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ASSESSMENT OF NUTRIENT AND SEDIMENT LOADS IN BUHISAN, BULACAO AND LAHUG RIVERS, CEBU, PHILIPPINES

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ABSTRACT
The study aimed to provide baseline data by assessing the nutrient levels and sediment load in Buhisan, Bulacao and Lahug Rivers. Specifically, the study assessed the nitrates, Total Phosphorus (TP), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) concentrations of the rivers. Water samples were taken by grab sampling from three designated sites (upstream, midstream and downstream) along each river. Laboratory analyses were performed according to standard protocols. Results of the study were compared with the standard set by the Department of Environmental and Natural Resources (DENR). The nitrate, TSS and TDS levels did not exceed the allowable concentration set by the government but the TP did. The mean TP values observed at Buhisan, Bulacao and Lahug Rivers ranged from 0.10-1.82 mg·L$^-$, 0.05-0.48 mg·L$^-$, and 0.17-2.75 mg·L$^-$, respectively. The TP levels in the midstream and downstream areas of Buhisan and Lahug Rivers exceeded the 0.4 mg·L$^-$ limit. High TP levels could be attributed to anthropogenic sources like untreated domestic waste discharges, unsanitary sewer systems in the surrounding communities, and runoffs from fertilized backyard gardening, and piggery.

Keywords: Nutrients, Total phosphorus, Nitrates, Sediment load, Rivers, Cebu, Philippines.

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Contribution/ Originality

This study provides baseline information on the water quality of Buhisan, Bulacao, and Lahug Rivers in Cebu. The results of the study will be used for the monitoring, management, and rehabilitation of these river ecosystems.

1. INTRODUCTION

Phosphorus (P) and nitrogen (N) are essential nutrients in surface waters but excessive amounts can cause pollution and significant water quality problems. Elevated levels of these nutrients, in combination with a number of other factors, can lead to algal bloom in water bodies. This rapid plant growth upsets the natural balance of the ecosystem. When these plants die and

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decay, they consume the available oxygen in the water, causing the death of fish and other aquatic organisms and producing very filthy odors (US EPA, 1997). Nitrogen is essential to the production of plant and animal tissue. It is used primarily by plants and animals to synthesize protein. Common sources of excess nitrate reaching lakes and streams include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps. Phosphorus is the limiting nutrient in freshwater aquatic systems. That is, if all phosphorus is used, plant growth will cease, no matter how much nitrogen is available (US EPA, 1997; Kukelana, 2004).

The slow weathering, erosion and leaching of rocks and soils are the primary sources of phosphorus in nature. Phosphorus may be released from lake and reservoir bottom sediments during seasonal overturns. Animal excreta together with dead plants and animals return phosphorus to the soil by microbial decomposition (US EPA, 1997).

The study aimed to provide baseline data by investigating the nutrient levels and sediment load in Buhisan, Bulacao and Lahug Rivers. Specifically, the study aimed to assess the nitrates, Total Phosphorus (TP) levels, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) levels. Results obtained were compared with the standards set by the Department of Environmental Natural Resources (DENR) for surface waters. The outcome of this study will be helpful to develop appropriate management strategies for the protection of these freshwater resources.

Table-1. Coordinates of the sampling sites in Buhisan, Bulacao, and Lahug Rivers

Water Body	Sampling Site	Coordinates
Buhisan River	Upstream (BnR1)	N 10° 48' 24.8" E 123° 51' 16.3"
	Midstream (BnR2)	N 10° 17' 55" E 123° 52' 11.7"
	Downstream (BnR3)	N 10° 17' 32" E 123° 52' 50.6"
Bulacao River	Upstream (BoR1)	N 10° 16' 49.6" E 123° 50' 26.4"
	Midstream (BoR2)	N 10° 16' 18.2" E 123° 50' 49.4"
	Downstream (BoR3)	N 10° 15' 54.6" E 123° 51' 23.3'
Lahug River	Upstream (LaR1)	N 10° 20' 33.1" E 123° 53' 19.4"
	Midstream (LaR2)	N 10° 19 '30.3" E 123° 53' 48.8"
	Downstream (LaR3)	N 10° 18' 4.90" E 123° 54' 14.70"

Source: Maglangit *et al.* (2015)

2. MATERIALS AND METHODS

2.1. Study Sites

Samples were taken from three designated points (upstream R1, midstream R2, downstream R3) in Buhisan, Bulacao, and Lahug Rivers. The sites were identified and marked by the Global

Positioning System (GPS). The coordinates and sampling areas are shown in Table 1 and Figure 1, respectively.

Buhisan River has a basin area of 17.8km^2 and length of approximately 11.8 km. It is a complex river system extending across 11 barangays and drains into the Mactan Channel. Bulacao River traversed downstream into Barangay Inayawan. It spans approximately 12.7 km and has a basin area of 10.7 km^2. Lahug River which extends from Barangay Busay to Pier III serves as a natural flood drain of Cebu City. It is 8.5 km long with a basin area of 6.3 km^2.

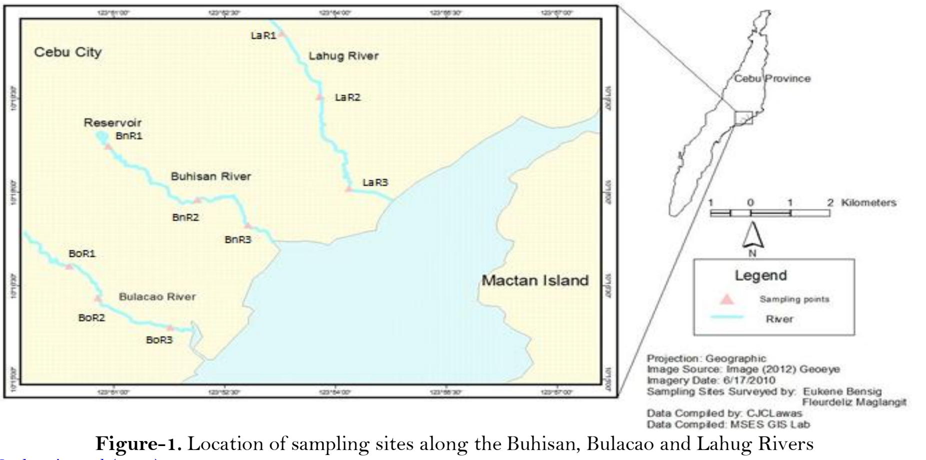

Figure-1. Location of sampling sites along the Buhisan, Bulacao and Lahug Rivers

Source: Maglangit *et al.* (2015)

2.2. Sample Collection

Water samples were collected by grab sampling from the designated points in clean polyethylene containers. The samples were kept in ice buckets at 4^{0}C till they were transported to the laboratory for analysis. Samples were collected monthly for a period of 6 months between the hours of 9am and 4pm in accordance with the standard protocols prescribed in APHA AWWA-WEF (2005) and US EPA (1997).

2.3. Analysis

Temperature, pH and TDS parameters were measured on-site using a standard, calibrated portable multiparameter kit (Thermo Scientific Orion 5-star Model EW-58822-20). The nutrient levels were analyzed in the laboratory following the methods prescribed by APHA AWWA-WEF (2005). NO_3^- was determined by chromotropic-colorimetric method, TP was analyzed by acid digestion followed by stannous chloride colorimetric method and TSS by gravimetric method.

3. RESULTS AND DISCUSSION

Buhisan, Bulacao and Lahug Rivers are situated in an urban area and become more densely populated with the presence of more residential areas, commercial and business establishments as they traverse downstream.

The results obtained in the study were compared with the standards set by the Department of Natural Resources (DENR) for surface waters (Table 2).

Table-2. Results of the Study in Comparison with DENR standards

Parameters	Buhisan River			Bulacao River			Lahug River			*DAO 90-34 standard
	BnR1	BnR2	BnR3	BoR1	BoR2	BoR3	LaR1	LaR2	LaR3	
pH	7.2	7.6	7.3	8.0	7.5	7.4	7.7	7.6	7.4	6.0-9.0
Temp, ^{0}C	27.5	28.4	28.9	28.1	28.5	29.5	26.4	27.5	28.6	3 ^{0}C rise
Nitrates, mg·L$^-$	2.10	0.20	0.06	0.86	1.15	0.47	2.07	0.10	0.63	10 mg·L$^-$
Total P, mg·L$^-$	0.10	1.90	1.82	0.05	0.17	0.48	0.17	3.30	2.75	0.4 mg·L$^-$
TSS, mg·L$^-$	6.20	34.8	31.17	7.17	15.67	14.50	20.0	29.5	47.17	Not more than 30mg·L$^-$ increase
TDS, mg·L$^-$	393	536	559	240	283	348	371	526	637	1000 mg·L$^-$

***Source:** DENR (1990)

Temperature values ranged from 27.5-28.9 ^{0}C, 28.1-29.5 ^{0}C, and 26.4-28.6 ^{0}C, in Buhisan, Bulacao and Lahug Rivers, respectively (Fig. 2, Table 2). There were no observable drastic changes in temperature readings throughout the entire study period and these results fall within the standard set by DENR of not more than 3^{0}C increase or change in ambient temperature. The results showed increasing temperature measurements from upstream to downstream (Fig. 2, Table 2). The presence of trees in the upstream areas provided a canopy cover in the water body that they were not directly exposed to sunlight (Flores and Zafaralla, 2012) resulting in lower temperatures compared to other areas.

The pH values varied from 7.2-7.6, 7.4-8.0, and 7.4-7.7 (neutral to slightly alkaline) in Buhisan, Bulacao and Lahug Rivers, respectively (Fig. 2, Table 2). The results were within the DENR standard for pH range of 6.0-9.0. The highest pH was observed in Bulacao River which could be attributed to the yellow rocks which is made mostly of limestone that dominated the substrate of the river.

The average NO_3^- levels in Buhisan, Bulacao and Lahug Rivers ranged from 0.06-2.1 mg·L$^-$, 0.47-1.15 mg·L$^-$, 0.10-2.07 mg·L$^-$ (Fig. 2, Table 2), respectively. The US EPA (1997) and DENR (1990) standard for Class A to C freshwaters is 10 mg·L$^-$ NO_3^-. All the mean values of the three rivers did not go beyond this limit. Atmospheric deposition, nitrifying activity, excreta and urine from domestic wastes, domestic wastewater discharges, and inputs from fertilized gardens might have contributed relatively to the NO_3^- levels in these sites (US EPA, 1997; Dike *et al.*, 2010; Kaur and Singh, 2012) but did not result in higher than standard concentrations.

The mean TP concentrations observed at Buhisan, Bulacao and Lahug Rivers ranged from 0.10-1.82 mg·L$^-$, 0.05-0.48 mg·L$^-$, and 0.17-2.75 mg·L$^-$ (Fig. 2, Table 2), respectively. The maximum TP level for Class C freshwaters set by DENR (1990) is 0.4 mg·L$^-$. The levels in R2 and R3 in Buhisan and Lahug Rivers exceeded the allowable concentration. The downstream part of Bulacao River had a mean TP level of 0.48 mg·L$^-$ and slightly exceeded the allowable concentration. Kukelana (2004) attributes modern changes in land use and other natural influences such as rainfall which have accelerated weathering or erosion of phosphate-rich soils and rocks into these rivers. The influence of human activity might have contributed to the TP levels observed. Domestic wastewater discharges rich in phosphorus-containing detergents and soaps, and surface runoffs from fertilized gardens which used NPK, animal feeds, and abattoir (US EPA, 1997; Dike *et al*., 2010) could have had significant contribution to the observed TP values. Some households in the nearby vicinity didn't have sanitary sewer systems resulting in increased phosphorus level through overland flow or groundwater seepage. High phosphorus levels will result in the eutrophication of the river. However, no excessive plant growth was observed during the duration of the study. The TSS levels in Buhisan, Bulacao and Lahug Rivers ranged from 6-31 mg·L^{-}, 7-2-16 mg·L^{-}, and 20-47 mg·L^{-}. There were no abrupt increase of not more than 30 mg·L^{-} in the TSS levels in all sampling sites during the entire study period. The values fall within the DENR standard (Fig. 2, Table 2). The relatively high TSS in LaS3, BnS2 and BnS3 could be due to the effects of quarrying and dredging activities that disturbed the river beds. There were occasions when these activities occurred during sample collection and there were occasions that these did not happen. These river beds could be silted from denuded areas and agricultural lands surrounding both rivers (EMB, 2006).

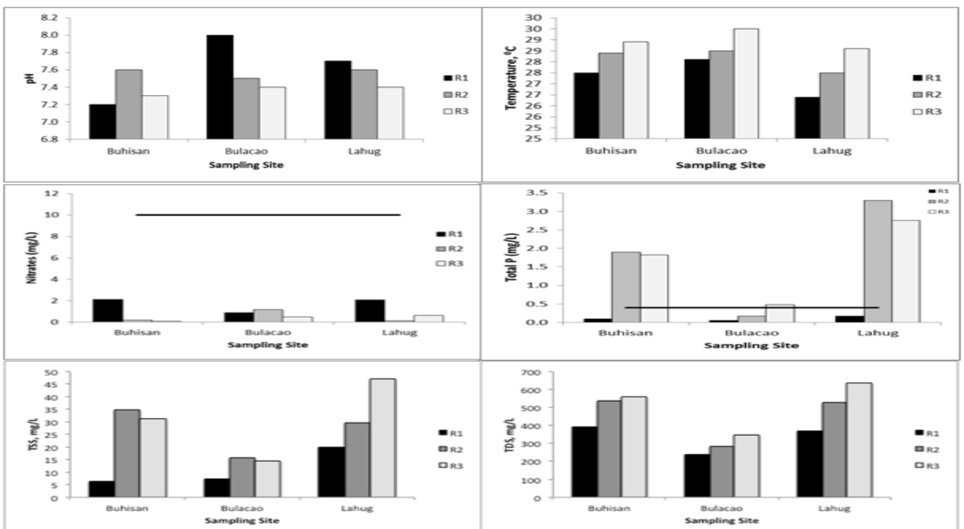

Figure-2. Temperature, pH, Nitrates, Total P, TSS and TDS Levels in Buhisan, Bulacao and Lahug Rivers

The mean TDS levels in Buhisan, Bulacao and Lahug Rivers increased from upstream to donwstream indicating more inorganic salts and dissolved materials in these areas. The concentrations were 393-559 mg·L^{-}, 240-348 mg·L^{-}, and 371-637 mg·L^{-}, respectively and did not go beyond the limit of 1000 mg·L^{-} for Class D surface waters set by the DENR (EMB, 2006) (Fig. 2, Table 2).

4. CONCLUSION

The assessment study showed that the mean nitrates, TSS and TDS levels did not exceed the DENR standards. The mean TP concentrations for midstream and downstream Buhisan and Lahug Rivers ranged from 1.9-1.82 mg·L^{-} and 2.75-3.30 mg·L^{-}, respectively were beyond the 0.40 mg·L^{-} P limit for Class C freshwaters. The downstream part of Bulacao River had a mean TP level of 0.48 mg·L⁻ and slightly exceeded the standard. The major pollutant loads in the rivers come from point sources – households with drainage pipes directly discharging wastewater in the rivers. Other non-point sources of pollution included car washing activities, abattoir, failing septic systems and runoffs from fertilized gardens where NPK was used. The study suggests that steps must be taken to clean-up, restore, and protect these freshwater resources.

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