Journal of Namibian Studies, 34 S2(2023): 493-502 ISSN: 2197-5523 (online)

Water Quality Assessment of Santa Cruz River in 2011 and 2022 in the Vicinity of Liliw and Nagcarlan, Laguna, Philippines

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Abstract

Santa Cruz River has significant importance for the economic development of the Philippines and the inhabitants depending on this river for various purposes. It is also one of the 21 major tributary rivers of Laguna de Bay that has a substantial contribution of 15% to the total lake water. This study aims to determine water quality in part of Liliw-Nagcarlan, Laguna of the Santa Cruz River in 2011 and 2022 and to identify the sub-watershed experiencing changes in water quality. There are three sites used for sampling (Talahibing, Bangkuro, and Lapad rivers). Physicochemical and hydrometry were measured in situ. Temperature, pH, and conductivity are within the normal limits. However, dissolved oxygen was generally above the normal limits based on the DENR Water Quality Guidelines. The results showed that the water quality in 2011 and 2022 was projected to change. The number of

settlements, recreational activities, and nature park areas increased while the riparian vegetation decreased. The change in land cover will affect the water quality. The result of the assessment for the temperature and conductivity in 2022 was higher compared to 2011. The increase that occurred was influenced by the reduced dissolved oxygen and the pH level, which can cause fish kills and create significant harm to ecosystems. Flowrate was higher from 2022 compared to 2011, since the temperature increased, and the dissolved oxygen levels decreased from this study. Important correlations between the different parameters and the year of the study were proved.

Introduction

A river is a natural watercourse characterized by flowing water originating from high places, such as mountains and hills. It is a lotic ecosystem that can move nutrients, sediments, and pollutants from the upland. The water then drains into inland bodies of water such as lakes, where nutrients, sediments, and pollutants are suspended (Taylor and Stokes, 2005). Conserving the river environment is essential because it is used in the transportation system, in agricultural and industrial activities, for recreation and tourism purposes, as a source of food and water, and as a habitat to flora and fauna species (Srinivas, 2016). However, due to industrialization and population growth, maintaining the quality of the rivers is a challenge in many regions of the world (Fleituch and Amirowicz, 2005; Tanida, 2009)

In the Philippines, river systems are usually affected by improper domestic use, rapid irrigation, and continuing urbanization (Dayo et al., 2016). In 2003, the World Bank cited the rivers in Metro Manila, Central Luzon, Central Visayas, and Southern Tagalog as significantly affecting poor water quality based on ISO standards. They require proper monitoring and rehabilitation. Thus, programs like the Clean Water Program of the Department of Environment and Natural Resources (DENR) (www.denr.gov.ph), the “Sagip Ilog (Save the River)” program of the Villar Foundation (www.laspinascity.gov.ph), and the Recognizing Individuals/Institutions towards Vibrant and Enhanced Rivers (RIVERs) for Life Award of the DENR (Siytangco, 2018), among others, were launched to promote river conservation in the country. One of the key indicators for a successful river conservation program is the achievement and maintenance of the acceptable water quality as reflected on its physicochemical characteristics (Boulton et al., 2016).

There are various research and development projects in the Philippines that monitor the lotic systems across the country. Some of the rivers commonly studied include Pasig River, Mt. Makiling, Forest Reserve, Pagsanjan-Lumban Catchment, Pampanga River Basin, Marikina River, and Pasig-Potrero River Basin (Magbanua et al., 2017). In the systematic

review of Magbanua et al. 2017 on 25 years (1988-2012) of freshwater research in the Philippines, research activities on freshwater ecosystems must be intensified in the less represented areas.

One of the river ecosystems that needs attention is the Talahibing, Bangkuro, and Lapad river continuum in Liliw and Nagcarlan, Laguna. It is a long river stretch called Santa Cruz River with several sub-names based on the sections of water per locality. The river is subjected to riverine communities and increased recreational, domestic, and industrial activities within its vicinity. This study compared the data on the qualities of the river from the two-time points in 2011 and 2022. It sought to determine the river's water quality changes in the 11-year interval and draw implications on the possible reasons for change.

Methodology

Characteristics of the sampling stations

The study carried out a descriptive quantitative assessment of the physicochemical qualities of the Santa Cruz River in Liliw and Nagcarlan, Laguna, Philippines. Santas Cruz River system contributes about 15% freshwater of the total water of Laguna de Bay (LLDA, 2012). A major portion (75%) of this river system is located in the province of Laguna, particularly in the municipalities of Liliw, Nagcarlan, Sta. Cruz, Magdalena, Majayjay, and Rizal. The rest of the river system is located in the province of Quezon, particularly in the municipalities of Candelaria, Dolores, Sariaya, and Lucban, and the city of Tayabas.

Along the stretch of the river, the researchers identified the three sampling stations, namely the upstream (US) in Talahibing Bridge, Nagcarlan, Laguna (14°08'19.1"N, 121°25'10.6"E), the midstream (MS) in Batis, Bangkuro, Nagcarlan, Laguna (14°10'16.7"N 121°24'47.2" E), and the downstream (DS) in Barangay Mojon, Calumpang, Liliw, Laguna (14°11'35.2"N 121°24'29.6" E). Figure 1 shows the map of the sampling sites.

The sections of the river continuum have distinct characteristics based on the site ocular assessment

Few residential houses and establishments are found in the US stations. There are more human inhabitants doing domestic activities, like bathing and washing their clothes, in the MS station. It is also characterized by thriving grasses and trees. In the DS station, commercial establishments and national highways arere found. Increased domestic activities and more industrial affluence characterize it. In this station, during the sample collection in 2022, sand and gravel quarrying was done.

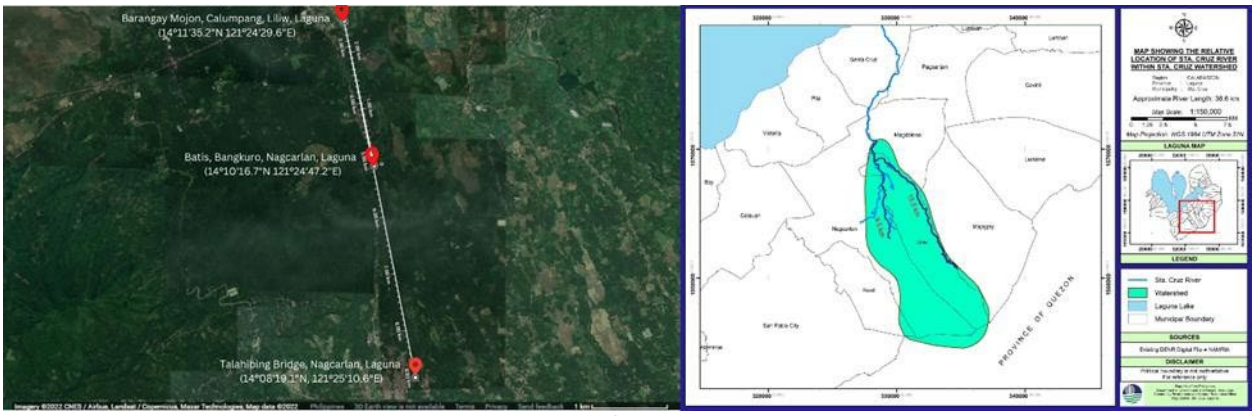

Figure 1. The geographic location of the study area is Santa Cruz River in Liliw and Nagcarlan, Laguna, Philippines.

Water Quality Testing

Temperature (˚C), pH, dissolved oxygen (DO), and conductivity (µS/cm) were determined with the Aquaread Probe Meter water quality checker. All results obtained from the physicochemical parameters were compared to DENR (Order No. 2016-08) standards, except conductivity (EPA, 2012), turbidity (MPCA, 2008), and streamflow (NIWA, 2016).

The hydromorphological parameters, such as the depth and flow rate, were determined using the Valeport Braystroke Model BFM001 probe meter. At the same time, using a 100-meter plastic tape meter, the width and length were measured.

Statistical Analysis

All data were stored in Microsoft Excel and subjected to Mean values and Standard deviation. The researcher performed a paired t-test to determine the difference between Sta's physicochemical and hydromorphology qualities. Cruz River in 2011 and 2022. Descriptive statistics were analyzed using the Statistical Package for the Social Sciences (SPSS) with a P=0.05 level of significance.

Results And Discussion

Water quality characteristics of Santa Cruz River in the upstream, midstream, and downstream.

The results of the physicochemical analysis of the Santa Cruz River are shown in Table 1 below.

Table 1. Water quality characteristics of Santa Cruz River (2011 and 2022).

Parameter	Standard*	2011			2022		
Physicochemical		US	MS	DS	US	MS	DS
DO (mg/L)	>5	7.98	11.70	7.76	7.50	7.58	4.59
Temperature (˚C)	25-31	25.55	27.70	29.28	26.26	28.87	29.47
pH	6.5-9.0	8.47	8.35	6.71	6.74	7.89	6.50
Conductivity (µS/cm)	200-1000[a]	212.56	219.00	235.83	225.67	302.67	321.87
Hydromorphology							
Flow rate (m/s)	0-3.1[b]	0.94	0.56	0.33	2.95	0.97	0.81
Depth (cm)	-	41.61	90.00	11.73	40.00	87.64	6.15
Width (m)	-	26.18	40.00	8.10	9.00	28.33	6.37

Note: *Based on DENR Order No. 2016-08 unless indicated.

a Environmental Protection Agency (EPA, 2012)

b National Institute of Water and Atmospheric (NIWA, 2016).

Water analysis of the Santa Cruz River showed that temperature and pH are within the permissible range for freshwater source C waters based on the DENR standards. Though these two parameters are generally acceptable, there are observable changes in the data in 2011 and 2022. The 2022 data shows higher temperatures in all sites compared to the 2011 data. In contrast, the pH level is lower in 2022 data compared to 2011 data. The measurements of conductivity in all stations at all sampling periods were acceptable based on the normal range, according to EPA (2012). The data on the dissolved oxygen shows that most sampling sites have acceptable measures of >5 mg/L, except the 2022 data for DS with a DO of 4.59 mg/L. Additionally, the data on hydromorphology parameters shows acceptable measures in 2011 and 2022 based on the desirable range, according to NIWA (2016).

Differences of water quality characteristics of Santa Cruz River in 2011 and in 2022

The physicochemical water parameters of Sta. In 2011 and 2022, the researchers assessed, recorded, and analyzed the Cruz River on their significant differences. The mean values of each parameter are showed in table 2 together with the computed P-value.

Table 2: Mean values and standard deviation of physicochemical parameters and hydromorphology of Sta. Cruz River in 2011 and in 2022.

Parameter	Standard*	2011		2022		P-value
Physicochemical		**Mean**	**SD**	**Mean**	**SD**	
DO (mg/L)	>5	9.15	2.21	6.56	1.70	0.14
Temperature (˚C)	25-31	27.51	1.87	28.2	1.71	0.13
pH	6.5-9.0	7.84	0.98	7.04	0.74	0.23
Conductivity (µS/cm)	200-1000[a]	222.46	12.02	283.4	50.91	0.13
Hydromorphology						
Flow rate (m/s)	0-3.1[b]	0.61	0.31	1.58	1.19	0.21
Depth (cm)	-	47.78	39.5	44.6	40.94	0.12
Width (m)	-	24.76	15.99	14.57	11.99	0.15

Note: SD = Standard Deviation

Significant P-value = ≥0.05

Water temperature values ranged from 25.55-29.28°C for the year 2011 and 26.26-29. 47°C for the year 2022.The lowest values of water temperature with 25.55°C (2011) and 26.26°C (2022) obtained in the upstream, while the highest values of 29.28°C (2011) and 29.47°C (2022) were obtained at the downstream. The researchers observed no significant difference (P-value = 0.14) in the temperature of Sta. Cruz River within 11 years. This study shows that the temperature of the river is acceptable in either year; and it is consistent for the stream stations for US and DS, respectively.

Water temperature is one of the aquatic ecosystems' most important physical properties, influencing various water quality parameters. It is accounted for when determining photosynthesis production, water density, and dissolved gas concentrations (Hatfield, 2019). Temperatures can vary throughout the river, with surface water being more affected by air temperature due to its proximity to the mountain. The study's results could mean no significant changes in the atmospheric characteristics in the area and the flow of the thermal energy, which can be affected by the presence of biotic and abiotic factors through the past 11 years.

The pH of the water in 2011 and in 2022 were found to be within the normal limits with no huge differences of values between stations, between two different years. When P-value was calculated, there is no significant difference between the measurements. The highest pH value (8.47) was obtained upstream in 2011, while the lowest (6.50) was obtained downstream in 2022. According to the USEPA (1980), accepted water quality criteria indicate that pH levels lower than 6.5 units may harm to many fish species. As a result, a pH range of 6.5-9.0 is appropriate for aquatic habitat protection. The acidic pH is a feature of oligotrophic

water bodies, whereas the neutral and alkaline pH are characteristics of eutrophic and mesotrophic water bodies, respectively (Soni et al., 2013). According to Turkish water pollution control regulations, if a lake, pond, or usage of a dam reservoir is for natural protection or recreational purposes, a pH of 6.5 to 8.5 should be obtained (Anonymous, 2008).

Dissolved oxygen concentrations slightly varied between stations. The highest dissolved oxygen concentration value of 11.70 mg/L was obtained in the midstream (2011), while the lowest value of 4.59 mg/L was obtained downstream (2022). When computed the mean values of DO in 2011 and 2022, both met the standards set by the DENR, and there was no significant difference between the two measurements. Dissolved oxygen is one of the important essential parameters in water quality assessment and reflects the biological and physical processes prevailing in the water. Dissolved oxygen is an important essential factor for aquatic life and the chemical characteristics of the environment. In inland ecosystems, the minimum dissolved oxygen may not be less than 5.0 mg L–1 for aquatic life (Egemen, 2011). The recorded values of dissolved oxygen imply that Santa Cruz River was good for aquatic life in 2011 and still have a healthy water ecosystem in 2022 despite some industrial and domestic development in the communities along the river.

The conductivity value ranged from 212.56 to 235.83 (2011) and 225.67 to 321.87 (2022). The highest conductivity value of 321.87 was obtained downstream (2022), while the lowest value of 212.56 was obtained upstream (2011). According to Polat (1997), conductivity levels above 1000 indicate pollution in a lake or body of water. The conductivity values of Sta. Cruz River in 2011 (222.46±12.02 µS/cm) and 2022 (283.4±50.91) were acceptable according to the prescribed limits. There is no significant difference between the two measurements.

Hydromorphology necessitates a thorough understanding of the dynamism and complexity of rivers, which involve multidimensional geomorphic processes and adjustments as responses to impacts and disturbances at various spatial and temporal scales (González del Tánago et al., 2016). The flow rates of the Sta. Cruz River in 2011 with a range of 0.33 to 0.94 m/s were acceptable based on the NIWA standard with a range of 0 – 3.1 m/s. The flow rate of Sta. Cruz River in the US in 2022 (2.94 m/s) measured the highest compared to all other stations, regardless of the year of water quality assessment. Despite a big difference from other measurements, it is still within the acceptable limits. There are several factors that affect the speed of a river such as the slope gradient, the roughness of the channel, and tides. Also, these lotic ecosystems tend to flow from higher elevation to a lower elevation. Therefore, the rivers speed is at its maximum at the higher elevation (high gradient, high energy) and at its minimum at the downstream (no gradient, lowest energy) (Gaballa, 2006).

Overall, the mean values of flow rate, depth, and width of the Sta. Cruz River have no significant differences in 2011 and in 2022. In this paper, we argue that based on hydromorphological assessments, the need for effective river management in Sta. Cruz River is not yet in the critical level despite the quarrying activities in the area. The basis of this argument is the concept that hydromorphology data can help in identifying problems and defining needs for river restoration actions by identifying current deficits or distances from conditions that would naturally occur in the absence of impacts (González del Tánago et al., 2016; Klösch and Habersack, 2017; Polvi et al., 2020).

Conclusion

Santa Cruz River in Liliw and Nagcarlan, Laguna, is a typical Class C freshwater source. Observed are the variations in DO and pH across the river's upstream, midstream, and downstream. It decreased in 2022 compared to 2011 data. Despite this variation, the physicochemical qualities of Sta. Cruz River were was within the acceptable limits. There is also no significant difference in the river's water quality in 2011 and 2022 based on the assessed temperature, pH, conductivity, DO, and hydromorphology characters.

The continuous quality assessment of the Sta. Cruz River is important. This study shows no red alert on the need for river conservation as far as the river's physicochemical and hydromorphological qualities are concerned. Despite an acceptable water quality, other factors need further study especially that quarrying is being conducted in the area during the 2022 visit. Additionally, the National Irrigation Administration (NIA) completed the installation of an automated sluice gate for the Santa Cruz River Irrigation System (Sta Cruz RIS) on November 4, 2021, in Barangay Calumpang, Liliw, Laguna. This study seeks to provide the 1,542 farmers and their families in the Municipalities of Sta. Cruz and Pila, Laguna, with year-round irrigation water. A nature park is also being built in the area during the 2022 visit. The long-term effect of these developments in the communities along the Sta. Cruz River is unidentifiable in this study. It makes the area an ideal location for further study focusing on other indicators of healthy river system.

Acknowledgement

The authors would like to thank the local government of Liliw and Nagcarlan, Laguna, especially in the Barangay Talahibing, Bangkuro, and Mojon, who helped conduct the study in 2011 and 2022.

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