Selected Water Physico-Chemical Characteristics of Iloilo Batiano River, Philippines: A Baseline Study

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***Abstract*—Protecting our natural resources is one of the important thrusts of every organization. In this study, the waters of Iloilo Batiano River, Philippines is explored. This study was conducted because there is a dearth of information on the water physico-chemical characteristics of the river. Since this is an initial assessment, this study will serve as a baseline data and the results will serve as a basis for future reference for conservation measures of the river. The present study aimed to determine the selected water physico-chemical characteristics of the river such as the electrical conductivity (EC), temperature, pH, and calcium content; assess if these parameters exceed the limit set by the DENR Administrative Order No. 20F16-08 of the Republic of the Philippines and other available literatures; and to determine if there was no significant difference in the water physico-chemical characteristics among the six sampling stations. Results revealed that EC and calcium content of the river exceed their limits except for temperature and pH levels. Furthermore, EC and temperature were statistically different among the six sampling stations except for pH values. This study concludes that the river is saline due to the mixing of saltwater and surface water as the river is near to the sea and has high calcium content that can threaten the life of freshwater aquatic organisms.**

***Index Terms*—Electrical conductivity (EC), temperature, pH, calcium content, Iloilo.**

I. Introduction

Rivers serve as livelihood source, water source, agricultural lifeblood and key to economic prosperity. Much of our ancient civilizations thrive near river banks. Rivers also carry nutrients from high lying mountains down to the lowland plains. Nitrogen (N) and Phosphorus (P) are some of the nutrients that rivers transport especially during monsoon seasons [1]. Along with the thriving benefits ultimately, rivers promote urbanization. However, urbanizations that lack planning brings negative impact to the environment [2]. In addition, natural disasters and climate change also bring about changes on the river environments [3].

The present study focused on Batiano River, Iloilo, Philippines. This river is a waterway of approximately 9.8 km (6.1 mi) in length originating from Brgy. Santa Clara, Oton, Iloilo (10°41'N, 122°28'E) approximately 10 km (6.1 mi) from Iloilo City to Brgy. Villa Alegre, Molo, Iloilo City (10°41'N, 122°33'E) and empties into the Iloilo Strait [4]. The river originates on agricultural fields adjoining the Iloilo River on the north of Oton, Iloilo passing down to Arevalo and Molo, Iloilo City [5] where mostly residential and commercial areas are situated. Since water is a vital source of life, the underlying aquatic sediments also pose the same importance [6]. A group of researchers [7] assessed the Iloilo Batiano River's sediments for heavy metal assessment and found out that the river was contaminated with heavy metals such as chromium and lead and exceed the Philippine standard values. Similarly, the Iloilo River was found out to have similar heavy metals with varying conditions. To add to, according to the study about 50% of the heavy metals found may be released to the water column infecting aquatic organisms in effect [8].

Furthermore, the Ambient Water Quality Report of Batiano River for 2015 revealed that the river is a recipient of many pollutants. Present estuarine of Iloilo is a subject of great pollution which deteriorates the quality of the river due to urbanization. Major pollution sources include commercial establishments, institutions, informal settlers, sewage, animal wastes, transportation, crude oil residues and human refuses [9]. In addition, the Station 7 (Sta. Cruz Bridge, Molo, Iloilo City, Philippines) exceeded in BOD value. Coliform concentration is also high exceeding the standard value bringing the river non-compliant to water quality standard criteria for Class "C" water [5]. To bring remedy to this, several conservation plans have been drawn out by the provincial government with the Integrated River Basin Management and Development Master Plan for Iloilo-Batiano River Basin [10] as the highlight mainly to improve river water quality [11] through different projects mainly based on ecological river engineering [12] for supporting the river's sustainability. This project was materialized under the office of the River Basin Control Office (RBCO) by virtue of Executive Order 510 [13].

The physico-chemical characteristics such as electrical conductivity and pH levels denote water quality [14].

With regards to physico-chemical properties of waters, Itaogbolu area in Nigeria was found to have pH (6.59 – 7.68), temperature (21.10 ℃ – 27.10 ℃), and electrical conductivity (300 μΩ/cm – 1150 μΩ/cm) [15]. Similarly, Kollegal stretch of River Cauvery in India rages its physico-chemical properties as pH (7.46 – 8.31), temperature (22.9 ℃ – 30.5 ℃), electrical conductivity (261.3 μS/cm – 419.9 μS/cm), and calcium (60.94 mg/L – 105.8 mg/L). According to the Bureau of Indian Standards (BIS) and National River quality standards, the river is not essentially polluted and falls within permissible limits [14].

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Meanwhile, on River Kapila in India, the waters were found out to have the following: pH (6.7 – 7.35), temperature (24 ℃ – 27 ℃), and calcium (7.80 mg/L – 24.48 mg/L) [16]. In contrast, untouched water systems that are free from human disturbance like Manipur River in India showed permissible parameters where pH (6.8 – 7.9), calcium (6.01 mg/L – 8.52 mg/L), temperature (16.0 ℃ – 26.0 ℃), and electrical conductivity (124.0 μS/cm – 460 μS/cm) [17].

The identification and classification of water quality of Salak River in Malaysia based on physico-chemical characteristics found out that pH (6.98 – 7.52), electrical conductivity (36000 μS/cm – 41000 μS/cm), and temperature (28.1 ℃ – 28.7 ℃) levels fall under Class V of Malaysian waters [18].

On the other hand, the physico-chemical analysis of Buhisan River in Cebu, Philippines was also conducted and revealed that temperature (27.52 ℃ – 28.87 ℃) and pH (7.17 – 7.60) were under normal parameters [19]. In addition, the Mananga River also in Cebu, Philippines was also analyzed. Only pH (8.03 – 8.76) was found to be higher than Buhisan River [20]. Meanwhile, the Mamba River of Southern Luzon, Philippines was also tested for water assessment such as pH (8.1) and temperature (26.9 ℃) and based on the given standards of the DENR, the waters are non-polluted and suitable for development and agricultural use [21]. Furthermore, in the Carangan Estero, Ozamiz City, Philippines, the results denote a deteriorating water quality mainly due to commercial and residential refuses attributed to dense population and thriving commerce [22].

Human activity has by far the greatest reason of water pollution. Truth is that not only rivers are polluted but also waterways and reservoirs. Manair Reservoir at India was tested and it was found out that physico-chemical characteristics are within permissible limits of the standards and hence, can be used for consumption [23]. Effluents, as a human by product of South Africa, water effluents were tested and all exceeded the levels of South African Guidelines and World Health Organization's [24] tolerance limits [25].

Thus, this study was conceptualized because of the following reasons: First, there is a dearth of information on the water physico-chemical characteristics in Iloilo Batiano River. Second, since this is an initial assessment, this study will serve as a baseline data. Third, the results will serve as a basis for future reference, and finally, for conservation measures of Iloilo Batiano River.

The present study aimed to determine the selected water physico-chemical characteristics of the Batiano River in Iloilo, Philippines such as electrical conductivity (EC), temperature, pH, and calcium content; identify if the selected water physico-chemical characteristics meet the standard values; and to evaluate if there are significant differences in the selected water physico-chemical characteristics among the six sampling stations.

This study is only limited to selected water physico-chemical characteristics such as electrical conductivity (EC), temperature, pH, and calcium content. Other parameters were not measured due to resource limitations.

II. Materials and Methods

A. Research Design

This research used survey as a research design to determine the values of the selected water physico-chemical characteristics such as electrical conductivity (μS/cm), temperature (℃), pH, and calcium content (mg/L) among the six sampling stations of Iloilo Batiano River for the month of November 2018.

B. Materials

The materials used were the electrical conductivity measurement device (WTW Cond 3110), also capable of measuring the temperature; pH (1-14) measuring paper; and calcium testing kit (Manual MColortest – Calcium Test / HC548200 / 1.11110.0001).

C. Location of the Sampling Stations

There were six sampling stations (see Figure 1) located at Poblacion North at Oton, Iloilo Province (Station 1), Alegre in Oton, Iloilo Province (Station 2), Sto. Nino Sur at Arevalo, Iloilo City (Station 3), Yulo Drive at Arevalo, Iloilo City (Station 4), Calumpang, Iloilo City (Station 5), and Molo Boulevard at Molo, Iloilo City (Station 6). Figure 2 shows the sample photographic views.

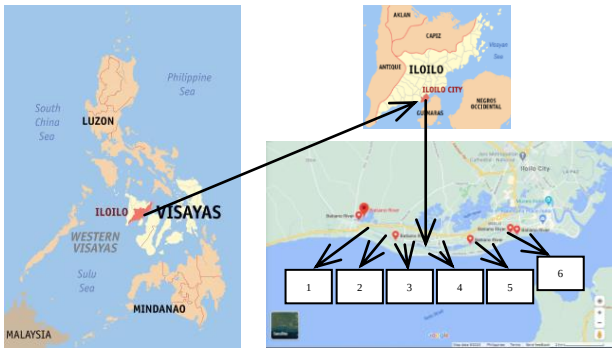

Fig. 1. Location of six sampling stations (credit to Wikipedia for the Philippine and Western Visayas maps while Iloilo Batiano River to Google Map).

Fig. 2. Sample photographic views of sampling stations: Station 1 (left) and Station 2 (right).

D. Data Collection

Every location consisted of three measurements: one on the right, one in the middle, and at last one at the left. Every sample measuring starts with testing the salinity. After the salinity measurement, the pH was determined. This makes use of a pH paper, with yellow plain color. Then it was compared with the color table, where every color has a number from 1 -14. Finally, the calcium content was measured. This was done by a MColortest Calcium testing kit.

The testing kit contains potassium hydroxide. After following some steps by using the method titrimetric with titration pipette, the amount of calcium (in mg/L) in a water sample was determined. Note that the chloride testing kit has not been used. Since the salinity was extremely high in the river, it was not possible to determine the chloride current, since an extreme amount of measuring liquid is then needed.

E. Data Analysis

One-way Analysis of Variance (ANOVA) set at .05 level of significance was used to test if there were no significant differences in the selected water physico-chemical characteristics such as electrical conductivity, temperature, and pH among the six sampling stations of Iloilo Batiano River. In addition, Scheffe test was used to compare the means of the selected water physico-chemical characteristics among the six sampling stations.

The Philippine values [26] was used as a basis to compare if the selected water physico-chemical characteristics exceed or still at the normal values. Table I shows the values of electrical conductivity (EC), and its application [27]. The amount of calcium in freshwater range from 75 mg/L [28].

TABLE I: VALUES OF ELECTRICAL CONDUCTIVITY (EC) AND ITS CORRESPONDING APPLICATIONS

Conductivity	Application
1 µS/cm	Laboratory
5 µS/cm	Irons, batteries
30 µS/cm	Excellent drinking water
600-800 µS/cm	Most common tap water
50,000 µS/cm	Seawater

III. RESULTS AND DISCUSSION

A. Water Physico-Chemical Characteristics in Station 1

In Station 1, the average EC is 13856.7 µS/cm which exceeds 600-800 µS/cm, thus, considered saline [27] and not fit for propagation and growth of freshwater fish, agriculture, irrigation, and livestock watering [26].

The average temperature is 28.1℃ which is within the limit [26]. Malaysian Salak River has also the same temperature range by 28.1 ℃–28.7 ℃ [18].

The pH of the river at Station 1 is also within the limit (7.1) which is between 6.5 and 9.0 [26]. Moreover, the Buhisan River exceeds this pH by around 6% ranging from 7.17 to 7.60 [19]. Meanwhile, the calcium content is 192 mg/L which is very high that might affect the freshwater organisms [28].

TABLE II: WATER PHYSICO-CHEMICAL CHARACTERISTICS OF STATION 1

Location	Latitude	Longitude	EC (µS/cm)	Temp (°C)	pH	Calcium (mg/L)
Right	106,934,328,430	1,224,801,516,150	13660	28.0	7.2	192
Middle	106,934,459,310	1,224,801,556,740	13960	28.2	7.1	
Left	106,933,929,330	1,224,801,463,530	13950	28.1	7.0	
		Grand Mean	**13856.7**	**28.1**	**7.1**	

B. Water Physico-Chemical Characteristics in Station 2

The average EC of Station 2 is 16423.3 µS/cm which exceeds 600-800 µS/cm, thus, considered saline [27] and not fit for propagation and growth of fish, agriculture, irrigation, and livestock watering [26]. This exceeds Manupur River's conductance in India [17] by around 36 times.

The average temperature is 29℃ which is within the limit [26]. The results complemented the findings for Kollegal River stretch in India [14].

The pH of the river at Station 2 is also within the limit (7.0) which is between 6.5 and 9.0 [26]. The results also complement with the findings in the Nigerian Itaogbolu waters [15].

On the other hand, the calcium content is 133 mg/L which is very high (despite its being the lowest of all stations). A very high calcium content might be critical to freshwater organisms [28]. The river's calcium content exceeded India's Kapila River [16] by more than 5 times.

TABLE III: WATER PHYSICO-CHEMICAL CHARACTERISTICS OF STATION 2

Location	Latitude	Longitude	EC (µS/cm)	Temp (°C)	pH	Calcium (mg/L)
Right	106,877,564,310	1,224,938,560,160	16750	29.2	6.9	133
Middle	106,877,914,290	1,224,938,734,430	16330	28.9	7.0	
Left	106,877,025,380	1,224,937,878,280	16190	29.0	7.2	
		Grand Mean	**16423.3**	**29.0**	**7.0**	

C. Water Physico-Chemical Characteristics in Station 3

In Station 3, the average EC is 19563.3 µS/cm which exceeds 600-800 µS/cm, thus, considered saline [27] and not fit for propagation and growth of freshwater fish, agriculture, irrigation, and livestock watering [26]. Meanwhile, the Kollegal River shows less conductance [14].

The average temperature is 28.9℃ which is within the limit [26]. The temperature is close to the Salak River in Malaysia [18].

The pH of the river at Station 3 is in good condition (7.1) which is between 6.5 and 9.0 [26]. In comparison to Mananga and Buhisan Rivers [20], the pH result was much lower compared to the aforementioned rivers.

Moreover, the calcium content is very high (186 mg/L). This is more than twice the limit where the situation might threaten the life of aquatic organisms [28]. It is around 28 times the calcium current of Manipur River in India [17].

TABLE IV: WATER PHYSICO-CHEMICAL CHARACTERISTICS OF STATION 3

Location	Latitude	Longitude	EC (µS/cm)	Temp (°C)	pH	Calcium (mg/L)
Right	106,847,912,660	1,225,005,269,290	19810	28.8	7.0	186
Middle	106,847,961,060	1,225,004,704,610	19360	28.9	7.3	
Left	106,848,115,310	1,225,005,219,570	19520	29.0	7.1	
		Grand Mean	**19563.3**	**28.9**	**7.1**	

D. Water Physico-Chemical Characteristics in Station 4

Stations 1 to 3 were measured between 8 AM to 9 AM while Stations 4 to 6 were measured between 4 PM to 6 PM. Station 3 was measured when the high tide was coming in, where Station 4 was measured when the low tide was coming in. Since Station 4 is the closest to the Iloilo Strait, it is very tide-sensitive.

The EC is 18416.7 µS/cm which exceeds 600-800 µS/cm, thus, considered saline [27] and not fit for propagation and growth of freshwater fish, agriculture, irrigation, and livestock watering [26].

The average temperature is 31.9℃ which exceeds the limit [26] that maybe due to the time of sampling however, a minimal increase. The temperature readings are closely similar [5] for the river monitoring.

The pH of the river at Station 4 is in good condition (7.2) which is between 6.5 and 9.0 [26].

Furthermore, the calcium content is very high (191 mg/L) that might be critical to the growth of biotic ecosystem [28]. As compared to that of Kapila River [16], the calcium content exceeds by around 7.8 times.

TABLE V: WATER PHYSICO-CHEMICAL CHARACTERISTICS OF STATION 4

Location	Latitude	Longitude	EC (µS/cm)	Temp (℃)	pH	Calcium (mg/L)
Right	106,810,868,690	1,225,173,432,520	18480	32.1	7.4	
Middle	106,811,103,680	1,225,173,432,520	18650	32.1	7.2	191
Left	106,810,905,760	1,225,173,618,500	18120	31.4	7.1	
		Grand Mean	**18416.7**	**31.9**	**7.2**	

E. Water Physico-Chemical Characteristics in Station 5

Salinity is the second highest in Station 5. The EC is 34700 µS/cm which exceeds 600-800 µS/cm, thus, considered saline [27] and not fit for propagation and growth of freshwater fish, agriculture, irrigation, and livestock watering [26]. The numbers exceeds Kollegal River [14] and Manipur River [17]. Since Station 5 is near the Iloilo Strait, high values may be attributed to the brackish nature of the water. Regardless of the tide, salt and other minerals attributed to seawater are deposited in its bed giving overwhelming readings of electric conductance.

The average temperature is 30.2℃ which is within the limit [26]. Contrasting temperatures of waters is attributed to heat convection. In comparison, Buhisan River [19] is much lower on temperature with Batiano River.

The pH of the river at Station 5 is in good condition (6.9) which is between 6.5 and 9.0 [26]. The pH reading is closely comparable to the Indian Maniar Reservoir [23].

Meanwhile, the calcium content is very high (174 mg/L) that can be fatal to the like of freshwater organism [28]. Calcium is around 64% higher compared to Kollegal River [14] and about 6 times higher than Kapila River [16].

TABLE VI: WATER PHYSICO-CHEMICAL CHARACTERISTICS OF STATION 5

Location	Latitude	Longitude	EC (µS/cm)	Temp (℃)	pH	Calcium (mg/L)
Right	106,877,626,130	1,225,389,038,180	35300	30.1	6.9	
Middle	106,877,520,950	1,225,388,432,850	33600	30.3	7.0	174
Left	106,879,840,320	1,225,387,663,320	35200	30.3	6.8	
		Grand Mean	**34700**	**30.2**	**6.9**	

F. *Water Physico-Chemical Characteristics in Station 6*

Station 6 is the station which is located the nearest to the Iloilo Strait. The average salinity is extremely high (39733.3 µS/cm) but not unexpected (because the location is near the Iloilo Strait). The current is very close to the salinity of seawater (around 50000 µS/cm) thus, considered saline [27] and not fit for propagation and growth of freshwater fish, agriculture, irrigation, and livestock watering [26]. This is closely comparable to the Salak River in Malaysia with conductivity range of 36000 to 41000 µS/cm [18].

The average temperature is 29.3 ℃ which is within the limit [26]. This is close to the readings made on Salak River [18] and Buhisan River [19].

The pH of the river at Station 6 is in good condition (7.1) which is between 6.5 and 9.0 [26]. The pH is close to the results of the water testing on Manair Reservoir [23] and is greatly lower than Buhisan River [20].

The calcium content on the other hand is very high (198 mg/L) that can be fatal to the growth of freshwater organisms [28]. The calcium content is around 7 times higher than that of Kapila River [16] and about 87% higher than that of Kollegal River [14].

TABLE VII: WATER PHYSICO-CHEMICAL CHARACTERISTICS OF STATION 6

Location	Latitude	Longitude	EC (µS/cm)	Temp (℃)	pH	Calcium (mg/L)
Right	106,908,955,000	1,225,491,223,870	40700	29.4	7.2	
Middle	106,907,862,940	1,225,492,852,250	41200	29.2	7.0	198
Left	106,909,516,450	1,225,491,820,810	37300	29.2	7.1	
		Grand Mean	**39733.3**	**29.3**	**7.1**	

Table VIII shows that there are significant differences in terms of EC, F (5, 12) = 364.864, p = .000 and temperature, F (5, 12) = 134. 297, p = .000 among the six sampling stations. This means that one of the sampling stations is different from each other.

Meanwhile, no significant difference was observed in pH, F (5, 12) = 2.220, p = .120 among the six sampling stations. This implies that pH values are the same regardless of the station. Calcium was excluded in the One-ANOVA computation due to similarity of values in the respective station.

TABLE VIII: ONE-WAY ANOVA RESULTS FOR THE SIGNIFICANT DIFFERENCES IN THE EC, TEMPERATURE, AND PH VALUES

Test	Sources of Variation	SS	df	MS	F	Sig.
EC	Between Groups	1.719	5	3.437	364.864*	.000
	Within Groups	1.131	12	942094.444		
	Total	1.730	17			
℃	Between Groups	26.113	5	5.223	134.297*	.000
	Within Groups	.467	12	.039		
	Total	26.580	17			
pH	Between Groups	.185	5	.037	2.220	.120
	Within Groups	.200	12	.017		
	Total	.385	17			

Note. Asterisk (*) means significant at .05 level of probability.

Furthermore, Stations 5 and 6 are both significantly different from the rest of the sampling stations. However, Station 6 has the highest value in EC and at the same time, significantly different from the other sampling stations. This might be attributed to the nearness of the river to the sea. Nevertheless, the results greatly support that commercial and residential refuses deteriorates the water quality in conjunction with the rapid increase of population and the boom of commerce [22]. This study also supports that pollution sources which are present along the stretch of the river [9]. To add, the presence of heavy metals on the sediment bed of the river also gives more meaning to the results [7]. In effect, the release of heavy metals on water column will highly destroy the river's ecosystem since the Philippine is closely approaching the typhoon season [8].

TABLE IX: COMPARISON OF MEANS IN EC AMONG STATIONS

Station	Mean
1	$13,856.7^{a}$
2	$16,423.3^{ab}$
3	$19,563.3^{c}$
4	$18,416.7^{bc}$
5	$34,700^{d}$
6	$39,733.3^{e}$

Moreover, Stations 1, 4, and 5 are significantly different from the rest of the sampling stations as shown in Table X. However, Station 1 has the lowest values in temperature while Station 4 has the highest temperature of them all and is statistically different from other stations. This might be attributed to the varied chemicals dumped in the river.

TABLE X: COMPARISON OF MEANS IN TEMPERATURE AMONG STATIONS

Station	Mean
1	28.10[a]
2	29.0[b]
3	28.90[b]
4	31.9[d]
5	30.2[c]
6	29.3[b]

IV. CONCLUSIONS

Based on the foregoing results, this study concludes that Batiano River is saline because the river is near to the sea and has high calcium content that might threaten the life of freshwater aquatic organisms. This may be attributed to irresponsible management of wastes being thrown in the river.

The city government of Iloilo must focus its attention in saving Batiano River. A water filter and litter trap can be placed in the middle of Stations 1 and 2, then at the middle of Stations 5 and 6, and finally, at the end point of Station 6 to filter wastes and litter before these get further downstream or even flow into the Iloilo Strait. Furthermore, different stakeholders such as the Local Government Units (LGU's), private sectors, and residents should strategize to conserve Batiano River as a legacy to the next generation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

B. N. Wiederhold and T. Lichtenberg collected water samples, measured its physico-chemical parameters, and contributed inputs to the manuscript; R. Germo analyzed the data and contributed inputs to the manuscript especially for related literatures; and B. G. Sarinas wrote and edited the final manuscript. All authors had approved the final version.

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