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ORIGINAL RESEARCH

Biodiversity of benthic macroinvertebrates as bioindicator of water quality in Badiangon Spring, Gingoog City

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ABSTRACT

Declining water quality in streams and rivers has been a serious problem since 1960's. One way to assess water quality is biodiversity study on benthic invertebrates. Benthic invertebrates are animals that live on rivers and lake bottoms. Any substrate change or any toxic chemical deposited in the bed of stream will affect its abundance. Biodiversity was correlated with water quality of the stream. The study was conducted to determine the biodiversity of benthic macro invertebrates in Badiangon spring and correlate it with the water quality of the stream. Inventory of benthic invertebrate's species in three sampling spots revealed a total of 255 individuals in the three kick nets or 86 per kick net in 1 m x 1m area below the cobble substrate. This includes 9 species of fly, 7 species of snails, 4 species of larvae and 1 species of crab and scuds. Stonefly species is the most diverse in the three sampling spots. The stream is inhabited by the different groups of flies which are indicators of healthy stream site. The Shannon- Weiner index ranges from below 1. 5 (very polluted water) to 4.0 (unpolluted water). The diversity value of benthos in the area is 2.707, falls on the average range but may possibly decline and affects water quality in the future. The total biotic water quality score is 62.82 that indicates a good water quality but slightly impacted area. Chemical analysis showed that pH value, total dissolved solids and total hardness are within the normal range, which means less chemical pollutants. While microbiological analysis, showed that there is fungi, bacteria and fecal contamination in Badiangon spring water. Human intervention and anthropogenic pressures are inevitable. Therefore, protection and conservation of stream water shall be implemented to maintain the good water quality of Badiangon spring.

Keywords: Benthic, Macroinvertebrates, Biodiversity, Indicator, Gingoog City.

Introduction

Declining water quality in streams and rivers has been a serious problem and concern since 1960's. This is due to different pollutants such as heavy metals, sewage and other chemical wastes from industrial and municipal origins. These are harmful to both human and stream ecosystem health (Feminella 1999).

Physical and chemical analyses of water samples are the traditional water quality monitoring approaches. These methods often cannot detect non point source of pollution problem because sampling and analyses are expensive and concentration varies greatly with time and location.

One way to assess water quality is to study biodiversity especially benthic invertebrates (Rai 2000). The use of biodiversity indicators in habitat quality assessments has gained increasing importance in the recent years (Paoletti 1999).

Benthic invertebrates or benthos are animals that live on rivers and lake bottoms or simply called bottom-dwelling organisms. Many of these inhabitants are immature stages of insects such as mayflies, stoneflies, caddisflies and midges. Other types of animals include aquatic earthworms or bristle worms, roundworms, snails and leeches.

Any substrate change or any toxic chemical deposited in the bed of stream will affect its abundance. Biodiversity is correlated with water quality of the stream. High biodiversity indicates an excellent stream site with low human influence. Several different types of stoneflies, mayflies, and caddisflies which indicate a healthy site are very well distributed in this area. Average biodiversity on the other hand, indicates a moderate stream site. Relative proportions of soft-bodied worms may increase in this site. Poor stream site got a low taxa richness where soft-bodied animals are most often found and stoneflies are absent entirely.

In the Philippines, a study assessing the headwaters of Lawayan River in Mt. Malindang, Misamis Occidental was conducted. It showed that aquatic macroinvertebrates found in the headwaters are mostly indicators of good water quality (Hansel et al. 2004). Assessment of eutrophication of Pasig River using benthic invertebrates as bioindicator of water pollution revealed that the organisms no longer support a diverse composition, indicating a low water quality.

In the province of Misamis Oriental, Gingoog City is naturally blessed with Badiangon spring, which is known for its ice-cold spring water. Badiangon cold spring, 4 km west of Poblacion of Gingoog City is formed by a stream flowing towards the sea. It covers the salt water with its refreshing coolness. It is the source of water that residents and nearby barangays use every day for drinking, domestic and other purposes. However, increasing amount of trash and high sedimentation are already observable since the people in Gingoog City go to Badiangon for a dip, swimming and relaxation.

Thus, this study was conducted to determine the biodiversity of benthic macro- invertebrates in Badiangon spring and correlate it with the water quality of the stream.

Materials and methods

Selection of Sampling Sites (Single Habitat Approach)

The samples (Benthic Macroinvertebrate) were collected for experiments.Three sampling spots within the riffles and run areas of the stream were selected. Each sampling spot represent different velocities. Sampling spots were marked and mapped using GPS gadget.

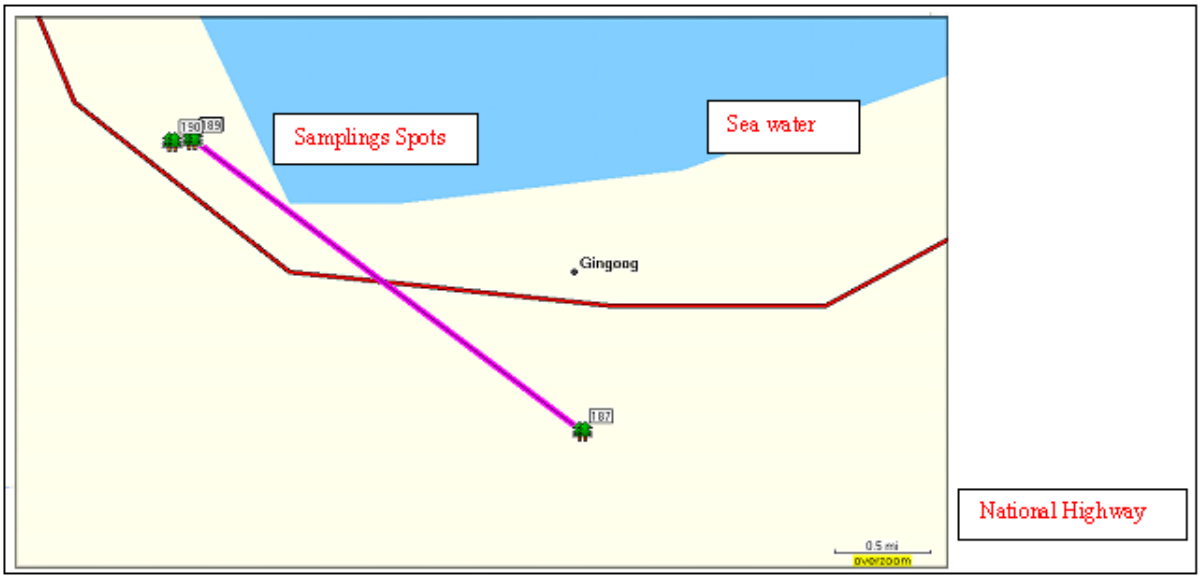

Fig. 1. GPS Map of the Sampling Site.

Collection of Specimens – Kick Net Sampling (Zimmerman 1998)

The kick net was set 1 meter downstream from the riffle. Using the heel of the boot, the upper layer of the gravel and rocks was dislodged while the underlying bed was scraped by kicking 1m x 1m area behind the riffles to stir up sediments and allowed to flow downstream into the net. The contents of the net were rinsed into the sieve bucket. Any organism found was placed into the sample container and preserved in 95 % ethyl alcohol.

Laboratory analysis

The samples from the sample container were carefully transferred to the pan. The specimens were sorted, counted and placed in the containers/vials. Each vial was properly labeled.

Classification and identification of Specimens

The specimens were classified and identified using some keys of identification (people.virginia.edu/sosiwla/key/Macrokeyinfo.html). Microscopy was also done to examine the detailed parts and aid in the identification. The specimens were also brought to Higher Institution for further identification of an expert.

Determination of Biodiversity Indices

The following measures were used to determine the species richness and diversity of benthic invertebrates;

a. Density = Number / kick net

b. Relative Density = $\frac{\text{Density of species A}}{\text{Density of All species}} \times 100$

c. Shannon – Weiner Index = P1 x (log 2 P1)

P 1 (M 1 / N)

Determination of Biotic Water Quality - (Source: Robert Bode, NYS DEC Nov. 1999)

A x B = Product (A x B / 10)
(Number In each taxon) (Biotic Value)

Invertebrate Count to Determine Stream Health - Beck Biotic Index (Pollock, 2009)

BI – Beck Index
BI – 2n1 + n2 (2 x 8 + 5) = 21

n1 = number of class 1 genera identified
n2 = number of class 2 genera identified

Physical and Chemical Analyses
Water samples were collected in a sterile container and subjected to microbiological and chemical analyses at the Department of Science and Technology, Butuan City.

Results

Twenty-two species of benthic invertebrates were found thriving in three sampling spots of the surveyed area; 7 species of snails, 1 crab, 1 amphipods, 4 larvae and 9 species of flies in 14 taxa.

Species density and biodiversity indices
As shown in Table 1, there were 22 species of invertebrates in three sampling spots. Thirteen species were observed in spot 1, 11 in spot 2 and 12 species were noted in spot 3. A total of 255 individuals were found in the three kick nets.

The species richness varies with the velocity of the running water. Of the three sampling spots, spot 3 got the highest total number of individuals as observed to have low velocity of running water as compared to spots 1 and 2.

In the three sampling spots, the stonefly (sp 1) obtained the greatest number of individuals having a total of 87.

This was followed by the snail (sp.2) with a total of 48. The invertebrate species that has the least number are the riffle beetle larvae, caddisfly larvae, cranefly larvae, midgefly larvae, midgefly, and snails sp. 20 and sp. 21.

This table also shows the total mean density value with 86 individuals per kick net. This represents the number of species found in 1 m x 1m area below the cobble substrate. Furthermore, Table 2 shows the relative density value of benthic invertebrates species. Stonefly (sp 1) which has the highest number of individuals exhibiting the highest relative density value of 33.72 %. This was followed by snail (sp 2) and dobsonfly (sp. 6) with 18.60 % and 11.63 % , respectively.

As presented in Table 3 , the diversity value of the benthic invertebrates species is 2.707. Table 4 shows the biotic water quality score of each taxon derived from multiplying the number of individuals and its biotic value. Taxon Plecoptera (stonefly) got the highest biotic water quality score of 29. Followed by Megaloptera (Dobsonfly) with 10 and gastropoda snail sp 19. The total biotic water quality score is 62.82.

Table 5 shows, the Beck Biotic computation which classifies the status of species into three namely; Class 1 – sensitive or intolerant of pollution, class 2 – facultative or tolerate varied conditions and class 3 – pollution tolerant.The beck Biotic index is 21.

A.Classification, identification and description of species.

Invertebrate Species		Local Name	Order	Description
Snails	sp. 2	unidentified	Gastropoda	Brown snail, conical shape
	sp.3	unidentified		Black snail, rounded body, smooth outer surface
	sp.16	unidentified		Brown snail, outer body with pointed structures
	sp.19	Spike Tail Trumpet		Gray in color, cone shape,curved apex
	sp.20	unidentified		Colored black with orange
	sp.21	Zebra Nerite Snail		Striped colored (yellow and black)
	sp.22	unidentified		Orange snail, small, round shaped
Crab	sp. 4	Spider Crab	Decapoda	Black in color with red at the tip of its legs
Amphipods	sp. 5	Fresh water scuds	Amphipoda	Reddish in color, has a pair of large claws followed by four pairs of small legs called swimmerts
Larvae	sp.10	Riffle beetle larvae	Coleoptera	Orange, with three pair of legs below the head
	sp.11	Caddisfly larvae	Trichoptera	Worm-like with three pairs of legs on the three 1st body segments and hooks on the last one
	sp.12	Cranefly larvae	Tipulidae	Light brown, rounded segmented body, has several finger-like lobes, no legs
	sp.17	Midgefly larvae	Diptera	Dark head, slightly curved,segmented, worm-like body
Fly	sp1	Stonefly	Plecoptera	Grayish green, has two long antenna and tails
	sp 6	Dobsonfly	Megaloptera	Color green and have long antenna, many veined forewing
	sp 7	Midgefly	Diptera	Yellow, with one pair of wing
	sp 8	Water spider	Arachnida	Brown like spider
	sp.9	Dragonfly	Ansioptera	Light brown, many veined wings, hind pair legs as large as front pair
	sp.13	Mayfly	Epheneroptera	Black , moth like, with two big eyes
	sp.14	Riffle beetles	Coleoptera	Beetle-like , tiny with one pair of antenna
	sp.15	Water bugs	Hemiptera	Black, small, with four pairs of legs
	sp.18	Blackfly	Simuliidae	Black, with antenna at the head

The chemical and microbiological analyses of the water sample are presented in Tables 6 and 7 respectively. Based on the microbiological analysis of water made in DOST CARAGA, the Badiangon spring has the heterotrophic plate count of <30 estimated cfu/ml .Its total coliform count and fecal coliform count is 2.0 MPN/100ml. Report on its chemical analysis showed that the ph value of water in Badiangon spring is 7.98. Its total hardness is 42 mg/l or 0.15 g/g while its total dissolved solids is 79 mg/l.

Discussion

Benthic invertebrates live in the water for all or most of their life, they stay in areas suitable for their survival, they differ in their tolerance to amount and types of pollution and they are one integrators of environmental condition. These indicate that these organisms are good indicators of water quality (http://www3.gov.ab.ca/env/water/SWQ/faqs04.cfm).

Inventory of benthic invertebrates species in three sampling spots revealed a total of 255 individuals in the three kick nets or 86 per kick net in 1 m x 1m area below the cobble substrate . This includes 9 species of fly, 7 species of snails, 4 species of larvae and 1 species of crab and 1 species of scuds.

The survey revealed that stonefly species is the most diverse in the three sampling spots. The

result also suggests that the stream is mostly inhabited by the different groups of flies. It is reported that several different types of stoneflies, mayflies, and caddisflies which indicates a healthy site are very well distributed in this area. This means that Badiangon spring still inhabits benthic organisms which represent a good stream site.

Table 1. List of benthic macroinvertebrates in three sampling spots.

Invertebrate Species		Common Name	Spot 1	Spot 2	Spot 3	Total	Mean
Snails	sp. 2	unidentified	19	10	19	48 2nd	16
	sp.3	unidentified	4	0	6	10	3
	sp.16	unidentified	0	0	8	8	3
	sp.19	Spike Tail Trumpet	0	2	0	2	1
	sp.20	unidentified	0	1	0	1	0.3
	sp.21	Zebra Nerite Snail	0	1	0	1	0.3
	sp.22	unidentified	0	3	0	3	1
Crab	sp. 4	Spider Crab	1	0	0	1	0.3
Amphipods	sp. 5	Fresh water scuds	12	0	3	15	5
Larvae	sp.10	Riffle beetle larvae	1	0	0	1	0.3
	sp.11	Caddisfly larvae	2	0	0	2	1
	sp.12	Cranefly larvae	2	0	0	2	1
	sp.17	Midgefly larvae	0	1	0	1	0.3
Fly	sp1	Stonefly	22	12	53	87 1st	29
	sp 6	Dobsonfly	15	8	6	29 3rd	10
	sp 7	Midgefly	0	0	1	1	.3
	sp 8	Water spider	8	4	0	12	4
	sp.9	Dragonfly	4	0	2	6	2
	sp.13	Mayfly	8	0	5	13	4
	sp.14	Riffle beetles	0	0	2	2	1
	sp.15	Water bugs	1	0	2	3	1
	sp.18	Blackfly	0	4	3	7	2
			99	46	110	255	86

Table 2. Relative density value of benthic invertebrates species.

Invertebrate Species		Common Name	Density (Number / kick net)	Relative Density %
Snails	sp. 2	unidentified	16 2nd	18.60
	sp.3	unidentified	3	3.49
	sp.16	unidentified	3	3.49
	sp.19	Spike Tail Trumpet	1	1.16
	sp.20	unidentified	0.3	0.35
	sp.21	Zebra Nerite Snail	0.3	0.35
	sp.22	unidentified	1	1.16
Crab	sp. 4	Spider Crab	0.3	0.35
Amphipods	sp. 5	Freshwater scuds	5	5.81
Larvae	sp.10	Riffle beetle larvae	0.3	0.35
	sp.11	Caddisfly larvae	1	1.16
	sp.12	Cranefly larvae	1	1.16
	sp.17	Midgefly larvae	0.3	0.35
Fly	sp1	Stonefly	29 1st	33.72
	sp 6	Dobsonfly	10 3rd	11.63
	sp 7	Midgefly	0.3	0.35
	sp 8	Water spider	4	4.65
	sp.9	Dragonfly	2	2.33
	sp.13	Mayfly	4	4.65
	sp.14	Riffle beetles	1	1.16
	sp.15	Water bugs	1	1.16
	sp.18	Blackfly	2	2.33
			86	100

It was found that spot 1 has 99 invertebrates, spot 2 has 46 and spot 3 has 110 resulting to a total number of about 255 invertebrates. In spots 1, 2 and 3, among all the invertebrates, stonefly has highest number of individuals of 87, followed by snail sp. 2 with a total of 48 and dobsonfly with 28.

Another measure of species diversity is by getting the density value through the formula density = to number of individuals / kick net. A number of 86 comprised the total density value of all the invertebrate species by adding up the density of the 14 taxon. The average density or number of individuals per kick net is 86, a very low value compared to other study that captured 700 specimens per kick net.

Table 3. Shannon –Wiener diversity index.

Invertebrate	Species	Common Name	Taxon	Number In each taxon	P 1 (M 1 / N)	P1 x (log 2 P1)
Snails	sp. 2	unidentified	Gastropoda	24.6	0.287	-0.517
	sp.3	unidentified				
	sp.16	unidentified				
	sp.19	Spike Tail Trumpet				
	sp.20	unidentified				
	sp.21	Zebra Nerite Snail				
	sp.22	unidentified				
Crab	sp. 4	Spider Crab	Decapoda	0.3	0.003	-0.025
Amphipods	sp. 5	Freshwater scuds	Amphipoda	5	0.058	-0.238
	sp.10	Riffle beetle larvae				
	sp 14	Riffle beetles	Coleoptera	1.3	0.015	-0.091
	sp.11	Caddisfly larvae	Trichoptera	1	0.012	-0.077
	sp.12	Cranefly larvae	Tipulidae	1	0.012	-0.077
	sp.17	Midgefly larvae	Diptera	0.6	0.007	-0.050
	sp 7	Midgefly				
Fly	sp1	Stonefly	Plecoptera	29	0.338	-0.529
	sp 6	Dobsonfly	Megaloptera	10	0.117	-0.362
	sp 8	Water spider	Arachnida	4	0.047	-0.207
	sp.9	Dragonfly	Ansioptera	2	0.023	-0.125
	sp.13	Mayfly	Epheneroptera	4	0.047	-0.207
	sp.15	Water bugs	Hemiptera	1	0.012	-0.077
	sp.18	Blackfly	Simuliidae	2	0.023	-0.125
TOTAL				86		2.707

Stonefly sp. 1 exhibited the highest density value of 29 and relative density of 33.72 %. This was followed by snail (sp.2) with 16 or 18.60 % then dobsonfly (sp.6) with 10 or 11.63%. The snails sp.20 and sp.21, crab sp.4, larvae sp.10 and sp.17 and midgefly sp.7 with 0.3 or 0.35 %, respectively, are the invertebrates which were found scarcely in the three sampling spots.

The Shannon - Weiner index value ranges from below 1. 5 (very polluted water) to around 4.0 (unpolluted water). In the study, the diversity value of benthos in this area has diversity value of 2.707. The result suggests in the mid value. Hence, there is a possibility that biodiversity may decline if natural and anthropogenic pressures will not be controlled. This value is comparable to the diversity index of Saskatchewan river which is 2.59.

Benthos are bottom - dwelling organisms and any substrate change or any toxic chemical

deposited in the bed of stream will affect its abundance. Analysis of the benthic organisms will reveal the long term check on the quality of water unlike chemistry test which are quick checkers.

Biotic water quality score were also determined by multiplying the number of individuals of each taxon and its biotic value. The biotic score is based on the tolerance of different benthic organisms to pollutants; some organisms are assigned high values and tolerant organisms are assigned low values. This suggests that invertebrates differ in their sensitivity to amount of pollution according to its biotic value.

Table 4. Biotic Water Quality Score (Source: Robert Bode, NYS DEC Nov. 1999).

Invertebrate Species		Common Name	Taxon	Number In each taxon A	Biotic Value B	Product (A x B / 10)
Snails	sp. 2	unidentified	Gastropoda	24.6	4	9.84
	sp.3	unidentified				
	sp.16	unidentified				
	sp.19	Spike Tail Trumpet				
	sp.20	unidentified				
	sp.21	Zebra Nerite Snail				
	sp.22	unidentified				
Crab	sp. 4	Spider Crab	Decapoda	0.3	6	0.18
Amphipods	sp. 5	Freshwater scuds	Amphipoda	5	6	3
	sp.10	Riffle beetle larvae				
	sp 14	Riffle beetles	Coleoptera	1.3	10	1.3
	sp.11	Caddisfly larvae	Trichoptera	1	10	1
	sp.12	Cranefly larvae	Tipulidae	1	8	0.8
	sp.17	Midgefly larvae	Diptera	0.6	5	0.3
	sp 7	Midgefly				
Fly	sp1	Stonefly	Plecoptera	29	10	29
	sp 6	Dobsonfly	Megaloptera	10	10	10
	sp 8	Water spider	Arachnida	4	2	0.8
	sp.9	Dragonfly	Ansioptera	2	6	1.2
	sp.13	Mayfly	Epheneroptera	4	10	4
	sp.15	Water bugs	Hemiptera	1	2	0.2
	sp.18	Blackfly	Simuliidae	2	6	1.2
				86		62.82

80-100 non-impacted (excellent water quality)
60-80 slightly impacted (good water quality)
40-60 moderately impacted (fair water quality)
0-40 Severely impacted (poor water quality.

The computed average value of a collected sample yields the benthic water quality score.Taxon Plecoptera (stonefly) got the highest biotic water quality score of 29. Followed by Megaloptera (dobsonfly) with 10 and Gastropoda (snail sp.19). with 9.48. Among the 14 taxa, there are 5 species that exhibit a biotic value of 10. This means that about 36 % of benthic species are ecologically important in determining good water quality. The total biotic water quality score of benthic invertebrates is 62.82. This indicates

a good water quality or slightly impacted area as based on the score guide of Robert Bode, (NYS DEC Nov. 1999). This means that the spring water does not have so many pollutants. Another index to determine the water quality is by using the Beck Biotic index which classifies the status of species into three, namely; Class 1 – sensitive or intolerant of pollution, Class 2 – facultative or tolerate varied conditions and Class 3 – pollution tolerant. There are 8 taxa, 5 taxa and 2 taxa in class 1, 2 and 3 respectively. This shows that there are many benthic invertebrates which are sensitive to pollution that thrive in the areas sampled. The Beck Biotic index is 21 which indicates clean but limited habitat quality.

Table 5. Beck Biotic Index (Pollock, 2000).

GROUP 1 TAXA	TAXA PRESENT	GROUP 2 TAXA	TAXA PRESENT	GROUP 3 TAXA	TAXA PRESENT
Mayfly (Epheneroptera)	4	Dragonfly (Ansioptera)	2	Blackfly (Simuliidae)	2
Stonefly (Plecoptera)	29	Cranefly (Tripulidae)	1	Midgefly (Diptera)	0.6
Dobsonfly (Megaloptera)	10	Scuds (Amphipoda)	5	Nematoda	0
Caddisfly larvae (Trichoptera)	1	Crab (Decapoda)	0.3	Leeches	0
Riffle beetle (Coleoptera)	1.3	Water spider (Arachnida)	4		
Snails (Gastropoda)	24.6	Damselfly (zygoptera nymphs)	0		
Caddisfly Nymph	1	Crayfish	0		
Water bugs (Hemiptera)	1	Clams	0		
No. of Taxa	8		5		
Beck Index = 21					

BI = Beck Index

BI = 2n1 + n2 [2 (8) + 5] = 21

n1 = number of class 1 genera identified, n2 = number of class 2 genera identified.

However, microbiological analysis of water made in DOST CARAGA,showed the Badiangon spring has the heterotrophic plate count of <30 estimated cfu/ml, this means that the water has fungi present but in a very low value. Its total coliform count and fecal coliform count is 2.0 MPN/100ml which are both above the standard value of 0-1TC/100ml.

The EPA maximum contamination level (MCL) for drinking water should be 0 or (no count) TC per 100 ml while 1 TC per 100 ml for fecal coliform count. This means that there are bacteria and ecal contamination in spring water. This is probably because the stream is within the residential area. No proper septic tanks for their toilets were observed.

Beck Index	Water Quality Assessment
0-10	Grossly Polluted
11-20	Moderately Polluted
21-30	Clean but limited habitat quality
30 or higher	Clean

Report on its chemical analysis showed that the ph value of water in Badiangon spring is 7.98, lies in the normal range values for a freshwater ecosystem. Its total hardness is 42 mg/l or 0.15 g/g, this value belongs to the soft water containing low level of dissolved calcium(Ca), magnesium(Mg) and other minerals.

Total dissolved solids of Badiangon water has 79 mg/l , this is less than the standard value which is 500 mg/l based on the Secondary Drinking Water Standard. Badiangon spring water has a very less amount of contaminants.

Conclusion

Inventory of benthic invertebrates species in three sampling spots revealed a total of 255 individuals in the three kick nets or 86 per kick net in 1 m x 1m area below the cobble substrate . This includes 9 species of fly, 7 species of snails, 4 species of larvae and 1 species of crab and scuds.

The survey revealed that stonefly species is the most diverse in the three sampling spots. The result also suggests that the stream is mostly inhabited by the different groups of flies which are indicators of healthy stream site. The most species rich benthos is the stonefly (sp 1) with the highest density value of 29 or 33.72 %. This was followed by snail (sp 2) with 16 or 18.60 % then Dobson fly (sp 6) with 10 or 11.63%. No worms and leeches were found that present a very polluted area.

The Shannon - Weiner index value ranges from below 1. 5 (very polluted water) to around 4.0 (unpolluted water). In the study, the diversity value of benthos in this area has a diversity value of 2.707. The result suggests in the mid value. Biodiversity value of benthic invertebrates falls on the average range which may possibly decline and affects water quality in the future.

The total biotic water quality score of benthic invertebrates is 62.82. This indicates a good water quality or slightly impacted area. Among the 14 taxa, there are 5 species that exhibit a biotic value of 10. This means that about 36 % of benthic species found in Badiangon spring are ecologically important in determining good water quality.

The same result obtained using the Beck Biotic index. The BI value is 21 which indicates clean but limited habitat quality. This denotes that the spring water has less chemical pollutants. However, microbiological analysis showed that there are fungi, bacteria and fecal contamination in the spring water. These pathogens may came from various trashes including human waste from the residentials and other run-offs from the municipals.

Therefore, it is recommended that the water should be subjected to boiling and other purification methods for safety especially the residents and nearby barangays are using it for drinking and other household purposes.

Report on its chemical analysis showed that the ph value, total hardness and total dissolved solids of Badiangon spring water are within the normal range. However, increasing amount of trash and high sedimentation are already observable since the people in Gingoog City go to Badiangon for a dip, swimming and relaxation. Nevertheless, human intervention and other anthropogenic pressures are inevitable. Therefore, protection and conservation of stream water should be implemented on the site to maintain the good water quality status of the Badiangon spring.

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