Print ISSN 2094-1064
Online ISSN 2244-0437

Liceo Journal of Higher Education Research
doi: http://dx.doi.org/10.7828/ljher.v11i1.903

Riverine Ecosystem Assessment of Cagayan de Oro River for Sustainable Resource Utilization

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ABSTRACT

Assessment of the environmental health of Cagayan de Oro River was conducted in five different stations namely Uguiaban Bridge in Sitio Balaun, Rafting Site in Barangay Mambauaya, Pelaez Bridge in Taguanao, Poblacion (Ysalina Bridge) and Macajalar Bay Estuary. The environmental health assessment of the river was based on water quality indicators, biological indicators and social indicators. The water quality indicators included flow rate, color, pH, temperature, biological oxygen demand (BOD), dissolved oxygen (DO), nitrate (NO3), nitrite (NO2), phosphate (PO4), pesticide and total coliform. Biological indicators on the other hand included macro invertebrates and riparian vegetation. While social indicators covered the anthropogenic activities and environmental awareness of the barangay residents which was attained by conducting a survey. The research design used qualitative and quantitative methods to analyze data gathered from the foregoing indicators. The findings revealed that water quality testing were well within standards except for total coliform which always showed exceedingly high values. In terms of the total coliform, the water quality is not within Class A standards. The biological assessment through the bio indicators revealed Field Biotic Index (FBI) values interpreted as having the likelihood of substantial organic pollution. This assessment served to supplement the result of the water quality testing. Hence, there is a need to bring back the water quality in terms of total coliform to Class A. The riparian vegetation survey also showed a decline from upstream to downstream. On the aspect of environmental awareness of the barangay residents, the survey indicated only at moderate level and has some policy implications especiallly in areas which are greatly impacted by

land-based activities particularly residential, commercial and industrial activities.

Keywords: Ecosystem, Cagayan de Oro River, assessment, sustainability.

INTRODUCTION

The Cagayan de Oro River originates from a peak of 2,865 meters above sea level (masl) in the Kalatungan Mountain Range of the province of Bukidnon. It is one of the city's rivers which have become part of the daily activities of about 596,069 Kagay-anons (NSO Population Estimate, 2008). Its vast drainage area of 1,521 sq. km. and a river length of 90 km serve different physical and ecological functions like temperature regulation, aesthetics, recreational uses such as boating and fishing, irrigation and source of drinking water. These functions put the river in the Class "A" category that caters to the demand of a burgeoning population in terms of the said uses. This classification, however, remains as is provided that the water quality conditions stipulated in DENR Department Administrative Order Number 34, series of 1990, are maintained. In other words, the measurable values of the parameters considered in classifying the river according to its functions should be within the standards set by the said regulation. Under such conditions, the river is also able to support varied species of organisms. These organisms and its interaction with the physical features of the river environment compose the riverine ecosystem.

Riverine health then is also measured based on the presence of the biological components. Hence, humans should relate to and utilize the river with utmost consideration of its ecological sensitivity and maintain its water quality at acceptable levels.

While riverine ecosystems offer these much benefits to the community, these systems are also dynamic. They are constantly changing with time and the social and economic activities of people. They get affected by external factors and the river conditions change with the said factors. Its resilience enables it to withstand disturbance and even recover from it. But this can be used to a limited extent only beyond which the system may possibly suffer from irreversible damage. With just enough of the pollutants discharged into the river, it can still be in a homeostatic state, but more than it is able to assimilate would otherwise create a big problem.

With a growth rate of 2.54% (NSO, 2008), the city's population is expected to increase in the next few years and hence economic activities will also increase

and consequently will cause an increase in wastewater discharge into the river. This will subsequently harm the living organisms and the vegetation around the area making the area unfit for their existence. Hence, this eventually may lead to the death of the ecosystem and not provide the uses which the river is intended for.

EMB Water Quality Monitoring Reports also showed evidences in the increase of total coliform beyond the standards with values ranging from 26,000 to 90,000 MPN/100ml in areas like Estuary, New Bridge in Kauswagan, Pelaez Bridge, and Cabula River. Recently certain perturbations have already caused disturbance on the CDO riverine ecosystem like flooding in January 2009 and December 2011 which contributed to the increase in siltation in the river. Current developments may exert stress (pollution and ecosystem imbalance) on the system which essentially includes the components that make up the riverine ecosystem as well as the normal pattern of activities that take place in the same. River features in the riparian areas provide benefits for the ecosystem as well as humans by such cleaner water and flood storage and should again be given careful consideration.

The riverine ecosystem is a function of its water quality which is dependent on different factors found in the environment. Future alteration on the river should then be considered in any development plans.

The Environmental Management Bureau (EMB) of the Department of Environment and Natural Resources (DENR) established the standards for water quality and undertakes the periodic monitoring as well as the classification of the rivers throughout the country. US-EPA (2000) describes that "water quality standards designate the uses to be protected (e.g. drinking water, recreation, fish and wildlife habitat) and the criteria for their protection (e.g. how much of a pollutant can be assimilated by a water body without impairing its designated uses." Water quality standard is based on the specific parameters provided in DENR Administrative Order Number 34 (DAO-34). It becomes the basis against which results of this study will be compared with to determine river water quality. The DAO-34 then will serve to protect the uses of Cagayan de Oro River under the class A category.

As DENR-Accredited Pollution Control Officer, member of the Guardians of the Earth Association, Inc. and at the same time DENR-certified Environment Practitioner, the researcher found it necessary to conduct the study to help ensure that the Cagayan de Oro riverine ecosystem is protected and still serves its intended uses according to "A" classification to meet the water demands of a

growing population. It was also the intention of the same to find out the effect of different land uses on the health of Cagayan de Oro river. The results gathered were used as basis for formulating measures for proper resource utilization and to enable the riverine ecosystem to sustain itself.

It is also the hope of the researcher to help the community and LGUs view the riverine ecosystem from a wider perspective so as to provide an in-depth understanding on the effects of socio-economic activities on the said ecosystems. This can be used also as basis for a sound management and development of CDO riverine ecosystem in the light of the principles of sustainable development.

OBJECTIVES OF THE STUDY

The protection of the CDO riverine ecosystem for present and future generations requires planning and management especially in areas where certain land uses create problems. As part of a goal towards attaining environmental sustainability, the CDO riverine system should be assessed comprehensively to have an update of its current water quality condition. The same should be done so as to use it to its maximum advantage while carefully protecting and preserving it and allowing it to serve its purpose according to environmental standards. Specifically, the study aims to: 1) assess the integrity or health of Cagayan de Oro Riverine Ecosystem through biological and water quality indicators; 2) Find out the anthropogenic activities along the sampling areas which can impact the riverine ecosystem; 3) assess the level of environmental awareness of residents on environmental management and environmental policies and laws; and 4) come up with proper intervention approaches to help maintain the integrity of the riverine ecosystem, sustainable resource utilization, restoration and rehabilitation as the case may be.

FRAMEWORK

This study is anchored on the ecosystem concept which maintains an interrelatedness of its components. An ecosystem is a stable, self–regulating unit and in order to maintain itself, it must have a continuous input of energy (Enger and Smith 2003). When one component is affected, so are the others because everything should be in place before the system can function as a whole. Such that, different land uses may impact the riverine ecosystem considering that it is dynamic. However humans, being the key component in an ecosystem can take

the responsibility in maintaining them. The environmental regulations stipulated in Department of Administrative Order (DAO) Number 34, series of 1990, formulated by the Department of Environment and Natural Resources (DENR) will enable the key component to limit its movement around the system to an extent that is non-damaging.

This study is focused on the existing water quality, biological characteristics and social indicators of Cagayan de Oro River as basis for sustainable resource utilization. The diagram (Figure 1) typifies the idea that sustainable resource utilization not only depends on one aspect of the system but all aspects which include social, environmental, and economic dimensions since they compose the system. And since the society in which humans are part of is made up of component systems, then these systems must be taken into account in formulating strategies and plans toward a sustainable resource utilization through interventions at the sites specified in the results of the study.

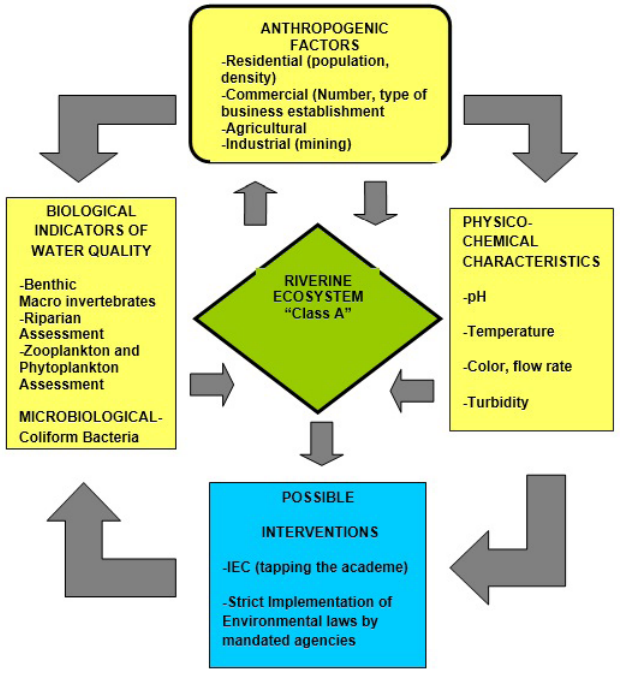

Figure 1. Schema of the study showing Factors Affecting River Quality.

METHODOLOGY

The treatment of data (water quality indicators, biological indicators and social indicators) in this study was made through qualitative and quantitative analysis. Data sampling and collection was done for four months (October, November, January and February). Data collection on water quality parameters made use of grab sampling from five sampling stations. Results were compared to DAO-34 standards and validated through statistical analysis employing Analysis of Variance for test of difference. Sampling and preservation methods employed were according to DENR-accredited standards. The collection of biological indicators on the other hand made use of use D-net and kick net methods and riparian vegetation survey through cross-section and green-line composition methods in the five sampling stations. Further data analysis was done through the use of Canonical Correspondence for both the water quality and bio indicators. For the social indicators, primary data collection on environmental awareness was done using structured survey questionnaire using a 4-point scale. Survey results were analyzed through ANOVA. Secondary data collection on economic activities were sourced out from EMB-DENR 10 office.

RESULTS AND DISCUSSION

Table 1 presents the summary of the status of river water characteristics from October 2010 to February 2011 as compared with DENR standards.

It can be gleaned from the table that in the period of October 2010, the parameters that did not comply with the standards under Class A waters were color, TSS, phosphate and total coliform. Color intensities were much higher in stations D and E which are located in the downstream area along Poblacion river stretch. The likely cause of the increase in these values may be the occurrence of rainfall in this period which may have increased urban and agricultural runoff.. This is conforming to the study of Dittman, Cantin, Noble and Pocking which showed seasonal influence to their obtained values. The same applies to phosphate and TSS. Nitrite values ranged from 0.03 to 0.05 mg/L, however, the DAO-34 has no standard value for surface water.

Table 1. Summary of the status of CDO River based on DENR standards (Class A)

Parameter	October	November	January	February
Physical				
1. Flow Rate	NA (No DENR standard value)			
2. Color (H)	Not complied Uguiaban bridge -74 Bgy. Mambuaya -70 Pelaez Bridge -70.66 Poblacion -93.33 Estuary -142	complied	complied	complied
3. Temperature	Complied	complied	complied	complied
4. TSS (mg/L)	Not complied Uguiaban Bridge-53.63 Bgy. Mambuaya-51.06 Pelaez Bridge -51.73 Poblacion -88.06 Estuary -142	complied	Not complied Taguanao – 15.7 Poblacion – 16.83	complied
Chemical				
5. pH	complied	complied	complied	complied
6. BOD (mg/L)	complied	complied	complied	complied
7. DO (mg/L)	complied	complied	complied	complied
Physical				
8. Nitrate (mg/L)	complied	complied	complied	complied
9. Nitrite (mg/L)	NA (No DENR standard value)			
10. Phosphate (mg/L)	Not complied Uguiaban bridge -0.13 Pelaez Bridge -0.32 Poblacion -0.16 Estuary -0.15	complied	complied	complied

11. Pesticide (one-time sampling)	Complied	complied	complied	Not complied Uguiaban Bridge - 0.22 ppb
Microbiological				
12. Total Coliform (MPN/100mL)	Not complied Uguiaban Bridge - 134,667 Bgy. Mambuaya - 101,667 Pelaez Bridge - 112,333 Poblacion - 553,000 Estuary - 76,667	Not complied Uguiaban Bridge - 27,667 Bgy. Mambuaya - 66,667 Pelaez Bridge -65,001 Poblacion - 251,333 Estuary - 263,333	Not complied Uguiaban Bridge - 49,000 Bgy. Mambuaya - 70,667 Pelaez Bridge -99,333 Poblacion -620,000 Estuary - 566,667	Not complied Uguiaban Bridge - 33,000 Bgy. Mambuaya -145,000 Pelaez Bridge -273,333 Poblacion - 244,667 Estuary - 376,667

On the microbiological aspect, all stations had values which were way beyond the standard of 1000 MPN/100 ml regardless of the season. The minimum obtained value was at station E (estuary) while the maximum value was in the next station, station D. Both are along the Poblacion area with dense settlements which may have been the likely cause of such increase in values. This is conforming to the findings of McMurray and Pond (2002) and Boyer and Caccia (2005). Water quality is really "highly dependent on land use and influence from the watershed."

The period of November exhibited non-compliance only with Total Coliform. In this period, there was lesser rainfall observed.

Total coliform values in all the stations were consistently very high compared to the standard and were at a range of 27,667 to 263,333 MPN/100 ml though showing variations in the different stations. The obtained values though were lower in the upstream stations than in the downstream stations D and E. The latter showed exceedingly high values. This trend in values is also in agreement with the claim of Boyer an Caccia (2005) on the dependence of water quality on land use. Station D (Poblacion) is surrounded with dense human settlements and commercial establishments. The values for this sampling period generally speak of a fairly good water quality in terms of the majority of the parameters except for total coliform.

Values obtained in January 2011 also exhibited compliance with DENR stan-

dards except again for Total Coliform. All other values were within acceptable limits. The values for total coliform were consistently high above the standard and followed an increasing trend from upstream to downstream. There is a significant increase from station B to C. The water that flows into this station come from the reference site and Bubunawan River which is located between Baungon and Libona in the province of Bukidnon. There are several livestock and dressing plants found in Baungon area. Baungon and Libona are agricultural areas.

In February 2011 the standards were generally complied with except for pesticide and Total Coliform. There were however pesticide detections in station A and E. The pesticide detected was Total Endosulfan, which belongs to the organochlorine group and classified as persistent. No further conclusion, however, can be drawn from this datum since sampling per station was not conducted in replicates. However, the detection may be caused by a seasonal spraying of pesticide tha occurred in these areas.

The values for total coliform were still exceedingly high and in increasing progression from upstream to downstream. The lowest value was in the reference site, Sitio Balaun (station A) and the highest in the Estuary (station E). However from Mambuaya (station B) to Taguanao (station C) there is a drastic increase in values. This may be attributed to the additional wastewater coming from Bubunawan River which receives wastewater from residential areas, and existing livestock and dressing plants.

Of all periods, it was in November 2010 and February 2011 that the river water showed a fairly better quality except on total coliform. Total coliform contains bacteria coming from either human or animal waste. It can be noted that throughout the duration of sampling, whether at a dry or wet season, the problem on exceedingly high values of coliform persisted from upstream to downstream. But the latter obtained higher values most of the time. The general trend on Total Coliform values is again conforming to the related studies herein cited which claims the dependence of water quality on land use. Water quality is a function of land use. Water quality conditions depend on the factors influencing it. Since the surrounding areas in the downstream portion of the river is densely populated, then more pollution load are conveyed through the outfalls into the river.

Table 2. Statistics on Test of Difference by Station and Period

Parameter	F-Computed Value	F-Test At 5% Critical Value
Flow rate	station -36.980	*
	period -8.797	**
Color	period -32.980	**
Temperature	Station -14.589	*
TSS	period - 14.071	**
pH	Period - 3.995	**
BOD	Period - 11.308	**
Nitrate	Period - 23.454	**
Nitrite	Period - 61.237	**
Phosphate	station -36.980	*
	period -8.797	**
Total Coliform	Station - 2.892	*

* *There is significant difference between stations*

** *There is significant difference between months*

Table 2 shows the summary of the statistics on test of difference per parameter.

The F-calculated values by station and by period for the flow rate are both lower than the 5% level of significance indicating a significant difference in the flow rate by month and by period. Therefore, the null hypothesis is rejected. As for color, the F-calculated value by period (32.980) which is greater than 5% level of significance indicated a significant difference. The findings revealed that there is no significant difference in the water qualities by station only. This implies further that the water quality is the same by station in terms of color and different by period. Therefore, the null hypothesis for the by-month category is rejected.

For the test of difference on temperature according to station, the F-calculated value exhibited a significant difference between stations but not by period. This implies that water quality in terms of temperature significantly vary by station. Therefore, the null hypothesis on by-station category is rejected.

With regards to Total Suspended Solids, it is the F-calculated value by period (14.071) which indicated a significant difference since it is lower than %5 level of significance. The findings revealed that there is a significant difference in the water qualities by period in terms of TSS. It can be gleaned from the table that

higher values were from the wet season. Therefore, the null hypothesis for the by-month category is rejected.

Similarly for pH and BOD, the values indicated a significant difference by period which implied a seasonal influence during the period of sampling.

On test of difference on dissolved oxygen (DO) the F-calculated values by station and by period exhibited significant difference. The findings revealed that there is a significant difference in the water qualities both by station and by period in terms of DO. Therefore, the null hypothesis is rejected. On test of difference for nitrate, the F-calculated value by period indicated a significant difference. The findings revealed that there is a significant difference in the water qualities only by period in terms of nitrate. There is then a seasonal influence on values and this is in agreement with the findings of Dittman, Cantin, Noble and Pocking in their study. On nitrite, it is only the F-calculated value by period that exhibited a significant difference in the water quality. For phosphate, the F-calculated value by station and by period which are both lower that the 5% level of significance exhibited a significant difference. This implies that the water quality by station and by period in terms of phosphate is not the same. Therefore, the null hypothesis is rejected.

On test of difference for Total Coliform, the F-calculated values for station indicated a significant difference by station and exhibited none by period. The findings revealed that there is a significant difference in the water qualities by station only. It can be recalled from the previous tables that regardless of station and season, the total coliform values from October 2010 to February 2011 were consistently high yet there is a big difference in values between upper and lower stations. Lower stations (Poblacion and Estuary) have extremely higher values. Therefore, the null hypothesis is rejected only for the by-station category.

Over all, a significant difference by period is more caused by seasonal influence, that is, wet and dry seasons. On the other hand, a significant difference by station means that the water quality is habitat-influenced. In this study, the significant difference between stations is made evident by the values obtained during the period of sampling in which the upstream areas especially the reference site have lower values than the downstream part which have more anthropogenic influences than the former.

The biological assessment through the bioindicators revealed Field Biotic Index (FBI) values that were interpreted as having the likelihood of substantial organic pollution. This assessment served to supplement the result of the water quality testing. Hence, there is a need to bring back the water quality in terms of

total coliform to Class A. The riparian vegetation survey also showed a decline from upstream to downstream.

Figure 2 shows an ordination diagram of a biplot between Coliform, FBI, sites, months, and water quality. The amount of variation explained for the first of the four quadrants is 35.085%. This explains the largest amount of variation and eigenvalue (5.613). This further shows that stations A, B, and C for the month of October have the largest variation in terms of DO, nitrite, color, phosphate and TSS. The second quadrant shows stations A,B,C, during the months of February and November showed a variation and relationship with pH and flow rate. The third quadrant shows stations A,B,C,D, E during the month of January showed variation and relationship with BOD,nitrate, FBI, coliform and temperature.

Considering increase in values and FBI descriptive measure, Coliform is much more correlated with FBI especially in the month of January with values that is at its highest in the Poblacion Area (Station D) and followed by the Estuary value (station E).

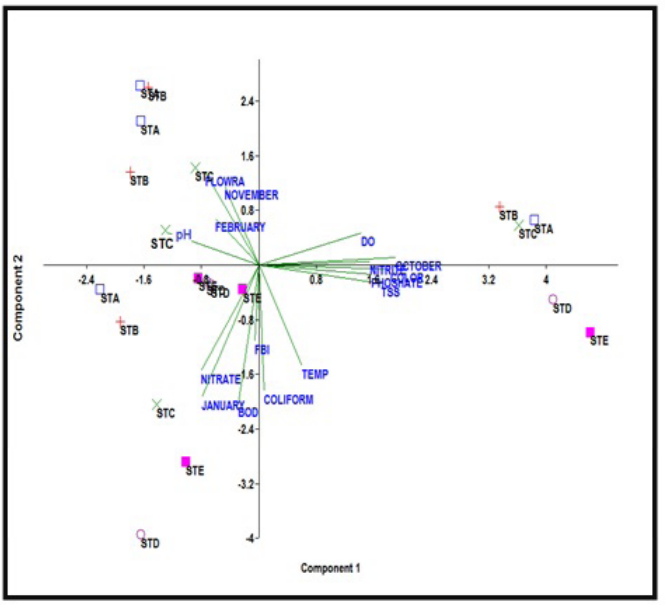

Figure 2. An ordination diagram showing relationship between sampling sites and water quality (Eigenvalue of 5.613 and %variation of 35.084).

Table 3 presents a summary of the over-all descriptive measure of respondents' level of environmental awareness.

As shown the highest mean (3.34) falls in Barangay 7 –Burgos verbally described as very much aware. On the other hand, the lowest mean (2.24) falls in Barangay Kauswagan verbally described as slightly aware. All the rest have a level of awareness indicated at moderately aware.

Most of the barangay residents who were interviewed also obtained their environmental awareness through media resources like radio, TV and newspapers. It indicates that information drive on environmental awareness has not been intensified.

Table 3. Over-All Descriptive Measure Of Respondents' Perception (All Areas Surveyed)

Barangays	Mean (X)	Descriptive Measures
Taguanao	2.90	Moderately Aware
Barangay 7 –Burgos	3.34	Very Much Aware
Balulang	3.05	Moderately Aware
Carmen	2.86	Moderately Aware
Barangay 17 –Burgos	3.16	Moderately Aware
Kauswagan	2.24	Slightly Aware
Consolacion	2.39	Slightly Aware
Bonbon	2.98	Moderately Aware
Lumbia –airport	3.03	Moderately Aware
Macabalan –riverside	3.10	Moderately Aware
Bayabas	2.70	Moderately Aware

CONCLUSIONS

From the findings of this study, the following conclusions are drawn: 1) the water quality of Cagayan de Oro River in terms of the physico-chemical characteristics complied with standard values. However water quality in terms of the microbiological characteristic is impaired; 2) a difference in the water quality of the river between stations in terms of flow rate, temperature, dissolved oxygen,

phosphate and total coliform is habitat-influenced but by period, it is influenced by season; 3) the water quality of Cagayan de Oro River generally falls under class A except for total coliform which went way beyond the standards. The Cagayan de Oro River stretch is organically polluted. The Pollution loading in terms of total coliform is higher than the standard values stipulated in DAO-34 and must require some measures to bring it back to Class A level; 4) it is the downstream part of Cagayan River particularly the estuary and poblacion areas that are greatly impacted by land-based pollution in terms of total coliform and has a condition which suggest some organic pollution being probable and substantial pollution likely as described in the obtained FBI values. The other areas along the CDO river stretch are described as having generally good water quality which is interpreted as having the likelihood of possible to probable pollution; and 5) the potential sources of organic pollution are the residential, commercial, and industrial areas.

RECOMMENDATIONS

Policy Implication

More efforts should be geared towards intensifying environmental awareness through more extensive Education Campaign, symposia and seminars. More stringent implementation of environmental regulations should be done.

Management Implication

The LGUs should look into the areas identified as potential causes of pollution namely checking of waste water treatment facilities of the livestock and dressing plants in the upstream areas (right-hand tributary of CDO river, inadequacy of sanitation facilities (septic systems), drainage systems and come up with a rehabilitation program that would particularly address stream bank stability to filter organic materials and at the same retard run-off. The use of organic farming should be promoted in agricultural areas. In areas where construction is undertaken, the use of silt fences should be advised and constantly monitored. The residents can do their part by cleaning their storm drains and removing liters and leaves that may eventually find their way in to the river.

Research Implication

It is recommended that future researchers should establish more sampling sites. Since pesticide was detected in a one-time sampling only, it is recommend-

ed that this should be included as part of the parameters to be tested in future researches.

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