Benthic Macroinvertebrate Diversity Index as Water Quality !Indicator of Govantes River in Vigan City, Itocos Sur

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Abstract

This study was conducted to determine the water quality of Govates River i Wigan Cay, Iocos Sur using the diversity index (DI) of the river's benthic macroinvertebrates as an instrument for evaluation from May – October 201.

This research adopted the natural substrate sampling method devised hy Mitchell and Stapp. Six sampling stations were established during the course of the study: Station A in Brgy. II, Station B in Brgy. [II, Sration C in Rrgy. Pantay Daya, Station D in Pantay Fatima, Station E in eastern portion of Brgy Pantay Laud, and Station F in western portion of Brgy Pontay I.and.

A total of eighteen species of benthic macroinvertebrates were collected from the river. ANOVA results indicated significant differences among and between the average number (taxa richess) ad average distri lui indices (SCh) of benthic macroinvertebrates of the six stations. Their computed diversity indices (DI) were all in the lowest bracket of the scale in qualifying water. All the indices indicted poor water quality.

In as much as Govantes River is being revived as a prime aquaculture site, it was recommended that an investigation should be conducted to find out the causes of the poor water quality of the river sa 1al approriate measures should he undertaken to prevent progressive deterioration of the river. Furthermore, there should be a yearly monitoring of the quality of the river water. Ht was also recommended that other biological components of the river should be 1upped as pollution indicators such as plankton.

Introduction

Rationale

A river is any body of freshwater considered as the largest channel fonnc:d by the convergence of tributaries and smaller channels which start on mountains or hillsides. Humans have used rivers since the beginning of civilization. Rivers play important roles in tie life of humans by supplying them fresh drinking water, serving as home for important fishes in their diet, providing transportation routes, and by serving as a source for irrigation water and hydroelectrie power. Aside from these, rivers provide a zone between land and water environments. Floodplains and channels are diverse habitats that support the world's largest wetlands, which are home to innumerable species of plants and animals. Most fish that live in rivers use the channel and floodplain, in some rivers, the deltas and estuaries, during their lite cycle (Microsoft Encarta Encyclopedia, 2000).

However, with the rapid growth of population that comes along with progress, negative factors pose threat to the aquatic environment. It cannot be denied that most river systems are now used as recipients of effluents containing large quantities of organic matter from domestic and municipal wastes, inorganic nutrients and heavy metal from advanced agricultural practices and industries, and a variety of other substances. Because of these discharged effluents, a river becomes unfit for fish and other aquatic life. Today, much attention is given to the pollution of aquatic habitats becuse effluents dumped into them pose serious heaith problems (Cocoros *et al.*, 1973 and Jamil *et al.*, 1984). Many rivers, lakes, estuaries, and coastal waters are now deteriorating at an alarming rte.

The Govantes River in Vigan City, Ilocos Sur is one of the two most important rivers in Metro Vigan. Tie river starts as one arm of the two branches of the Boquig River in Capangpangan, Vigan City; the other is the Mestizo River. The eastern part of the Govantes River runs along north of Vigan Hotel and Restaurant, the Divine Word College of Vigan City, the Archbishop's Palace of Nueva Segovia. old St. Paul's College, the Provincial Capitol of Ilocos Sur, the Provincial Jail, and residential houses of Barangay IV and Pangada, Sta. Catalina, {locos Sur. The river's western portion runs through Pantay Daya, Panlay Fatima, and Pantay Laud. The flow of the river in its eastern portion is discontinuous due to the establishment of private and public institutions and the development of three main roads (considered as "dikes") that connect Vigan City to the adjacent town, Bantay, llocos Sur. But the flow of the river's western portion is continuous up to its mouth where it meets the South China Sea. In a cursory survey of the river, it was noted that few hundred residential houses and shanties are built alcng the river banks. Most notable is the presence of the City's big sewerage tank on the river bank in Barangay IV. The sewerage tank is without any system of treatment. Through out the river, plenty of water hyacinths *(Eichhoria crassipes)*, kangkong *(Ipomea* *aquatica*), and water lilies *(Nymphia sp.)* thrive in large patches. Household effluents (liquid and solid wastes) of the city find their way to the said river either directly or through conveyance channels such as underground pipes or canals. Surface drainage systems in the form of open canals are also utilized as conveyors of domestic wastes into the main river. No sewage treatment is employed or available.

Many studies have been undertaken to study the degree of pollution of bodies of water through chemical and analytical analyses. However, because of high costs demanded by such analyses, many researchers have diverted their attention to the use of the biological components of the aquatic habitat as indicators of its degree of pollution with an assumption that it is the living components of the system that are the ones directly affected by pollution (Kovacs, 1992 and Verma *el al.*, 1995). Certain species of animals and plants can accumulate various toxic compounds without any harm or injury. These are oflen invariably referred to as biological indicators (Harding, 1981). The use of plant or animal monitors gives an integrated picture of pollution within a particular area and is cheaper than chemical monitoring over a long period of time (Christman ,1978). According to Nandan and Azis (1995), an indicator organism is used primarily to identify rather than measure environmental changes. Under conditions of environmental stress, the more sensitive organisms will be eliminated and the successful species would increase in number to dominate the community. These species, while indicating pollution, help in evaluating the effects of pollution. Indicator species of marine and fresh water pollution were reported by several workers (Philips, 1977 and Viale, 1994).

This study focused its determination of the water quality of Govantes River, a dying river, using the diversity index of its benthic macroinvertebrates. Benthos represents an extremely diverse group of aquatic animals and a large number of species possess a wide range of responses to stressors such as organic pollutants, sediments, and toxicants (Bartsch, 1994). Unlike fish, benthic macroinvertebrates cannot move around as much thus less able to escape the effects of sediments and other pollutants that diminish water quality. Hence, they can give us reliable information on river water quality. Aside from these, benthos are long-lived organisms, allowing detection of past pollution events.

One of the projects of the City Government of Vigan included in the rehabilitation of its UNESCO World Heritage *Pohlacion* and Save Vigan Movement and in the development of projects for the sustainability of the city is the revival of its two previously mentioned major rivers as prime aquaculture sites transforming them back to their once glorified stature. This research is one of the initial steps undertaken by the University of Northern Philippines' academe in support to such endeavor. Furthermore, no such study using the diversity index of the benthic macroinvertebrates present in the Govantes River for determining its water quality was ever conducted. Thus, this study was deemed necessary. Data of this study will serve as baseline information for future monitoring of the water quality of the river.

Statement of the Problem

This study concentrated in the determination of the water quality of Govantes River using the diversity index of its benthic macroinvertebrates from May to October 2001. Specifically, it sought to determine the benthic composition of the river (taxa richness); the Sequential Comparison Indices (SCI); the significant differences of these parameters; and the Diversity Indices (DI) of the six stations established along the river during the course of this study.

Operational Definition of Terms

For clearer understanding of this study, some terms used operationally are defined.

Benthos. This is the term given to an animal without backbone that lives on rocks, logs, sediments, debris, and aquatic plants during some period in their life. This group includes insect larvae, annelids, oligochaetes, crustaceans, mollusks, and gastropods (Bartsch, 1994).

Invertebrate. This is an animal that does not have backbone.

Macroinvertebrate. This is a large invertebrate. in this particular study, macroinvertebrate is a benthos that is separated from the river sediment and retained by the mesh of a kick screen.

Diversity Index. The Diversity Index (DI) is equal to the Sequential Comparison Index (SCI) multiplied by the taxa richness. This measure is based on the theory of runs and the number of taxa found at a site (Mitchell and Stapp, 1993).

Sequential Comparison Index. The Sequential Comparison Index (SCI) is a measure of the distribution of individuals among groups of organisms. This is based on the theory of runs (Mitchell and Stapp, 1993).

Taxa Richness. The taxa richness is the number of taxa (orders, families, genera, and species) present in the sample, as identified by their gross physical differences. In this study, the taxa richness was calculated by counting the number of benthic macroinvertebrate species in the sample (Mitchell and Stapp, 1993).

Kick Screen. The kick screen consists of window screening material stretched between two poles. Sampling is done by pushing the poles into the substrate until the edge of the screen rests on the bottom, and in which kicked river substrate is sifted through (Mitchell and Stapp, 1993).

Review of'Related Literature

With all the existing circumstances in our environment, there is increasing uncertainty regarding the possible effects of globl climate change on worldwide patters of rainfall and snowfall. And with all the changes that come along with the advancement of science nd technology, and with the ever increasing human population, conservation and preservation of rivers have become more important. It has been said that tie largest unpolluted rivers are far from the centers of the densest populations (Microsoft Encarta Encyclopedia, 2000). This implies that it is now very rate to find unpolluted rivers within the vicinities of communities whose biological activities depend much on the biotic components of the rivers.

Because of the high costs of chemical analyses of water quality, advocates of saving polluted aquatic habitats have turned their attention to the biological components of the habitats as indicators of pollution (Kova'cs, 1992 and Verma *et al.*, 1995) with the premise that they are the ones directly affected by pollution.

Studies have found out that large marine mammals *(Cetaceans)* can continuously absorb environmental pollutants in their food, their air, and their seawater, such as pesticides, hydrocarbons, metals, and new synthetic molecules. As reported by Viale (1995) changes in the Mediterranean water quality are demonstrated by the demographic variations of three species of dolphins *Tursiops truncatus*, *Delphimus delphise*, *Stenella coeruleoalba*. Histological studies and scanning observations of tissue samples from the lung and mesenterium show that the diseases are concomitant with high levels of Hg, Pb, Cd. Nandan and Azis (1995) conducted a study on pollution indicators of coconut retting area in the Kayals of Kerala, India. Indicator organisms specific to pollution in said kayals are seven species of benthos and five species of plankton. The researchers used the indices of diversity and dominance of said organisms as indicators of pollution. These indices were also correlated with the water quality parameters.

According to Mitchell and Stapp (1993) two commonly used methods for evaluating water quality by looking at macroinvertebrates are indicator organisms and diversity indices. The concept of indicator organism is based on the fect that every species has a certain range of physical and chemical conditions in which it can survive. Some organisms can survive in a wide range of conditions and are tolerant of pollution. Others are very sensitive to changes in conditions and are intolerant of pollution. Mitchell and Stapp have mentioned some pollution-sensitive organisms and these are: mayflies, stoneflies, some caddiesflies, riffle, beetles, and hellgrammites. While pollution-tolerant species are sludge worms, leeches, certain midge larva, and mollusks. The evaluation of water quality is linked to the numbers of pollution-tolerant organisms at the site compared with intolerant organisms. A large number of tolerant organisms and few or no intolerant organisms would indicate pollution.

Bartsch (1994) in his studies on pollution indicator organisms such as algae, bacteria, fish, and macroinvertebrates found out that these organisms can indicate water quality based on their biological characteristics. Benthic macroinvertebrates are preferred for the following reasons: they are easy to collect and handle, they do not require special culture protocols, they arc visible to the naked eye, and they have fascinating adaptation to stream life.

Methodology

This study evaluated the water quality of Govantes River from May to October 2001 using the diversity indices of its benthic macroinvertebrate components.

During the course of this study, six stations were established along the river and they are as follows: Station A in *Barangay* II, Station B in *Barangay* II, Station C in *Barangay Pantay Daya*, Station D in *Pantay Fatima*, Station E in *Barangay Pantay Laud* (eastern portion), and Station F in *Barangay Pantay Daya* (western portion near the mouth of the river in South China Sea).

The natural substrate sampling method by Mitchell and Stapp (1993) was adopted and strictly followed in gathering data for this particular study.

A representative of the samples collected was preserved in 10% formalin. The samples were initially identified as to their common names (Iluko and English) while their scientific names were verified by the experts of the Zoological Division of the National Museum in Manila.

The following were used to treat the data gathered in this study;

a. Sequential Comparison Index (SCI):

$$SCI = \frac{\text{no. of runs}}{\text{total no. of organisms picked}}$$

This was used to determine the distribution of the benthic macroinvertebrates in the river by computing the number of runs over the total no. of organisms picked from each of the six stations.

b. Taxa Richness

This was used to determine the number of species of benthic macroinvertebrates in a sample through simple counting. The idea of this measure is that better water quality is generally associated with a higher number of taxa.

c. Diversity Index (DI):

$$DI = \text{Taxa Richness} \times SCI$$

This measure is based on the theory of runs and the number of taxa found at a site. From the computed DI, the quality of the river water was determined using the following scale devised by Mitchell and Stapp (1993) as a guide:

Water Quality Rating:

0–8	Poor
8–12	Fair
12–24	Good

d. ANOVA

The analysis of variance (ANOVA) was utilized to find out the significant difference of the data among and between the stations.

e. Scheffe Test

This statistical treatment was employed to find out in which compared stations lie the significant difference.

Results and Discussion

A total of eighteen (18) species of benthic macroinvertebrates were found thriving in Govantes River distributed at the six stations established along the river during the course of the study (Table 1).

As reflected in the table, only two benthic macroinvertebrate species from the total of eighteen species gathered in this study were present in all the six stations set along the river and these were *Melanoides granifera (duriken)* and *Melanoides tuberculate (suso). Ampullaria sp. (bisukol)* was collected in five stations (A, B, C, and D) except in Station F near the mouth of the river at the South China Sea. Aquatic worm was gathered from four stations, namely, B, C, E, and F. In like manner, *ipes* was collected in four stations too and these are A, C, D, and F. Species that were collected at the eastern portion of the river were *birabid* (in Stations A,B, and C), *duran-duran* (in Stations A and C), *kusikos* (in Station A only), *Syncera (leddeg)* (in Stations A, B, and C), mayfly (in Stations A and B), *Crangon* sp.(shrimp) (in Stations A and C). Those that were collected from the western portion of the river were the following: *Curbicula fluminea (benek;* in Stations E and F), *Paphia* sp.(clams) (in Stations E and F), *Varuna litterata (kappi)* (in Stations D and F), *onnok* (in Station F), *Modiolus fiavidus (rusangis)* (in Station E and F), *Clithon flavovirens* (shek) (in Stations D, E, and F), again *Crangon* sp.(shrimp) (in Station E), and *Crassostrea sp. (tirem)* (in Stations D, E, and F).

Table 1. The benthic macroinvertebrates present in Govantes river, Vigan City, Ilocos Sur.

Common Name (Iluko/English)	Order/ Scientific Name	Station					
		A	B	C	D	E	F
Aquatic worm	Order Polychaete		+	+		+	+
Bennek	*Curbicula fluminea Mull.*					+	+
Birabid	Species X	+	+	+			
Bisukol	*Ampullaria sp.*	+	+	+	+	+	
Clams	*Paphia sp*					+	+
Duran-duran	Order Coleoptera	+		+			
Duriken	*Melanoides granifera Lam.*	+	+	+	+	+	+
Ipes	Order Coleoptera	+		+	+		+
Kappi	*Varuna fluminea Fab.*				+		+
Kusikos	Species X	+					
Leddeg	*Syncera sp.*	+	+	+			
Mayfly	Order Ephemeroptera	+		+			
Onok	Species X						+
Rusangis	*Modiolus flavidus Dunk.*					+	+
Shek	*Clithon corona Linn*				+	+	-}
Shrimp	*Crangon sp.*	+		+		+	
Suso	*Melanoides tuberculata Mull*	+	+	+	+	+	+
Tirem	*Crassostrea palmipes Sow*				+	+-	+

Legend: Station A: *Brgy* II Station C: *Pantay Daya*
Station E: *Pantay Laud* (eastern portion) x: undetermined
Station B: *Brgy* III Station D: *Pantay Fatima*
Station F: *Pantay Laud* (western portion) + : presence

Average Taxa Richness and Average Sequential Comparison Index (SCI) of Govantes River

The average number and average distribution of species of the benthic macroinvertebrates of Govantes River during the course of this study is presented in Table 2.

Table 2. The average taxa richness and average sequential comparison indices (SCI) of Govantes river.

Station	Average	
	Taxa Richness	SCI
A	7.33	0.517
B	4.33	0.527
C	7.667	0.526
D	2.667	0.131
E	4.167	0.148
F	4.167	0.260

It can be noted in the table that the highest average taxa richness vlue of 7.667 was in Station C, followed by 7.33 in Station A, and 4.33 in Station E. Each of the Stations E and F had an average taxa richness value of 4.167/. Station D got the least average value of2.667.

The average SCIs of three of the six stations set along the Govants River have values within the same range, and these are: 0.517 for Station A, 0527 for Station B, and 0.526 for Station C. Stations D and E's average SCIs are within close range, too, with values 0.131 and 0.148, respectively. As for Station F, its average SCI value is 0.260.

Inasmuch as the average taxa richness and the average SCIs O the six stations varied from each other, the Analysis of Variance (ANOVA) was employed to find out if there was a significant difference in the values among and be:ween the six stations. The summary of the ANOVA is presented in Table 3 for the taxa richness and Table 5 for the SCI.

Table 3. Summary of the ANOVA on the significant difference on the tara richness between and moug the six stations.

Source of Variation	Sum of Squares	Degrees of Freedom	Mea Square	F	Significance
Between Groups	118.889	5	23.778	13.987	p<.01
Within Groups	51.000	30	1.700		
Total	169.889	35			

significant

The table above reveals that the F-ratio of 13.987 is significant at .01 probability level. This finding indicates that the taxa richness or the number of benthic macroinvertebrate species among and between the six stations set along the length of Govantes River differ significantly. To find out which song the paired stations were significantly different, the *Scheffe test* was utlized. Results of which are presented in Table 4.

Table 4. *Scheffe Test* on the taxa richness.

Comparison Station		Station	Mean Difference	Significance
A	vs	B	3.000	p <.05
		C	• 0.333	p>.05
		D	4.667	p<.01
		E	3.167	p<.05
		F	3.167	p<.05°
B	vs	C	- 3.333	p <.01
		D	1.667	p<.05
		E	0.167	p> .05
		F	0.167	p> .05
C	vs	D	5.000	p<.01°
		E	3.500	p<.01
		F	3.500	p<.01
D	vs	E	- 1.500	p>.05
		F	- 1.500	p>.05
E	vs	F	0	p>.05

significant

It is reflected in Table 4 that the taxa richness of Station A when compared with the taxa richness of the other stations is significantly different with the values of Stations B, D, E, and F but not significantly different with that of Station C. While the taxa richness of Station B is significantly different with those of Stations C and D, it is not significantly different with those of Stations E and F. Station C's taxa richness is significantly different with those of Stations D, E, and F. The taxa richness of Station D when compared to those of Stations E and F is not significantly different. The same finding is observed with Station E's taxa richness as compared to that of Station F.

Table 5. Summary of the ANOVA on the significant difference in the SCI values among and between the stations.

Source of Variation	Sum of Squares	Degrees of freedom	Mean Squares	F. value	Significance
Between Groups	1.120	5	0.224	11.9$5	P<.01
Within Groups	0.561	30	0.019		
Total	1.681	35			

significant

The ANOVA table above reveals that the F-ratio of 11.95 is significant at .01 probability level. This finding indicates that the average SCI values or the distribution of the benthic macroinvertebrates among and between the six stations are highly significant.

The *Scheffe' test* was then used to further determine which compared stations lie the significant difference. Results of this statistical treatment are presented in Table 6.

Table 6. ***Scheffe test*** **on the SCI.**

Station D)	Comparison Station (D)	Mean Difference (I--J)	Significance
A vs	B	-0.010	D >.05
	C	-0.009	p>.05
	D	0.386	p <.01
	E	0.369	D<.01°
	F	0.257	>.05
B vs	C	0.002	D >.05
	D	0.396	D<.01°
	E	0.379	p<.01
	F	0.267	p>.05
C vs	D	0.394	p<.01
	E	0.377	p<.01
	F	0.266	p>.05
D vs	E	- 0.017	p>.05
	F	- 0.129	p>.05
E vs	F	- 0.112	D > .05

significant

From the table, it can be noted that the SCI level of Station A is not significant with the SCI levels of Stations B, C, and F but significantly different with those of Stations D and E. Station B's SCI is not significantly different with the SCIs of Stations C and F but significantly different with those of Stations D and E. Station C's SCI level is significantly different with those of Stations D and E but not with Station F's. The SCI of Station D is not significantly different with those of Stations E and F. Likewise, Station E's SCI is not significantly different with that of Station F.

The Diversity Indices (DI) and Water Quality of Govantes River

Inasmuch as the focus of this study was to determine the water quality of Govantes River from the computed DI (SCI multiplied by taxa richness), the average DIs of the six stations and their indications of water quality are presented in Table 7.

Table 7. The average diversity indices (DI) and water quality description of the six stations in Govantes River.

Station	Average DI (SCI x Taxa Richness)	Water Quality Description
A	3.840	Poor
B	2.246	Poor
C	4.035	Poor
D	0.248	Poor
E	0.342	Poor
F	0.716	Poor

The table above reveals that the average DIs of each of the six stations set along Govantes River during the course of the study differs from each other. Highest DI among them is that of Station C in *Brgy Pantay Daya* with 4.035 followed by Station A in *Brgy* II with 3.840, then Station B in *Brgy* III with 2.246. The DI of the stations at the western portions of the river is not much different from each other. Among the three, Station F in *Brgy Pantay Laud* (western area) gets the highest DI with 0.716, followed by Station E in *Brgy Pantay laud* (eastern portion) with 0.342, and by Station D in *Brgy Pantay Fatima* with 0.248.

The very low computed DI values indicate lesser diversity of the benthic macroinvertebrates of Govantes River. This lesser diversity, in turn, indicates an unstable community. Based on the scale devised by Mitchell and Stapp (1993) for categorizing the quality of the river water using diversity index of the benthic macroinvertebrates of the area being examined, the Dls of the six stations of Govantes River, while the values differ from each other, all fall under the bracket 0 – 8, the bracket for poor water quality. As Mitchell and Stapp have pointed out, pollution tends to reduce the number of species in a community by eliminating organisms that are sensitive to changes in water quality.

Summary of Findings

The average taxa richness of the six stations differed from each other: 7.33, 4.33, 7.667, 2.667, 4.167, and 4.167 for Stations A, B, C, D, E, and F, respectiveiy.

Likewise, different average SCI values were computed as follows: 0.517 (Station A), 0.527 (Station B), 0.S26 (Station C), 0.131 (Station D), 0.148 (Station E), and 0.260 (Station F).

ANOVA results indicated significant differences among and between the average taxa richness and average distribution indices (SCI) of the benthic macroinvertebrates of the six stations.

Despite the significant differences mentioned above, computed diversity indices (DI) of the six stations, 3.840 (station A), 2.246 (station B), 4.035 (station C), 0.248 (station D), 0.342 (station E), and 0.716 (station F), all fall under the lowest bracket (0–8) of the scale devised by Mitchell and Stapp.

Conclusion and Recommendations

The very low DI levels simply indicate poor water quality and very low sustainability of the river to benthic macroinvertebrates. This necessitates an investigation as to the cause/s of such poor water quality of Govantes River and that preventive and rehabilitation measures should be undertaken by all concerned people to save the river.

It was further recommended that there should **be a** yearly monitoring of the quality of the river water so that appropriate measures will be undertaken to safeguard the river from further destruction. It was also recommended that other biological components of the river should be used as indicators of the quality of the **river** such phytoplankton, the primary producers of an aquatic habitat, and zooplankton, the primary consumers of such ecosystem.

Actions Taken

Last July, this particular endeavor was continued and this time the Mestizo River is included. Last year, Accion Contra el Hambre (ACH), a Spanish government organization based in Vigan City, whose primary objective is to reach out to developing countries to fight hunger, and which works hand in hand with the city government of Vigan in transferring technology/development projects to prevent hunger, has started the chemical analyses of the rivers' waters to identify precipitating factors in the deterioration of said rivers.

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