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Relationship of coliform and physicochemical factors of Buhisan, Bulacao and Lahug Rivers, Cebu, Philippines

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Abstract: The study was conducted to evaluate the relationship of coliforms and physico-chemical parameters such as biological oxygen demand (BOD), conductivity, dissolved oxygen (DO), nitrate, pH, phosphate, salinity, temperature, total dissolved solids (TDS) and total suspended solids (TSS) from the water samples taken from Buhisan, Bulacao and Lahug rivers in Cebu Philippines . Monthly sampling was conducted from November 2011 to April 2012 to cover the rainy and dry seasons from three established stations namely upstream, midstream and downstream in each river. The methods for the examination of water and wastewater (APHA AWWA WEF 2005) and the multiple tube fermentation technique (MTFT) were employed for the analyses of the physico-chemical parameters and coliforms respectively. Of the physicochemical parameters tested, BOD, conductivity, DO, nitrate, phosphate, salinity and TDS showed a significant correlation with FC and TC ($p \leq 0.05$). The high levels of organic pollutants combined with the presence of coliforms could be related to an accumulation of waste along the river stretch, the lack of wastewater treatment plants and the high impact of human activities across the river networks.

Key words: *Coliform; Physico-chemical factors; Rivers; Cebu; Philippines*

1. Introduction

Natural and human activities, physical influences and physico-chemical parameters could affect the water quality of surface waters like rivers. In turn, this can influence or affect the abundance of microorganisms in aquatic environment. Total coliform (TC) bacteria are microorganisms which are generally harmless and can be found in the environment whereas fecal coliforms (FC) are subsets of total coliform commonly found in the fecal matter. The presence of coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material either of man or other animals. Therefore, their presence in rivers and streams suggests that pathogenic microorganisms might also be present. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste (United States Environmental Protection Agency, 1997). Sources of fecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff .

In general, physico-chemical factors such as biological oxygen demand (BOD), conductivity, dissolved oxygen (DO), nitrates, pH, phosphates, salinity, temperature, total dissolved solids (TDS) and total suspended solids (TSS) could affect the growth and abundance of microorganisms. Hence, monitoring of rivers using microbiological and physico-chemical parameters can be helpful in assessing its water quality. The goal of the study was to correlate the TC and FC levels with the physicochemical parameters such as BOD, conductivity, DO, nitrates, pH, phosphates, salinity, temperature, total dissolved solids and total suspended solids. The results of the study can be used in assessing the state of the three rivers and in setting initiatives to protect and prevent their further deterioration.

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2. Materials and methods

2.1 Study Sites

The map (Fig. 1) and coordinates (Table 1) show the study sites with the sampling points designated as upstream, midstream and downstream of the 3 rivers namely Buhisan, Bulacao and Lahug.

Table 1: Coordinates of the sampling sites.

River	Sampling Sites	Coordinates
Buhisan	Upstream	N 10□48'24.8 E 123□51'16.3"
	Midstream	N 10□17'55" E 123□52'11.7"
	Downstream	N 10□17'32" E 123□52'50.6"
Bulacao	Upstream	N 10□16'49.6" E 123□50'26.4"
	Midstream	N 10□16'18.2" E 123□50'49.4"
	Downstream	N 10□15'54.6" E 123□51'23.3"
Lahug	Upstream	N 10□20'33.1" E 123□53'19.4"
	Midstream	N 10□19'30.3" E 123□53'48.8"
	Downstream	N 10□18'4.90" E 123□54'14.70"

Source: An assessment of the organic pollution level of Buhisan, Bulacao and Lahug rivers, Cebu, Philippines. Maglangit et al. (2015)

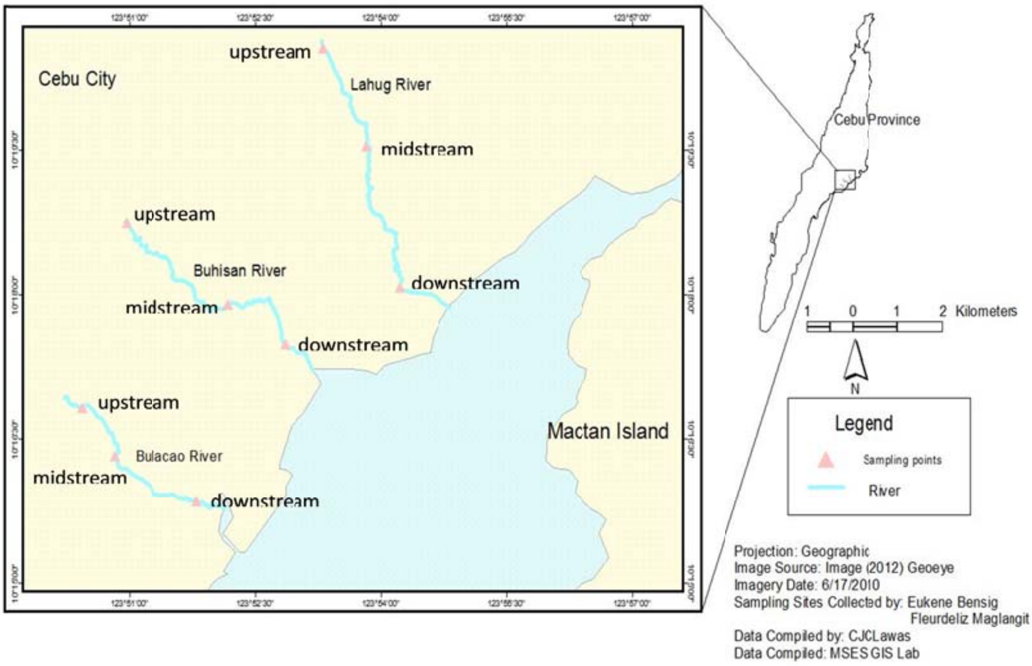

Fig. 1: Map of the sampling sites. Source: Fecal and total coliform levels of Buhisan River, Cebu City, Philippines. Bensig et al. (2014)

2.2. Sample Collection and Analysis

Sample collection started in November 2011 to April 2012 to account for the rainy and dry seasons. In-situ sampling was conducted for conductivity, salinity, temperature and TDS using a calibrated portable meter (Thermo Scientific Orion 5-star Model EW-58822-20). Water samples were taken for laboratory analyses for coliform, DO, BOD, nitrates, phosphates, pH and TSS. They were collected from the stream center and kept in a container with ice. The methods for the examination of water and wastewater (APHA AWWA WEF, 2005), US EPA Volunteer Stream Monitoring Manual (1997) and the Multiple Tube Fermentation Technique (MTFT) were employed for the laboratory processing and analysis of the physico-chemical parameters and coliform respectively. Field and laboratory results were recorded and the Pearson correlation was used for the Statistical Analysis to identify and find out the relationship between coliform bacteria and the physicochemical whether it is positive or negative.

3. Results and discussion

The most probable number (MPN) was used to report the results for the total and fecal coliform counts. The average values for the coliform and the physico-chemical analysis were recorded (Table 2).

TC (r=0.676), Conductivity (r=0.401), Salinity (r=0.413), TDS (r=0.372), DO (r= -0.334), BOD (r=0.285) and Nitrate (r= -0.327) showed significant relationship with the FC counts (Table 3). For the TC, FC (r=0.676), Conductivity (r=0.396), Salinity (r=0.423), TDS (r=0.363), DO (r= -0.325), and Nitrate (r= -0.298) showed significant relationship with the FC counts (Table 4).

Table 2: Mean values of the coliform and the physico-chemical parameters of Buhisan, Bulacao and Lahug Rivers

	Buhisan			Bulacao			Lahug		
Parameters	Upstream	Midstream	Downstream	Upstream	Midstream	Downstream	Upstream	Midstream	Downstream
Fecal coliform (MPN/100ml)	6.26E+05	1.02E+13	2.05E+12	8.55E+04	6.01E+09	1.49E+11	2.43E+05	3.14E+12	6.80E+11
Total Coliform (MPN/100ml)	2.15E+06	3.54E+13	3.93E+13	6.18E+05	1.18E+11	3.49E+12	2.54E+06	3.66E+13	8.64E+12
Temp (^oC)	27.5	28.4	28.9	28.1	28.5	29.5	26.4	27.5	28.6
pH	7.2	7.6	7.3	8.0	7.5	7.3	7.7	7.6	7.4
DO (mg/L)	4.4	0.1	0.1	8.1	3.5	2.1	6.5	0.1	0.0
BOD (mg/L)	2.0	66.7	53.8	1.3	7.8	7.8	1.8	58.0	72.2
TSS (mg/L)	9.3	34.8	31.2	10.8	15.7	14.5	24.0	35.4	47.2
TDS (mg/L)	392.7	536.7	558.8	240.3	283.3	348.5	370.5	525.7	636.5
Conductivity (µS/cm)	784.7	1064.8	1152.0	468.5	552.7	731.2	747.8	1088.2	1202.0
Salinity (ppt)	0.4	0.5	0.6	0.2	0.3	0.3	0.4	0.5	0.6
Nitrate (mg NO_3^-/L)	2.1	0.3	0.2	0.9	1.1	1.4	2.1	0.2	1.0
Phosphate (mg PO_4^{3-}/L)	0.1	1.9	1.8	0.1	0.2	0.5	0.2	3.3	2.8

Table 3: Pearson's correlation coefficients between fecal coliform and selected physicochemical parameters of Buhisan, Bulacao and Lahug Rivers

	Temp (°C)	pH	DO (mg/L)	BOD (mg/L)	TSS (mg/L)	TDS (mg/L)	Conductivity (µS/cm)	Salinity (ppt)	Nitrate (mg NO_3^-/L)	Phosphate (mg PO_4^{3-}/L)
Correlation coefficient [r]	-0.081	0.068	-0.334	0.285	0.167	0.372	0.401	0.413	-0.327	0.119
Significance	0.059	0.624	0.014	0.037	0.229	0.006	0.003	0.002	0.016	0.391

***Correlation is significant at the 0.01 level (2 tailed)
*Correlation is significant at the 0.05 level (2 tailed)

Table 4: Pearson's correlation coefficients between total coliform and selected physicochemical parameters of Buhisan, Bulacao and Lahug Rivers

	Temp (°C)	pH	DO (mg/L)	BOD (mg/L)	TSS (mg/L)	TDS (mg/L)	Conductivity (µS/cm)	Salinity (ppt)	Nitrate (mg NO_3^-/L)	Phosphate (mg PO_4^{3-}/L)
Correlation coefficient [r]	0.006	-0.096	-0.325	0.259	0.134	0.363	0.396	0.423	-0.298	0.178
Significance	0.965	0.489	0.016	0.058	0.333	0.007	0.003	0.001	0.029	0.197

***Correlation is significant at the 0.01 level (2 tailed)
*Correlation is significant at the 0.05 level (2 tailed)

Temperature and pH did not show significant relationship with coliforms. Temperature is an important controlling factor which can influence bacterial growth. In climates where water temperatures are warm, bacterial growth may be very rapid. Further, coliforms are significantly higher when water temperatures were above 15 °C. Fecal coliform showed a positive relationship with BOD and negative correlation with DO. BOD is a measure of how much oxygen is used by microorganisms during breakdown of organic matter. Usually, the higher the amount of organic material found in the stream, the more oxygen is used for aerobic oxidation. Consequently, when bacterial count is high, the greater will be the BOD and the lesser they DO (Missouri Department of Natural Resources, 2011).

Coliforms also had a positive relationship with conductivity and salinity mainly because inorganic dissolved solids are essential ingredients for aquatic life. They regulate the flow of water in and out of organisms' cells and are building blocks of the molecules necessary for life. A high concentration of dissolved solids, however, can cause water balance problems for aquatic organisms and decrease dissolved oxygen levels (Murdoch et al., 1991).

A negative relationship existed between nitrate concentration and coliform levels. As coliform levels become high, nitrate concentration tends to decrease due to uptake. Generally the nitrate concentration in water reaches high levels as a result of agricultural runoff, refuse dump runoff or contamination with human or animal waste (Kazmi and Khan, 2005). TDS in fresh waters play a role in maintaining normal osmotic gradients to support aquatic life hence, a positive correlation was noted between coliforms and TDS. The primary sources of TDS in receiving waters are agricultural runoff, leaching of soil contamination, and point source water pollution from industrial or domestic sewage (Environmental Management Bureau, 2006).

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