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Water quality and socio-demographic assessment of Mahuganao Stream: inputs to water resource management

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Abstract

Small as they may appear, headwater streams are very important because the health of the organism depends on that network of streams. The present study deals with the assessment of water quality of Mahuganao Stream, the socio-demographic and economic profile of residents living near the stream, the way they utilize the stream and how much waste they can produce. The analysis of the water samples collected was done in the laboratory to determine the Water Quality Index. Twelve (12) households were interviewed to elicit information on their socio-demographic and economic profile, how they utilize the stream and the amount of waste each household produces. Overall, Mahuganao stream is within the standard set by the agencies concerned such as DENR, PNSDW and USEPA. The socio-demographic profile of the community and its solid waste management is seen to be changing over time due to the fact that the median age at present is found to be within their late teens. There is a need to manage the stream as this group of people has the capacity to reproduce and could increase the anthropogenic activities and waste generation in the area.

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Introduction

The Philippines is endowed naturally with having an outstanding water resource, like lakes, rivers and streams. These originate from a lot of smaller streams and wetlands. A lot of them are so small that they do not appear on any map. However, these headwater streams and wetlands have a major influence on the character and the quality of downstream waters. This means that the health of rivers depends on the health of the network of streams. The natural processes that happened in such headwater systems is beneficial to people by mitigation of flooding, maintenance of water quality and quantity, recycling of nutrients, and provision of habitat for plant and animals (Meyer *et al.*, 2003).

Cagayan de Oro City is the most populous city in Northern Mindanao, with the population of 675, 950 according the 2015 consensus done by the Philippine Statistics Authority (PSA). Its population grows in 5 years by 2.23% compared to 1.72% nationwide. Because of that, the state of the water quality in Cagayan de Oro City, especially its rivers and streams, is affected by its growing population.

Barangay Cugman is the 11th most populated barangay in all of Cagayan de Oro with the total population of 20,531 with having 4,538 households (Philippine Statistics Authority, 2010). It is also in the said barangay where the proposed Mahuganao Watershed Forest Reserve is located. This watershed serves as the source of Mahuganao Stream - a perennial stream. Mahuganao or 'magunaw' as the locals say literally means 'cold'. It is one of the two bigger headstreams of Bigaan River in Barangay Cugman. Bigaan River is one of the seven rivers that are found in the said city, and it is noted to have been surrounded with communities that show a high rate of population growth and urbanization (Canencia and Gomez, 2016; Walag and Canencia, 2016).

There is a farming community situated near Mahuganao Stream. The stream serves many purposes to the lives of the people that live near the area. As observed by the researchers, most of the residents wash their laundry and bathe themselves and their livestock - like cows, carabaos and pigs on the stream. In addition, observable trash is strewn on the stream. Thus, there is a need for the management of the stream.

Furthermore, local knowledge and practices have played a vital role at a local level for water management. The sustainability of water management depends on the cooperation of the community. It is important to involve the community in the management of the stream. Their involvement is critical in identifying potential issues, conflicting values, opportunities and constraints. The changes in policy that affect water management will benefit from the evaluation of likely impacts on the communities since the community is often the most affected by any local management on the stream.

The objectives of the present study were to determine the water quality of the stream, assess the socio-demographic and economic profile of the residents living near the stream, determine the way they utilize the stream and calculate how much waste they can produce. This may provide baseline information on the current situation in the area. This research can also be a rationale for stream management plan from the local government as well as for further related studies.

Materials and methods

Water Sampling

Description of Sampling Site

The whole study area is found in Malasag, Cugman, in the city of Cagayan de Oro. Three sampling sites were chosen along the Mahuganao Stream in Malasag, Cugman, Cagayan de Oro. All the sites were found in private lands that have coconut trees and other agricultural crops. The water from the stream flows toward Bigaan River, a Class B river, a standard set by the DENR (Canencia and Gomez, 2016).

Table 1. Coordinates of the sampling areas.

Sampling Area	Latitude	Longitude
1	8°26'37.5"N	124°41'38.3"E
2	8°26'38.5"N	124°41'27.2"E
3	8°26'38.6"N	124°41'14.9"E

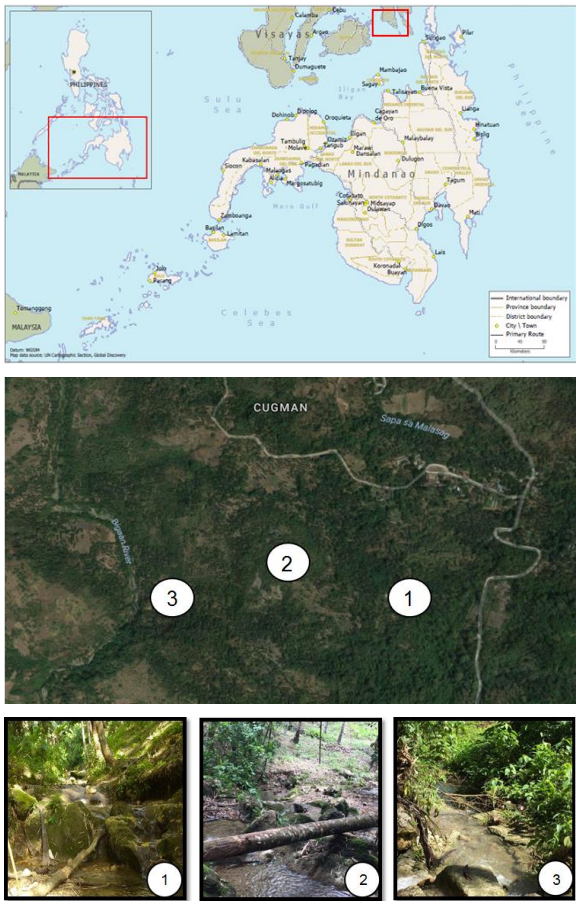

Fig. 1. Map of the sampling site with sampling areas 1, 2 and 3.

Sampling technique procedures

The study collected samples from upstream, midstream and downstream of the stream. A GPS device was used to determine the exact location for the sampling areas. All the samples were stored in polyethylene containers (PET) which were pre-washed with distilled water in triplicates. Before the sampling, the containers were washed with the flowing stream water on site. All the containers were labeled properly. The temperature was measured on site. The collected samples were placed in a container with chunks of ice inside as these samples were brought to the laboratory for analysis (Bansilay, *et al.,* 2017; Canencia and Gomez, 2016; and Galarpe and Parilla, 2014).

Physicochemical Analysis

The conductivity, TDS, pH, and DO were analyzed in the laboratory using Oyster meter series 3413550A and the turbidity was analyzed using La Motte 2020we Turbidity Meter 1970-epa. The temperature was measured using a laboratory thermometer. All analyses were done in triplicates.

Survey

There were 12 households purposively selected of which are located near the area, at least 200 meters away from the stream. They were interviewed and asked to answer the survey questionnaires (questions were in English but the interviewer sometimes translate the questions to Cebuano) to elicit information on their socio-demographic and economic profile, the way they manage their solid waste and their suggestion on how they could manage the use of the stream.

Fig. 2. Interview conducted to some of the households near the stream.

Data Analyses

Both descriptive and inferential statistics were employed to analyze the obtain data. Mean is used to get the average of the water quality parameters. One way-ANOVA was employed to compare the physicochemical parameters of the three sampling stations (0.05 level of significance). Median is used for the age of the sample respondents.

Results and discussion

Physicochemical Analysis of Mahuganao Stream

The physicochemical parameters were assessed to determine if these parameters conform to the standards set by the Department of Environmental and Natural Resources - Environmental Management Bureau (DENR-EMB) and other agencies such as the United States Environmental Protection Agency (USEPA) and Philippine National Standards for Drinking Water (PNSDW). Generally, the physicochemical analyses of all stations are comparable.

The result of the current study shows that the stream can be considered as having a good quality.

Table 2. Physicochemical analyses of Mahuganao Stream.

Parameters	Station 1	Station 2	Station 3	Standard		
				DENR Class AA	USEPA	PNSDW
Conductivity ppm	682.67	709	665	-	250 ppm	-
Turbidity (cm)	0.1667	0.65	0.75	-	-	5
TDS (ppm)	458	471.33	447.67	-	500 mg/L	-
pH	7.82	7.73	7.4	6.5-8.5	-	-
Dissolved Oxygen (mg/L)	5.29	5.4067	5.6433	5	-	-
Temperature (°C)	25.94	25.77	25.7	26-30	-	-

It is observed that station 2 has the highest conductivity recorded. Chapman (1996) as cited by Galarpe, *et al.* (2017) mentioned that conductivity may indicate that there are potential ions in water. Thus, the recorded conductivity is greater than the standard based on USEPA. In terms of turbidity, station 3 was recorded higher than in stations 1 and 2 respectively. This can be attributed through the dust and runoff of the anthropogenic activities (Galarpe *et al.,* 2017). This can be confirmed because station 3 is located next to the station where the most of the community inhabits. The residents made mentioned that, this stream is where they cross when they go to the adjacent places, where they wash their clothes and even bathe their livestock such as pigs, cows and carabaos.

The recorded Total Dissolved Solids (TDS) is less than the standards set by the USEPA. However, according World Health Organization (WHO) guidelines on drinking water quality, 300-600 mg/L is classified as good. The TDS of the stream then can be classified as such. TDS provides a qualitative measure of the amount of dissolved ions. To add, the result does not give insight into the specific water quality issues, like Elevated Hardness, Salty Taste, or Corrosiveness. The total dissolved solids test is used as an indicator test to determine the general quality of the water.

The TDS concentration is a secondary drinking water standard and, therefore, is regulated because it is more of an aesthetic rather than a health hazard (Oram, 2014).

Living things depend on having a steady pH in their environment. The pH level conforms to the standards of DENR-EMB. It can be gleaned that pH level in station 1 is higher compared to those in stations 2 and 3 respectively. The pH is one of the most important factors that determine the suitability of water for various purposes such as toxicity to plants and animals (Venkatesharaju *et al.*, 2010). WHO's criteria for aquatic life list the pH value of 6.5-8 to be the most suitable. Moreover, average pH level is extremely significant to aquatic life as low pH may cause the death of fishes in rivers and lakes (Martinez and Galera, 2011).

The Dissolved Oxygen (mg/L) and the pH are both within the standard set by the Department of Environmental and Natural Resources (DENR). Since the dissolved oxygen is within the standard level, this implies that there is a high tendency that aquatic organisms such as fish can thrive in this stream. Dissolved oxygen is necessary for the survival of aquatic organisms (Martinez and Galera, 2011).

Moreover, the recorded temperature was below the standard set by the DENR. This may be due to the location and altitude of the stream and the surrounding of the stream. The area where the stream is located is heavily vegetated and is surrounded by shrubs and trees.

Parameters such as conductivity, turbidity, and total dissolved solids (TDS) were recorded higher either in stations 2 or 3. This is expected since in these areas are where the bulk of residents live close by. The recorded amount of the parameters still conforms to the standards set by the DENR, USEPA and PNSDW. Therefore, a proper natural resource management must be made in order to preserve this water resource.

Table 3. ANOVA of the physicochemical parameters of the sampling stations of Mahuganao Stream.

Parameters	F	p-Value	Decision
Conductivity	9.80	0.013	Significant Difference
Turbidity	19.2	0.002	Significant Difference
TDS	15.3	0.004	Significant Difference
pH	18.9	0.003	Significant Difference
Dissolved Oxygen	6.63	0.030	Significant Difference
Temperature	0.35	0.720	No significant Difference

Statistical comparison

Table 3 shows the parameters conductivity, turbidity, TDS, pH and dissolved oxygen shows a significant difference ($p<0.05$) among the three sampling stations. This has been confirmed through Analysis of Variance (ANOVA). As such, there is variation on the concentrations and values among parameters. This variation can be caused by the location, the demographic profile, the households and the type of people living near the stream. Similar studies done by Galarpe *et al.* (2017), Köse *et al.* (2014) and Tokath *et al.* (2014) show a positive correlation between conductivity, turbidity and TDS. On the other hand, the temperature of the stream does not vary as shown in the result of ANOVA ($p<0.05$). The altitude of the location of the stream can be a factor that can be considered, since Malasag is located in a higher altitude. Another factor that can be seen why there is variation in temperature is the presence of riparian vegetation. Riparian vegetation can shade and could trap cool air around (Beschta, 1997; Johnson and Jones 2000). Generally, the residents living near Mahuganao Stream have a great role to play in maintaining the water quality so that the generations to come could still enjoy the richness of the stream.

Socio-economic and Demographic Profile

The socio-demographic and economic profiles of the residents were surveyed in this research in order to come up with the baseline information of the individuals who could directly benefit the richness of the stream. Moreover, this information is also useful in characterizing the area for designing a management plan on the conservation of Mahuganao stream.

Table 3 shows the socio-economic and demographic profile of the respondents. The median age of the respondents is 19 years old, the youngest and the oldest respondents were a month old and a 78-year old respectively. About 61.1% of the respondents were 24 years old and below. The result also reveals that in the area there are more females than of the males. There are 24 males or 44.44% and 30 females or 55.56% respectively. Looking at the median age, it can be seen that the population of the area will be changing over time due to the fact that these ages are capable of reproducing offspring. With this, the demand of the water supply will also increase. It is really a challenge on how to manage the water resources for the coming generation to experience high quality stream water.

In terms of the educational background of the respondents, 14 or 25.93% of them declared that they were able to finish high school and the same percentage declared that they were able to reach at least high school level. None of them were able to reach at least college level. On the other hand, there is only one (1) person who was able to study technical-vocational course. There are also a number of children who are still in the elementary level. Generally, the highest educational attainment of the residents living near the vicinity of Mahuganao stream is within the high school level. It can be implied that a good number of the residents can still be educated on the conservation of Mahuganao stream.

Table 4. Socio-economic and Demographic Profile.

Variable		Frequency	Percentage
Age			
	Under 5 years	7	12.96
	5-9 yrs	7	12.96
	10-14 yrs	6	11.11
	15-19 yrs	8	14.81
	20-24 yrs	5	9.26
	25-29 yrs	5	9.26
	30-34 yrs	1	1.85
	35-39 yrs	4	7.41
	40-44 yrs	3	5.56
	45-49 yrs	3	5.56
	50-54 yrs	0	0.00
	55-59 yrs	1	1.85
	60-64 yrs	1	1.85
	65-69 yrs	2	3.70
	70-74 yrs	0	0.00
	75-79 yrs	1	1.85
Total		54	100
Gender			
	Male	24	44.44
	Female	30	55.56
	Total	54	100
Educational attainment			
	Unschooled	7	12.96
	Elementary Level	13	24.07
	Elementary Graduate	5	9.26
	High School Level	14	25.93
	High School Graduate	14	25.93
	Technical-Vocational	1	1.85
	Total	54	100
Income			
	10,000 and above	2	16.67
	5,000-9,999	2	16.67
	1,000-4999	7	58.33
	1000 below	1	8.33
	Total	12	100

Table 4 also shows the monthly income of the 12 households living within the vicinity of Mahuganao stream. It was revealed that the 83.33% of the households earns 5000 pesos and below per month. This monthly income is related to their modal source of income among households which is more on agricultural as their source of income. Thus, majority of the respondents make use of the resources found in Mahuganao stream such as water for their agricultural products.

Residents' Utilization of the Stream

The utilization of the stream among residents has been surveyed in-order to get baseline information on how the stream affects their living. This is to develop a program and activities that may preserve its water quality.

Table 5. The Residents' Utilization of the Stream.

Activities	f	Percentage
Bathing themselves	9	75.00
laundry	8	66.67
Bathe their livestock	8	66.67
Recreation	12	100.00

The residents living near the stream have different ways of utilizing the stream and its water. As shown in table 5, the residents use the stream as a place where they recreate, especially among young children as mentioned by one of the respondents. It is where the children sometimes play and bathe. Moreover, the stream is used by the residents as a place where they do their laundry and also bathe their livestock. In poor rural communities water resources can be shared by multiple households and would support a variety of sanitary or hygienic and household uses. Water contact activities would be expected like bathing, laundering and other uses. Waterborne bacteria and protozoa, like *E. coli*, can cause gastrointestinal illness in humans as a result of livestock wastes in water. The presence of fecal indicator organisms presents a risk to people who make use of the stream (WHO, 2003).

Solid Waste Generated

The average solid waste generated daily by the housed was surveyed in order to come up with a baseline data on how much waste they produce each day. It is essential to look into the practices of the households on their solid waste management, whether they throw them in a trash bin or throw them in to the stream. The survey shows that the average amount of solid waste generated by household is 3 kg per day. This means that if there are 12 households in the community, an average of 36 kg of solid waste a day will be generated. These wastes include plastics, food wastes and residuals. It was also revealed during the interview with the respondents that in a week, they visit the stream twice to do their laundry or to bathe. With that, shampoo or soap wrappers are left at the riparian zone or even at the stream.

Fig. 3. Different trash found in sampling areas 1, 2 and 3.

Table 6. Average solid waste generated by households daily.

Variable	Average amount generated per day kg/day
solid waste	3

With this, the residents must adhere to the policy on solid waste management through section 2, (a) Ensure the protection of the public health and environment; (b) Utilize environmentally-sound methods that maximize the utilization of valuable resources and encourage resource conservation and recovery; (c) Institutionalize public participation in the development and implementation of national and local integrated, comprehensive, and ecological waste management programs of RA 9003.

Conclusion

It has been concluded during the water quality sampling that Mahuganao stream is within the standard set by the agencies concerned such as DENR, PNSDW and USEPA. These parameters include conductivity, Total Dissolved Solids (TDS), pH and temperatures respectively. It is also evident that the three stations significantly vary in terms of Turbidity, Conductivity, Total Dissolved Solids, pH and Dissolved oxygen. In terms of temperature the three stations has the same water temperature.

On the other hand the socio-demographic profile of the area and its solid waste management is seen to be changing over time due to the fact that the median age at present is found to be within the their late teens. The possibility of the changes of the quality of water in the stream is high. There is a need to manage the stream as this group of people has the capacity to reproduce and could increase the anthropogenic activities and waste generation in the area.

Recommendations

With the result obtained on the analyses on water quality of the stream this can be sustained by the community if:

1. They will maintain the richness of riparian vegetation;
2. They will create a community-based management of stream by monitoring the area regularly;
3. They will sustain the richness and evenness of the plant biodiversity in the area;
4. There will be a strict implementation of the policies on RA 9003;
5. There will be proper storage bins for the solid wastes;
6. Information Education and Communication is still essential.

These are recommended in order for the quality of the stream and the water will be preserved for the next generation to see and experience the richness of Mahuganao stream.

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