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 °C – 27.10 °C), 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 °C – 30.5 °C), 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].
Meanwhile, on River Kapila in India, the waters were found out to have the following: pH (6.7 – 7.35), temperature (24 °C – 27 °C), 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 °C – 26.0 °C), 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 °C – 28.7 °C) 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 °C – 28.87 °C) 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 °C) 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.
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 content, 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].

The average temperature is 29°C 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.

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°C 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 Buhsan 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].

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°C 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**

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
<th>EC (μS/cm)</th>
<th>Temp (℃)</th>
<th>pH</th>
<th>Calcium (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>106.810,868,690</td>
<td>1,225,173,452,520</td>
<td>18480</td>
<td>32.1</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>106.811,103,660</td>
<td>1,225,173,452,520</td>
<td>16650</td>
<td>32.1</td>
<td>7.2</td>
<td>191</td>
</tr>
<tr>
<td>Left</td>
<td>106.810,905,760</td>
<td>1,225,173,618,500</td>
<td>18120</td>
<td>31.4</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td><strong>Grand Mean</strong></td>
<td>18416.7</td>
<td>31.9</td>
<td>7.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 Salak River in Malaysia with conductivity range of 36000 to 41000 μS/cm [18].

**TABLE VI: WATER PHYSICO-CHEMICAL CHARACTERISTICS OF STATION 5**

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
<th>EC (μS/cm)</th>
<th>Temp (℃)</th>
<th>pH</th>
<th>Calcium (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>106.877,826,180</td>
<td>1,225,359,038,180</td>
<td>35300</td>
<td>30.1</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>106.877,520,950</td>
<td>1,225,338,432,850</td>
<td>33600</td>
<td>30.3</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>106.879,840,320</td>
<td>1,225,387,663,320</td>
<td>35200</td>
<td>30.3</td>
<td>6.8</td>
<td>174</td>
</tr>
<tr>
<td><strong>Grand Mean</strong></td>
<td>34700</td>
<td>30.2</td>
<td>6.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F. Water Physico-Chemical Characteristics in Station 6

Station 6 is the station which is located the nearest to the Iloilo Strait. The available 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 VIII: ONE-WAY ANOVA RESULTS FOR THE SIGNIFICANT DIFFERENCES IN THE EC, TEMPERATURE, AND pH VALUES**

Table VIII shows that there are significant differences in terms of EC, \( F(5, 12) = 364.864, p = .000 \) and temperature, \( F(5, 12) = 134.297* \) 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 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 has a significant impact on the will highly destroy the river’s ecosystem since the Philippines is closely approaching the typhoon season [8].

**TABLE IX: COMPARISON OF MEANS IN EC AMONG STATIONS**

<table>
<thead>
<tr>
<th>Station</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13,856.7*</td>
</tr>
<tr>
<td>2</td>
<td>16,423.3*</td>
</tr>
<tr>
<td>3</td>
<td>19,563.3</td>
</tr>
<tr>
<td>4</td>
<td>18,416.7*</td>
</tr>
<tr>
<td>5</td>
<td>34,700</td>
</tr>
<tr>
<td>6</td>
<td>39,733.3</td>
</tr>
</tbody>
</table>

Note: Asterisk (*) means significant at .05 level of probability.
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>
<thead>
<tr>
<th>Station</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28.10°</td>
</tr>
<tr>
<td>2</td>
<td>29.0°</td>
</tr>
<tr>
<td>3</td>
<td>28.90°</td>
</tr>
<tr>
<td>4</td>
<td>31.9°</td>
</tr>
<tr>
<td>5</td>
<td>30.2°</td>
</tr>
<tr>
<td>6</td>
<td>29.3°</td>
</tr>
</tbody>
</table>

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 12, 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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