

MONITORING AND STUDIES ON WATER QUALITY IN RIVERS AND RELATED WATER BODIES IN INDONESIA

*By: Achmadi Partowijoto & Ratna Hidayat
IWP & RDCWR*



Introduction

- More than 5000 rivers flows in Indonesia with a total discharge of 2 billion cum
- Most rivers have been degraded and many in critical condition
- Minister of PW Regulation 239/PRT/1989 grouped river basins into 90 units; 15 managed by CG; 73 by LG and 2 by PJT
- 30 units in Sumatra, 15 in Java, 7 in Bali and NT, 14 in Kalimantan, 17 in Sulawesi and 4 in Papua.



In the near future

- River basin to be managed as PJT : J. Seluna, Serayu, Bengawan Sala, Ciliwung-Cisadane, W.Sekampung-W.Seputih, and Jeneberang
- At present there are 136 units, may increase in response to local government proposals
- Many river basins are critical: 22 in 1984; 39 in 1994; 42 in 1998; 58 in 2000, and more in 2005
- River potential are evaluated from both water quantity and quality, where pollution sources may derive from domestic, industrial and agricultural waste



Monitoring and studies

- Monitoring of WQ in rivers was conducted by many institutions, for the purpose of various objectives and referred different criteria
- Universities, research centers, professional societies, industry and non-government organization
- This paper presents brief information on the result of monitoring and studies on water quality in some rivers, lakes and reservoirs.



Classification of water quality

- According to GR 82/2001 water is classified into :
- Class I ; water used as raw water for drinking, or other uses with similar quality requirements
- Class II ; water used for recreation, fishery, life stock and irrigation, or other uses with similar quality requirements.
- Class III ; water used for fishery, life stock and irrigation, or other uses with similar quality requirements
- Class IV ; water used for irrigation or other uses with similar quality requirements.



**MONITORING OF WATER
QUALITY IN RIVERS
(30 PROVINCES)**



Map of Indonesia



BOD and COD

- Majority of rivers exceed standard criteria for BOD, highest in Citarum (162) and Tallo (160), one meet criteria is river Dendeng in East NT
- Majority are high in COD (>100 mg/L), far exceed criteria for Class I and II (Deli, Citarum, Kahayan, Tallo, Palu, B.Gajah, B.Merah, Anafre)
- BOD : 26 % meet criteria for Class I and 33 % for Class II. COD: 29 % meet criteria for Class I
- pH: 90 % meet standard criteria of Class I and II, rivers Batanghari, Musi, Kapuas, Ciliwung, Citarum are low in pH and Kampar very low (4,9).



DO and TSS

- For DO, 40 % met the standard criteria of Class I, 72 % of Class II
- Rivers Deli, Ciliwung, Citarum and Surabaya showed values approaching to zero.
- For TSS, 71 % meet the standard criteria for water quality of Class I
- Rivers Progo; Kahayan, Martapura and Anafre showed a wide range of TSS and the highest value detected in river Jeneberang



Nitrogen and Phosphorus

- 78 % of rivers met standard criteria of Class I and II for NO₂.
- NO₃, 78% meet standard criteria of Class I and II. For NO₂ rivers Progo and Tukad Badung exceed standard criteria
- NH₃, most rivers such as Deli, Tallo, Rangkui and Anafre, showed high value exceed the standard criteria at most stations
- Highest concentration was detected in river Anafre (55.2 mg/L) and river Brantas (32.8 mg/L)
- PO₄, almost all rivers exceed the standard criteria of Class I and II, highest concentration detected in Batang Agam (13.5 mg/L)

Fecal Coliform and Total Coliform

- Majority of rivers flowing in densely populated urban and industrial areas, particularly in Java, tend to be highly polluted by bacteria.
- Those particular rivers are Progo in Yogyakarta, Ciliwung in Jakarta and Citarum in West Java
- Highest concentration of bacteria coli detected in Ciliwung with FC/TC concentration approaching/over 1 million cells



Status of Rivers

- The status of water quality in rivers are classified based on GR No.82/2001 and Minister of Environment Decree No.115, 2003
- The status is differentiated for up-stream (US) and down-stream (DS), parameters vary for different provinces
- The status are categorized into normal or not polluted (NP), lightly polluted (LP), moderately polluted (MP) and highly polluted (HP).



Status of rivers at US and DS

- For US: 2,5% NP, 56% LP, 23% MP and 8% HP
- US meet standard criteria are: Tamiang, Progo, Dendeng, Jangkok, Palu, Batu Merah, Tabobo.
- US heavily polluted are : Ciliwung, Cisadane, and Kahayan
- For DS: 10% NP, 40% LP, 42% MP and 3% HP
- DS meet standard criteria are: Tamiang, Rangkui, Kapuas, Jeneberang, Tabobo



WQ status of rivers in Sumatra

River	Province	US	DS
K.Tamiang	Aceh	NP-LP	NP
Deli	N. Sumatra	LP	LP
Kampar	Riau	LP-MP	MP
B. Agam	W. Sumatra	LP	MP
B. Hari	Jambi	MP	MP
Musi	S. Sumatra	LP	LP-MP
S.Kampung	Lampung	LP	LP
Rangkui	Babel	LP	LP

WQ status of rivers in Java-Bali-NT

River	Province	US	DS
Cisadane	Banten	<u>HP</u>	LP
<u>Ciliwung</u>	Jakarta	<u>HP</u>	<u>HP</u>
Citarum	West Java	MP	MP
Progo	Yogyakarta	NP-LP	MP
Brantas	East Java	MP	-
Badung	Bali	LP	LP
Jangkok	West NT	LP	MP
Dendeng	East NT	NP	LP

WQ status of rivers in Kalimantan

River	Province	US	DS
Kapuas	W.Kalimantan	LP	NP-LP
<u>Kahayan</u>	C.Kalimantan	<u>LP-HP</u>	LP-MP
Martapura	S.Kalimantan	LP	MP
Mahakam	E.Kalimantan	LP	LP

WQ status of rivers in Sulawesi

River	Province	US	DS
Tondano	N.Sulawesi	LP	LP
Bone	Gorontalo	LP	LP
Palu	C.Sulawesi	MP	LP
Jeneberang	S.Sulawesi	LP	LP
Konaweha	SE.Sulawesi	MP	MP
Batu Gajah	Maluku	LP	MP
Tabobo	N. Maluku	LP	NP
Anafre	Papua	LP	MP

**MONITORING OF WATER
QUALITY IN 16 RIVERS
(SUMATRA, JAVA, KALIMANTAN**



Observation and parameters

- Monitoring of water quality were conducted at 16 (sixteen) rivers in Sumatra, Java and Kalimantan in 2001-2002
- The observations were differentiated between the up stream and the down stream part of each river
- The parameters used in the observation are BOD, COD, DO, TDS, TSS



WQ in 6 rivers (Sumatra, 2000/01)

River	Prov	U/D	BOD mg/L	COD mg/L	DO mg/L	TSS mg/L	TDS mg/L
B.Hari	West Sum	U	-	0	7.5	0.5	10.0
		D	-	-	5.9	2.5	40.0
B.Hari	Jambi	U	4.3	7.5	6.5	-	87.0
		D	7.4	45.5	7.6	-	<u>370.0</u>
Siak	Riau	U	-	-	4.2	55.0	-
		D	-	-	2.4	79.0	-
Musi	South Sum	U	3.7	8.0	4.2	45.0	-
		D	5.3	12.5	3.9	35.0	-
Terusan	Lamp	U	4.3	12.7	5.4	-	20.0
		D	8.3	18.5	3.6	-	<u>356.0</u>
Pangubuan	Lamp	U	2.5	15.1	5.2	-	22.0
		D	<u>20.5</u>	<u>46.6</u>	4.9	-	<u>321.0</u>

WQ in six rivers (Java,00/01)

River	Prov	U/D	BOD mg/L	COD mg/L	DO mg/L	TSS mg/L	TDS mg/L
Citarum	W.Java	U	-	30.95	5.7	-	202.5
		D	-	8.2	2.8	-	137.6
Ciujung	Banten	U	1.8	8.2	-	55.2	-
		D	4.8	22.4	-	13.3	-
Ciliwung	Jakarta	U	17.8	34.8	-	105.5	-
		D	15.4	29.8	-	88.0	-
Cipinang		U	11.2	22.9	-	30.0	-
		D	23.9	60.3	-	40.0	-
<u>Moke vaart</u>		U	<u>35.6</u>	<u>88.21</u>	-	<u>86.0</u>	-
		D	<u>56.3</u>	<u>197.2</u>	-	<u>259.0</u>	-
Opak	Yogya karta	U	27.4	14.6	5.2	-	-
		D	4.5	16.6	5.4	-	-

WQ in 3 rivers (Kalimantan,00/01)

River	Prov	U/D	BOD mg/L	COD mg/L	DO mg/L	TSS mg/L	TDS mg/L
Maha kam	E.Kal	U	22.2	37.5	5.10	115.0	23.0
		D	11.0	46.9	4.65	113.0	10.3
Kapu as	W.Kal	U	12.8	23.0	-	21.0	16.4
		D	14.4	32.5	-	16.0	14.4
Marta pura	S.Kal	U	-	-	4.60	76.0	13.0
		D	-	-	2.02	<u>230.0</u>	45.0



Cases of river pollution

- River Rokan, Riau, uncontrolled disposal of liquid waste from PT Mahkota, 2002
- River Siak, Riau, liquid waste from pulp & paper factory, 2002
- River Citarik, West Java, caustic soda from pipe leakage in textile factory, 2001 (skin irritation)
- River Banger, Central Java, liquid waste from textile factories in Pekalongan (dead life stock)
- River Ngringo, Central Java, liquid waste from MSG Factory



Monitoring in Bali

**MONITORING OF WATER QUALITY
IN 25 RIVERS AND 4 LAKES (BALI)**



Result of monitoring

- Condition of WQ were evaluated against GR 8/2001 criteria with observations at 38 locations
- For Class I and Class II are categorized as heavily polluted for all locations
- For Class III are categorized as moderately polluted (37%) and heavily polluted (63%)
- For Class IV: very good (8%), good (58%), moderately polluted (21%), heavily polluted (13%)



MONITORING ON WATER QUALITY IN 22 RIVERS (SUMATRA)



WQ in 22 rivers in Sumatra

- Observation on water quality in 22 rivers in Sumatra was conducted in 1989-1990
- The rivers are located in Aceh, N. Sumatra, W. Sumatra, Jambi, S. Sumatra and Lampung
- Rivers were classified into Class A, Class B and Class C
- The criteria for the classification are :
turbidity (A<50; B = 50-100; C>100 mg/L) and
coli (A<5000; B<20.000; C>20.000 (total/100 ml))



Classification of rivers in Sumatra

Province	Rivers
	Class A
N. Sumatra	Asahan at Porsea, Siruar, Tangga
W. Sumatra	Bt Tambuo-Ikua Labuah
S. Sumatra	Komeriing-Sungai Dua
	Class B
Riau	Siak
Jambi	Batang Hari, Batang Tembesi
S. Sumatra	Musi-Pulokerto
Lampung	Way Seputih Dalam
	Class C
Aceh	Peusangan-Matang
N. Sumatra	Deli, Semayang, Asahan-T. Balai, Merbau
Riau	Tapung Kn-Kotagaro, Tapung Kr-Tandun
W. Sumatra	Batang Agam, Kampung Durian
Jambi	Batang tambir, Rantau Panjang,
Lampung	W. Seputih-P. Ratu, W. Pangubuan-T. Besar

WQ of rivers in Java, Sumatra and Kalimantan

River	BOD mg/L	COD mg/L
North Java (Citarum, Cimanuk, Cipunagara, Cisanggarung, Pemali, Comal, Sambong, Pekalongan)	1.8 - 33.0	7.7- 14.5
Cisangkuy	<u>9.90</u>	24.0
Ciliwung	4.4	14.6
Cisadane	6.2	25.0
Madiun	7.5	28.0
Brantas	4.9	64.0
Musi	9.1	30.0
Kapuas	6.1	12.0

WQ in river Cidanau, Banten

- Observation at 14 (fourteen) sampling stations from up stream to down stream
- River water are neutral to basic, lowest pH is 6.6 (13) and the highest pH is 8.8 (2)
- Electrical conductivity range from 2 (3) to 3.2 (9), turbidity from 16 (11) to 90 (5)
- DO vary from 1.9 (4) to 5.1 (3), temperature from 25.6 °C (3) to 28.8 °C (12), NO₂ from 2 (7,8,12) to 4 mg/l (1,2,5,6,9,10).



WQ of rivers in 9 cities

- Observation on river water quality was conducted in 1993-1998
- Observation covered 9 (nine) rivers in Sumatra, Java, Bali, Kalimantan and Sulawesi
- The parameters are FC, DO, NH₃, Cu, Cr, Cd, Pb, Zn, and Phenol
- Result of the study showing parameters exceeding the standard criteria of Class B is presented in the following table



Parameters exceed standard criteria

No	City	River	Parameter exceeding standard criteria (Group B)
1	Jakarta	<u>Ciliwung</u>	FC,DO,NH-3-N,CU,Zn
2	Bandung	Cikapundung	FC,NH3-N,DO
3	Semarang	K. Garang	FC,NH3-N,DO
4	Surabaya	<u>K. Surabaya</u>	FC,NH3N,DO,Cr,Cd,Pb
5	Palembang	Musi	NH3-N,DO
6	Pekanbaru	Siak	NH3-N,DO
7	Pontianak	Kapuas	FC,NH3-N,DO
8	Manado	Tondano	NH3-N,DO
9	Denpasar	T. Badung	FC,NH3-N,DO



Study of river Ciliwung, West Java

- Implemented in 2004 with 15 (fifteen) sampling stations
- Cover physical, chemical and biological parameters
- BOD plays an important role, FC and TC significantly decrease the water quality
- Bacteria pollute river water starting from up stream to the down stream.
- The river status decrease from Puncak (50) at up stream to Manggarai(85) at down stream



Ten year Clean River Program in Jakarta (1989-98)

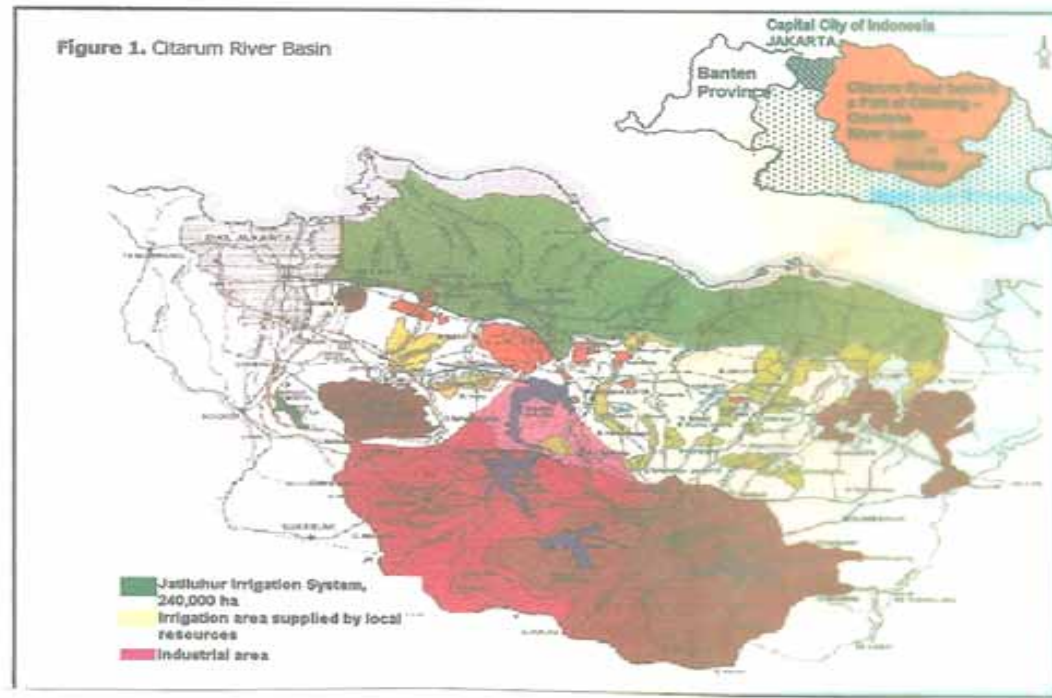
River	BOD (mg/L)		COD (mg/L)		TSS (mg/L)	
	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.
Ciliwung	10,590	556	19.79	1.44	4,120	635
Cipinang	537	484	18.79	1.03	1,940	210
Moke vaart	24,220	523	56.71	1.40	1,670	167
Grogol	336	<u>63</u>	918	130	423	218
Cakung	1,050	1,720	10. ,30	650	820	<u>78</u>

WQ study in river Citarum

- Study on water quality of river Citarum was conducted for 10 (ten) years from 1993 to 1999.
- The observation use BOD as the parameter for water quality
- The BOD increase in 7 sampling locations and decrease in 3 locations
- Highest BOD was detected at Nanjung and increasing, the lowest in R.Dengklok and decreasing during the period



Citarum river basin



Variation of BOD (mg/L)

River	Location	1993	1997	1999
Citarum	Sapan	31.43	33.30	34.50
	Batujajar	60.01	70.20	76.80
	Tj. Pura	12.67	14.30	10.60
	R.Dengklok	10.53	16.00	9.20
Cikapundung	D. Kolot	56.88	28.33	30.27
Cisangkuy	D. Kolot	37.91	19.68	23.87
Cimahi	Nanjung	186.03	197.99	236.43
Cikao	Bandung	15.55	29.05	31.17
Cikaran	K.Muara	35.43	45.19	18.67
K.Bekasi	W.Pojok	14.55	19.88	14.10

Other WQ study in Citarum

- Other study on water quality in Citarum was conducted at 13 locations in 2001 using physical, chemical and biological parameters
- Criteria used is the National Standard for PW on Water Quality (1990) and Method for Examination of Water Quality (1992)
- Source of pollution are industrial and domestic wastes from Bandung, Purwakarta and Karawang regencies.



Physical-Chemical Index

Tributary	Location	PCI
Cidurian	Jl. Suci, Bandung	30
Cikapundung	Jl. Siliwangi, Bdg	91
Cibeurem	Ledeng	69
Cimahi	Cisarua	85
Ciwedey	Soreang	91
Cisangkuy	Banjaran	86
Cirase	Ciparay	84

Proposed measures for upper Citarum (1)

- Reduce pollution by installation of Treatment Plants
- Increase control measures through law enforcement (93% industries own TP but operated improperly)
- Increase public participation in caring the rivers as a vital asset for life
- Limitation of new potential polluters industries through tight licensing



Proposed measures for upper Citarum (2)

- Increase water holding capacity by construction of small reservoirs
- Reduced Nitrogen and Phosphorus to prevent eutroficcation at Saguling through application of appropriate technology
- Set-up detail of ater Pollution Control action plan and formulating definite task for each involved institution
- Maintain continues monitoring of water quality for evaluation of the action plan achievement



Study in river Brantas

- A study on water quality in river Brantas was conducted in 1987 to set-up target for water quality management enacted by Gov.Decree
- Master plan for water quality control was prepared in 1989 and evaluated in 1997
- There are Short Term (→ 1995), Intermediate Term (→ 2000), and Long Term Plan (→2010)
- Scenario was set-up to decrease liquid waste load to achieve LTP target to reduced 80 % of industrial and 50% of domestic waste



Pollution control target (without/with measures)

Target of waste load	STP (→1995)	ITP (→2000)	LTP (→2010)
Without	control	measures	
Domestic	109	140	212
Industrial	54	63	73
Total	163	203	285
With	control	measures	
Domestic	28	107	49
Industrial	12	7	7
Total	40	114	56

STUDIES ON WATER QUALITY IN LAKES



Lake Toba and Batur

- Study on water quality was conducted in lake Toba (North Sumatra) and lake Batur (Bali)
- For BOD both lakes exceed the standard criteria of Class I
- Cadmium was detected at 6 locations in lake Toba
- Existence of heavy metal and organic pollutant of industrial, domestic and agricultural waste from the surrounding area.



Lake Cidanau, Banten

- Study on water quality in lake Cidanau was conducted at 7 sampling locations
- Water acidity range from pH values of 6 to 7.6
- Electrical conductivity range from 103 to 272, turbidity from 4 to 85
- DO range from 0.20 to 4.66, temperature from 25.6 to 27.0 °C, NO₃ are similar at all locations.
- Change of water quality is caused by drainage water from paddy field in upper area



Lake Gede and lake Cipondoh

- Study on WQ was conducted in lake Gede (Tangerang) and lake Cipondoh (Bogor) in 1999.
- Water in lake Gede is used to be utilized for fish culture, and from the result of the study it was stated as good in quality
- Water in lake Cipondoh also used for fish culture from the result of the study it was stated as good in quality



Water quality in lake Gede

Parameter	Unit	Sta-1	Sta-2	Sta-3
TDS	mg/L	40	45	45
TSS	mg/L	30	43	58
Turbidity	NTU	0.48	0.50	0.52
pH	-	6.8	6.5	6.0
DO	mg/L	5.7	5.7	5.5
BOD	mg/L	4.7	5.9	6.3
N-NH3	mg/L	0.34	0.43	0.49
N-NH2	mg/L	1.46	3.40	4.03
N-NO3	mg/L	trace	0.02	0.02

Water quality in lake Cipondoh

Parameter	Unit	Sta-1	Sta-2	Sta-3	Sta-4	Sta-5
TSS	mg/L	32	26	60	48	48
Turbidity	NTU	7.1	4.5	135	110	105
pH	-	7.4	7.3	6.9	7.1	6.9
DO	mg/L	5.7	5.7	4.1	4.1	6.6
BOD	mg/L	3.5	3.7	5.9	3.5	2.9
N-NH ₃	mg/L	0.34	0.28	0.20	0.19	0.14
N-NO ₃	mg/L	0.15	0.07	0.12	0.18	0.01
N-NO ₂	mg/L	0.04	0.02	0.02	0.01	0.01

Recommendation for fishery

- For fishery development, suggestions include awareness in water quality, preservation and skill development.
- Site selection should consider :
 - a. location ; open to oxygen penetration process from the air, and free from pest and pollutant disturbance
 - b. depth of water ; > 4 m for floating net, 1-3 m for embedded net



STUDIES ON WATER QUALITY IN RESERVOIRS



WQ study Saguling, Cirata, Jatiluhur

- Study on water quality was conducted in Saguling, Cirata and Jatiluhur reservoirs
- The method used is the Indonesia National Standard 06-2412-1991 (Sampling Method for Water Quality Analysis)
- During the period of the study (1993-1999), observations revealed deterioration of water quality and increase in BOD



Increase of BOD in the reservoirs

Reservoir	Capacity (MCM)	Average BOD (mg/L)		
		1989	1997	1999
Saguling	982	18.04	19.54	23.75
Cirata	2.165	7.15	7.70	<u>18.76</u>
Jatiluhur	3.000	3.19	2.58	4.74

Content of Organic Matter

Reservoir	Content (ton/year)		
	OM	N	P
Saguling	49.974	2.186	311
Cirata	199.224	8.715	1.242
Jatiluhur	16.791	735	105

Fishery area in Jatiluhur reservoir

- Study on water quality at the fishery area of Ciganea in Jatiluhur reservoir was conducted in 1996 to respon the incident of fish death
- Approaching the time of incident, oxygen content was decreasing from 8 to 4 mg/L
- At the time of incident, oxygen content was very low (1-2 mg/L) and ammonia content increased significantly (0.369 to 1.476 mg/L)
- Ten days after, oxygen content increased to 5.86 mg/l and ammonia decreased to traceable



Oxygen content (mg/L)

Time to incident	Date (1996/97)	At surface	2 m depth
Prior	November 3	7.7	7.7
During	December 5	2.1	3.7
After	January 5-7	4.5	4.0



Recommendations for fish culture

- Select appropriate location for fish culture
- Limit population to recommended amount
- Do not practice excessive fertilization
- Preferably use floating type of fertilizer



WQ parameters for Saguling, Cirata, Jatiluhur

- Study in 2001 at Saguling, Cirata and Jatiluhur detected several parameters exceeding the standard criteria of Group B,C and D
- Observations were implemented in July and September 2001 at inlet and outlet of each reservoir
- Depth of the observation is 0.2 m, 5 m, 10 m, 15 m and 20 m.
- Result of the study is shown in the following table



Parameters exceeding the standard criteria (B,C,D)

Location:	Depth (m)	July 01	Sept. 01
Sgl : Bongas	0.2/15	COD/NH₃,DO,S	-/DO,S
Intake	0.2/	BOD,COD/	COD,BOD/
Outlet	15	NH₃,DO,COD,S	COD
	0.2	S	COD,S
Crt: P.Buleud	0.2/10	-/DO	-/DO
Intake	0.2/10	NH₃/NH₃	-/DO
Outlet	0.2	DO,COD	COD
Jtl: T.Sindang	0.2/10	-/S	-/
Intake	0.2/15	-/NH₃,S	-/
Outlet	0.2	DO,COD	DO,COD

Concluding remarks (1)

- Results of monitoring and studies on water quality in rivers, lakes and reservoir, showed that many, if not mentioned as most, had been polluted at various level, by domestic, industrial and agricultural wastes, particularly in the densely populated and industrial areas
- Possible causes for pollution of water bodies are lack of public awareness, improper spatial planning, lack of coordination, limited treatment plant, lack of incentives, limited budget allocation and ineffective law enforcement



Concluding remarks (2)

- **Monitoring and studies on water quality have been implemented for many years, but limited to selected locations/subjects, and lack of effective coordination**
- **Implementation have been done by various institutions (universities, research center, industries, professional societies and NGO)**
- **Parameter, standard criteria and accuracy vary from one to other institutions and locations, depending on the different objective and budget allocation**
- **Result and data from the monitoring and studies are not properly distributed among the implementing institutions as well as its dissemination to the users**



Concluding remarks (3)

- **Coordination and integration in the implementation of monitoring and studies, as well as data exchange and utilization need to be enhanced**
- **National standard criteria should be comprehensive and integrated in its formulation, well socialized and effectively applied**
- **Public awareness should be highly motivated and reward system applied for better performance in water quality control and management**
- **Support from national, regional or international institutions will be very useful to help in achieving better water quality control and management.**



THANK YOU

