City of Jakarta (DKI JAKARTA)

Ministry of Public Works (PU)

Wastewater Management Enterprize (PD PAL JAYA)

JICA Data Collection Survey

on

Water Environment Improvement through Low-Cost Wastewater Treatment System in Jakarta

Final Report

October 2010

Japan International Cooperation Agency

Hiroshima University

Currency rate (monthly from 2006 to present)

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
2006												
USD1＝JPY	116.47	114.58	112.17	116.32	114.66	116.94	117.63	117.45	116.07	118.8	121.77	119.78
IDR1＝JPY	0.01235	0.01307	0.01219	0.01247	0.01272	0.01289	0.01279	0.0129	0.01265	0.01314	0.01338	0.01324
2007												
USD1＝JPY	117.38	119.03	121.59	123	118.53	115.73	115.55	114.67	109.98	114.21	106.98	106.18
IDR1＝JPY	0.01286	0.01312	0.01381	0.01357	0.01299	0.0123	0.01266	0.01261	0.01172	0.01213	0.01159	0.01174
2008												
USD1＝JPY	99.29	104.05	105.1	106.17	108.05	109.33	105.9	98.23	95.37	90.44	90.02	97.95
IDR1＝JPY	0.01079	0.01119	0.01126	0.01157	0.01185	0.01196	0.01116	0.00923	0.0076	0.00812	0.00789	0.00819
2009												
USD1＝JPY	97.29	96.87	96.47	95.55	95.25	93.13	89.98	90.87	86.66	91.45	90.14	89.25
IDR1＝JPY	0.00842	0.00905	0.00914	0.0093	0.00959	0.00928	0.00925	0.00946	0.00922	0.00969	0.00969	0.00952
2010												
USD1＝JPY	92.7	94.06	91.1	88.66	87.05							
IDR1＝JPY	0.01022	0.01044	0.00986	0.00975	0.00969							

(Source: JICA rate table)

Map of the Citarum, Ciliwung, and Cisadane Rivers System and Major Dams

Member List of the Survey Team and Survey Schedule

Assined Area	Name	Affiliation	grade	FY 2009	FY 2010					man-month					
										FY2009		FY2010		total	
				3	4	5	6	7	8	Indonesia	Japan	Indonesia	Japan	Indonesia	Japan
Survey team leader/ Comprehensive environmental	YAMASHITA Takao	Graduate School for International Development and Cooperation, Hiroshima University	2	■ 11days		■ 15days			■ 7days	11		22		33	
Assessment of effectiveness of sewage treatment	LEE Hansoo	Graduate School for International Development and Cooperation, Hiroshima University	4	■ 12days		■ 15days	■ 14days			12		29		41	
Water quality analysis	TANAKA Kazuhiko	Graduate School for International Development and Cooperation, Hiroshima University	3	■ 10days			■ 7days		■ 7days	10		14		24	
Environmental monitoring and data transfer technology	ONODERA Shin-ichi	Graduate School of Integrated Arts and Sciences, Hiroshima University	3	■ 17days		■ 13days			■ 10days	12		28		40	
Sewage treatment system	OHASHI Akiyoshi	Dept. of Social and Environmental Engineeering, Hiroshima University	3	■ 7days		■ 8days			■ 7ays	7		15		22	
Low cost sewage treatment supporting system	UCHIDA Katsumi	Graduate School for International Development and Cooperation, Hiroshima University	3	■ 11days		■ 15days			■ 7days	11		22		33	
									Sub-total	63		130		193	
Survey team leader/ Comprehensive environmental	YAMASHITA Takao	Graduate School for International Development and Cooperation, Hiroshima University	2	☐ 2days	☐ 2days		☐ 2days	☐ 2days	☐ 2days		2		8		10
			4	☐ 3days	☐ 6days	☐ 6days		☐ 6days			3		18		21
			3	☐ 2days	☐ 5days	☐ 5days		☐ 5days	☐ 2days		2		17		19
			3	☐ 3days	☐ 4days	☐ 4days	☐ 4days	☐ 4days	☐ 3days		2		20		22
			3	☐ 2days	☐ 5days		☐ 5days	☐ 5days	☐ 2days		3		18		21
			3	☐ 2days	☐ 2days		☐ 2days	☐ 2days	☐ 2days		2		8		10
									Sub-total		14		89		103
Report	Timing of Submission			△ Inception report	△ Progress Report			△ Draft Final Report	△ Final Report						
	Domestic Work			14	24	15	13	24	11		14		89		
	(Total MM)			0.47	0.8	0.5	0.43	0.8	0.37		0.45		2.97		3.35
	■ Survey in Indonesia									63	14	130	89	193	103
	☐ Domestic Work									2.57		7.3		9.87	

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List of Abbreviations

ADB:	Asian Development Bank
ADIPURA:	Clean and Green Cities Program
APBD:	*Anggaran Pendapatan dan Belanja Daerah* local government budget
APBN:	*Anggaran Pendapatan dan Belanja Negara* National Budget
BAF:	Biological Aerated (or Anoxic) Filter
Bappenas:	National Development Planning Board
BKB:	West Flood Canal
BKT:	East Flood Canal
BMG :	Meteorology and Geophysics Agency
BOD :	biochemical oxygen demand
BPLHD:	*Badan Pengelolaan Lingkungan Hidup Daerah* Regional Environmental Management Board
BPLP:	*Badan Pengelola Lingkungan Pluit* Management Board of Pluit Area
CAS:	conventional activated sludge
CCM:	Community Climate Model
CCMP:	Chesapeake Community Modeling Program
CCSM:	Community Climate System Model
COD:	chemical oxygen demand
CDOM :	colored dissolved organic matter
CMAQ:	Community Multiscale Air Quality modeling system
CMAS:	Community Modeling and Analysis System
CSDMS:	Community Surface Dynamics Modeling System
CST:	communal septic tanks
CSTMS:	Community Sediment-Transport Model System
DAK:	*Dana Alokasi Khusu*s Specific Allocation Fund
DHS:	Down-flow Hanging Sponge
DINAS PU:	Public Work Department (of DKI Jakarta)
DKI:	*Daerah Khusus Ibukota* Special Capital City District
DO:	dissolved oxygen
DOC:	Dissolved Organic Carbon
DPU:	DINAS PU
EA:	Environmental Assessment group
EC:	European Community
EC:	electrical conductivity
EIA :	environmental impact assessment
EPA :	Environmental Protection Agency in the United States
EPT:	Ephemeroptera, Plecoptera and Trichoptera
FDDA:	Four-dimensional Data Assimilation
FMPLP:	*Forum masyarakat Peduli Lingkungan Pluit* Community Forum of Pluit Environment Care
FY:	Financial Year
GaWC:	Globalization and World Cities
GC:	gas chromatography
GEBCO :	General Bathymetric Chart of the Oceans
GPS:	Global Positioning System
HPC:	High Performance-computing Cluster
HRT:	Hydraulic Retention Time
IAIA:	International Association for Impact Assessment
IC:	ion chromatography
ICP-MS:	inductively coupled plasma mass spectrometry

IDEC:	Graduate School for International Development and Cooperation, Hiroshima University
IM4E:	Integrated Modeling for the Environment
IPCC:	Intergovernmental Panel on Climate Change
ISO:	International Organization for Standardization
ITB:	Bandon Institute of Technology
IWRM:	integrated water resource management
JABODETABEK :	Jakarta, Bogor, Depok, Tangeran and Bekasi
JBIC:	Japan Bank for International Cooperation
JICA:	Japan International Cooperation Agency
JIS:	Japanese Industrial Standards
KDP:	Kecamatan Development Program
KEC:	*Kecamatan* Sub-District
MBR:	membrane bioreactors
MDG:	Millennium Development Goals
MIB:	methylisoborneol
MLSS:	mixed liquor suspended solids
MLLT:	Ministry of Land, Infrastructure and Transport in Japan
MM5:	NCAR Mesoscale Model
MMAF:	Ministry of Marine Affairs and Fisheries
MME:	Ministry of Mining and Energy
MODIS:	Aqua Moderate Resolution Imaging Spectroradiometer
MOE:	Ministry of Environment (*KLH : Kementerian Lingkungan Hidup*)
MOH :	Ministry of Health
MPMD:	Multiple Program Multiple Data
MRP:	Million-Hectare Mega Rice Project
MSL:	Mean Sea Level
MSW:	Municipal Solid Waste
NCR:	National Center for Atmospheric Research
NCEP FNL:	National Center for Environment Prediction Final Analysis Data
NGO:	Non-governmental Organization
NOAA:	National Oceanic and Atmospheric Administration in the United states
NSF:	National Science Foundation in the United States
ODA:	Official Development Assistance
OECD:	Organization for Economic Co-operation and Development
OGC:	Open Geospatial Consortium, Inc.
ORP:	oxygen reduction potential
OS:	open-source
pH:	Potential Hydrogen
PI	pollution index
PDAM:	Water Supply Enterprise
PD PAL JAYA:	Wastewater Management Enterprise
PPSP:	*Percepatan Pembangunan Sanitasi Permukiman* Settlement Sanitation Development Acceleration
PROKASIH:	Clean River Program
PROPER:	Pollution Control Evaluation and Rating Program
PSI:	Pollution Standard Index
PU:	*Pekerjaan Umuml* Ministry of Public Works
PUSAIR:	*Pengembangan Sumber Daya Air* Research Center for Water Resources Development
RBC:	rotating biological contactors
RES:	Regional Environment Simulator

RPJMN:	*Rencana Pembangunan Jangka Menengah Nasional* National Mid-term Development Program
RW:	*Rukuu Warga* Community (administrative unit at the next to lowest level: RT)
SAPS:	Special Assistance for Project Sustainability
SBT:	Soil Bio-Technology
SDPU:	Sub-Unit of DINAS PU
SE:	Subsurface Environment
SOP:	Standard Operation Procedure
STS:	Sewage Treatment System group
SWAN:	Simulating Waves Nearshore
TDS:	total dissolved solids
TPA:	final disposal site
TPS:	temporary disposal site
TSS:	total suspended solid
UASB:	Up-flow Anaerobic Sludge Blanket
UI:	University of Indonesia
UNDP:	United Nations Development Programme
UNEP:	United Nations Environment Programme
UV:	Ultraviolet
WHO:	World Health Organization
WJEMP:	Western Java Environmental Management Project
WQM:	Water Quality Monitoring group
WRF:	Weather Research and Forecast
WRI:	World Resources Institute
YAP:	Yamuna Action Plan

1. Preface

Indonesia, officially the Republic of Indonesia, is a country that comprises 17,508 islands with a population of around 239 million people (2010). It is the world's fourth most populous country, and has the world's largest population of Muslims. The country shares land borders with Papua New Guinea, East Timor, and Malaysia. Indonesia is a founding member of ASEAN and a member of the G-20. The nation's capital city is Jakarta.

Jakarta, officially the Special Capital Territory of Jakarta, is the capital and largest city of Indonesia. Located on the northwest coast of Java, it has an area of 661 km^2 and a population of 9,146,181 in 2009 (Table 1.1.1).

Table 1.1.1 Jakarta's municipalities in 2009

City/Regency	Area (km^2)	No. of District (KEC)	No. of Sub-District (KEL)	No. of Neighborhood (RW)	No. of House-holds	Total population	Population Density (km^2)	Population Growth (%) (2000-2008)
South Jakarta	141.27	10	65	576	406,020	2, 141,773	15,160	2.65
East Jakarta	188.03	10	65	679	600,131	2 ,428,213	12,914	0.44
Central Jakarta	48.13	8	44	495	237,476	894,740	18, 590	0.33
West Jakarta	129.54	8	56	578	438,963	2,202, 672	17,004	2.10
North Jakarta	146.66	6	31	424	347,751	1, 459,360	9,951	0.40
Thousand Islands	8.70	2	6	24	5,505	19,423	2,233	1.71
Total	662.33	44	267	2,794	2,035,846	9,146,181	13,809	

Source: DKI Jakarta, 2010

Jakarta is the country's economic, cultural and political center. It is the most populous city in Indonesia and in Southeast Asia, and is also the twelfth-largest city in the world. The metropolitan area, JABODETABEK (Fig. 1.1.1), is the second largest in the world. Jakarta is listed as a global city (a city deemed to be an important node point in the global economic system) in the 2008 Globalization and World Cities (GaWC) Study Group and Network research. The city's name is derived from the Sanskrit word which translates as "victorious deed", "complete act", or "complete victory". Established in the fourth century, the city became an important trading port for the Kingdom of Sunda. It grew as the capital of the colonial Dutch East Indies. It was made capital of Indonesia when the country became independent after World War II. It was formerly known as Sunda Kelapa (397–1527), Jayakarta (1527–1619), Batavia (1619–1942), and Djakarta (1942–1972). The city is the seat of the ASEAN Secretariat. Jakarta is served by the Soekarno-Hatta International Airport and Tanjung Priok Port, as well as connected by several intercity and commuter railways, and served by several bus lines running on reserved busways. (from Wikipedia)

Fig. 1.1.1 Map of JABODETABEK

Officially, Jakarta is not a city, but a province with special status as the capital of Indonesia. It has a governor (instead of a mayor), and is divided into several sub-regions with their own administrative systems. As a province, the official name of Jakarta is *Daerah Khusus Ibukota Jakarta* ("Special Capital City District of Jakarta"), which in Indonesian is abbreviated to DKI Jakarta. Jakarta is divided into five *kota* or *kotamadya* ("cities" - formerly municipalities), each headed by a mayor, and one regency (*kabupaten*) headed by a regent. (from Wikipedia)

A new law in 2007 forbids the giving of money to beggars, buskers and hawkers, bans squatter settlements on river banks and highways, and prohibits spitting and smoking on public transportation. Unauthorized people cleaning car windscreens and taking tips for directing traffic at intersections are also penalized. Critics of the new legislation claim that such laws are difficult to enforce and it tends to ignore the desperate poverty of many of the capital's inhabitants. Surveys show that "less than a quarter of the population is fully served by improved water sources. The rest rely on a variety of sources, including rivers, lakes and private water vendors. Some 7.2 million people are without clean water." (from Wikipedia)

The 2007 Jakarta flood was a major disaster in Jakarta. It affected the capital of Indonesia and several other areas around the city, such as West Java and Banten. The flood, beginning on February 2, 2007 was a result of heavy rain, deforestation in areas south of the city, and waterways clogged with debris. The flood was considered the worst in the last three centuries, including the 1996 and 2002 Jakarta floods, which killed 10 and 25 people respectively. The most significant reason of the flood disaster is the increase of rain intensity, since the rainy season in Indonesia starts in December and ends in March. In 2007, the rain intensity reached its peak in February, with the greatest intensity towards the end of the month. The combination of the increased loss of vegetation in the upper catchments of rivers that flow into the Jakarta region, and the lack of adequate flood prevention being constructed by either the national or city governments - has created a situation where floods created by heavy rainfall cannot be adequately diverted away from the Jakarta area. Eventually, water flowing into Jakarta overflows some of the city's flood control systems and causes devastation in these areas.

The flood in 2007 affected 80 separate regions in and around Jakarta, and over 70,000 homes were flooded, resulting in the displacement of some 200,000 people, of which 5,729 were still to return by March 11th, 2007. Although the highest officially confirmed death toll was 54, there were reports that it was as high as 68. There was a high level of illness, with 1,066 patients treated in hospitals due to diarrhea and 329 due to dengue fever. The flood had caused Rp.8 trillion (US$879.12 million) in losses. A total of approximately 190,000 people had fallen ill due to flood-related illnesses. The nature of the flood in which it extended from riverbanks to surrounding areas had caused the lower-class communities, many of which lived on the riverbanks themselves in wooden houses, to take the strongest impact of the flood. (from Wikipedia)

According to a survey of the United Nations Development Programme, and the World Bank in 1996, the water environment problems and their measures in Jakarta are summarized below.

1) Jakarta's water quality is suffering from the combined strain of domestic and industrial pollution. Water pollution has impacts on both human health and aquatic life.
2) The backbone of the sanitation system is still an open ditch system that serves as a conduit for all wastewater.
3) In 1989, an estimated 200,000 m^3 of wastewater per day, largely untreated, was disposed of into the city's waterways.
4) Domestic wastewater is estimated to contribute 80% of surface water pollution, although industrial discharges are a growing concern.
5) In some areas, groundwater is polluted with nitrates and microorganisms from domestic waste and toxics leached from industrial landfills.
6) Water pollution has impacts on both human health and aquatic life. Diarrhea is responsible for 20% of deaths for children 5 and under in Jakarta.
7) Organic pollution has also contributed to the decline of coral reefs within Jakarta Bay. In the Angke estuary in Jakarta Bay, the mercury content in commercial fish species far exceeds World Health Organization guidelines for human consumption.
8) Jakarta's aquifer is also suffering from over-extraction and sea water intrusion. At least 30 % of Jakarta's population relies on the aquifer for water.

9) Parts of the city have sunk 30 to 70 cm in the past 15 years due to land subsidence. Urban expansion into the water catchment areas southwest and southeast of Jakarta is further threatening the aquifer.

As abovementioned the status quo of Jakarta water environment, the problem is quite complicated. The degradation of water environment is also affected by the deforestation and agriculture development upper stream. The perplexed problem of flood in the Jakarta Metropolitan area is also closely related to natural environment destruction, wastewater and solid waste management in the watershed of JABODETABEK that consists of three major rivers of Citarum, Ciliwung and Cisadane and many small tributaries (Fig. 1.1.2).

Fig. 1.1.2 Citarum, Ciliwung, and Cisadane Rivers and three major dams

When water environmental improvement measures in this area are considered, the following components should be implemented simultaneously:

1) Forest reproduction (equivalent to the construction of green-dams) in an upper region
2) Improvement of water quality (sewage disposal, pollutants removal) in the urban flood plain of DKI Jakarta
3) Subsurface/ground water management in water quality (for drinking) and watertable lowering (for prevention of land subsidence and salt water intrusion)
4) Solid waste abandonment in the rivers, canals and sea (the Jakarta Bay)
5) Prevention and mitigation measures for flooding caused by changes in river/runoff system in the watershed and the sea level rise in the Jakarta Bay due to the global warming (several percent, 1-2 mm/year) and land subsidence (the relative sea level rise)

The Survey team conducted the following surveys and analyses for six months from March to August, 2010, in collaboration with researchers in University of Indonesia (UI), Bandung Institute of Technology (ITB), Research Center for Water Resources Development (PUSAIR) of The Ministry of Public Works (PU).

1) Water environment problems (surface and subsurface water quality, flooding) in JABODETABEK
2) Wastewater and solid waste treatments in JABODETABEK
3) Low-cost & high precision water quality monitoring system (for DKI Jakarta)
4) Low-cost & high performance numerical assessment system for local environment
5) Low-cost & high performance system for sewage treatment (for DKI Jakarta) at the pond of the Wastewater Management Enterprise (PD PAL JAYA) (Fig. 1.1.3)

Through these survey and analyses, the project made clear the theoretical background and proposed the suitable technologies for improvement of water environment in DKI Jakarta, JABODETABEK that have the complex water environmental problems mingling with wastewater, solid waste, flooding in the lowland caused by land subsidence and sea level rise due to global warming. Finally, the project concluded with the proposals of the following technologies to improve water environment in Jakarta Metropolitan area.

1) The low-cost & high performance system for sewage treatment for DKI Jakarta. One of candidate measures is a combination of Up-flow Anaerobic Sludge Blanket (UASB) and Down-flow Hanging Sponge (DHS) which enables sewage water purification in the small scale and closed catchment.
2) Comprehensive water environment monitoring system which consists of a low-cost and high precision water quality analysis method and a 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 suitable sewerage system in DKI Jakarta that would be proposed in consideration with both effectiveness of sewage treatment system and flood control by sustainable development plan in the lowland area of Jakarta (with reclamation in Jakarta Bay and land subsidence abatement by groundwater management)

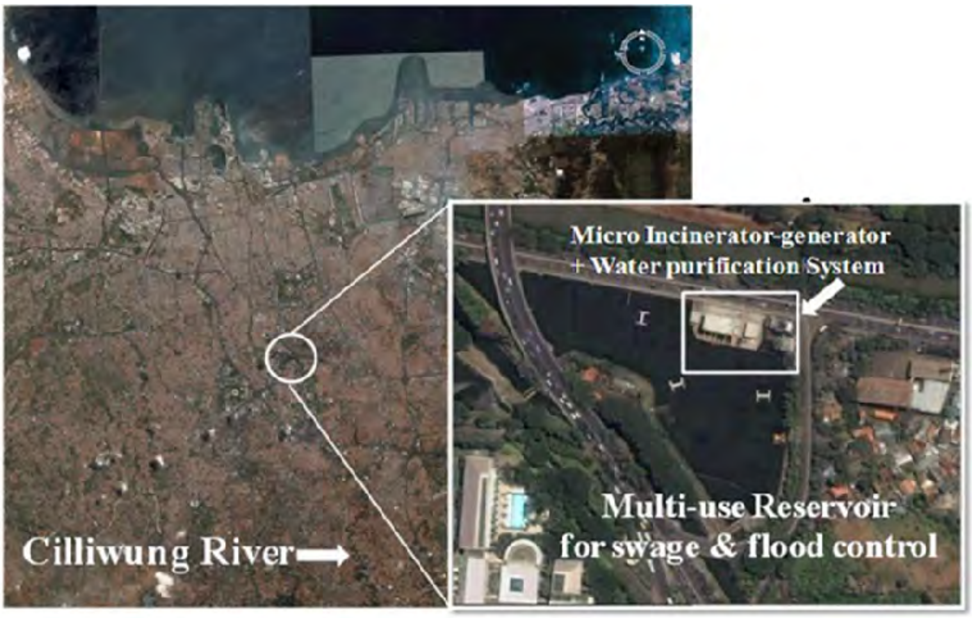

Fig. 1.1.3 Aerial photos of the pond of PD PAL JAYA

2. Social, Natural and Technological Backgrounds of Water Environment

2.1. Sewerage and Water Environmental Issues in Indonesia

According to the National Mid-term Development Program (RPJMN) 2010–2014 that is harmonious with the Millennium Development Goals (MDG) targets, 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, these being:

1) Basic sanitation access has to be expected to reach around 75% by 2015.
2) Functioning of wastewater treatment and fecal sludge treatment system are expected to reach up to minimum of 65% at the end of 2014.
3) Development of wastewater treatment services as well as to reduce river pollution from the fecal sludge up to 45% from existing conditions by the end of 2014.

2.1.1. The Status Quo

Despite best endeavor of the government, the access for safe sanitation is still considerably low, of only 32% and 71% in rural and urban area, respectively (2007 National Socio-Economic Survey). There still exist the problems in the municipal wastewater management systems resulting from the following reasons:

1) Lack of people awareness on the importance of municipal wastewater treatment
2) Insufficient legislation for municipal wastewater treatment system
3) Poor local institutional roles in organizing municipal wastewater treatment
4) Limited government funding which hinders the off-site wastewater system development since the cost is considerably high

2.1.2. Law

Domestic wastewater facilities development is one of the commitments undertaken by the Government of Indonesia. The commitment is put into action by consistently implementing the MDG and the enactment of Law No.7 of 2004 on Water Resource and Government Regulation No.16 of 2005 on the Development of Drinking Water Supply System, as well as other related policies. In the mentioned 2005 Government Regulation No.16, wastewater management is considered essential to protect the deteriorating raw water resources that have led to the difficulty in acquiring raw water.

2.1.3. Policy

The Government Regulation implies that plans to develop drinking water supply should be complemented by efforts to dispose and treat effluent of wastewater. Within the framework of developing the national sanitation conditions, the Government of Indonesia has established 5 (five) National Policies and Strategies.

These Policies and Strategies include:

1) Increasing sanitation access
2) Improving community and private participation
3) Strengthening law and regulations enforcement
4) Institution development
5) Enhancement of fund

2.1.4. Fund

Strong commitments from all stake holders are needed in order to embody the development of wastewater sector, since lacking of support from Central Government, Local Government, private sector or community would make the task much harder. Furthermore, the implementation of this commitment needs abundant of fund of approximately Rp. 8.4 trillion from the *Anggaran Pendapatan dan Belanja Daerah* (APBN) and Rp. 1.3 trillion from the local government budget (APBD), since sanitation services are mainly the responsibility of the latter.

In order to increase the commitments of local governments, starting from 2010, Special Allocation Fund (*Dana Alokasi Khusus* or DAK) for sanitation has been arranged.

DAK are only given to the regions that have shown admirable concern and commitment to improve sanitation service, including those that show satisfactory performances of sanitation basic service.

2.1.5. Settlement Sanitation Development Acceleration (PPSP)

In order to reach MDG targets, the Government of Indonesia established the Settlement Sanitation Development Acceleration (*Percepatan Pembangunan Sanitasi Permukiman* or PPSP) plan which includes a five-year program of sanitation development covering the area of sanitation, solid waste, and drainage infrastructure. Acceleration of sanitation development can be implemented through the approach of City Sanitation Strategy (Strategi Sanitasi Kota or SSK) that reflects the district/city government and community needs for sanitation and involves bottom-up process within the framework of national policy and strategy as prescribed by national government. Therefore, direct action plans for sanitation development in respective cities are needed in order to carry out the scenarios. The roadmap will be developed within five years, from 2010 to 2014 (inclusive). The target locations for PPSP are urban areas which are vulnerable to sanitation issues with a total of 330 cities.

With decentralization, the responsibility for financing urban sanitation has been transferred to the regional governments, which in most cases allocate insufficient funds for system maintenance and improvement. The lack of investment and cost recovery tariffs in the sanitation sector has resulted in acute urban pollution from residential, commercial, and industrial premises in most cities. Overall sewerage coverage is about 3% of the urban population. Approximately 75% of the existing access to sanitation in urban areas is through on-site sanitation. Households are responsible for treating and disposing of wastewater and sludge from septic tanks and other types of facilities (e.g., pit latrines). Many low-income families rely on grossly polluted drains and urban waterways. As a consequence, partially treated wastewater is simply discharged into open drains and water bodies that are already polluted from indiscriminate solid waste disposal and other liquid wastes.

Solid waste management, including collection and treatment of garbage, is another cause of concern. In general, almost all solid waste disposals being conducted are in complete disregard of regulations and acceptable practice. A large proportion of solid waste is discharged to city watercourses (rivers, canals, and drainage channels) that should be subject of a general cleanup under a sanitation program.

The Asian Development Bank (ADB) - funded "Metropolitan Sanitation Management and Health Project", 2006-2010 was launched to improve public health and to reduce environmental pollution in urban areas. It supports the Government of Indonesia in its effort to achieve the related MDG. Participating cities in this ADB-funded project are Medan, Makassar, and Yogyakarta.

This technical assistance project focuses on the following aims.

1) Reduce exposure of urban communities, particularly the low-income groups, from health risks associated with the discharge of raw or partially treated sewage into city drains and rivers
2) Contribute to a significant reduction of pollution in water bodies
3) Improve solid waste collection and treatment practices
4) Contribute to improved local urban environments and overall reduction of environmental pollution
5) Address serious institutional constraints affecting the sector

In Indonesia, the following 18 municipalities have launched the sanitation management projects with various methods and different financial support schemes, to achieve the related MDG.

1) Balikpapan
2) Bandar Lambung
3) Bandung
4) Banjarmasin
5) Batam
6) Bogor
7) Cirebon

8) Den Pasar

9) DKI Jakarta

10) Jogyakarta (ADB funded)

11) Makasar (ADB funded)

12) Malang

13) Medan (ADB funded)

14) Palenbang

15) Prapat

16) Surabaya

17) Surakarta

18) Tangerang

(Source: PU)

2.2. Water Quality Issues in Jakarta

2.2.1. Water Quality Issues in Jakarta (1996-1997)

Reports available on water quality issues in Jakarta (e.g., from World Resources Institute (WRI), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), and the World Bank) had summarized problems and their measures of environmental deterioration in Jakarta (World Resources 1996-97: The Urban Environment). The findings published in these reports on water environmental problems in Jakarta were summarized as below.

1) Jakarta had been the country's center of government, finance, commerce, and education. The city was leading the country's incredible economic growth (Indonesia's gross domestic product (GDP) increased 5.7% per year between 1980 and 1992).

2) With economic growth, Jakarta had made major strides in improving overall health and quality of life in the city. In 1989, mortality rates for infants were lower for the city than for

the country as a whole, 31.7 per 1,000 live births compared with 58 nationally. Combined male and female life expectancy was 66.5 years compared with 62 years nationally.

3) Jakarta's water quality was suffering under the combined strain of domestic and industrial pollution. The backbone of the sanitation system was still an open ditch system that serves as a conduit for all wastewater. While this system may had been adequate for a city of less than half a million (the size of the city when the system was planned) it could not cope with the wastes of the current 11.5 million residents.

4) In 1989, an estimated 200,000 m^3 of wastewater per day, largely untreated, was disposed of into the city's waterways. Domestic wastewater was estimated to contribute 80% of surface water pollution, although industrial discharges were a growing concern. In some areas, groundwater was polluted with nitrates and microorganisms from domestic waste and toxics leached from industrial landfills.

5) Water pollution had impacted on both human health and aquatic life. Diarrhea was responsible for 20% of the deaths for children 5 and under in Jakarta. Organic pollution had also contributed to the decline of coral reefs within Jakarta Bay. In the Angke estuary in Jakarta Bay, the mercury content in commercial fish species far exceeded World Health Organization (WHO) guidelines for human consumption.

6) Jakarta's aquifer was also suffering from overextraction and salinization. At least 30 % of Jakarta's population relied on the aquifer for water. Because the city lacked a system for registering and controlling water extraction, more water was withdrawn than was naturally recharged. Parts of the city had sunk 30 to 70 cm in the past 15 years due to land subsidence. Urban expansion into the water catchment areas southwest and southeast of Jakarta was further threatening the aquifer.

7) For Jakarta's 1.4 million poor, however, the greatest environmental threats still occurred at the household and neighborhood level. Some survey found that in the poorest wealth quintile, 31% of the households had neither a piped water connection nor accessed to a private well, compared with 12% for the city as a whole. In addition, the poorest households were less likely to have neighborhood waste collection and more likely to share toilets and have problems with flies both near the toilet and in food-handling areas.

8) Jakarta officials had taken a number of steps to reverse environmental degradation. One of the most successful programs had been the Kampung Improvement Project, which had

improved living conditions for more than 3.5 million people. The program had been duplicated in 200 cities throughout Indonesia. In partnership with local communities, the government identified priority actions such as water supply networks, which included a standpipe for each 25 to 35 families. Other improvements included paved footpaths with side drains, sanitary facilities, garbage carts and waste collection stations, and public health centers. Funding came primarily from the government and donor agencies, although in some cases community members match these investments. The communities themselves were responsible for the operation and maintenance of these facilities.

9) To protect natural resources, the government passed a 1992 "spatial planning" law designed to restrict development in environmentally sensitive areas. The Clean River Program (PROKASIH), a cooperative agreement between local communities and the government of Jakarta, had managed to reduce the pollution of the Ciliwung River within just 3 years, from 1989 to 1992, although much remained to be done. For Jakarta, continued investment in environmental management was crucial if it hoped to contain and even reverse environmental deterioration.

2.2.2. Water Quality Issues in Jakarta (1998-2004)

When the economic crisis happened in Indonesia in 1998, most of industries had no adequate capability to treat their effluents. PROKASIH was in the worst condition because almost 60% of the industry effluents discharged into the rivers did not meet the criteria according to Government Regulation No 20 of 1990. The Pollution Control Evaluation and Rating Program (PROPER) as of compliance approach was not proper enough to support the PROKASIH program to improve the river condition. With issuance of a new Government Regulation No 82 of 2001, the river conditions were not becoming better instantly. The effort was made by soft approach to socialize those new regulations. From 2000 to 2004 the situation improved with slightly positive progress and since then it has become a better situation.

2.2.3. Water Quality Issues in Jakarta (2004-2008)

The ENVIRONMENT QUALITY HANDBOOK 2007 issued by the Regional Environmental Management Board (BPLHD), DKI Jakarta, summarized the status quo of water quality in Jakarta, including groundwater quality, dam/weir water quality, and that in the Jakarta Bay.

Monitoring was conducted at 67 spots along 13 rivers. A total of 70% of the pollution sources was domestic with 30% from others. Dominant parameters were coliforms, fecal coli, detergent, phosphate and organic matters. Quality evaluation is based on the Governor Decree No.582 of 1995. Decision of water quality status into pollution index (PI) is based on Ministry of Environment (MOE) Decree No.115 of 2003 (Table 2.2.1).

Table 2.2.1 Water quality status determination

Pollution Index (PI)	
$0 \leq PI \leq 1.0$	Good: water that may be used directly for drinking without treatment
$1.0 < PI \leq 5.0$	Lightly Polluted: water to be used for drinking after conventional treatment
$5.0 < PI \leq 10.0$	Moderately Polluted: water to be used for fisheries and watering animals
$10.0 < PI$	Heavily polluted: water to be used for agriculture, municipal supplies, industry, and hydropower

$PI_j = (C_1/L_{1j}, C_2/L_{2j}, C_3/L_{3j} \ldots C_i/L_{ij})$.

Where:

C_i : concentration of water (each parameter)

L_{ij} : concentration of water base on water used standard

(j) : water used standard

Source: BPLHD, DKI Jakarta

The following Table 2.2.2 shows the water quality status in Jakarta, based on PI.

Table 2.2.2 Water quality status in Jakarta

Quality (status)	(%)				
	2004	2005	2006	2007	2008
Good	0%	0%	0%	0%	0%
Lightly polluted	3%	4%	9%	0%	0%
Moderately polluted	16%	16%	10%	6%	12%
Heavily polluted	81%	79%	78%	94%	88%

*Dominant parameters: Coli form, Fecal Coli, Detergent, Phosphate, Organic

Surce: BPLHD DKI Jakarta

2.2.4. Groundwater Quality in Jakarta, 2004-2005

Monitoring was conducted at 75 ground wells. Similarly pollution sources are domestic pollutant and others. Dominant parameters were coliform, fecal coli, detergent. Quality evaluation is based on the Ministry of Health (MOH) Regulation No. 416 of 1990. Decision of water quality status into PI is based on MOE Decree No. 115 of 2003. Table 2.2.3 indicates the groundwater quality status in Jakarta.

Table 2.2.3 Groundwater quality in Jakarta

Quality (status)	(%)	
	2004	2005
Good	18%	16%
Lightly polluted	33%	33%
Moderately polluted	28%	35%
Heavily polluted	21%	16%

Source: BPLHD DKI Jakarta

2.2.5. Dam/Weir Water Quality in Jakarta, 2004-2006

Monitoring was carried out at 20 sites. Measurements were conducted at inlet, middle and outlet of dam or weir. Pollution sources are domestic and others. Dominant parameters were coliform, fecal coli, detergent, phosphate and organic matters. Quality evaluation methods follow Governor Assessment No.582, 1995. Decision of dam/weir water quality status into PI is based on MOE Assessment No.115, 2003. Table 2.2.4 exhibits the dam/weir water quality in Jakarta

Table 2.2.4 Dam/Weir water quality in Jakarta

Quality (status)	(%)		
	2004	2005	2006
Good	0%	7%	0%
Lightly polluted	22%	33%	38%
Moderately polluted	20%	37%	38%
Heavily polluted	58%	33%	25%

Source: BPLHD DKI Jakarta

2.2.6. Jakarta Bay Water Quality (Pollution), 2004-2006

Monitoring points were located at 23 sea spots and 9 spots in estuary. Measurement was conducted in spring tide and neap tide conditions. Pollution sources were land based pollutant (domestic and others) and sea based pollutant (oil spilled, sea transport). Dominant parameters are detergent, phosphate, organic matters, nutrient, DO and plankton. Quality evaluation is based on Governor Decree No.582 of 1995. Decision of diverse index quality is based on Shanon Weiner in Staub et al (1975), 2003. Table 2.2.5 reveals the water quality status in Jakarta Bay for spring and neap tide conditions.

Table 2.2.5 Jakarta Bay water quality status

Spring tide condition

Quality (status)	(%)		
	2004	2005	2006
Good	0%	0%	0%
Lightly polluted	4%	11%	0%
Moderately polluted	33%	83%	22%
Heavily polluted	2%	6%	78%

Neap tide condition

Quality (status)	Pollutant index (%)		
	2004	2005	2006
Good	0%	0%	0%
Lightly polluted	22%	44%	0%
Moderately polluted	17%	0%	56%
Heavily polluted	58%	33%	25%

Source: BPLHD DKI Jakarta

Furthermore, from the data sources of BPLHD, DKI Jakarta, PSI, MOE Decree No.115 of 2003, the domestic wastewater effluent standard in DKI Jakarta based on the Governor Regulation No.122 of 2005 are tabulated in Table 2.2.6.

Table 2.2.6 Domestic wastewater effluent standard (mg/l)

parameter	Individual/household	communal
pH	6-9	6-9
Organic($KMnO_4$)	85	85
TSS	50	50
Ammonia	10	10
Oil & fat	10	10
Methylene Blue compound	2	2
COD	100	80
BOD	75	50

Source: PD PAL JAYA

2.3. Japan's Comprehensive Basin-wide Planning of Sewerage Systems

With legal and financial systems reinforced, the sewerage service achieved rapid progress in Japan, demonstrating effective improvements in water environments of rivers and sea areas. At present, the coverage rate of sewerage exceeds 70% or even 80% when the on-site treatment is included. The prevailing state of Japan's wastewater treatment in 2009 are sewerage (72.7%), johkasou (septic tank) (8.9%), wastewater from agricultural community/village (2.9%), community plant (0.2%), and no-sewered (15.3%).

2.3.1. Wastewater Treatment System

The basic style of sewerage-based wastewater treatment system in Japan is illustrated in Fig. 2.3.1 that was cited from Indonesia-Japan Seminar on Sewerage and Water Environmental Issues Jakarta, Indonesia, February 23, 2010.

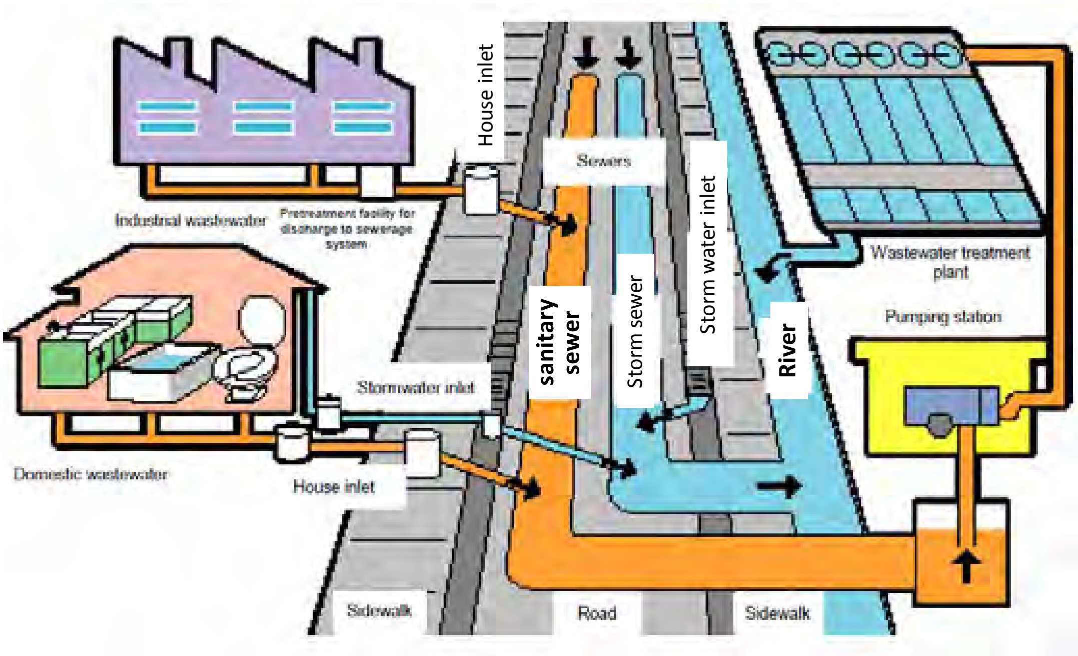

Fig. 2.3.1 Japanese case of sewerage-based wastewater treatment system

2.3.2. Sewage Law

Japan has established sound development for her cities, with improvement of public sanitation, quality conservation of public water bodies through the sewage law and its strong enforcement system. Prefectural governments ought to develop the comprehensive basin-wide planning of sewerage systems in order to meet the environmental water quality standards based on the Basic Environment Law. From the project planning point of view, the sewage works administrator must develop a project plan in compliance with the comprehensive basin-wide planning of sewerage system. Once the public sewerage is opened for service, every house and office must connect to the sewage as soon as possible. In the case of government subsidy, the central government provides part of the costs related to installation or renewal of sewerage for local authorities (e.g., the arterial conduits or the wastewater treatment plant). For management, installation, renewal, repair, maintenance, and other managements of public/basin-wide sewerage system are responsible for the municipalities. As a structural standard, the sewerage structure must comply with the technical guidelines stipulated separately which include the seismic standard, standard for effluent quality from the wastewater treatment plant (water quality in terms of biochemical oxygen demand (BOD) and nonylphenol (NP) in compliance with the treatment policy). The administrator is also responsible for collecting he charges for using the public sewerage services from the users. Punitive clauses have stipulated the fine on those who have damaged sewerage facilities, and those who have discharged harmful wastewater into a sewerage system.

2.3.3. Comprehensive Sewerage Inundation Countermeasure Plan

The comprehensive sewerage plan has been conducted in Japan, where both the inundation countermeasures and basin-wide sewerage systems are considered together. The local authorities select the sewerage planned area by identifying the priority areas for sewerage systems against inundation and deciding the degree of safety in the system (maximum rainfall in mm/hr) and setting the period for planning to achieve the measures, in which structural and nonstructural measures are combined effectively, through public and self-assistance. The design of comprehensive sewerage inundation countermeasure plan in Japan is conducted by the flowing processes.

1) Basic Survey
- Identifying the features and causes of damage
- Fact finding of rainfall
- Identifying the regional features
- Coordination and sharing of objectives, targets and necessities of the plan

2) Target of the Plan
- Setting the rainfall concerned
- Classifying the priority area
- Setting the target of mitigating inundation damage
- Setting the plan period

3) Setting the Priority Area
- Setting the candidate priority area
- Estimating the expected inundation area
- Estimating the expected inundation damage
- Setting the priority area

4) Reviewing the Measures
- Selecting the countermeasure approaches
- Evaluating the capacity of facilities
- Combining the measures

5) Evaluating the Most Appropriate Plans as well as the Priority Order
- Evaluating the most appropriate plan within the priority areas
- Evaluating the priority among priority Areas

6) Considerations for Planning

7) Implementation of the Project
- Evaluating the progress state and the project effects

2.4. Water Environment of the Ciliwung River

A drainage basin is an extent of land where rainwater drains into a water flow (river), lake and reservoir, wetland, and estuary. The drainage basin acts as a funnel collecting all the water within the area covered by the basin and a waterway. Each drainage basin is separated topographically from adjacent basins by a mountain ridge. A drainage basin is called “catchment”, “drainage area”, “river basin”, “water basin” or “watershed”. A drainage basin drains into other drainage basins in a hierarchical pattern, with smaller sub-drainage basins combining into larger drainage basins. JABODETABEK has been developed in the drainage basin of major three rivers of the Citarum, Ciliwung and Cisadane (Fig. 2.4.1).

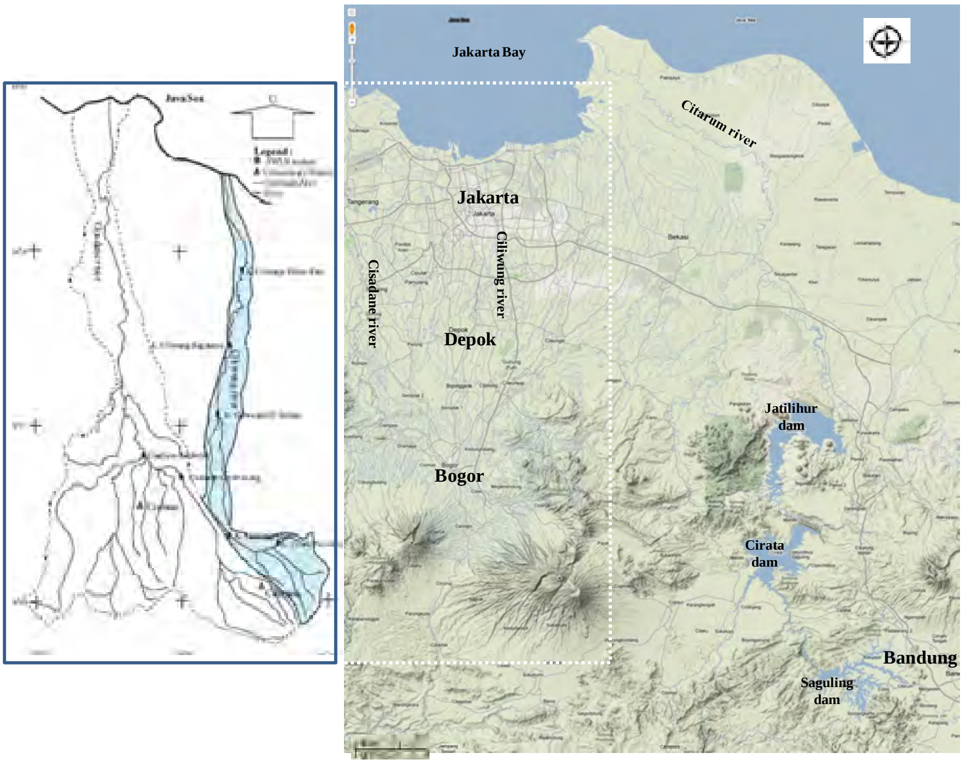

Fig. 2.4.1 Ciliwung and Cisadane River watersheds

Estuaries are bodies of water and their surrounding coastal habitats typically found where rivers meet the sea. Estuaries are some of the most productive ecosystems in the world. Many animal species rely on estuaries for food and as places to nest and breed. Human communities also rely on estuaries for food, recreation, and jobs.

Most of largest cities in the world are located on estuaries. Not surprisingly, human activities have led to a decline in the health of estuaries, making them one of the most threatened ecosystems on Earth. This is the human-caused estuary disturbance, of which Jakarta is its typical case. As transitional areas between the land and the sea, and between freshwater and saltwater environments, estuaries can be seriously impacted by any number of human, or anthropogenic, activities.

In the case of Jakarta, 13 rivers flowing into the Bay of Jakarta transport the solid waste that contains pollutants and sediment that forms a new land in the estuary and coastal lowland that is the most vulnerable space. The poor people illegally settle in this area under the shadow of flood disasters and under the insanitary conditions.

By rapid overconcentration to the large city of population and an economic capital (urban sprawl), water environmental problems, such as degradation of surface and subsurface water quality, groundwater contamination, land subsidence, in the coastal lowland area and frequent occurrence of flooding, have been aggravating in the so-called mega-city of many developing countries which are mainly developed in the lowland of river mouth delta. DKI Jakarta, Indonesian Capital, is one of the typical examples of these mega-cities. When the cause of the flood of Jakarta is investigated, it turns out that the following four scenarios have contributed to flood occurrence and water environment degradation.

1) Increase of the runoff coefficient due to over-logging in upstream forest and urbanization in the major river watershed has resulted in the outflow of many agricultural chemicals from the cultivated land and orchard, the contaminant from urbanized city region.
2) Reduction of the river channel area caused by abandonment of the household garbage to a river, resulting in and aiming at the reclamation of river channel for getting more space to live in.

3) Corrosion oxidization of underground wood peat due to groundwater table subsidence by pumping water for industrial and drinking uses which may have caused a large-scale and rapid land subsidence in the west part of lowland area in Jakarta.
4) The reduction of river conveyance due to land reclamation (needs as a city waste disposal place) in the Jakarta Bay. On the other hand, this reclamation reduces the possibility of tide-induced flooding in the estuary. In addition to the sea level rise due to global warming, the increase in sea level caused by fluctuation of moon path with 18.6 years period enhanced flooding in Jakarta Bay in 2007.

It turns out that the flooding of Jakarta may be closely related to natural environment destruction in watershed and water pollution as mentioned above and is more serious than the problems of river management. Aggravation of such water environment is a local environmental problem shared by many cities in the river mouth delta of many developing countries. And it also becomes one of the causes of river mouth flood disasters. In order to solve these problems, it is necessary to establish the adaptation measures which consider the consistent water environment management in the whole river basin from the upper stream to river mouth and ocean.

2.4.1. Ciliwung Watershed Conditions (2010)

As reported in recent study and modelization, the Ciliwung River is unique with a multi-function role (Moersidik and Rahmasari, 2010), and its watershed has social and economy functions. Across the capital region of Jakarta, the Ciliwung River has become an urban watershed that has strategic significance in the national context, hence requiring special attention and management. Its total length from the upstream to the estuary on the coast of Jakarta Bay is about 117 km, with the total watershed area of 347 km^2 approximately, comprising that in the upstream in Tugu Puncak (Bogor) to the downstream in Jakarta Bay (North Jakarta). Many development activities have taken place around of the Ciliwung watersheed, in both the upstream and downstream. These activities are very intensive, resulting in high population growth and excessive entry of pollutants from sources of domestic, industrial, agricultural and livestock waste.

The results of monitoring given by BPLHD of DKI Jakarta (2007) reveal that the water quality in the Ciliwung River was increasingly polluted in the downstream sector and its condition was classified as class IV, indicating that the water can only be used for watering the plants. The Fadly (2007) research also revealed that water quality of the Ciliwung River, which entering DKI Jakarta as part of downstream, was above the river water quality standard DKI Jakarta Governor Decree No.582 Jakarta 1995. This means the water has been contaminated. Under normal conditions, a river or water body has the ability to recover and clean itself at a certain limit called “self-purification”. However, the increasing pollution load beyond this limit could impede the ability of self-recovery, causing degradation to river water quality. Nowadays, comprehensive study is not available for the capacity of the Ciliwung River from upstream to downstream, and the water in the River has increasingly contaminated which leads to increase in pollution load. Therefore, it is imperative to investigate the carrying capacity of pollution load in the Ciliwung River, in order to form the basis of pollution control in managing the Ciliwung River.

The study by Prof. Setyo S. Moersidik, UI was conducted between December 2009 and February 2010. The study aimed to: (1) analyze changes in water quality from upstream to downstream in the River from year to year during the period of five years; (2) determine the amount of pollution load in the River, (3) determine the carrying capacity of the River; and (4) execute river management programs, especially to control pollution load.The approach used to determine the pollution load and river carring capacity included application of QUAL2Kw program by Streeter Phelps, data collection through field observations, in-depth interviews and literature studies. The study used secondary data, such as river water quality data (year 2004-2008), as well as the river hydrological, rainfall and socioeconomic data. On the other hand, the primary data was obained form of in-depth interviews with stakeholders of the Ciliwung management and village heads in the surrounding area of the Ciliwung.

The results derived from his study are as follow:

1) The water quality based parameters, such as dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) fluctuated along the River during

2004 to 2008 (Figs. 2.4.2 and 2.4.3). The DO decreased from upstream to downstream (PIK), while BOD increased, thus suggesting the existence of a polluted downstream.

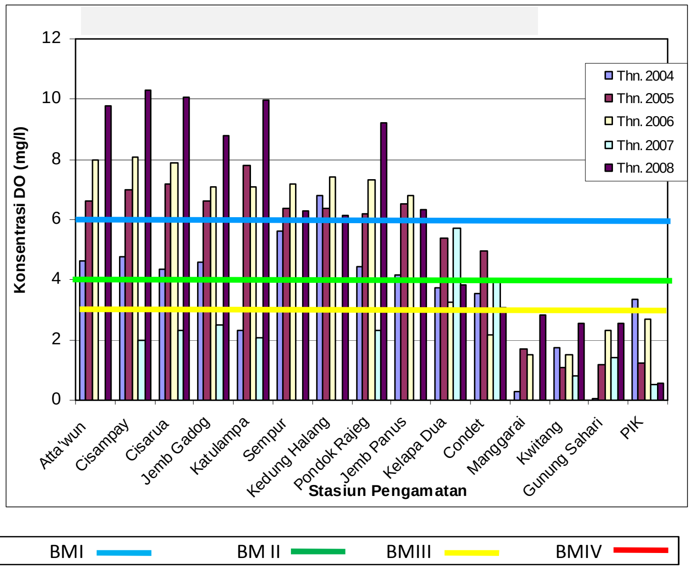

Fig. 2.4.2 DO concentration along the Ciliwung River

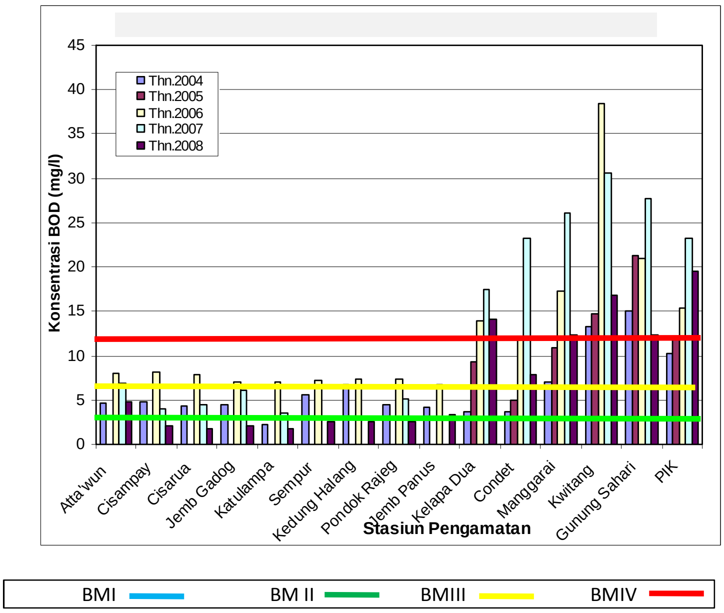

Fig. 2.4.3 BOD concentrations along the Ciliwung River

2) In 2008, the averaged DO concentration at the upstream (Atta'awun-Katulampa) ranged from 6.1 to 10.3 mg/l; reduced to 3.9 to 9.2 mg/l in the middle (Katulampa-Kelapa Dua) and decreased further to 0.6 to 3.1 mg/l in downstream (Kelapa Dua-PIK). The smaller the DO concentration in the downstream, the greater the BOD concentration. In 2008, the BOD concentration at the upstream (Atta'awun-Katulampa) was 1.8 to 4.8 mg/l; became 2.6 to 14.2 mg/l in the middle (Katulampa-Kelapa Dua) and increased to 7.9 to 19.6 mg/l in the downstream (Kelapa Dua-PIK).
3) In the calculation using program QUAL2Kw, the entire river length was divided into six segments. The results indicated that the highest pollution load occurred in segment 6 (Manggarai-Ancol), which amounted to 20,674.66 kg/hr. River pollution load increased significantly from upstream to downstream in DKI Jakarta.
4) The results of QUAL2Kw analysis also showed DO in the upstream of the River reached 7.0 to 9.8 mg/l, began declining in the central part (2.0 to 6.8 mg/l) and decreased further in the downstream (0.30 to 2.0 mg/l).
5) From the simulation of carrying capacity of pollution load (BOD), it was found that the sixth segment had no capacity for standard classes I and II, segment 1 and 2 still had class III capacity while segment 3 (joint-Cottage Kedung Halang Rajeg) exceeded the class III capacity. Thus, segment 3 to segment 6 had no capacity for standard class III. Moreover, segment 1 to segment 5 met the capacity of class IV, but the monitoring station at Kwitang-Ancol (segment 6) exceeded the capacity for standard class IV. Thus, segment 6 did not have the capacity to class IV standard. These results were supported by a consistent small aeration downstream of the aeration implying the ability shelf-healing in the water body downstream was virtually in non-existent.
6) Pollutant load control program can be performed through the management of water bodies and environmental management. Media management should be focused on improving the quality of river water by reduction of BOD, increase of the water discharge and increase in the supply of oxygen.

Based on the results of Moersidik and Rahmasari (2010) mentioned above, it could be concluded that:

1) Based on the water quality standard class using DO, BOD and COD parameters (based on Government Regulation No. 82 of 2001, on Management of Water Quality and Water Pollution Control) (see Table 2.4.1), the results of monitoring revealed that in 2008 the upstream (Atta'awun-Katulampa: Segment 1) of the River might be classified as in Class III, middle (Katulampa-Kelapa Dua: Segment 2-4) in Class IV, and downstream (Kelapa Dua-Ancol: Segment 5) in Class IV, except for the parameters of BOD exceeded the quality standard grade IV or under heavy polluted condition.

Table 2.4.1 Class criteria for water quality parameters based on government regulation No. 82 of 2001

Parameters	Units	Class			
		I	II	III	IV
DO	mg/l	6	4	3	0
BOD	mg/l	2	3	6	12
COD	mg/l	10	25	50	100
TSS	mg/l	50	50	400	400

Source: DKI Jakarta

2) River pollution load increased significantly from upstream to downstream, with the highest at downstream in segment 6 in Jakarta area, where low concentration of DO preventing self-purification in water mass.
3) In the normal calculation of the load capacity, BOD was used as standard target parameter for load capacity. The results showed that the burden of pollutants in segment 6 exceeded the capacity of pollution load of BOD at the standard value. Using the BOD concentration in the standard class IV as a target, segment 1 to segment 5 still had the capacity of class IV standard. The BOD indicator at Kwitang-Ancol monitoring station (segment 6) exceeded the capacity for class IV standard.
4) Based on available research findings, it is recommended that each river segment should adopt specific pollution load control programs, with focus on supplier pollution load factor.

For example, segments 1 and 2 should focus on control programs for domestic and industrial waste; segment 3 on domestic and farm waste; segment 4 on control of industrial, domestic and livestock waste, segments 5 and 6 on domestic waste control program. In addition, segments 5 and 6 on intensive program of waste management and control of the slums along the River.

2.5. Citarum River Basin Management with Large Scale Dam System

The Citarum River is one of three major rivers in JABADETABEK. Currently, this river is notorious for the most polluted water quality in Indonesia. In this section, as a part of comparative survey of the three major rivers, the history of the Citarum River development with construction large scale dam system for hydropower generation, irrigation and flood control in the downstream flood plain is stated in order to give the useful information for the future water environment management in the Citarum Basin.

The Citarum River in West Java, Indonesia has an important role in the life of the people in West Java, as it is used for agriculture, water supply, industry and sewerage. The Citarum River is one of Indonesia's most strategic waterways; supplying water for three big Dams in West Java, generating electricity and supporting millions of people and providing water to the country's capital, Jakarta. But overuse and increasing industrial pollution over the last two decades has severely damaged the River. Through the hills above the Jakarta, the Citarum River collects sediment from eroded land, and pollutants from villages and factories. Floods are commonplace. The River is heavily polluted by human activities; and about five million people live in the basin of the River are currently under threat. In December 5, 2008, ADB approved a $500 million loan for cleaning up the River, calling it the dirtiest in the world. Dr. Loebis from the Research Institute of Water Resource and Management, Bandung, PU, mentioned the reservoir operation conflict in the Citarum River basin in his paper submitted to the Proceedings of Extreme Hydrological Events: Precipitation, Floods and Droughts in 1993. In this paper, he commented that water management in the Citarum River has had a very complicated problems and interesting development history.

In 1964, Jatiluhur reservoir was the only reservoir existed along the Citarum River. This multipurpose reservoir was aimed to generate electric hydropower and provided irrigation water for 234,000 ha of rice field and drinking water for the Djakarta metropolitan city. The dam was constructed downstream of the Citarum River basin, covering an area of 540 km^2 with total volume about 2,556 million m^3 at maximum water level of 107 m MSL (mean sea level). The Jatiluhur Authority Project, a government owned company under parenthood of the Ministry of Public Works was responsible for the operation of this reservoir. By contract, all the electricity generated has to be sold to the State Electric Company.

In 1985, the Saguling reservoir located upstream Jatiluhur reservoir began operation. This reservoir in the upper reach of the Citarum River basin covers an area of about 2,283 km^2 with a total volume of 881 million m^3 at maximum water level 643 m MSL. The reservoir has been operated mainly to support the hydropower plant for generating electricity.

In 1988, the Cirata reservoir, the third in a row, was completed and became ready to operate for hydropower, to fulfill electricity demands on Java and Bali. It has been also managed by the State Electric Company, a state owned company under parenthood of the Ministry of Mining and Energy (MME). This reservoir is located between the Saguling and the Jatiluhur reservoirs, covering an area of 1,778 km^2 and has volume of 1,973 million m^3 at the maximum water level of 220 m MSL.

Figs. 2.5.1 and 2.5.2 show the longitudinal profile of the Citarum River and the location of the three reservoirs mentioned above. Since all reservoirs have to be operated jointly, the problem of water regulation appears. It is important especially during the dry season. In this respect, the Jatiluhur reservoir is in an inferior condition as there is no natural inflow entering the reservoir. Technically, electric energy production may be put to optimum in the Saguling and Cirata reservoirs but not in the Jatiluhur reservoir, since the Jatiluhur is also responsible for irrigation, drinking water and flushing purposes.

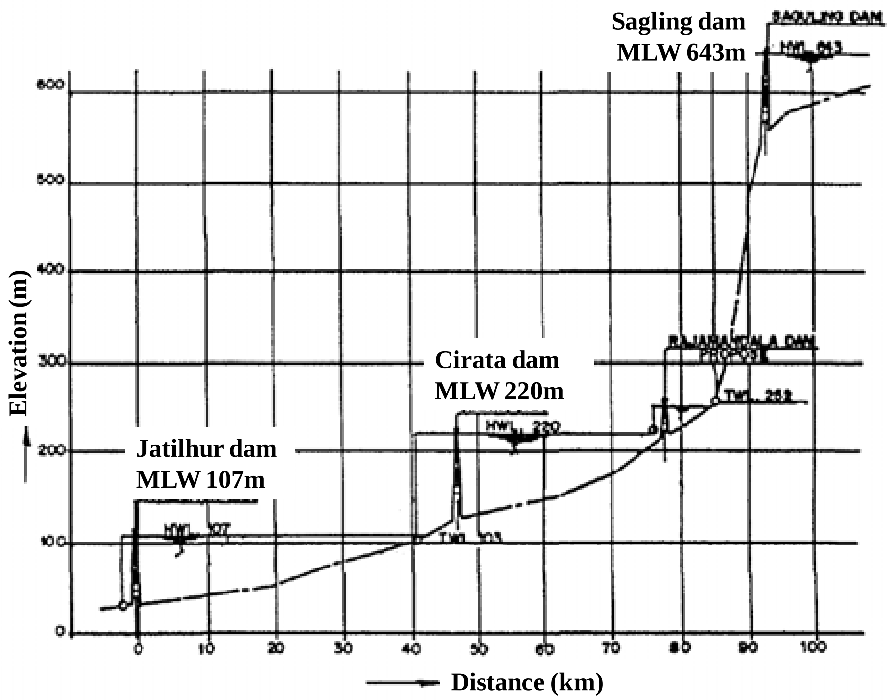

Fig. 2.5.1 Longitudinal profile of the Citarum River showing dam locations

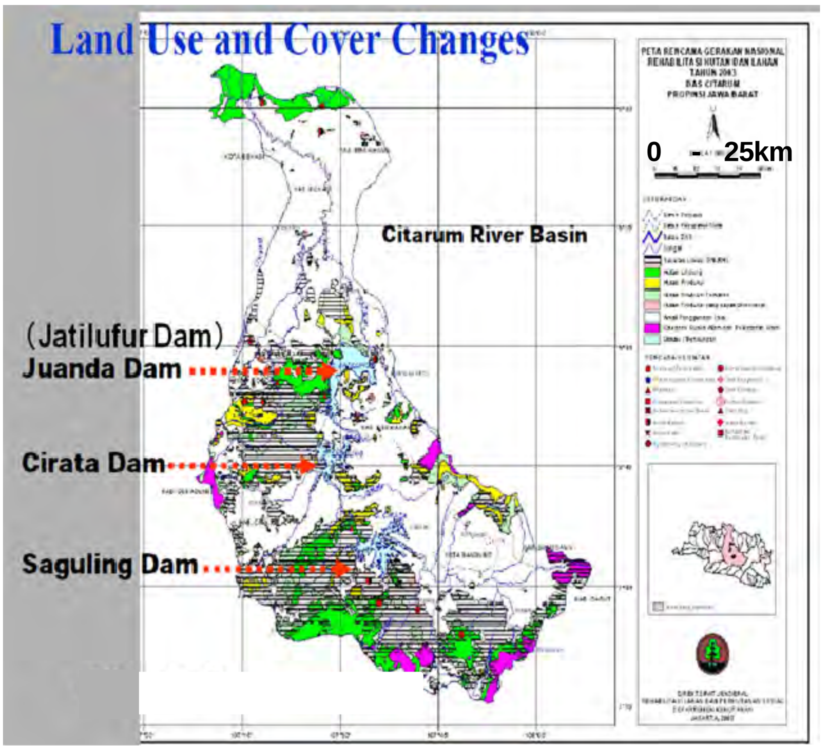

Fig. 2.5.2 Locations of the four dams in the Citarum River basin

Because all three reservoirs are operated simultaneously in series, the Jatiluhur reservoir faces a complicated operation problem, weighing between its requirements and conditions as follow:

1) In wet and dry season planting times, or at least half of the whole area, rice field about 234, 000 and 223,000 ha, respectively should be supplied free of charge by the Jatiluhur Authority Project.
2) Jatiluhur reservoir is absolutely dependent on Cirata outflow; and in turn Cirata inflow is dependent on Saguling outflow. The volume of water which should be released by Jatiluhur reservoir is large, whereas inflow entering Jatiluhur reservoir is relatively restricted for the sub-basin between Cirata and Jatiluhur and is relatively small. The Jatiluhur reservoir, however, has to give priority to irrigation water programmed for harvesting twice a year. Consequently water supply has to be relatively constant for the whole year.
3) Saguling can produce more electricity compared with Cirata, while Cirata produces more than Jatiluhur reservoir. If Saguling and Cirata intend to produce electricity in line with their full capacity during peak hours, they have to store water to certain level, which would certainly affect Jatiluhur reservoir operation, making it unable to retain a certain level in the dry season.
4) Water stored in Jatiluhur reservoir has little commercial value such as merely for electricity, drinking water and industrial uses. Irrigation water is given free of charge.
5) Jatiluhur reservoir may not function properly if the water level is less than 87.5 mMSL. Due to the requirements and conditions described above, careful regulation of reservoir operation is obviously needed and the operation pattern chosen must not significantly affect the function of these three reservoirs. Some disadvantages due to operation constraints are (1) optimum electricity cannot be obtained, since a certain water level cannot be reached, and (2) farmer's income is decreased due to lack of irrigation water supplied.

In solving such problems, river characteristics should also be taken into account.

The main objective in constructing dams is to improve people's welfare in the agriculture or energy sector. Apparently, reservoir operation pattern obtained by technical method did not fulfill the demand of water users due to different water levels required for commitment.

Considering this complicated situation, the Secretariat Working Team of Coordination for Regulation Implementation of the Citarum River was set up and adjusted the reservoir operation pattern to be applied in each related institution. The working team resolved the commitment of a three- reservoir-operation pattern, based on the water balance principle without achieving the optimum energy production.

Table 2.5.1 gives the details of the outflows from each of the three dams. For example, outflow from the Saguling reservoir always conforms to the inflow except during the dry season when reserve storage has to be used. For Cirata and Jatiluhur reservoirs, outflows should be managed properly based on the outflow of the Saguling and local inflows. The main principle in this non-technical approach is that water levels during January to December should be kept almost constant at a certain level.

Table 2.5.1 Operation pattern of the Citarum cascade reservoirs (dry year 1992)

(1) SAGULING

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Storage (10^6 m^3)	165.2	175.9	183.9	209.0	230.9	231.6	219.0	186.8	149.8	114.2	89.8	96.3	
Water Level (m)	638.8	639.4	639.4	639.5	639.5	639.5	639.5	639.5	639.4	639.3	639.4	639.4	
Inflow (m^3/sec)	111.6	109.0	124.0	121.5	72.9	49.6	30.0	19.9	21.2	31.7	67.2	99.3	857.9
Outflow (m^3/sec)	100.0	100.0	98.0	98.0	70.0	60.0	60.0	55.0	55.0	55.0	60.0	69.7	880.7
Evaporation (mm/day)	6.0	6.0	6.0	9.0	12.0	12.0	12.0	12.0	12.0	9.0	6.0	6.0	108.0
Production (GWh)	232.9	217.9	228.2	220.9	163.0	135.2	139.7	128.1	124.0	128.1	135.2	162.3	2015.5

(2) CIRATA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Storage (10^6 m^3)	131.3	160.4	193.8	243.8	298.0	298.2	282.1	252.0	211.0	180.7	157.5	136.5	
Water Level (m)	212.0	213.4	215.0	217.3	219.6	219.6	218.9	217.6	215.8	214.4	213.3	212.0	
Inflow (m^3/sec)	90.3	84.7	98.3	98.3	58.0	36.8	22.7	16.8	17.3	23.8	60.2	86.9	694.1
Outflow (m^3/sec)	190.3	184.7	196.3	196.3	128.0	96.8	82.7	71.8	72.3	78.8	120.2	156.6	1574.8
Evaporation (mm/day)	6.0	6.0	6.0	9.0	12.0	12.0	12.0	12.0	12.0	9.0	6.0	6.0	108.0
Production (GWh)	119.0	104.4	107.9	100.8	93.0	79.2	81.8	81.8	72.0	74.4	100.8	119.4	1134.5

(3) JATILUHUR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Storage (10^6 m^3)	315.6	393.2	454.4	513.4	576.9	585.5	499.8	423.8	385.4	378.0	334.1	330.9	
Water Level (m)	92.0	95.4	98.1	100.5	102.8	103.1	99.8	96.7	95.1	94.7	92.8	92.7	
Inflow (m^3/sec)	29.0	24.8	28.6	31.0	17.0	11.8	7.2	4.8	5.6	8.4	18.2	26.6	213.0
Outflow (m^3/sec)	110.0	110.0	110.0	110.0	130.0	204.0	190.0	150.0	110.0	150.0	160.0	165.0	1699.0
Evaporation (mm/day)	6.0	6.0	6.0	9.0	12.0	12.0	12.0	12.0	12.0	9.0	6.0	6.0	108.0
Production (GWh)	48.1	47.2	52.7	52.9	66.4	98.1	89.6	68.1	47.0	65.5	66.1	70.5	772.2

Source: PU

2.6. Water Environment Management Technology

2.6.1. Water Quality and its Measurement

Water quality involves the physical, chemical and biological characteristics of water. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to drinking water, safety of human contact and health of ecosystems.

Water chemical analysis is carried out to identify and quantify the chemical components and properties of certain water. This includes pH, major cations and anions, trace elements and isotopes. Water chemistry analysis is used extensively to determine the possible uses water may have or to study the interaction it has with its environment. Water chemistry analysis is often the groundwork of studies of water quality, pollution, hydrology and geothermal waters.

Components commonly analyzed are pH, the cations Na, K, Ca, Mg, Si, the anions Cl, F, SO_4, the trace metals and metaloids Rb(rubidium), Ti, Fe, Mn, etc, unstable volatiles such as CO_2, H_2S and O_2, isotope ratios of ^{18}O and ^{2}H, organic material and nutrients.

Depending on the components, different methods are applied to determine the quantities or ratios of the components. While some methods can be performed with standard laboratory equipment, others require advanced devices, such as inductively coupled plasma mass spectrometry (ICP-MS).

1) Oxygen and H_2S are most commonly measured by titration.
2) Ion chromatography is a sensitive and stable technique that can measure Li, NH_4, Na, K, Ca and Mg quantities among other components.
3) For steam samples, gas chromatography can be used to determine methane, carbon dioxide, oxygen and nitrogen quantities.
4) Spectrophotometry is most commonly used to measure iron content in water samples.

5) Saturated calomel electrode and glass electrode are often used in conjunction to determine the pH of water.

(1) Methods

Titration is a common laboratory method of quantitative chemical analysis that is used to determine the unknown concentration of a known reactant. Because volume measurements play a key role in titration, it is also known as volumetric analysis. A reagent, called the *titrant* or *titrator*, of a known concentration (a standard solution) and volume is used to react with a solution of the analyte or titrant, whose concentration is not known. Using a calibrated burette or chemistry pipetting syringe to add the titrant, it is possible to determine the exact amount that has been consumed when the *endpoint* is reached. The endpoint is the point at which the titration is complete, as determined by an indicator. This is ideally the same volume as the equivalence point - the volume of added titrant at which the number of moles of titrant is equal to the number of moles of analyte, or some multiple thereof (as in polyprotic acids). In the classic strong acid-strong base titration, the endpoint of a titration is the point at which the pH of the reactant is just about equal to 7, and often when the solution takes on a persisting solid color as in the pink of phenolphthalein indicator.

Ion-exchange chromatography (or ion chromatography) is a process that allows the separation of ions and polar molecules based on their charge. It can be used for almost any kind of charged molecule including large proteins, small nucleotides and amino acids. The solution to be injected is usually called a *sample*, and the individually separated components are called analytes. It is often used in protein purification, water analysis, and quality control.

Gas chromatography (GC) is a common type of chromatography used in analytic chemistry for separating and analyzing compounds that can be vaporized without decomposition. Typical uses of GC include testing the purity of a particular substance, or separating the different components of a mixture (the relative amounts of such components can also be determined). In some situations, GC may help identify a compound. In preparative chromatography, GC can be used to prepare pure compounds from a mixture.

In gas chromatography, the *moving phase* (or "mobile phase") is a carrier gas, usually an inert gas such as helium or an unreactive gas such as nitrogen. The *stationary phase* is a microscopic layer of liquid or polymer on an inert solid support, inside a piece of glass or metal tubing called a column (a homage to the fractionating column used in distillation). The instrument used to perform gas chromatography is called a *gas chromatograph* (or "aerograph", "gas separator").

Spectrophotometry is the quantifiable study of electromagnetic spectra. It is more specific than the general term electromagnetic spectroscopy in that spectrophotometry deals with visible light, near-ultraviolet, and near-infrared. Also, the term does not cover time-resolved spectroscopic techniques.

Spectrophotometry involves the use of a spectrophotometer. A spectrophotometer is a photometer (a device for measuring light intensity) that can measure intensity as a function of the light source wavelength. Important features of spectrophotometers are spectral bandwidth and linear range of absorption measurement.

Perhaps the most common application of spectrophotometers is the measurement of light absorption, but they can be designed to measure diffuse or specular reflectance. Strictly, even the emission half of a luminescence instrument is a type of spectrophotometer.

The complexity of water quality as a subject is reflected in the many types of measurements of water quality indicators. Some of the simple measurements listed below can be made on-site, (e.g., temperature, pH, dissolved oxygen, conductivity, oxygen reduction potential (ORP) or in direct contact with the water source in question. More complex measurements that must be made in a laboratory setting require a water sample to be collected, preserved, and analyzed at another location. Making these complex measurements can be expensive. Because direct measurements of water quality can be expensive, ongoing monitoring programs are typically conducted by government agencies. However, there are local volunteer programs and resources available for some general assessment. Tools available to the general public are on-site test kits commonly used for home fish tanks and biological assessments.

(2) Testing in Response to Natural Disasters and Other Emergencies

Inevitably after events such as earthquakes and tsunamis, there is an immediate response by the aid agencies as relief operations get underway to try and restore basic infrastructure and provide the basic fundamental items that are necessary for survival and subsequent recovery. Access to clean drinking water and adequate sanitation are a priority at times like this. The threat of disease increases tremendously due to the large numbers of people living close together, often in squalid conditions, and without proper sanitation.

After a natural disaster, as far as water quality testing is concerned, there are widespread views on the best course of action to take and a variety of methods can be employed. The key basic water quality parameters that need to be addressed in an emergency are bacteriological indicators of fecal contamination, Free Chlorine Residual, pH, turbidity and possibly conductivity/TDS. There are a number of portable water test kits on the market widely used by aid and relief agencies for carrying out such testing.

The following is a list of indicators often measured by situational category:

1) Drinking Water

- Alkalinity
- Color of water
- pH
- Taste and odor (geosmin, 2-methylisoborneol (MIB), etc)
- Dissolved metals and salts (sodium, chloride, potassium, calcium, manganese, magnesium)
- Microorganisms such as fecal coliform bacteria (*Escherichia coli*), Cryptosporidium, and Giardia lamblia
- Dissolved metals and metalloids (lead, mercury, arsenic, etc.)
- Dissolved organics: colored dissolved organic matter (CDOM), dissolved organic carbon (DOC)
- Radon
- Heavy metals (e.g. Hg, Cd, As, Pb, Cr, Zn etc)

- Pharmaceuticals (any chemical substance intended for use in the medical diagnosis, cure, treatment, or prevention of disease)

2) Chemical Assessment

- Conductivity (also see salinity)
- Dissolved oxygen (DO)
- Nitrate-N
- Orthophosphates
- Chemical oxygen demand (COD)
- Biochemical oxygen demand (BOD)
- Pesticides

3) Physical Assessment

- pH
- Temperature
- Total suspended solids (TSS)
- Turbidity

4) Biological Assessment

Biological monitoring metrics have been developed in many countries, and one widely used measure is the presence and abundance of members of the insect orders Ephemeroptera, Plecoptera and Trichoptera (EPT). (Common names are, respectively, Mayfly, Stonefly and Caddisfly.) EPT indexes will naturally vary from region to region, but generally, within a region, the greater the number of taxa from these orders, the better the water quality. Environmental Protection Agency (EPA) and other organizations in the United States offer guidance on developing a monitoring program and identifying members of these and other aquatic insect orders.

2.6.2. Environmental Impact Assessment

An environmental impact assessment (EIA) is an assessment of the possible impact - positive or negative - that a proposed project may have on the environment, together with the natural, social and economic aspects.

The purpose of the assessment is to ensure that decision makers consider the ensuing environmental impacts when deciding whether to proceed with a project. The International Association for Impact Assessment (IAIA) defines an environmental impact assessment as "the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made."

After an EIA, the precautionary and polluter pays principles may be applied to prevent, limit, or require strict liability or insurance coverage to a project, based on its likely harms. Environmental impact assessments are sometimes controversial.

In environmental law, the polluter pays principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment. It is regarded as a regional custom because of the strong support it has received in most Organization for Economic Co-operation and Development (OECD) and European Community (EC) countries. In international environmental law it is mentioned in Principle 16 of the Rio Declaration on Environment and Development.

Environmental law is a complex and interlocking body of treaties, conventions, statutes, regulations, and common law that, very broadly, operate and regulate the interaction of humanity and the rest of the biophysical or natural environment, toward the purpose of reducing the impacts of human activity, both on the natural environment and on humanity itself. The topic may be divided into two major areas: (1) pollution control and remediation, and (2) resource conservation and management. Laws dealing with pollution are often media-limited - i.e., pertain only to a single environmental medium, such as air, water (whether surface water, groundwater or oceans), soil, etc. - and control both emissions of pollutants into the medium, as well as liability for exceeding permitted emissions and responsibility for cleanup. Laws regarding resource conservation and management generally focus on a single resource (e.g., natural resources such as forests, mineral deposits or animal species) or more intangible resources (such as especially scenic areas or sites of high archeological value), and provide guidelines for and limitations on the conservation, disturbance and use of those resources. These areas are not mutually exclusive - for example, laws governing water pollution in lakes and rivers may also conserve the recreational value of such water bodies. Furthermore, many laws that are not exclusively "environmental" nonetheless include significant environmental components and integrate environmental policy decisions. For examples, these include municipal, state and national laws regarding development, land use and infrastructure are examples.

Environmental law is influenced by principles of environmentalism, including ecology, conservation, stewardship, responsibility and sustainability. Pollution control laws generally are intended to protect and preserve both the natural environment and human health. Resource conservation and management laws generally balance the benefits of preservation and economic exploitation of resources.

From an economic perspective environmental laws may be understood as concerned with the prevention of present and future externalities, and preservation of common resources from individual exhaustion. The limitations and expenses that such laws may impose on commerce continue to generate significant controversy.

2.6.3. Community Approach to Earth Systems Modeling for Environment Impact Assessment

(1) Earth System Model

Earth science often deals with complex systems spanning multiple disciplines. These systems are best described by integrated models built with contributions from specialists of many backgrounds. But building integrated models can be difficult; modular and hierarchical approaches help to manage the increasing complexity of these modeling systems, and there is a need for framework and integration methods and standards to support modularity. Complex models require many data and generate lots of output, so software and standards are required for data handling, model output, data distribution services, and user interfaces. Complex modeling systems must be efficient to be useful, so they require contributions by software engineers to ensure efficient architectures, accurate numeric, and implementation on fast computers. Further, integrated model systems can be difficult to learn and use unless adequate documentation, training, and support are provided.

Meeting all of these requirements can exceed the resources of typical research teams, and even those of a government agency, so there is a clear need for good mechanisms for designing, building, testing, and maintaining complex modeling systems. One such mechanism is the community modeling approach.

A community modeling system is an open-source (OS) suite of modeling components coupled in a framework. The system emerges through the collective efforts of a community of individuals who code, debug, test, document, run, and apply the modeling system. The community often includes both developers and users and may be distributed among different institutions and organizations.

Community models first emerged in the Earth sciences in the 1980s as a means to address the challenge of developing and applying complex models in the fields of air quality modeling, climate prediction, and weather forecasting. Since then, an increasing number of community modeling projects have emerged. This approach highlights specific strategies that reflect the promise and challenges of community modeling in Earth and environmental sciences.

(2) Community Approach for Complex Modeling Systems

An increasing number of community modeling projects have emerged over the past 3 decades. The first generation of community models, including the U.S. EPA Models-3 System (Community Multiscale Air Quality modeling system (CMAQ); http:// www.epa.gov/asmdnerl/CMAQ/cmaqmodel.html), the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM; http://www.cgd.ucar.edu/cms/ccm3/ history.shtml), and the Pennsylvania State/NCAR Mesoscale Model (MM5; http:// www. mmm.ucar.edu/mm5/overview.html), demonstrates that freely available, portable, well-documented, OS models would be enthusiastically received and used by the broader scientific community as research tools.

The next generation of community modeling projects was more ambitious. The Community Climate System Model (CCSM; http://www.ccsm.ucar.edu/models/atm-cam/), the successor to CCM, continues to incorporate new physical processes and even human impacts at an accelerating rate.

The CCSM project participated in the demanding Intergovernmental Panel on Climate Change (IPCC) assessments while continuing to serve as a vehicle for research. The Weather Research and Forecast (WRF) model (http://www.wrf-model.org/index.php), the successor to MM5, has attempted to serve both the research and operational communities. These models are widely used and have developed networks of contributors. They have also struggled to meet the demands placed on them: to satisfy diverse user bases, to keep up with the integration of new science, and to create governance bodies that can support scientific processes and scale to large numbers of participants.

More recently, much attention has been given to integrated modeling, which brings together different models from various disciplines to work together through exchanging data and information within the same framework. It is in this context that researchers in integrated environmental modeling and related domains, such as Earth surface dynamics, hydrology, and some geographically focused areas (e.g., the Chesapeake Bay; see Fig. 2.6.1) are seeking to organize and create new community modeling systems.

Some examples of integrated modeling projects in Earth science include the U.S. National Science Foundation (NSF)–funded Community Surface Dynamics Modeling System (CSDMS; http:// csdms .colorado.edu); The EPA-funded Community Modeling and Analysis System (CMAS; http:// www.cmascenter.org/); the U.S. National Oceanic and Atmospheric Administration (NOAA)–funded Chesapeake Community Modeling Program (CCMP; http://ches.communitymodeling.org); the Community Sediment-Transport Model System (CSTMS; http://cstms.org), supported through the National Oceanographic Partnership Program; and others.

Yet another effort has been instigated by EPA, the Community for Integrated Environmental Modeling, also known as the Integrated Modeling for the Environment (IM4E) effort (http://groups.google.com/group/commiem?hl=en). These initiatives are less focused on individual processes and are more about arranging and linking various model components in a flexible and transparent way. Key to these efforts is a culture of scientific research based on collaborative development and open sharing of information and skills. In contrast to the previous community models, here the communities are formed around more general topics and research areas and are not centered on a particular model or modeling system.

Fig. 2.6.1 shows the migration of turbid floodwaters down the Chesapeake Bay after the severe floods of 2004 (true-color image captured by Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) on 26 June 2004). The Chesapeake Bay is the focus region for the application of community models such as the Weather Research and Forecast (WRF) model and integrated modeling projects such as the CSDMS and the CCMP.

Fig.2.6.1 Migration of turbid floodwaters down the Chesapeake Bay

(3) Advantages to a Community Approach

There are several advantages to a community approach. It provides a way to integrate effort among multiple institutions, which is crucial because Earth systems models are too multidisciplinary and complex for individual research groups. Community engagement can maintain project momentum and more project robustness in the face of uncertain funding and institutional support. An open, community approach can decrease redundant efforts because new models can be built upon already existing concepts, algorithms, and code.

Additionally, community modeling systems are often closely linked with their users, which promote user participation and input at early stages of the project and during the testing phase. More user input allows for wider and more diverse testing, more robust models, and wider understanding and acceptance of results.

Most community modeling efforts rely on OS code. Within this system, OS and its philosophy satisfy the practical need of allowing many developers access to examine and modify the code. There is significant experience in protecting intellectual property rights gained in OS, as well as in open-data communities. Organizations such as the Open Geospatial Consortium, Inc. (OGC; http://www.opengeospatial.org/), have developed a variety of licensing schemes, which can be well applied to models. Moreover, OS provides complete information transfer, and this transparency is important because code is the ultimate statement of the scientific understanding embodied in a numerical model. OS also facilitates peer review and replication of results, and it can be more easily reused, helping to reduce redundancy. Finally, OS seems appropriate for publicly funded science projects because it ensures delivery of the results to the public.

(4) Challenges

Complex systems are inherently hard to build and maintain, regardless of the approach, so building Earth systems models will never be easy. Researchers and administrators are still learning how best to develop OS scientific software using a community approach. There are technical challenges, including the need to develop fundamental algorithms to describe processes and implement these in efficient code. All of the other aspects of the model system must be designed, integrated, and built, including software for manipulating, analyzing, and assimilating observations and to facilitate collaborations; standards and ontology for data and model interfaces; and substantial improvements in hardware (e.g., network and computing infrastructure).

However, the most difficult challenges can often be social or institutional. In many institutions the scientific reward structure is skewed toward publications and away from technical contributions. Funding is discontinuous and not reliably available for long-term support of technical infrastructure. Intellectual property policies of universities and private companies may be incompatible. Software is often viewed as a competitive advantage among competitors for funding and academic honors. There are inefficiencies associated with informal project organizations that lack hierarchal structure. Many community projects are organized like bazaars, with simultaneous efforts by many participants and without clear management, subordination, responsibilities, or strategies to deal with conflict and inefficiency. Informal management is not conducive to deadlines or customer-driven deliverables. It is also often difficult to work across disciplines, distances, and time zones with a diverse group of people, and to communicate effectively among scientists, engineers, users, and decision makers, who may have their own culture, vocabulary, and objectives.

(5) What Is Needed?

Suggestions for supporting community modeling efforts and enhancing their success generally fall into two categories: organizational and technical. The organizational suggestions address the cultural and social background that is important for community modeling, as well as the programmatic decisions that can make projects more successful. The technical suggestions concern the actual software and analytical tools that are required. Within this framework, suggestions can be tailored to specific segments of the Earth science modeling community.

Funding agents and program managers should require that code be OS and meet a minimum level of standards or protocols as a prerequisite for receiving public funds. They should recognize the value of stable (longer-term) funding of software architects and engineers within the research environment, together with technical staff support of large academic or medical labs. They should support repositories of models and software and ensure that researchers exchange information and standards among themselves. Code and documentation should be accessible as early and openly as possible during development to ensure that code from completed projects is archived and accessible, in the same way that field data and measurements are now. Model output from experiments should be made available to assist model validation and evaluation.

Further, institutional leadership should recognize the value of producing OS code and contributing to community modeling efforts to support collaborative environments that minimize the need for temporal and spatial localization. Producing well-documented, peer-reviewed code should become worthy of merit, while effective ways of peer review, publication, and citation of code, standards, and documentation should be introduced. OS should be embraced as a means of protecting intellectual property rights.

Community modeling project leaders should also encourage communication between scientists, technicians, and end users and should develop realistic criteria and metrics for success, considering project objectives, scope, and resources. Project governance should be formalized and enable teams to set priorities and make decisions as a unified effort working toward a common goal. Project governance must accommodate, and also be able to supersede, the interests and priorities of individuals, subgroups, disciplines, or institutions participating in the project.

Developers and the broader modeling community should adopt existing standards for data, model input and output, and interfaces.

They should also help to develop standards for model conceptualization, formalization, and scaling. A good strategy may be to understand, use, and adapt existing tools first before developing new ones. However, if new tools are needed, those involved should provide good documentation, including examples and test cases.

Good software development practices should favor transparency, portability, and reusability and should include procedures for version control, bug tracking, regression testing, and release maintenance.

(6) Making the Complex Easier

There are significant scientific and technical challenges associated with constructing complex Earth systems models. Overcoming these difficulties will require a collaborative modeling approach based on the fundamental principles of open scientific research, including sharing of ideas, data, and software. Improved software design and systems architecture in support of distributed community modeling efforts could significantly increase the efficiency and utility of the community approach. However, it is unlikely that the technical problems can be resolved unless the cultural problems of community modeling can be resolved. Thus, concerted progress toward more efficient community modeling will require the efforts of participants at all levels.
(from EOS, Transactions, American Geophysical Union, Volume 91 number 13, 30 MARCH 2010, pages 117–124)

2.6.4. Sewage Water Treatment Technology

Sewage treatment is the process of removing contaminants (pollutant) from household sewage and wastewater. The objective is to produce a waste stream or treated effluent and a solid waste or sludge suitable for discharge or re-use back into the environment. This material is often inadvertently contaminated with many toxic organic and inorganic compounds.

Sewage can be treated close to where it is created (in septic tanks, biofilters or aerobic treatment systems), or collected and transported via a network of pipes and pump stations to a municipal treatment plant (see sewerage and pipes and infrastructure).

Sewage collection and treatment is typically subject to local, state and federal regulations and standards. Industrial sources of wastewater often require specialized treatment processes. Conventional sewage treatment may involve three stages, called primary, secondary and advanced treatment.

(1) Primary treatment consists of temporarily holding the sewage in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface. The settled and floating materials are removed and the remaining liquid may be discharged or subjected to secondary treatment.

In the primary sedimentation stage, sewage flows through large tanks, commonly called "primary clarifiers" or "primary sedimentation tanks." The tanks are used to settle sludge while grease and oils rise to the surface and are skimmed off. Primary settling tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank where it is pumped to sludge treatment facilities. Grease and oil from the floating material can sometimes be recovered for saponification (converted into soap). The dimensions of the tank should be designed to effect removal of a high percentage of the floatables and sludge. A typical sedimentation tank may remove from 60 to 65% of suspended solids, and from 30 to 35 % of BOD from the sewage.

(2) Secondary treatment removes dissolved and suspended biological matter. Secondary treatment is typically performed by indigenous (ecology), water-borne micro-organisms in a managed habitat. Secondary treatment may require a separation process to remove the micro-organisms from the treated water prior to discharge or advanced treatment.

Secondary treatment is designed to substantially degrade the biological content of the sewage which is derived from human waste, food waste, soaps and detergent. The majority of municipal plants treat the settled sewage liquor using aerobic biological processes. To be effective, the biota requires both oxygen and food to live. The bacteria (single-celled) and protozoa (subkingdom of microorganisms) consume biodegradable soluble organic contaminants (e.g. sugars, fats, organic short-chain carbon molecules, etc.) and bind much of the less soluble fractions into floc.

Secondary treatment systems are classified as fixed-film or suspended-growth systems.

Fixed-film or attached growth systems include trickling filters and rotating biological contactors (RBC), where the biomass grows on media and the sewage passes over its surface.

Suspended-growth systems include activated sludge, where the biomass is mixed with the sewage and can be operated in a smaller space than fixed-film systems that treat the same amount of water.

However, fixed-film systems are more able to cope with drastic changes in the amount of biological material and can provide higher removal rates for organic material and suspended solids than suspended growth systems

Typical secondary treatment methods are summarized below.

1) Activated Sludge

In general, activated sludge plants encompass a variety of mechanisms and processes that use dissolved oxygen to promote the growth of biological floc that substantially removes organic material. The process traps particulate material and can, under ideal conditions, convert ammonia to nitrite and nitrate and ultimately to nitrogen gas. A generalized schematic diagram showing an activated sludge process is demonstrated in Fig. 2.6.2.

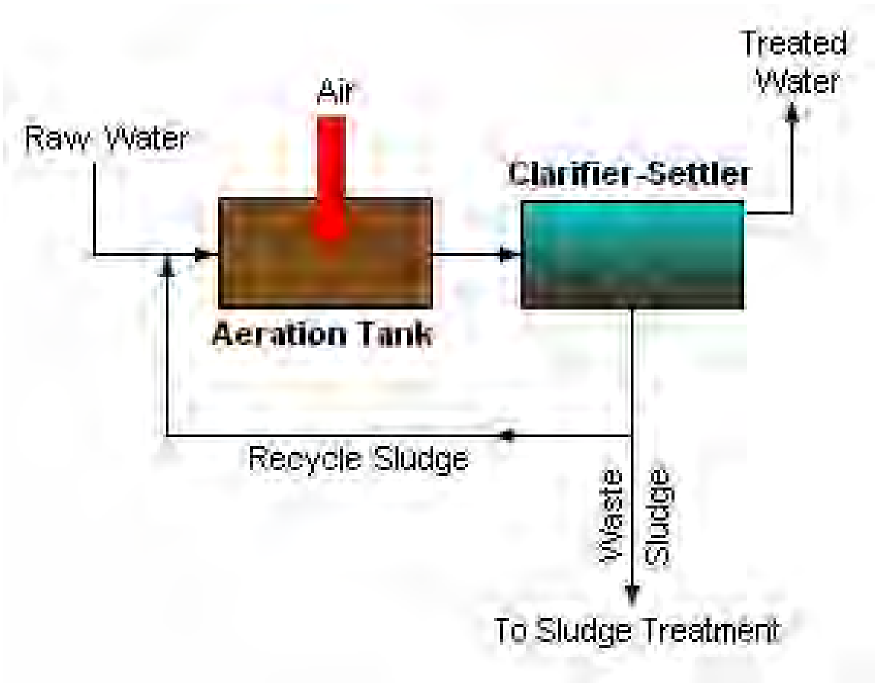

Fig. 2.6.2 Schematic diagram showing an activated sludge process

2) Surface-aerated Basins (Lagoons)

Many small municipal sewage systems (1 million gal./day or less) in the United States use aerated lagoons. Most biological oxidation processes for treating industrial wastewaters have in common the use of oxygen (or air) and microbial action. Surface-aerated basins (Fig. 2.6.3) achieve 80 to 90 % removal of BOD with retention times of 1 to 10 days. The basins may range in depth from 1.5 to 5.0 m and use motor-driven aerators floating on the surface of the wastewater. In an aerated basin system, the aerators provide two functions: (1) they transfer air into the basins required by the biological oxidation reactions, and (2) they provide the mixing required for dispersing the air and for contacting the reactants (that is, oxygen, wastewater and microbes). Typically, the floating surface aerators are rated to deliver the amount of air equivalent to 1.8 to 2.7 kg O_2/kW·h. However, they do not provide as good mixing as is normally achieved in activated sludge systems and therefore aerated basins do not achieve the same performance level as activated sludge units. Biological oxidation processes are sensitive to temperature and, between 0 °C and 40 °C, the rate of biological reactions increase with temperature. Most surface aerated vessels operate at between 4 °C and 32 °C.

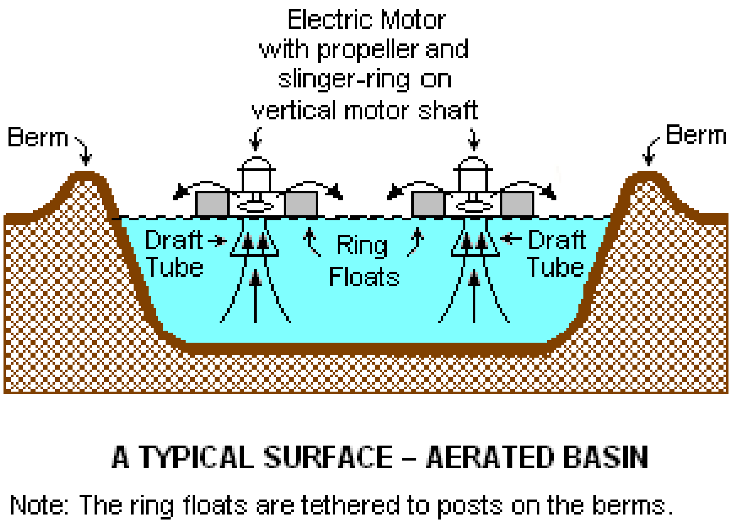

Fig. 2.6.3 A typical surface-aerated basin (using motor-driven floating aerators)

3) Filter Beds (Oxidizing Beds)

In older plants and those receiving variable loadings, trickling filter beds are used where the settled sewage liquor is spread onto the surface of a bed made up of coke (carbonized coal), limestone chips or specially fabricated plastic media. Such media must have large surface areas to support the biofilms that form. The liquor is typically distributed through perforated spray arms. The distributed liquor trickles through the bed and is collected in drains at the base. These drains also provide a source of air which percolates up through the bed, keeping it aerobic. Biological films of bacteria, protozoa and fungi form on the media's surfaces and eat or otherwise reduce the organic content. This biofilm is often grazed by insect larvae, snails, and worms which help maintain an optimal thickness. Overloading of beds increases the thickness of the film leading to clogging of the filter media and ponding on the surface. Recent advances in media and process micro-biology design overcome many issues with the Trickling filter designs (Fig. 2.6.4).

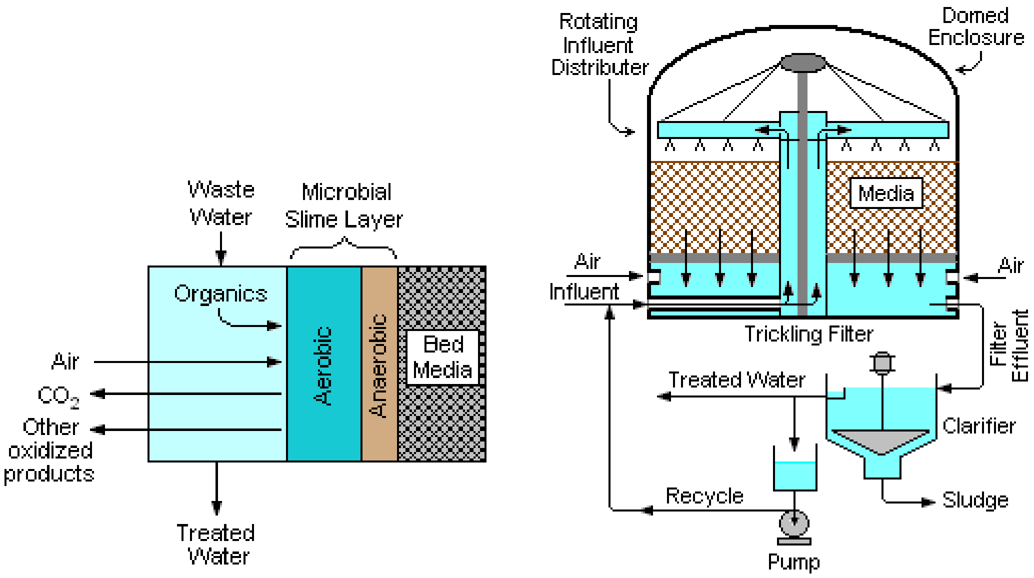

Fig. 2.6.4 A schematic cross-section of the contact face of the bed media in a trickling filter (left) and a typical complete trickling filter system (right)

A trickling filter consists of a fixed bed of rocks, gravel, slag, polyurethane foam, sphagnum peat moss, ceramic, or plastic media over which sewage or other wastewater flows downward and causes a layer or film of microbial slime to grow, covering the bed of media. Aerobic conditions are maintained by splashing, diffusion, and either by forced air flowing through the bed or natural convection of air if the filter medium is porous. The process mechanism, or how the removal of waste from the water happens, involves both absorption and adsorption of organic compounds within the sewage or other wastewater by the layer of microbial slime. Diffusion of the wastewater over the media furnishes dissolved air, the oxygen which the slime layer requires for the biochemical oxidation of the organic compounds and releases carbon dioxide gas, water and other oxidized end products. As the slime layer thickens, it becomes more difficult for air to penetrate the layer and an inner anaerobic layer is probably formed. This slime layer continues to build until it eventually sloughs off, breaking off longer growth into the treated effluent as a sludge that requires subsequent removal and disposal. Typically, a trickling filter is followed by a clarifier or sedimentation tank for the separation and removal of the sloughing. Other filters utilizing higher-density media such as sand, foam and peat moss do not produce a sludge that must be removed, but require forced air blowers and backwashing or an enclosed anaerobic environment.

The terms trickle filter, trickling biofilter, biofilter, biological filter and biological trickling filter are often used to refer to a trickling filter.

4) Soil Bio-Technology (SBT)

A new process called Soil Bio-Technology (SBT) developed at IIT Bombay has shown tremendous improvements in process efficiency enabling total water reuse, due to extremely low operating power requirements of less than 50 J/kg of treated water. Typically SBT systems can achieve COD levels less than 10 mg/l from sewage input of COD 400 mg/l. SBT plants exhibit high reductions in COD values and bacterial counts as a result of the very high microbial densities available in the media.

Unlike conventional treatment plants, SBT plants produce insignificant amounts of sludge, precluding the need for sludge disposal areas that are required by other technologies.

In the Indian context, conventional sewage treatment plants fall into systemic disrepair due to (1) high operating costs, (2) equipment corrosion due to methanogenesis and hydrogen sulphide, (3) non-reusability of treated water due to high COD (>30 mg/l) and high fecal coliform (>3000 NFU) counts, (4) lack of skilled operating personnel, and (5) equipment replacement issues.

Examples of such system failures have been documented by Sankat Mochan Foundation at the Ganga basin after a massive cleanup effort by the Indian government in 1986 by setting up sewage treatment plants under the Ganga Action Plan failed to improve river water quality.

5) Biological Aerated Filters (BAF)

Biological Aerated (or Anoxic) Filter (BAF) or Biofilters combine filtration with biological carbon reduction, nitrification or denitrification. BAF usually includes a reactor filled with a filter media. The media is either in suspension or supported by a gravel layer at the foot of the filter. The dual purpose of this media is to support highly active biomass that is attached to it and to filter suspended solids. Carbon reduction and ammonia conversion occurs in aerobic mode and sometime achieved in a single reactor while nitrate conversion occurs in anoxic mode. BAF is operated either in upflow or downflow configuration depending on design specified by manufacturer.

6) Rotating Biological Contactors (RBC)

RBCs are mechanical secondary treatment systems, which are robust and capable of withstanding surges in organic load. RBCs were first installed in Germany in 1960 and have since been developed and refined into a reliable operating unit. As shown in Fig. 2.6.5, the rotating disks support the growth of bacteria and micro-organisms present in the sewage, which break down and stabilize organic pollutants.

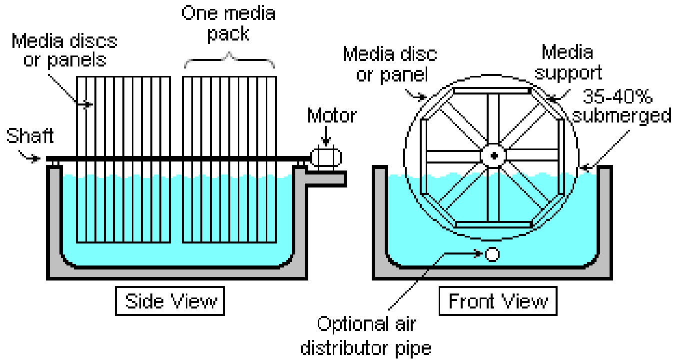

Fig. 2.6.5 Schematic diagram of a typical rotating biological contactor (RBC)

(The treated effluent clarifier/settler is not included in the diagram.)

To be successful, micro-organisms need both oxygen to live and food to grow. Oxygen is obtained from the atmosphere as the disks rotate. As the micro-organisms grow, they build up on the media until they are sloughed off due to shear forces provided by the rotating discs in the sewage. Effluent from the RBC is then passed through final clarifiers where the micro-organisms in suspension settle as sludge. The sludge is withdrawn from the clarifier for further treatment.

A functionally similar biological filtering system has become popular as part of home aquarium filtration and purification. The aquarium water is drawn up out of the tank and then cascaded over a freely spinning corrugated fiber-mesh wheel before passing through a media filter and back into the aquarium. The spinning mesh wheel develops a biofilm coating of microorganisms that feed on the suspended wastes in the aquarium water and are also exposed to the atmosphere as the wheel rotates. This is especially good at removing waste urea and ammonia urinated into the aquarium water by the fish and other animals.

7) Membrane Bioreactors (MBR)

Membrane bioreactors (MBR) combine activated sludge treatment with a membrane liquid-solid separation process (Fig. 2.6.6). The membrane component uses low pressure microfiltration or ultra-filtration membranes and eliminates the need for clarification and tertiary filtration. The membranes are typically immersed in the aeration tank; however, some applications utilize a separate membrane tank. One of the key benefits of a MBR system is that it effectively overcomes the limitations associated with poor settling of sludge in conventional activated sludge (CAS) processes. The technology permits bioreactor operation with considerably higher mixed liquor suspended solids (MLSS) concentration than CAS systems, which are limited by sludge settling. The process is typically operated at MLSS in the range of 8,000–12,000 mg/l, while CAS is operated in the range of 2,000–3,000 mg/l. The elevated biomass concentration in the MBR process allows for very effective removal of both soluble and particulate biodegradable materials at higher loading rates. Thus increased sludge retention time, usually exceeding 15 days, ensures complete nitrification even in extremely cold weather.

The cost of building and operating an MBR is usually higher than conventional wastewater treatment. Membrane filters can be blinded with grease or abraded by suspended grit and lack a clarifier's flexibility to pass peak flows. The technology has become increasingly popular for reliably pretreated waste streams and has gained wider acceptance where infiltration and inflow have been controlled, however, and the life-cycle costs have been steadily decreasing. The small footprints of MBR systems and the high quality effluent produced make them particularly useful for water reuse applications.

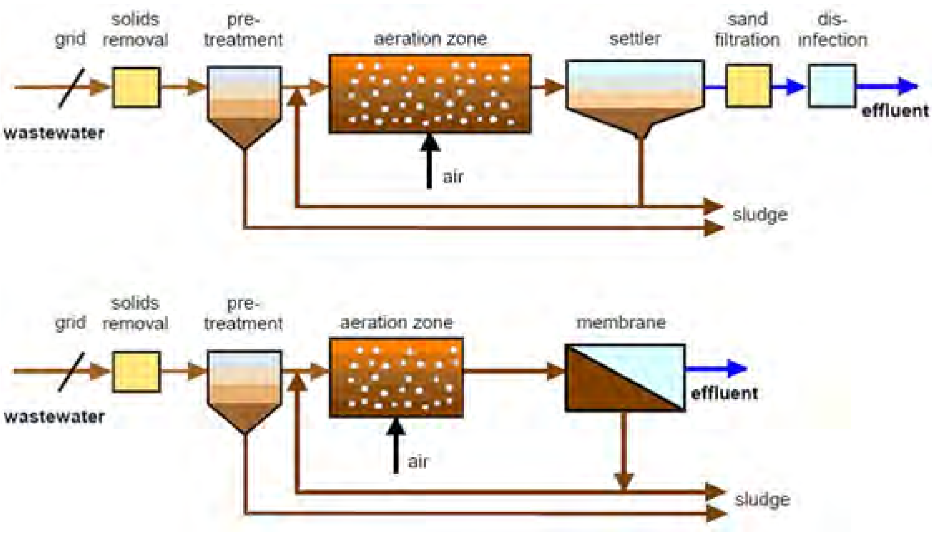

Fig. 2.6.6 Schematic of conventional activated sludge process (top) and membrane bioreactor (bottom)

(3) Advanced treatment is sometimes defined as anything more than primary and secondary treatment. Treated water is sometimes disinfected chemically or physically, for example, by lagoons and microfiltration, prior to discharge into a stream, river, bay, lagoon or wetland, or it can be used for the irrigation of a golf course, green way or park. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes.

The purpose of advanced treatment is to provide a final treatment stage to raise the effluent quality before it is discharged to the receiving environment (sea, river, lake, ground, etc.). More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also called "effluent polishing."

1) Filtration

Sand filtration removes much of the residual suspended matter. Filtration over activated carbon, also called carbon adsorption, removes residual toxins.

2) Lagooning

Lagooning provides settlement and further biological improvement through storage in large man-made ponds or lagoons. These lagoons are highly aerobic and colonization by native macrophytes, especially reeds, is often encouraged. Small filter feeding invertebrates (an animal without a backbone) such as *Daphnia* and species of *Rotifera* greatly assist in treatment by removing fine particulates.

3) Constructed Wetlands

Constructed wetlands include engineered reedbeds and a range of similar methodologies, all of which provide a high degree of aerobic biological improvement and can often be used instead of secondary treatment for small communities, also see phytoremediation (Fig. 2.6.7). One example is a small reedbed used to clean the drainage from the elephants' enclosure at Chester Zoo in England.

Fig. 2.6.7 A sandy lake shore colonized by reeds forming a reed bed

4) Nutrient Removal

Wastewater may contain high levels of the nutrients nitrogen and phosphorus. Excessive release to the environment can lead to a build-up of nutrients, called eutrophication, which can in turn encourage the overgrowth of weeds, algae, and cyanobacteria (blue-green algae). This may cause an algal bloom, a rapid growth in the population of algae. The algae numbers are unsustainable and eventually most of them die. The decomposition of the algae by bacteria uses up so much of oxygen in the water that most or all of the animals die, which creates more organic matter for the bacteria to decompose. In addition to causing deoxygenation, some algal species produce toxins that contaminate drinking water supplies. Different treatment processes are required to remove nitrogen and phosphorus.

5) Disinfection

The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of microorganisms in the water to be discharged back into the environment. The effectiveness of disinfection depends on the quality of the water being treated (e.g., cloudiness, pH, etc.), the type of disinfection being used, the disinfectant dosage (concentration and time), and other environmental variables. Cloudy water will be treated less successfully, since solid matter can shield organisms, especially from ultraviolet light or if contact times are low. Generally, short contact time, low doses and high flows all militate against effective disinfection. Common methods of disinfection include ozone, chlorine, ultraviolet light, or sodium hypochlorite. Chloramine, which is used for drinking water, is not used in wastewater treatment because of its persistence.

Chlorination remains the most common form of wastewater disinfection in North America due to its low cost and long-term history of effectiveness. One disadvantage is that chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogenic or harmful to the environment. Residual chlorine or chloramines may also be capable of chlorinating organic material in the natural aquatic environment. Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically dechlorinated, adding to the complexity and cost of treatment.

Ultraviolet (UV) light can be used instead of chlorine, iodine, or other chemicals. Because no chemicals are used, the treated water has no adverse effect on organisms that later consume it, as may be the case with other methods. UV radiation causes damage to the genetic structure of bacteria, viruses, and other pathogens, making them incapable of reproduction. The key disadvantages of UV disinfection are the need for frequent lamp maintenance and replacement and the need for a highly treated effluent to ensure that the target microorganisms are not shielded from the UV radiation (i.e., any solids present in the treated effluent may protect microorganisms from the UV light). In the United Kingdom, UV light is becoming the most common means of disinfection because of the concerns about the impacts of chlorine in chlorinating residual organics in the wastewater and in chlorinating organics in the receiving water. Some sewage treatment systems in Canada and the US also use UV light for their effluent water disinfection.

Ozone (O_3) is generated by passing oxygen (O_2) through a high voltage potential resulting in a third oxygen atom becoming attached and forming O_3. Ozone is very unstable and reactive and oxidizes most organic material it comes in contact with, thereby destroying many pathogenic microorganisms. Ozone is considered to be safer than chlorine because, unlike chlorine which has to be stored on site (highly poisonous in the event of an accidental release), ozone is generated onsite as needed. Ozonation also produces fewer disinfection by-products than chlorination. A disadvantage of ozone disinfection is the high cost of the ozone generation equipment and the requirements for special operators.

6) Odour Control

Odours emitted by sewage treatment are typically an indication of an anaerobic or "septic" condition. Early stages of processing will tend to produce smelly gases, with hydrogen sulfide being most common in generating complaints. Large process plants in urban areas will often treat the odours with carbon reactors, a contact media with bio-slimes, small doses of chlorine, or circulating fluids to biologically capture and metabolize the obnoxious gases. Other methods of odour control exist, including addition of iron salts, hydrogen peroxide, calcium nitrate, etc. to manage hydrogen sulfide levels.

3. Outline of the Survey

3.1. Background of the Survey

In order to popularize sewage treatment system in the developing countries, a preferred system should be low cost and simple handling. The activated sludge method, which is popular in Japan, hence, is not always adequate transfer technology for the developing countries because the disposal of the surplus grime which occurs at the process of its treatment system sometimes generates serious problem. Instead, the most favored option is the low cost and easy-operating simple sewage treatment process introduced at a town of Haryana Province in India, under Yamuna Action Plan (YAP) funded by Japanese ODA loan of 17.77 billion yen. The system was enabled by linking the DHS reactor to UASB. The DHS reactor was introduced as a pilot plant and the treatment capacity is 1,000 m^3/ day for around 5,000 people. The methane gas from the UASB-DHS system can be also utilized as energy of an electrical generator.

Besides the above sewage problem, many cities in the developing countries which have developed in the estuary are facing serious water environmental problems such as the illegal discharge of industrial wastewater, the pollution of surface water and potable groundwater, frequent flooding.

In order to solve these urban environmental problems, it is essential to take measures under the integrated water resource management (IWRM). In reality, however, considering the water environmental issues as a complex phenomenon in water circulation system has not yet been made in the developing countries.

3.2. Objective of the Survey

This Survey purposed to examine the possibility of the introduction and the diffusion of a low-cost sewage treatment system, and the formulation of a comprehensive environmental monitoring and assessment technology for the improvement of water environment in DKI Jakarta through data collection and analysis.

Through the Survey, it was expected to derive the following concrete results.

1) To bring out the current water quality condition throughout Jakarta and prediction of water quality improvement after the introduction of the sewage treatment systems. Water quality measuring was conducted to make clear the current water quality. For the existing 10 water quality monitoring stations along the Ciliwung River in Jakarta, adaptation measures for rehabilitation to become functioning was investigated by deliberate survey of suitable measuring equipment upon sufficient consultations with the departments in charge of DKI Jakarta.
2) To lay out how to introduce low-cost sewage treatment system. The concept how to introduce a low-cost sewage treatment system in PD PAL JAYA was presented based on the data acquired through the bench-scale experiments of UASB-DHS sewage treatment system.
3) To bring up how to build adequate water quality monitoring system based on the IC water quality analysis which can measure industrial effluent, groundwater contamination, as well as sewage in real time and without reagents. Real-time river water quality monitoring system that is linked to the Regional Environmental Simulator (RES) was surveyed. Subsurface water quality monitoring system was also investigated by using existing groundwater monitoring well system in DKI Jakarta. Environmental assessment technology using the RES together with ion-chromatography (IC) water quality analysis method was investigated focusing on its feasibility in Jakarta metropolitan areas under the cooperation of ITB (for RES operation) and UI (for IC analysis).
4) To lay out how to establish a comprehensive water environment management system based on environment simulator which includes flood forecasting and disaster prevention, as well

as water quality management. Integrating all survey results and compiling existing data in DKI Jakarta, problems in the water environment (e.g., surface and subsurface water quality, solid waste in the river, river and ocean-driven flooding in the lowland area) were made clear and the related database was constructed for practical use in future water management in Jakarta. Finally the water environment improvement measures through the low-cost wastewater treatment system and low-cost and high-performance environmental assessment technology would be presented for consideration to determine to most desirable water management for DKI Jakarta.

5) In addition, it was expected to transfer basic knowledge of the environment simulation technology, the IC water quality technology and the UASB-DHS wastewater treatment technologies through a joint survey with the local higher education institutions and to bring up of Indonesia counterparts (saucer) for promoting water environment improvement project based on these technologies.

3.3. Location of the Survey

The location of the Survey is DKI Jakarta, Republic of Indonesia. A brief overview of the water environment in Jakarta is given as follows.

Neither any major city in Indonesia appears to have a sufficient sewage treatment system, although its extension and improvement are needed according to the progress of urbanization. As the present sewerage coverage in Indonesia is 1.3% and the Ministry of Public Works (PU) aims to increase the coverage in 15 major cities to 20% by 2014. Under these circumstances, these cities are required to promote the introduction, extension or improvement of sewage treatment systems. However, there are difficulties because the local governments are incapable of managing the sewage treatment systems in aspects of the structure and the public finance.

Even in Jakarta, the capital of Indonesia, although PU has carried out feasibility studies for the construction of sewage treatment facilities with the assistance of JICA, the facilities has not yet been introduced. At present PU has a plan to construct a large sewage treatment system (Rp.7 trillion) at Kota Tua, North-West Jakarta.

Indonesia categorizes the sewage in two types, black water (i.e. toilet water) and gray water (any wastewater other than toilet water). While the 90% black water discharged from the 2 million households in Jakarta is processed by septic tanks, only 1% gray water is discharged into a sewage pipeline. The other 80% gray water seeps underground and the remaining is released into the rivers. In addition, the 35 modular sewerage systems with the pipeline are not running effectively due to insufficient maintenance and shortage of fund (according to a staff of PD PAL JAYA). These modular sewage systems have been introduced by the Cleansing Department once. In this way Jakarta's water environment is in a tough situation. The Graduate School of International Development and Cooperation (IDEC), Hiroshima University, Japan measured the water quality of the Ciliwung River at 60 points in Jakarta in April 2009. Most of the measured water was heavily polluted. The 10 water quality monitoring stations along the Ciliwung River in Jakarta was non-functional for the illegal dumping waste into the River.

JICA also conducted the survey on the residents’ attitudes toward the introduction of sewage treatment system in January 2009. The result has revealed many people want to introduce the facilities even if they have to pay sewage charges (according to a staff of PU). In addition, according to a survey to the companies in Jakarta conducted by PD PAL JAYA, which manage wastewater in Jakarta, many companies have their latent demands for reused water. In other words, the residents have incentive to clean environment and the companies have needs for reused water.

PD PAL JAYA is a company founded under national policy along with the construction of a sewage treatment pond in 1991. The Survey team recognizes that PD PAL JAYA is one of the key organizations to improve the water environment through low-cost sewage treatment in Jakarta and the company has a potential capacity to operate the system. The Survey mainly focused on technical aspects but its organizational analysis would be added to the content at later stage.

3.4. Main Organizations Surveyed

Concerning the current state of water environment in the investigation area, the Survey team collected data and information through a number of public organizations, such as BPLHD of DKI Jakarta, PU, PD PAL JAYA, MOE, Bandon Institute of Technology (ITB), and University of Indonesia (UI) and so on.

3.5. Technical Policy of the Survey

Overall goal to be expected from the objective of the Survey is to introduce and disseminate low-cost sewage treatment systems and to build technology of environmental monitoring and assessment in the future.

Keeping in mind the feasibility of the goal, the Survey was conducted under the following directions.

1) First, it aimed to improve the sustainable urban water environment through examining appropriate technologies for developing countries, regarding (1) environmental assessment, (2) water quality analysis system and, (3) low-cost sewage treatment system. Considering the status of water environment and economic and social development in Jakarta, the Survey team implemented the Survey based on the introduction of the specific technologies: (1) environment simulation technology by using parallel computer system, (2) water quality analysis method requiring no reagent, and (3) low-cost sewerage treatment system, respectively. The appropriate technology referred to here is defined as technologies which have ease of technology transfer, low-cost technology in their construction and maintenance and ease of operation and maintenance without compromising the high level of effectiveness and reliability of the latest technology.

2) Second, it was conducted through ensuring the organic linkage among the Survey components, namely, (1) environmental assessment, (2) water quality analysis system and (3) low-cost sewage treatment system. For the proper planning of sewage treatment system, it is essential that the systems of water quality measurement, analysis and assessment are established in the target area. Through the establishment and the spiral-up of the circulation cycle of this system, DKI Jakarta can promote comprehensive improvement of the water environment sustainably, efficiently and effectively. As a result, the Survey was conducted based on building networks between each element.
3) Third, although the Survey was conducted in the DKI Jakarta, the technology surveyed was a flexible system that could be applied to not only large cities like Jakarta but also small local cities. Therefore, it was conducted with a view to disseminating the systems around the country and other Asian cities in the future. According to JICA, Indonesia is considering the development plan for the introduction of large-scale sewage treatment system in DKI Jakarta. The Survey didn’t compete with the above development plan. Instead, it aimed to build a role water environmental model in Jakarta in the future, which will be an appropriate site because of its easy-to-access to the necessary information and facilities to build a model.

3.6. Operational Policy of the Survey

The Survey team consisted of leading experts of the above mentioned respective technologies and each expert has built a human network between academic institutions of higher education in Indonesia, respectively. Therefore, the operational policy of the Survey was to submit a realistic and concrete proposal based on the situation in Indonesia about the feasibility of introducing low-cost sewage treatment facilities and building environmental monitoring and assessment technologies in Jakarta. During the survey, the Survey team stipulated the sharing of data and information collected among local higher education institutions, while seeking technology transfer to them.

A total of six surveyors in group of two conducted the following thee specific surveys:

1) Environmental Assessment group (EA) (comprehensive environmental monitoring and assessment/ prospective analysis of sewage treatment effect) examined the regional environmental simulator to assess the water flow properties and water quality in the Jakarta metropolitan area
2) Water Quality Monitoring group (WQM) (water quality analysis/ environmental monitoring and data transfer technology) reviewed the introduction of low-cost and high-precision water quality measuring technology linking to regional environmental simulator of the Environmental Assessment group
3) Sewage Treatment System group (STS) (sewage treatment system/ low-cost sewage treatment supporting system) investigated the introduction of low-cost sewage treatment system in PD PAL JAYA.

The purpose of the surveys was to accomplish the mission by integrating the findings of each group and sharing the responsibilities as partners within the Survey team shown in Fig. 3.6.1.

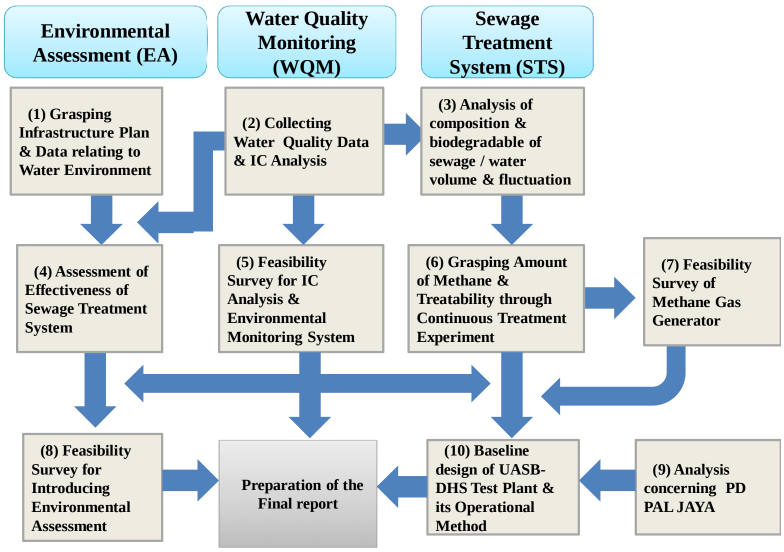

Fig. 3.6.1 Survey flowchart

In addition, as low-cost sewage treatment system could be introduced as a key part of the overall water environment in Jakarta, the experts in charge of the comprehensive environmental monitoring and assessment had the overall responsibility for the final report as the Survey team leader.

3.7. Scope of the Survey

The following survey was implemented in consultation with the Indonesia's counterpart.

1) Collection and analysis of data and information to examine the possibility of introduction of low-cost sewage treatment system (UASB-DHS system) in Jakarta
- Identification of the state of wastewater treatment process in Jakarta
- Data collection related to the introduction of UASB-DHS sewage treatment system in the survey areas
- Analysis of composition and biodegradability of sewage, water volume, and water fluctuation in survey areas
- Baseline design for the introduction of the UASB-DHS test plant

2) Collection and analysis of data and information to examine the possibility of introduction of dry waste gasification and methane gas power generation in order to increase the effectiveness of the above mentioned low-cost sewage treatment system
- Data collection of the daily amount of garbage and analysis of the possibility of dry waste gasification and methane power generation plant combined with UASB-DHS system in the target areas
- Basic concepts for the introduction of dry waste gasification and methane power generation system

3) Collection and analysis of data related to river water, sewage and industrial effluent in Jakarta in order to provide basic information for developing sewage treatment systems, and to build a water quality analysis system which can provide wide-ranging and real-time water quality information on a regular basis

- Collection of water quality data of river, sewage and industrial effluent and identification of current environmental monitoring activities in Jakarta
- Identification of workability and effectiveness of water quality analysis in the survey areas and implementation of experimental water quality analysis
- Identification of the status of environmental monitoring data transfer technology in the survey areas and implementation of data transfer experiment
- Basic plan for building up an environmental monitoring data transfer system

4) Collection and analysis of data and information to build a comprehensive environmental monitoring and assessment technology in order to cope with water environmental problems observed as a complex phenomenon of water system in the region

- Collection of information related to urban infrastructure planning which would affect the water environment in Jakarta
- Collection of information from organization and institution for building environmental monitoring system
- Prospective analysis of sewage treatment effect by running environmental simulator set up at a counterpart institution in Indonesia
- Proposal for building up a comprehensive environmental monitoring and assessment system

4. Findings and Results of the Survey

4.1. Design and Implementation Tests of Water Environmental Assessment System

4.1.1. Comprehensive Environmental Monitoring and Assessment

The Survey team conducted the feasibility survey of introducing a comprehensive environmental assessment technique including the Regional Environment Simulator (RES). The RES was employed for a numerical simulation of the water-quality-improvement effect of low cost sewage treatment system. The validity of this technology was also conducted together with the feasibility survey for 2007 Jakarta flooding.

Moreover, the practical feasibility of the comprehensive environmental assessment technology to be introduced to PU under planning was examined, besides the feasibility of establishing the RES in Bandon Institute of Technology (ITB).

(1) Outline of Environmental Assessment Technology

The feasibility survey of numerical simulation technology with the RES developed in IDEC, Hiroshima University was conducted. The RES is the numerical model system which combined three simulation parts comprising atmosphere-ocean circulation, atmosphere-land surface circulation, and coastal-estuarine circulation. Basic modules of the RES are codes of numerical models established by several top-level research institutions and researchers in the world, and have been used in many research institutions all over the world. In addition, in Indonesia, the same environmental simulator has been developed in the department of meteorology and oceanography of ITB under the support of Hiroshima University, Kyoto University and Kyushu University.

The system configuration of the RES is as follows (see also Fig. 4.1.1):

1) A meso-scale meteorological model, MM5 (developer: Pennsylvania State University, U.S. NCR)

2) Ocean models, MITgcm (developer: Massachusetts Institute of Technology) and POM (developer: Princeton University)

3) Open-ocean wave models, WW3 (developer: NOAA) and a shallow sea wave model, SWAN (developer: Delft Hydraulics)

4) A land surface model, SOLVEG2 (developer: Japan Atomic Energy Agency) and a hydrological model, HSPF (developer: U.S. EPA)

5) An urban air quality model, CMAQ (U.S. EPA)

6) An estuary model, ECOMSED+COSINUS (developer: Hiroshima University) and a coastal ocean circulation model & beach change prediction model (developer: Hiroshima University)

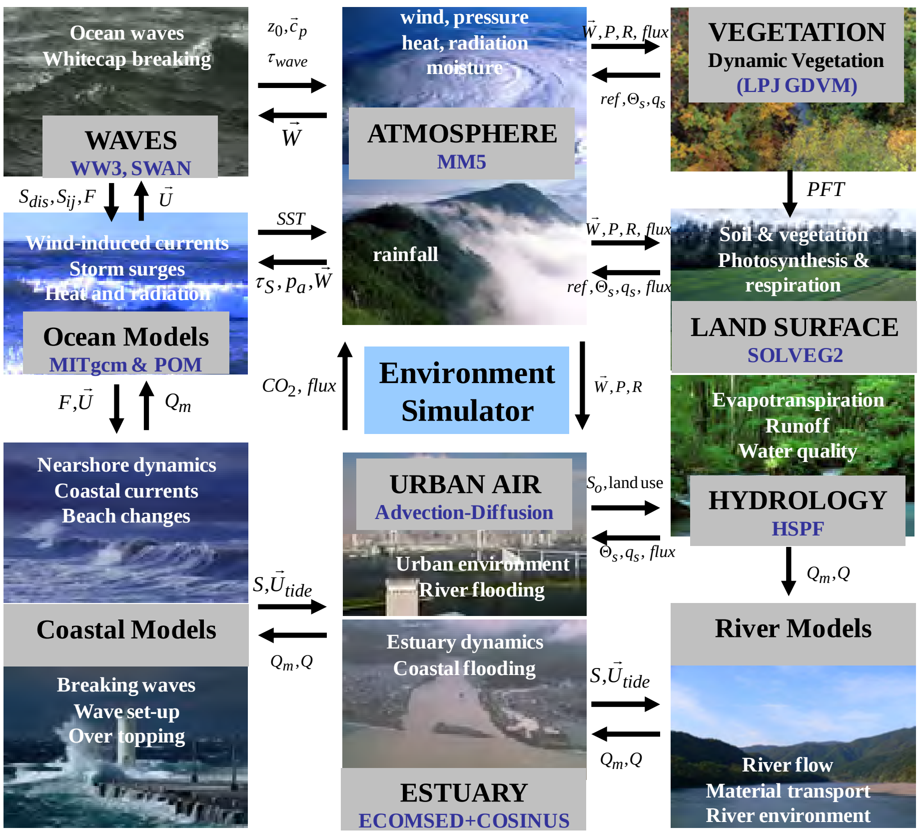

Fig. 4.1.1 System configuration of the RES

These models are adopted as main composition modules in the RES. According to the candidate phenomenon for analysis, the joint composition system is constructed by using the above modules. Moreover, the hardware employed is a High-Performance Linux Cluster (parallel computing environment). The system combines each computational module with Multiple Program Multiple Data (MPMD) model coupler, and it is a system which can be reasonably built even in a developing country.

(2) Investigation of Comprehensive Environmental Assessment Technology

The likelihood of implementing the comprehensive environmental assessment technology planned to be used in PU was investigated alongside with the feasibility of conducting water environment simulation by the RES in ITB.

More specifically, the following tasks were conducted:

1) Water quality monitoring system: Organic water pollution indices (e.g., BOD and COD) and the monitoring data for fundamental water pollution indices (e.g., nutrient, acidity, alkalinity, anion and cation), which are measured by the high-precision water quality analysis technology using Ion-chromatography (IC) technology, were investigated in this survey. The system was designed to concentrate all the monitoring data in PD PAL JAYA.
2) Monitoring water quality data transfer: All the data obtained from automatic and manual measurement were transferred to the water quality monitoring center in PD PAL JAYA through internet circuit and/or mobile system. Data assimilation method in the water quality simulation using the data transfer by internet circuit to ITB to be used in RES through was examined in both likelihood and efficiency.
3) Water-quality analysis using RES: The likelihood of real-time RES analysis upon assimilation of transmitted data was investigated, as well as for the inclusion of the feasibility of a water quality forecasting system.

Moreover, the feasibility of environmental impact assessment to the scenario of water environmental measures was investigated focusing on the hind-casting analysis of water quality assessment by using the data assimilation technique for existing water quality data.

4.1.2. Assessment of Effectiveness of Sewage Treatment

Water environment simulation analysis by the RES was conducted focusing on the effect of Jakarta Bay reclamation on the flooding in Jakarta together with river conveyance. Water environmental impact assessment was carried out to examine the effects of water quality improvement with the Low-cost Sewage Treatment System.

In collaboration with ITB, the environment simulator system which was developed by its Department of Meteorology and Oceanography was enhanced to establish the RES in ITB. The feasibility of the RES in the practical application to the water environmental assessment in Jakarta City was performed in the case of 2007 Jakarta flooding.

(1) The Method of Water Environmental Assessment

By the rapid increase of population and overconcentration of an economic capital, water environmental problems, such as declining water quality in river and coastal sea, groundwater contamination, land subsidence, and frequent occurrence of flood, have been aggravating in the mega city of a developing country that has been developed in estuary of major rivers; of which Jakarta is one of the most typical examples in the world. In reality, four complex issues have contributed to the cause of a flood in Jakarta as follows:

1) Increase of run-off coefficient due to over-logging in the forest and urbanization in a drainage basin together with the outflow of many agricultural chemicals from cultivated land, orchard, and the contaminant from a city region.
2) Reduction of river channel area due to abandonment of household garbage to the river (equivalent to river channel reclamation).
3) Large-scale land subsidence due to groundwater pumping for drinking water and industrial water uses.

4) Reduction of river conveyance due to the reclamation in Jakarta Bay used as a waste disposal place for the city.

In addition to the sea level due to global warming, flood occurred frequently since 2007 by the sea level rise and by approach of the moon's path following an ecliptic route in a cycle of 18.6 years. Furthermore, the flooding in Jakarta was also closely related to water pollution and environmental degradation in the river basin, besides the problem of river management.

In order to solve this problem, it is indispensable to set up the adaptation measures which consider the water environment management in the whole water basin systems from the upper stream to the ocean along a river. To improve the water environment, it is also indispensable to consider an adaptation measure which includes the influence of coastal reclamation, problems of river garbage and sewage treatment.

In this investigation, using the modules in the RES (Hiroshima University), such as a meso-scale meteorological model (MM5), a hydrological model (HSPF), an estuary model (ECOMSED+COSINUS), environmental impact assessment was conducted in the water quality environmental improvement effect of the Low-cost Sewage Treatment System, flooding in Jakarta and reduction of river conveyance that may be caused by the reclamation in the Jakarta Bay.

Calculation conditions were as follows.

1) Region: the Ciliwung River Basin
2) Reproduction of precipitation: Collective analysis of observational data. Rainfall analysis by the meso-scale meteorological model MM5 in which reanalyzed data of global weather simulation was employed as boundary and initial conditions.
3) Hydrological runoff and water-quality analysis: Water quality analyses, such as total phosphorus, total nitrogen, BOD and river discharge in the Ciliwung River basin by hydrological simulation model, HSPF.
4) Water environment analysis in the river mouth and the low-land area of DKI Jakarta: By imposing a downstream boundary condition with tidal change in the Jakarta Bay, and an upper boundary condition with hydrological runoff and water quality analysis, numerical

analysis of river flows, coastal currents, and constituent transport were conducted by estuary model, ECOMSED+COSINUS. The advection and diffusion analysis of pollutant and substances examined the water quality improvement effect by the Low-cost Sewage Treatment System. Moreover, the advection-diffusion computation of river garbage to the Jakarta Bay showed the improvement effect of the water environment by garbage collection in the upper stream

5) Impact assessment of the reclamation in the Jakarta Bay: As shown in Fig. 4.1.2, a large-scale reclamation in the Jakarta Bay has been currently under planning. Environment impact assessment of this reclamation on flooding in the Ciliwung River mouth and coastal community were conducted by ECOMSED+COSINUS.

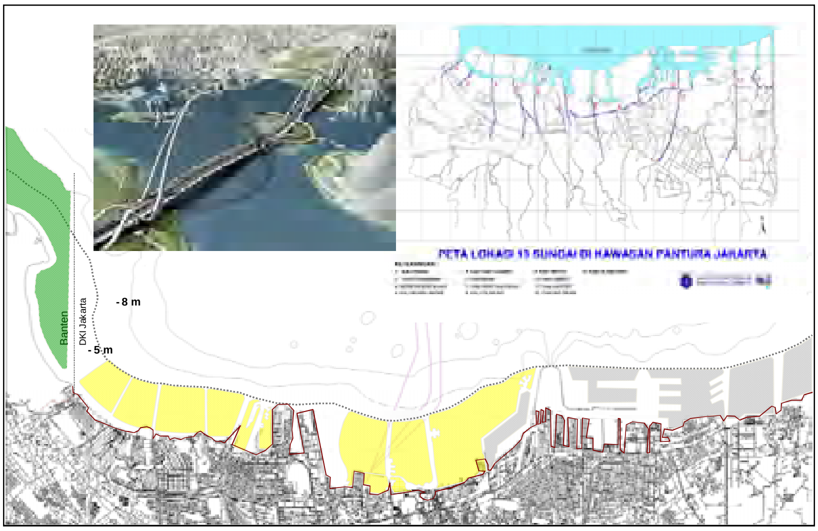

Fig. 4.1.2 Reclamation plan in the Jakarta Bay (from Appendix A)

(2) Feasibility Survey of Practical Use of Environment Simulator, RES

The minimum base element of a parallel computer system (PC cluster) was tentatively introduced in ITB, and the enhancement of the environment simulator which ITB has developed was conducted in the feasibility survey.

Furthermore, the possibility of the organization for management and employment of the environment simulator system (RES in ITB) by ITB and PU collaboration was reviewed. This investigated the validity and practicality of the assessment system of the RES in ITB to evaluate the water-quality-improvement effect by the Low-cost Sewage Treatment System.

(3) Results of the First Field Survey

1) Hardware Purchasing for RES in ITB

On the original plan for purchasing and establishing the computing environment of the RES in PU and ITB, the following 5 items were to be bought in Indonesia.

- Two rack mount servers
- Rack
- Console (KVM) switch
- Ethernet switch
- Monitor

After the first field survey, it was found that Rack, Monitor, and Ethernet switch were already available in Department of Oceanography, ITB and they were ready to use. Regarding the KVM switch, the Survey team decided to purchase a KVM switch in Japan and brought it to Indonesia after investigating the current situation from a number of local distributors and retailers that it was very difficult to find a console switch in Indonesia. Regarding the two servers, the Survey team made a deal with one of local distributor and had them delivered to ITB on 21 May 2010. The details of hardware purchased were as follows:

- DELL PowerEdge R710 (2 units)
- KVM switch (ATEN Japan CS-1716A)

Fig. 4.1.3 depicts the photos of the servers and KVM switch in ITB taken by the Survey team during the third survey (13 June ~ 26 June, 2010).

The deployment of two new servers in PU was later suspended because of network and management problem in the first feasibility survey of this survey project.

2) Computing Environment in ITB

During the third survey (13 June ~ 26 June, 2010), the parallel cluster system was successfully setup and the test for model compilation was satisfactory succeeded without problems. Hardware configuration after the RES setup including the donated servers by this JICA survey project (2 units) and ITB-owned existing servers (8 units) is tabulated in Table 4.1.1. Table 4.1.2 shows the operating system, software installed and numerical models from the RES tested in ITB.

Fig. 4.1.3 Photos showing parallel system in ITB

Table 4.1.1 Hardware specifications of the RES computing servers

Name	Model number	CPU	RAM	HDD	Network Interface Connector	Remark
Compute-1-0	Dell PowerEdge R7610	Intel Xeon Quad-core processor (×2)	16Gb	300Gb × 6 (1.8Tb)	4 embedded GigaBit ethernet	Donated by this JICA survey project
Oseano_itb.org	Dell PowerEdge R7610	Intel Xeon Quad-core processor (×2)	16Gb	300Gb × 6 (1.8Tb)	4 embedded GigaBit ethernet	Donated by this JICA survey project
Compute-0-6	Dell PowerEdge SC1435	AMD Opteron Dual-core processor (×2)	4Gb	16Gb×1	4 embedded GigaBit ethernet	ITB-owned servers
Compute-0-5	Dell PowerEdge SC1435	AMD Opteron Dual-core processor (×2)	4Gb	16Gb × 1	4 embedded GigaBit ethernet	ITB-owned servers
Compute-0-4	Dell PowerEdge SC1435	AMD Opteron Dual-core processor (×2)	4Gb	16Gb × 1	4 embedded GigaBit ethernet	ITB-owned servers
Compute-0-3	Dell PowerEdge SC1435	AMD Opteron Dual-core processor (×2)	4Gb	16Gb × 1	4 embedded GigaBit ethernet	ITB-owned servers
Compute-0-2	Dell PowerEdge SC1435	AMD Opteron Quad-core processor (x2)	4Gb	16Gb × 1	4 embedded GigaBit ethernet	ITB-owned servers
Compute-0-1	Dell PowerEdge SC1435	AMD Opteron Quad-core processor (×2)	4Gb	16Gb × 1	4 embedded GigaBit ethernet	ITB-owned servers
Compute-0-0	Dell PowerEdge SC2970	AMD Opteron Quad-core processor (×2)	4Gb	16Gb × 1 + 300Gb × 5	4 embedded GigaBit ethernet	ITB-owned servers
Oseano.itb.org	Dell PowerEdge SC2970	AMD Opteron Quad-core processor (×2)	4Gb	16Gb × 1 + 300Gb× 2	4 embedded GigaBit ethernet	ITB-owned servers

Source: drawn up by the Survey team

Table 4.1.2 Operating system, software installed and numerical models tested

Name	OS and Software	Numerical models from RES (Test completed)
Oseano.itb.org	Rocks Cluster v4.3 (CentOS 4.3) Intel Fortran and C, C++ compilers NetCDF 4.0 GMT4.3 GrADS2.0.a8 FERRET v6.0 MPICH1.2.7, OpenMPI and so on	MM5 SWAN POM MITgcm WW3 ECOMSED
Oseano_itb.org	Rocks Cluster v4.3 (CentOS 4.3) Intel Fortran and C, C++ compilers NetCDF 4.0 GMT4.3 GrADS2.0.a8 FERRET v6.0 MPICH1.2.7, OpenMPI and so on	MM5 SWAN POM MITgcm WW3 ECOMSED

Source: drawn up by the Survey team

3) RES Manual for ITB

A user's manual of the RES (totaling 63 pages) for ITB system was prepared and transferred to ITB members on 23 July 2010. The manual contains the theoretical background of the RES and the practical usage of the RES on the Oseano.itb.org system (Fig. 4.1.3) for modeling which includes the connection and data transfer from local users, and the detailed step-by-step instructions on how to compile and run the models on the system. Fig. 4.1.4 displays the conceptual diagram of the ITB system. Fig. 4.1.5 shows the cover page of the user's manual for the RES.

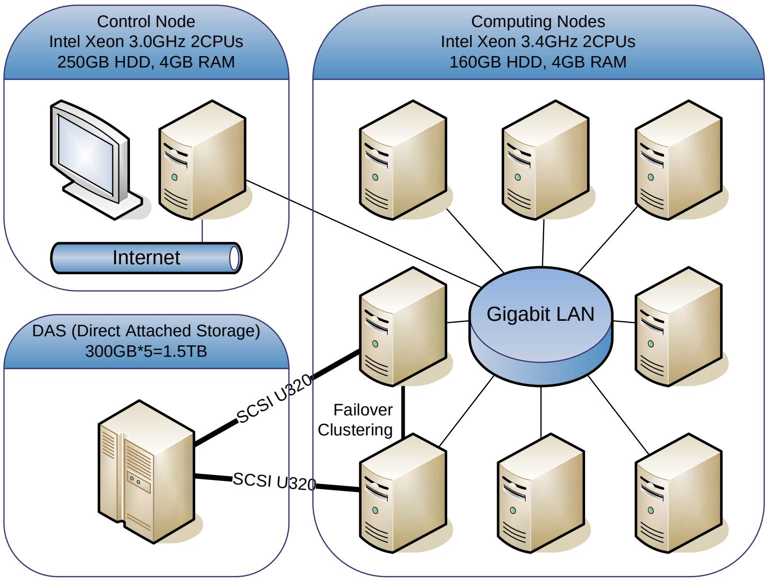

Fig. 4.1.4 Schematic diagram of the present computing environment in ITB

Oseanographi.itb.org system

(High Performance Cluster)

- User's Manual -

Graduate School for International Development and Cooperation,
Hiroshima University,
and
Department of Oseanographi, Faculty of Earth Sciences and Technology,
Institute Technologi Bandung (ITB)

Han Soo Lee
and
Totok Suprijo

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Fig. 4.1.5 Cover page of the user's manual for ITB RES

4.1.3. Implementation Test of Environmental Impact Assessment

(1) ITB RES Calibration: 2007 Jakarta Flood

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. Details of the 2007 Jakarta flooding are as follows:

1) Brief Description of the Major Flooding

The 2007 Jakarta floods hit Jakarta and surrounding areas for about one week commencing from the night of February 1, 2007. In addition to poor drainage systems, flooding from heavy rainfall lasted for two day from the afternoon on February 1, with additional water discharge from 13 rivers (originating from Jakarta, Bogor-Puncak-Cianjur), and adverse sea level at high tide, resulted in nearly 60% of the Jakarta area being inundated with water depth reaching up to 5 m at some locations.

Records at the 11 rain observation posts of Meteorology and Geophysics Agency (BMG) revealed the rain that occurred on Friday, February 2, 2007, reached an average of 235 mm/ hr, while the highest record at Pondok Betung station was 340 mm/ hr. Average rainfall in Jakarta that reached 235 mm was comparable with the 100-year return period rainfall events with a probability of 20%.

The flood in 2007 affected broader area and more human casualties than similar disasters that struck in 2002 and 1996. At least 80 people were declared dead in the first 10 days due to drift, electric shock, or illness. Material losses due to interruption of the business turnover were estimated as Rp. 4.3 trillion. Until February 7, 2007, 320,000 residents fled the flooded area.

2) Main Cause

The main cause of this flood was the high rainfall in the rainy season in Indonesia, which start from December and ended in March. In 2007, rainfall intensity reached its peak in February, with the greatest intensity at the end of the month.

3) Anticipation (Jakarta Flood Control System)

To handle future floods, local government of DKI Jakarta has built a series of Flood Control System. A brief summary of the System of Flood Control and Drainage Area Jakarta until 2010 is given in Table 4.1.3.

Table 4.1.3 Jakarta flood control system initiated by the 2007 Jakarta flood

Jakarta Flood Control System						
North Jakarta	West Jakarta	Central Jakarta	South Jakarta	East Jakarta	Macro Chanel System	Flood Canal
*Sunter Timur I *Sunter Timur II *Kelapa Gading *Sunter Barat *Sunter Selatan * Ademangan * Jembatan V * Teluk Gong *Angka Bawah	* Jelambar * Grogol * Pinangsia * Jati Pulo *Kali Sekretaris * S.P.Barat	*Sawah Besar * Sumur Batu *Cideng Bawah	* Kali Grogol Atas * Duren Tiga *Pondok Karya * Sangrila	*Duren Sawit * Cipinang	1.Kali Mookevart 2. Kali Angke 3.Kali Pesanggrahan 4. Kali Grogol 5. Kali Krukut 6. Kali Baru (Pasar Minggu) 7.Kali Ciliwung 8. Kali Baru Timur 9.Kali Cipinang 10. Kali Sunter 11. Kali Buara	1. Banjir Kanal Barat 2. Banjir Kanal Timur

Source: DINAS PU, DKI Jakarta

4) Flood Locations

Jakarta Governor Sutiyoso noted that some areas of West Jakarta around Kali Angke reached to alert status due to high water of 3.75 m from the threshold of 3 m. Other regions with the water level lower than the threshold value were classified as in standby status.

Traffic congestion due to floods also occurred in the area of Jl. DI Panjaitan, Cipinang, East Jakarta. Motorbikes that could not pass, changed its course through the toll road on higher elevation.

Heavy rain also caused the collapse of flood levee at West Flood Canal (BKB) exactly in the flow of Kali Sunter. Water flooded the offices and residential areas. BKB dike collapsed in early Friday morning, while BKB dike in Kali Sunter collapsed in that afternoon. Due to the collapse of both dikes, the Jatibaru-Tanah Abang and Petamburan area was inundated with water up to as high as 2 m. Evacuation of residents in Petamburan met some difficulties because many settlements located between the narrow hallways, not even fit to pass the raft.

Vehicles could not pass Jl. Besar Kampung Melayu in East Jakarta and the residents used the carts to transport the drivers and motorbikes. Most of the North Jakarta, from Marunda, Rorotan, Koja, Kelapa Gading, to the west (i.e., Sunter, Tanjung Priok, Pademangan, Angke, Pluit, and Kapok) were also inundated. The water depth varied, from 30 cm to 1 m.

In Jl. Raya Kembangan, West Jakarta flood level was up to the knee-high of an adult. Usually, daily traffic jams occurred in the street, but at that time, it was extremely quiet and dark at night. Only vehicles with big wheels, carts and cart pulled by a horse could pass through the area. Electric power experienced an outage over three days. Flood water receded on day after.

5) Victims

Up to February 8, 2007, according to data of Jakarta-Metro Police Office, death toll from this flooding in Jakarta, Depok, Tangerang, and Bekasi reached 48, and in Bogo alone was as high as 7.

On February 9, 2007, total death toll increased to 66 in three provinces, namely Jakarta, West Java and Banten, according to Antara News Agency: National Coordination Agency for Disaster Management (Bakornas PB).

On February 10 the final casualty account rose to 80, comprising 48 in DKI Jakarta, 19 in West Java, and 13 in Bantam.

6) The Impact and Losses

All activities in the inundated areas were disrupted. Telephone and internet networks were also disrupted. Electricity in some areas was also cut.

Ten thousands of people in Jakarta and surrounding areas were forced to flee to the nearby regions. Some others until Friday February 2 evening still trapped inside their houses flooded up to around 2-3 m. They could not get out saving themselves because the boat rescue teams were no avail.

Within cities, traffic congestion occurred in many locations, including the Toll Road Town. Puddles in the road up to 1 m more also affected a number of accesses from surrounding areas.

Flood flows that grinded the streets of Jakarta caused various damages and aggravated congestion. It was estimated that as many as 82,150 m^2 of the roads damaged in Jakarta could be classified as mild to severe, ranging from small holes to stripping of asphalt and large deep holes. The most severe damage occurred in West Jakarta, where the surface area of the damaged roads reached 22,650 m^2, followed by 22,520 m^2 in North Jakarta, 16,670 m^2 in Central Jakarta, and 11,090 m^2 in East Jakarta. The least road damage was experienced in the East Jakarta, with 9,220 m^2. The total budget to rehabilitate the damaged road was estimated at Rp. 12 billion.

Floods also paralyzed some railroad system. Railway crossing leading to Tanah Abang Station was not approachable because the rail lines around the station were inundated by river overflow approximately 50 cm.

Around 1,500 homes in East Jakarta were swept away or damaged. The worst damage was found in the District of Jatinegara and Cakung. The statistics figures Kampung Melayu (72 houses), Bidaracina (5), Kambang Bale (15), Cawang (14), and Cililitan (5), Pasar Rebo damaged (14), Makassar (49), Kampung Melayu (681), Bidaracina (16), South Great Cipinang (50), Northern Great Cipinang (3), Bale Kambang (42), Cawang (51), Cililitan (10), and Cakung (485).

Losses in Bekasi were estimated as high as Rp. 551 billion. The biggest loss was the destruction to buildings, both private houses and government offices. A total of 98 km of road was damaged, while at least 7,400 ha of paddy fields were devastated.

7) Diseases

After the flood, some people were infected by respiratory tract infections, diarrhea and skin diseases, especially in refugee camps. This might be caused by weather conditions and poor sanitation. Several cases of dengue fever and leptospirosis were also found resulting from pollution from the inundated water.

8) Post-disaster

Until nearly a week after the flood, 14 February 2007, 20 traffic lights throughout DKI Jakarta remained malfunction, which disrupted the traffic in some areas and caused traffic congestion. In Central Jakarta traffic at several intersections were not guided by traffic lights. In the area of Roxy, for example, malfunction in traffic lights caused severe traffic congestion throughout the morning until late afternoon. A similar situation had appeared in Kramat Bunder area.

9) Garbage

After the floods being receded, the volume of waste that had to be handled increased. The garbage carried down by river stream doubled from 300 m^3 to 600 m^3 per day until February 8. They comprised construction debris, woods and furnitures. In addition, the number of garbage sent to the Bantargebang final disposal site (TPA), Bekasi, was also increasing. Until February 15 additional garbage due to the flood was estimated at 1,500 tons per day.

10) Further Flood

Heavy rain since Tuesday morning of February 13, 2007, in Jakarta, Depok and southern parts caused a new flooding to some flooded houses and residents who had just dried their household items from the previous week's was once exposed to the new flood. Kali Krukut rain caused damage across the region and Petogogan Kemang, South Jakarta was overflowed again.

Widespread flood inundated homes and residents in the township to the depth of an averaged adult’s knee. The areas with low contour near the river were also inundated. In Kemang area and Kelurahan Bangka, water flooded hundreds of houses around the back row of the elite café area in Jalan Kemang Raya. In the area near Kali Krukut, water had flooded into many houses to the depth of an adult’s calf. Major flooding in the previous week caused inundation of this village up to the height of 2 m.

Similar flooding happened again the resident in Pondok Payung Mas, Village Cipayung, Ciputat district, Tangerang, and Banten.

The rain which fell on Saturday, February 17 led to as many as 2,761 people in Jakarta from 612 families being forced to seek refuge again due to the new inundation, which occurred in several settlements in Pancoran, Kebayoran Baru, Jatinegara, and Kramat Jati. Water level surged as high as 40 to120 cm.

11) Other affected Areas

(a) Karawang

Floods caused by overflowing of the Citarum River occurred in early February 2007 to 17,000 ha of paddy field in Karawang regency, West Java. Losses were estimated as US$ 1.7 billion approximately. Floods that inundated 25 out of the 30 districts in Karawang worsened due to the collapse of the Citarum River Levee in Kaceot I and II, Tangkil, as well as North Tarung parent channel. Until February 10, there were five districts that were still considered vulnerable to flooding, namely Pakisjaya, Batujaya, Rengasdengklok, Jayakerta, and Tirtajaya. The Ministry of Agriculture, Forestry and Plantation noted that rice fields in 22 districts within Karawang regency were inundated with water depth varying between 20 and 70 cm.

(b) Subang and Indramayu

Flooding lasted in nearly a week to many paddy fields and settlement areas in Subang and Indramayu in the northern coastal area of West Java. At least 18,488 ha of paddy fields were affected. Based on observations in Subang Regency, the most extensive damage occurred in the District of Pamanukan (2,101 ha), Pusakanegara (1,275.5 ha), and Legon Kulon (2,792 ha), while floods also destroyed paddy fields in Kandanghaur District, Indramayu.

12) Some Comments from the Authorities

Jakarta Governor Sutiyoso responded to criticism by saying that this flood was a natural phenomenon, and was a five-yearly flood. Sutiyoso indicated that the government was trying its best to handle the maximum flood. The previous major floods occurred in 1996 and 2002, implying an interval of re-occurrence about six years.

Mr. Aburizal Bakrie, Coordinating Minister for People's Welfare had commented that the flood victims "are still able to laugh" and the flood event were simply exaggerated by the media "as if the world would end". So, he was later criticized by victims and members of the parliament. Yet the fact in the field showed that many flood victims could not even comment on the result of the stress and poor living conditions in the refuge.

(2) ITB RES Calibration: Modeling of 2007 Jakarta Flooding

1) Model Set-up

Domain set-up: 3 domains for MM3 and SWAN, 1 domain (corresponding to Domain 3 in Fig. 4.6.1) for POM.

Simulation period: 20 January - 10 February 2007 (20 days) including the Jakarta flooding period from February 1to 2, 2007.

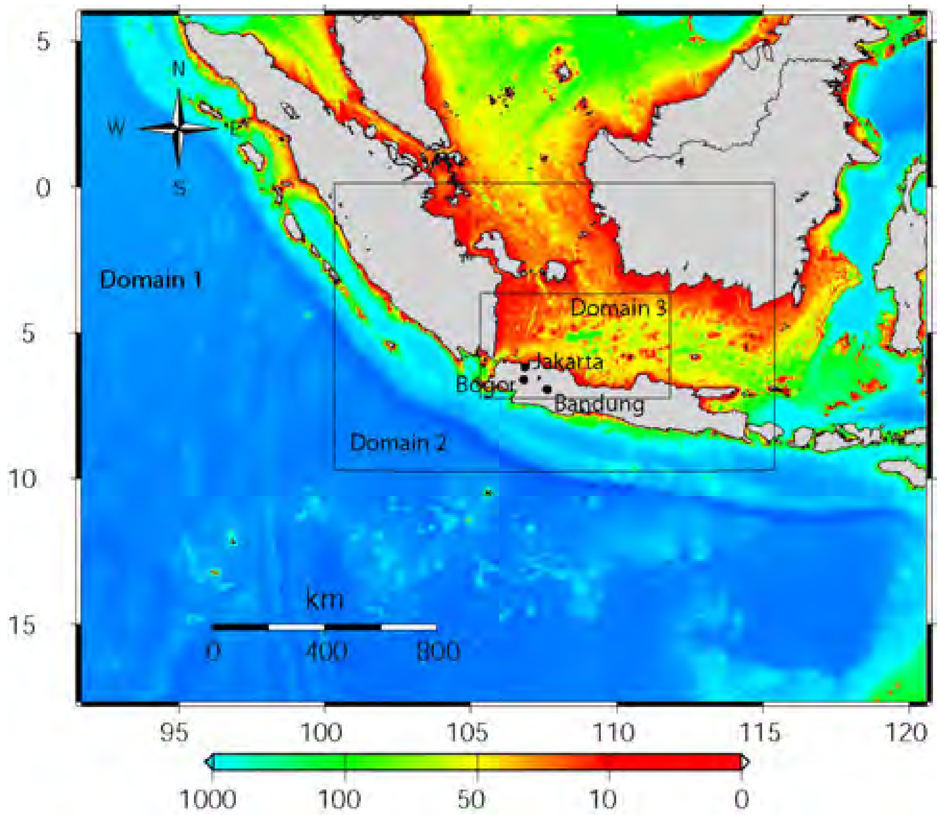


Fig. 4.1.6 Domain set-up for MM5, SWAN, and POM simulations with bathymetry

MM5: Background data from NCEP FNL data with FDDA applied for Domain 1.

SWAN: Bathymetry from GEBCO 30 arc-sec data, with external forcing of wind velocity from the MM5 results.

POM: Bathymetry also from GEBCO 30 arc-sec data with external forcing of wind and pressure fields from MM5 results. Tidal open boundary for 8 constituents is from NAO99.

2) Results

MM5: The MM5 results show that there was strong convergence zone along the Java Island during the flooding period which brought the heavy rainfall around Jakarta and over the Java Sea (see Figs. 4.1.7 and 4.1.8 for the calculated wind velocities and accumulated rainfall during the 2007 Jakarta flood by MM5).

SWAN: Due to the strong convergence in wind fields, the wave fields near Jakarta in Java Sea were abnormally high. Fig. 4.1.9 shows the distribution of calculated maximum significant wave height during the simulation period.

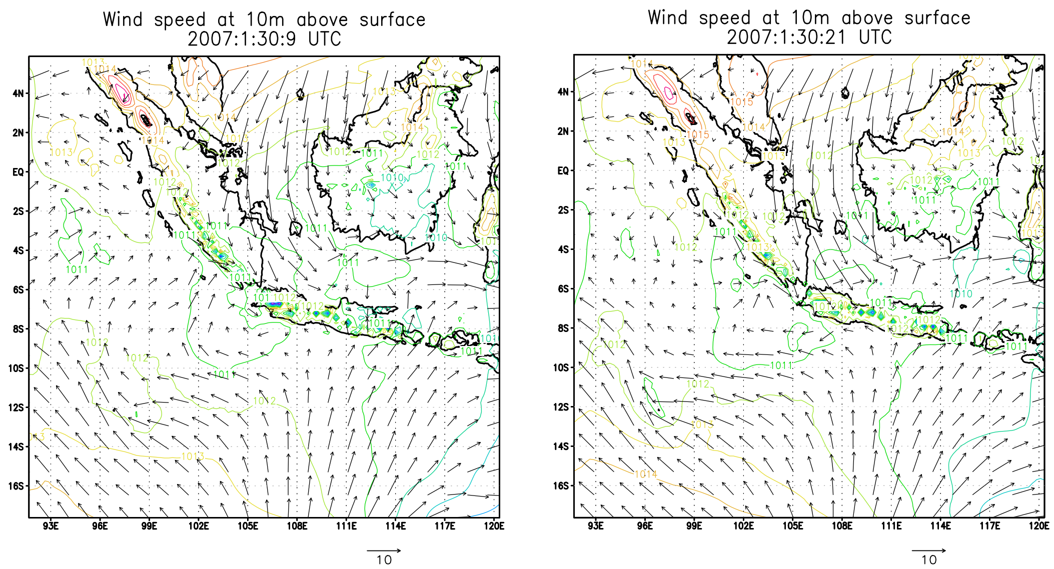


Fig. 4.1.7 Snapshots of atmospheric fields around the 2007 Jakarta flooding period

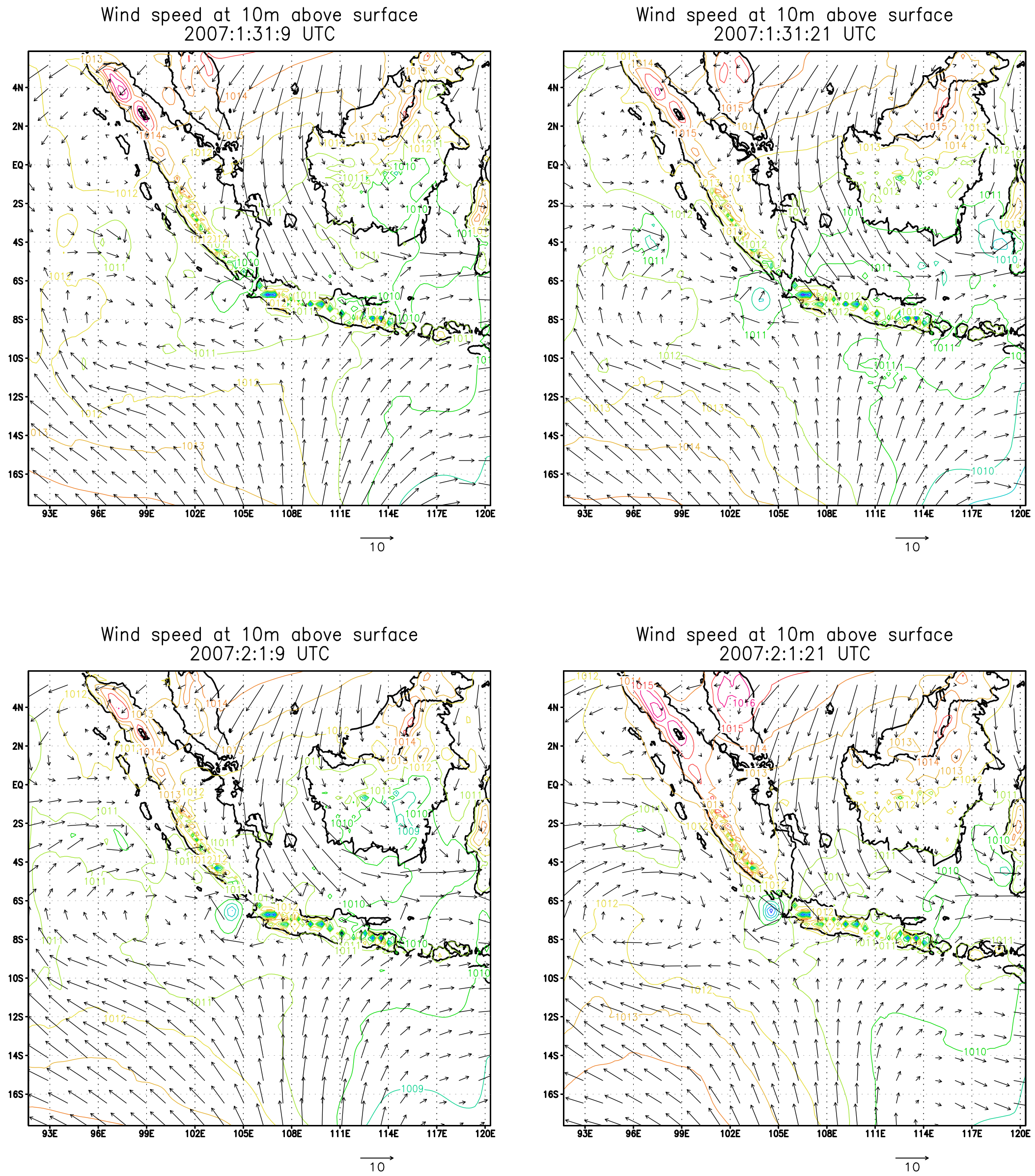


Fig. 4.1.7 Snapshots of atmospheric fields around the 2007 Jakarta flooding period (Continued)

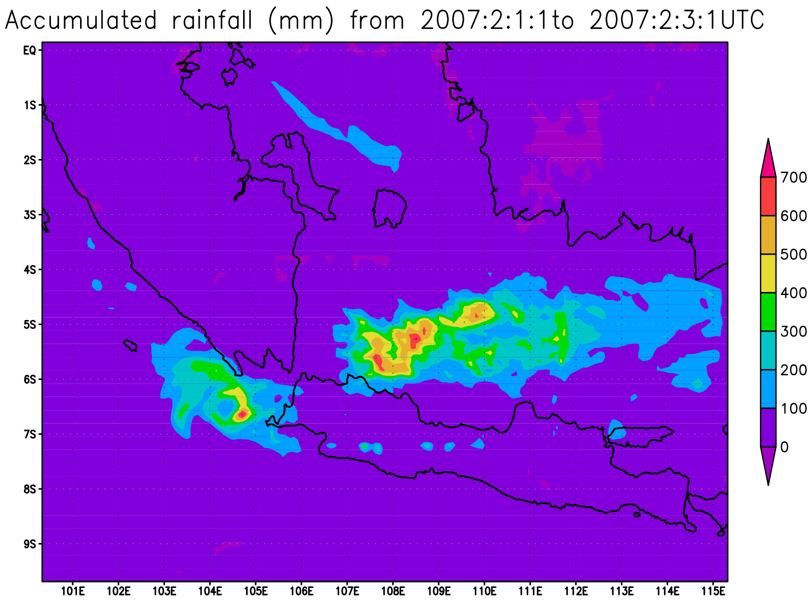


Fig. 4.1.8 Accumulated rainfall during 2007 Jakarta flood (01:00 1 to 01:00 3 Feb 2007)

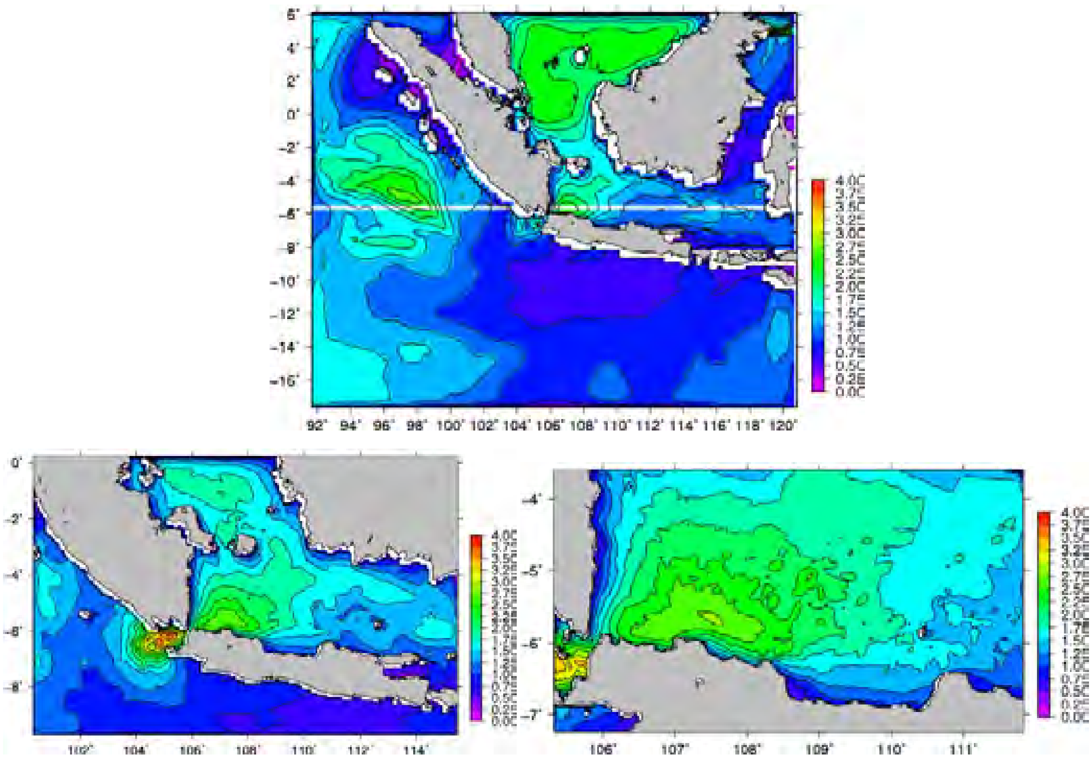


Fig. 4.1.9 Spatial distributions of the maximum significant wave height (H_{sig})

in domains 1, 2, and 3

4.2. Water Environmental Changes in the Ciliwung River Basin

There are many coastal areas being infected by sulphide sediments throughout the world, and some can be found in the Asia-Pacific region. These acid soils are still being formed in mangrove forests and salt marshes, estuarine and tidal lagoons which accompanying the tropical wetland and peatland. Mangroves have a fair tolerance to sulphide sediment condition. Peat formation in the tropics starts on the inland side of mangrove when the fine sediments get the trapped into tangled mangrove roots. As the coastline withdraws from the sea, new organic deposits become less frequently inundated by salty tidal water. Anaerobic conditions and high sodium sulphide concentration restrict development of decomposing bacteria and slow organic matter decomposition, and peat starts to accumulate.

However, when disturbed and exposed to oxygen through drainage or excavation, these soils produce sulphuric acid and thiosulphate. The soils in which these processes are active are defined as actual acid sulphate soils. The acids so formed can be partially neutralized by neutralizing bacteria and appropriate chemical environment in the soil component while the rest can leach and cause severe acidification in drainage water. The acid attacks clay particles and causes the dissolution of structural aluminium, iron, manganese, and other heavy metals which become available to biota in potentially toxic quantities in soil solution. Combined acidification and toxic elements could cause ecologically and economically enormous losses to vegetation and aquatic life.

Furthermore this process may trigger a land surface subsidence because of oxidation of peat inside the land mass on a land development projects. Subsurface water pumping in the peat land causes the watertable deepening and peat oxidization starts resulting in a land subsidence. One of the largest single development projects in South East Asia has been the Million-Hectare Mega Rice Project (MRP), an ambitious attempt aiming to convert massive tropical peat land area into rice fields in Central Kalimantan. The MRP had run between 1995- 1999, and it was stopped because continuous rice cultivation proved to be impossible in 90% of the planned work area. At present the ex-MRP affected area covering about 1.5 Mha is almost a treeless and non-productive wound in vast peat-covered landscape; a legacy of over 4,600 km long network of malfunctioning drainage- and irrigation canals, rapidly oxidizing peat, and an endangered terrain susceptible to outbreaks of large-scale fires.

Jakarta located in low-lying alluvial fans formed with enormous sediment supplied by rivers flowing from the surrounding southern mountains. In the river mouth of the Cisadane and Citarum Rivers, west and east part of the Jakarta Bay, there were mangrove forests and tropical peat land. These mangrove forests have been developed since 1980 to 1995 on the course of the rapid sprawling of the metropolis, Jakarta (Fig. 4.2.1). These once mangrove area is vulnerable to land subsidence following the development and groundwater uptake for drinking and industrial uses.

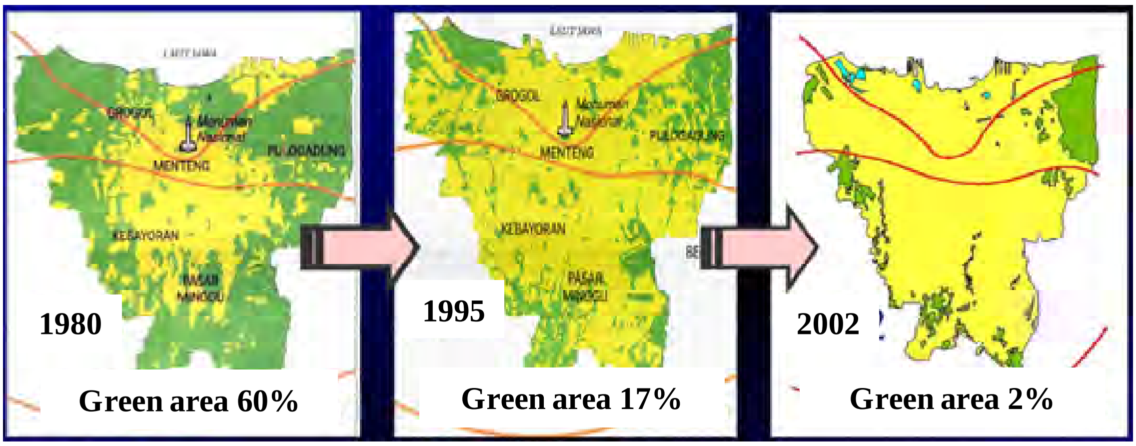


Fig. 4.2.1 Green area reduction by city development and land use change

4.2.1. Causes of Flood in DKI Jakarta

Jakarta has so far experienced quite frequent massive river floods in 1976, 1996, 1998, 2002 in addition to the flood in 2007 which was caused by excessive river flow and enhanced ocean tides by lunar nutation of which period is 18.6 years. The next highest tidal constituent of lunar nutation mode is expected in December 2025. Especially in February 2002, about 13% of

Jakarta Special Province was inundated as shown in Fig. 4.2.2 that showed about 10,000 ha or 100 km^2 were flooded on February 4, 2002, which was 1/6 of Jakarta-city area (in total 661 km^2).

The Indonesian Government considers the major causes of the flood in JABODETABEC are as follows and these reasons leave nothing to be desired.

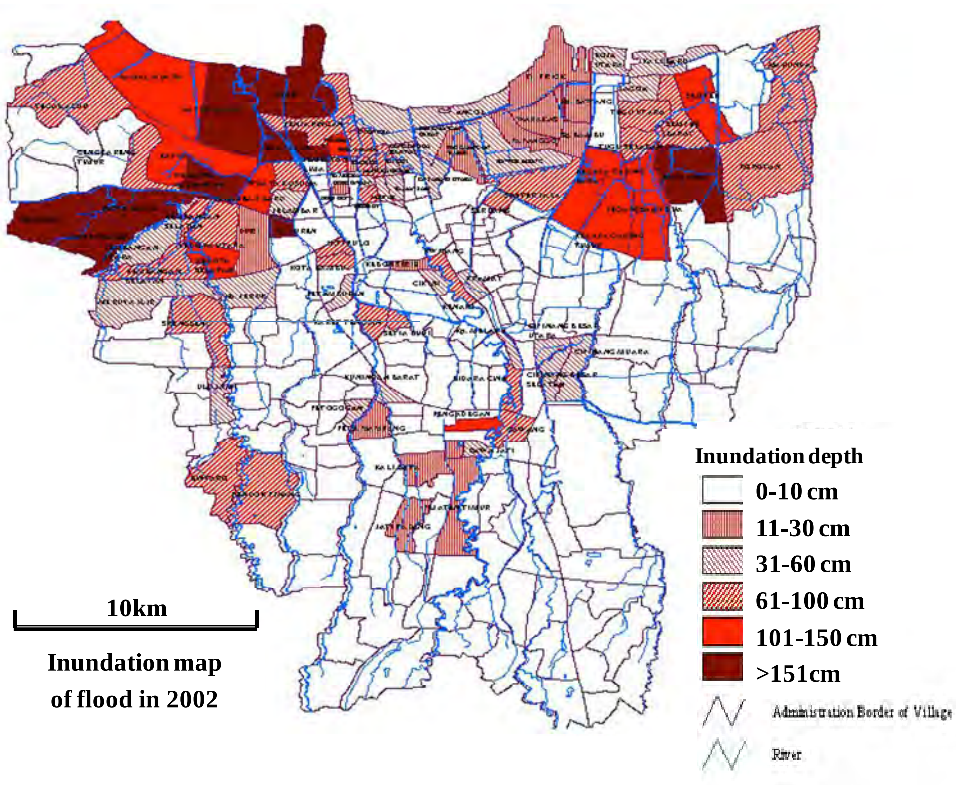


Fig. 4.2.2 Inundation map in DKI Jakarta caused by flood in 2002

(1) Loss of Natural Flood Reduction Functions of Land Use Practices

The run-off coefficient becomes nearly unity in the Ciliwung River basin. Based on analysis using satellite imagery (Fig. 4.2.1), the green area was about 60% of the total area of DKI

Jakarta in 1980, 17% in 1995 and shrunk dramatically to about 2% in 2002 in urban areas. This rapid land use change was caused by rapid and escalating economic development in Jakarta.

(2) Encroachment of River Bank by Man and Structures

All 13 rivers flowing into the Jakarta Bay (Fig. 4.2.3) have been narrowed more and more with the sprawling of illegal housing on the river surface or reclaimed area with garbage dumped into the river as shown in Fig. 4.2.4. The width of major floodway has been gradually encroached and narrowed; as a consequence, the river water level becomes higher and higher. This encroachment cause is conspicuous in the downstream area of the river system. To make the matter worse, the large amount of floating garbage from the upper stream, Bogor, accelerates this cause together with deterioration of river water quality.

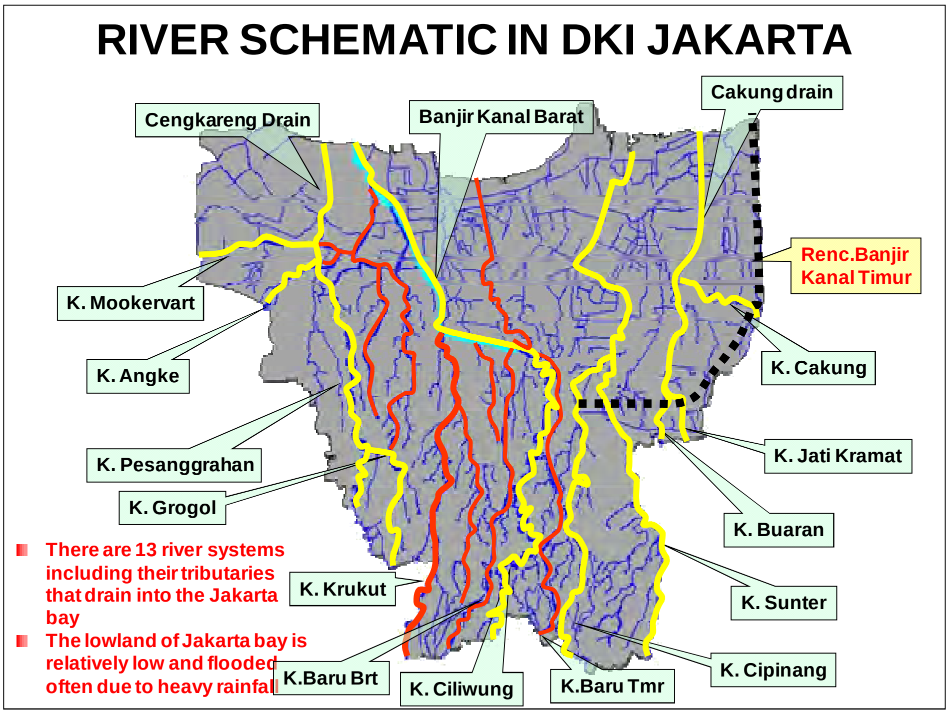


Fig. 4.2.3 Major 13 Rivers flowing into the Jakarta Bay

Fig. 4.2.4 Houses built on the river (from Appendix A)

(3) Sedimentation of River Outlet

All river outlets to the sea (river mouth or estuary) have been silted up because the flow velocity is very low. And, occasionally, the river flow direction reversed towards upstream, due to the occurrence of ocean waves, wave/wind–induced currents and tidal motion. Sand and flock of silt/clay deposit onto the river bottom resulting in the river bed rise and formation of tidal flat in the estuary (Fig. 4.2.5).

Fig. 4.2.5 Sedimentation at river outlet

(4) Dumping of Solid Waste into the Rivers

Solid waste is accumulated on river banks (Fig. 4.2.6 from Appendix A). When water overtops, all solid waste is washed into the river and becomes floating. Debris, heavy metal parts, and broken glass pieces remain on the river bed. Dumped solid waste into river is expected to be 10% of total solid waste estimating about 21,000 - 24,000 m^3/day. This vast amount of solid wastes is thrown into the river every day as a bed material of the river with consequence of becoming another cause of river bed rise. To reduce this effect, DINAS PU, DKI Jakarta (the Public Work Department of DKI Jakarta) has embarked an expensive river bottom dredging project for flood control in Jakarta. The 13 rivers are now shallow because of sediment laid down during the past 30 years' neglect of dredging. In 2009, the administration dredged and revitalized 13 major rivers, the dredging project was funded by US$150 million World Bank loan and is expected to complete in 2012.

Fig. 4.2.6 Dumping of solid waste into the rivers

(5) Clogging of City Main Drains

Due to poor operation and management, solid waste and sediments have been accumulated in the city main drains in Jakarta over the years (Fig. 4.2.7 from Appendix A). When the January/February rain storms came, these main drains could not conveyed the storm waters. Consequently, streets and houses were flooded.

Fig. 4.2.7 Clogging of city main drain (from Appendix A)

(6) Land Subsidence in Alluvial Soil and Former Mangrove Forest

Land subsidence is continuing as long as groundwater is extracted. This has worsened the flood risks particularly in many venerable areas.

Verstappen's study on the geological condition and the formation of Jakarta Bay pointed out that the alluvial plain bordering Jakarta Bay began to develop about 5,000 years ago. Fluvial deposition was helped by sediment carried by rivers discharging into the bay. Main causes of land subsidence are groundwater extraction and natural consolidation of alluvial soil.

The other form of land subsidence near the coast, former mangrove forest, becomes very serious after the development in the west regions of Jakarta. On the process of rapid sprawling of Jakarta Metropolis around 1980-1995 (Fig. 4.2.1), the mangrove forests of the Cisadane River mouth have been developed resulting in severe land subsidence of over 12 cm/year (Fig. 4.2.8). Abidin et al (2008) investigated the spatial and temporal variations of subsidence in the Jakarta region from 1982 to 2007 and found out the average subsidence rates were about 1 to 15 cm/year. Several locations where were once mangrove forest had subsidence rates between 20-25 cm/year (Fig.4.2.8). The original paper by Abidin et al (2008) is included in Appendix-4.3.

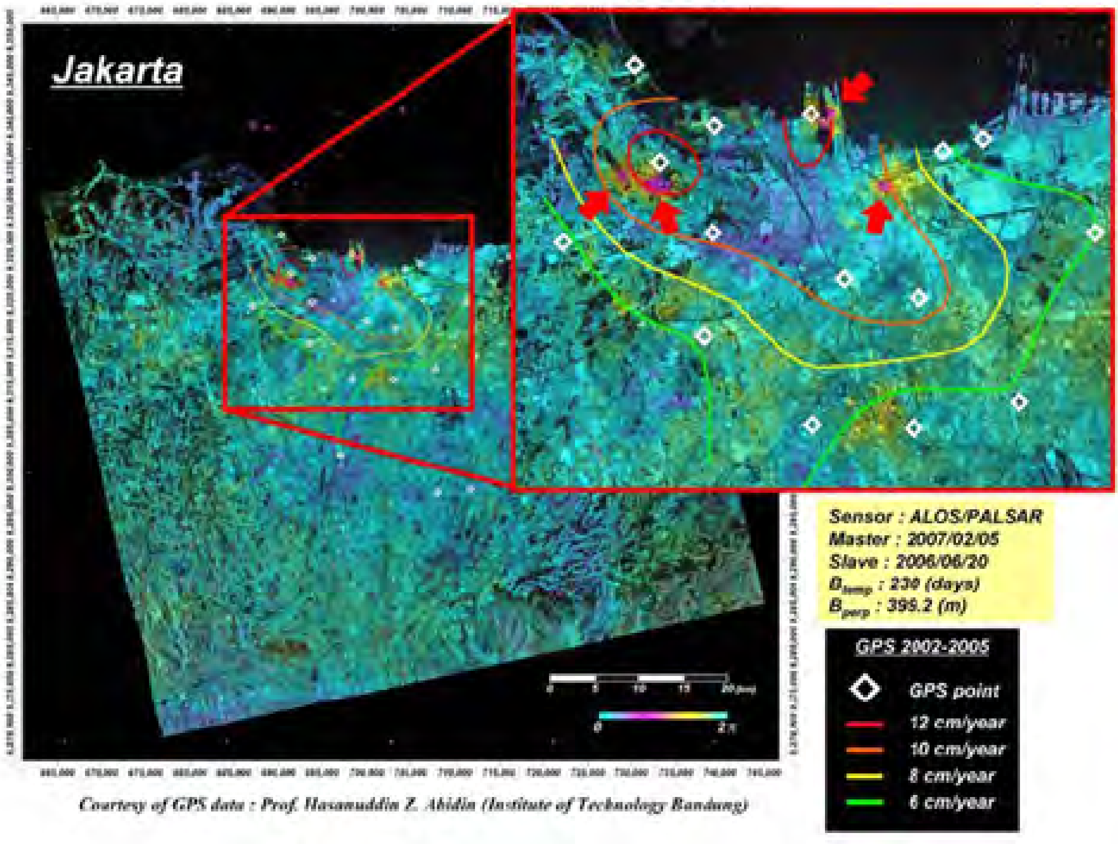


Fig. 4.2.8 Contour map of land subsidence using satellite imagery and GPS data

4.2.2. Flood Control Measures in DKI Jakarta

The drainage system in Jakarta consists of a comprehensive network of rivers, main drains, local drains, canals, retention basins, polders, flood gates, regulating gates, siphons, and pumping stations, which together regulate the discharge and retention of rainwater in relation to the Jakarta Bay. About 40% of Jakarta sits in low-lying areas and is therefore subject to floods during high tides. The city also has 13 rivers running through it from surrounding administrative areas such as Bogor, Depok and Bekasi in West Java, and Tangerang in Banten (Fig. 4.2.3). New construction of the East Flood Canal and the revitalization of the West Flood Canal, and dredging the rivers and lakes are the current effective but expensive flood control measures in DKI Jakarta (Fig. 4.2.9).

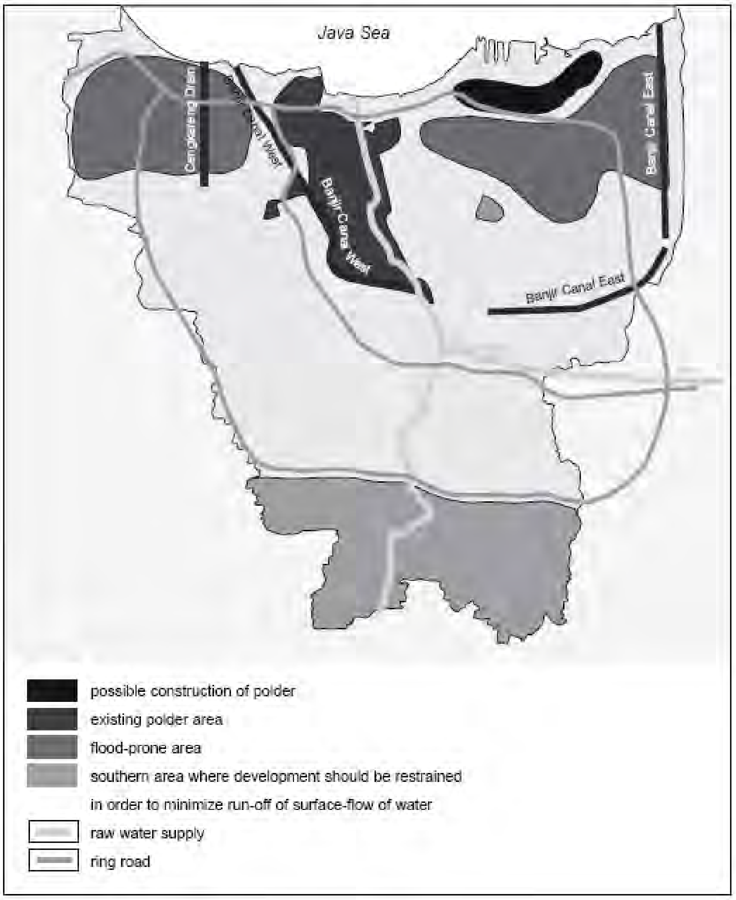


Fig. 4.2.9 West Canal and East Canal for flood control and drainage plan

The East Flood Canal, ultimately to be 23.5 km long and between 100 m and 300 m wide, will function as a shortcut to direct the flood water from six major rivers that run through Greater Jakarta - Cipinang, Sunter, Buaran, Jatikramat, Cakung and Blencong to the sea. The project, which is designed to provide relief for a 270 km^2 flood-prone area in East and North Jakarta, has been hampered since 2001 by land acquisition problems. The canal, with total cost estimated at Rp. 4.9 trillion (US$ 405 million) and original target of completion in 2007 is now scheduled to complete in 2011. The original target was 2007. The Ciliwung-Cisadane Flood Bureau is also working on expanding the 88-year-old West Flood Canal from its current capacity of less than 400 m^3 up to 800 m^3 by building up the concrete banks and dredging its bottom. The west canal stretches 17 km from Manggarai in South Jakarta to Pantai Indah Kapuk in North Jakarta. Twenty-one lakes and 11 rivers in the Greater Jakarta area were also dredged this year, including Ciliwung, Pesanggrahan, Mookervart, Angke, Cisadane, Bekasi, Cikeas, Cileungsi, Cirarat and Tengah. Targeted for the dredging project are 12 canals and rivers, with length ranging from 467 m to 3,533 m.

(1) West Flood Canal (BKB) Construction

The West Flood Canal System Basin (421 km^2, 17 km length) was built in 1918 and collects floodwater from the Ciliwung and Krukut Rivers. It also receives water from the Cideng and Angke Drains. In Central Jakarta, at the Manggarai flood gate, the Ciliwung River splits, partly discharging into the West Flood Canal and partly continuing in multiple smaller drains and flowing into the Jakarta Bay. The Krukut joins the West Flood Canal at the Karet Weir. In 2002 large improvement works were undertaken for the West Flood Canal, such as the strengthening of embankments and, dredging works. Pictures showing the construction process are exhibited in Fig. 4.2.10.

(a)Batavia Canal

(b) West Canal constructed in 1920

(c) West Canal in 2006

(d) West Canal in 2006

Fig. 4.2.10 Jakarta West Canal construction for flood control (Kompas Papers)

(2) East Food Canal (BKT) Planning

The East Flood Canal System Basin (207 km^2) are based on the East Flood Canal (BKT) that was first proposed by NEDECO in 1973 and is meant to divert run-off from the Cipinang, Sunter, Jatikramat, Buaran and Cakung Rivers along the eastern border of DKI Jakarta. Pictures showing Jakarta East Canal construction are illustrated in Fig. 4.2.11. Until its completion, these rivers will flow into the Jakarta Bay at separate locations. Under the existing situation the Cipinang joins the Sunter at Kelurahan Cipinang and continues as the Sunter, which discharges into the Jakarta Bay at the port of Tanjung Priok. Near the eastern DKI Jakarta border, the Buaran joins the Jatikramat and continues as the Buaran. Farther downstream, the Buaran joins the Cakung and continues as the Cakung Drain. Before flowing into the Jakarta Bay, the Cakung Drain splits into the Cakung Drain and the old Cakung River course.

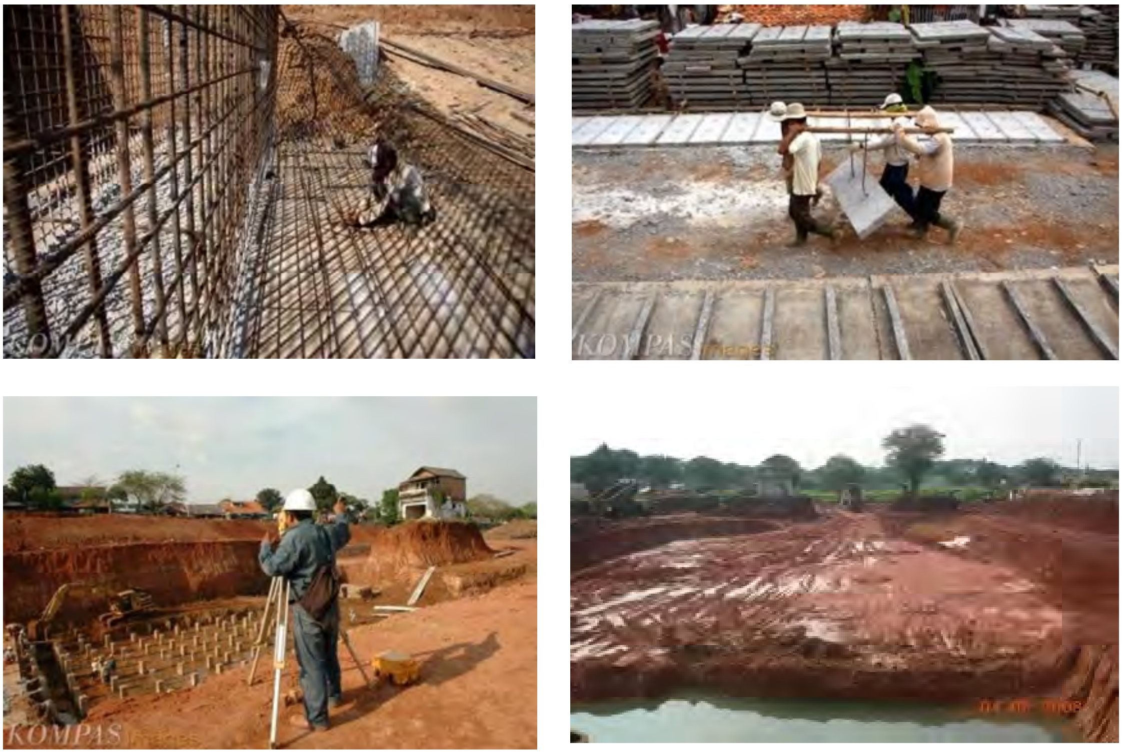


Fig. 4.2.11 Jakarta East Canal construction for flood control (Kompas Papers)

4.2.3. Coastal Region

The human-caused estuary/coast disturbance is one of the most important factors to be considered in JABODETABEK. Human activities have led to a decline in the health of estuaries, making them one of the most threatened ecosystems on the Earth. Because estuary and coast are transitional areas between the land and the sea, and between freshwater and saltwater environments, estuaries can be seriously impacted by any number of human, or anthropogenic, activities. Improvement and revitalization of the coastal and estuary region might be the key point for water environment improvement in DKI Jakarta.

(1) Survey of Coastal Region (on March 28, 2010)

A survey of coastal community was conducted on March 28, 2010, by the Survey team. The survey results are summarized below.

1) In Muara Angke: the sources of pollutant are fish market and fisherman residential (slum area) in Muara Angke (Fig. 4.2.12) at the river mouth of Muara Angke River connecting to West Flood Cannal. The environmental condition of this slum area is terrible because of wastewater and garbage from the fish market and fisherman’s restaurants.

Fig. 4.2.12 Muara Angke (March 28, 2010)

2) Rehabilitation and improvement project of Jakarta Fishing Port (Fig.4.2.13) has been conducted by MMAF (the Ministry of Marine Affairs and Fisheries) with JICA ODA Loan (L/A No. IP-519).

Fig. 4.2.13 Jakarta Fishing Port Improvement Project

3) Pluit is located in Penjaringan Sub-District (*Kecamatan*:KEC) in North of Jakarta. West part of the lake (Fig. 4.2.14) was developed as the Pluit Residential area in 1970 by Regional Government Company named Management Board of Pluit Area *(Badan Pengelola Lingkungan Pluit*:BPLP). However, slam area has been developed in the west bank of the Pluit Reservoir (Lake), where land subsidence of the lake has become alarming at 10-12 cm/year and the difference between the lake and sea level was about 5 m. The seepage of sea water lifts the lake water level and causes innundation of the lake side area. To prevent the flood, a pumping station was constructed and three pumps have been working around the clock (bottom-left picture in Fig. 4.2.15). The south weir into the lake is shown in the upper pictures of Fig. 4.2.15 together with slam on the opposite side of the weir.

Fig. 4.2.14 Pluit Polder (Community Forum of Pluit Environment Care (FMPLP))

Fig. 4.2.15 South entrance barrage (weir) of the Pluit Lake (top) and the pump station in northern mouth of the lake (bottom-left)

(2) Water Quality Problems along the Jakarta Bay

Water quality of Jakarta Bay is degrading due to the water discharged by the rivers into the bay. It was reported that the polluted sea water can still be detected as far as 10 km from the coast. Fig. 4.2.16 shows the sources of pollutant and water quality problems around the Jakarta Bay, with heavily polluted area in the central part of the bay. In Muara Angke (M3 in Fig. 4.2.16), the pollution source is fisherman's residential (slum area) near Muara Angke. In Muara Karang (M4) the source of pollutant includes industrial waste, electric power station, and industrial area in Pluit. Tanjung Prio Harbor has a source of pollutant inside its industrial port, waste dumping by ship. Sources of pollutant in Marunda are domestic waste from residential area and industrial waste in Marunda.

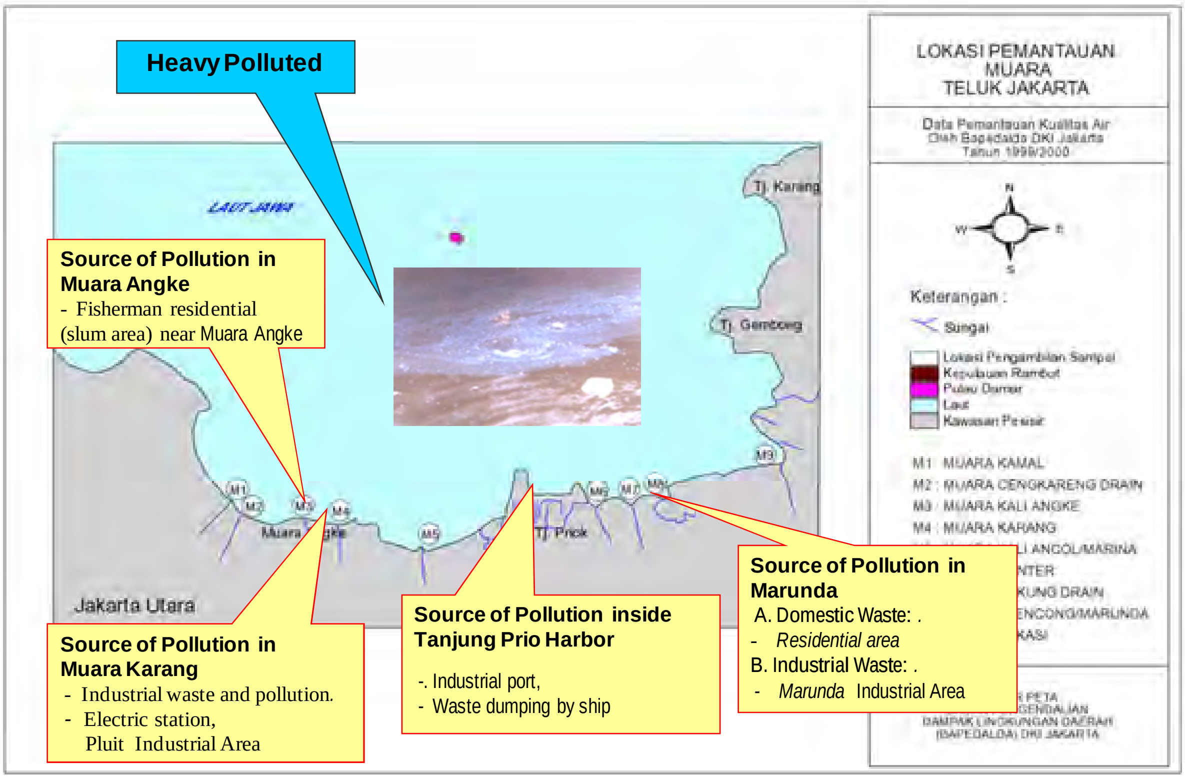


Fig. 4.2.16 Pollutants around the Jakarta Bay

(3) Reclamation and Revitalization Plan

"Jakarta Bay Reclamation Possible Impacts Hydraulic and Coastal Engineering" was summarized by Dr. Subandono Diposaptono, the Deputy Director for Integrated Coastal and Ocean Management, MMAF. His presentation file is attached in Appendix-4.1 of this report. A brief summary is shown below.

Fig. 4.2.17 shows a time series of the sea level measured in the Tanjung Priok Port. This sea level data includes anthropogenic and geological land subsidence.

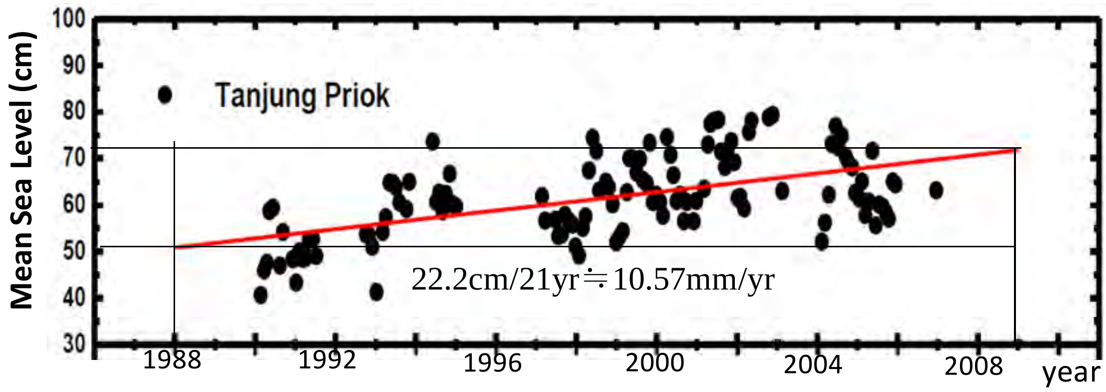


Fig. 4.2.17 Sea level rise in Tanjung Priok port

Fig. 4.2.18 displays the projection of potential inundation area in DKI Jakarta when the scenario of 80 cm sea level rise occurred including anthropogenic and geological land subsidence.

Fig. 4.2.18 Projection of inundation area in DKI Jakarta (80 cm sea level rise)

Fig. 4.2.19 illustrates land use in the projected inundation area in DKI Jakarta when the scenario of 80 cm sea level rise occurred including anthropogenic and geological land subsidence (Fig. 4.2.18).

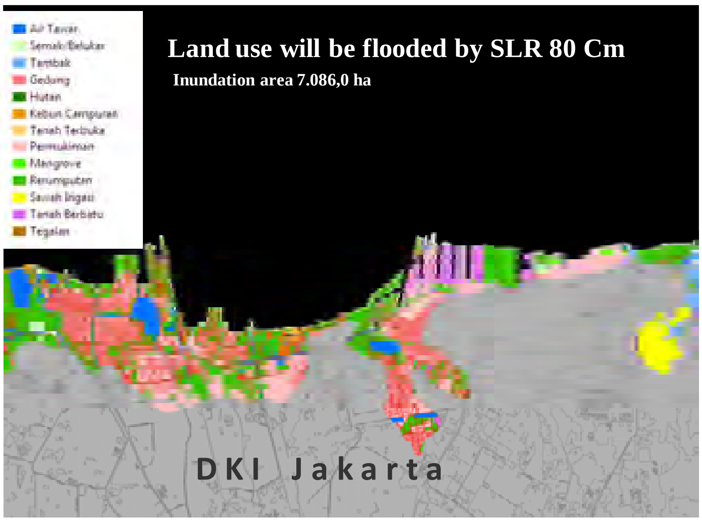


Fig. 4.2.19 Land use in the projected inundation area in DKI Jakarta

Fig. 4.2.20 outlines the reclamation plan in the Jakarta Bay proposed by DKI Jakarta.

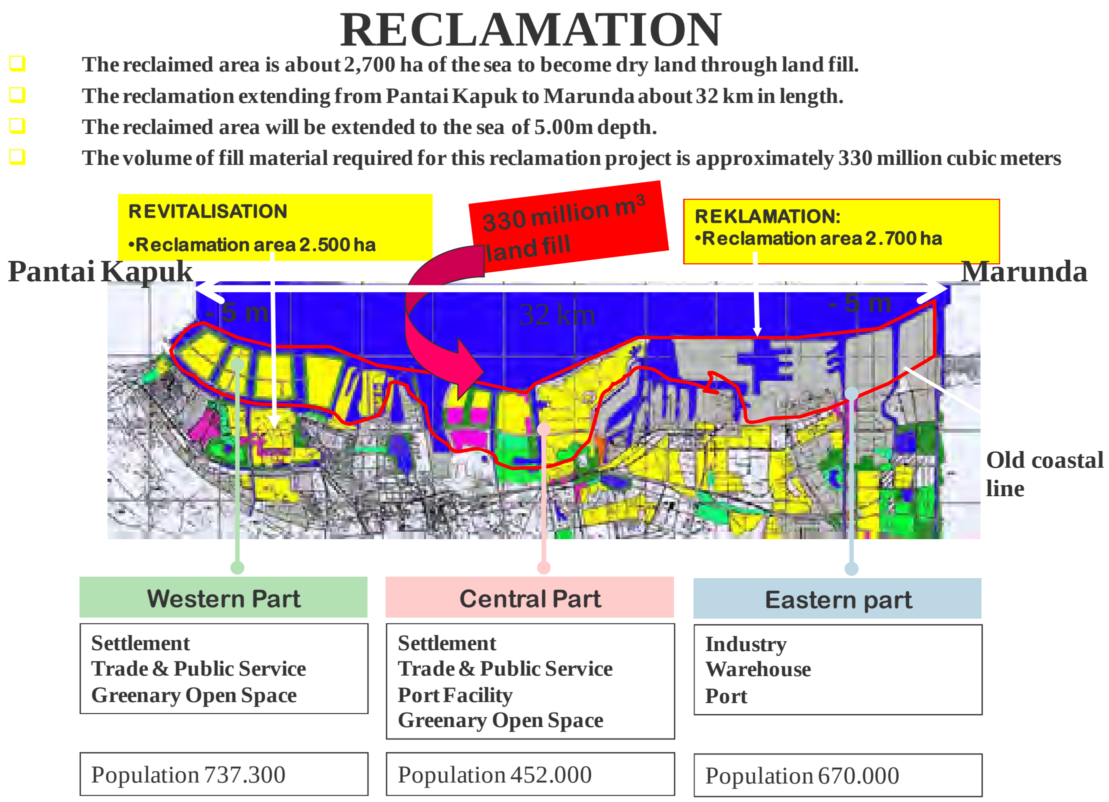


Fig. 4.2.20 Reclamation plan in the Jakarta Bay

Figs. 4.2.21 and 4.2.22 reveal a framework of Jakarta Waterfront development plan against the land subsidence problems proposed by DKI Jakarta. These figures depict the prospective of a new reclamation that will generate new commercial, residential, and tourism areas together with employment. It also includes a private sector provision of public facilities, open space, and infrastructures. When completed, the outcome could stimulate the revitalization and contribute to developing social programs for the existing established area.

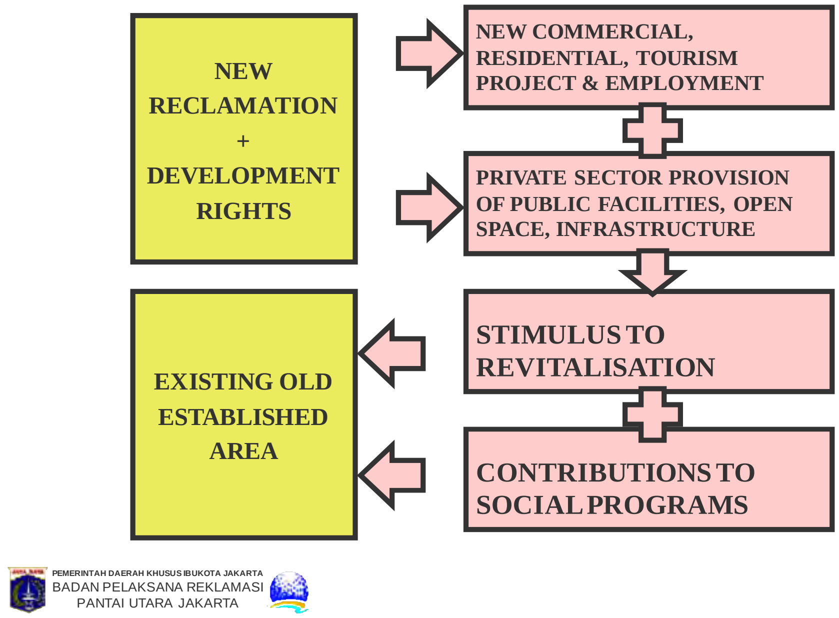
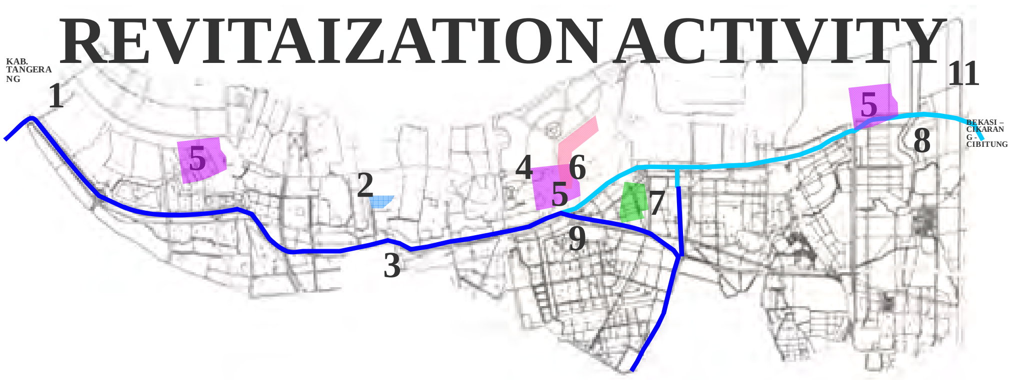


Fig. 4.2.21 Waterfront development plan by DKI Jakarta



Remarks :

1. Development of Fisher village at Muara Kamal
2. Revitalisation of Sunda Kelapa
3. Development of pedestrian in Kota Tua
4. Maritim Expo
5. Public space and Beach Pool
6. Development of Passenger Port
7. Revitalisation of Tanjung Priok Railway Station
7. Toll road of Karang Tanjung
8. Utilization of Sunter Pond for Social Care Centre
9. Normalisation of river mouth
10. Construction and utilization of Muara Banjir Kanal Timur
11. Mangrove Conservation

Fig. 4.2.22 Plan of reclamation activities by DKI Jakarta

(4) Coastal Reclamation Assessment

In 1999-2000, Reclamation Authority Agency (Jakarta North Coast) of DKI Jakarta conducted an assessment research on "Hydrodynamics Mathematic Model of Jakarta Bay". This water environmental assessment was carried out by the Hydraulic Laboratory, Civil Engineering Faculty, Gadjah Mada University. A file presenting the results of this research is attached in Appendix-4.2 of this report. The main results of the assessment were summarized as follows.

1) The time-honored practice of discharging the polluted waste to the drainage system has deteriorated the water quality in Jakarta bay further offshore.
2) The reclamation would cause changes to the natural equilibrium of the coastline.
3) The reclamation may hinder the flow of drainage discharge.
4) The reclamation may cause the obstruction to the cooling water intake for power plant.
5) Waste disposal which degrades the beach environment would affect the water recreational activities.
6) Coastal protection structures may cause serious downcoast erosion and consequently affects the stability of the present beach equilibrium.
7) Dredging of reclamation material may cause short-term direct mortality to sessile organisms, modifies seafloor habitats and sedimentary character.
8) Reclamation may cause burial of plants (mangrove) and organisms (shellfish).
9) The reclamation may cause intensive land subsidence in Jakarta region due to groundwater extraction for water supply in reclamation area.
10) The existing flood problem in Jakarta may worsen due to the reclamation.

Dredging too close to shore can also cause beach erosion.

Amongst these possible impacts, reliability of the results relating to the coastal erosion shown by 2), 6), and 9) may still be open to question. The environmental impact assessment should be conducted by up-to-date simulation technology. The regional environment simulator in ITB is appropriate for future work.

4.2.4. Ciliwung River Basin

Fig. 4.2.23 shows utilization information of the Ciliwung River basin, and Fig. 4.2.24 depicts the source of pollutant in the Ciliwung River. Following the information given by Pusair (2005) a survey of the Ciliwung River Watershed (Bogor, Depok and Jakarta) was conducted in April 2010. This survey focused on the water quality monitoring system conducted by local government, the solid waste conditions in the River, and pollutant sources along the River. According to the Cleansing Department, DKI Jakarta, total waste production in Jakarta was 6,000 ton/day (equivalent to 28,000m^3/day) in 2004 (Fig. 4.2.25).

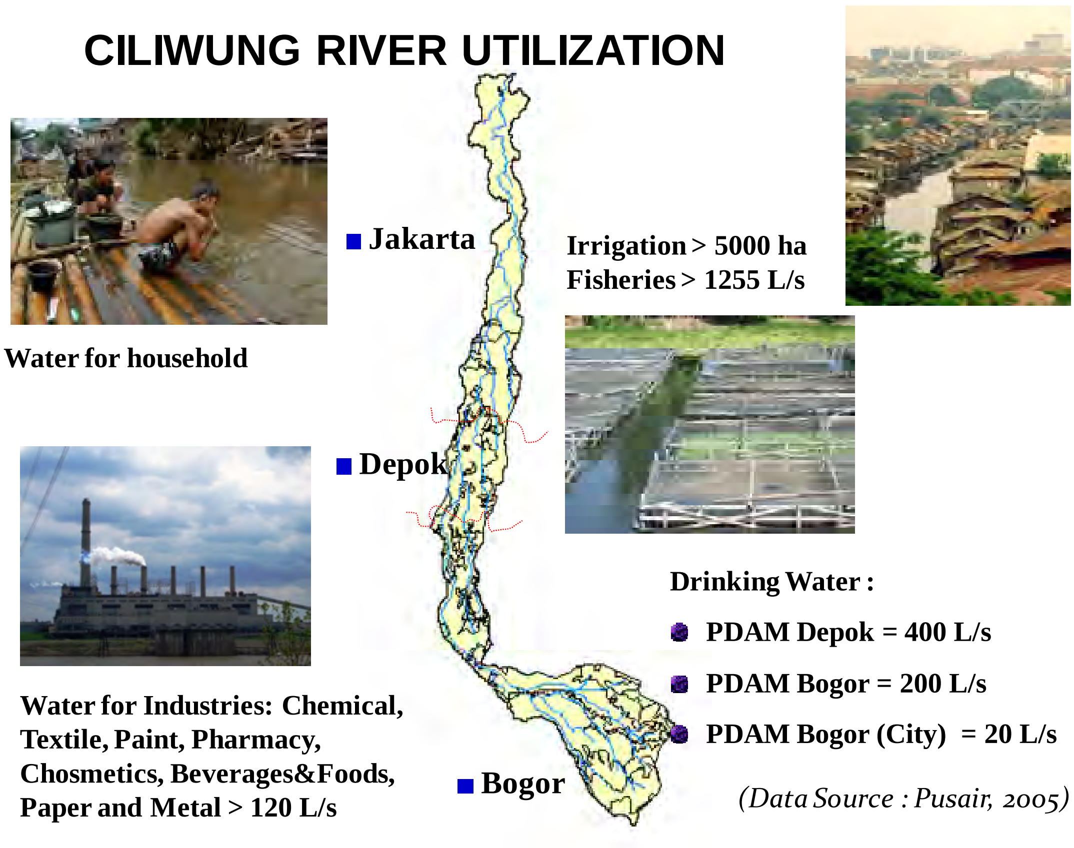


Fig. 4.2.23 Utilization information in the Ciliwung River (Pusair, 2005)

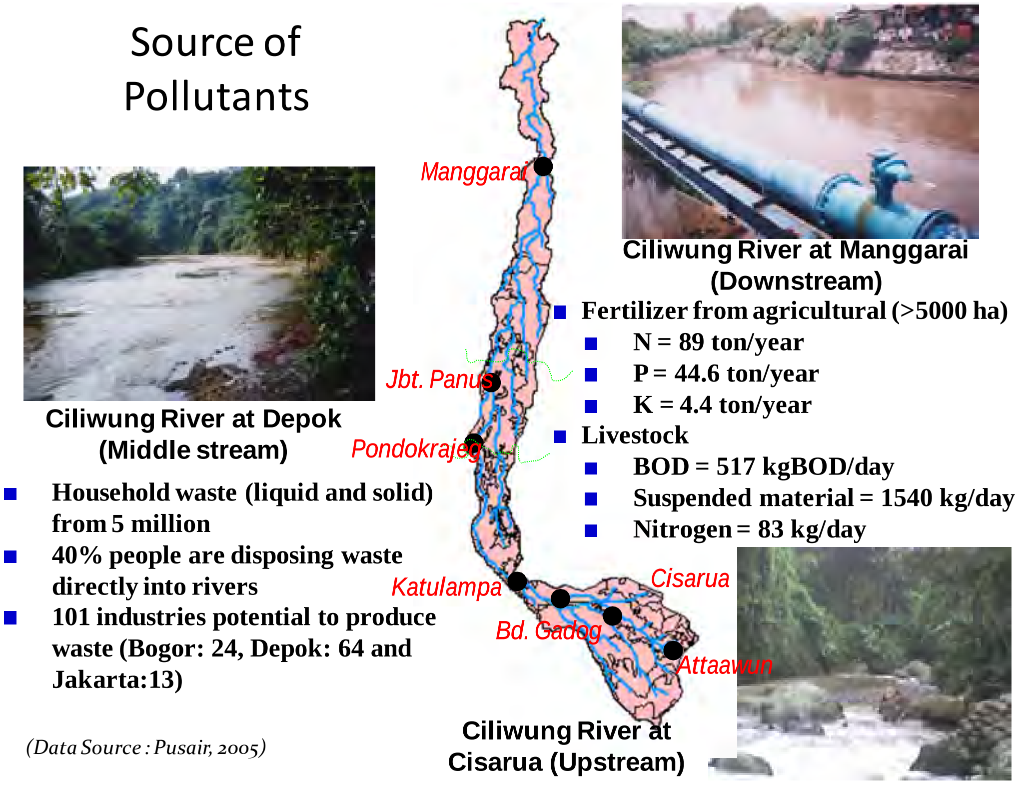


Fig. 4.2.24 Source of pollutant in the Ciliwung River (Pusair 2005)

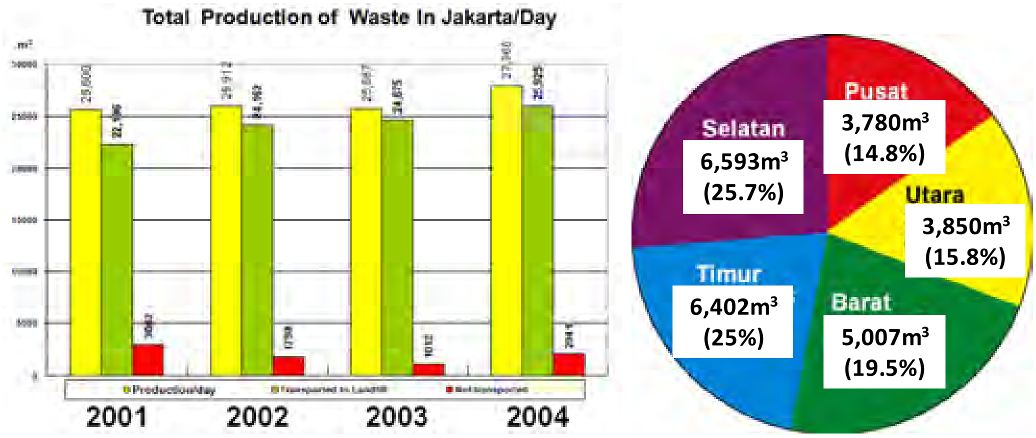


Fig. 4.2.25 Total waste production in Jakarta (left) and its share rate in 2001 (Cleansing Department DKI Jakarta)

(1) Survey in Upper Stream

Fig. 4.2.26 is a bottom profile of the Ciliwung River showing steep slope from the top of mountain (1,500 m) to Bogor (400 m). The River can be divided into three parts, namely, upper, middle, and lower/down streams based on the terrain, in which each watershed has different hydrological characteristics (Fig. 4.2.27).

The Survey was carried out from the upper stream, Bogor. Fig. 4.2.28 shows the current situation of the Katulampa River Discharge Station in Bogor.

Bogor watershed is a residential area with a steep river slope, from which a large amount of household garbage was throwing into the rivers, Ciliwung and Cisadane. Agricultural and household effluent contained several pollutants which become a heavy load for both major rivers.

Water quality monitoring system was also investigated. BPLHD Jabar (Jawa Barat province), being identical to BPLHD DKI Jakarta, is the institution that has the requested responsibility of managing the environmental system in West Java Province (Jl. Naripan No. Bandung, West Java, Telp: +62-22 4204871, Fax: +62-22 4231570, Website: http://www.bplhdjabar.go.id, e-mail: lusia_boer@bplhdjabar.go.id). The Survey team needed the data and information from this institution because Ciliwung River upstream is located in West Java Province. In this office, the Survey team met and discussed with Mrs. Lusia Boer (Head of Environment and Control of Contamination Division).

The Survey team collected the monitoring data at 9 stations of the Ciliwung River upstream from 2001 to 2009. Data available was limited, for example only 2 stations in 2001, and 7 stations in 2003. Data parameters included physical (suspended material, turbidity and pH), chemical (BOD, COD organic, ammonia, sulfide, etc.) and microbiology (coliform and fecal coli) and discharge (measured by PU). Monitoring months were in July, September and October. However, it has to be noted that monitoring month/date varied from year to year.

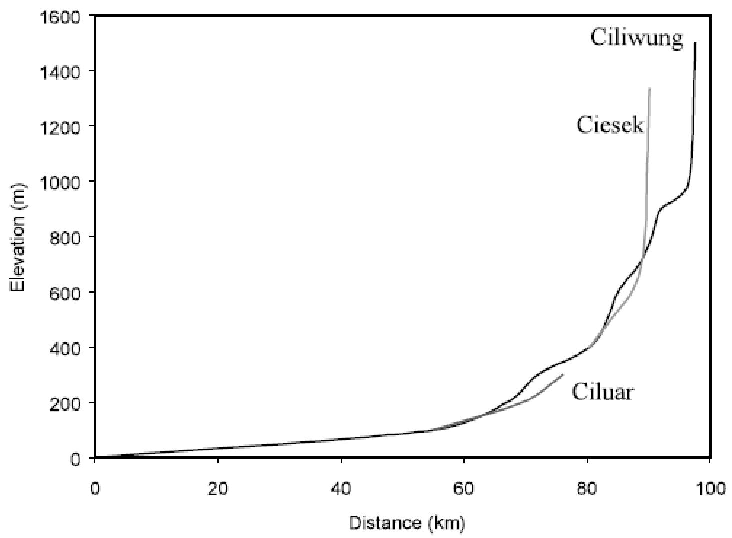


Fig. 4.2.26 Bottom profile of three major rivers, the Ciliwung, Ciluar and Ciesek

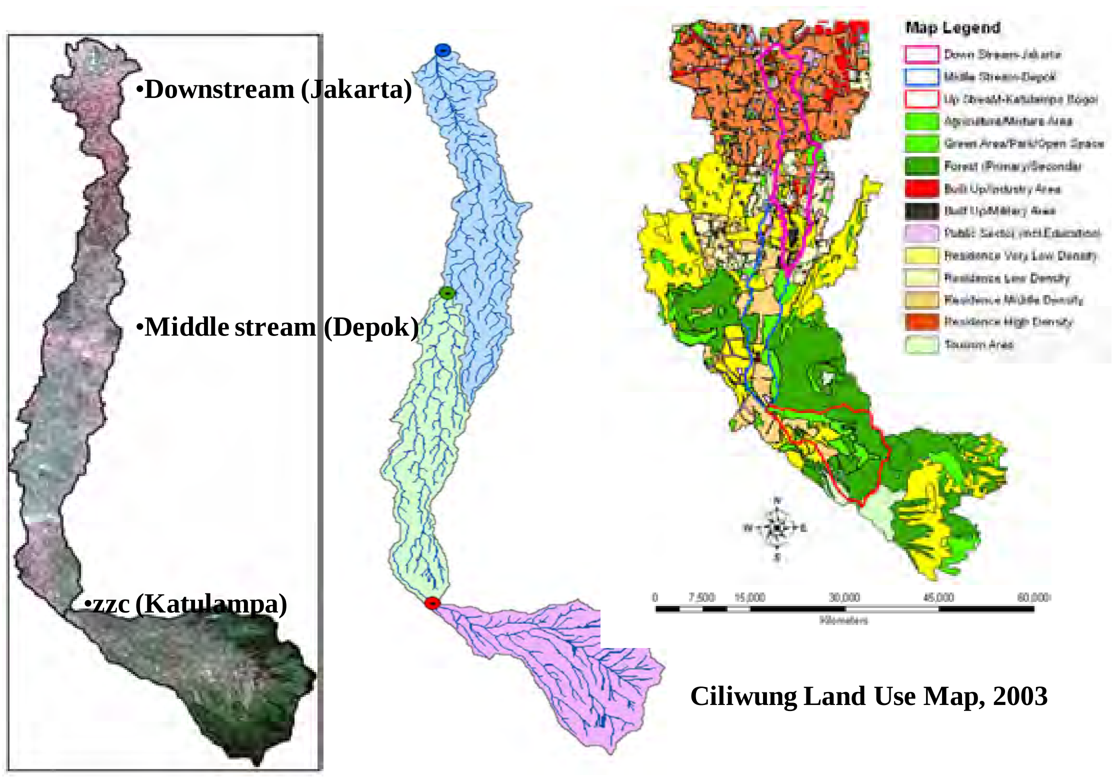


Fig. 4.2.27 Land use map of the Ciliwung River basin in 2003(right) and the three watersheds (upper, middle, and down streams) under investigation (left)

Fig. 4.2.28 Katulampa River discharge station in Bogor

(2) Survey in Middle and Down Streams

In the downstream Jakarta, for the solution of its flooding control, it is believed that Integrated Water Resource Management (IWRM) is compulsory to be implemented. Global Water Partnership defined IWRM as, "A process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". In the implementation of IWRM, the Survey team should consider sustainability issues, comprising technical, social, economic and environmental aspect. As well known, IWRM is conducted with holistic approach and dealing with overall hydrological cycle, and the management actually covers 16 aspects as follows:

1) Social Facilitation, Legal and Institutional Setup
2) Water Allocation (quantity & quality)
3) Catchment/ River Basin Planning and Management (development control of land use and the urban surface run-off, or known as Low Impact Development)
4) Landscape Design
5) Drainage Planning & Management
6) Floods Control and Mitigation
7) Drought Management
8) Financial Management
9) Information Management
10) Stakeholder participation
11) Environmental Impact Assessment (EIA)
12) Drinking Water Supply
13) Pollution Control and Wastewater Management
14) Water Monitoring (quantity & quality)
15) Solid Waste Management
16) Wastewater Reclamation, Desalination

In the middle and down streams, measures of flood control have to be considered together with many aspects, especially of the water quality environment (drinking water supply), pollution and wastewater management, solid waste (floating garbage and sedimentation material on the river bottom in the downstream) management. Unfortunately, there are many tough issues to be solved for the middle and downstream of the Ciliwung River.

Both water quality monitoring system (by local government) and river discharge measuring system (by PU) have been conducted for decades after the decentralization. Measured data are more or less correct and ready for use with complete data inventory.

However, water quality monitoring and river discharge measurement were not yet synthesized or used simultaneously to evaluate fluxes of substances. Moreover, continuous data measurement for water quality monitoring was not conducted. Observed concentration and fluxes were strongly dependent on the river flow condition. During the flood period, river water was cleaner than the nomal condition. The continuous measurements for river discharge and water quality had to be conducted together with a synthesized data analysis.

Pictures of the Ciliwung River at Depok and Jakarta (Manggarai) are shown in Fig. 4.2.29. A typical river cross section of the Ciliwung River used for hydrological runoff simulation is given in Fig. 4.2.30.

Presently, flood control scheme in DKI Jakarta is more or less completed. DINAS PU has a high potential responsibility for flood control. This institution published and revised flood control manual almost every year. Fig. 4.2.31 displays the flood control chart in Jakarta DKI showing also the responsibility of the Central and local governments for flood control. (Pedoman Siaga Banjir Provinsi DKI Jakarta, Tahun 2009 by DINAS PU, DKI Jakarta).

Middle stream at Depok, the household waste (liquid and solid) from 5 million people are the heavy burden for the Ciliwung River. It was reported that 40% people are disposing waste directly into rivers. Total number of 101 industries (Bogor: 24, Depok: 64 and Jakarta: 13) have high potential to effluent pollutant and to produce floating garbage and sedimentation materials found in the River.

(a) Depok river discharge station (Middle stream)

(b) Manggarai weir (Downstream)

Fig. 4.2.29 Middle and downstream of the Ciliwung River

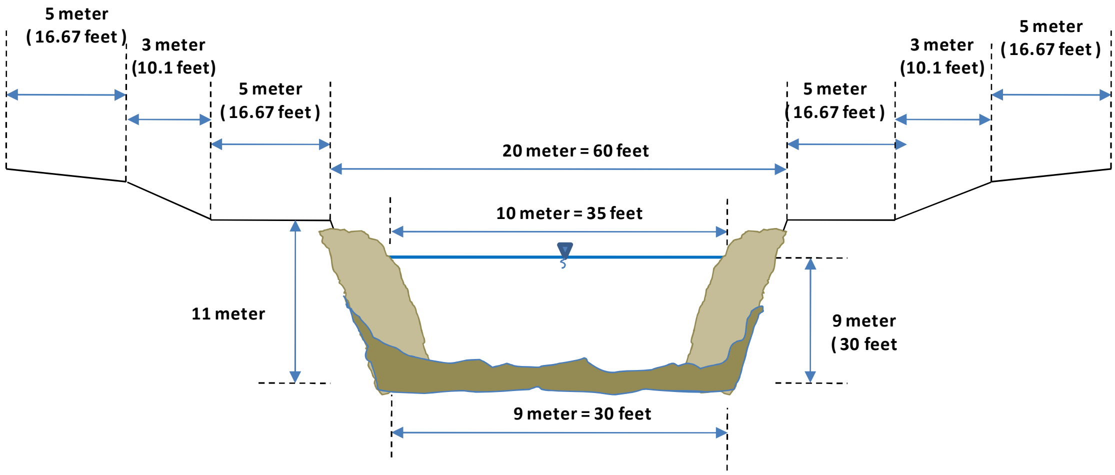


Fig. 4.2.30 Typical river cross section of the Ciliwung River

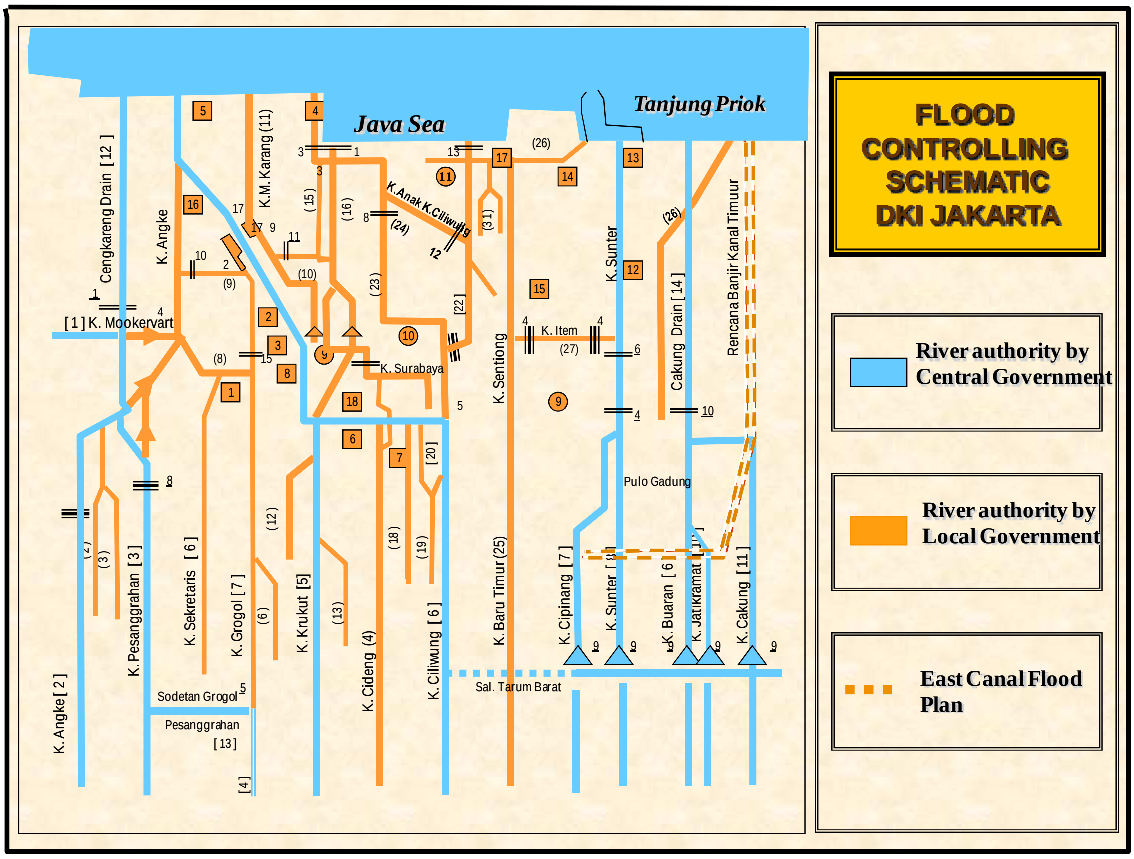


Fig. 4.2.31 Flood control chart in DKI Jakarta (from Appendix A)

4.2.5. Significant Comments

According to the article "Are floods on the way or out of the way?" by Agnes Winarti, The Jakarta Post, on December 22, 2008, the following comments are relevant to the Survey team for the consideration of the flood management in Jakarta.

The sporadic nature of the administration's flood mitigation programs is regrettable, said Basah Hernowo, the director of forestry and water resource conservation at the National Development Planning Board (Bappenas)."The flood mitigation programs will be effective only if it is done systematically, not only in the downstream area but also in the upstream area because sediment is usually carried by the upstream current".

According to Basah, the city administration should cooperate with surrounding administrations in terms of environmental conservation of the upstream territory. Such cooperation could take the form of joint law enforcement to limit property developments in upstream areas and prevent illegal settlements along the banks of rivers and canals, as well as restoring green spaces.
It is estimated 70 to 80% of illegal settlements are built along the river banks between Depok and Manggarai.

"The urban planning regulation that bans any settlements within 50 square meters of the river banks must be enforced," Basah said. The drainage network must also be looked at, he said.

"All micro drainage systems from residences, for example, must be linked to the macro drainages. This is not the case in Jakarta, where either the connection is blocked with silt or there is no (micro to macro) link at all." He said the administration would be better off constructing more polder systems than creating more lakes or adding more water pumps, which served only as a mid-term solution.

A polder system is a water reservoir with attached sluice gates and water pumps, which will automatically drain the polder once the water reaches a certain height, these must be integrated," Basah said.

And for the crucial issue of tidal floods, the administration should raise the height of the dikes along the North Jakarta coastline.

"The key to successful flood mitigation is a shared commitment between Jakarta and surrounding administrations," he said. "The problem is the city administration's commitment to stick to the flood mitigation master plan at any cost."

(from http://www.thejakartapost.com/news/2008/12/22/are-floods-way-or-out-way.html)

4.3. Water Quality Monitoring

4.3.1. Introduction

Detailed chemical component data and monitoring data of water quality are two of the most fundamental components to manage the sewerage system and water environment, as well as to develop the sewerage system and to validate the environmental simulation in a basin scale. In particular, for the performance evaluation of biological treatment system in terms of BOD / COD and nitrogen removal, the water quality management is absolutely necessary. Therefore, water quality parameters have routinely been measured as part of quality testing, particularly at discharge point into surface water such as wastewater treatment plants, and at some points along the main rivers. At the treatment plants, the BOD/COD and nitrogen of the incoming sewage water is monitored periodically, using official analytical methods such as US-EPA, JIS, and ISO methods. These methods have been world-widely applied and also in the Indonesian water monitoring laboratories like BPLHD, DKI Jakarta and PD PAL JAYA.

In addition, the accumulation of monitoring data is important for not only the control of water environments but also the management of watersheds and land use. It is possible to detect the effect of urbanization, land use change, and climate changes on water environment, using the confirmation of long-term variation in annual average data or monthly data longer than 10 years.

The temporal variations, such as daily, hourly and minutely, in water quality of rivers and sewage is more important for evaluating influence of municipal and industrial contamination on the water environment and ecosystem, such as pollution control and watch, and evaluation of flood effects. However, these types of monitoring have not widely been established, because variable methods have not been thoroughly evaluated.

For example, which chemical parameters are optimum in terms of the direct and essential view point or cost performance? The BOD and COD are important as standard and comprehensive monitoring parameter. Therefore these values are useful to compare the pollution conditions in various sites and to estimate long term variations in the degree of pollution. Consequently, they have been collected over a long period of time. But the BOD analysis includes complicated method and process. The BOD value indicates the pollution potential and relative pollution degree, and they are indirect and inconvenient to evaluate the pollution sources and effective remediation points. However, it is necessary to determine the direct and convenient chemical parameters for future monitoring works.

In addition, it is difficult to monitor the BOD automatically in terms of cost performance. Although some methods of automatic BOD monitoring are available, but they are very expensive and inconvenient for maintenance, because of new types of biosensors or in situ and automatic flow injection analysis. Under a polluted condition such as sewages or rivers in Indonesia, it is important to consider the durability and cost performance of the sensors. This Survey aims to propose optimum methods of water quality monitoring in Jakarta, Indonesia, with due attention to cost performance, benefit, durability, and convenience.

4.3.2. Previous Water Quality Monitoring

In Jakarta, several government offices have conducted water chemical monitoring in surface waters, for example, BPLHD, DKI Jakarta and MOE etc. In addition, some previous researches have been conducted in groundwater, for example JICA project, and the hydro-chemical researches in the project of “Subsurface Environment (SE)” supported by Research Institute of Human and Nature (Project Leader is Mr. Makoto Taniguchi in that institute).

BPLHD, DKI Jakarta has compiled 35 water quality parameters at 67 sites in rivers around Jakarta to a database for the last 10 years. The parameters comprise the electrical conductivity, total dissolved solid, total suspended solid, turbidity, temperature, pH, dissolved oxygen, some anions, some trace metals, COD, and BOD etc. Part of the database on 61 sites in Jakarta in 2009 is showed in Table 4.3.1. The sampling frequency was about five times per year. Because many of the monitoring parameters by the Ministry of Land, Infrastructure and Transport (MLLT) in Japan have monthly frequency, the frequency of monitoring in Jakarta should be improved at least. The location of water sampling sites by DKI Jakarta is shown in Fig. 4.3.1. The river runoffs in some rivers were also measured by DKI Jakarta.

Table 4.3.1 Example of water quality data from rivers in Jakarta in 2009 (by DKI Jakarta)

No	Parameter	Unit	Test results of each site				Water quality standard
			6	8	8A	8B	
	I. Physical parameter						
1	Electrical conductivity (EC)	µmhos/cm	188.0	242.0	311.5	183.0	1,000
2	Total dissolved solid (TDS)	mg/L	88.5	93.6	118.8	67.3	200
3	Total suspended solid (TSS)	mg/L	25.0	24.0	30.0	25.0	200
4	Turbidity	NTU	13.5	11.5	29.5	40.0	
5	Temperature	°C	27.4	29.0	27.5	26.9	Normal water temp.
6	Color	Pt Co scale	28.0	20.0	25.0	55.0	
7	Dissolved oxygen (DO)	mg/L	0.7	5.9	6.3	6.4	3.0
8	pH		6.1	7.2	5.9	6.1	6.0 - 8.5
9	Rate of flow	m^3/second	No flow	1.7	3.7	0.3	
	II. Chemical parameter						
10	Mercury (Hg)	mg/L	*	*	*	*	0.0005
11	Iron (Fe)	mg/L	0.83	0.96	0.99	0.44	
12	Cadmium (Cd)	mg/L	*	*	*	*	0.010
13	Chromium (total)	mg/L	*	*	*	*	
14	Crom Hexavalent (Cr^{6+})		*	*	*	*	0.050
15	Nickel (Ni)	mg/L	*	*	*	*	0.10
16	Zinc(Zn)	mg/L	0.03	0.03	0.02	0.03	1.0
17	Copper (Cu)	mg/L	*	*	*	*	0.10

No	Parameter	Unit	Test results of each site				Water quality standard
			6	8	8A	8B	
18	Plumbum (Pb)	mg/L	*	*	*	*	0.10
19	Mangan (Mn)	mg/L	0.29	0.49	0.52	0.04	1.0
20	Phosphate (PO_4)	mg/L	0.06	0.05	0.34	0.04	0.50
21	Sulfate (SO_4)	mg/L	12.85	9.18	11.90	10.90	100
22	Oils and fats	mg/L	0.08	0.04	0.06	0.09	nil
23	Methylene blue active compounds	mg/L	0.09	0.08	0.46	0.06	0.50
24	COD ($KMnO_4$)	mg/L	24.53	18.05	38.55	27.97	25.0
25	BOD (20°C, 5 days)	mg/L	12.30	7.20	24.10	7.40	20.0
26	COD (Cr)	mg/L	53.33	23.62	49.52	53.33	30.0
	III. Microbiologic parameter						
27	Bacteria (total)	n/100 mL	130×10^4	220×10^5	350×10^5	70×10^3	20×10^3
28	Bacteria feces (total)	n/100 mL	170×10^3	94×10^4	280×10^5	49×10^3	4×10^3

Source: BPLHD, DKI Jakarta

PD PAL JAYA has also conducted water quality monitoring of some sewages in the past 10 years. The parameters consist of total dissolved solid, total suspended solid, temperature, pH, dissolved nitrogen, COD, and BOD etc. The sampling frequency was also about five times per annum. The example of water quality data of sewage by PD PAL JAYA in 2000 is tabulated in Table 4.3.2, while the locations of sampling sites are shown in Fig. 4.3.2. Five types of sewage flowed into the ponds near that office at PD-I1 to PD-I5 (Fig. 4.3.2b). These ponds play the role to deposit and remove the polluted and suspended solids. Though the inflow rates were not monitored, the outlets by pumping up from the ponds to the adjacent river at PD-O1 and PD-O2 (Fig. 4.3.2b) were recorded hourly and manually.

Table 4.3.2 Example of water quality data of effluent in the East pond in Jakarta in 2000

	temperature (℃)	Dissolved material (mg/L)	SS (mg/L)	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	Organic (mg/L)	NH_4 (mg-N/L)	NO_3 (mg-N/L)
2000/7/12	26.2		33.5	7.19	0.46	67.3	220.19	51.09	11.96	3.65
2000/7/19	29.1	430	191.5	7.38	0.5	57.88	62.49	96.97	13.20	2.04
2000/7/26	28.1	560	126.5	7.37	1.41	24.23	42.72	105.60	7.06	2.50
2000/8/2	24.0	810	73.0	7.03	0.12	1.68	56.96	37.53	8.21	2.55
2000/8/9	27.7	640	10.0	6.98	0.65	11.11	48.27	35.39	ttd	2.86
2000/8/16	28.7		43.0	7.10	0.15	52.49	59.98	90.06		
2000/8/23	27.3		25.0	7.43	1.77	31.32	56.51	55.30		
2000/8/30	27.3	300	96.0	7.10	1.5	30.47	78.37	62.28		
2000/9/6	27.4	510	75.5	7.28	0.74	31.00	74.08	47.46	9.40	4.58
2000/9/13	28.2		41.5	7.33	1.56	23.41	62.76	33.70		
2000/9/20	28.6	560	42.0	7.23	0.51	23.08	36.76	42.03	10.59	4.22
2000/9/27	27.5	440	77.0	6.95	0.18	20.44	89.9	46.32		

Source: PD PAL JAYA

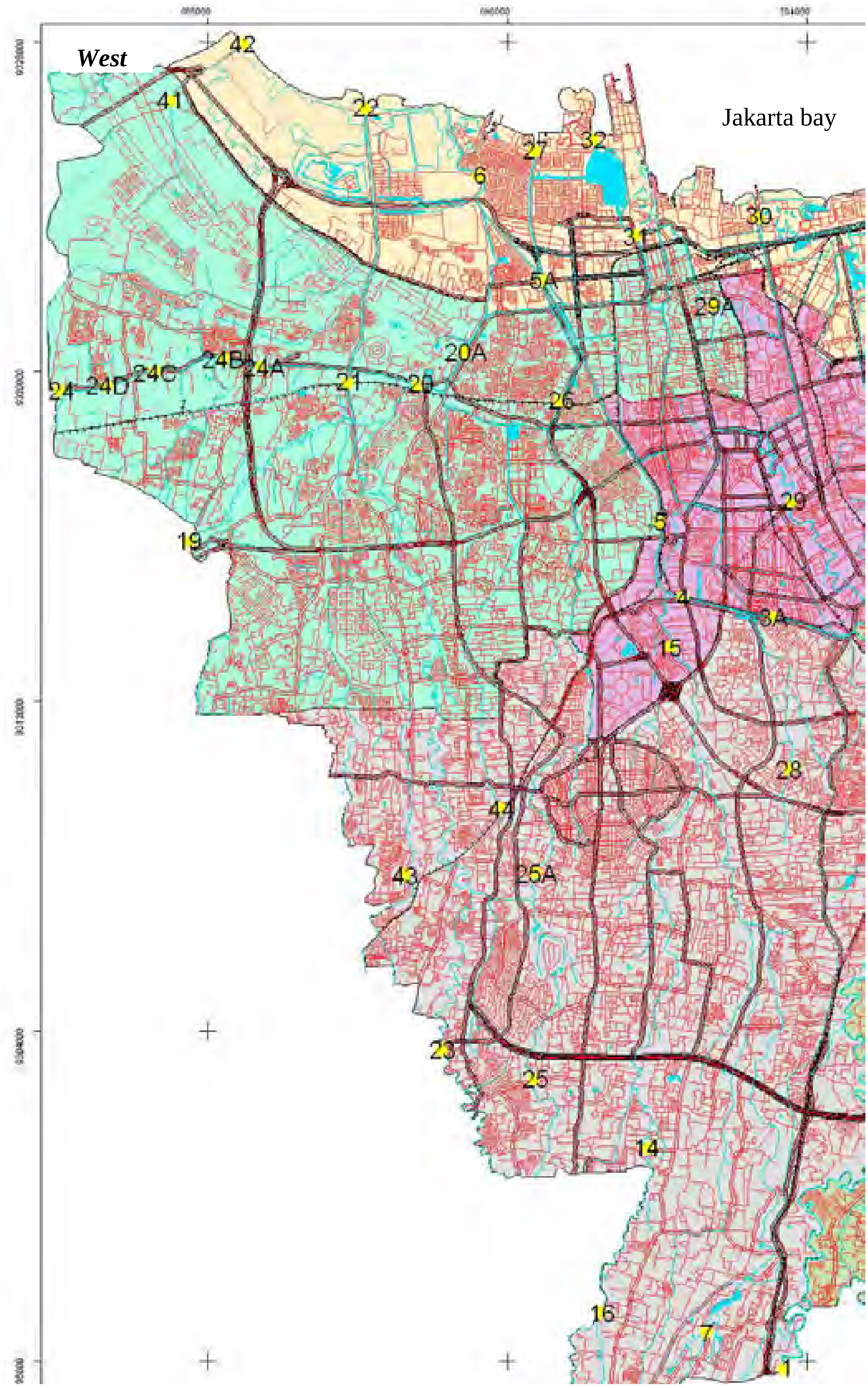


Fig. 4.3.1 Locations of water quality sampling sites by DKI Jakarta (west and east)

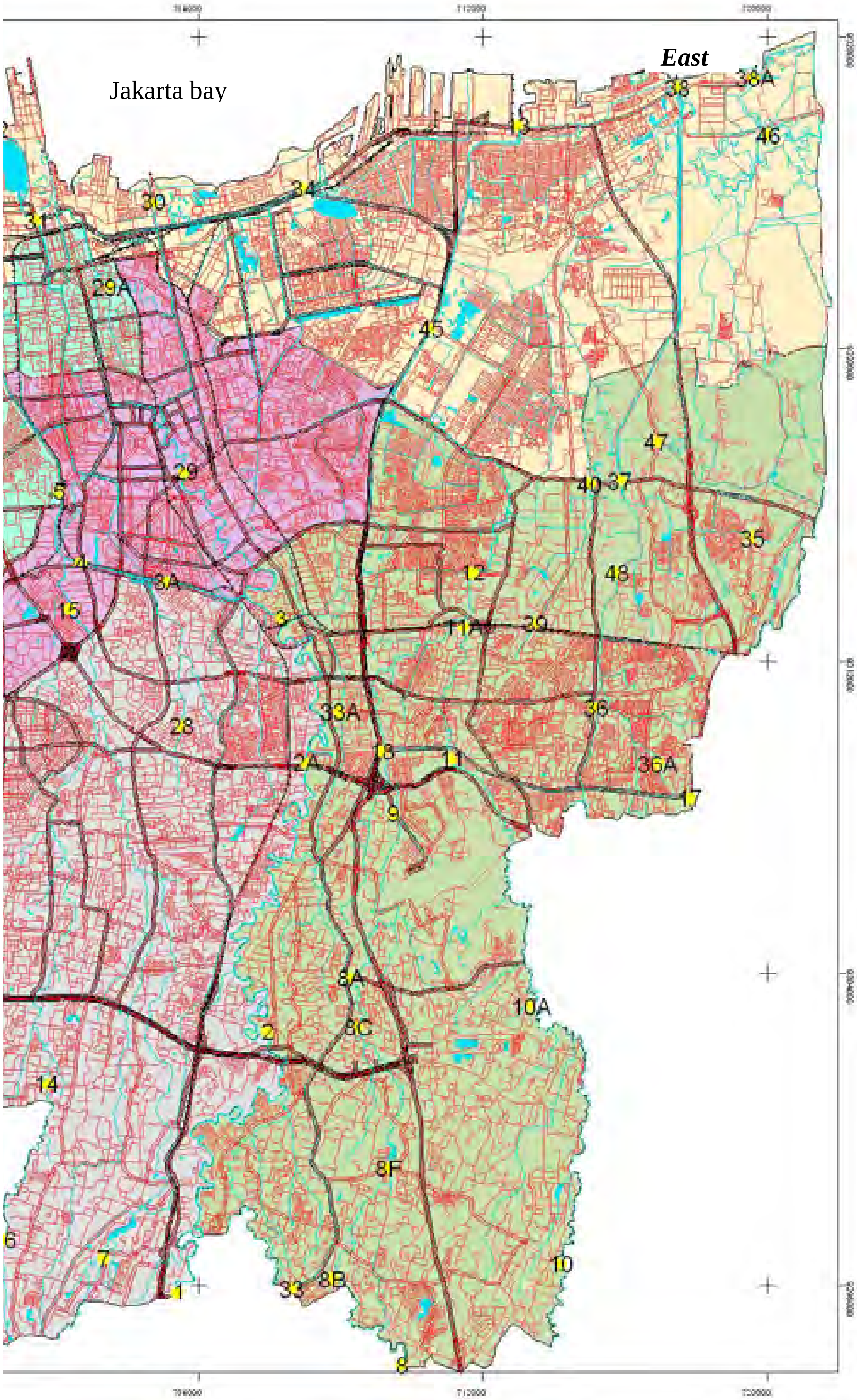
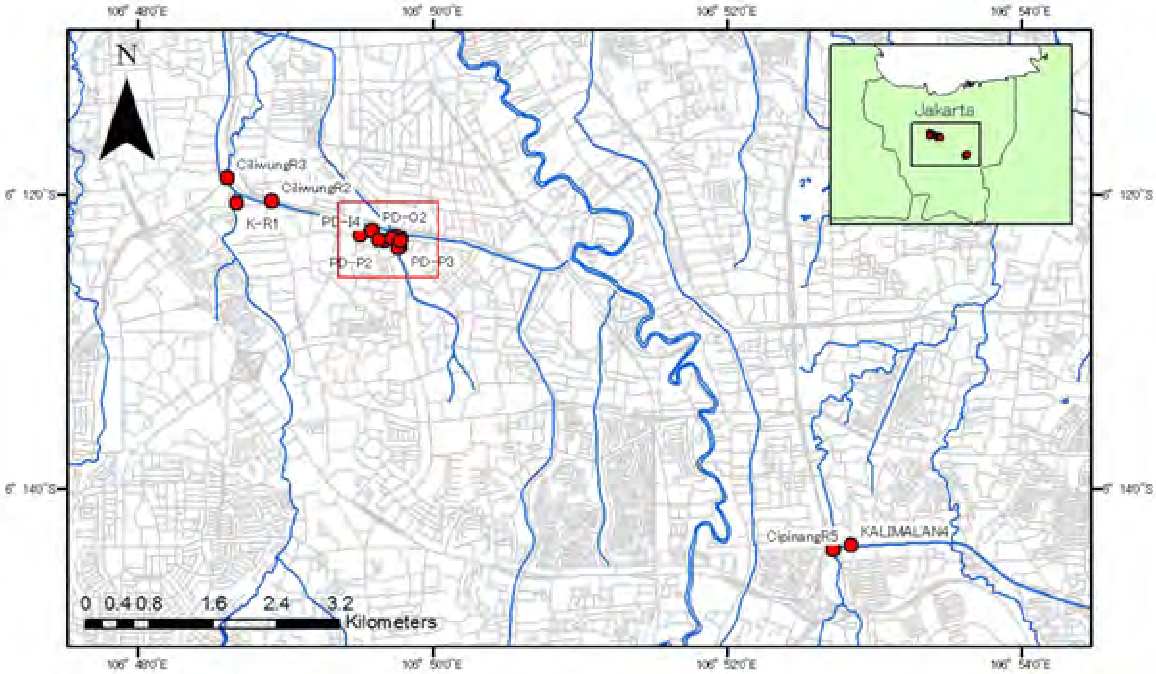


Fig. 4.3.1 Locations of water quality sampling sites by DKI Jakarta (west and east) (continued)

(a)



(b)

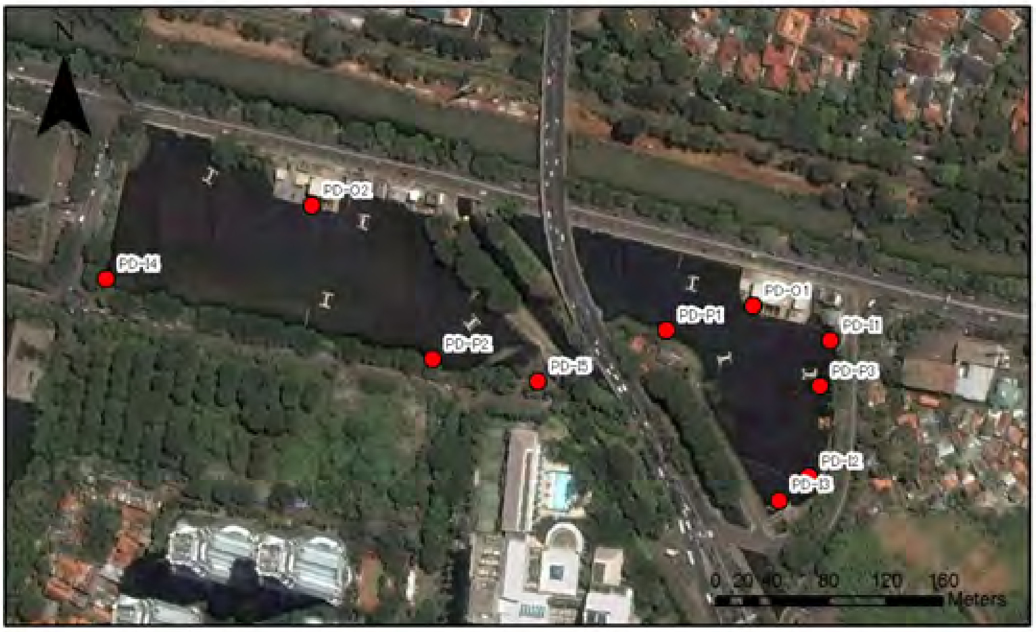


Fig. 4.3.2 Example of locations of water monitoring stations along the river (a) and two sewage ponds (b)

The example of outlet rates from the east pond in 2009 is plotted in Fig. 4.3.3. It is worth nothing that the discharge volume remained constant from mid-June to mid-November (Fig. 4.3.3) in the dry season, improving daily average of sewage discharge. On the other hand, the discharge fluctuated during the months in the wet season.

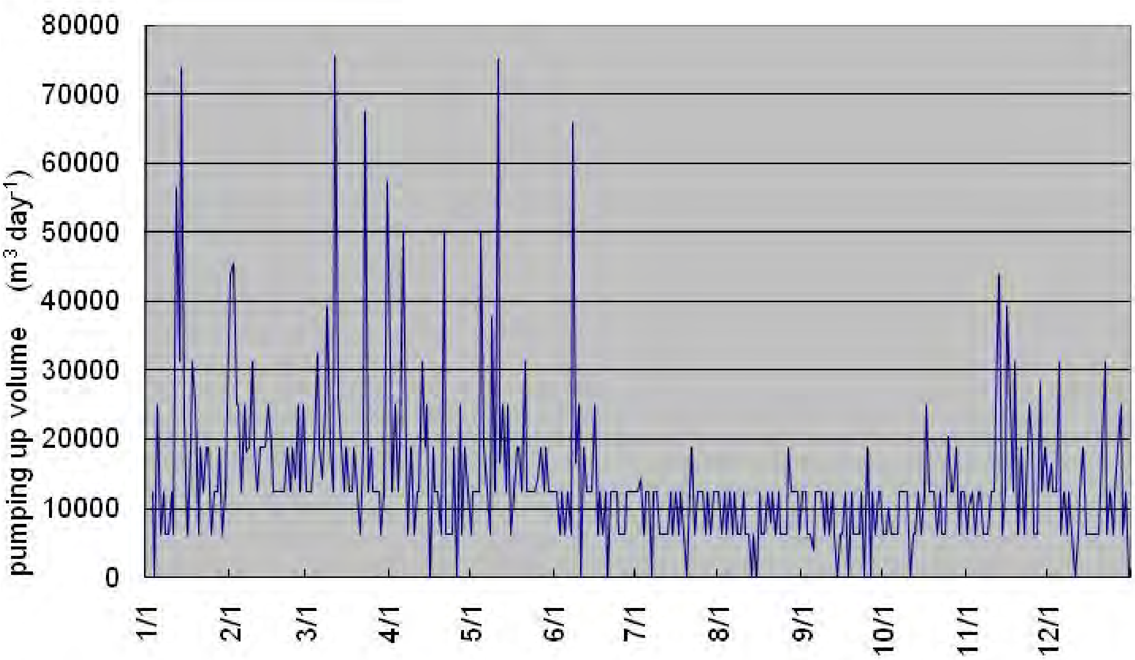


Fig. 4.3.3 Daily pumping up volume (discharge rate) from the east pond in 2009 managed by PU (source: PD PAL JAYA)

The previous water monitoring database and present monitoring system in Jakarta is extremely useful to estimate the long-term variation and spatial distribution in pollutant load in a watershed. However, it is necessary to improve the monitoring system, such as the redetermination of chemical parameters as direct and simple indicators, as well as the adoption of shorter sampling interval, at least hourly or daily.