Biological index of Benthic insects in Pilan River, Santa Cruz, Davao del Sur

[1]Katleya Abiog*, [1]Jaireh Baclayon, [1]Regine Viracis, [1]Xavier S. Fuentes
[1]Deparment of Teacher Education, UM Digos, Philippines
**Corresponding author:* katleyaabiog@gmail.com

ABSTRACT

This study aimed to identify the different benthic insects that are present In Pilan River Sta. Cruz, Davao del Sur. Benthic insects are said to be organisms that do not have backbones but are considered as indicator species of water quality on their habitat. In conducting the research, qualitative and quantitative approaches were employed in discriminating and describing the samples. There were total of 263 individuals under 11 taxa in the upstream and 439 individuals under 8 taxa in the downstream of Pilan River wherein the physical and chemical parameters were also taken for observation. Specimens were cleared and examined to identify their family and morphological features as well as the pollution tolerance index they indicate. The research results showed the water quality status of the upstream and downstream of the river is on its very good condition. The research also found the diversity and abundance of insects on the habitat and also the factors that affect the species assemblage's variations on the river.

Keywords: biological index, Benthic insects, Pilan River, Sta. Cruz

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INTRODUCTION

The type of quality a water habitat possesses is determined by the organisms that live beneath or over it. Benthic macroinvertebrates are considered to be one of the tools used to assess water quality of a riparian system. Through a bio monitoring process aided by these benthic organisms, the context of a certain water habitat can be recognized (Resh & Rosenberg, 1993).

The biological communities that are found in aquatic ecosystems are constantly used by the US government and other environmental agencies to check the status of the different water forms found in their localities. As they live in the water undergoing the stages of their life cycles, they show a complete evidence of both short and long-term water condition on the environmental settings they belong (Society for Freshwater Science, n.d.). The Department of Environment and Natural Resources, Department Administrative Order 34, series of 1990 used benthic insects as one of the parameters to evaluate the water quality of a water body in the Philippines.

However, there are no recorded researches on the benthic insect diversity in Pilan River which is one of the major rivers in Santa Cruz, Davao del Sur. The filling in of knowledge gap in the scientific community in understanding the biodiversity of benthic insects in Pilan River, Santa Cruz, Davao del Sur is deemed a priority. Specifically, this study aimed to ascertain the biological and biodiversity index of benthic insects. The data gathered from this study served as a basis of information for future researches on benthic insects and water quality in Pilan River.

This study aimed to identify the benthic insect's assemblages that are indicators of water quality in Pilan, River Santa Cruz, Davao del Sur. Specifically, this study described the physicochemical profile of Pilan River in terms of substrate, Ph, temperature, salinity, and dissolved oxygen. Moreover, the biological profile of the river was assessed in terms of pollution tolerant index. The biodiversity index of the river was intended to be revealed in this study in terms of richness, evenness, Shannon index and Simpson indices. On the other hand, this study aimed to explore the differences in species diversity between sampling sites and the possible factors that could explain the species diversity between the sampling sites.

METHOD

This study is descriptive research in type with field observation and laboratory analysis and identification as its core methods. As stated by the Office of Human Research Protections, a descriptive study is not experimental. It implies that there is no change in the studying site provided that there is an observation between the relationships of things around its environment. This includes the physicochemical parameters relating to the population of the benthic insects at the specific sites of Pilan River. Glass and Hopkins (1984) stated that in a descriptive study, data gathering should describe, organize, tabulate, and depict the data collection. Hence, this research is an observational study without interaction of the population and uses the data collection method in describing the sampling sites and the existence of indicator macroinvertebrate species.

Plate 1. *Map of the Sampling Sites*

The subject of this study were benthic insect assemblages in Pilan River, Santa Cruz, Davao del Sur. The diversity of species groups was measured by biodiversity indices and the pollution rate of species were measured by using a biological index. Some physicochemical parameters were also determined and used as a basis in the analysis of the research results.

This study underwent a site selection at Pilan River. The researchers identified two sampling sites located at Barangay Napon. Both selected sites were located at the downstream portion of the main river body. Both sites have different description regarding its physical attributes with the environment. The researchers conducted field observations with the stream organisms in the upper and lower sites. The pollution tolerance of organisms was measured using the Pollution Tolerance Index by the Biological Monitoring Data Sheet. The organisms were collected and identified by comparing its structure to specific charts and keys. However, to distinguish the best quality of the stream of Pilan River, chemical tests were conducted.

The researchers conducted a sampling site selection to ensure the sampling location prior to the approval of the Brgy. Officials and Municipal Mayor. Thus, the researchers have chosen two sites located at downstream portion of the riparian system of Pilan (Plate 1). The upper site has the coordinates of 125°23'35.93"E, 6°50'22.54"N and the lower site has the coordinates of 125°24'4.91"E, 6°50'19.80"N. The study happened during the last week of the month of May.

Specimen Collection
Two methods were used during sampling. One was by hand picking the specimens on the substrates and the other by using a sieve. Rocks, leaves, twigs and other possible substrate were examined and organisms that were found were picked using tweezers and soft tip brushes. Sieve was used to filter water on the middle portion and from both sides and of the sampling site.

Preservation
Specimens collected were preserved using a Pampel's solution. This preservative was prepared by mixing 30 parts of distilled water, 15 parts 95% ethyl alcohol, 6 parts of 40% formaldehyde and 4 parts of glacial acetic acid. Collected organisms were placed in a bottle container with this media.

Mounting
The specimens were placed in glass slides and mounted with water. It was then observed under the microscope and some pictures of the species were taken.

Identification and Naming of Species
Species identification of field samples was done using the taxonomic key of macroinvertebrates in the river. Each physical characteristics were identified

under a microscope and were recorded. Each species was classified up to the family level.

Frequency of Collected Samples on each Sampling
Site Field collected specimens were grouped and counted according to the location where it was found. Each species from Site 1 was separated from species collected in Site 2 samples and were then recorded.

Identification of Species according to its Pollution Tolerance Category
The sample specimens from the two different sites were identified and clustered according to their pollution tolerance. Organisms were also classified according to the same pollution tolerance category.

Benthic macroinvertebrates are very sensitive to biotic and abiotic factors affecting their environment. Macroinvertebrate faunas are distributed in determining the physical structure of the substrate and nutrients, the degree of constancy and the oxygen level in a certain water body (Sharma, Sudha, & Dave, 2013)

Category 1- Very Intolerant of Pollution.
This category consists of a group of insects needing dominant clean water. The water habitat must have high dissolved oxygen, has neutral pH and is cold flowing (Chadde,n.d). These insects include family of Plecoptera (stonefly), family of Megaloptera (dobsonfly), family of Diptera Athericidae (snipe fly), species that belong to family Ephemeroptera (mayfly), Trichoptera (caddiesfly) and even Argyroneta Aquatica (water spider) (Perckarsky, 1990).

Category 2-Moderately Intolerant of Pollution.
Organisms that belong to this category live in moderate polluted waters and have sensitivity on an increase in pollution. Insects that belong to this are species found in the families of Ephemeroptera (mayfly), Trichoptera (caddiesfly), Coleoptera (beetle larvae), Odonata (dragonfly and damselfly) and those Diptera Tipulidae (cranefly) (Perckarsky, 1990).

Category 3-Fairly Intolerant of Pollution
These are macroinvertebrates that are dominant in fairly polluted waters. They are the Diptera Simuliidae (black fly larvae), Diptera-Chironomidae (midges) and Isopoda-Asellidae (sowbugs/pillbugs).

These species are typically found in stream riffles, ponds and areas of some shallow lakes (Perckarsky, 1990).

Category 4-Very Tolerant of Pollution
Those aquatic biotas that have intense pollution, lowest or highest pH, warmer water and low oxygen (Chadde, nd). The species that are dominant in this much polluted habitat are Tubuficid Oligochaetes and red Chironomid Diptesran larvae. Oligochaeta or aquatic worms and Tubifex worms are found in rich organic matter substrate. Leeches (Hirudimea) are generally pollution tolerant (Pennak, 1989). Gastropoda snails can also be found in polluted water because they have lungs that allow less oxygen or no oxygen at all (Pennak, 1989).

Biological Index Computation
The frequency of the samples being counted according to the site where it came from and the classification of pollution tolerance where it belonged were used to compute the pollution tolerance index through the Biological Monitoring Data Sheet.

The macroinvertebrate index was divided into four PT Group or Pollution Tolerance Group. PT Groups 1,2,3 and 4. The PT groups represent the different levels of pollution tolerance. The higher the species group number, the higher the pollution tolerance level.

Insects that have the same body shape belonged to the same taxa. To find the total number of taxa for each PT Group, add the number of types of organisms and if the species is not available, put zero. Next, multiply each number of taxa by its weighing factor. Lastly, total all the group scores to get the Pollution Tolerance Index Rating (Hoosier Riverwatch of the Indiana Department of Environmental Management Watershed Planning and Assessment Branch, n.d.).

Biodiversity Index Computation
The frequency of the insects from both sampling sites were used to compute evenness and richness on each location with the use of Paleontological Statistics (PaST). As stated by Hammer, Harper & Ryan (2001), this software is constructed for comprehensive and convenient execution of standard numerical analysis and operation used for quantitative purposes. This integrates spreadsheets-type data entry with univariate and multivariate statistics, curve fitting, sign-series analysis, data plotting and simple phylogenetic analysis.

Interpretation of Biological Index Results

The results taken from the Biological Monitoring Data Sheet were interpreted. The interpretation described the water quality through the benthic insects' assemblages. The specimens were totaled according to the pollution tolerance category they belong. The final index values for each group was added and the result determined the pollution tolerance rating (Table 7, Appendix B).

Interpretation on Biodiversity Index Results

Results from PaST were interpreted to determine how dominant and even the assemblages of insects on the two chosen locations. In Shannon Index, a value near 0 would be an indicator that the species in each site were the same. A value near 4.6 indicated that individuals were evenly distributed among all the species. As the Shannon Index increases, both the richness and the evenness of the community increases (Kerkhoff, 2010). Simpson's Diversity Index (D) measured the probability that two individuals randomly selected from a sample would belong to the same species. In this index, 0 represents an infinite diversity and 1 with no diversity at all. The bigger the value of D, the lower the diversity (Country Side Information, n.d.).

Ecologists and naturalist found out that there is a diverse population of species of plants and animals. Thus, this has drawn to the formulation of a new idea regarding diversity that describes and compares some differences among the community through three basic components. The alpha, beta and gamma diversities. The alpha (α) diversity is the local variety of some forest, grassland and streams. On the other hand, the gamma (γ) diversity is the total regional diversity area that contains the communities. Lastly, the beta (β) diversity is the measure of differences among the community samples in an area. However, as stipulated by (Whittaker, 1972), beta diversity links the alpha and the gamma diversity. (Krebs C. J., 1817).

Consequently, due to the fast evolution of ecological ideas, the species diversity became clear that there are two distinct concepts that evolved in this matter. Using biological indicators as water quality determinant, numerous indices for diversity help quantify the distribution of benthic organisms in connection with their habitat quality. Diversity index is the basic idea of obtaining quantitative estimate of biological variability to compare biological entities that are composed of discrete components in space or time (Heip, Herman, & Soetaert, 1998). Diversity indices are mathematical functions that conflate to the number of species (Richness) and homogeneity abundance (Evenness). These are the following indices to be used in this study.

Species Richness was coined by McIntosh in 1967 referring to the count of individuals/species in a localized area. Species Evenness, on the other hand, was first suggested by Lloyd and Ghelardi (1964) and measures the quantity of an unequal representation against a hypothetical community which suggests that species are all commonly equal.

Another way to measure diversity was proposed by Simpson, E.H (Simpson, 1949). He suggested that diversity is inversely related to the probability in which two individuals which are sampled randomly representing the same species and called it Simpson Diversity Index. It has the formula of

$$D = \sum \frac{N(n-1)}{N(n-1)}$$

D: Simpson Diversity Index
N: Total number of individuals

Shannon-Wiener diversity index is characterized by the species diversity in its community. Like the Simpson Diversity Index, this also accounts the abundance and evenness of the species present in the ecological system. The formula for it is

$$\mathrm{H} = -\sum_{i=1}^{n} \mathrm{Pi} \log \mathrm{Pi}$$

H': Shannon Diversity Index
N: Total number of individua

RESULTS AND DISCUSSION

Physicochemical Parameters of Pilan River

In the upstream, the substrate consisted of sand and mud, water floor with large rocks while the downstream have substrate large builders and the water current is fast. The pH in the upstream was 8.23 while the downstream was 9.95 which was high in alkalinity and the downstream exceeded the normal pH value for freshwater biotas. The upstream has 23.67 °C and the downstream had 24.5°C which meant that the upstream had a cold and moist environment compared to the downstream site. Salinity in the upstream was 0.10 ppt while the downstream salinity was not detected upon the analysis. The dissolved oxygen was greater in the upstream having 8.7 mg/l while the downstream had about 8.0 mg/l of dissolved oxygen.

Table 3. *Physicochemical Profile of Pilan River*

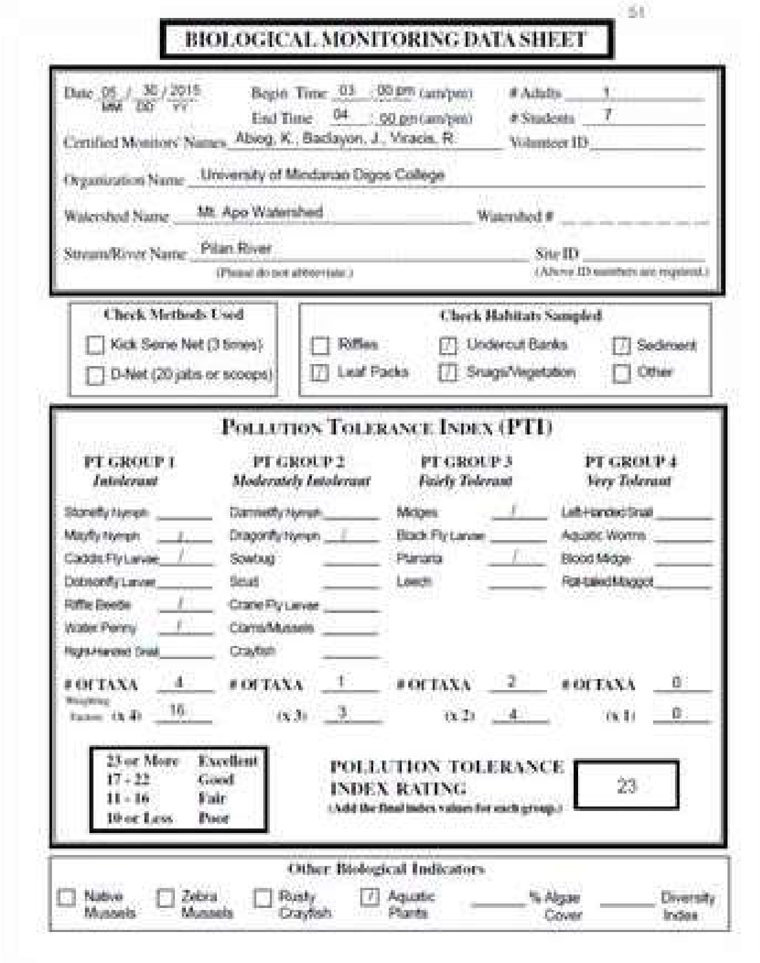
Sampling Sites	**Temperature**	**Salinity**	**Dissolved Oxygen**	**pH**
Upstream	23.67°C	0.10 ppt	8.7 mg/L	8.23
Downstream	24.5°C	nd	8.0 mg/L	9.95

Biological Profile of Pilan River

A total of number of 702 individuals that belonged to 9 families under 8 taxa were identified from the two sampling sites of Pilan River (Table 2). They were classified according to the pollution tolerance group they belonged to and were tabulated by the use of Pollution Tolerance Data Sheet.

The upper stream comprised of various orders like Ephemeroptera, Odonata, Trichoptera, Diptera, Coleoptera, Lepidoptera and also included class Gastropoda and Tubellaria. The lower stream has the least number of orders like Ephemeroptera, Odonata, Trichoptera, Coleoptera, class Gastropoda and Tubellaria. The upper portion of the stream has four taxa that were intolerant to pollution, which included mayfly nymph (Ephemeroptera), caddis fly larvae (Trichoptera), riffle beetle and water penny which belonged to order Coleoptera. The lower part has three taxa that were intolerant to pollution, such as Ephemeroptera, Trichoptera and Coleoptera. Order Ephemeroptera and Trichoptera exhibited good biotas as they are an indicator species of a polluted sensitive environment (Resh & Rosenberg, 1993). The dragonfly nymph (Odonata) was the only benthos that displayed a moderate tolerance to pollution in both of the sampling sites. The dragonfly nymphs have respiratory demands and needed vast amounts of oxygen (Key to Aquatic Macroinvertebrates, 2002). Midges, which belonged to order Diptera were present in the upper stream only and planarias (Tubellaria) were visible on both of the sites and belong to a fairly tolerant group. Planarias were present when there are large amounts of organic waste matter and midges were capable of adjusting their bodies to a type of aquatic system that contained low levels of dissolved oxygen (Bouchard, 2004).

The upstream has a total of 8 orders, whereas the downstream has 6 orders. Each taxa was classified according to the group of pollution tolerance they displayed. The total number of taxa per group was multiplied on the given weighting factor and summed up to get the Pollution Tolerance Rating. Upstream (Figure 2) has 23 on its Pollution Tolerance Rating and belonged to the range of 23-more in which the water quality was excellent. The downstream (Figure 3) has a lower Pollution Tolerance Rating which was only 17 and fitted into the range of 17-22 which indicated that the water was in good condition.



51

BIOLOGICAL MONITORING DATA SHEET

Date 05 / 30 / 2015 (MM DD YY) Begin Time 03 : 00 pm (am/pm) # Adults 1
End Time 04 : 50 pm (am/pm) # Students 7
Certified Monitors' Names Abiog, K., Badayon, J., Viracis, R. Volunteer ID
Organization Name University of Mindanao Digos College
Watershed Name Mt. Apo Watershed Watershed #
Stream/River Name Pilan River Site ID
(Please do not abbreviate.) (Above ID numbers are required.)

Check Methods Used
☐ Kick Seine Net (3 times)
☐ D-Net (20 jabs or scoops)

Check Habitats Sampled
☐ Riffles ☑ Undercut Banks ☑ Sediment
☑ Leaf Packs ☑ Snags/Vegetation ☐ Other

POLLUTION TOLERANCE INDEX (PTI)

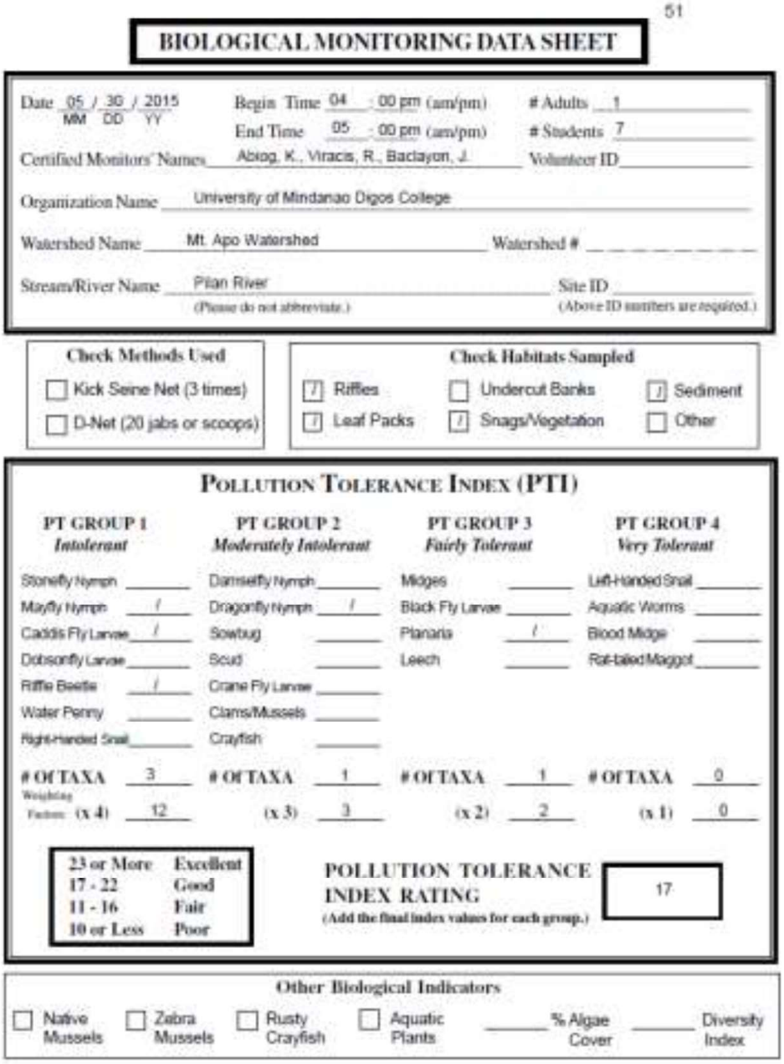
PT GROUP 1 *Intolerant*		PT GROUP 2 *Moderately Intolerant*		PT GROUP 3 *Fairly Tolerant*		PT GROUP 4 *Very Tolerant*	
Stonefly Nymph		Damselfly Nymph		Midges	/	Left-Handed Snail	
Mayfly Nymph	/	Dragonfly Nymph	/	Black Fly Larvae		Aquatic Worms	
Caddis Fly Larvae	/	Sowbug		Planaria	/	Blood Midge	
Dobsonfly Larvae		Scud		Leech		Rat-tailed Maggot	
Riffle Beetle	/	Crane Fly Larvae					
Water Penny	/	Clams/Mussels					
Right-Handed Snail		Crayfish					
# OF TAXA	4	# OF TAXA	1	# OF TAXA	2	# OF TAXA	0
Weighting Factors (x 4)	16	(x 3)	3	(x 2)	4	(x 1)	0

23 or More	Excellent
17 - 22	Good
11 - 16	Fair
10 or Less	Poor

POLLUTION TOLERANCE INDEX RATING (Add the final index values for each group.) 23

Other Biological Indicators
☐ Native Mussels ☐ Zebra Mussels ☐ Rusty Crayfish ☑ Aquatic Plants ___ % Algae Cover ___ Diversity Index

Figure 1. Pollution Tolerance Index of the upstream in Pilan River



51

BIOLOGICAL MONITORING DATA SHEET

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Check Habitats Sampled
☑ Riffles ☐ Undercut Banks ☑ Sediment
☑ Leaf Packs ☑ Snags/Vegetation ☐ Other

POLLUTION TOLERANCE INDEX (PTI)

PT GROUP 1 *Intolerant*		PT GROUP 2 *Moderately Intolerant*		PT GROUP 3 *Fairly Tolerant*		PT GROUP 4 *Very Tolerant*	
Stonefly Nymph		Damselfly Nymph		Midges		Left-Handed Snail	
Mayfly Nymph	/	Dragonfly Nymph	/	Black Fly Larvae		Aquatic Worms	
Caddis Fly Larvae	/	Sowbug		Planaria	/	Blood Midge	
Dobsonfly Larvae		Scud		Leech		Rat-tailed Maggot	
Riffle Beetle	/	Crane Fly Larvae					
Water Penny		Clams/Mussels					
Right-Handed Snail		Crayfish					
# Of TAXA	3	# Of TAXA	1	# Of TAXA	1	# Of TAXA	0
Weighting Factors (x 4)	12	(x 3)	3	(x 2)	2	(x 1)	0

23 or More	Excellent
17 - 22	Good
11 - 16	Fair
10 or Less	Poor

POLLUTION TOLERANCE INDEX RATING 17
(Add the final index values for each group.)

Other Biological Indicators
☐ Native Mussels ☐ Zebra Mussels ☐ Rusty Crayfish ☐ Aquatic Plants ____ % Algae Cover ____ Diversity Index

Figure 2.Pollution Tolerance Index of downstream in Pilan River

Biodiversity Index of Pilan River

The entire population representing nine families of five specific orders and two classes were classified by Table 3 and Table 4. The dominant species on both of the sampling sites belonged to Order Ephemeroptera. The mayflies comprised 55.51% (Graph 1) of the entire population in the upper sampling site and 79.7% (Graph 2) in the lower sampling site. The least individuals came from the order Lepidoptera in the upstream which made up the population of 1.14% (Graph 1). In the lower stream, the lowest population was from order Odonata which was only 0.23% (Graph 2).

Order Ephemeroptera with the family of Heptaginiidae had 96 individuals which were only 36.5% of the entire upstream population and have 270 individuals comprising 62% of the downstream population respectively. They were scrapers and commonly found in slow or fast flowing water where they live in rock surfaces and thick vegetation (Bouchard, 2004). Family of Siphlonuridae was also dominant in both of the sampling sites. However, it was only 19% (50 individuals) in the upstream and 17.7% (77 individuals) in the downstream. It was commonly found in vegetation along river sides and belonged to the feeding group of gatherers (Bouchard, 2004).

Table 2. *Macroinvertebrates classification by family in Pilan River, Santa Cruz, Davao del Sur*

<table>
<tr><th>Species</th><th>Picture</th><th>Description</th><th>Site</th><th>Count</th></tr>
<tr><td rowspan="2">Order: Ephemeroptera Family: Heptaginiidae</td><td></td><td rowspan="2">The width of the head is 2x less than the antennae. There is presence of gills and the gills are oval in shape. There is a long setae in the caudal filament (Bouchard, 2004).</td><td>Upper</td><td>96</td></tr>
<tr><td></td><td>Lower</td><td>273</td></tr>
</table>

Order: Ephemeroptera Family: Siphlonuridae		The width of the head is 2x less than the antennae. There is presence of gills and the gills are oval in shape. There is a long setae in the caudal filament (Bouchard, 2004).	Upper Lower	50
			Lower	77

Order Coleoptera was the second most dominant species in upstream with 31 individuals (11.78%) but only had 14 individuals (3.19%) in downstream. The entire population of water beetles consisted of family Hydrophilodae, Elmidae and Psephenidae. Water scavenger beetles or Hydrophilodae were mostly found in stream backwaters with vegetation (Merritt & Cummins, 1996). Elmidae or commonly known as riffle beetle lived in a cool environment with well oxygenated water as well as the water pennies or Psephenidae that lived in rocks and debris of woods (Merritt & Cummins, 1996).

Species	Picture	Description	Site	Count
Order: Coleoptera Family: Hydrophilodae		They are hard bodied with short antennae possessing pectinate club.The hind coxa is not extending posterly dividing the first abdomenal segment into two sections (Bouchard, 2004).	Upper	8
			Lower	9

Order: Coleoptera Family: Elmidae		The adults have hard bodies with antennae slender or clubbed, elytra that have rows of indentions and longer legs than the body (Bouchard, 2004).	Upper	22
			Lower	5
Order: Coleoptera Family: Psephenidae		The body is flattened in which the abdominal segments and even the throracic part are expanded. The head and legs are obscured from above wherein the legs are segmented compose of single claws. (Bouchard, 2004).	Upper	1
			Lower	0

Order Trichoptera had 30 individuals which were 11.40% in upstream population and 27 individuals which were 6.15% of the downstream population. Only the family of Polycentropodidae were being classified from both of the sampling sites. Polycentropodidae made silk nets and are called clingers (Keller & Krieger, 2009). They lived in warmer water making their silken nets (Bouchard, 2004).

<table>
<tr><th>Species</th><th>Picture</th><th>Description</th><th>Site</th><th>Count</th></tr>
<tr><td rowspan="2">Order: Trichoptera
Family:Polycentropodidae</td><td></td><td rowspan="2">The labrum is rounded and even sclerotized. The pronotum is scleraotized and the metanotum and mesonotum are membranous. At apex, the trochantin is being pointed and there is no sclerotized plate on the abdominal segment, gills in the abdomen are also absent (Bouchard, 2004).</td><td>Upper</td><td>30</td></tr>
<tr><td></td><td>Lower</td><td>27</td></tr>
</table>

Dragonflies or Order Odonata with the family of Gomphidae were much visible in the upper and lower stream. There counts were not as large like any species. They were only 2.66% (frequency of 7) in the upstream and only 0.23% (1 individual) downstream. Gomphidae were burrowers that lived in sands on the edges of the streams (Bouchard, 2004).

<table>
<tr><th>Species</th><th>Picture</th><th>Description</th><th>Site</th><th>Count</th></tr>
<tr><td rowspan="2">Order: Odonata
Family: Gomphidae</td><td></td><td rowspan="2">The palpal lobes and prementum are flattened not forming scoop shape, have four segments of antenna and the third antennal segment is larger than the others that are cylindrical or oval shape. The fourth antennal segment is very small and the body shape is from long to broad and flattened one. They are large and measures up to 30-45 mm (Bouchard, 2004).</td><td>Upper</td><td>7</td></tr>
<tr><td></td><td>Lower</td><td>1</td></tr>
</table>

Order Diptera was only noticeable in the upstream as well as order Lepidoptera. Diptera (Chironomidae) was 3.80% and made up of 10 counts of individuals and Lepidoptera of the family Pyralidae was 1.14% or 3 counts of individuals of the entire population making up the upstream of the river. They dwelled in the sands and snags of large streams (Bouchard, 2004).

<table>
<tr><th>Species</th><th>Picture</th><th>Description</th><th>Site</th><th>Count</th></tr>
<tr><td rowspan="2">Order: Diptera Family: Chironomidae</td><td></td><td rowspan="2">The head is sclerotized, round in shape and the head is separated from the thorax. The body is elongated and looks like worm. The mandibles are moving against each other with two prolegs with hooks that are ventral to the body (Bouchard, 2004).</td><td>Upper</td><td>10</td></tr>
<tr><td></td><td>Lower</td><td>0</td></tr>
<tr><td rowspan="3">Order: Lepidoptera Family: Pyralidae</td><td></td><td rowspan="3">They look like land caterpillars which have elongated lateral gills, head capsule that is sclerotized, pairs of three segmented legs and abdomen with protuberances ending with hooks (Bouchard, 2004).</td><td rowspan="2">Upper</td><td rowspan="2">3</td></tr>
<tr><td></td></tr>
<tr><td></td><td>Lower</td><td>0</td></tr>
</table>

Class Gastropoda and Tubellaria also existed. Gastropoda was 6.46% (17 individuals) upstream and 9.34% (41 individuals) downstream. Tubellaria had 19 individuals upstream (7.22%) and 6 individuals (1.37%) downstream.

Species	Picture	Description	Site	Count
Class: Tubellaria		The body is dorsally flattened consisting of two eyespots and head shaped like an arrow (West Virginia Department of Environment Protection, n.d.).	Upper	19
			Lower	6
Class: Gastropoda		The shell is in flat cone or in doomed shape with no operculum (Bouchard, 2004).	Upper Lower	13 23
		Single shell and usually coiled (Bouchard, 2004).	Upper Lower	1 6
		The shell is brown in color and rounded. It is lighter than mussel and separated by ridges (Bouchard, 2004).	Upper Lower	3 12

Table 3. *Macroinvertebrate's composition and abundance in the upstream of Pilan River, Santa Cruz, Davao del Sur*

Insect (Order/Class)	Total Frequency of Species
Ephemeroptera (Mayfly)	7
Trichoptera (Caddisfly)	146
Coleoptera (Aquatic Beetles)	30
Diptera (Chironomids)	31
Lepidoptera (Aquatic Moths)	10
Gastropoda (Snails)	3
Tubellaria (Planaria)	17
Total Population:	19

Table 4. *Macroinvertebrate's composition and abundance in the downstream of Pilan River, Santa Cruz, Davao del Sur*

Insect (Order/Class)	Total Frequency of Species
Odonata (Dragonfly)	1
Ephemeroptera (Mayfly)	350
Trichoptera (Caddisfly)	27
Coleoptera (AquaticBeetles)	14
Gastropoda (Snails)	41
Tubellaria (Planaria)	6
Total Population:	439

Comparison of Diversity Indices

Using the Paleontological Statistics, the diversity indices both of the sampling sites were measured (Table 5). The different measurements were computed and recorded. Figure 4 shows the taxa richness, Figure 5 indicates the evenness of the species distribution, Figure 6 shows the result of Shannon Index and Figure 7 presents the Simpson Index of both the sampling sites in Pilan River.

Table 5. *Paleontological Statistics results in diversity indices in upstream and downstream of Pilan River*

	Upper	Lower	Upper	Lower	Upper	Lower
Taxa_S	11	11	11	8	8	8
Individuals	263	263	263	439	439	439
Dominance_D	0.202	0.1752	0.2391	0.4307	0.3857	0.4782
Simpson_1-D	0.798	0.7609	0.8248	0.5693	0.5217	0.6143

Table 5. *Paleontological Statistics results in diversity indices in upstream and downstream of Pilan River (cont)*

	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Shannon_H	1.905	1.784	1.995	1.197	1.098	1.291
Evenness_eH/S	0.6108	0.5411	0.6684	0.4137	0.3747	0.1256
Brillouin	1.826	1.708	1.914	1.163	1.066	1.348
Menhinick	0.6783	0.6783	0.6783	0.3818	0.3818	0.3818
Margalef	1.795	1.795	1.795	1.15	1.15	1.15
Equitability_J	0.7944	0.7439	0.832	0.5756	0.5279	0.621
Fisher_Alpha	2.321	2.321	2.321	1.389	1.389	1.389
Berger_Parker	0.365	0.308	0.4221	0.6219	0.574	0.6651
Chao-1	11	11	12	8	8	8.5

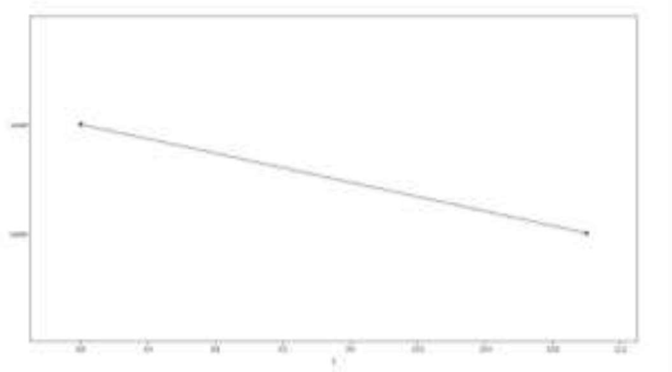

Figure 3.Taxa Richness of the upstream and downstream in Pilan River

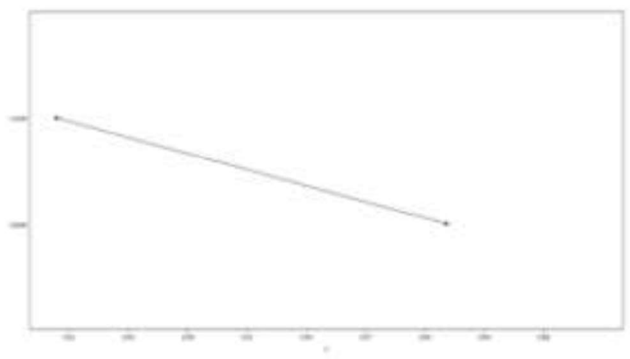

Figure 4.Evenness of the upstream and downstream in Pilan River

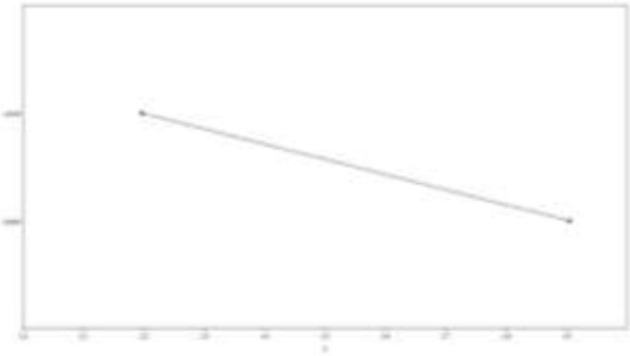

Figure 5.Shannon Index in upstream and downstream in Pilan River

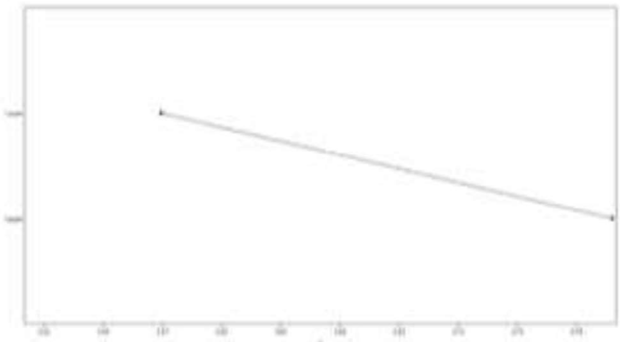

Figure 6.Simpson Index in upstream and downstream in Pilan River

Upon the result of the computation, the upstream sampling site is the most diverse and even on species distribution as it is primarily constituted with thick vegetation and is undisturbed from any activities of humans. The upper sampling site is rich with 11 species resulting an index of evenness of 0.61 that comprised only 37.46% of the entire population. It is dominated with the order of Ephemeroptera having 55.51% of the whole community. Regarding the other sampling site, it only has 8 species with a low evenness index of 0.41 but has the largest contribution into the population of 62.53%. The most dominant species is also order Ephemeroptera of 79.70% of the whole community.

Shannon Index comprised the richness and evenness of species in a certain population. It stated that when the richness and evenness become higher, Shannon index also increases (Kerkhoff, 2010). As in the upstream site, both of the richness and evenness increased, thus the value of the Shannon index also increased into

1.905 compared to the downstream that has low richness and evenness resulting a value of 1.197 from its entire population.

As for the Simpson index, it varied a lot on the evenness but not on richness. It showed that when a population's dominance was high, the diversity decreased (Kerkhoff, 2010). The downstream has the highest dominance of 0.4307 but still the diversity was low, resulting an index of 0.5693. The upstream has only 0.202 dominance however, resulted in a high diversity index of 0.798.

Factors Affecting Species Diversity

Species diversity varied on both of the sampling sites. This clearly showed that the sampling sites have different factors that could explain its variation. The upstream site was considered undisturbed. It has thick vegetation and many possible food sources can be distinguished on the site. There were substrates that served as the species habitat for them to have their reproduction as well as the completion of their life cycles. There were no signs of human activities that could possibly change their nutrient components as well as the inhabitants of the site. The downstream has slightly polluted environment wherein garbage were visible. Few substrates were present. Downstream was dominated by some anthropogenic activities like washing, taking baths, and mining that might cause the change of nutrient intake and affect the species habitat.

CONCLUSIONS AND RECOMMENDATIONS

In view of the result of the preceding findings of the study, it was concluded that the profile of Pilan River in regards of the physicochemical parameters is still on its normal level wherein benthic insects can still survive, reproduce and live. Furthermore, the entire river can still sustain organism's life. On the other hand. the biological aspect of Pilan River showed that the water is not contaminated by any pollution and still in good condition wherein indicator species can still live. More so, the entire river is diverse with benthic assemblages wherein the population is good to determine the water quality status of the river. Furthermore, the indices shows that the river, in any part of it have different types and ranges of different benthic organisms. Lastly, the insects' assemblages' habitat is affected by the structure and morphological features of the environment as well as the anthropogenic activities occurring on the river.

Upon the findings and the results of the data gathered, it is recommended that the local government may conduct ecological seminars or projects to maintain and nurture the river status. Secondly, the citizens may be aware on the status of the river and be responsible for their waste disposal to avoid the river from being contaminated and polluted. Then, the researchers may further study the biological index of benthic insects as well as monthly monitoring of the physical, chemical and biological aspects of the river possible causes of benthos variation. They may also study the headwaters of Pilan River.

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