

ANNEX 8

RESULTS OF WATER QUALITY ANALYSIS

OF NAM NGUM DAM AND RIVER

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The water quality of the Nam Ngum River, and the Nam Ngum Dam (which will be the water source for the new treatment plant which is one of the alternatives for the future) was examined in order to test the water quality as a source of drinking water. The water sampled in the dry and the rainy seasons were examined separately.

The samplings for water quality analysis were conducted on the dates as below:

	Dry Season	Rainy Season
Nam Ngum Dam	2 nd and 8 th April 2003	11 th and 18 th September 2003
Nam Ngum River	2 nd and 8 th April 2003	11 th and 18 th September 2003

1. Parameters of water quality analysis

The following parameters were examined in consideration of practicable analysis of local and water quality standard for raw water and drinking water.

Parameters: Temperature, pH, Turbidity, Color, Odor, Taste, Dissolved Oxygen, Suspended Solid(SS), Biochemical oxygen demand(BOD),Chemical oxygen demand(COD), Ammonia-Nitrogen(NH₄-N),Nitrite-Nitrogen (NO₂-N), Nitrate-Nitrogen(NO₃-N), Chloride, Postassium Permanganate Consumed, Total Colony, Total Coliform, Cyanide, Mercury, Ethyl para nitrophenyl(ENP), Copper, Iron, Manganese, Zinc, Lead, Chromium, Cadmium, Arsenic, Fluoride, Hardness, Phenol, Alkalinity

2. Result

The result of the analysis is summarized in Table 2-1.

The water was sampled at the following places:

- Nam Ngum Dam: 50 m down stream from the spillway
- Nam Ngum River (Thangone): at the irrigation pumping station

Nam Ngum Dam was constructed for purpose of power generation and irrigation. The water quality will vary according to the sampled location and depth because the dam reservoir is large. Thus, the discharged water from the dam is assumed as representing that of the dam reservoir water. In addition, the degree of water pollution will be confirmed by comparing samples of the dam water with sampled water from Thangone. Results of water quality were evaluated based on both dry and rainy seasons' results.

Table 2-1 Results of Water Quality Analysis

Item of Analysis	Unit	Water Standard	Nam Ngum Dam				Nam Ngum River(Thangone)				
			2003.04.02	2003.04.08	2003.09.11	2003.09.018	1999.10.14	2003.04.02	2003.04.08	2003.09.11	2003.09.018
Water Temperature			25.0		24.0	28.1	28	25.1		26.1	24.3
Ph	-	6.5 ~ 8.5	7.1	7.0	7.5	7.3	7.4	7.3	7.2	7.6	7.3
Odor	-	No offensive	NONE	NONE	NONE	NONE	-	NONE	NONE	NONE	NONE
Taste		No offensive	Normal	Normal	Normal	Normal	-	Normal	Normal	Normal	Normal
Color	°	5	0.4	0.5	2.5	3.0	-	0.5	0.5	6.0	4.0
Turbidity	NTU	5	1.0	0.3	7.0	12.0	25	6.0	3.9	50.0	35.0
Dissolved Oxygen	mg/L		14.0	8.1	8.9	7.6	4.9	11.0	7.6	10.2	7.3
Suspended Solid (SS)	mg/L	1000	7.0	0.5	<1	<1	35	6.0	4.0	4.9	8.0
Biochemical oxygen demand (BOD)	mg/L		25.0	10.0	10.0	10.0		15.0	5.0	5.0	15.0
Chemical oxygen demand (COD)	mg/L		1.2	0.6	1.0	2.2		1.6	1.2	4.0	4.3
Ammonia Nitrogen (NH ₄ -N)	mg/L		N.D<0.01	N.D<0.01	0.05	0.04		N.D<0.01	N.D<0.01	0.2	0.06
Nitrite-Nitrogen (NO ₂ -N)	mg/L	0.1 or less	N.D<0.01	N.D<0.01	N.D<0.01	0.02	0.12	N.D<0.01	N.D<0.01	N.D<0.01	0.03
Nitrate-Nitrogen(NO ₃ -N)	mg/L	10 or less	N.D<0.01	N.D<0.01	0.04	0.04		N.D<0.01	N.D<0.01	N.D<0.01	0.1
Chloride ion (Cl)	mg/L	250 or less	14.0	4.8	3.4	3.9	10.3	10.0	6.7	4.1	3.4
Total Bacteria	cell/mL	less than 100/1mL	168	84	28	140	84	136	86	219	660
Total Coliform group	MPN	0/100mL	3/5	3/5	0/5	3/5	230	1/5	1/5	5/5	5/5
Cyanide (CN)	mg/L	0.07 or less	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01	N.D.	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01
Mercury (Hg)	mg/L	0.005 or less	N.D<0.0005	N.D<0.0005	N.D<0.0005	N.D<0.0005	N.D.	N.D<0.0005	N.D<0.0005	N.D<0.0005	N.D<0.0005
Copper (Cu)	mg/L	1.0 or less	N.D<0.02	N.D<0.02	N.D<0.01	N.D<0.01	-	N.D<0.02	N.D<0.02	N.D<0.01	N.D<0.01
Iron (Fe)	mg/L	0.3 or less	0.47	0.34	0.11	0.37	0.4	0.63	0.42	0.28	1.34
Manganese (Mn)	mg/L	0.1 or less	0.09	0.04	N.D<0.01	0.05	-	0.03	0.02	N.D<0.01	0.16
Zinc (Zn)	mg/L	3.0 or less	0.10	0.17	0.16	0.15	-	0.14	0.18	0.18	0.17
Lead (Pb)	mg/L	0.02 or less	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01	N.D.	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01
Chromium (Cr ⁺⁶)	mg/L	0.05 or less	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01	N.D.	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01
Cadmium (Cd)	mg/L	0.01 or less	N.D<0.005	N.D<0.005	N.D<0.001	N.D<0.001	0.003	N.D<0.005	N.D<0.005	N.D<0.001	N.D<0.001
Arsenic (As)	mg/L	0.05 or less	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01	N.D.	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01
Fluoride (F ⁻)	mg/L	1.0 or less	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01	0.41	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01
Total Hardness(CaCO ₃)	mg/L	300 or less	42	44	60	122	52	54	52	52	72
Phenol	mg/L	0.005 or less	N.D<0.01	N.D<0.01	N.D<0.001	N.D<0.001	-	N.D<0.01	N.D<0.01	0.002	N.D<0.001
Electric Conductivity	mS/cm		0.106	0.110	0.107	0.110		0.102	0.83	0.09	0.082
Alkalinity	mg/L						-		48		

Water quality analysis results of samples taken in the dry season, April 2003 and rainy season, September 2003, are summarized as follows:

2.1 Nam Ngum Dam Water

- **pH** : The value of pH ranged from 7.0 to 7.5. There is no fluctuation of pH value by season. No significant effect on water quality to pH by phytoplankton growth appeared while detailed discharge information is not available.
- **Turbidity** : The value of turbidity ranged from 0.3 to 12.0 NTU. Dry season turbidity was very low ranging from 0.3 to 1.0 NTU. Rainy season turbidity was high ranging 7.0 to 12.0 NTU. This result is likely because suspended solids from inflowing rivers have settled in the reservoir as the reservoir is very large.
- **Dissolved Oxygen (DO)** : Contents of DO ranged from 8.1 to 14 mg/liter This result is likely because the oxygen dissolved in the water during aeration during discharging or because of a short retention time of the water in the reservoir.
- **Biochemical Oxygen Demand (BOD)**: The result of the analysis indicated high values of BOD ranging from 10 to 25 mg/liter and a high content of organic matter.
- **Chemical Oxygen Demand (COD)** : The analysis indicates a low value of COD, ranging from 0.6 to 2.2 mg/liter and a high content of decomposed organic matter.
- **Iron and Manganese**: Iron content ranged from 0.11 to 0.47 mg/liter and was higher than the permissible limit of the water quality standards. Contents of manganese indicated lower level than lower limit of analysis, rather high value and ranged from <0.01 to 0.09 mg/liter. The removal of iron and manganese oxidation with chlorine etc. will be facilitated during the water purification process.
- **Ammonia Nitrogen, Nitrite Nitrogen, and Nitrate Nitrogen**: Contents of ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen are indexes of the degree of eutrophication. In the dry season, contents is lower than the lower limit of analysis, 0.05 mg/liter was obtained from samples in rainy season. Generally, level of concentration is very low. It was concluded that no eutrophication have developed in Nam Ngum dam reservoir because each of the contents tested for was less than the detectable lower limit.
- **Others**: Zinc was detected, but the content was less than the permissible limit for the water quality standards. Thus the level of zinc in the sampled water is acceptable. Contents of the other heavy metals were less than the permissible limit. Thus the level of heavy metals in the water means that the quality of the water is acceptable.

2.2 Nam Ngum River Water (Thangone)

- **pH** : The value of pH ranged from 7.2 to 7.6. Almost no difference in sampled water from Thangone was detected from the Nam Ngum dam reservoir sampled discharge water. It can be concluded that there is no retention of pH from the dam reservoir to Thangone.
- **Turbidity** : Turbidity ranged from 3.9 to 50.0 NTU. In the dry season, turbidity was slightly higher than the one of the Dam, it was increased by 50 NTU in rainy season. Turbidity levels slightly increased when compared with water discharged from the dam. This increase was a likely result of the flushing of suspended solids from the riverbed by incoming streams.
- **Dissolved Oxygen (DO)** : Contents of DO ranged from 7.6 to 11 mg/liter. There was no seasonal fluctuation.
- **Biochemical Oxygen Demand (BOD)** : The analysis result of BOD also indicated a high value at Thangone ranging from 5.0 to 15 mg/liter.
- **Chemical Oxygen Demand (COD)** : The result of the analysis of sampled COD indicated similarly low, as that of the Nam Ngum, ranging from 1.2 to 4.3mg/liter. There was a tendency that the contents increase in rainy season, and a high content of decomposed organic matter.
- **Iron and Manganese** : Iron content ranged from 0.42 to 1.34 mg/liter and was higher than the permissible limit of water quality standards. It was obtained that content on September 18 was high as 1.34 mg/liter and it may be caused by seasonal fluctuation. Contents of manganese ranged from 0.02 to 0.16 mg/liter. Oxidation in the course of water flowing to Thangone can be expected due to it containing high DO. However the oxidation will not be effective if examined the water quality. Between Thangone and the river, about 100km upstream, no effective oxidation occurred. It will be necessary to remove iron and manganese oxidation with chlorination during the water purification process.
- **Ammonia Nitrogen, Nitrite Nitrogen, and Nitrate Nitrogen** : According to the results in rainy season, ammonia nitrogen was contained in sample from the Dam and concentration was increased in sample in Thangone. It may be caused by influent from catchments area. In the dry season it was not found and 0.2 mg/liter was obtained in rainy season, it seems to exist contamination by human activities and treatment in rainy season will require special attention.
- **Others** : Zinc was detected, but the content was less than the permissible limit of the water quality standards. Thus, concerning, zinc the water quality is acceptable. Contents other than heavy metals were less than the permissible limit. Thus, concerning heavy metals, the levels detected indicated that the water quality is acceptable.

3. Water Treatment Process

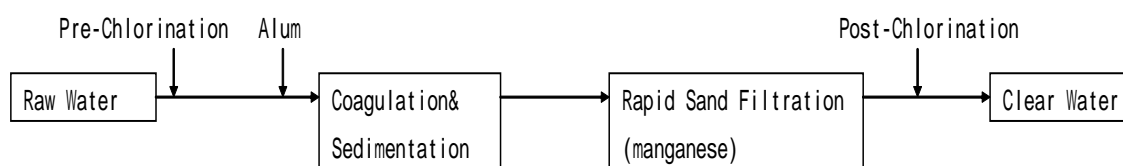
A jar test was conducted for the sampled water at Thangone to confirm the water quality for the planned water treatment plant. The results are as follows:

The water quality of samples taken on April 8th, was expressed as turbidity 2.6 NTU, pH 8.4, and Alkalinity 48 mg/liter. Direct filtration will be applicable to the water because the results of the jar test concluded that turbidity of the water was 0.33 NTU after Alum fed at 5 mg/liter. However, the coagulation and sedimentation processes will not move iron and manganese from the water if the contents of these are as high as mentioned above. The removal of iron and manganese will require chlorination plus manganese sand filtration.

While direct filtration with manganese sand plus pre-chlorination will be able to remove iron and manganese, intervals between filter washing will shorten due to increased clogging if there is a high content of iron and manganese.

According to the results obtained from samples taken during rainy season, water contained ammonium nitrogen and this will be treated by pre chlorination. For iron and manganese, manganese sand filtration will be required.

As a result of the considerations mentioned above, the recommended water treatment process is by coagulation and sedimentation, plus manganese sand filtration.



4. Chemical Dosage Rate

Chemical dosage rate was studied based on the results of water quality analysis and results of jar-test. Since there is a tendency that contents of organic matters and ammonium nitrogen will increase during the rainy season, chemical dosage planning was prepared based on worse quality in rainy season.

1) Alum(aluminum sulfate)

Since turbidity during the rainy season was 35 to 50 NTU, turbidity will increase during the rainy season. Dosage rate of alum is set as 40 mg/liter as maximum.

2) Hypochlorite

Hypochlorite will be consumed by ammonium nitrogen, iron, and manganese which were found high concentration in rainy season. Consumption of the Hypochlorite will be calculated as follows:

$$\begin{aligned}
 \text{Ammonium Nitrogen} & : 1\text{mg/L} = 10\text{mg/L (Cl}_2\text{)} \\
 & \qquad 0.2\text{mg/L} \times 10\text{mg/L} = 2\text{mg/L} \\
 \text{Iron} & : 1\text{mg/L} = 0.63\text{mg/L (Cl}_2\text{)} \\
 & \qquad 1.34\text{mg/L} \times 0.63\text{mg/L} = 0.844 \quad 0.84\text{mg/L} \\
 \text{Manganese} & : 1\text{mg/L} = 1.29\text{mg/L (Cl}_2\text{)} \\
 & \qquad 0.16\text{mg/L} \times 1.29\text{mg/L} = 0.206 \quad 0.21\text{mg/L} \\
 \text{Total consumption of Hypochlorite} & = 2\text{mg/L} + 0.84\text{mg/L} + 0.21\text{mg/L} \\
 & = 3.05\text{mg/L}
 \end{aligned}$$

Based on the calculation above, total consumption of the Hypochlorite is 3.05 mg/liter, maximum dosage rate of Hypochlorite is set as 5 mg/liter.

Dosage rate of post-chlorination is determined based on the required concentration of residual chlorine since required chlorine for other consumables are already balanced by the pre-chlorination.

3) Lime (Calcium hydroxide)

Since raw water contains enough alkalinity, 48 mg/liter in raw water and 30 mg/liter after dosing alum, pre lime dosage will not be required. At the point of maximum dosage of alum, pH will be maintained at about 7.0, post dosage of lime also is not required.

Table 4-1	Chemical Feeding Rate		unit: mg/liter
	Max.	Average	Min.
Coagulant	40	5	1
Pre-Chlorination	5	3	0.5
Post-Chlorination	2	1	0.5

5 Jar Test for sampled water from Namgum River (Thangone)

The result of the jar Test for Namgum River (Thangone) from water sampled on 8th April 2003, is summarized in the following table:

Turbidity of raw water could be reduced by 0.33 NTU by dosing 5 mg/liter of alum and to achieve lower turbidity, 10 mg/liter of alum was required. Decrease of pH value was not observed even though alum dosage. It was judged that adequate alum dosage rate is 10 mg/liter considering dry season condition.

Table 5-1 Jar Test Result

Thangon 2003/4/8

		Raw Water	No1	No2	No3	No4
Alum	ml	-	0.1	0.25	0.5	0.75
Alum dosage	mg/L	-	2	5	10	15
Floc Size		-	x			
Settling		-	x			
Turbidity	NTU	2.61	0.70	0.33	0.00	0.00
pH		8.40	8.52	8.40	8.25	8.13
Alkalinity	mg/l	48	52	48	48	42

Floc Size : 2 mm < 1 ~ 2 mm 1 mm > x None
 Settling : Excellint Good Fail x

