# Physico-chemical and Bacteriological Characteristics of Señora River, Siquijor Island, Central Philippines

Hermilita L. Paculba
Rosalina E. Catid
Ronald Alexis L. Tan
Glory J. Barrera
Septima C. Aque
Diogenes M. Barrera
Siquijor State College
Larena, Siquijor, Philippines

The water quality of Señora River in Lazi, Siquijor, Philippines was assessed in terms of its physico-chemical and bacteriological (*Escherichia coli*) characteristics. The study aimed to establish baseline data on its water quality for future studies. It also determined the spatial and seasonal variation of the parameters used. Sampling was done in the upstream, midstream, and downstream sections of the river from February to July 2011. Major findings are as follows: [1] all values of the parameters monitored are within the permissible limits (based on the standards set by the DENR, except for *E. coli*; [2] there is no significant difference in the spatial variation (among the three stations) of dissolved oxygen (DO), salinity, water sub-surface temperature, water surface temperature, nitrates-N, phosphates-P, and *E. coli* contents [however, levels of total dissolved solids (TDS), pH, and conductivity of the river are significantly higher in the downstream station]; [3] there is no significant difference in the seasonal (wet and dry months) variation of all the parameters; and [4] Based on *E. coli* content of the water, Señora River failed to meet standards set by the Philippine National Standard for Drinking Water (PNSDW). The middle and downstream part of the river can be classified as Class B and C intended for primary contact recreation such as bathing and swimming only.

**KEYWORDS:** physico-chemical and bacteriological characteristics of rivers, Señora River

## INTRODUCTION

Agriculture is among the greatest water users as well as the largest contributor to water pollution (Enger, 2000) as a result of an expanding global population growth (Cunningham & Cunningham, 2008). Siquijor Island, being one of the smallest provinces in the Philippines with only one river existing is not an exception.

The island province of Siquijor in Region 7 is bounded in the north by the islands of Cebu, Bohol in the northwest, mainland Mindanao in the south, Camiguin in the east, and Negros Island in the west, and is geographically located at 9°05.76′00″ and 9°18.19′00″ N and 123°26.51′00″ and 123°42.02″E (Bendijo et al., 2004). The island is hilly and mountainous, made up mostly of limestone rocks. The climate of Siquijor is characterized by the dry season from January to May, and the wet season from June to December. Rainfall is minimal in this province than it is in the rest of Region 7. Typhoons usually affect only the southern part of the Island—in the towns of Lazi and San Juan (Bendijo et al., 2004).

Señora River in Lazi, is the major river in the province of Siquijor. It traverses the barangays of Capalasanan, the Cangclaran-Tagmanocan border, Nagerong, and the Simacolong-Tigbawan

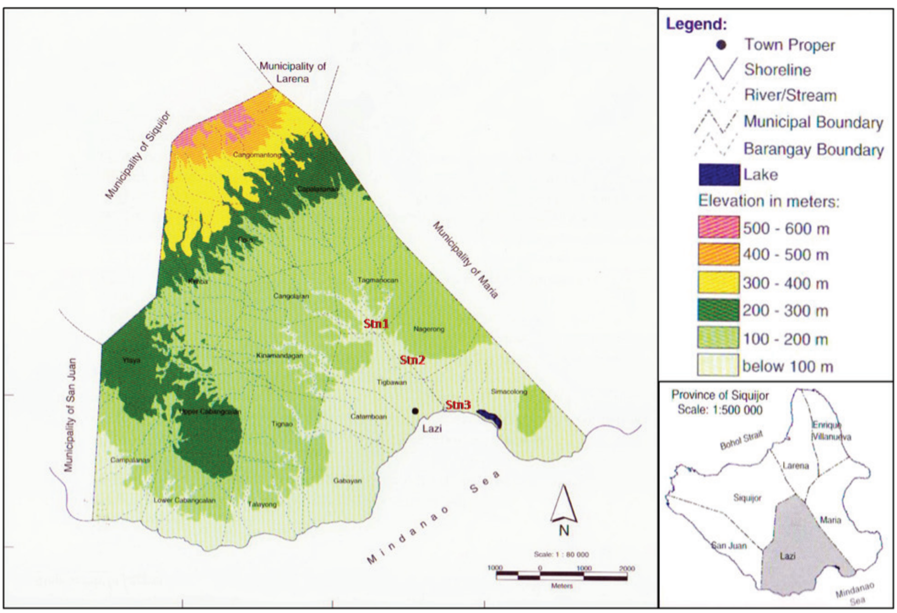



*Figure 1.* **Map of the Lazi municipality showing the location of the sampling stations in Señora River. Modified from Geographic Atlas of Siquijor (1999).**

border. The tributaries in the upper reaches of the river irrigated the rice paddies which in turn contribute agricultural runoff to the river. In the middle segment of the river is the Cambugahay Falls which is frequently visited by both domestic and foreign tourists. It receives one of the tributaries from the barangays of Canggomantong and Po-o. The downstream portion of the river, Barangay Tigbawan, is densely populated. Residential wastewaters are directly discharged into the river without any treatment.

*Table 1.*

**Geographic Coordinates of the Sampling Sites.**

| Station | Site | Coordinates | Station | Site | Coordinates | Station | Site | Coordinates |
|---|---|---|---|---|---|---|---|---|
| | 1 | 9°10′37.6″ N<br>123°36′55.3″ E | | 1 | 9°10′21.4″ N<br>123°37′02.8″ E | | 1 | 9°10′06.1″ N<br>123°37′07.7″ E |
| **1** | 2 | 9°08′48.3″ N<br>123°37′24.4″ E | **2** | 2 | 9°08′39.6″ N<br>123°37′27.2″ E | **3** | 2 | 9°08′27.8″ N<br>123°37′35.2″ E |
| | 3 | 9°07′50.8″ N<br>123°38′15.7″ E | | 3 | 9°07′45.7″ N<br>123°38′17.4″ E | | 3 | 9°07′35.5″ N<br>123°38′24.1″ E |

Many river studies have been conducted across the Philippine archipelago. The much known Pasig River in Metro Manila was declared virtually dead in 1990 by DENR (Cruz, 1997) during dry summer months since the dissolved oxygen content dropped below standard that can support aquatic life. It was revealed that the water quality had deteriorated which were attributed to the indiscriminate discharging of waste into the river by manufacturing industries and from the households as a result of urbanization. Pampanga River, being the fourth largest basin in the Philippines, is susceptible to ecological imbalance due to pollution and natural changes (Angeles, 2008). Borlongan (2010) reported the alarming deterioration in the physico-chemical quality and rise in the nutrient levels of Jalaur River in Iloilo. Cagayan de Oro River in Cagayan de Oro City is contaminated with fecal coliform which was due to improper disposal of human and animal wastes into the river due to unavailability of toilet facilities (Lubos, 2008). The quality of water in Naboc River in Mindanao was assessed by Mines and Geo-sciences Bureau (MGB) XI in 2009. It was reported that Naboc River is heavily burdened by poisonous deposits from mining tailings of Mt. Diwalwal gold panning operations. Aside from mercury and cyanide, it is ailing with other heavy metals such as copper (Cu) and lead (Pb) and suspended solids of clay and soils, turning its once clear waters into murky. It is also heavily silted as revealed by the presence of suspended solids.

It is in view of these revelations that the researchers were interested to dwell on this area, thus this study was conceived. The results will help find mitigating endeavors of all of the stakeholders of the river. This study was conducted particularly to establish baseline information of the water quality of the river. The different water quality parameters monitored were dissolved oxygen (DO), total dissolved solids (TDS), pH, conductivity, salinity, water surface and water subsurface temperatures, nitrates-N, phosphates-P, and biological parameter using *E. coli*. The seasonal (wet and dry months) and spatial variations and correlations between parameters were also determined. The quality of the water is compared with the standards set by the Department of Environment and Natural Resources (DENR), and USEPA, while the classification of the river is based on DENR standards.

## MATERIALS AND METHODS

### Sampling Stations

Three sampling stations with three sampling sites each, approximately at five hundred-meter distance in between sites, were strategically established to determine the physico-chemical and coliform (*E. coli*) content of the water. Station 1 is located upstream (Capalasanan), Station 2 is in the middle segment (Cambugahay Falls), and Station 3 in the downstream or estuarine portion of the river (Tigbawan). There were three samples per sampling sites with three replicates for each water quality conducted during the entire duration of the study.

### Sample Collection and Frequency

Water quality parameters such as dissolved oxygen (DO), total dissolved solids (TDS), pH, conductivity, salinity, water and ambient temperatures were monitored *in situ* each month, using portable meters, from February to July 2011. Samples of about 500 mL of river water were obtained using sterilized polymeric bottles and brought to Chemistry and Biology laboratories of Silliman University, Dumaguete City for analysis of nitrates-N, and phosphates-P, and *E. coli*.

### Statistical Analysis

The laboratory results obtained each month were subjected to descriptive statistics. Mean + standard deviation were used and one-way ANOVA (with 95% level of significance and 5% margin of error) was utilized to determine the significant difference of the parameters between stations and between dry and rainy months.

## RESULTS AND DISCUSSION

This study provides baseline information about the water quality of the three sampling stations in Señora River, including variations in the parameters during wet and dry months. The monthly average values of the different parameters are presented in Appendix B. Mean and standard deviation of the parameters are presented in Table 1. Comparisons of the river quality vs. water quality standards set by the DENR are also presented (Tables 2 and 3).

### a. Dissolved Oxygen (DO)

Dissolved Oxygen is an important parameter which determines the quality and suitability of water to support aquatic life. The dissolved oxygen (DO) level of the water in Señora River ranged from 5.91– 9.77 ppm. This range is higher than the acceptable limit (more than 5 ppm) for fishes and other aquatic organisms to survive (Mapa & Trinidad, 2001). The higher DO values indicate unpolluted water (Varunprasath & Nicholas, 2010; Moniruzzaman et al., 2009). Station 3 has the lowest DO value of 6.81 + 0.567 mg/L, which might be attributed to several factors, including direct dumping of organic wastes from neighboring households.

Organic waste demands oxygen for decomposition (http://www.dnr.mo.gov/env/esp/ water quality-parameters). This is in agreement of the results of other studies conducted elsewhere (Hart & Zabby 2005; Davies et al. 2008; Abowei 2010). In this study, a slight decrease of DO values was observed during dry months, probably due to increased water temperature (Miller, 1998; Abowei, 2010).

### b. Total Dissolved Solids

Total Dissolved Solids (TDS) is a measure of the amount of material dissolved in water such as carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, calcium, magnesium, sodium, organic ions, and other ions. Sources of TDS include fertilizer in agricultural runoff, salinity from tidal mixing, minerals, returned irrigation water, and acidic rainfall.

The total dissolved solids (TDS) content of the water was lowest in Station 1 (216+ 34.205 148 mg/L) during the wet months (February, April, and June) and highest in Station 3 (1045.56+1016.425 mg/L) during the dry months (March, May, and July). A slight increase in the TDS values during dry months in the three stations was observed. However, this increase is not statistically significant.

### c. pH

pH is a measure of the acidity or alkalinity of substance. Acidic surface waters (pH < 7) decrease the survivability of animal life in lakes and streams. In more severe instances, acidity eliminates some or all types of fish and other aquatic organisms. Healthy rivers have pH values of 6.5 or slightly above (Eubanks et al., 2006).

The pH of water in Señora River ranged from 6.7–8.1, which is slightly acidic to slightly basic. The lowest pH of the water (6.7–slightly acidic) was observed in Station 1 in February, 2011. Station 2 has the highest mean pH value of 7.93 ±0.166 (S.D.) during the dry months. The alkalinity of water in this Station might be attributed to the run-off coming from rice paddies and other domestic discharges. The difference of the pH of the water did not vary significantly between wet and dry months.

### d. Conductivity ($\mu$S)

The conductivity of the water in Señora River ranged from 310–4600 $\mu$S. Station 1 has a mean value of 456.22 $\mu$S and standard deviation of 73.641 μS during wet months and Station 3 with 1784.44 ± 1584.775 S.D. $\mu$S during dry months. Station 3 has significantly higher conductivity values relative to other stations since it is the downstream of the river where fresh and seawater mixed. Sea water has higher conductivity than freshwater because of dissolved salts or electrolytes. The high standard deviation value in this station can be accounted by the lowest value of 547 $\mu$S registered in the month of July since sampling was done during a low tide (High Tide at 10:36 AM with 1.9 m and Low Tide at 6:11 PM with -0.2 m). While it is possible that the conductivity of the water in Station 3 might be affected by the discharges coming from Tagmanocan and Nagerong (residential and agricultural) and Tigbawan (commercial and residential) areas, statistical tests revealed negative.

### e. Salinity (‰)

The salinity of the water in Señora River ranged from 0.1-1.0‰ in the upstream stations and 0.2-5.4‰ in the downstream station. The increase in salinity in the downstream station is due to the influx of seawater (which has salinity of about 35‰) during high tide (Castro & Huber, 2005).

### f. Water Surface Temperature (°C)

Temperature affects the concentration of dissolved oxygen in a water body. The oxygen content of river water is inversely correlated with temperature. Oxygen supplies are generally richest in cold thoroughly mixed headwater streams and lower in the warm downstream sections of the rivers (Molles, 2005).

In this study, the water temperature of Señora River ranged from 25°C – 29.6°C which is within the normal limits. Results showed that there is a slight increase in the water temperature during dry months for the upstream and midstream of the river but not true for Station 3. This is justifiable since most sampling was done from upstream in the morning to downstream in late afternoon. The slight increase in temperature of the river during dry months was found to be insignificant. This result means that there is no thermal pollution of the water that can cause changes in the chemical kinetics of the water, considering that no industries are discharging high temperature water into the river.

### g. Water Subsurface Temperature (°C)

It is disclosed that Station 1 has water subsurface temperature value ranging from 25.8 – 30.2°C; Station 2 with 25–28.9°C; and Station 3 with 25–30.2°C. The registered maximum water subsurface temperature of river was 30.2°C during the month of April (the driest month with a least amount of rainfall as recorded by PAG-ASA Lazi Bay Station) and the lowest temperature of 25°C in the month of March (a wet month based on PAG-ASA data).

There was no significant difference between the average values of water subsurface temperature within stations and the difference in water subsurface temperature between wet and dry months is insignificant.

### h. Nitrates – N (mg/L)

Nitrates can cause excessive growth of algae and other aquatic plants, which then die and decay, depleting dissolved oxygen in water and killing fish. Drinking water with excessive levels of nitrates lowers the oxygen-carrying capacity of the blood. This can kill unborn children and infants, especially those under one year old (Miller, 1998).

Station 1 has the nitrates-N content ranging from of 0.34-1.28 mg/L; Station 2, has 0.25-1.48 mg/L; and Station 3 with 0.068-1.17 mg/L. The registered maximum nitrates-N content of river water was 1.48 mg/L at site 3 of Station 2 during the month of February and the lowest value of 0.068 mg/L at site 3 of Station 3 in the month of March. The higher nitrates-N content of the water might be attributed to the runoff from the rice paddies discharged directly to the river. Nitrate enters streams from natural sources like decomposing plants and animal waste as well as human sources like sewage or fertilizer (Behar, 1997).

The natural nitrate level is usually less than 1 mg/L. Concentrations over 10 mg/L may have an effect on the freshwater aquatic environment (Behar, 1997). In this study, the nitrate content of the water in the river is within the normal acceptable range. No significant difference was observed between the average nitrates contents of the water per station and during wet and dry months.

### i. Phosphates – P (mg/L)

Together with nitrates, phosphates are another inorganic plant nutrient which is considered as water pollutant (Miller, 1998).

Across stations, the month of February has higher value of phosphate contents than the rest of the months. Phosphate source might be the minerals from surrounding areas, animal waste, detergent, and fertilizer. The lowest value of 0.007 mg/L was observed at Station 1 in the month of May and the highest reading of 0.054 mg/L at Station 1 February.

The range of the phosphates-P content of the water is 0.007-0.054 mg/L which is within the normal limits. Phosphates do not pose a human or health risk except in very high concentrations. Larger streams may react to phosphate only at levels approaching 0.1 mg/L, while small streams may react to levels of PO4-3 at levels of 0.01 mg/L or less. In general, concentrations over 0.05 will likely have an impact while concentrations greater than 0.1 mg/L will certainly have impact on a river (Behar, 1997). No significant difference was observed between the average nitrates contents of the water per station and during wet and dry months.

### j. *Escherichia coli*

Certain strains of *E. coli*, a fecal bacterium, can cause diarrhea, nausea and even death, if not treated (Todar, 2008; Lubos, 2008). According to Money et al. (2008), *E. coli* is a widely used indicator of fecal contamination in water bodies.

In this study, *E. coli* contents of the river water, in terms of Colony Forming Unit (CFU) per 100 mL (CFU/100 mL) was observed highest in Station 3 (103,333 CFU/100 mL), in March followed by Station 1 in the same month. The *E. coli* content in all stations exceeded the standards set by DENR and USEPA of 1000 CFU/100 ml, which is an indication of human and animal waste discharged into the river.

As shown in Table 4 some barangays (Gabayan at Station 3 with 48.8% of the households; Cangomantong at Station 2 with 33.1%; and Tagmanocan at Station 3 with 29.4%) near the river lack toilets. Pigpens near the river were also documented during an ocular visit in the different stations. This result supported the findings of other studies (e.g. Lubos, 2008). The presence of this bacteria means that the water in Señora River is not ideal for swimming.

Siquijor Province is not yet urbanized and industrialized. There are no manufacturing companies and industries that will alter the quality of the water as evidenced by the parameters chosen in the study being still within the permissible limits (based on the standards set by the DENR, except for *E. coli*.

There is no significant seasonal (wet and dry months) variation of all the parameters and no significant spatial variation (among the three stations) of dissolved oxygen (DO), salinity, water sub-surface temperature, water surface temperature, nitrates-N, phosphates-P, and *E. coli* contents. However, levels of total dissolved solids (TDS), pH, and conductivity of the river are significantly higher in the downstream station. TDS is usually associated with conductivity of the water and Dissolved Oxygen with water temperature. The solubility of gases decreases with an increase in temperature.

## CONCLUSION

Based on the findings of this study, the values of the different physico-chemical characteristics of Señora River in Lazi, Siquijor are still within the permissible limits which make the river unique relative to other rivers found in literatures except for the bacteriological parameter, *E. coli*, the values of which exceeded the standards, in all stations.

The water quality is threatened to be impacted by human activities, specifically the downstream of the river, as indicated by the significant increase in certain parameters. The whole stretch of the river can support aquatic life and can be used for agricultural and other industrial purposes.

## RECOMMENDATIONS

Based on the significant findings of the study, it is recommended that the Local Government Unit of Lazi, Siquijor and other concerned government and private agencies conserve Señora River. Specific recommendations are as follows:

1. Information, education, and awareness campaign be conducted with emphasis on the importance of Señora River with the stakeholders.
2. Environment-friendly farming practices shall be planned, developed, and implemented in order to minimize agricultural wastewater problems.
3. Planning and implementation programs for the residents along the river banks pertaining to clean and healthy environment shall be made a priority in order to correct the problems created by residential and other domestic wastewater discharged into the river.
4. Monitoring of physico-chemical (including pesticide and heavy metal contents) and bacteriological parameters of the river water be conducted.

*Table 1.*

**Mean ± SD of Physico-chemical Parameters of Señora River During Wet and Dry Months.**

| Parameters | Station 1 (Capalasan) | | Station 2 (Cambugahay Falls) | | Station 3 (Bukana/Estuary) | |
|---|---|---|---|---|---|---|
| | **Wet Months** | **Dry Months** | **Wet Months** | **Dry Months** | **Wet Months** | **Dry Months** |
| Dissolved Oxygen (mg/L) | 7.96+ 1.010 | 7.15 +0.787 | 8.01+ 0.578 | 8.01+0.639 | 7.85+0.840 | 6.81 +0.567 |
| Total Dissolved Solids (mg/L) | 216 + 34.205 | 219.78+30.728 | 225+14.816 | 233.78+15.123 | 501.78 +549.175 | 1045.56 + 1016.425 |
| pH | 7.56+ 0.208 | 7.32+0.471 | 7.84+0.058 | 7.93+0.166 | 7.62+0.083 | 7.63 + 0.122 |
| Conductivity ($\mu$S) | 456.22+ 73.641 | 458.56+69.820 | 473.67+35.507 | 493.89+14.278 | 940.67 + 928.072 | 1784.44 + 1584.775 |
| Salinity (‰ ) | 0.19+ 0.033 | 0.21+0.033 | 0.20+0.000 | 0.47+0.400 | 0.71 +1.131 | 1.30 +1.729 |
| Water Temperature (°C) | 26.86+ 1.114 | 27.64 +1.394 | 26.99+0.984 | 27.50+0.400 | 28.17 +1.447 | 26.10 +1.093 |
| Subsurface Temperature (°C) | 26.89+ 1.114 | 27.77+1.839 | 27.71+1.036 | 26.86+1.396 | 28.10+1.823 | 28.14+ 2.000 |
| Nitrates-N (mg/L) | 0.57+ 0.206 | 0.65+0.298 | 0.72+0.262 | 0.62+0.376 | 0.59+0.287 | 0.63+ 0.297 |
| Phosphates-P (mg/L) | 0.02 +0.010 | 0.03+0.017 | 0.02+0.007 | 0.03+0.018 | 0.02+0.005 | 0.02+ 0.008 |
| *E. coli* (CFU/mL) | 38900.00 ± 249156.38 | 9274.00±10772.384 | 14085.11±13413.401 | 16677.67±10797.312 | 54822.11 ±21738.479 | 23344.33 ±19991.609 |

*Table 2.*

**Comparison Between Señora River Water Quality and Surface Water Quality Standards Based on DENR and USEPA.**

| Parameters | Señora River | Standard |
|---|---|---|
| DO (mg/L) | 7.63 | > 5 |
| Total Dissolved Solids (mg/L) | 390.82 | 500 |
| pH | 7.65 | 6.5 to 8.5 |
| Conductivity ($\mu$S) | 767.91 | 1000** |
| Salinity (‰ ) | 0.51 | 0 - 5 |
| Water Temperature (°C)* | 27.21 | Not more than 5o rise in natural temp |
| Water Subsurface temperature (°C) | 27.58 | — |
| Nitrates-N (mg/L) | 0.63 | 10 |
| Phosphates-P (mg/L) | 0.023 | 0.2 |
| *E. coli* (CFU/100mL) | 37,673 | 1000 |

* OERCD ** USEPA

*Table 3.*

**Señora River Water Quality and Water Quality Guidelines and Water Classification.**

| Parameters | AA | A | B | C | D | Señora River |
|---|---|---|---|---|---|---|
| DO (mg/L)* | 5 | 5 | 5 | 5 | 2 | 7.63 |
| Total Dissolved Solids (mg/L) | | | | | | 390.82 |
| pH* | 6.5 – 8.5 | 6.5 – 8.5 | 6.5 – 8.5 | 6.5 – 9.0 | 6.0 – 9.0 | 7.65 |
| Conductivity ($\mu$S) | — | — | — | — | — | 767.91 |
| Salinity (‰ ) | — | — | — | — | — | 0.51 |
| Water Temperature | — | — | — | — | — | 27.21 |
| Subsurface temperature, °C* | 26-30 | 26-30 | 26-30 | 25-31 | 25-32 | 27.58 |
| Nitrates-N (mg/L) | 7 | 7 | 7 | 7 | 15 | 0.63 |
| Phosphates-N (mg/L) | <0.003 | 0.5 | 0.5 | 0.5 | 5 | 0.023 |
| *E. coli*** (CFU/100mL) | 0 | 0 | | | | 37,673 |

*based on DENR Administrative Order 2008-XX

*Table 4.*

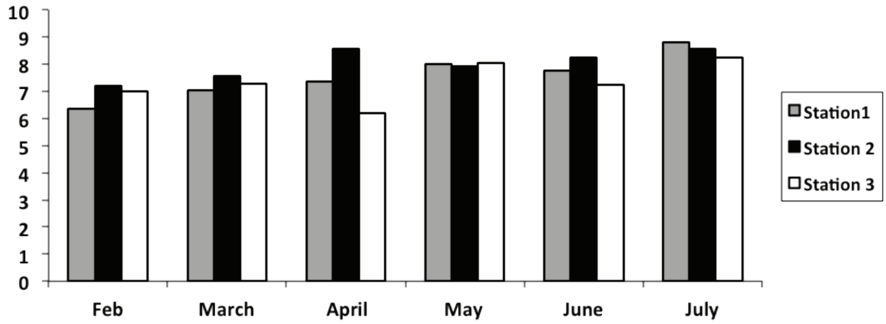
**Status of Sanitary Facility of the Barangays Along the Vicinity of Señora River in Lazi, Siquijor (2010)***

| Barangays | Population | No. of Households | With Toilets | | Without Toilets | | Near Station |
|---|---|---|---|---|---|---|---|
| | | | No. | % | No. | % | |
| Cangclaran | 520 | 87 | 74 | 85.1 | 13 | 14.9 | 2 |
| Cangomantong | 1083 | 181 | 121 | 66.9 | 60 | 33.1 | 2 |
| Capalasanan | 1252 | 209 | 178 | 85.2 | 31 | 14.8 | 1 |
| Gabayan | 1785 | 297 | 152 | 51.2 | 145 | 48.8 | 3 |
| Nagerong | 1245 | 208 | 162 | 77.9 | 46 | 22.1 | 3 |
| Poo | 815 | 136 | 124 | 91.2 | 12 | 8.8 | 2 |
| Simacolong | 1787 | 298 | 273 | 91.6 | 25 | 8.4 | 3 |
| Tagmanocan | 817 | 136 | 96 | 70.6 | 40 | 29.4 | 3 |
| Tigbawan | 1756 | 293 | 283 | 96.6 | 10 | 3.4 | 3 |

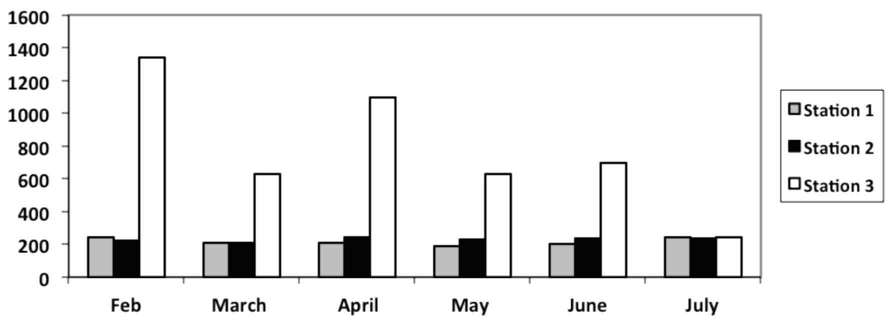
* Taken from the Rural Health Unit report of the Municipality of Lazi

# APPENDIX A

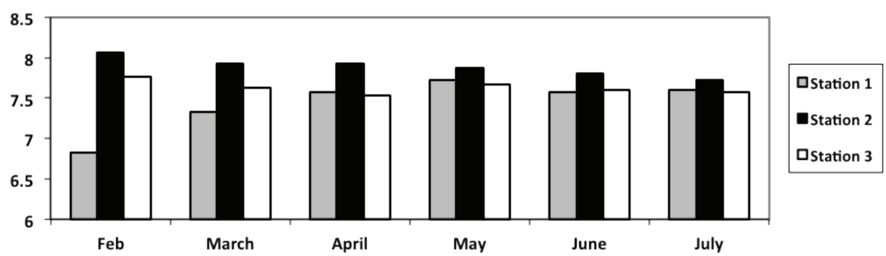
**Monthly Variations in the Physico-chemical Parameters in the Three Sampling Stations of Señora River (February-July, 2011).**



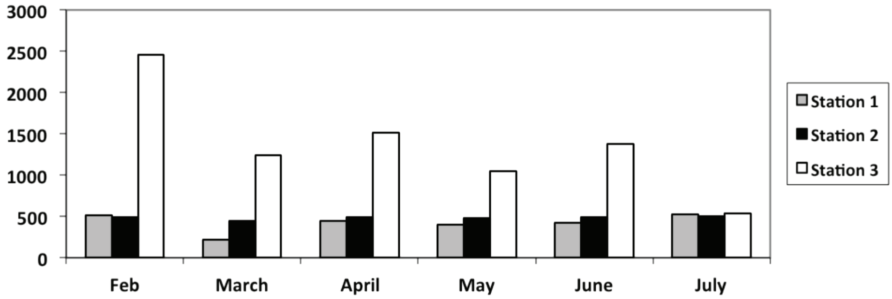

1. **Monthly mean dissolved oxygen of the river water**



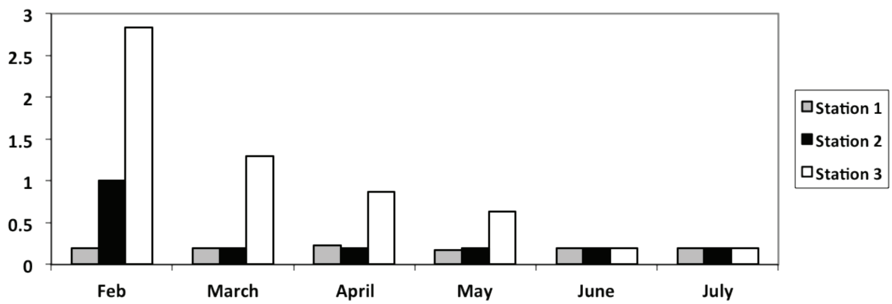

2. **Monthly mean Total Dissolved Solids**



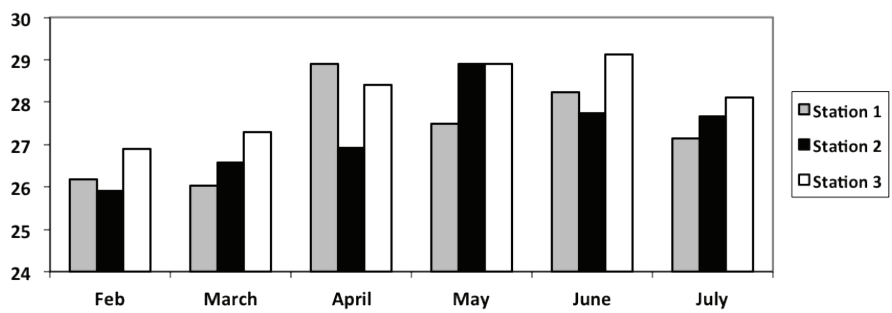

3. **Monthly mean pH values**



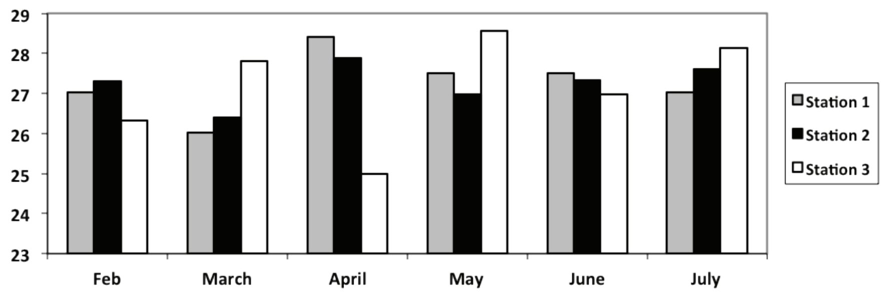

4. **Monthly mean conductivity**



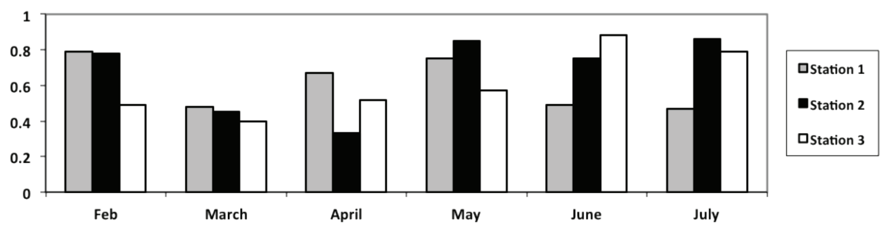

5. **Monthly mean salinity**



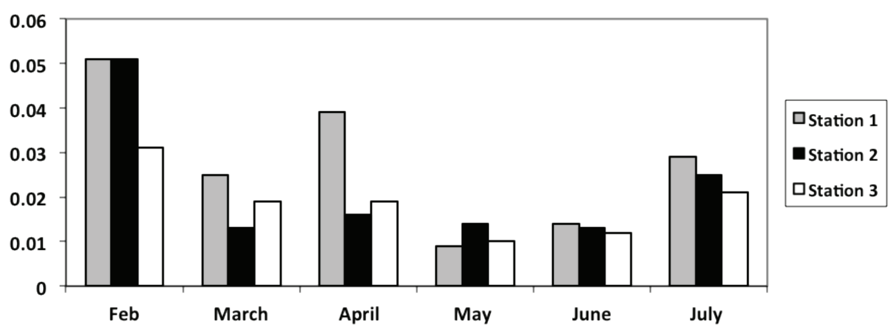

6. **Monthly mean subsurface temperature**



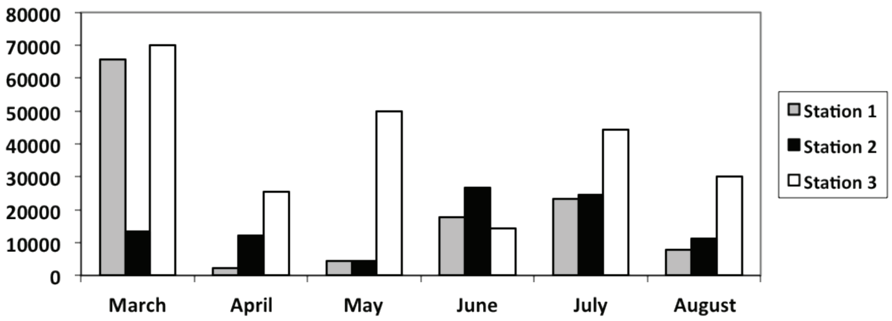

7. **Monthly mean water temperature**




8. **Monthly mean $NO_3$-N concentration of the water**



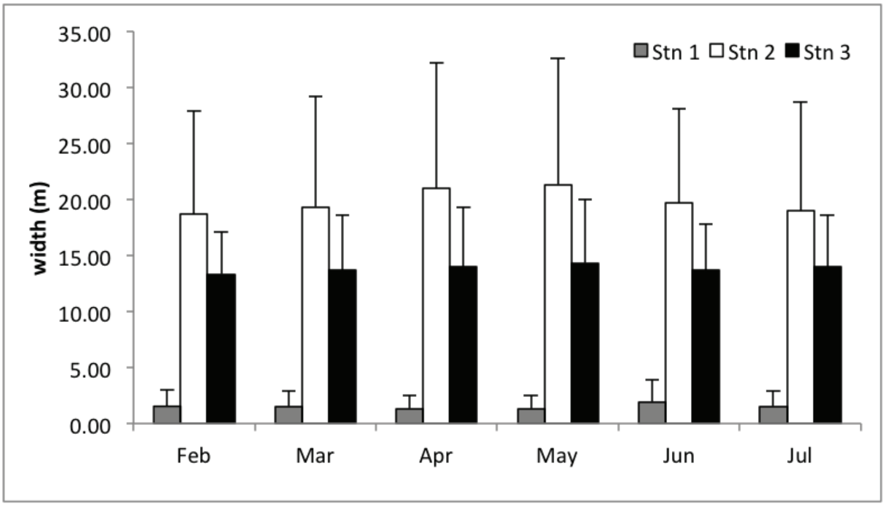

9. **Monthly mean $PO_4$-P of water per station**



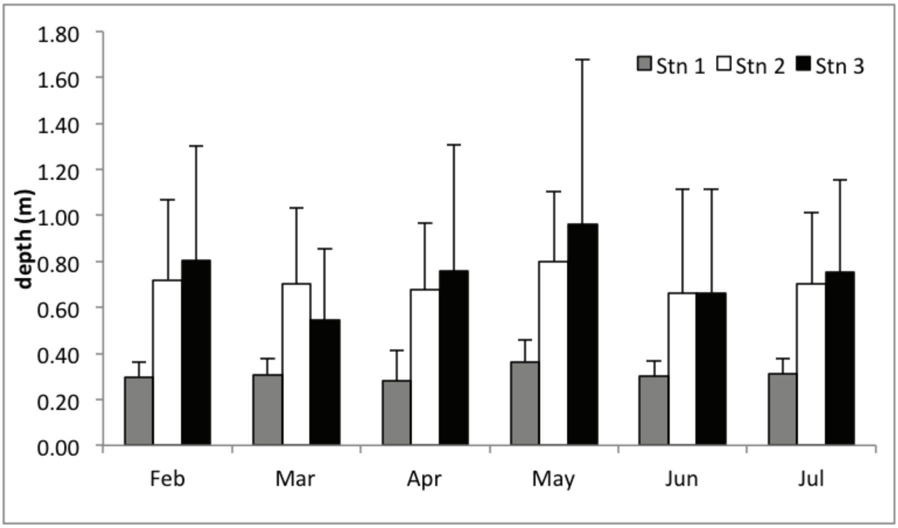

10. **Monthly mean *E. coli* concentration (in CFU)**

**APPENDIX B**

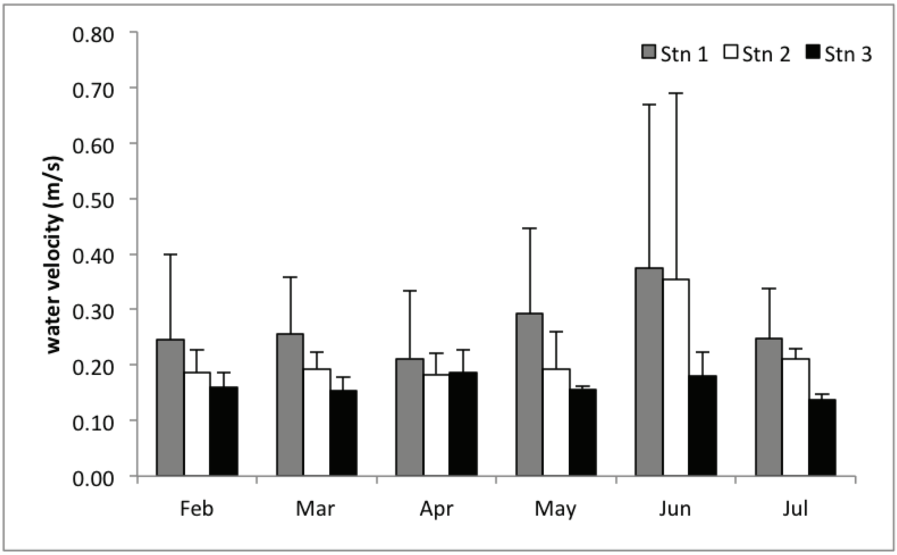
**Monthly variations in hydrological parameters of Señora River (February to July 2011).**



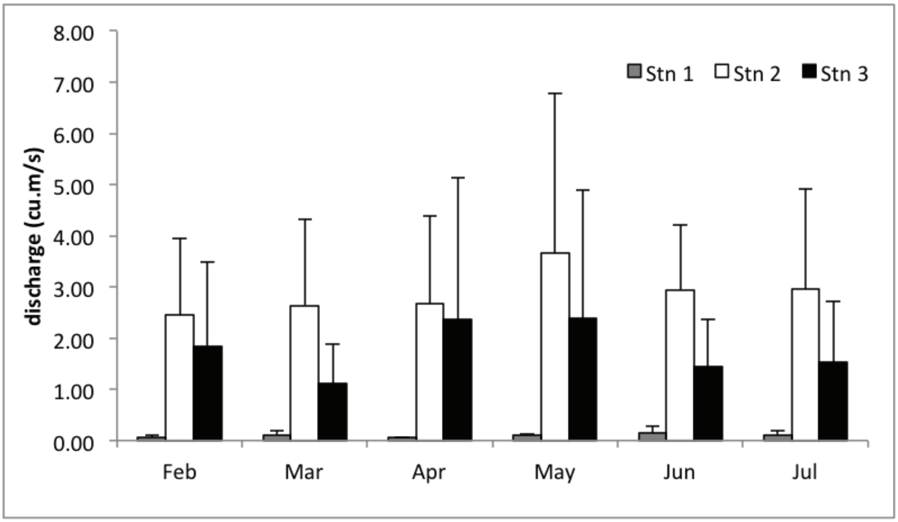

1. Monthly variation in river width of Señora River.




2. **Monthly variation in river depth of Señora River.**




3. **Monthly variation in water velocity of Señora River.**




4. **Monthly variation in water discharge of Señora River.**

## REFERENCES

Abdullahi, B.A., Kawo, A.H., & Na'aliya, J. (2008). Observations on the seasonal and spatial variations in water quality and ecological implications of Challawa River, Nigeria. *Bioscience 20*(3).

Abowei, J.F.N. (2010) Salinity, dissolved oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. *Advance Journal of Food Science and Technology 2*(1), 36-40.

Adeyemo, O.K., Adedokun, O.A., Yusuf, R.K., & Adeleye, E.A. (2008). Seasonal changes in physico-chemical parameters and nutrient load of river sediments in Ibadan City, Nigeria. *Global NEST Journal 10*(3), 326-336.

Behar, S. (1997). *Definition of water quality parameters*. Testing the waters: Chemical and physical vital signs of a river. Retrieved from http://fosc.org/WQDataParameters.htm

Bendijo, R., Alcala, M.L., Dolumbal, A., & Amor, C. (2004). Siquijor Province: The Coastal Environment Profile, Dumaguete City, Philippines.

Buijs, P. & Toader, C. (2007). Organization for Economic Co-operation and Development (OECD) Retrieved from www.oecd.org/env/eap

Castro, P. & Huber, M. (2005) *Marine biology* (5th ed.). New York: McGraw Hill Higher Education.

Cunningham, W. & Cunningham, M.A. (2008). *Principles of environmental science: Inquiry and applications* (4th ed.). New York: Mc Graw-Hill.

Enger, E.D. & Smith, B.F. (2004). *Environmental science: A study of interrrelationships*. (9th ed.). New York: Mc Graw-Hill.

Eubanks, L.P., Middlecamp, C., Pienta, N., Heltzel, C., & Weaver, G. (2006). *Chemistry in context: Applying chemistry to society* (5th ed.). New York: McGraw-Hill.

Lubos, L.C. (2009) Extent of *Escherichia coli* contamination of Cagayan de Oro River and Factors Causing Contamination. *Liceo Journal of Higher Education Science and Technology Section 6*(1).

Mapa, A. & Trinidad, F. (2001). *Chemistry textbook for science and technology III*. Quezon City, Philippines: SD.

Molles, M., Jr. (2005). *Ecology concepts and applications* (3rd ed.). New York: McGraw-Hill.

Moniruzzaman, M., Elahib, S.F., & Jahangira, Md. A.A. (2009). Study on temporal variation of physico-chemical parameters of Buriganga River water through GIS (Geographical Information System) Technology. *Bangladesh Journal of Scientific and Industrial Research, 44*(3), 327-334.

Philippine Information Agency. (2009). *Knowing the state of Naboc River*. Retrieved from http://archives.pia.gov.ph

Prasanna, M.B. & Ranjan, P.C. (2010) Physico-chemical properties of water collected from Dhamra Estuary, Bhubaneswar, India. *International Journal of Environmental Sciences 1*(3).

Sawyer, C., McCarty, P., & Parkin, G. (1994) *Chemistry for environmental engineering* (4th ed.). New York: Mc Graw-Hill Inc.

US Environmental Protection Agency. (n.d.). Water quality standards for surface waters. Retrieved from water.epa.gov/scitech/.../standards/index.cfm

Varunprasath, K. & Nicholas, D. (2010). Physico-chemical parameters of River Bhavani in three stations, Tamilnadu, India. *Iranica Journal of Energy and Environment 1*(4): 321-325.

Water quality with computers. Total dissolved solids. (n.d.). Retrieved from http://www.ualberta.ca/~edtechpd/documents/activity_probes_procedure dissolvedsolids_boora_v1.pdf