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CONTENTS

RAW WATER QUALITY DEVELOPMENT: STRATEGY AND CONSTRAINT. A CASE STUDY AT SEVERAL DISTRICT CORPORATION OF DRINKING WATER (*Perusahaan Daerah Air Minum/PDAM*)

Wati Pranoto[1], Ratna Hidayat[2],and Reri Hidayat[3]

ABSTRACT

In one hand, the demand of Raw Water has increased significantly, following Raw Water scarcity supplies in 308 PDAM. On the other hand, the advantage of using river raw water is based on its plentiful quantity for supporting the services of urban water. However, most of the available water is often polluted. This caused greater operation cost compared to the operational cost of spring water. The river raw water quality for PDAM in Sumatera, Java, Kalimantan and Sulawesi are not suitable to be used for drinking water, due to number of parameters exceeding the concentration criteria, which are: (1). BOD: 3.5-52 mg/L(criteria 2 mg/L); (2). COD: 12–87 mg/L (criteria 10 mg/L); (3). Dissolved Oxygen too low: 2- 4.5 mg/L (Criteria greater than 6 mg/L); (4). Detergent too high: 0.20 – 0.75 mg/L(criteria 0.20 mg/L); (5). Concentration of Fecal Coli bacteria at PDAM Jakarta: 2,800,000 Total Amount/ 100 mL (Criteria 100 Total Amount /100 mL). Another problem is caused by sea water intrusion which had increased the concentration of chloride (15,200 mg/L) and sulfate (2,900 mg/L). Strategies such as technical and law enforcement are needed.

Keywords: PDAM. Raw water, Polluted water sources, Technical strategy. Law enforcement

INTRODUCTION

About 60% of the available raw water that are provided by rivers are supplying a total of 308 PDAM and the rest of water supply are provided by spring water, deep wells, reservoirs and lakes (Anonymous, 2000). The number of people receiving clean water from PDAM is still very low, which is 18 % (39.5 million) of the total population within the 33 provinces. Other water needs are provided by uncontaminated domestic wells (61% or 133.8 million people) and by contaminated domestic wells (21% or 48.1 million).

Concerning the increasing demand of clean water, The Millenium Development Goal 2015 (MDG) program aim that the community should had enough access to safe clean water.

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Therefore PDAM should develop its capacity in supplying clean water (Directorate General for City and Rural Development, Department of Public Works, 2005).

The constraint in developing DWSS (Drinking Water Supply System) is substituting the raw polluted water contaminated by waste disposal, which should be purified by PDAM. The burden of debt is another constraint for developing PDAM performance. For example, in PDAM Samarinda, the operation of providing clean water must be postponed just because of sea water intrusion in dry season (Hidayat, R.2001).

The prime objective of this study is to evaluate the performance of PDAM using raw water from rivers and explore a development strategy based on the evaluation.

The study is focused on river water as source of raw water, technical data and financial condition at 17 PDAM.

The methods of study are as follows:

Phase 1: Identification of PDAM and raw water quality evaluation

Phase 2: Analysis of clean water use per person per day, service area, and PDAM capacity

Phase 3: Development of strategy for PDAM to fulfill clean water demand

Identification of services and financial condition of PDAM

Based on the observation conducted at Java, Sumatera, Kalimantan and Sulawesi, The 17 PDAM are providing clean water for 18% - 61% of the total amount of population. 8 PDAM among the 17 PDAM are supplying only 50 % of population which are in Tangerang, Semarang (Java), Pekanbaru, Padang, Bengkulu (Sumatera), Palangkaraya, Samarinda (Kalimantan) and Manado (Sulawesi). Such conditions indicate that PDAM should improve its consumer services.

Financial constraints encountered have been solved by loan for development of PDAM. The financial conditions can be divided into three categories: healthy, less healthy and unhealthy (Directorate General for City and Rural Development, Department of Public Works, 2005), explained in the following table.

Table 1. PDAM dependencies on river water in 17 cities

Island	PDAM	Raw Water	Population	Services	Financial Condition
Jawa	1Tangerang	S.Cisadane	1,533,963	22 %	Less Healthy
	2.Jakarta	Kanal Pejompongan	8,398,269	44 %	(-)
	3.Bekasi	S. Bekasi	3,414,000	9 %	(-)
	4.Semarang	K.Garang	1,415,400	46 %	Unhealthy
	5.Surabaya	K.Surabaya	2,864,100	54 %	Healthy
Sumatera	6.Pakanbaru	S.Siak	615,534	18 %	Less Healthy
	7.Padang	Bt.Kuranji	781,508	35 %	Unhealthy
	8.Sawahlunto	Bt.Ombilin	53,837	64 %	(-)
	9.Jambi	S.Batanghari	416,841	55 %	Less Healthy

	10.Sorolangon	Tembesi	525,100	8 %	(-)
	11.Bengkulu	Air Bengkulu	358,300	18 %	Less Healthy
	12.Palembang	S.Musi	1,523,200	31 %	(-)
Kalimantan	13.Pontianak	S.Landak	513,977	50 %	Unhealthy
	14.Palangkaraya	S.Kahayan	182,300	31 %	Unhealthy
	15.Banjarmasin	S.Alalak	575,000	61 %	Less Healthy
	16.Samarinda	S.Mahakam	660,000	46 %	Less Healthy
Sulawesi	17.Manado	S.Tondano	441,900	39 %	Unhealthy
Note : (-) : no data ; Source : Direktorat Cipta Karya, DPU, Januari, 2006					

The PDAM financial constraints can be overcome by debt restructuring through the following process:

(1) Rescheduling of debt refunding, capital, interest rate, and fine. Rescheduling is processed by evaluating the performance of PDAM and compromises: (a).With or without time extension (refunding capital, interest rate, and fine), (b).Without time extension for rescheduling of commitment fee.

(2) Change of debt requirements: (a).PDAM obtain change of requirements when its financial conditions are not sufficient to carry out refunding to maximum limit of 20 years, (b).Change of interest rate (loan in local currency-maximum 4% below interest rate stipulated formerly and new interest rate not smaller than 8.3%. whereas for loan in foreign currency-maximum 0.25%, below the interest rate of stipulated loan)

(3) Total nullification, put into effect for PDAM with insufficient financial conditions when rescheduling is implemented or when financial conditions are still insufficient when a change of requirement in the form of interest rate reduction is granted.

The process of restructuration is completed when PDAM conveys an application to the Minister of Finance through the Directorate General of Treasury, then forwarded to local authorities and Legislative Assembly (Budiman Sidik, 2006), with attached documents as follow: (1). Performance report of last 3 years audited by an independent auditor on financial profit/loss cash flow, financial balance and PDAM last year performance evaluation; (2). Work program and enterprise payment installment (WPEPI), cost estimation for last 3 years; (3). Statement by the Director of PDAM on the commitment of implementing WPEPI.

Quality Evaluation of PDAM Raw Water in Term of Measurement

The term of measurement applied to evaluate water sources quality in Indonesia means the "Baku Mutu dan Peruntukan Sumber Air" (Standard Criteria and Supply of Water Resources Beneficial Use) mentioned in PP 82/2001 (Government Regulation), on "Water Quality Management and Water Pollution Control". It is categorized into four classes, as follows:

- **Class I,** water used for raw drinking water and other usage with similar water criteria.
- **Class II,** water used for water recreation facilities/apparatus; fresh water fish cultivation, life stock, irrigation water, and other usage with similar water criteria

- **Class III,** water used for fresh water fish cultivation, life stock, irrigation water, and other usage with similar water criteria
- **Class IV,** water used for irrigation water, and other usage with similar water criteria

PDAM raw water quality is evaluated by a comparison between criteria measurement results and Class I water source usage.

Quality Analysis of PDAM Raw Water related to Organic and Bacterial Pollutants

The measurement of PDAM raw water quality had been held for five years (1995–1999), with measurement frequency of 5 to 25 times (Research Institute for Water Resources Development, 1995 to 1999). The result showed pollution degree of raw water can be calculated by comparing parameters insufficient to criteria of total measurement data described in percentage (Table 2). Following table indicates that three of five parameters are not fulfilling the raw water criteria as observed as the standard water quality at all PDAM raw water intake.

Table 2. PDAM Raw Water Quality

PDAM	Min-Max Concentration (Data Percentage of Unsuitable Criteria)				
	BOD	COD	DO	Detergent	Coliform Bacteria
1.Tangerang n=8	2.5-5.8 (100%)	4-9.2 (0%)	3.2-5.8(100%)	0.008-0.025(0%)	28-280 (50%)
2.Jakarta,n=12	5.7-24(100%)	9.2-36(92%)	0.1-5.3(100%)	0.01-0.50(17%)	$(8\text{-}28)x10^3$(100%)
3.Bekasi, n=19	1.4-6.3(74%)	3.2-12 (5%)	3.9-6.7(47%)	0.01-0.03(0%)	34-1400 (82%)
4.Semarang , n=9	2.1-4.5(100%)	8.6-20 (71%)	4.9-7(43%)	0.05-0.61(25%)	(-)
5.Surabaya, n=9	5-52(100%)	8.6-87 (89%)	2-5.3(100%)	(-)	$(1.2\text{-}19)x10^3$(100%)
6.Pakanbaru , n=25	1.4-18(92%)	12-68(100%)	2.2-6.1(95%)	0.01-0.62(16%)	(-)
7.Padang , n=7	0.4-4.2(50%)	1.5-12(14%)	6-7.7(0%)	0.026-0.75(29%)	70-390(67%)
8.Sawahlunto ,n=4	0.6-2.1(25%)	3.6-13(50%)	6.5-7.2(0%)	0.021-0.17(0%)	150-150(100%)
9.Jambi, n=3	2.5-4.4(100%)	5.7-10(50%)	4.5-6.7(0%)	0.03-0.06(0%)	950-3590(100%)
10.Sorolangon , n=4	0.7-4.2(75%)	4.7-47(50%)	6.2-6.5(0%)	0.01-0.06(0%)	3255-7600
11.Bengkulu, n=5	1.3-7.1(75%)	14-22(100%)	5.8-7.4(67%)	0.28(20%)	(-)
12.Palembang, n=21	0.4-3.5(22%)	1.8-20(30%)	3.7-7.6(56%)	0.01-0.66(19%)	(-)
14.Palangkaraya , n=4	(-)	12-34(100%)	7.2-7.9 (0%)	0.01-0.23(25%)	(-)
13.Pontianak, n=25	1.9-3.1(60%)	6.3-47(83%)	3.1-5.4(100%)	0.01-0.53(13%)	(-)
15.Banjarmasin, n=24	4.3-15(100%)	3.8-67(90%)	3.7-6.4(96%)	0.01-0.21(5%)	(-)
16.Samarinda,n=20	(-)	6-46(79%)	2.5-6.8(82%)	0.02-0.34(26 %)	(-)
17.Manado, n=3	(-)	3.8-18(33%)	6.9-8.2(0%)	0.02-0.18(0%)	(-)
Class I Raw Water Criteria,PP 82/2001	**2 (mg/L)**	**10 (mg/L)**	**6 (mg/L)**	**0.20 (mg/L)**	**100 (Total/100mL)**
Note: n= total of water quality monitoring result data ;(-) : not measured					

BOD,COD,DO, Detergent and Coli form Bacteria concentration which found in each PDAM raw water are not suitable to criteria as illustrated on Figure 1,2,3 ,4 and 5.

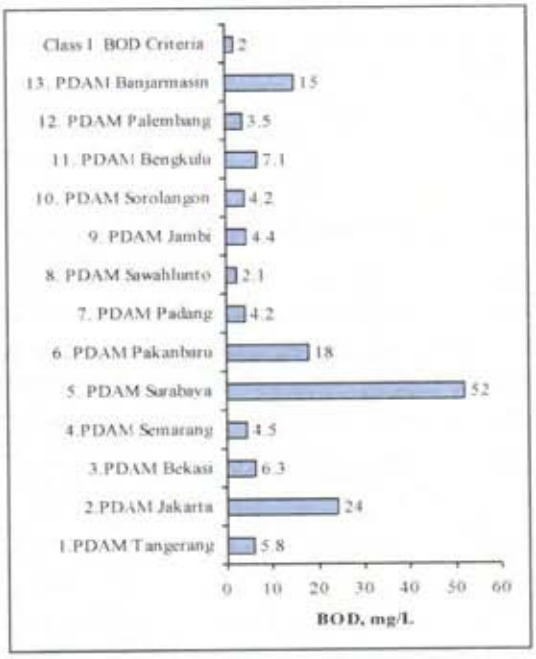


Figure 1. BOD concentration detected in PDAM raw water

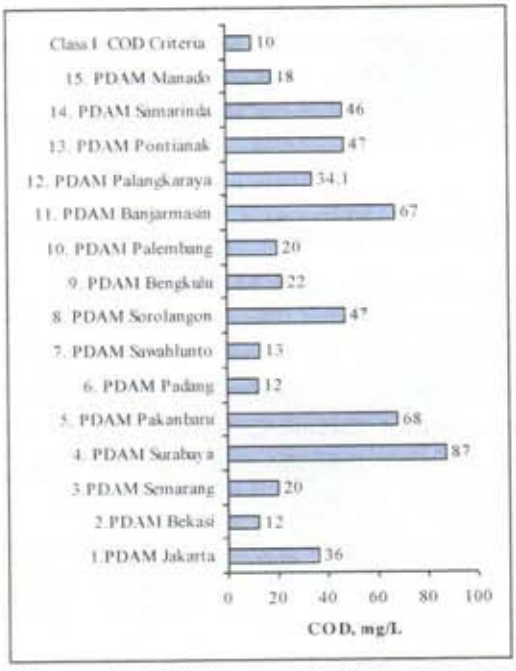


Figure 2. COD concentration detected in PDAM raw water

Figure 1 shows that most of BOD concentrations in certain provinces does not fulfill the standard criteria of raw drinking water. It is observed at 13 PDAM out of 17 PDAM that concentration range between: 2.1-52 mg/L (criteria 2 mg/L). Rivers on Java, Sumatera and Kalimantan are heavily polluted, proved by BOD concentration in raw water PDAM at Surabaya (Java): 52 mg/L, Jakarta (Java): 24 mg/L, Pekanbaru (Sumatera): 18 mg/L and Banjarmasin(Kalimantan): 15 mg/L. BOD concentration at other PDAM were below than 10 mg/L, indicating a relatively low pollution rate.

COD concentration not suitable to raw drinking water criteria (Figure 2), was observed at 15 PDAM Intake out of 17 PDAM in studied area, showing a concentration between: 12-87 mg/L (criteria 10 mg/L). A high COD concentration was detected in PDAM raw water at Surabaya (Java): 87 mg/L; Pekanbaru (Sumatera):68 mg/L; Banjarmasin (Kalimantan) 67 mg/L; and respectively 47 mg/L at Pontianak (Kalimantan) and Sorolangon Bangko (Sumatera); Samarinda (Kalimantan) 46 mg/L; Jakarta (Java) 36 mg/L; Palangkaraya (Kalimantan): 34 mg/L; Bengkulu (Sumatera): 22 mg/L; and respectively 20 mg/L at Palembang (Sumatera) and Semarang (Java); and Manado (Sulawesi) 18 mg/L. Other PDAM showed a COD concentration below 13 mg/L, indicating a relatively light pollution rate, detected in the rivers Cisadane, Batang Kuranji and Batang Ombilin.

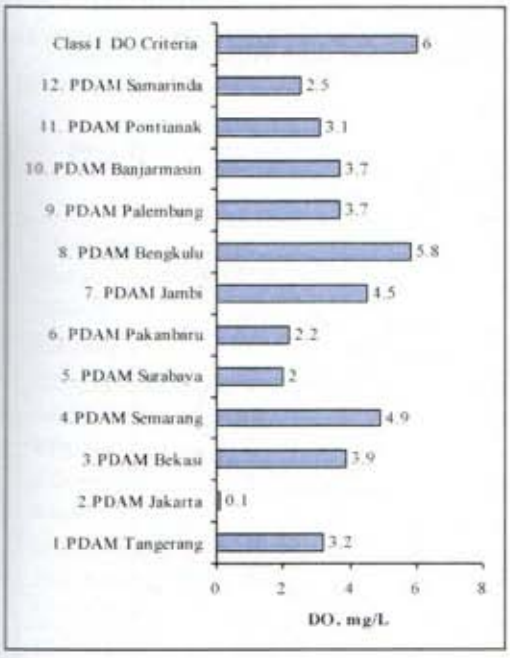


Figure 3. DO concentration detected in PDAM raw water

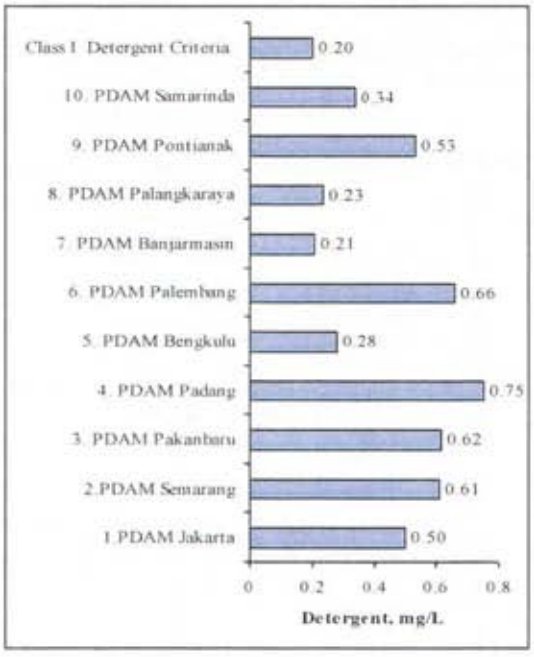


Figure 4. Detergent concentration detected in PDAM raw water

Low DO concentration which is not suitable to standard criteria of raw drinking water (Figure 3) was detected at 12 PDAM intake out of 17 PDAM in studied area, showing an concentration ranging between: 0,1-5,8 mg/L (Criteria must be greater thab 6 mg/L). Low DO concentration was detected in PDAM raw water at PDAM Jakarta (Java) 0.1 mg/L; Surabaya (Java) 2 mg/L; Pekanbaru (Sumatera) 2.2 mg/L; Samarinda (Kalimantan) 2.5 mg/L, whereas DO concentration in raw water at other PDAM showed a range between 3 – mg/L to 5.8 mg/L, detected at PDAM Pontianak (Kalimantan); Tangerang (Java); Palembang (Sumatera); Banjarmasin (Kalimantan); Bekasi (Java); Jambi (Sumatera); Semarang (Java) and Bengkulu (Sumatera).

Other pollutant indicators that exceed standard criteria are concentration rate of Detergent and Coliform Bacteria (Figure 4 and 5).

Detergent concentration at 10 PDAM out of 17 PDAM was not suitable to criteria, showing a range between: 0.21- 0.75 mg/L (criteria 0.20 mg/L). High Detergent concentration was detected at PDAM Padang (Sumatera) 0.75 mg/L; Palembang (Sumatera) 0.66 mg/L; Pekanbaru (Sumatera) 0.62 mg/L; Semarang (Java) 0.61mg/L; Pontianak (Kalimantan) 0.53 mg/L dan Jakarta (Java) 0.50 mg/L.

Coliform Bacteria as shown on Figure 5 was only detected in eight PDAM raw water, while raw water of the other nine PDAM could not be measured because of limited technical apparatus. Highest concentration was detected at PDAM Jakarta (Java) - 2.800.000 Total/100 mL, followed by PDAM Surabaya (Java) - 19.000 Total/100 mL.

Coliform Bacteria observed in PDAM water indicates that feces are disposed into rivers. Such conditions indicate the limited amount of Centralized Domestic Wastewater Treatment Installation Indonesia.

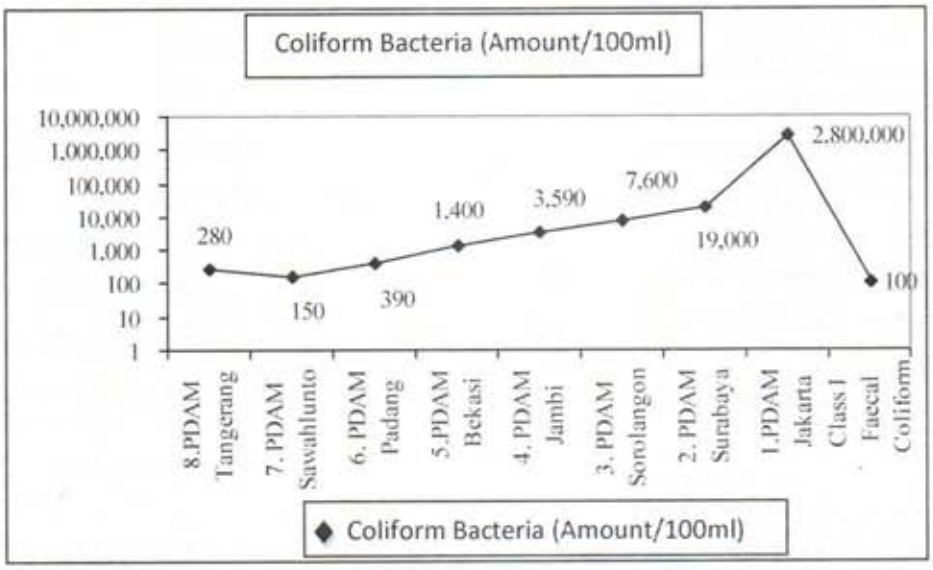


Figure 5. Fecal Coliform Bacteria Concentration Detected in PDAM Raw Water

PDAM Raw Water Pollution Rate Based on COD and DO Parameters

COD and DO parameters can be measured at each PDAM. Thus, both parameters are stating that the pollution rate in PDAM raw water described as data percentage which are not fulfilling the criteria of raw drinking water (Table.3).

The pollution rate based on COD and DO parameters are:

- ***Extremely Heavy*** (score: 40-49): 18 % - detected at PDAM Pakanbaru (Sumatera), Pontianak (Kalimantan), and Banjarmasin (Kalimantan):
- ***Very Heavy*** (score :30-39) : 6 % - detected at PDAM Samarinda(Kalimantan);
- ***Heavy*** (score :20-29) :6 % - detected at PDAM Jakarta (Java);
- ***Moderate*** (score :10-19) :24 % - detected at PDAM Bekasi (Java), Semarang(Java), Surabaya(Java) and Palembang (Sumatera):
- ***Light*** (score :1 -9) : 46% - detected at PDAM Tangerang (Java), Padang (Sumatera), Sawahlunto (Sumatera), Jambi (Sumatera), Sorolangon (Sumatera), Bengkulu (Sumatera), Palangkaraya (Kalimantan) and Manado (Sulawesi)

Table. 3. PDAM raw water pollution rate based on COD and DO parameters

PDAM	Score	PDAM Raw Water Quality Pollution Rate				
		Extremely Heavy (40-49)	Very Heavy (30-39)	Heavy (20-29)	Moderate (10-19)	Moderate (1-9)
1.Tangerang	8					√
2.Jakarta	23			√		
3.Bekasi	10				√	
4.Semarang	10				√	
5.Surabaya	17				√	
6.Pakanbaru	49	√				
7.Padang	1					√
8.Sawahlunto	2					√
9.Jambi	2					√
10.Sorolangon	2					√
11.Bengkulu	8					√
12.Palembang	18				√	
13.Pontianak	46	√				
14.Palangkaraya	4					√
15.Banjarmasin	45	√				
16.Samarinda	32		√			
17.Manado	1					√

Note : Processed from a five years period measurement results (1995-1999)

Sea Water Intrusion Detected in PDAM Raw Water.

Sea water intrusion detected at PDAM Samarinda with supply of raw water from the Mahakam River is showing chloride concentration (10,000 mg/L) and sulphate concentration (1000 mg/L) in dry season. Such constraint could postpone the proccess of the Water Treatment Installation (WTI)

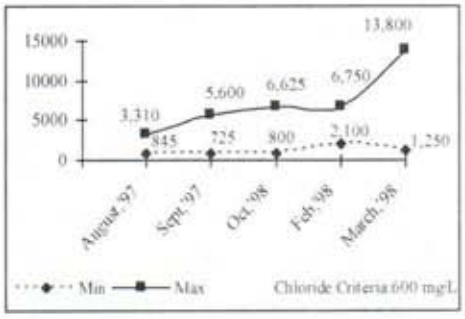
Evaluation on instrusion is done by comparing raw water quality against water salinity classification:

Table 4. Water salinity classification

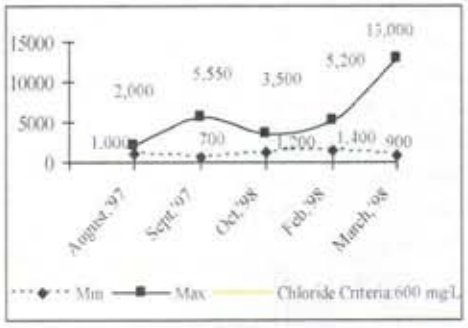
No	Classification	Intrusion Indicator Parameters, mg/L		
		Total Dissolved Solids(TDS)*)	Chloride**)	Sulphate **)
1	**Fresh Water**	< 1.000	< 560	< 80
2	**Brackish**			
	Low	1.000 – 3.000	560 – 1.680	80 – 240
	Moderate	3.000 – 6.000	1.680 – 3.360	240 - 480
	High	6.000 – 10.000	3.360 – 5.600	480 - 790

3	**Saline** **Moderate** **High**	 10.000 – 35.000 35.000 – 100.000	 5.600 – 19.600 19.600 – 56.000	 790 – 2.765 2.765 – 7.900
4	**Brine**	> 100.000	> 56.000	> 7.900
*). Anonymous,1979,"Water Quality Criteria, US EPA;**): Sea water Estimation, Water Loch,1981				

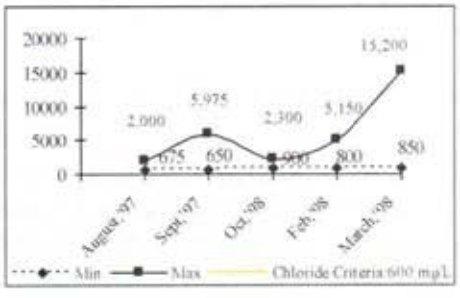
Chloride and sulphate are parameters of instrusion at PDAM Samarinda during three months of dry season in 1997 (August, September and October) and two months in 1998 (February and March). Chloride fluctuation indicated respectively minimum: 625-2,100 mg/L and maximum: 1,850-15,200 mg/L (Figure 6) and sulphate fluctuation minimum: 86 – 100 mg/L and maximum: 1,130 – 2,906 mg/L (Table 5).



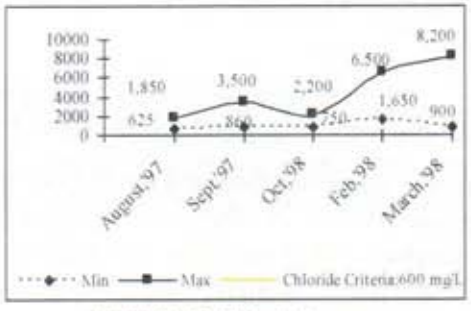
(a). PDAM Palaran



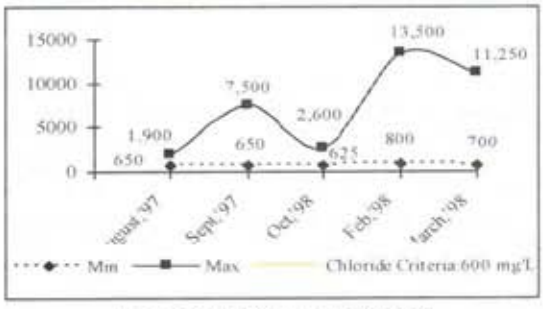
(b). PDAM Selili



(c) PDAM Samarinda Seberang



(d).PDAM Teluk Lerong



(e). PDAM Slamet Riyadi

Figure 6. Chloride fluctuation at PDAM Samarinda (Kalimantan)

Table 5. Sulphate concentration at PDAM Samarinda (Kalimantan)

No	PDAM	Sulphate, mg/L		Raw Drinking Water Criteria
		Min	Max	
1	Palaran	100	1.903	**400**
2	Selili	97	1.792	**400**
3	Samarinda Seberang	90	2.906	**400**
4	Teluk Lerong	86	1.130	**400**
5	Slamet Riyadi	86	1.862	**400**

Sea water intrusion has affected the raw water quality at PDAM Samarinda such that its quality is not suitable according to the raw drinking water criteria, therefore PDAM Samarinda has to stop its operation. Constraint at each intake is explained as follow:

(a) Intake of PDAM Palaran, Chloride salinity range: low brackish –moderately saline, and sulphate: low brackish – moderately brackish (44.4% of data not suitable to criteria). Constraint, clean water supply to consumers stopped for 2.5 – 6 days

(b) Intake of PDAM Selili, Chloride salinity range: low brackish –moderately saline, and sulphate: low brackish – moderately brackish (35.8% of data not suitable to criteria). Constraint, clean water supply to consumers stopped for : 4.7 – 9.5 days

(c) Intake of PDAM Samarinda Sebrang, Chloride salinity range: low brackish – moderately saline, and sulphate: low brackish – moderately brackish (33.1% of data not suitable to criteria). Constraint, clean water supply to consumers stopped for: 2.5 – 6 days

(d) Intake of PDAM Teluk Lerong, Chloride salinity range: low brackish –moderately saline, and sulphate: low brackish (31.1% of data not suitable to criteria). Constraint, clean water supply to consumers stopped for: 1.3 –7.6 days

(e) Intake of PDAM Slamet Riyadi, Chloride salinity range: low brackish –moderately saline, and sulphate: low brackish – moderately brackish (30 % of data not suitable to criteria). Constraint, clean water supply to consumers stopped for: 1- 8.9 days

The high sulphate concentration has resulted corrosive raw water and based on DIN 4030 (1969) concentration can be divided into three classifications: (1). Slightly Damaging, sulphate concentration range: 300 – 600 mg/L; (2). Very Damaging, sulphate concentration range: 600 – 3,000 mg/L and (3). Extremely Damaging, sulphate concentration > 3,000 mg/L

Based on sulphate concentration detected in PDAM raw water is classified as safe if referred to the minimum sulphate range of 86-100 mg/L, while considering maximum concentration rate the four PDAM raw water intake (Palaran, Selili, Teluk Lerong dan Slamet Riyadi) are very damaging. Raw water at PDAM Samarinda Seberang is classified as extremely damaging - concentration rate is approaching 3,000 mg/L.

When sea water instrusion occurs, the Operation of Water Treatment Installation at PDAM Samarinda must be stopped, because:

- Present available Water Treatment Installation at PDAM Samarinda is only operated to treat raw water with normal chloride concentration, which is 600 mg/L;
- Intake and Water Treatment Installation will be corosive when each unit is constructed of concrete and iron plates.

If clean water supply to consumers is being stopped then one of the consequence will be the occurance of *Water Borne Diseases* (Table 6).

Table 6. Diarrhea epidemic at Samarinda

Period	Victim			
	A	B	C	Total
August,1997	-	-	3.124	3.124
September,1997	4.470	1.755	-	6.225
October,1997	3.135	1.022	-	4.157
February,1998	-	-	1.415	1.415
March,1998	-	-	836	836

Source : PDAM Samarinda,1999
A=Hospitalized ; B=Medical treatment;C=Unknown to be categorized as A or B

Analysis of Clean Water Usage per Person per Day

This study is focused on water usage in liter per person per day (L/P/D), where column (5), is calculated from water usage distribution in cum/month (column 3) against number of domestic clean water consumers (column 2). Result of the computation is divided by the number of household members (assumed five persons/household) converted to L/P/D (Table 7).

Table 7. Existing service condition of PDAM at study area

PDAM	Household Consumers	Existing Water Usage			
		Cum/Month	Cum/Day/Household	L/P/D	Water Loss
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
1.Tangerang	54.294	79,402	0.05	10	20%
2.Jakarta	174.985	4,208,775	0.80	160	57%
3.Bekasi	51.908	881,702	0.57	113	38%
4.Semarang	100.151	2,108,657	0.70	140	39 %
5.Surabaya	232.010	6,470,391	0.93	186	38 %
6.Pakanbaru	13.125	224,960	0.57	114	46 %
7.Padang	38.593	79,780	0.07	14	32 %
8.Sawahlunto	2.256	40,375	0.60	119	31 %

9.Jambi	30.775	492,730	0.53	107	34 %
10.Sorolangon	5.020	(-)	(-)	(-)	22 %
11.Bengkulu	9.668	175,096	0.60	121	39 %
12.Palembang	71.675	2,209,489	1.03	206	37 %
14.Palangkaraya	38.509	910,078	0.79	158	29 %
13.Pontianak	6.782	103,407	0.51	102	31 %
15.Banjarmasin	39.199	(-)	(-)	(-)	25 %
16.Samarinda	47.192	(-)	(-)	(-)	45 %
17.Manado	25.866	444,282	0.57	115	40 %

Note :Column (2) and (3) = Direktori Perpamsi,2000; Column (4)=Computation results : Column (3) divided by Column (2), divided 30 ; Column (5)=divided results of Column (4) with number of household member , assumed five person per household

By comparing the criteria for clean water usage, it could be classified to several categories by the Directorate for Clean Water at 17 cities - Directorate General of Housing (Table 8) against water usage (**L/P/D**). Thus, the quality of water service to consumers should be improved.

Table 8. Clean water usage criteria based on city category

Clean Water Usage	City Category Based on Number of Population				
	Metropolitan	**Large**	**Medium**	**Small**	**Village**
	> 1,000,000	**500,000- 1,000,000**	**100,000 – 500,000**	**20,000 – 100,000**	**<20,000**
L/P/D	170-190	150-170	130-150	100-130	90-100

Source : Direktorat Air Bersih,Ditjen Cipta Karya,DPU, Majalah Perpamsi, 91/XXII,Jan, 2001

Water loss at 16 PDAM is relatively high (22% - 57%). According to MDG in Indonesia, quality services could be improved and distribution area could be expanded, if the water loss was reduced to 20%. The expansion of distribution area needs additional investment cost for the installment of new distribution piping network.

Evaluation on PDAM Clean Water Service Condition

The extension of clean water usage is not available at all PDAM that were observed, because of the limited datas. Only two PDAM out of 14 PDAM are serving clean water based on the criteria - PDAM Surabaya supplies to consumers 186 L/P/D and PDAM Palembang 206 L/P/D (Table 8). The remaining 12 PDAM do not meet the expectation of the criteria, therefore service extension to consumers must be improved.

Table 9. PDAM Clean Water Service Evaluation Againts Clean Water Usage Criteria

PDAM	Population In 1000	Clean Water Criteria		Existing Services L/P/D	Remark
		City Category	L/P/D		
(1)	(2)	(3)	(4)	(5)	(6)
1.Tangerang	2,959	Metropolitan	170-190	10	To be improved
2.Jakarta	9,696	Metropolitan	170-190	160	To be improved
3.Bekasi	3,414	Metropolitan	170-190	113	To be improved
4.Semarang	1,415	Metropolitan	170-190	140	To be improved
5.Surabaya	2,864	Metropolitan	170-190	**186**	Meeting Criteria *)
6.Pakanbaru	710,2	Kota Besar	150-170	114	To be improved
7.Padang	806,5	Kota Besar	150-170	14	To be improved
8.Sawahlunto	108,2	Kota Sedang	130-150	119	To be improved
9.Jambi	470,8	Kota Sedang	130-150	107	To be improved
10.Sorolangon	525,1	Kota Besar	150-170	(-)	(-)
11.Bengkulu	358,3	Kota Sedang	130-150	121	To be improved
12.Palembang	1,523	Metropolitan	170-190	**206**	Meeting Criteria *)
13.Pontianak	513,9	Kota Besar	150-170	158	To be improved
14.Palangkaraya	182,3	Kota Sedang	130-150	102	To be improved
15.Banjarmasin	575	Kota Besar	150-170	(-)	(-)
16.Samarinda	660	Kota Besar	150-170	(-)	(-)
17.Manado	441,9	Kota Sedang	130-150	115	To be improved

Note : (-) : No data ; *)= need improvement in future
Coloum (2) = Direktori Perpamsi,2000; Coloum (3) and (4) Criteria based on Table 10; Coloum (5) = Clean Water Usage (existing service)

Coverage of PDAM Service and Capacity of PDAM Installation

PDAM clean water service covers an area of 7 – 54 %. Lowest coverage was observed at PDAM Sorolangon and higest at PDAM Jakarta and Surabaya. Comparison between design production capacity and existing service capacity at 15 PDAM are between 10 - 93 % - lowest at PDAM Samarinda and highest at PDAM Bekasi (Table 10).

Table 10. PDAM service conditions at study area

PDAM	Household Consumers	Service Coverage (%)	Comparison Production Design Capacity and Existing Capacity
(1)	(2)	(3)	(4)
1.Tangerang	54.294	11 %	84%
2.Jakarta	174.985	54 %	86%
3.Bekasi	51.908	9 %	93%
4.Semarang	100.151	46%	86%
5.Surabaya	232.010	54 %	79%

6.Pakanbaru	13.125	14 %	(-)
7.Padang	38.593	31 %	74%
8.Sawahlunto	2.256	26 %	39%
9.Jambi	30.775	46 %	(-)
10.Sorolangon	5.020	7 %	68%
11.Bengkulu	9.668	18 %	80%
12.Palembang	71.675	31 %	91%
13.Palangkaraya	38.509	50 %	73%
14.Pontianak	6.782	24 %	50%
15.Banjarmasin	39.199	47 %	73%
16.Samarinda	47.192	46 %	10%
17.Manado	25.866	39 %	91%
Note : Coloum (2) and (3) = Direktori Perpamsi,2000; Coloum (4) = Production Design Capacity Divided by Existing Capacity.			

Increase of clean water service coverage to consumers could be obtained by the comparison between design production capacity and existing capacity which at present ranges between 10 – 93%. If the increasing process is held without the construction of new water treatment installation, a maximum production capacity will be achieved which result a rise of clean water usage per day.

Limited Water Distribution Time and Head loss Experienced by Consumers

Another problem encountered is the limited water distribution time and head loss experienced by consumers. Unfortunately, no quantitative data on distribution time is available while lately, several cities are not supplied with continuous water distribution as observed in Bandung, Tangerang and Jakarta. Other than lack of distribution time, water pressure in each consumer household is very low and water has to be collected in a basin with elevation lower than soil surface. When improvement of service quality is implemented, illegal water distribution by community pumping will be avoided.

PDAM Development Strategy for Supplying City Clean Water

PDAM in Indonesia must be improved concerning the increase of clean water demand and MDG clean water program target.

The PDAM development comprises several factors related to institution, technical apparatus and facilities, financial matters, community building & participation and socialization of PDAM development, with following explanation:

1. Institution and Rules of Law.

The development of PDAM is one of the government responsibillity. The welfare of community is depended by assuring that quality, quantity and continuity of clean water

keep on fulfilling the standard criteria. Institutional system is needed together with rules of law on:

- Strengthening of the function of regulator and operator in implementing PDAM
- Applying enterpreneurship
- Compiling criteria and register poor community liable for financial assistance
- Compiling rules of law

2. Technical Apparatus and Facilities

Raw water should be provided in term of quantitatively as well as qualitatively, therefore a program should be set up to increase and assure raw water quantity and quality. Those programs consist of:

a) Strategy to increase raw water units when polluted by waste and salt water intrusion so that clean water is assured by:

- Developing water resources management and its enviroment supporting the development of drinking water supply
- Developing raw water supply gradually and related to sanitary implementation

b) Strategy to extend clean water service to consumers from production units by:

- Improve PDAM production quality gradually

c) Strategy to increase ability of distribution units to improve service quality by:

- Forcing the development of drinking water supply for low income community
- Develop coverage of drinking water service to overcome the gap between rural and urban service
- Reducing water losses

3. Financial Matters

Funds are needed for the development of PDAM in order to produce better clean water supply which could be supplied to the community. Therefore the goverment should force the local authority and enhance cooperation between regions for developing clean water supply.

Programs on PDAM should increase the role of provincial, city and district government by applying following strategies such as:

- Force local administration to precede drinking water supply development
- Force local administration to cooperate in the drinking water supply development

4. Community Building and Participation

Community building and participation are important factors for the development of PDAM. However, the support of local policies to open new opportunities and to force joint cooperation between government, community and private sector.

Programs to create cooperation between the government and private sector need following strategies:

- Development of joint cooperation providing opportunities and entrepreneur assurance for the private sector in supplying drinking water (Conan, Herve, 2004).
- Improve the joint cooperation with local entrepreneurs particularly in the field of drinking water industry.

Another program is needed to create cooperation between the government and community with strategy on:

- Improvement of community role to fulfill the need for healthy drinking water

5. Socialization

Socialization to the community related to PDAM development covers:

a). Strategies of Raw water and water resources conservation:

- Education and understanding of school children on raw water preservation
- Education to general community on raw water supply and preservation
- Increase of women role in socializing raw water conservation and management

b). Raw water development in line with MDG needs following strategies:

- Education and understanding of school children on PDAM
- Education to general community on PDAM
- Education and understanding on MDG as well as explanation on raw water supply target for regional and central stake holder
- Women participation in designing, managing and socializing drinking water development

CONCLUSIONS

1) Strategy for optimum PDAM covers operation on: (a). Raw water units; (b). Water production units; and (c). Distribution units

2) Case study was conducted at 17 PDAM spread throughout 14 provinces in Java, Sumatera Sumatera, Kalimantan and Sulawesi which provide raw water from rivers.

3) Raw water unit problems: (1). Raw water quality polluted by waste (high concentration of BOD, COD, Fecal Coliform Bacteria and low concentration of DO); (2). PDAM installation that must be stopped due to salt water intrusion during dry season with Chloride concentration (10,000 mg/L).

4) The impact by postponed PDAM installation at Samarinda results water borne diseases with highest victim rates of 6,225 suffering from diarrhoea. (September, 1997 - 72 % or 4,470 have to be hospitalized)

5) PDAM service coverage at study area showed lowest case at 7 % and highest at 54 %, with service coverage at 10 PDAM below 40 %, namely at Tangerang; Bekasi; Pakanbaru; Padang; Sawahlunto; Sorolangon; Bengkulu; Palembang; Pontianak and Manado.

6) PDAM service rate between 10-206 L/P/D compared to Criteria on Clean Water Usage from Ditjen Cipta Karya - 11 PDAM did not fulfill criteria.

7) Strategy on raw water unit utilization improvement is facing problems on raw water polluted by waste and salt water intrusion. Government policies are needed to provide raw water which brings better quality and quantity on conservation and socialization of raw water supply.

8) Strategy on clean water service extension to consumers from production unit need to be supported by government policies, to encourage the regional authorities in developing drinking water supply.

9) Strategy on PDAM distribution unit must be taken as a consideration to improve the low income of community as well as enforcing the private sector and community to participate.

RECOMMENDATIONS

1) Education on the environmental pollution is essential to improve concern of water conservation especially to school children. In addition, efforts to develop community awareness on the importance of water for life must be socialized to various cause of generation.

2) Focus efforts in allocating raw water conservation financial aid obtained from PDAM consumers contribution

REFERENCES.

Anonymous (2000). *Direktori Perpamsi.*

Budiman, Sidik. (2006). *Optimalisasi Pengelolaan dan Penyelesaian Hutang PDAM.* Lokakarya Strategi Meningkatkan Kinerja Perusahaan Air Minum di Daerah, Jakarta 19-20 Januari.

Conan, Herve. (2004), *Water for All, Series Small Piped Water Networks , Helping Local Entreprenouers to Invest".* ADB Report.

Directorate General for City and Rural Development, Department of Public Works (DPU) (April 2005). *Program Air Minum dan Prasarana Lingkungan dalam rangka Pencapaian MDG 2015.*

Hidayat, R. (2001). *Pengaruh Intrusi Air Laut pada Intake PDAM Kota Samarinda.* Majalah Air Minum , ISSN No.0126-2785, No.91./Tahun XXII-Januari.

Majalah Perpamsi, 91/XXII, January, 2011

Research Onstitute for Water Recources Development, 1995, Water Quality Year Book.

Research Onstitute for Water Recources Development, 1999, Water Quality Year Book.

Sundaravadivel, M. et all. *Quality of Water Environment and Management of Urban Wastewater in India : Issues and Improvement Strategies*, pp. 180-187. Proceedings of The First International Symposium on Southeast Asian Water Environment, Oct 23-25,2003,AIT, Conference Center, Bangkok, Thailand.