6. Conclusions

According to the National Mid-term Development Program (RPJMN) 2010–2014 that is harmonious with the Millennium Development Goals (MDG), the Indonesian Government is committed to improve the sanitation services, public health, and environmental improvement. The Indonesian Government conducts the best endeavors to live up to the following national expectations.

1) Up to around 75% of basic sanitation access by 2015
2) Up to minimum of 65% of functioning of wastewater treatment and fecal sludge treatment system at the end of 2014
3) Up to 45% of wastewater treatment services as well as to decrease river pollution from the fecal sludge from existing conditions by the end of 2014

Following these perspectives of the Indonesian Government, DKI Jakarta, Ministry of Public Works and PD PAL JAYA consulted JICA to conduct of “Data Collection Survey on Water Environment Improvement through Low-Cost Wastewater Treatment System in Jakarta”. The Survey team of Hiroshima University conducted the survey for six months from March to August in 2010. This chapter summarized the main outcome of the report for this survey.

In this chapter, the survey results on the comprehensive water environment monitoring system (the low-cost and high precision water quality analysis method and the low-cost and high performance environment simulator of PC cluster) were summarized in sections 6.2, 6.3, and 6.4, following the outline of Survey Framework in section 6.1. The comprehensive water environment monitoring system was designed to assess the water environment (water quality and flood disasters) for the practices of UASB-DHS sewage treatment system and the solid waste management in DKI Jakarta, that were summarized in sections 6.5 and 6.6.

6.1. Survey Framework

Through the survey and analysis, the Survey team aimed to make clear the theoretical background and to propose the suitable technologies for improvement of water environment in DKI Jakarta, JABODETABEK that have the complex water environmental problems mingling with waste water, solid waste, flooding in the low land caused by land subsidence and sea level rise due to global warming. Finally, the Survey team summarized the proposals of the following technologies to improve water environment in Jakarta.

1) The low-cost & high performance system for sewage treatment for the City of Jakarta. One of the most preferred candidate measures is UASB-DHS system which enables sewage water purification in the small scale and closed catchment.
2) Comprehensive water environment monitoring system which consists of the low-cost and high precision water quality analysis method and the low-cost and high performance environment simulator of PC cluster.
3) The effectiveness of the low-cost & high performance system for sewage treatment that would be assessed by the comprehensive water environment monitoring system.
4) The possibility of effective sewerage system in DKI Jakarta that should be proposed in consideration with both low-cost sewage treatment system and flooding control by sustainable development plan in the lowland area of Jakarta (with reclamation in Jakarta Bay and land subsidence abatement by ground water management).

Fig. 6.1.1 depicts the overall survey framework, which consist of the technologies mentioned above.

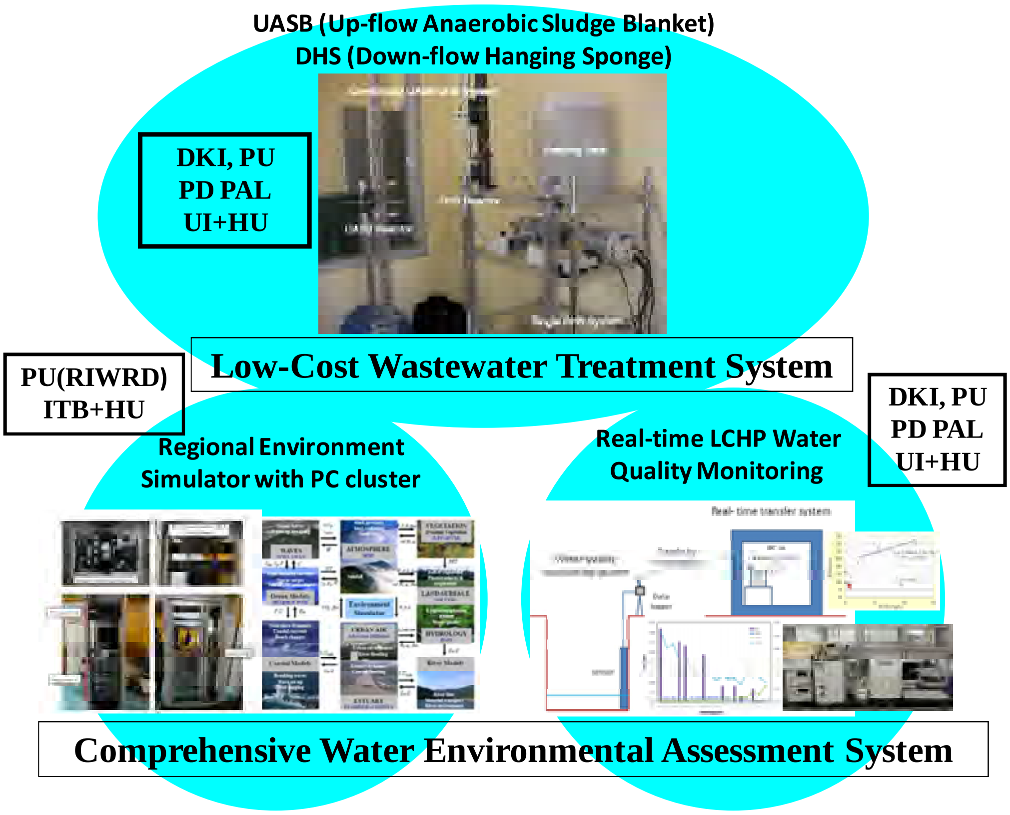


Fig. 6.1.1 Survey framework

6.2. Regional Environment Simulator

The Regional Environment Simulator (RES) developed in IDEC, Hiroshima University was employed for a numerical simulation of the water-quality-improvement effect of low-cost sewage treatment system in this survey. The validity of this technology shall be examined together with the summary of the project. Moreover, the practical feasibility of the comprehensive environmental assessment technology that could be introduced to the Ministry of Public Works (PU) was examined. The feasibility of RES that was established and used in ITB (Bandung Institute of Technology) was also examined.

The RES is a numerical model system which combined three simulation parts such as atmosphere-ocean circulation, atmosphere-land surface circulation, and coastal-estuarine circulation. Basic modules in the RES are codes of numerical models which have been established by many top-level research institutions and researchers in the world, and have been used in many research institutions all over the world.

In this survey, the RES in ITB was applied to the Jakarta flooding event in 2007 to check the performance of the system as well as to evaluate the water-quality-improvement effect by the Low-cost Sewage Treatment System (Fig. 6.2.1). Concerning the effect of water quality improvement by the Low-cost Sewage Treatment System, the Survey team unfortunately could not produce expected result because the data was either not available or incomplete.

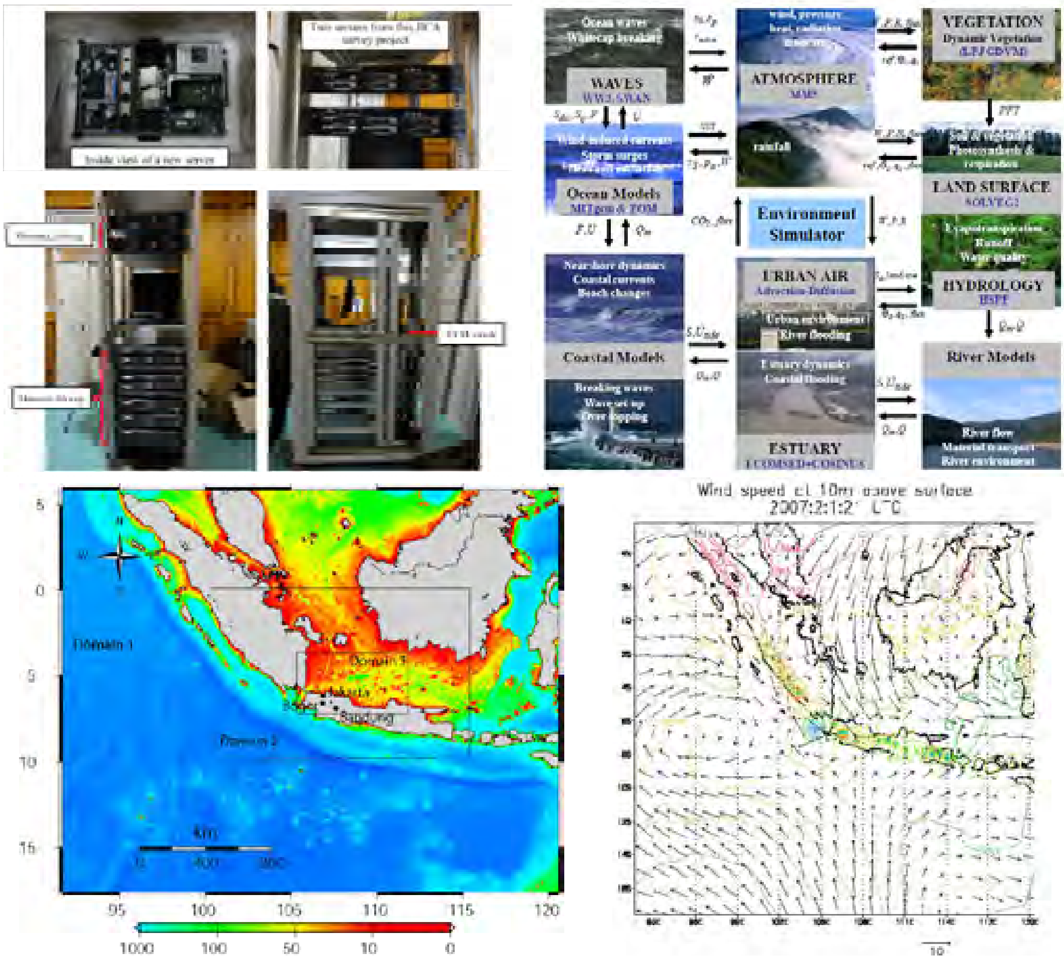


Fig. 6.2.1 Survey outcome from Regional Environment Simulator

6.3. Water Quality Monitoring

6.3.1. Real-time Water Quality Monitoring System

The monitoring with the high frequency, such as daily to weekly, is more useful for evaluating the influence of the municipal and industrial contamination on the water environment and ecosystem. However, difficulties may arise in terms of the price and time interval to analyze BOD as the water pollution index and other suitable chemical components as pollution indices for monitoring data with high frequency in developing countries. On the other hand, the electrical conductivity (EC) and dissolved oxygen (DO) are monitoring parameters with easy and simple method in low price. The Survey team completed the real time monitoring system and transfer system with low price and high performance, which comprises the monitoring sensors of EC, pH, temperature and DO and data transfer system (Fig.6.3.1).

To utilize such simple system, it is necessary to confirm the relationship amongst BOD and DOC, EC and other chemical components (e.g., EC and DOC, and EC and BOD) on the basis of the data in Jakarta. In this survey, the Survey team examined the followings:

1) Collections of previous data and construction of data base
2) Detailed analysis of water quality in rivers and canal sewage water samples
3) Confirmation of the technical merits among technologies available and applicability in Indonesia.
4) Quality check of low cost real-time monitoring system for water quality

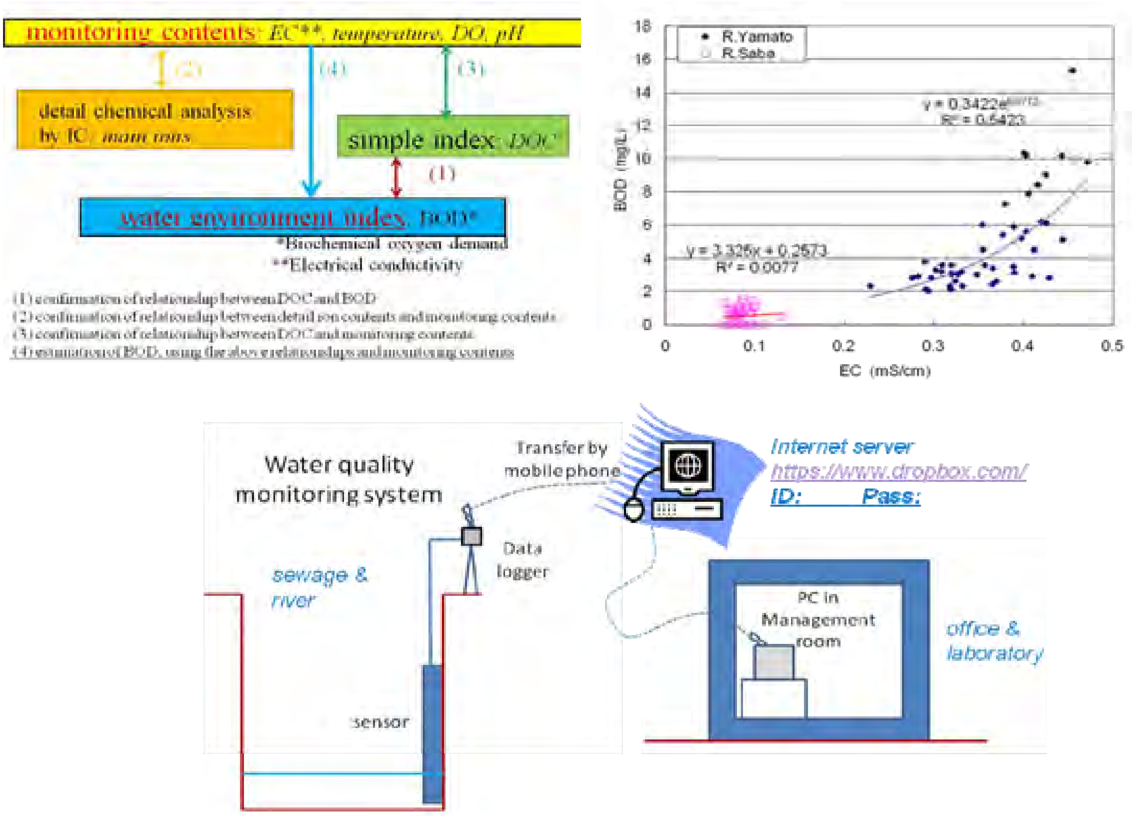


Fig. 6.3.1 Survey outcome in real-time water quality monitoring system

6.3.2. Ion Chromatography Analysis

When considering synthetically the above-mentioned water quality monitoring data and the analytical data provided from PD PAL JAYA on BOD/COD, the results of same biological reactions were discovered estimated from the two ponds near PD PAL JAYA office.

1) Negligible formation of biological oxidation reaction for BOD/COD removal in the pond due to un-aerobic conditions. However, there was slight biological nitrification reaction due to slightly increased concentration of NO_3^-
2) Considerable formation of biological de-nitrification reaction for NO_3-N removal in the ponds due to un-aerobic conditions under the presence of BOD/COD
3) Insufficient function of the two ponds near PD PAL JAYA office as biological treatment site

4) As a conclusion based on the viewpoints of water quality monitoring technology and water treatment technology, it is necessary to introduce a highly efficient biological treatment system such as Down-flow Hanging Sponge (DHS)
5) The presence of NH_4^+ as well as NO_3^- in an urban river indicates human activity in the urban area. In conclusion, strict prohibition is necessary for direct discharge of sewage wastewater into the urban rivers by water quality regulation

In this survey study of sewage treatment system for Jakarta, urban river waters in central Jakarta and the Ciliwung River watershed from Bogor to Jakarta, the usefulness of the advanced ion chromatography technologies for water quality monitoring were demonstrated on the applications to several practical waters discharged from housing and business complex, as well as any industrial and agricultural sectors along the urban rivers, such as the Ciliwung River watershed in Jakarta Metropolis.

The proposed ion chromatography technology which enables the water quality evaluation based on the simultaneous determination and highly sensitive detection of common anions, cations, nutrients, and alkalinity, is very useful for the applications to a developing country like Indonesia. In future the introduction in Indonesia and technical assistance from Japan is extremely essential for water quality monitoring method using the IC technology, as well as the educational support on environmental analytical chemistry, environmental sciences/chemistry, and wastewater treatment technology including biological and physical-chemical treatment technologies for wastewaters (Fig. 6.3.2).

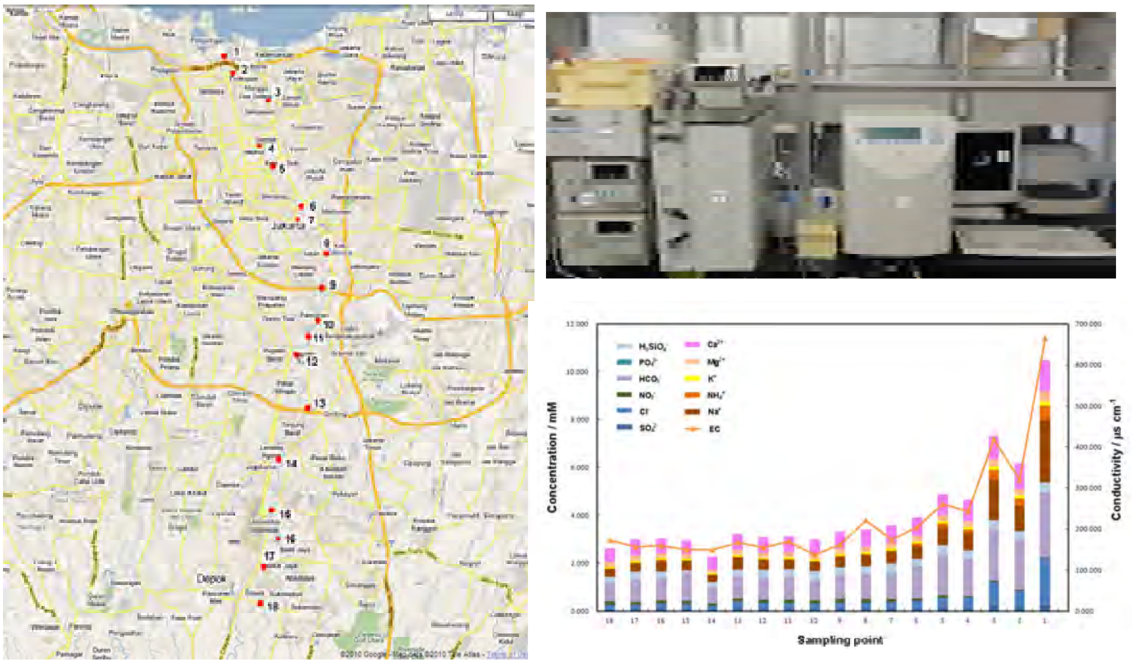


Fig. 6.3.2 Survey outcome from ion chromatography analysis

6.4. Comprehensive Water Environmental Assessment System

The Survey team proposed the “Comprehensive Water Environment Assessment System” which consisted of a low-cost and high precision water quality analysis method and the low-cost and high performance environment simulator of PC cluster, as shown in Fig. 6.4.1.

From the survey of Comprehensive Water Environment Assessment System, the Survey team confirmed the followings.

1) Available operation of regional environment simulator by ITB researchers
2) Necessity of effective use of simulation results by communities and governments
3) Availability of IC water quality analysis by UI/PD PAL JAYA
4) Necessity of continuous monitoring under the existing water quality monitoring system. IC water quality analysis should verify the results of existing water quality monitoring system

5) Working possibility of real-time water quality data transfer system

6) Necessity of continuous measurement of water quality monitoring through Real-time water quality data transfer system to link to the environment simulator

7) Possibility of assessment of river water quality as a flux (concentration multiply current). River discharge measurement and constituent concentration analysis data should be combined to obtain the fluxes of pollutant and nutrient

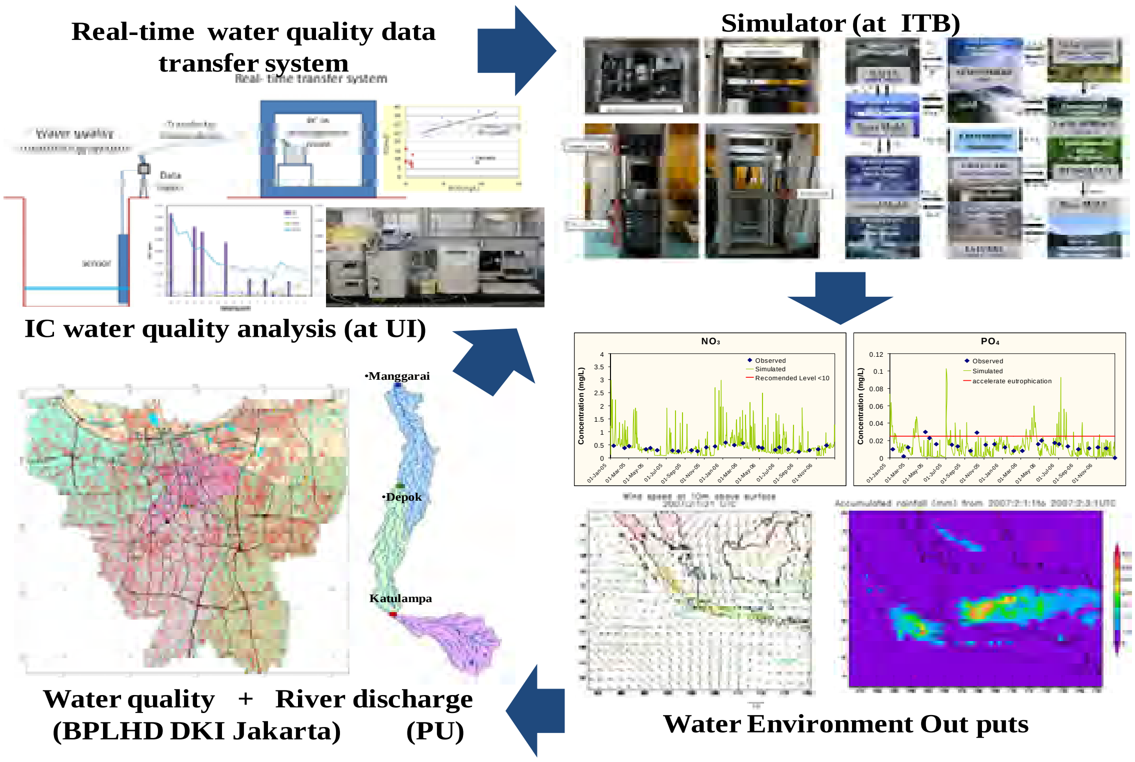


Fig. 6.4.1 Integrated components in the Comprehensive Water Environment Assessment System

The Survey team recommends the client to consider the introduction of Comprehensive Water Environment Assessment System for environmental preservation with community and government under the support of high-level universities (e.g., UI and ITB) in Indonesia.

The Survey team also recommends the client to consider the operation measures of the Comprehensive Water Environment Assessment System. For example, some fund to operate the system should be allocated to universities (e.g., UI and ITB) in the form of an official role from the central/local government.

6.5. Sewage Treatment System

6.5.1. Appropriate Technology System for Sewage Treatment

It is obvious that even though the sophisticated sewage treatment system, which is widely spread in Japan, is transferrable to developing countries such as Indonesia and others; the system may not work well as have been explained in this report. To popularize sewage treatment system in developing countries, the transfer of appropriate technology specified for them, not expensive in Japan, is absolutely required, which are also low cost and easy maintenance. It must be also considered the locality of developing countries in the structures of their economy, society and so on to make the sewage treatment system applicable and functioning.

UASB (Up-flow Anaerobic Sludge Blanket) reactor for sewage treatment has been adopted as the standard sewage treatment system in India. UASB would be the best promising method even in Jakarta because methane gas can be produced as energy from sewage. Not only in India but also several other countries, such as Brazil, Mexico, Colombia, Egypt, Jordan, Thailand and Indonesia, UASB has been installed this system for sewage treatment.

However, UASB reactor usually needs post-treatment to meet regulated water quality of effluent. As UASB post-treatment systems, there are several systems such as wetland, pond, trickling filter, aerated bio-filter and rotating biological contactor. Wetland and pond systems, which require large area, are not suitable for big cities and cannot produce good water quality. Trickling filter also has some limitations in effluent quality. With regard to rotating biological contactor, the operation is not straight forward. On the other hand, DHS (Down-flow Hanging Sponge) reactor with no external aeration process has good features of cost effectiveness and easy maintenance with good effluent. Okubo (2010) in Japan has summarized treatment performance, land area and electricity required, with regard to several post-treatment systems and concludes that DHS reactor would be the best for UASB post-treatment. Therefore, the Survey team had decided to investigate whether the combination system of UASB and DHS reactors may be applicable to sewage treatments in Jakarta.

6.5.2. Bench-scale Treatment Using Artificial Sewage

Before setting up a bench-scale UASB-DHS system on site in Jakarta and carrying out a long-term experiment for continuous treatment using actual sewage, the Survey team had to ascertain the rough performance and operation method of this system. From the experiments that the Survey team conducted on the artificial sewage treatment using the same UASB-DHS system at Hiroshima University, fundamental information was obtained. The UASB and DHS reactors were then designed and set up.

Prior to the real treatment experiment, sewages in the ponds by PD PAL JAYA in Jakarta were taken in the first stage of investigation (March 25-30, 2010), and the samples were analyzed. Based on the pond influent data, the Survey team finalized the composition of artificial sewage for the experiment and satisfactory results were found in the pilot experiment.

The Survey team then decided the use of a combination system of UASB and DHS reactors, which could be applicable to sewage treatments in Jakarta. However, just single DHS reactor without UASB might also be possible to treat the sewage flowing into the ponds in Jakarta because the influent COD concentration was relatively low compared with the general sewages due to dilution by river water. Finally, the Survey team operated two treatment systems, combined UASB-DHS and single DHS for about two weeks in Hiroshima University. The schematic diagrams of two systems and their operating parameters are shown in Fig. 6.5.1.

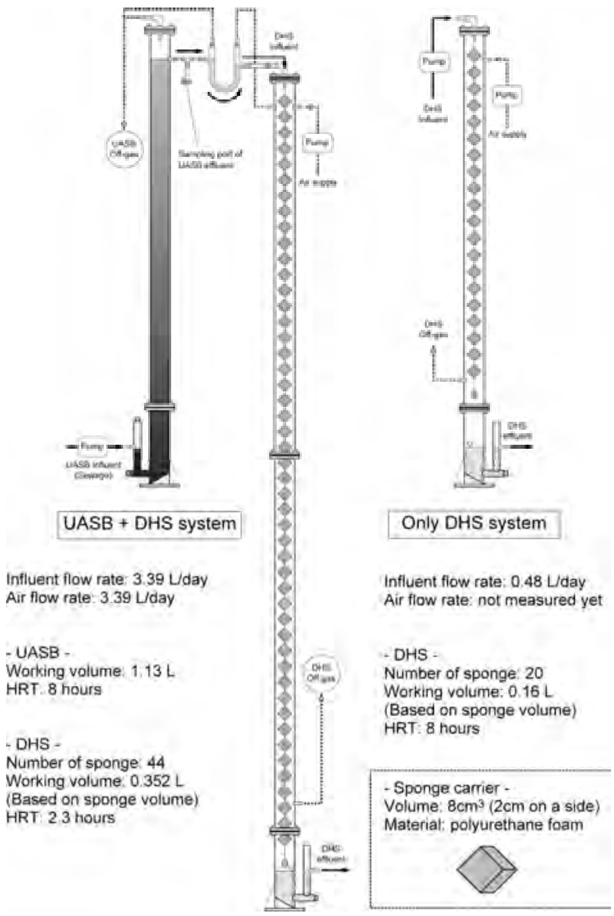


Fig. 6.5.1 Schematic diagrams and operating parameters of two sewage treatment systems

In the experiments, the most important operation parameter was HRT. When the two systems were operated at HRTs of 10.3 and 8 hrs for the combined UASB-DHS and the single DHS, respectively, which were identical to the activated sludge process in field condition, effluents of very good quality were obtained. The quality was at the same level of the activated sludge process. This means that the HRT operated was appropriate for the artificial wastewater modeled on the actual sewage in Jakarta. Eventually, this led to the determination of the Survey team to set up and operate both systems on site at the same HRT.

6.5.3. Actual Sewage Treatment by the Systems Set up in Jakarta

To investigate whether the combination system of UASB or DHS reactors is the most preferred for sewage treatment in Jakarta, both treatment systems, the combined UASB-DHS and the single DHS were moved to Jakarta. They were set up in a control room of PD PAL JAYA on May 4, 2010 and operated continuously for three months using the actual sewage in the pond.

In the combined UASB-DHS system, COD removal by UASB was insufficient, but a very good quality was obtained on the polishing DHS reactor without being affected by the fluctuating influent of COD. The whole COD removal achieved 90% on average throughout the operation. (The COD effluent of 18 mg COD/L on average sufficiently meets environmental standards.) Methane production from the UASB reactor was rather small (methane concentration 5%, gas production rate 0.7 ml-CH_4•m^{-3}-sewage•d^{-1}) because the amount of removed COD was small due to the low COD influent of 224 mg/l. The summary of the performance data is detailed in Table 6.5.1.

Table 6.5.1 On-site treatment performance data in Jakarta (Summary of the performance)

Analysis item	Unit	Raw sewage	Combined system		Single DHS system (10H)	Single DHS system (6H)	pond
			UASB	DHS			
Total-COD_{Cr}	mg/L	224	69	18	15	16	102
Soluble-COD_{Cr}	mg/L	65	51	13	13	11	36
Total-COD_{Cr} removal	%	-	90		88	94	54
Ammonia	mg-N/L	26.4	26.9	6.2	0.7	0.6	16.8
Nitrate	mg-N/L	0.1	0.1	6.8	6.1	12.0	0.3
temperature	˚C	28.2	27.9	27.7	28.3	27.6	28.6
pH	-	7.4	7.3	6.6	7.8	7.9	7.6
Methane production	mL-CH_4/L-	-	0.7	-	-	-	-

Source: This survey experiment

The single DHS system also worked well in not only COD but also ammonium removal. The effluent quality was comparable to the combined UASB-DHS system.

These onsite sewage treatment experiments demonstrated that the combined UASB-DHS system and the single DHS system are applicable for sewage treatment in Jakarta.

6.5.4. Recommended Low Cost Sewage Treatment

In designing a pilot-plant, its size is determined as a function of the amount of sewage and HRT. However, the most important parameter for design and operation of a pilot-plant is HRT. Based on the on-site experimental data in Jakarta, the Survey team determined HRT for appropriate treatment as follows.

1) Combined UASB-DHS system: 10.3 hrs (8 and 2.3 hrs for UASB and DHS reactors, respectively)
2) Single DHS system: 6 hrs (based on sponge volume)

In the combined UASB-DHS system, methane gas is generally produced and recovered from sewage. For low strength wastewaters like the sewage coming into the ponds in Jakarta, however, little methane production was expected. On the other hand, almost complete nitrification and some denitrification were expected in the single DHS system at shorter HRT. In conclusion, the Survey team recommends the single DHS system as the preferred low cost sewage treatment in Jakarta. If higher COD sewage can be collected from the pond, the combined UASB-DHS system should then be recommended because methane gas recovery would be expected.

6.6. Solid Waste Management at the Surface Water Area

The result of the Survey concerning solid waste management at the surface water areas in Jakarta revealed the following three important facts:

1) Firstly, the availability and reliable data regarding the solid waste at the surface water area in Jakarta were very limited. As daily waste collecting service is implemented at 244 places including the Manggarai Watergate by a private company, it may be possible to implement a detailed survey of the river-waste from the support of this company. However, it is necessary to hire interpreter when Japanese researcher conducting the survey.
2) Secondly, the effort of river cleaning service by DINAS PU is not sufficient due to budget shortfall. For the purpose of reducing flood damage, PU has commenced a large scale drainage work on 13 rivers since August 2010 using the World Bank's soft loan (Rp. 200 billion). However, for sustainable development of municipal solid waste management at the surface water areas, it is essential to allocate adequate budget to DINAS PU, DKI Jakarta.
3) Thirdly, it is necessity and important to conduct community based environmental education. Especially, the most important and fundamental solution is to provide environmental infrastructure, as well as environmental education for economically-deprived squatter communities residing along the rivers.

From the results of the continuous processing experiment, the Survey team found that it is difficult to use methane gas recovered from UASB reactor as power generator of incinerator and UASB-DHS combined system because of the low methane gas density in the Setiabudi Pond. In addition, the Survey team could not reach the consensus to actively promote the introduction of small incinerators to local communities along the river, even if the incinerator is inexpensive and safe for use.

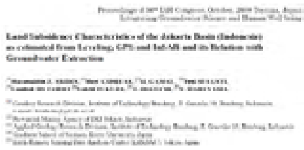
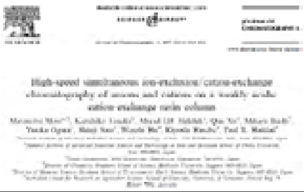
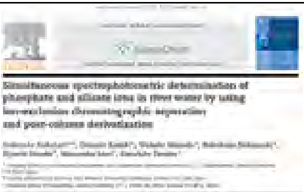
On the other hand, the Survey team found the automatic screens for intercepting the flowing waste have been installed at 21 river places in DKI Jakarta but with some of screens not operating due to technical problems with the devise and shortage in electricity. There are various types of waste removal screen, and the key to avoid operational difficulty is to recognize the existence of various screen types for removing waste from river, select the adequate screen fitting the river features, in addition to operation and maintenance status and implement detailed design individually. In the meanwhile, floats and rope can be utilized for floating waste removal as already in use in Japan. Since floats and rope system is simple and low cost, it is recommended to consider it as a useful facility.

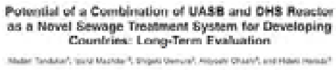
Acknowledgements

The Survey team acknowledges the kind assistance and suggestions from many professional persons and institutions while conducting this project. In particular, the Survey team consulted Prof. Setyo Sarwanto Moersidik, University of Indonesia, to learn the advanced technology in the field of Sanitary and Environment Engineering within Indonesian research community. He also kindly arranged necessary assistance during the survey. Prof. Nining Sari Ningsih and Dr. Totok Suprijo, ITB, engaged in setting up of the PC cluster and executing the RES.

Appendix A

Supplementary material in CD-ROM

Appendix-4.1	
Appendix-4.2	
Appendix-4.3	
Appendix-4.4	
Appendix-4.5	
Appendix-4.6	
Appendix-4.7	
Appendix-4.7	**Same as Appendix B.**

8c Reklamasi –BPR Pantura	
India-Japan International Collaboration	
LoebisIAHSYokohama1993	 Reservoir operation conflict in Citarum river basin management J. LOEBIS
PD PALpresentasi-kamis12 Feb ENGLISH	
Potential of a Combination of UASB and DHS Reactor	 Potential of a Combination of UASB and DHS Reactor as a Novel Sewage Treatment System for Developing Countries: Long-Term Evaluation
Seminar Sewerage and Water Environmental Issues	

Appendix B

Setup procedure

Connect all equipment and cables as shown in Fig. B.1.

Start laptop PC.

Confirm that laptop PC is connected to cell phone.

Start the Ecowatch software which controls the sensor. Maximize window of the Ecowatch, if it is small window.

Adjust port number to 'COM4' in the Ecowatch for communication with the PC. Ecowatch>Comm>Sonde>COM4>OK

(If you can't communicate with PC through COM4, please check port number of a convert cable from RS232C to USB. You can check it through 'device manager' in control panel of the Windows.)

Terminal window will be opened. Then type '#menu' and hit 'Enter key'.

Confirm the clock of the PC according to the following procedure. Type '5' to move to 'system'. Then type '1' to move to 'Date & Time'. If the PC needs to adjust the clock, type '6' to adjust the clock.

Adjust the interval to 5 seconds for confirmation the sensor works surely. Type '1' to move to 'Run', type '1' to move to 'Discrete sample', type '2' to move to 'Sample interval', then adjust the interval.

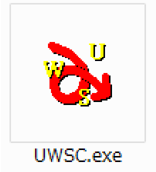
Type '1' to start measurement and you can see the result of measurement of every 5 seconds after stabilization of the sensor. Confirm whether the result is an acceptable value. If not so, clean up the sensor.

If the sensor is OK, type'0' and 'Esc key' to back.

Adjust the interval to 3600 seconds (1 hour) for logging.

Type '0,0,0,y' to terminate the Ecowatch.

Start 'UWSC software' in taskbar of Windows.



Click right button of the UWSC to open a programmed file.

Open ‘logging start.UWS’.

Click the center button of the UWSC to start a program.

Then, the PC will be in automated system. Do NOT touch any key when the PC is under automation system. There is a possibility that the control afterwards is not effective when the focus of the window changes. Therefore you must do again from step12 if the key somewhere is pushed or is clicked.

Logging will be started on next the hour.

How to see the result

Open the Dropbox web site (**https://www.dropbox.com/**).

Enter the site using following ID,

ID: monitor93726@yahoo.com, password: Jakarta.

You can see the result data of every day in ‘Public folder’.

You must not delete those files.

*Note

Client software is provided by the Dropbox.

It is useful to sync those files between your PC and monitoring PC.

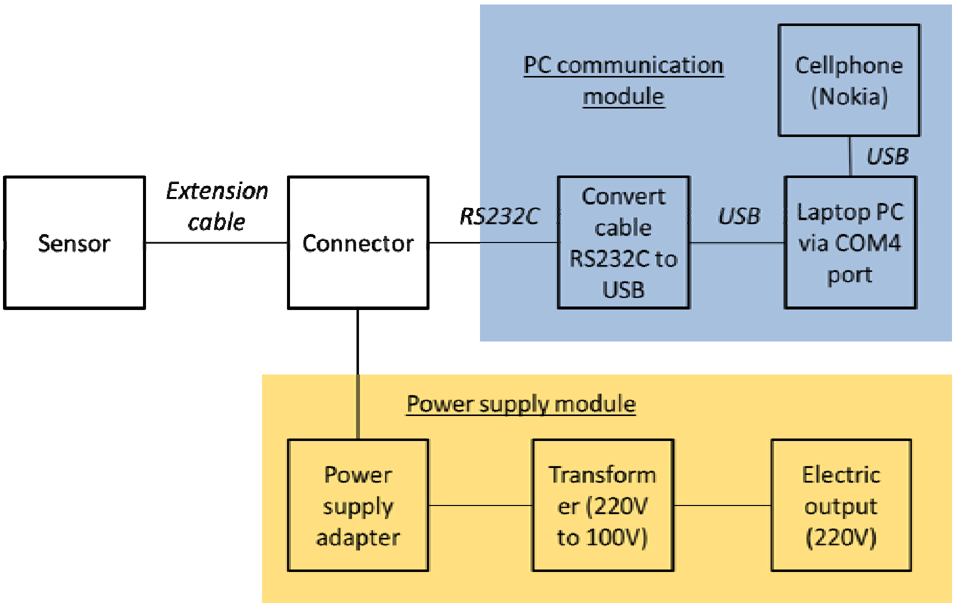


Fig. B.1 Schematic diagram of monitoring system

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