certain pollution load to the Hlaing River especially in terms of organic and nutrients pollution, which would deteriorate the Hlaing River water quality. The regular monitoring should be implemented, in order to maintain the sustainability of the Hlaing River. The pollution control measures at industries is required to prevent the discharge of wastewater without adequate treatment. Furthermore, the environmental regulations of pollution control should be strengthened although it will require some amount of cost burden.

Appendices

Appendix 1 Photographs

	
Haling River	Pan Hlaing River
	
Sub-stream of Hlaing River (Shwe-1)	Creek in ShwePhy Thar IZ in Yangon (Shwe-5)

Source: JICA Expert Team

Appendix 2 List of Data

A2.1 Analysis Results of 3rd Water Quality Survey

Table A.2.1-1 Results of 3rd water quality survey

No	Parameter	Date	30/1/2017	30/1/2017	30/1/2017	30/1/2017	30/01/17
		Time	9:30	10:25	12:30	13:08	13:45
		Abbreviated name	H1	H3	Shwe1	Shwe3	Shwe5
		Location name	Hlaing-1-C	Hlaing-3-C	Shwe-1-C	Shwe-3-C	Shwe-5-C
On-site measurement							
(1)	pH	-	7.79	7.74	5.7	4.68	7.22
(2)	Conductivity	mS/cm	11.362	1.27	0.805	0.379	0.684
(3)	Salinity	ppt	0.2	0.6	0.4	0.2	0.3
(4)	Turbidity	NTU	288	1000	169	149	23.1
(5)	TDS	g/L	0.235	0.812	0.533	0.246	0.451
(6)	Water Temperature	Degree C	25.89	26.19	28.69	28.56	31.63
(7)	ORP	mv	170	118	-131	-91	-77
(8)	DO	mg/L	7.3	6.34	1.24	0.84	2.59
(9)	Ambient air temperature	Degree C	29.7	33.5	35.1	34.6	34.3
Laboratory analysis							
(1)	Total Suspended Solids (TSS)	mg/L	192.00	948.00	396.00	426.00	7.00
(2)	BOD	mg/L	7.67	14.33	745.00	618.75	34.38
(3)	Cyanide(total)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

No	Parameter	Date	30/1/2017	30/1/2017	30/1/2017	30/1/2017	30/01/17
		Time	9:30	10:25	12:30	13:08	13:45
		Abbreviated name	H1	H3	Shwe1	Shwe3	Shwe5
		Location name	Hlaing-1-C	Hlaing-3-C	Shwe-1-C	Shwe-3-C	Shwe-5-C
(4)	Oil and grease	mg/L	13.30	24.50	64.00	34.24	12.03
(5)	Phenols	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
(6)	Total phosphorus (T-P)	mg/L	0.55	0.56	5.87	10.54	1.34
(7)	Phosphate (PO4-)	mg/L	N.D.	0.20	4.61	5.96	0.99
(8)	Total nitrogen (T-N)	mg/L	0.45	0.64	0.24	2.33	<0.05
(9)	Ammonia nitrogen(NH3-N)	mg/L	0.61	-	2.15	3.68	6.75
(10)	Nitrite nitrogen(NO2-N)	mg/L	<0.02	-	<0.20	<0.20	<0.20
(11)	Nitrate nitrogen(NO3-N)	mg/L	<0.50	-	<0.05	<0.05	<0.05
(12)	Zinc (Zn)	mg/L	0.0133	-	0.0189	0.0904	0.0462
(13)	Total chromium (T-Cr)	mg/L	0.0067	-	<0.0015	<0.0005	<0.0005
(14)	Chromium (Hexavalent)	mg/L	<0.025	-	<0.025	<0.025	<0.025
(15)	Arsenic (As)	mg/L	<0.0015	-	0.0020	0.0016	0.0031
(16)	Copper (Cu)	mg/L	0.0039	-	0.0036	0.0033	0.0152
(17)	Total Mercury (Hg)	mg/L	<0.0002	-	<0.0002	<0.0002	<0.0002
(18)	Cadmium (Cd)	mg/L	<0.0005	-	<0.0005	<0.0005	<0.0005
(19)	Lead (Pb)	mg/L	0.0039	-	0.0061	0.0050	0.0090
(20)	Total Coliform	MPN/100mL	2,400	7,000	240,000	3,300	1,100,000

No	Parameter	Date	30/1/2017	30/1/2017	30/1/2017	30/1/2017	30/01/17
		Time	9:30	10:25	12:30	13:08	13:45
		Abbreviated name	H1	H3	Shwe1	Shwe3	Shwe5
		Location name	Hlaing-1-C	Hlaing-3-C	Shwe-1-C	Shwe-3-C	Shwe-5-C
(21)	Total organic chlorine pesticides	mg/L	-	-	<0.001	-	-
(22)	Total organic phosphorus pesticides	mg/L	-	-	<0.005	-	-
(23)	PCB (Aroclor 1254)	mg/L	-	-	<0.01	-	-

A2.2 Analysis Results of 4th Water Quality Survey

Table A.2.2-1 Results of 4th water quality survey

No.	Location name	Unit	H1	H3	Shwe1	Shwe3	Shwe5
			Hlaing-1-C	Hlaing-3-C	Shwe-1-C	Shwe-3-C	Shwe-5-C
	Sampling Date		18/9/2017	18/9/2017	19/9/2017	19/9/2017	19/9/2017
	Sampling Time		10:10	11:05	13:11	13:46	8:40
On-site measurement							
1	Air Temperature	Degree C	31.61	29.83	34.60	32.00	29.80
2	Water Temperature	Degree C	28.98	29.11	28.75	28.47	27.68
3	pH	-	7.23	7.62	7.36	7.00	7.15
4	ORP	mv	300	286	262	236	130
5	Conductivity	ms/cm	0.110	0.102	0.134	0.144	0.315
6	Turbidity	NTU	578	626	451	54.60	148
7	DO	mg/L	6.60	8.92	7.16	8.84	4.46
8	TDS	mg/L	72	67	87	94	211
9	Salinity	ppt	0.1	0.0	0.1	0.1	0.1
Laboratory analysis							
1	BOD	mg/L	1.16	1.80	5.41	5.94	32.07
2	Total Coliform	MPN/100ml	-	-	> 160000	> 160000	>160,000
3	Total Suspended Solids (TSS)	mg/L	390	440	180	27	25

No.	Location name	Unit	H1	H3	Shwe1	Shwe3	Shwe5
			Hlaing-1-C	Hlaing-3-C	Shwe-1-C	Shwe-3-C	Shwe-5-C
	Sampling Date		18/9/2017	18/9/2017	19/9/2017	19/9/2017	19/9/2017
	Sampling Time		10:10	11:05	13:11	13:46	8:40
4	COD Cr	mg/L	14	14	19	22	44
5	Cyanide(total)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
6	Oil and grease	mg/L	< 1	< 1	< 1	< 1	1.3
7	Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
8	Total phosphorus (T-P)	mg/L	0.19	0.16	0.18	0.22	0.65
9	Total nitrogen (T-N)	mg/L	1.1	1.2	1.3	2.0	4.9
10	Zinc (Zn)	mg/L	0.060	-	0.032	0.021	0.042
11	Total chromium (T-Cr)	mg/L	0.048	-	0.024	< 0.005	0.010
12	Chromium (Hexavalent)	mg/L	< 0.005	-	< 0.005	< 0.005	< 0.005
13	Arsenic (As)	mg/L	0.0028	-	0.0019	0.0012	0.0033
14	Copper (Cu)	mg/L	0.019	-	0.013	< 0.005	0.014
15	Total Mercury (Hg)	mg/L	< 0.0005	-	< 0.0005	< 0.0005	< 0.0005
16	Cadmium (Cd)	mg/L	< 0.001	-	< 0.001	< 0.001	< 0.001
17	Lead (Pb)	mg/L	0.0098	-	< 0.005	< 0.005	< 0.005