Preliminary Study on Ambient Water Quality including Chemicals and Toxicity of Dili City, East Timor

Quazi S. Bushra[1], Masahiko Sekine[1], Riyanto Haribowo[1], Koichi Yamamoto[1], Justino Da Costa Soares[2], Alfred Ferreira[2], Sergio Freitas[2], Ariyo Kanno[1], Takaya Higuchi[1], Tsuyoshi Imai[1]

[1]Graduate School of Science and Engineering, Yamaguchi University, [2]Universidade Nacional Timor Lorosa'e, Timor-Leste

Abstract: This study entails an examination of the quality of ambient water in Dili city, where there is very few information on environmental condition. Water samples from 18 spots were analyzed for toxicity, physicochemical and biological parameters with standard methods. Among all considered parameters of surface water, the concentration of BOD, COD, TN, TP, Coliform, E-Coli were found above permissible limits. Toxicity test was done by using Medaka (*Oryzias Latipes*) fish with 100 times concentrated water to evaluate the fish safety level. The sources of organic toxicants were analyzed by GC/MS simultaneous analysis. Investigation showed that high toxicity found in household wastewater.

Key word: East Timor, developing country, water quality, toxicity

1. Introduction:

Assessment of water is not only for suitability for human consumption but also in relation to its agricultural, industrial, recreational, commercial uses and its ability to sustain aquatic life. Water quality monitoring is therefore a fundamental tool in the management of freshwater resources. However, water pollution has become one of the most serious problems in many countries, especially in the developing countries (Hunter et al. 2009; Tsuzuki, 2008). In East Timor, 57% of the total population doesn't have access to improved sanitation system as the sewerage system is not yet developed properly and 12% of urban people don't obtain drinking water from improved sources (Ministry of Finance, 2009-10). In addition there is lack of solid waste management and their water sources are not well protected as well. As a result the surface water is polluted due to the various human activities. Consequently, a remarkable number of people, 19.7% children under 5 year have died in each year for diarrhea in Dili city. As more 45,973 cases of malaria was reported in 2008 to the public health facilities (Ministry of Finance, 2009-10). The WHO estimates that 88% of diarrheal diseases is attributed to unsafe water supply and over 2 million people die each year from water-related diseases.
Therefore, the study of water quality is very important in East Timor. So the objective of this study is to conduct field survey for analyzing water quality, toxicity and to recommend the most potential natural remedial measure for prevention of contamination in water systems.

2. Materials and Methods:

2.1 Study Areas:

Water quality assessment was conducted in Dili city, capital of East Timor. Water samples were collected from the local rivers, Kangkun planting ditches, drainage canal systems which are normally connected to the sea for final discharge and from ground water. Figure 1 shows the study area with the sampling points denoted by C1, C2, C5, C6, C7, C8, C9 for Drainage canal in Caicoli village, L1 is the composite sample of D1, D2, D3, D4, D5, D6, D9, D10. L2-composite sampling point represents the Kuluhan catchment area, and B1, B2, B3, B4 sampling points are in Becora River. N1 and N2 are in Kangkun planting ditches.

2.2 Methods:

The field surveys were conducted in April 2012, March 2013 and August 2013. Standard procedure was carried out to measure BOD of the sample water. U-52 Multi parameter Water Quality Meter (Horiba) was used to measure the water temperature, pH, EC, turbidity and dissolved oxygen. COD, ammonium nitrogen, nitrate nitrogen were measured by Pack test (Kyoritsu Chemical Laboratory, Japan), TN-TP was measured by automated colorimetry. Coliform and E-coli were

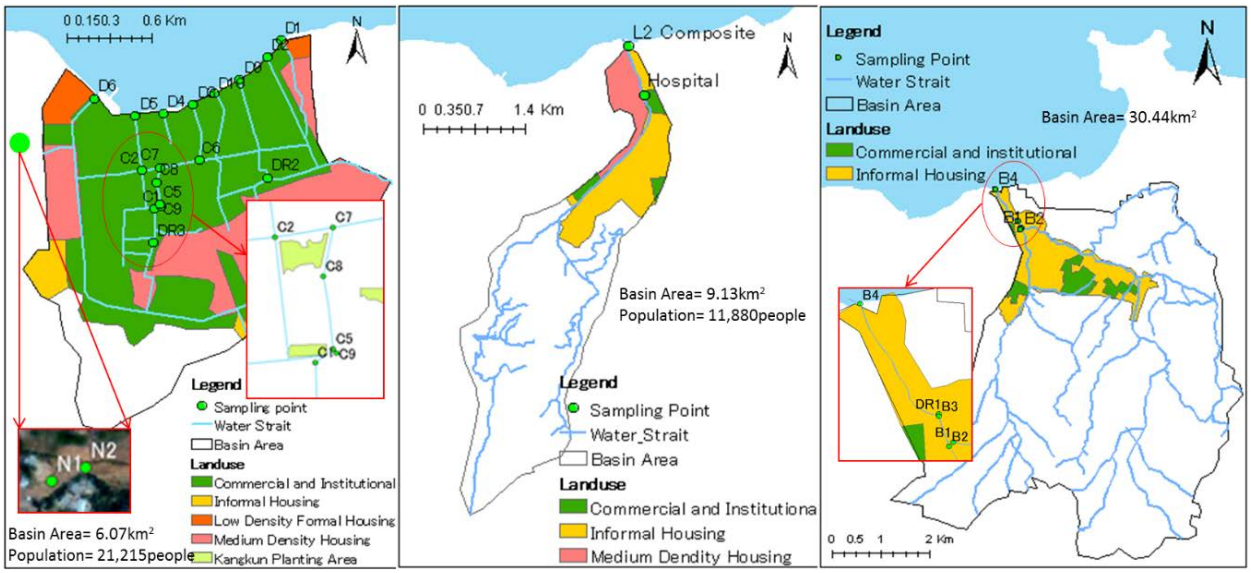

Figure 1: Study area showing sampling points in Dili city, East Timor

detected by EC Blue 10 (Nissui, Japan). To evaluate the safety level of aquatic species in ambient water, acute toxicity test was done with bioassay method by using the Medaka (*Oryzias laptipas*) fish and 100 times concentrated water (Haribowo et al.,2013). In brief, the number of death and disorder of medaka at 1,2,3,6,12,24,48 hours were counted and organic toxicity was expressed in Median Lethal Time(LT^{-1}_{50}) and Lithal Dilution ratio(LDR_{50}). A Shimadzu GC-2010 gas chromatograph (Kyoto, Japan) coupled with a Shimadzu QP2010 mass spectrometer was used for GC/MS simultaneous analysis (Yamashita et al., 2012). The sources of toxicity could be analyzed by this. Social survey on water quality was conducted to observe the causes and impacts of water pollution in Dili City. To understand the self-purification capacity of the water system, decay rate was estimated. Flow rate was measured and applied for calculating the decay rate.

3. Results and discussion:

3.1 Water Quality Parameter

The various water quality tests data are listed in Table 1 in different study areas. It is observed that for the case of drinking water (DR1, DR2 and DR3), all the water quality parameters are within the safe limit for DR1 and DR2 sampling points, however, turbidity (10 NTU) ,COD (6mg/l) and E-coli (49 MPN/100 ml) are found higher than the WHO standard in DR3 sampling point. For the case of canal water samples (C1,C2, C3, C4, C5, C6 and C7) it is shown that dissolved oxygen (DO) is much lower than the standard value (4mg/l) for all the sampling points. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are other important parameters of water quality assessment. Both BOD and COD show higher value than the standard in all the water samples from canal, composite sampling points (L1,L2), river sampling points (B1,B2,B3,B4) and Kangkun planting area (N1,N2) which indicates that the water quality is not suitable for sustaining aquatic life in surface water in Dili city, East Timor. This kind of result of water quality indicates that the drinking water and surface water of Dili city is contaminated by human activities such as waste disposal or untreated sewage disposal in the water body. Nutrient concentration in water is also important parameter for fishing, recreational and irrigation purpose. It is observed that total nitrogen, is always higher than the standard value for all the cases of surface water except drinking water. For the case of ammonium nitrogen, it is higher in the canals, composites samples and Kangkun planting sampling points. River water samples did not show higher ammonium content. Again, total phosphate value is higher for all the sampling points of canal, composites and Kangkun plant sampling points; however, it showed slightly lower value than the standard value for the case of all river water samples. Total coliform number shows higher value for all the sampling areas in Dili city which indicates that the water is polluted by human interactions including the unsafe discharge of human waste into the water body.

Table 1: Various water quality test results in different study areas

Sampling Point	Flow rate (m^3/s)	pH	DO (mg/l)	Temperature (^0C)	Turbidity (NTU)	EC (µS/cm)	COD (mg/l)	BOD (mg/l)	NH_4-N (mg/l)	NO_2-N (mg/l)	NO_3-N (mg/l)	TN (mg/l)	PO_4-P (mg/l)	TP (mg/l)	Coliform (MPN/100ml)	E-Coli (MPN/100ml)	TOC (mg/l)
DR1	--	7.05	4.70	27.30	0.61	0.04	3.00	0	0.16	0.00	1.20	1.86	0.08	0.06	240.00	0.00	--
DR2	--	7.44	6.66	27.40	0.52	0.04	3.00	--	0.17	0.00	9.00	2.40	0.00	0.03	7900.00	0.00	--
DR3	--	7.07	6.93	27.83	10.10	0.29	6.00	--	2.00	0.10	0.50	--	--	--	3300.00	49.00	--
C1	0.112	7.60	1.90	29.56	30.15	0.63	12.00	21.83	6.86	0.13	1.00	4.77	0.45	0.42	2476666.67	523333.33	34.20
C2	0.038	7.47	1.47	27.91	25.30	0.81	19.00	19.00	--	--	--	--	--	--	24550.00	3150.00	27.73
C5	0.086	7.51	1.32	28.77	15.29	0.48	9.00	6.67	6.97	0.32	2.00	7.28	0.59	0.77	13000000.00	2300000.00	--
C6	0.116	7.50	3.96	29.34	11.40	0.44	44.38	11.17	20.00	0.02	0.02	5.88	0.41	0.77	1650000.00	765000.00	--
C7	--	7.60	0.91	28.63	10.20	0.10	14.50	--	11.78	0.11	--	6.76	0.52	0.68	500000.00	1300000.00	--
C8	0.070	7.62	1.41	29.40	9.09	0.10	13.50	6.67	7.35	0.08	--	7.29	0.61	0.72	9500000.00	1200000.00	--
C9	0.008	7.36	1.35	29.67	17.07	0.09	19.00	30.00	10.15	0.14	--	15.05	1.32	1.67	104500000.00	25000000.00	--
L1	--	7.96	5.41	26.77	22.45	1.34	--	27.00	--	--	--	--	--	--	6625000.00	4525000.00	17.46
L2	--	--	--	--	--	--	--	15.67	--	--	--	--	--	--	13376666.67	1274333.33	15.70
B1	0.106	7.62	4.16	28.78	35.35	0.03	5.00	14.00	0.28	--	0.47	1.00	0.05	0.07	49000.00	79000.00	--
B2	0.042	7.45	5.48	29.43	13.55	0.05	5.00	4.00	0.36	0.10	--	2.70	0.11	0.13	130000.00	27000.00	--
B3	0.074	7.53	4.82	29.10	24.45	0.04	5.00	4.00	0.32	0.10	0.47	1.85	0.08	0.10	330000.00	6800.00	--
B4	0.210	7.65	6.74	28.30	25.35	0.05	5.00	4.00	0.35	0.03	--	1.69	0.06	0.09	2400000.00	70000.00	--
N1	--	7.74	3.72	27.40	20.08	0.07	30.00	46.67	14.62	--	--	19.62	3.17	3.24	240000000.00	3300000.00	--
N2	0.001	7.88	3.23	30.15	47.41	0.06	20.00	20.00	9.26	--	--	--	2.64	1.98	7000000.00	200000.00	--

3.2 Acute Toxicity

Figure 2 illustrates that the result of LT_{50}^{-1} and LDR_{50} of sampling water for toxicity analysis. It is observed that both LT^{-1} 50 and LDR50 are shown higher for most of the water samples in drainage canals(C1 , C5, C6, C7) and composite drainage systems (L1). On the other hand, it is not much prominent for drinking water (DR1, DR2, DR3) and river water (B1, B2, B3, B4) samples. For safety level of aquatic species, the allowable limit of LT_{50}^{-1} for clear stream benthic animal is 0.25 and for tolerant fish is 0.3 (Yamashita et al.,2012). The value of LT_{50}^{-1} is higher than the allowable limit for the case of all drainage canals in Caicoli Area and L1 and for the case of L2 and Becora River the value is in safe limit for aquatic species of water body.

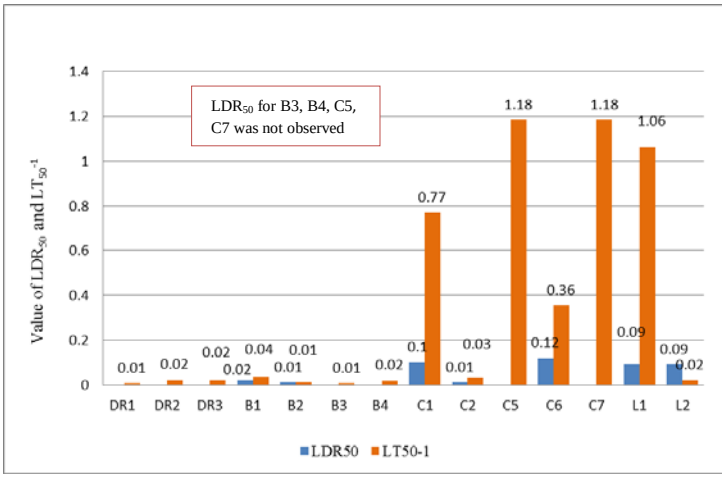

Figure 2: Result of LT_{50}^{-1} and LDR_{50} of sampling water

3.3 GC/ MS Simultaneous Analysis

Table 2 shows the list of possible sources of toxicity measured by GC/MS simultaneous analysis. The highest concentration of toxicity is present in drainage canal and the possible source is plasticizer. The other sources of chemical compound causing toxicity come from medical industry and agricultural insecticide.

Table 2: List of possible source of toxicity

Chemical compound	Uses	B1	B2	B3	B4	C1	C2	C5	C6	C9	N1	L1	L2	D3
Bis(2-ethylhexyl)phthalate	Plasticizer	2.710	2.420	4.943	1.725	6.835	1.475	3.604	4.592	10.811	4.007	3.395	10.307	3.082
Diisobutyl phthalate	Plasticizer	1.466	0.365	0.158	0.340	1.831	--	0.369	0.446	0.764	1.896	1.077	0.820	0.158
Di-n-butyl phthalate	Plasticizer	1.759	0.433	--	0.497	1.501	22.262	--	0.438	0.867	1.880	1.336	3.490	0.208
2(3H)-Benzothiazolone	Medical industry and pharmaceuticals	--	1.766	--	--	0.653	--	2.419	--	--	--	--	--	--
Diethyltoluamide	Insect repellent	0.404	0.250	0.102	0.138	4.804		2.093	0.794	2.556	3.651	4.127	2.072	0.067
Propoxur	Insect repellent and insecticide	0.453	--	--	--	--	--	--	--	0.080	3.686	0.756	0.287	0.380
Fenobucarb	Agricultural insecticide	--	--	--	--	5.016	--	0.659	--	--	--	--	--	--

3.4 Decay Rate:

Table 3: Results of decomposition rate

	k (1/day)									
	Becora River			Ditch						Kangkun Field
	B1-B3	B2-B3	B3-B4	C1-C2	C1-C5	C9-C5	C5-C8	C8-C7	C5-C7	N1-N2
BOD	261.1	0	0	13.93	0	887.48	0	-202.84	-	1.66
COD	0	0	0	-	-482.5	-65.63	35.06	35.62	-113.29	0.79
NH4N	92.08	128.5678	-28.52	-	68.72	-54.34	-49.53	3.5	-27.73	0.89
NO2N	-	223.32	0	-	-	-	-	-509.74	-	-
NO3N	-	-	-	-	-	-	-	-	-	-
TN	-110.63	85.32	0.329	-	-73.85	284.73	8.7	7.86	6.1	-
DN	-133.86	75.93	5.67	-	-59.1	257.08	20.21	-17.85	19.16	0.72
PN	141.6	223.06	-54.81	-	-167.94	416.77	-41.62	133.94	-82.89	-
PO4P	-97.96	59.07	12.34	-	-106.68	368.97	-2.28	34.72	11.18	0.98
TP	-73.67	57.81	2.28	-	-132.31	330.42	20.57	22.77	1.57	0.96
DP	-29.65	61.22	0.387	-	-81.78	431.47	6.85	-22.68	40.73	1.14
PP	-124.68	54.61	4.11	-	-196.25	198.08	37.01	102.96	-35.47	0.17
TOC_total	-	-	-	4.38	-	-	-	-	-	-
TOC_filtrate	-	-	-	0.28	-	-	-	-	-	-
Coliform	-397.51	-172.79	-85.11	99.58	-713.41	1481.16	68.145	613.79	-	6.91
E-coli	511.15	255.77	-100	84.54	-370.35	1474.706	166.97	-137.04	-	5.47

The result of decay rate is presented in Table 3. The decay of non-conservative substances is frequently modeled as a first-order Kinetic reaction; that is assumed that rate of substance is proportional to the amount of substance that is present.

$$C_t = C_0\, e^{-kt} \tag{1}$$

For higher rate constant in Becora river and drainage canal, this is because polluted water contains a larger proportion of easily degradable organics. The Kangkun field sampling points showed the lower rate of decomposition for all the water quality parameters which indicates Kangkun plant doesn't play any significant role for purifying water.

4. Conclusion:

It is observed that the quality of water is not within safe limit for drinking purposes, fisheries, irrigation or other activities in respect to dissolved oxygen, nutrient and pathogenic concentration in Dili city, East Timor. The toxicity level is higher than safe limit for all drainage canals in Caicoli area. This is probably due to the higher population density than L2 and Becora catchment area and consequent higher human activities. The possible sources of chemical compound causing toxicity come from plasticizer, medical industry and agricultural insecticide.As the decomposition rate is very high, the most appropriate natural remedial measure for wastewater system could be oxidation pond or composting toilet.

References:

1) Riyanto, H., Hiroe Y., Minami Y., Ariyo K., Masahiko S., Takaya H (2013).: Determination of unit loading ratio of toxicity water using concentrated water samples and toxicity tests by Medaka fish (*Oryzias latipes*). Water and Environment Technology Conference (WET2013) Tokyo, Japan, 15th-16th June 2013.
2) Yamashita, H., Haribowo,R., Sekine, M., Oda, N., Kanno, A., Shimono, Y., Shitao, W., Higuchi, T., Imai, T. and Yamamoto, K. (2012). Toxicity test using medaka (Oryzias laptipes) early fry and concentrated sample water as an index of aquatic habitat condition. Environmental science pollution research. Vol.19: 2581-2594.
3) Ministry of Finance, Democratic Republic of Timor-Leste, Dili, Timor-Leste.Demographic and Health Survey, Timor-Leste 2009-10.
4) Hunter, P.R, Zmirou-Navier, D., Hartemann, P. (2009). Estimating the impact on health of poor reliability of drinking water intervantions in developing countries. Science of the total environment. Vol. 407: 2621-2642.
5) Tsuzuki, Y. (2008). Relationship between water pollutant discharges per capita and indicators of economic level, water supply and sanitation in developing countries. Ecological economics. Vol. 68: 273-287.