INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 10, No. 3, p. 25-34, 2017
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Aquatic Macroinvertebrates composition, diversity and richness in Agusan river tributaries, Esperanza, Agusan del Sur, Philippines

Jerry T. Cuadrado*, Laurence B. Calagui

Biology Department, Caraga State University, Ampayon, Butuan City, Philippines

Article published on March 23, 2017

Key words: Wawa river, Ojot river, Macroinvertebrates, Water quality, Biodiversity indices

Abstract

The present work was carried out to assess the macroinvertebrates diversity, composition and richness in Wawa and Ojot River found in Esperanza, Agusan del Sur, Philippines.This fauna are bioindicator species in determining the water quality in freshwater bodies. Macroinvertebrates were assessed in upstream, midstream and downstream of the two rivers on February 20-21, 2016 using kick-net method. Identification of species was done using taxonomic keys. A total of 227 individuals of macroinvertebrates belonging to sixteen (16) families and seventeen (17) species were collected and identified in Ojot and Wawa River. Wawa River and Ojot River have a Shannon Diversity Index of "Very Low" and "Low" respectively. This could be attributed to some disturbances such as human activities which are observed in both areas. Macroinvertebrates species that belongs to Taxa 2 – organisms that can exist in a wide range of water quality conditions or moderate water quality, dominated both areas. WQI scores revealed that both rivers have a "rather clean-clean" water quality. Wawa River has FBI score of 4.82 which indicate"Some Organic Pollution" and Ojot River has 3.89 FBI score which indicates "Possible Slight Organic Pollution". These results could be due to human activities in the upland such as agricultural and industrial works in which waste products of these activities will be carried to the river during runoff and alters the water quality. Physico-chemical parameters of water and soil and seasonal variations of macroinvertebrates diversity should also be studied to better assess the water quality of the two areas.

***Corresponding Author:** Jerry T. Cuadrado ✉ jerry_cuadrado@ymail.com

Introduction

Macroinvertebrates are aquatic organisms without backbones. On some period of their life, these organisms live on or inside the deposit at the bottom of a water body (Idowu & Ugwumba, 2005; Dacayana *et al.,* 2013) or can be found on rocks, logs, sediments, debris and aquatic plants (Tampus *et al.,* 2012). The use of macroinvertebrates as biological indicator to assess water quality have been known worldwide (Ogbeibu, 2001; Hart & Zabbey, 2005; Arimoro & Osakwe, 2006; Dacayana *et al.,* 2013).

Because of the sensitivity of some macroinvertebrates species (Sigovini & Tagliapietra, 2010), the presence or absence of these particular species in a particular environment can be used as bio-indicator of specific environment and habitat conditions (Sarang& Sharma,2005), and because they are also known to respond to changes in the quality of water or habitat.

Macroinvertebratesas indicators are effective in assessing the quality of the water (Bode *et al.,* 1995). Sharma & Chowdhary (2011) stated that occurrence of specific genera and that the changes in macroinvertebrate assemblages were primarily due to changes in water quality.

Agusan River Basin is the third largest river basin in the Philippines and the largest in Mindanao with drainage of 10,921 km² and flows through three (3) provinces of Agusan del Norte, Agusan del Sur and Compostela Valley in Mindanao (ARBMP, 2008).The 350-km river originates from the slopes of Mounts Mayo and Tagopo in Compostela Valley; and traverses northward through Compostela Valley, Agusan Marsh in Agusandel Sur, and Agusan del Norte, before draining into Butuan Bay (ARBMP, 2008). The Forest Land Use Plan of Agusan del Sur has identified twelve (12) major rive rtributaries that drain into the Marsh and drain to Agusan River,(Provincial Development Council, 2010).

Two tributaries of Agusan River are located or can be found in Esperanza, Agusan del Sur namely Wawa River which drains in Barangay Poblacion and Ojot River in Barangay Langag.

Esperanza is one of the 14 municipalities of Agusan del Sur Province in the Philippines that lies in the Lower Agusan River Valley Zone. It is endowed with vast and extensive rivers which are significant resources of the nearby community. Irrigation, waterway in transporting logs, transportation through boats, laundry sites and bathing places of human and domesticated animals like pigs and carabaos (water buffalo) are among the functions of these rivers in the community. As climate unpredictably changes, these human activities might have an impact on the organisms living on these habitats. Strong *et al.* (2008) stated that the unsuitable use of water resources, habitat loss and degradation are the identified threats to the sensitive organisms.

No further studies have been conducted yet about macroinvertebrates in the tributaries of Agusan River in the Municipality of Esperanza, Agusan del Sur. Thus, has driven the author to study the said area to provide baseline data about these rivers. This study aims to assess the macroinvertebrates composition in Agusan River Tributaries. Specifically, it aims to determine the species richness and abundance of macroinvertebrates in the area; and determine the Water Quality Index and Family Biotic Index of the sampling stations using aquatic macroinvertebrates in order to determine the present status of the mentioned rivers. The results of the study serve as an important reference also for evaluating future water quality changes, as well as providing insights on how to protect the river and its biodiversity.

This study was limited only in identifying and determining the composition, abundance and richness of macroinvertebrates collected in the sampling sites during sampling period. Though, several factors affect these variables, therefore the temporal distribution were not studied due to limited data-gathering time. Physico-chemical parameters of water were not included also in this study.

Materials and methods

Study area and establishment of sampling stations

Sampling area are the Agusan river Tributaries found in Esperanza, Agusan del Surnamely the Ojot River and Wawa River (Fig. 1).

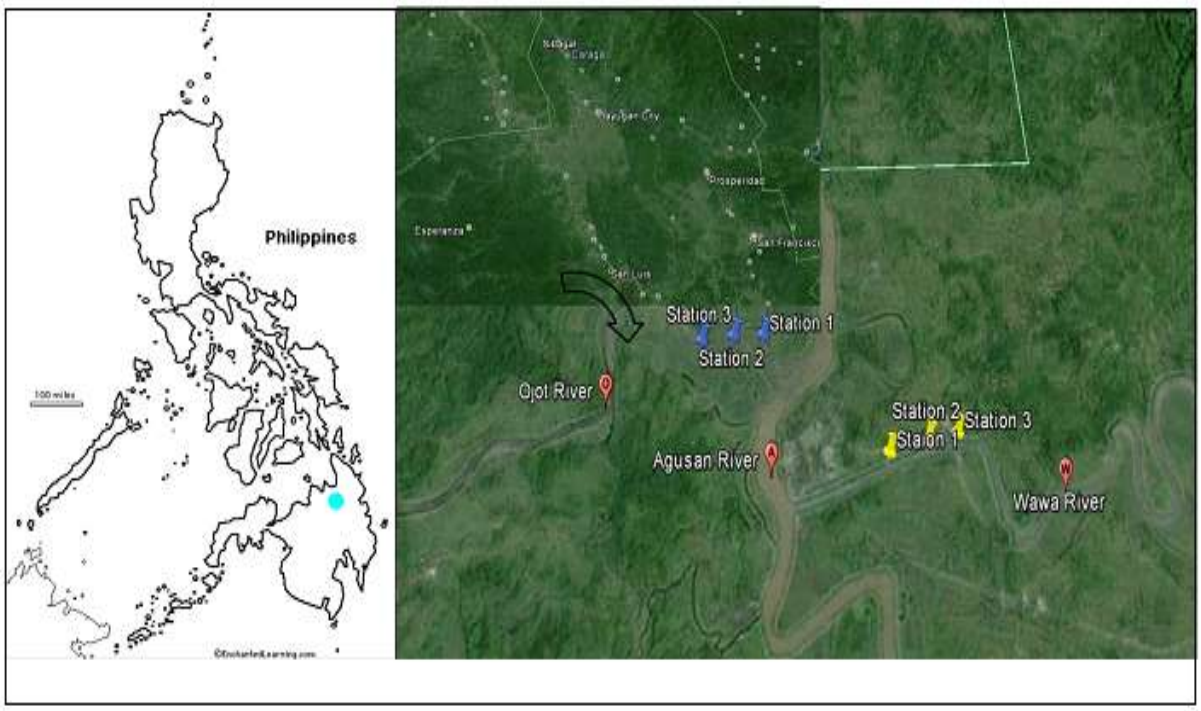

Fig. 1. Map showing Agusan River and the two tributaries namely Wawa and Ojot River in Esperanza, Agusan del Sur (www.google.com.ph).

Wawa is an extensive river that drains in the Municipality of Esperanza, Agusan del Sur. The river bank is rich in vegetation with shrubs, grasses and some fruiting trees and has muddy to clayish substrate (Fig. 2a). The Ojot River is found in Barangay Langag, Esperanza, Agusan del Sur. Sampling stations were established near the confluence of the river. Small ponds with muddy to clayish substrate surrounded with shrubs and tall grasses can be found in each area`s stations (Fig. 2b) and the area is also rich in macrophytes.

Three sampling stationswere determined in Ojot River and Wawa River; the upper stream, middle stream and lower stream. In each sampling stations, a 100-meter transect line parallel to the stream flowor perpendicular to the water body was established in accessible area. Five sampling points that serve as the replicates were established by marking ten meters with ten meter-interval in a 100-meter transect line.

Macroinvertebrates collection and identification

The collection of macroinvertebrates was done on February20-21, 2016 using kick-net method. D-framed net that measures 0.3 m width with 500 µm opening mesh size was used in collecting the organisms. Collection was done in a standard three-minute kick/sweep method (Armitage *et al.,* 1990) by disturbing the riverbed in a kicking motion towards the direction of the D-framed net. The sampling was done starting from the last sampling point on the downstream area towards the upper points.

The collected organisms were placed in a container with water with proper label. However, if samples have mixtures of sediments, these were sieved in a 0.5mm-mesh size sieve to separate the organisms from soil sediments. Collected specimens were sorted in the laboratory and were preserved with 70% ethyl alcohol. Identification was done up to its lowest possible taxon using the key guides of Bouchard (2004) and Hartman (2006).

Water quality index

The collected macroinvertebrates were grouped into 3 Taxa: Taxa 1, Taxa 2 and Taxa 3 based on their sensitivity or tolerance to pollution or aquatic disturbance (Barbour *et al.,* 1999).

Taxa 1 includes species belonging to orders Ephemeroptera, Plecoptera, Trichoptera and Coleoptera and was found in good water quality and are pollution-sensitive organisms. Taxa 2 species can exist in a wide range of water quality conditions, or moderate water quality and include species belonging to orders Hemiptera, Diptera, Odonata, Decapoda and Veneroida. Taxa 3 are species that are highly tolerant to poor water quality.

This taxon includes Tubificida, Gastropoda, Hirudinidae, Cerithioidea and Isopoda.

The identified macroinvertebrates were sorted and scored with their particular points based on Water quality index (WQI) scores developed by Armitage *et al.* (1983); the sum was obtained and subsequently divided by the number of species scored. The resulting value is the WQI and described in Table 1.

Family biotic index

Family Biotic Index developed by (Hilsenhoff, 1977, 1988a, 1988b) was also used as another means in determining water quality in the sampling stations. This was obtained by multiplying the number in each family by Family-level pollution tolerance value/scores, summing the products, and dividing by the total species in the sample. The value obtained is the FBI and described in Table 2.

Statistical analysis of data

Data collected was statistically analyzed using PAST Software to obtain Biodiversity Indices such as Evenness, Species Richness index (d`), Shannon-Wiener index (H'), and Simpson's Dominance index (D).To determine if there is significant difference between sampling sites, T-test was employed using 5% level of significance.

The diversity values for Shannon-Weiner (H') were classified based on the scale developed by Fernando (1995) and described in Table 3.

Results and discussion

Diversity, Richness and Distribution of macroinvertebrates

A total of 227 individuals of macroinvertebrates belonging to sixteen (16) families and representing seventeen (17) species were collected and identified in Ojot and Wawa River during sampling period. Of all taxa recorded, only *Palaemonid* sp. (freshwater shrimp), *Gerris remigis* (water strider)and *Dolomedes* sp. (water spider) were the most represented taxa which were collected in both sampling areas (Table 4).

On the other hand, *Gerris remigis* (water strider) of family Gerridae has the most number of individuals compared to other species and were commonly observed in the water surface of both areas.

Table 1. Water quality index scores and indication.

Score	Indication
7.6-10	Very clean water
5.1-7.5	Rather clean-clean water
2.6-5.0	Rather dirty-water average
1.0-2.5	Dirty water
0	Very dirty water (no life at all)

According to Stonedahl & Lattin (1982), water striders are very prominent and may occur in large groups but are rarely eaten by aquatic animals such as fish because of the scent gland secretions which is believed to be responsible for that apparent immunity.

The vast number of *Gerris remigis* (water strider) also can be associated with thick vegetation around the margins of the river (Dacayana *et al.*, 2013).

These might be the reasons why this fauna are common and predominantly in Wawa and Ojot river, since both areas are noticeably rich in vegetation.

Table 2. Water quality using the family-level biotic index.

Biotic Index	Water quality	Degree of organic pollution
0.00–3.50	Excellent	No apparent organic pollution
3.51–4.50	Very good	Possible slight organic pollution
4.51–5.50	Good	Some organic pollution
5.51–6.50	Fair	Fairly significant organic pollution
6.51–7.50	Fairly poor	Significant organic pollution
7.51–8.50	Poor	Very significant organic pollution
8.51–10.0	Very poor	Severe organic pollution

Most of the collected organisms in both areas belong to phylum Arthropoda (Fig. 3). However, Annelid of Class Oligochaete was collected in Ojot River only, represented by single (1) individual; and Mollusks particularly *Corbicula* sp. of Class Bivalvia and *Pomacea* sp. of class Gastropoda were also observed in the said river.

Table 3. H' diversity value and its qualitative equivalence.

H' value	Relative values
>3.5	Very high
3.0-3.49	High
2.5-2.99	Moderate
2.0-2.49	Low
<1.99	Very low

Biodiversity indices of the two sampling areas were also computed and shown in Table 5. Ojot River had the highest Taxa (species richness), number of individuals, Simpson Diversity Index (1-D). On the other hand, higher Dominance and Evenness were recorded in Wawa River. Evenness indices standardize abundance and higher in area when most individuals belong to a few species (Smith & Wilson, 1996).

Table 4. Inventory of the collected aquatic macroinvertebrates in two sampling areas.

			Number of Individuals		
Class/Family	Species Name	Common Name	Wawa River	Ojot river	Total
Oligochaeta	Oligochaeta sp.	Aquatic worm	NF	1	1
Corbiculidae	*Corbicula* sp.	Freshwater clam	NF	5	5
Ampullariidae	*Pomacea* sp.	Golden apple snail	NF	3	3
Pisauridae	*Dolomedes* sp.	Water spider	18	3	21
Palaemonidae	*Palaemonid* sp.	Freshwater shrimp	5	10	15
Dytiscidae	*Cybister sp.*	Predaceous diving beetle	NF	15	15
	Dytiscus sp.	Great diving beetle	NF	15	15
Psephenidae	*Psephenops* sp.	Water pennies	9	NF	9
Dryopidae	Dryopidae sp.	Long-toed water beetle	NF	17	17
Baetidae	*Callibaetis* sp.	Small minnow mayflies	5	NF	5
Gerridae	*Gerris remigis*	Common water strider	26	18	44
Nepidae	*Hydrometra* sp.	Marsh treader	13	NF	13
Macromiidae	*Macromiidae* sp.	Dragonfly	NF	9	9
Coenagrionidae	*Ischunura* sp.	Damselfly	19	NF	19
Odontoceridae	Odontoceridae sp.	Caddisfly	NF	14	14
Hydrophilidae	Hydrophilidae sp.	Water scavenger	NF	15	15
Perlidae	*Perlinae* sp.	Stoneflies	7	NF	7
			102	125	227
	Total				

NF- not found

The high evenness indices in Wawa river is due to the fact that most number of individual collected in Wawa River are higher compared to Ojot River but belongs to few species only. This implies that there is a greater probability of finding rarer families in samples with higher count (Dacayana *et al*., 2013).

In addition, Dominance is also higher in Wawa River given that it was dominated by single species only, the *Gerris remigis* (water strider), and this fauna dominated in the three sampling stations of Wawa river.

Table 5. Biodiversity indices of two sampling areas.

	Wawa_River	Ojot_River
Taxa_S	8	12
Individuals	102	125
Dominance_D	0.1644	0.1094
Simpson_1-D	0.8356	0.8906
Shannon_H	1.924	2.297
Evenness_e^H/S	0.8559	0.8285

Table 6. Shannon diversity index (H') diversity value of two sampling area and its qualitative equivalence.

Sampling Area	H' value	Relative values
Wawa river	1.924	Very low
Ojot river	2.297	Low

Shannon Diversity Index (H`) value of Wawa River and Ojot river have a qualitative equivalence of Very Low and Low respectively (Table 5). Low taxa richness indicates devastating impact of impoundment on the macroinvertebrate and pollution stress in the area due to increased human activities (Arimoro *et al*., 2007; Andem *et al*., 2012; Edward & Ugwumba, 2011; Latha & Thanga, 2010). Romero *et al*. (2013) stated that areas with some fragmentation and siltation points and pasture surrounding riparian vegetation significantly affect community richness.

Table 7. Water quality of two sampling areas using WQI score.

Sampling Area	WQI Score	Indication
Wawa river	6.1	Rather clean-clean water
Ojot river	5.6	Rather clean-clean water

Table 8. Water quality of sampling areas using FBI.

Sampling Area	Biotic Index	Water quality	Degree of organic pollution
Wawa river	4.82	Good	Some organic pollution
Ojot river	3.89	Very good	Possible slight organic pollution

These reasons could be attributed to the very low and low diversity of the two areas. For instance, few meters away from Wawa River were rice and corn fields, and fish ponds in which supply of water for the mentioned agricultural works are obtained from this river and probably,

Wawa River will be the catching basin of agricultural effluents during run off. Both rivers also serve as bathing places of domesticated animals and human, laundry sites and the riparian zone serve as pasture area of domesticated animals such as pig and carabao.

Fig. 2. Sampling area showing natural habitat for aquatic macroinvertebrates -a. Ojot river (8°41′03.14′′ N, 125°38′36.58′′ E); b. Wawa River (8°40′39.92′′ N 12, 125°39′33.53′′ E).

Water quality indices

Tables 7 and 8 present the Water quality of the two areas using aquatic macroinvertebrates through obtaining the WQI and FBI scores. Based on the WQI scores, results showed that the water quality of Wawa and Ojot river was "rather clean-clean water" with the scores of 6.1 and 5.6 respectively.

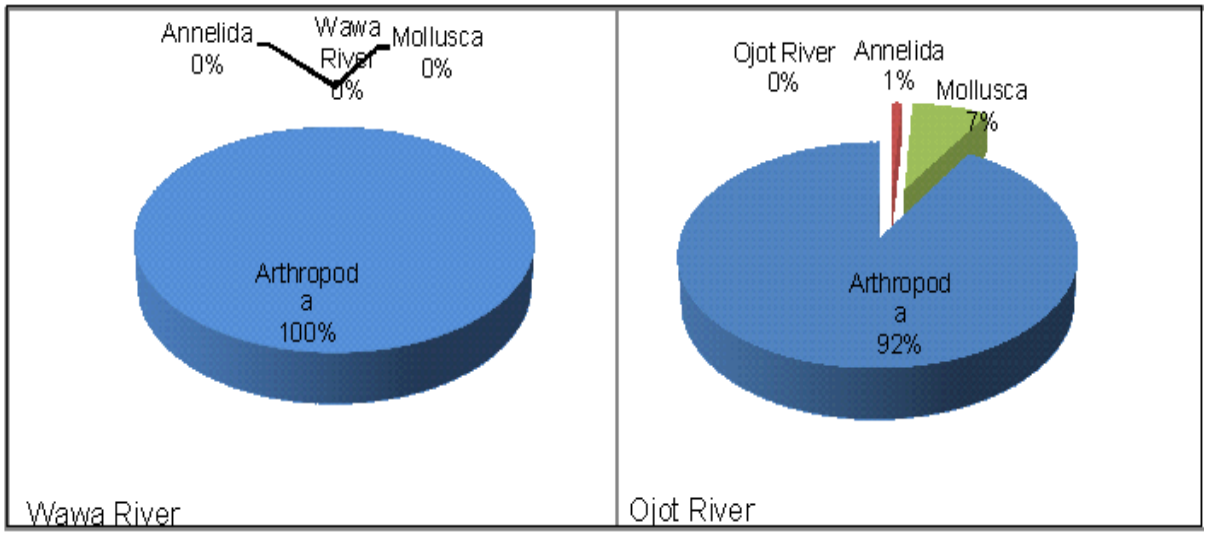

Fig. 3. Percent composition of major phyla of aquatic macroinvertebrates collected in Wawa river and Ojot river.

On the other hand, Wawa River has FBI score of 4.82 that can be rated with "Good Water Quality" which indicate having "some organic pollution". Furthermore, Ojot river has "Very Good" (3.89) water quality which indicates "Possible Slight Organic Pollution". This result could be due to lesser number of families belonging to Taxa 1 also known as pollution sensitive species (Fig. 4).

In wawa River, most of the collected organisms belong to Taxa 2 such as Hemiptera, Diptera, Odonata, and Decapoda which can exist in a wide range of water quality conditions, or moderate water quality, though Ephemeroptera and Plecoptera (represented with single species only) were also collected in this area but they were outnumbered by the other organisms.

The area is vulnerable also to various impacts such as domestic wastes, and vehicles passing by as the bridge was constructed across the river, agricultural activities, and the ongoing road construction in the upland. These activities could have altered the physical and chemical quality of water necessary for the occurrence of macroinvertebrates (Dacayana *et al.*, 2013).

With regards to Ojot river, the presence of Annelid (Oligochaeta) and Mollusk (Gastropoda) which are known to be highly tolerant to poor water quality affected the WQI and FBI scores of this area even though it has the highest number of species collected compared to Wawa River.

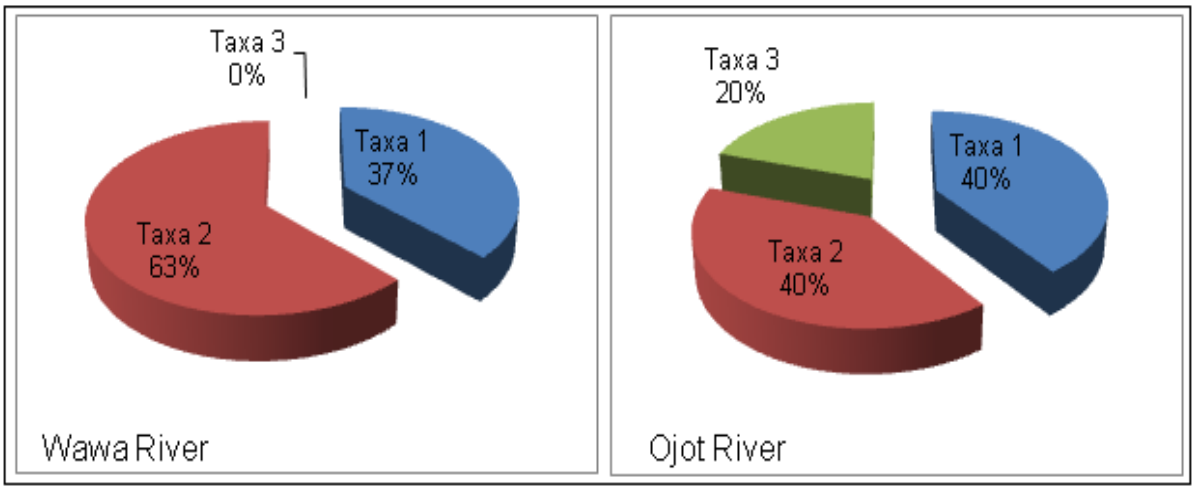

Fig. 4. Taxa grouping of macroinvertebrates based on sensitivity/tolerance to pollution.

According to Lenat (1988), streams that receive input from agricultural runoff would also have greater suspended solids and high sedimentation, increase in particulate organic matter and elevated nutrients concentration lowers the abundance of Ephemeroptera, Trichoptera and Coleoptera species that belong to Taxa 1, which is observed in both areas.

Conclusion

The present study is the first to report the diversity, composition and richness of macroinvertebrates in the tributaries of Agusan river in Esperanza, Agusan del Sur, Philippines, namely the Wawa and Ojot River. Results show that Ojot River has the highest number of species and individuals collected. Wawa River and Ojot river have a Shannon Diversity Index of "Very Low" and "Low" respectively. This could be attributed to some disturbances such as human activities which are observed in both areas. Major phyla collected were arthropoda and mollusca. Taxa 2 which can exist in a wide range of water quality conditions, or moderate water quality dominated both areas. In addition, WQI scores revealed that both rivers have a "rather clean-clean" water quality. Wawa River has FBI score of 4.82 that can be rated with "Good Water Quality" which indicate having "some organic pollution". Furthermore, Ojot River has "Very Good" (3.89) water quality which indicates "Possible Slight Organic Pollution".

Future studies should also include the Physico-chemical parameters of water and soil. Seasonal variations of macroinvertebrates diversity should also be studied to better assess the water quality of the two areas.

Acknowledgment

The authorsare thankful to the Local Government Unit of Esperanza, Agusan del Sur, Philippines for allowing us to conduct the study in their municipality.

References

Agarwal, Animesh, Saxena M. 2011. Assessment of pollution by physicochemical water parameters using regression analysis: A case study of Gagan River at Moradabad- India. Advance Applied Science Research **2(2)**, 185-189.

Agusan River Basin Master Plan. Master Plan for the Agusan River Basin Project, Final Report on May 2008. Retrieved from: www.adb.org/sites/default/files/projectdocument/68233/36540-phi-tacr.pdf

Andem AB, Okorafor KA, Udofia U, Okete KA, Ugwumba AAA. 2012. Composition, distribution and diversity of benthic macroinvertebrates of Ona River, Southwest, Nigeria. European Journal of Zoological Research **1(2)**, 47-53.

Arimoro FO, Osakwe EI. 2006. The influence of sawmill wood wastes on the distribution and population of macroinvertebrates at Benin River, Niger Delta Area, Nigeria. Chemistry and Biodiversity **3,** 578–592.

Arimoro FO, Ikomi RB, Efemuna E. 2007. Macroinvertebrate community patterns and diversity in relation to water quality status of River Ase, Niger Delta, Nigeria. Journal of Fisheries & Aquatic Science **2(5)**, 337-344.

Armitage PD, Pardo I, FurseMT, Wright JF. 1990. Assessment and prediction of biological quality: A demonstration of a British macroinvertebrate-based method in two Spanish rivers. Limnetica **6,** 147-156.

Barbour MT, Gerritsen GE, Snyder BD, Stribling JB. 1999.Rapid Bioassessment Protocols for Use in Streams and Wade able Rivers: Phytoplankton, Benthic Macroinvertebrates and Fish. Second Edition. EPA 841- B-99-002., U.S. Environment Protection Agency; Office of Water; Washington, D.C.

Bode RW, Novak MA, Abele LA. 1996. Quality assurance work plan for biological stream monitoring in New York State. NYS Department of Environmental 31 Protection; Division of water; Bureau of Monitoring and Assessment; Stream Biomonitoring Unit; Albany, NY.

Bouchard RW. 2004. Guide to aquatic macroinvertebrates of the Upper Midwest. Water Resources Center, University of Minnesota, St. Paul, MN. 208 P.

Dacayana CML, Hingco JT, Del Socorro MML. 2013. Benthic macroinvertebrates assemblage in Bulod river, Lanao del Norte, Philippines. Journal of Multidisciplinary Studies, **2(1).** Retrieved from: http://dx.doi.org/10.7828/jmds.v2i1.398.

Edward JB, Ugwumba AAA. 2011. Macroinvertebrate fauna of a tropical Southern Reservoir, Ekiti State, Nigeria. Continental Journal ofBiological Sciences **4(1)**, 30-40.

Hart AI, Zabbey N. 2005. Physico-chemistry and Benthic Fauna ofWoji Creek in the Lower Niger Delta, Nigeria. Environment and Ecology **23(2),** 361-368.

Hartman A. 2006. Key to Odonata (Dragonflies and Damselflies) of Hindu Kush-Himalayan (HKH) Region. Kathmandu University Dhulikhel, Nepal.

Hilsenhoff WL. 1977. Use of arthropods to evaluate water quality of streams. Technical Bulletin No. 100, Department of Natural Resources, Madison, Wisconsin.

Hilsenhoff WL. 1988a. Seasonal correction factors for the biotic index. Great Lakes Entomologist **21,** 9–13.

Hilsenhoff WL. 1988.Rapid Field Assessment of Organic Pollution with a Family-level Biotic Index. Journal of American Benthological Society **7(1),** 65-68.

Idowu EO, Ugwumba AA. 2005. Physical, chemical and benthic faunal characteristic of a Southern Nigeria Reservoir. The Zoologist **3,** 15.

Latha C, Thanga V. 2010. Macroinvertebrate diversity of Veli and Kadinamkulam lakes, South Kerala, India. Journal of Environmental Biology **31,** 543-547.

Lenat DR. 1988.Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. Journal of North American Benthological Society **7,** 222-233.

Ogbeibu AE. 2001. Distribution Density and diveristy of Dipterans in a temporary pond in Okomu Forest Reservoir, Southern Nigeria. Journal of Aquatic Science **16,** 43-52.

Provincial Development Council Agusan del Sur. 2010. The Provincial Development and Physical Framework Plan 2008-2017. Retrieved from: www.agusandelsur.gov.ph/index/images/uploadedfiles/PGAS%20Plans%20and%20Programs/PDPFP%202008-2017.pdf

Romero RDM, Ceneviva-Bastos M, Baviera GH, CasattiL. 2013. Community structure of aquatic insects (Ephemeroptera, Plecoptera, and Trichoptera) in Cerrado streams of Paraguay, Paraná, and São Francisco river basins. Biota Neotropica **13(1),** 97-107.

Sarang N, Sharma L. 2005. Macrobenthic fauna as bioindicator of waterquality in Kishore Sagar Lake, Kota, India. Department of Aquaculture, College of Fisheries Maharana Pratap University of Agriculture and Technology Udaipur, Rajasthan -313001, India. Retrieved from: www.wldb.ilec.or.jp/data/ilec/WLC13_Papers/others/4.pdf

Sharma KK, Chowdhary S. 2011. Macroinvertebrate assemblages as biological indicators of pollution in a Central Himalayan river, Tawi (J & K). International Journal of Biodiversity and Conservation **3(5),** 167-174.

Sigovini M, Tagliapietra D. 2010. Benthic Fauna: Collection and identification of macrobenthic invertebrates. NEAR Curriculum in Natural Environmental Science, Terre et Environment **88,** 253-261

Smith B, Wilson JB. 1996. A consumer's Guide to Evenness Indices. 70 – 82 P.

Stonedahl G, Lattin J. 1982. The Gerridae or water striders of Oregeon and Washington (Hemiptera: Heteroptera). Agricultural expirement station. Technical Bulletin 144, Oregon State University, Corvallis, Oregon.

Strong EE, Gargominy O, Ponder WF, Bouchet P. 2008. Global Diversity of Gastropods (Gastropoda: Mollusca) in Freshwater .pp. 149-166. Retrieved at: www.bioone.org./doi/abs/10.1899/0706/.1?journalcode.Jabs.

Tampus AD, Tobias EG, Amparado RF, Bajo L, Sinco AL. 2012. Water quality assessment usingmacroinvertebrates and physico-chemical parameters in the riverine system of Iligan City, Philippines. Advances in Environmental Studies Bioflux **4(2),** 59-68.
www.google.com.ph