Characterizing the Water Quality of the Cagayan River: Basis for Community Action Programs Toward Prevention of Water Pollution

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ABSTRACT

The study assessed the water quality of the Cagayan River as characterized by physical and chemical parameters to provide baseline information for the local government to implement stricter measures on wastewater management and in order to prevent remarkable contamination of the renowned longest river in the country. The grab method of specimen sampling was used in different stations with three strata. The obtained results of the physical and chemical properties of the river were compared to water quality standards set by the Bureau of Fisheries and Aquatic Resources (BFAR) and the Department of Environment and Natural Resources (DENR). The assessment showed that the Cagayan River in the study site is contaminated with ammonia that is remarkably high and denotes high level of nutrients from wastewater disposed into the river. Anthropogenic activities largely contribute to the change of river water quality. Hence, the study site is predisposed to pollution. Local dwellers and agencies in different sectors advocating care for the environment are encouraged to take aggressive actions to minimize the direct inflow of waste water into the river in order to control the increasing nutrient deposition that will bring a subsequent death of a river.

INTRODUCTION

Cagayan River is the longest in the Philippines. Its head waters start at the Caraballo Mountains near the boundary of the present provinces of Nueva Vizcaya, Quirino, Nueva Ecija, and Aurora. Moving north, the Cagayan River runs for some 450 km, growing stronger as it gathers more waters from the mountains of the Cordillera and Sierra Madre until it ends to the sea in Aparri, Cagayan (Gonzales and Cuevas, 2017). Its tributaries have deposited sediments of tertiary and quaternary origin, mostly limestone sands and clays, throughout the relatively flat Cagayan Valley which is surrounded by the mountains of the Cordillera in the west, Sierra Madre in the east and the Caraballo Mountains in the south. The Cagayan River passes through one of the few remaining primary forests in the Philippines. It supports the lives of numerous endemic and endangered species, like the rare fish, locally called *ludong* or lobed river mullet and also called president's fish. Other fishes like *itobi*, *aguat*, *maningat*, and *bukasing* as named by *yogads*, the native tribe of the municipality of Echague, recall that these fishes were present along the stretch of the Cagayan River in such town in the decade of 70's but have disappeared starting in the 80's. The disappearance of these fishes could be hypothesized as the effect of fishing patterns and practices, the possible invasion of other species that prey on them or the increasing effluents and waste water disposed of the river water from industrial, domestic, municipal, and agricultural activities. The waste water from dressing plants, feed mills, small scale swine farming, market places, excess pesticides and fertilizers that drain into the river are among the common sources. These scenarios illustrate how the human- driven causes of the decreasing diversity of aquatic resources coupled by pollution can affect the ideal goal of stability and sustainability of resources.

The rapid increase of population normally causes an exponential load of domestic wastes disposed into water resources which could limit the growth of aquatic organisms. Accompanied by population increase are the numerous socio-economic activities that contribute a great stress in the aquatic environment. A community bound for urbanized lifestyles as characterized by openness to industrialization within a crowding space can learn adaptation measures to keep life move normally but, the non-human factors like the physical environment suffer the consequences. The concept of development outweighs the understanding of the holding capacity of nature; hence, environmental problems are the consequences.

Catchment areas that carry waste waters can show the amount of contaminants or pollutants that are discharged from anthropogenic activities and provide an idea of an impending problem. In managing water quality it is important to determine the aggregate of point and non- point source pollution loads in order to set maximum allowable loads from each source that contribute to pollution of a river (Yusof, Manaf and Daud, 2009). And an assessment of a river in a local community that for some time in the past, have basically sustained the people for livelihood but has been changed by modernization and development can provide the needed scenario. Routine monitoring programs on river water quality are of most value in determining the effects of continuous inputs of waste waters to reflect the probability of an impending pollution (EPA-Ireland, 2017). This paper henceforth, sought to investigate on the presence of water contaminants disposed from anthropogenic activities that possibly caused the changes in the aquatic environment. The study site for this purpose is the stretch of the Cagayan River along the town proper of Echague , Isabela in Cagayan Valley region. Its classification is class C water body characterized for usage as fishery water for the propagation and growth of fish and other aquatic resources, it can also be used as recreational water class II for boating, fishing or other similar activities. It is likewise used for agriculture, irrigation and livestock watering (DAO No. 8. 2016).

The study sought to assess the physical and chemical properties of the Cagayan River along the stretch of local communities in the municipality of Echague, Isabela and compare the obtained results to water quality standards set by the Bureau of Fisheries and Aquatic Resources (BFAR) and the Department of Environment and Natural Resources (DENR).

The estimated amount of contaminants identified in the local community of Echague, Isabela can bring about a wider picture of the possibility of contaminating the vast Cagayan River in the future, should mitigating actions will not be taken seriously. Standards of water quality that apply for natural water resources serve as guide in determining concerns of aquatic ecosystem as a whole. Common water quality characteristics could provide an index of an imminent problem that can be prevented by proper information that drives active efforts toward early mitigating actions.

Dissolved oxygen is probably the single most important quality factor that fishermen need to understand as part of sustainable fishing concerns. While the farmers and the people of the vicinity of river should be informed of the nutrients disposed that harm the aquatic ecosystem. Runoff water that carry residues of fertilizers and pesticides that drain into rivers, failing septic systems, wastes from domestic animals are typical sources of excess nutrients in surface waters. Excessive amounts of nutrients can lead to an abundant supply of vegetation and cause low

DO, dissolved oxygen. A decreasing DO is also related to ammonia which is associated with municipal discharges. Whereas, the pH of water affects the solubility of many toxic and nutritive chemicals hence, the availability of these substances in excessive amounts can adversely affect aquatic organisms.

Physical characteristics such as turbidity, color, odor and temperature of natural waters likewise bring information of ecological concerns. In the light of these physical and chemical parameters, the authorities can bring about local ordinances enforced strictly for the prevention of pollution and firm measures for the protection of the Cagayan River, the unifying identity among the peoples of the Cagayan Valley.

METHODOLOGY

The selection of exact sampling stations considered the following factors as suggested by Estrada (2001), these were: representativeness, flow rate, accessibility and safety, homogeneity, and sampling facilities. The sampling was done within a ten-meter distance from edge of each of the three catchment areas of wastewater (Figure 1) leading toward the main body of the river. A collecting vessel was used to get a sample from each of the three strata the surface, middle and bottom layer. Water samples from the surface were obtained opposite the flow of river current. The samples from the middle layer were taken from a depth of about 2-3 m deep while the samples from the bottom were taken from a depth of about 5 m. Proper labeling, handling and preservation were observed as strictly as possible to ensure the integrity of the water samples. The collection of water samples was done on a sunny day of February in 2015. Sawyer, C.; McCarty, C. and Parkin, G. (2003), and Estrada (2001) suggested that once daily grab sample is adequate for large rivers where change occurs slowly. The Cagayan River is large and considered the longest river in the country which is why the once daily grab sample was deemed suitably performed.

Standard facilities for water testing were utilized under the supervision of a specialist from the Bureau of Fisheries and Aquatic Resources (BFAR) Station in San Mateo, Isabela. Specific materials were used to assess the river water quality as described below:

Physical Parameters

Transparency. The measurement of transparency was done using a secchi disk attached with a calibrated rope. The disk was submerged into the water until it was still visible to the observer and then lowered further until the disk disappeared from view. The depth of disappearance and appearance

Figure 1. The three sampling stations: 1) the catchment area for industrial wastewater coming from a feed processing plant and cornfields along the riparian zone, 2) the catchment area for domestic and agricultural wastewater, and 3) the area where wastewater from municipal (commercial activities) and agriculture is disposed.

were noted and computed to derive the transparency reading of the water.

Odor. The odor of the water was evaluated by a trained staff of the Bureau of Fisheries and Aquatic Resources (BFAR). The evaluation made use of the form for describing odor adapted from Estrada (2001). Each of the water samples was described following the legend below:

Quantitative description for the severity of odor

0 - No odor detected

1 - Very faint. The odor would not be detected by an average consumer but would be detected by an experience observer.

2 - Faint. The odor might be detected by an average consumer but only if his/her attention were called to it.

3 - Distinct. The odor would be readily detected and might cause the water to be regarded with disfavor.

4 - Decided. The odor would force itself upon the attention and might make the water unpalatable.

5 - Very strong. The odor of this intensity would render the water absolutely unfit to drink.

Color. The distinct observable color on-site provided a quick description of the coloration of the river water. An arbitrary symbol of **a** was used to describe no abnormal discoloration from unnatural causes. Should unnatural color was observed, the symbol is **x**; the determination of color need laboratory exploration of its nature.

Temperature. This parameter was measured using the DO meter equipped with temperature sensing device.

Chemical Properties

Dissolved Oxygen. This chemical property was measured using the DO meter administered on-site at different depths in each sampling station.

Ammonia, pH, and nitrite were measured using standard laboratory procedures utilizing reagents specified in the water analysis kit of the Bureau of Fisheries and Aquatic Resources, San Mateo station.

RESULTS AND DISCUSSIONS

The Cagayan River is class C freshwater body characterized for usage as fishery water for the propagation and growth of fish and other aquatic resources, it can also be used as recreational water class II for boating, fishing or other similar activities. It is likewise used for agriculture, irrigation and livestock watering (DAO No. 8. 2016); it is relatively mature considering the size of its valleys, number of tributaries and area; it has been noted as home of diverse species of aquatic resources where fisher folks and farmers obtain food and means of livelihood. The river is also a source of water to irrigate farmlands during drought season and an accessible source of water for the entire region of Cagayan Valley for commercial and industrial activities. Additionally, the Cagayan River is a catch basin for all small rivers in the region; carrying flood waters during rainy season and drain its water and nutrients to the sea in Aparri, Cagayan province.

The reliance of people upon the bounties of the river sends a message of action to prevent its degradation and eventual death. Community action programs for the protection of the river can be mapped appropriately when based on scientific data characterizing which parameters contribute to vulnerability to pollution and ultimate loss of its resources.

The physical and chemical characteristics of water in Cagayan River

The physical water quality in station 1 as shown in Table 1 is distinct of a pigpen odor and high normal level of transparency.

The brown color (a, no abnormal coloration) as observed on-site could be attributed to the quality of the substrate that is clay-loam soil. The average temperature (26.63°C) is also within normal limit that could allow growth of some aquatic organisms. The odor associated to a pig pen can be related to the feed processing in such industrial area near the river. However, the chemical characteristics of the water in station 1 exceeds normal limit of ammonia from surface (2 mg/L), middle (1.8 mg/L) to bottom (1.2 mg/L) strata. The surface has the highest level of ammonia that is forty times greater than the normal and acceptable limit (0.05mg/L) for freshwater aquatic ecosystem. The middle layer shows thirty six times higher than normal limit, while the bottom layer is twenty four times higher than normal. The remarkable amount of ammonia in station 1 could be a factor to relate with the presence of an industrial area situated at about 500 m adjacent the Cagayan River. This assumption is consistent with the explanation of Brown and Caldwill (1999) that ammonia is associated with municipal treatment discharges which could be similar with industrial treatment discharges.

The presence of high ammonia in river water in its un- ionized form (NH^3) can be highly toxic to aquatic life (Aquatic Life Criteria-Ammonia, 2013). This can cause fish and shellfish unable to excrete sufficiently the toxicant and eventually result to build up in tissues and blood that end up to death. Environmental factors, such as pH and temperature, can affect ammonia toxicity to aquatic animals; typical events that can make a river vulnerable to water pollution.

The stressing effect of ammonia on aquatic organisms increase at low level of dissolved oxygen (Brown and Caldwill, 1999). This has been observed in station 1 where most of the effluents are disposed from industrial and agricultural activities. There is an inverse distribution of dissolved oxygen with ammonia noted from surface through the bottom layer of the river; the surface layer has high ammonia but less of dissolved oxygen.

Table 1. Physicochemical characteristics of Station 1, industrial and agricultural waste water catchment area

Parameters	Surface	Middle	Bottom	Average	Normal limit (*DAO No.8. 2016)	Remarks
Physical						
Temperature	26.5 °C	26.4°C	27°C	26.63°C	*25-31°C	Passed
Transparency	Appearance 25 cm Disappearance 57 cm			32 cm (disappearance-appearance)	20-40 cm	Passed
Odor	Distinct smell of pigpen			3	0	Failed
Color	Brown (on site)			a	a	Passed
Chemical	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	
Ammonia	2	1.8	1.2	1.67	* 0.05	Failed
pH	7	7.5	8	7.5	*6.5-9	Passed
Dissolved Oxygen	4.8	5	5.5	5.1	*5(minimum)	Passed
Nitrite	0.03	0.04	0.05	0.04	< 0.1	Passed

Legend

Odor: 0- no odor detected; 1-very faint; 2-faint; 3-distinct; 4-decided; 5-very strong

Color: a- no abnormal discoloration from unnatural causes; x- with abnormal discoloration

**- standard set in DENR Administrative Order No.8. 2016*

It denotes that the source of high ammonia is more of the disposed liquid wastes suspended in the upper layer of the river rather than those coming from fish and other aquatic organisms at bottom layer. Consequently, the amount of dissolved oxygen at the surface is low but the amount of ammonia is high so while the dissolved oxygen has been observed to increase toward the bottom layer, the amount of ammonia decreases. Ammonia is toxic to many aquatic organisms that normally come from domestic, agricultural and industrial effluents (Ausseil, 2013). Whereas, pH, temperature and nitrite values in station 1 are said to be stable within normal range.

Station 2 is turbid (transparency, 50 cm) as the normal transparency limit (20-40cm) is exceeded by 10 cm (Table 2) but there is no abnormal discoloration from unnatural causes. Ammonia (mean,1.03 mg/L) and dissolved oxygen (mean, 5.3 mg/L) are almost evenly distributed among the three strata: surface, middle and bottom of the river and similar with station 1, the level of ammonia decreased toward the bottom layer (surface,1.2 mg/L; middle,1.1 2 mg/L; bottom, 0.8 2 mg/L) but could still be considered very much higher than the normal range. It was also observed that stations 1 and 2 are both deficient of fish fry as compared to station 3 where fish fry can be seen at nearby edges of the river downstream.

There is a distinct septic odor rated unanimously as 3 by the observers because of the offensive smell. The description to the odor was associated with the smell of a leaking septic tank. It was traced that a huge canal that directly drains into the river carries domestic wastewater passing through small scale pig pens at the backyard of community dwellers near the river. The domestic wastewater that may come from failing septic tanks discharged to the river via drainage could be the cause of the odor.

Whereas, the temperature in as assessed using a DO meter equipped with

Table 2. Physicochemical characteristics of Station 2, domestic and agricultural wastewater catchment area

Parameters	Surface	Middle	Bottom	Average	Normal limit (*DAO No.8. 2016)	Remarks
Physical						
Temperature	26.1°C	26.6°C	28.1°C	26.93°C	*25-31°C	Passed
Transparency	Appearance Disappearance	30 cm 80 cm		50 cm (disappearance-appearance)	20-40 cm	Failed
Odor	Faint earthy			3	0	Failed
Color	Light brown (on site)			a	a	Passed
Chemical	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	
Ammonia	1.2	1.1	0.8	1.03	* 0.05	Failed
pH	8	7.5	8	7.83	*6.5-9	Passed
Dissolved Oxygen	5.3	5.2	5.4	5.3	*5 (minimum)	Passed
Nitrite	0.03	0.04	0.04	0.037	< 0.1	Passed

Legend

Odor: 0- no odor detected; 1-very faint; 2-faint; 3-distinct; 4-decided; 5-very strong

Color: a- no abnormal discoloration from unnatural causes; x- with abnormal discoloration

**- standard set in DENR Administrative Order No.8. 2016*

thermometer and found sampling station 2 to be within normal range of water temperature. The laboratory tests performed on the collected water samples showed normal limit of pH and nitrite. Hence, the distinct odor is dependent of the waste water source and not a result of interaction with other parameters.

The third station is situated where discharges of wastewater from the business or commercial district, residential and agricultural areas reach the river. The network of drainage canal carrying these wastewaters pour down the small manmade lagoon about 4 m away from the edge of the river water then drains gradually to the main body of the river as it overflows. Nevertheless, the water is very turbid (75 cm), exceeding the transparency limit by 35 cm. The collection schedule coincided with the cement mixing for the infrastructure project of the local government unit. An area of the riparian zone is utilized as storage of gravel and sand where mechanized mixing with cement is occasionally being done. Thus, the turbidity could also be occasionally attributed to such activity.

A school of small fish approaching the drainage area could be assumed that the level of turbidity is also on account of phytoplanktons that attract the small fish. The pH values (surface, 8 mg/L; middle, 9 mg/L; bottom, 8.5 mg/L) as shown in Table 3, manifest normal level but within the upper limit. Brown and Caldwill (1999) explained in their guidebook for watershed protection plan that pH varies diurnally, reaching values as high as 10 during the day when algae are using carbon dioxide in photosynthesis. The dissolved oxygen is evenly distributed in the three strata despite high levels of ammonia. Nitrite on the other hand is maintained within normal limits below 0.1 mg/L.

Other physical parameters such as temperature and color show that station 3 is within normal range; however, a faint earthy odor is detected as probably brought by the

Table 3. Physicochemical characteristics of Station 3, municipal and agricultural wastewater catchment area

Parameters	Surface	Middle	Bottom	Average	Normal limit (*DAO No.8. 2016)	Remarks
Physical						
Temperature	27.7°C	27.5°C	27.6°C	27.6°C	*25-31°C	Passed
Transparency	Appearance 50 cm Disappearance 125 cm			75 cm (disappearance-appearance)	20-40 cm	Passed
Odor	Faint earthy			2	0	Failed
Color	Light brown (on site)			a	a	Passed
Chemical	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	
Ammonia	0.6	0.7	0.7	0.67	* 0.05	Failed
pH	8	9	8.5	8.5	*6.5-9	Passed
Dissolved Oxygen	5	5	5.1	5.03	*5 (minimum)	Passed
Nitrite	0.03	0.04	0.04	0.037	< 0.1	Passed

Legend

Odor: 0- no odor detected; 1-very faint; 2-faint; 3-distinct; 4-decided; 5-very strong

Color: a- no abnormal discoloration from unnatural causes; x- with abnormal discoloration

**- standard set in DENR Administrative Order No.8. 2016*

cement and gravel mixing activity in the river bank.

The water quality of Cagayan River compared to standards of natural water

The average physical characteristics of the Cagayan River in Echague, Isabela as represented by the three sampling stations in terms of temperature is within the standard range, its color depicts no abnormal discoloration from unnatural causes but with distinct odor and turbidity (Table 4). The transparency value beyond 40 cm denotes high turbidity or low transparency. The presence of fine particles in water decrease transparency that could reduce light penetration, decreasing algal growth; and low algal productivity can reduce the productivity of aquatic invertebrates, as they serve as food source for many fish (Brown and Caldwill, 1999). The fine particles that turn water turbid can also eliminate spawning habitats as they fill gravel spaces where some species of fish and other aquatic organisms use to lay their eggs. The distinct odor of the river water reveals the land use activities of the people within the vicinity of the river that may have contributed to the low transparency and very high level of ammonia. The deterioration of river water quality is largely attributed to effluents from agricultural, domestic, and industrial activities as also explained in the study of Al-Badii, F.,Shuhaini-Othman, M., and Gasim, M.B. (2013).

The chemical properties of water of the Cagayan river as shown in Table 5 is within normal limits in the amount of dissolved oxygen, pH level and nitrite content but results of water analysis on ammonia showed exceedingly higher than the standard range. The value of ammonia is consistently very high in the three sampling stations and within strata. This excessive amount of ammonia particularly in station 1, where an industrial company is situated and the overall average range of ammonia in all the three stations can contribute to an increasing nutrient content of the natural water, henceforth, affect productivity of the water. It could also be noted that ammonia can affect water quality within a limited amount and could affect

Table 4. The physical characteristics of the three waste water catchment areas

Physical	Station 1	Station 2	Station 3	Average	Standard	Remarks
Temperature	26.63°C	26.93°C	27.6°C	27.05°C	*25-31°C	Passed
Transparency	32 cm	50 cm	75 cm	52.33 cm	20-40 cm	Failed
Odor	3	3	2	2.67	0	Failed
Color (on site)	a	a	a	a	a	Passed

Legend

Odor: 0- no odor detected; 1-very faint; 2-faint; 3-distinct; 4-decided; 5-very strong

Color: a- no abnormal discoloration from unnatural causes; x- with abnormal discoloration

**- standard set in DENR Administrative Order No.8. 2016*

Table 5. The chemical characteristics of the three waste water catchment areas

Chemical	Station 1 (mg/L)	Station 2 (mg/L)	Station 3 (mg/L)	Average (mg/L)	Normal limit* (mg/L)	Remarks
Ammonia	1.67	1.03	0.67	1.12	0.05	Failed
pH	7.5	7.83	8.5	7.94	6.5-9	Passed
Dissolved Oxygen	5.1	5.3	5.03	5.14	5 (minimum)	Passed
Nitrite	0.04	0.037	0.037	0.038	<0.1	Passed

**DENR Administrative Order No. 34. 1990 and DENR Administrative Order 08. 2016.*

levels of pH and dissolved oxygen.

Ammonia on surface water exists in two forms: the unionized NH_3 and the ionized NH_4+. The latter does not easily cross fish gills and is less bioavailable; the former (NH_3 , unionized) form can cross from water into fish which causes cellular damage; it is this chemical species that is responsible for toxic effects in the body and because of this, NH_3 is the most toxic form for aquatic life (Levit, 2010).

The toxic form of ammonia () in the study site had exceeded the general effluent standards based on DENR Administrative Order 08, 2016 of less than 0.05 ppm or mg/L . While the pH value is within 7.5 to 8 that is within normal limits for an A classification freshwater but with a chance for its temperature to increase by 1^{o}C would also cause the river water to exceed ammonia values (Zamzow, 2009) hence, poisonous to fish and other aquatic organisms.

Stream ecologists have categorized the productivity of lakes and streams into three classes, the first is oligatrophic that is characterized with clear water and have very low inputs of nutrients. Second is mesotrophic, has moderate amounts of nutrients where aquatic life tends to be very diverse and, third, is eutrophic which tends to be unstable in chemistry and biology and as a result tends to have low species richness and diversity despite high biomass. This eutrophic category most likely describe the Cagayan River along the its stretch in the town of Echague, Isabela. Invasive and pollution tolerant species of fish like carp had been a common catch this present times in the Cagayan River and this could somehow tell the natural possibility of the loss of some species of fish like *ludong* (president's fish), *itobi*, *aguat*, *maningat*, and *bukasing* as named by the indigenous peoples *yogads* of Echague, Isabela. Consistent to this finding has been explained by Kolawole, O.M., Ajayi, K.T., Olayemi, A.B., and Okoh, A.I. (2011) that the amount of discharge of chemicals from industry, agriculture, and commercial activities lead to deleterious effects on aquatic organism. Common sources of these nutrients disposed to river include failing septic tanks, excess feeds and fertilizers, animal manure, and industrial waste waters hence, geology and land use determine the amounts of nutrients that enter a water body through surface run-off (Minnesotta Pollution Agency, 2008). An aggressive control mechanism may be instituted to control discharge of untreated sewage direct into river to prevent an impeding pollution. However, solutions that utilize soft measures are preferred according to the study of Rennie (2012) until such time an ecological impact assessment is conducted.

CONCLUSION AND RECOMMENDATIONS

Conclusion

1. The Cagayan River in Echague, Isabela is contaminated with ammonia. The level of ammonia is remarkably high and denotes high level of nutrients from wastewater disposed into the river from industrial processing, farming, domestic, and business activities. It is eutrophic in the category of river productivity.
2. The physical, chemical and biological properties of water quality are associated together and form the overall characteristics of the Cagayan River in Echague as vulnerable to pollution. The presence of offensive odor, high turbidity (low transparency), and very high amount of ammonia contributes to the growth and survival of pollution tolerant organisms in the river but the probable cause of the gradual loss of native fish species.
3. Effluents from households, and wastewater from activities in industries, commercial, and farming largely contribute to the change of river water quality. Nutrient deposition in small amounts through run-off water from farms and direct waste

water discharge carried by municipal drainage can be tolerable within a couple of years for large rivers like the Cagayan River but can subsequently damage the river water quality that supports aquatic resources when the gradual deposition turn to exponential load in the passing of time.

Recommendations

1. Results of the study should be utilized by the local community in identifying land use activities of residents and land owners within the vicinity of the river and implement stricter measures of wastewater disposal into the river.
2. A comprehensive program on the prevention of water pollution in Cagayan River can be formulated based on the findings of this study. Community dwellers may take aggressive participation in pollution prevention once a program based on scientific data is crafted.
3. Water analysis on the presence of heavy metals should be conducted to ascertain safety of the river water as source of food and livelihood.

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