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Aquatic macroinvertebrate diversity and physico-chemical characteristics of freshwater bodies in Tubay, Agusan Del Norte, Philippines

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Abstract
Macroinvertebrates have been utilized to monitor water bodies to evaluate water quality and complement water quality surveys. The physico-chemical features of four freshwater bodies near nickel mining activity was assessed using selected physico-chemical parameters in combination with macroinvertebrate composition scoring and diversity indices. Results showed that a total of 20 species from 13 families of aquatic macroinvertebrate were collected. Tagmamarkay stream had higher species richness and abundance with 16 species but with notable Taxa 3. In Bugnam creek and upstream stations, macroinvertebrates, particularly Taxa 2 and Taxa 1 species make up majority of the organisms. Physico-chemical parameters studied in all four stations are within acceptable limits. Results of this study would serve as baseline data for water quality of these water bodies near mining activity. Long term monitoring and improvement of riparian vegetation nearest these water bodies are recommended to improve macroinvertebrate population and quality of water.

Keywords: Macroinvertebrates, Freshwater Conservation, Water quality, Mining

Introduction

Mineral extraction and construction can potentially increase sedimentation in rivers and streams that may result to a low habitat quality [1]. Although sedimentation is naturally occurring in rivers, increase in anthropogenic inputs and intensely managed land-use may contribute to this problem. Wetland deterioration and land reduction might cause the loss of biodiversity [2].

Aquatic macroinvertebrates species are animals without backbone and can be seen with the naked eye. Aside from that, they were also involved in nutrient cycles, primary productivity, translocation of materials and decomposition of organic material within aquatic environment [3]. Monitoring macroinvertebrates could be a powerful tool in the assessment of habitat quality [4] because aquatic macroinvertebrates can indicate changes in environment the reason why they were utilized as bioindicators [5-7]. Studying macroinvertebrates is an essential way to detect aquatic pollution such as high level of sediment inputs that is influenced by mining activity and decomposition [1]. In most studies, using macroinvertebrates to assess water and habitat quality, water chemistry parameters were also measured to develop possible impact of that specific chemical characteristic to biological data that has been obtained [8]. While there are several reviews that suggest different bioindicators to utilize for the assessment water quality, the use of aquatic macroinvertebrates is still the best [9] and it is well documented because of the amount of sample that the researcher could get, they were manageable and relatively easy to collect [10, 11]. The frequency at which macroinvertebrate species appear in certain parameters could give significant information about the quality of water that every species could tolerate [8].

Threats like large scale nickel effluents are situated in Tubay, Agusan Del Norte, Philippines. Pollution and fine sedimentation due to mining activity could alter natural flora and fauna assemblage that thrive inside the mining area. Riparian zone, as an ecotone serves as the vector propagating matter, energy and organisms [12]. Riparian vegetation has the ability to control and recycle allochthonous input from upland area thus riparian zone alterations may affect the whole river ecology [12, 2]. The primary aim of this study is to assess the population of macroinvertebrates and physico-chemical features at the four sampling stations (1) Bugnam (2) MBR (3) Dumlao and (4) Tagmamarkay, in Tubay, Agusan Del Norte, Philippines.

Material and Methods

Study period and location

Four freshwater bodies in Tubay, Agusan del Norte, Philippines (Figure 1) were utilized for collection of samples. This research was conducted last June-July 2015. Study sites for macroinvertebrates collection, and physico-chemical analysis includes Bugnam (station 1), Mountain Beach Resort (station 2), Dumlao (station 3) and Tagmamarkay (station 4). Among the four sampling sites Bugnam is located at the highest elevation (136 meters above sea level). It is exactly located inside the mining area with visibly disturbed physical appearance and minimum channel enlargement resulting from sediment accumulation hence, silts are common (due to bank erosion). Upstream Mountain Beach Resort or MBR is the second study station with tight vegetation and rocks that are present in the streams. It is located far from mining activities in a slightly elevated area (94 meters above sea level). Dumlao (station 3) and Tagmamarkay (station 4) are located at lowland agricultural landscape where runoff is high and this serves as catchment basin from high elevated streams. Different types of farming are employed with various physical modifications.

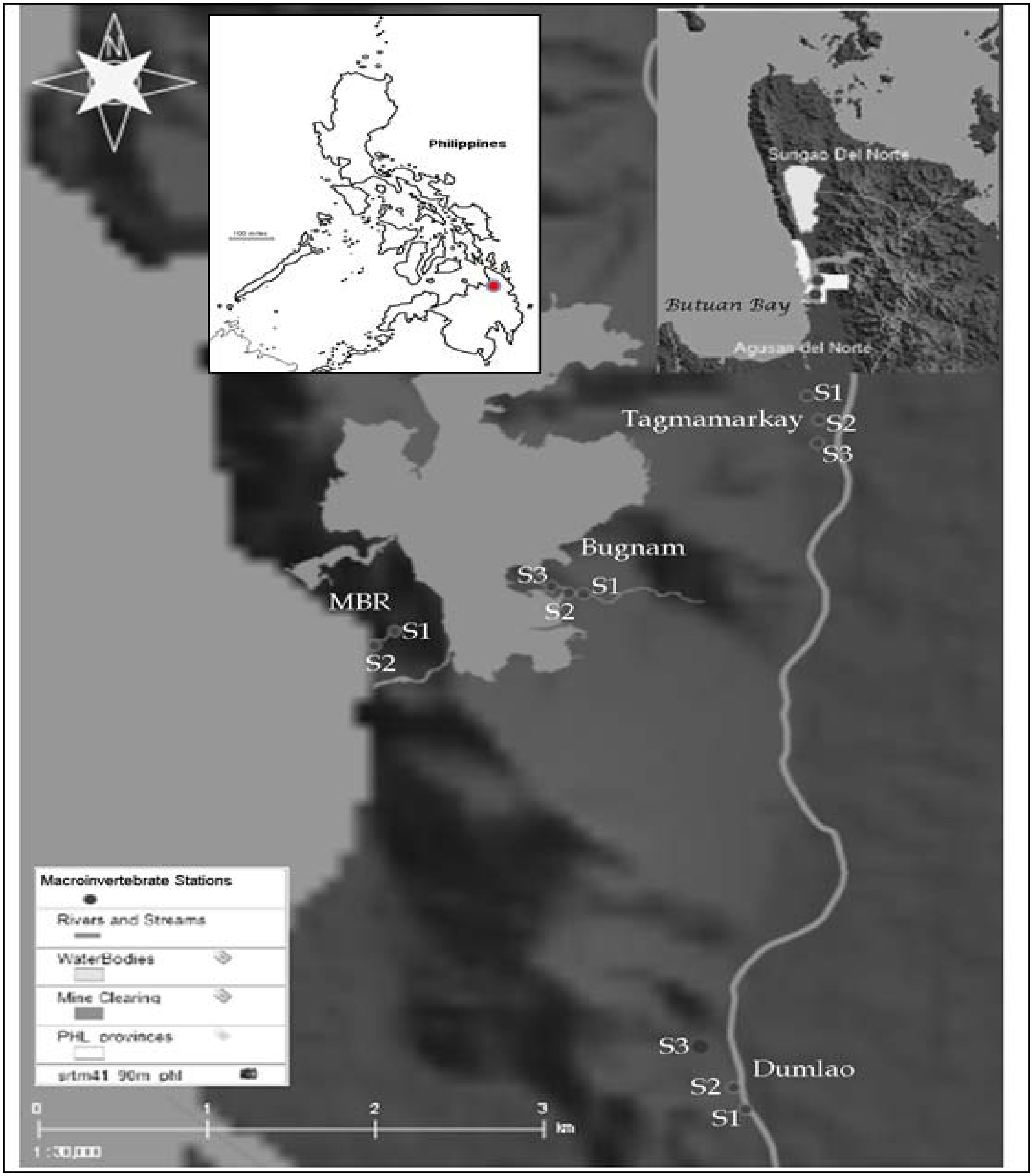

Fig 1: Map showing four freshwater bodies studied in Tubay, Agusan del Norte, Philippines

Diversity of aquatic macroinvertebrates

Collection of macroinvertebrates was conducted following the Reach-wide benthos (Multihabitat) procedure of SWAMP (2007) with some modifications. Each station consist of three replicated transect lines with a length of 100 m. A 100 m transect line was established perpendicular to the water body. Collected samples were identified up to the lowest practical level, generally genus or species with the aid of LASEZ (Leica Application Suite) ver. 1.7.0. The identification of macroinvertebrates was done using the information from the Journals and Internet data base. Macroinvertebrates were classified as to their tolerance value depending on their response to specific changes in water conditions. Stream invertebrates were grouped into three Taxa based on their tolerance to aquatic disturbances [13]. Taxa 1 were pollution sensitive organisms found in good water quality and included species belonging to orders Ephemeroptera, Plecoptera, Tricoptera, and Coleoptera. Taxa 2 were from orders Hemiptera, Diptera, Odonata, Decapoda, and Veneroida that could exist in moderate water quality. Taxa 3 were species that were very tolerant to poor water quality and belonged to order Tudificida, Gastropoda, Hirudinidae, Cerithioidea and Isopoda. Water quality index (WQI) scores developed by Armitage *et. al.* (1983)[16] were used, the identified macroinvertebrates were sorted and scored with their particular points then, the sum was obtained and subsequently divided by the number of species scored (Table 1).

Table 1: Water Quality Index

Score	Indication
7.6-10	Very Clean
5.1-7.5	Rather clean-clean water
2.6-5.0	Average
1.0-2.5	Dirty Water
0	Very Dirty (No life found)

Water Quality Assessment

In each study station, three replicates at 30 m distances within each of the 100 meter were utilized to measure some physico-chemical parameters. To record temperature (°C), dissolved oxygen (mg/L), pH (1-14), Total Dissolved Solids (ppm) and conductivity (microsiemens), Waterproof Cyberscan CD 650 multimeter kit (®Eutech Instruments) a standard hand-held meter was used.

Analysis

Diversity indices such as abundance, evenness, richness and Shannon-Weiner Index of diversity were determined using Paleontological Statistics Software (PAST). Nonparametric analysis to compare indices between stations was done using nMDs and cluster analysis through PAST® software.

Results and Discussion

Macroinvertebrate study

Study stations differ mainly from channels structure, substrate appearance, vegetation in riparian zone, elevation and degrees of anthropogenic disturbances. Hence, differences of aquatic macroinvertebrate community in study stations are evident. Macroinvertebrates found in four sampling stations within the premises of nickel mine site were shown in Table 4. Twenty (20) aquatic macroinvertebrates belonging to thirteen (13) families were collected and identified. Most of the collected of organisms belonged to Phylum Arthropoda (Figure 2A) which was dominated by family Gerridae with 5 species. Compared to other stations, Tagmamarkay had the most number of species and individuals observed, followed by Dumlao, upstream MBR and Bugnam creek. According to Wood and Armitage (1997) fine sediments could alter the feeding activities of filter feeder organisms such as most of benthic invertebrates. Deposition of silt in Bugnam creek due to unstable substrate, could affects the respiration of macroinvertebrates from silt, due to low oxygen concentration. That explains why collected samples from Bugnam creek were dominated by two species of water strider *Gerris marginatus* and *Rhagovelia* sp. (Table 3). Further, upstream MBR has thick riparian vegetation that provides shade to the bodies of water and the only station that has the presence of large boulders of rock especially at the elevated part of the station. Pollution sensitive species such as damselfly and whirligig beetle were found at MBR. Thiarids (snails) dominated the macroinvertebrate population in Tagmamarkay. It is important to note that freshwater shrimps were only observed abundantly in this area, *Hirudo* (leech) species which is known to be highly tolerant to poor water quality were also found at Tagmamarkay. Portion of the Tagmamarkay stream were clogged with water hyacinth, it has clear water but becomes easily turbid when disturbed.

Water quality based on bioindicator aquatic macroinvertebrates species show WQI scores that says the water quality is of "average" quality. The results obtained may be due to the fact the there was a minimal number of families from Taxa 1 that are known to be pollution sensitive species like whirligig beetles and coccinellid beetles. In contrast, Taxa 2 species which are species that can exist in a wide range of water quality such as Gerrids, damselflies and dragonfly nymphs were found abundantly in most areas. Accordingly, Ephemeroptera, Plecoptera and Tricoptera representative were absent in all areas. Lenat (1984)[7] reported that streams that receives inputs from agricultural runoff would also have greater suspended solids and high sedimentation, increase in particulate organic matter and elevated nutrients concentrations, which lowers the abundance of Ephemeroptera, Plecoptera and Trichoptera. Such groups are known as pollution sensitive species. The disturbances along the riparian zone also contributed to these results. Figure 2B showed that the composition in Bugnam and upstream MBR were mostly Taxa 1 and Taxa 2 while in Dumlao and Tagmamarkay were mostly Taxa 2 and Taxa 3. The observation of large number of palemonid shrimps and thriarids along with single species of leech have affected the WQI of Tagmamarkay although there was high diversity and abundance of macroinvertebrates in this study station. This explains the distinct cluster of macroinvertebrates population in Tagmamarkay compared to the three other stations (Figure 3).

Table 2. Description of the four sampling sites showing their coordinates and respective physical parameters

Site/Parameter	Bugnam	MBR	Dumlao	Tagmamarkay
GPS readings	N 09°11'47.5'' E 125°32'32.2''	N 09°11'38.8'' E 125°31'55.8''	N 09°09'44.6'' E 125°33'04.5''	N 09°12'34.1'' E 125°33'15.3''
Elevation	136 masl	94 masl	53 masl	37 masl
River width (average)	2.4m	1.6m	17.4m	1.4 m
River depth (average)	1.1m	0.5m	11.6m	0.7m
Width of riparian area (average)	2.4m	1.6m	17.4m	1.9m

Table 3. Inventory of aquatic macroinvertebrates and their corresponding Taxa grouping based on sensitivity/tolerance to pollution

Phylum	Order	Family	Scientific Name	Common Name	Taxa
Annelida	Hirudinida	Hirudinidae	*Hirudo* sp.	Leech	3
Arthropoda	Hemiptera	Notonectidae	*Notonecta* sp.	Back swimmer	2
		Gerridae	*Gerris marginatus*	Water striders	2
			Gerris sp.	Vertical stripped strider	2
			Gerris najas	River skater	2
			Metrobates sp.	Short bodied strider	2
			Rhagovelia sp.	Small water strider	2
		Belostomatidae	*Diplonychus rusticus*	Water bug	2
		Nepidae	*Ranatra linearis*	Water stick	2
	Odonata	Coenagrionidae	*Ischnura* sp.	Damselfly nymph	2
		Coenagrionidae	*Enallagma* sp.	Damselflies	2
		Macromiidae	*Macromidae* sp.	Dragonfly nymph	2
	Coleoptera	Gyrinidae	*Dineutus* sp.	Whirligig Beetles	1
		Coccinellidae	*Harmonia axyridis*	Lady bug	1
	Decapoda	Palaemonidae	Palaemonid sp.	Small-sized Freshwater Shrimp	2
		Parathelpusidae	Brachyurid sp.	Small freshwater crab	2
Mollusca	Gastropoda	Thiaridae	*Melanoides tuberculata*	Red rimmed melania	3
			Thiara scabra	Spike tail snail	3
			Pomacea canaliculata	Channeled apple snail	3
	Veneroida	Corbicula	*Corbicula fluminea*	Asiatic clam	3

Taxa 1- Pollution sensitive organisms found in good water quality
Taxa 2- Can exist in wide range of water quality conditions; generally moderate water quality
Taxa 3- Can exist in wide range of water quality conditions; highly tolerant to poor water quality

Table 4: List of aquatic macroinvertebrates and their WQI from waterways of Tubay, Agusan Del Norte

	Sampling Sites and WQI							
Scientific Name	**Bugnam**	**WQI**	**MBR**	**WQI**	**Dumlao**	**WQI**	**Tagmamarkay**	**WQI**
Hirudo sp.	0	0	0	0	0	0	1	3
Notonecta maculata	0	0	5	5	0	0	0	0
Gerris marginatus	28	5	9	5	48	5	8	5
Gerris sp.	3	5	0	0	2	5	1	5
Gerris najas	0	0	19	5	0	0	0	0
Metrobates sp.	1	5	0	0	0	0	2	5
Rhagovelia sp.	13	5	28	5	13	5	0	0
Diplonychus rusticus	0	0	0	0	1	6	1	6
Ranatra linearis	0	0	0	0	0	0	9	6
Ischnura sp.	0	0	0	0	2	6	8	6
Enallagma sp.	0	0	1	6	0	0	6	7
Macromidae sp.	0	0	0	0	0	0	9	6
Dineutus sp.	2	5	1	5	0	0	0	0
Harmonia axyridis	0	0	0	0	0	0	1	5
Palaemonid sp.	0	0	9	4	1	4	28	4
Hemigrapsus nudus	0	0	0	0	0	0	8	4
Melanoides tuberculata	0	0	0	0	0	0	8	3
Thiara scabra	0	0	0	0	7	3	5	3
Pomacea canaliculata	0	0	0	0	4	3	13	3
Corbicula fluminea	0	0	0	0	0	0	3	4
Total	47	25	72	35	78	37	111	75
WQI score		5		5.28		4.5		4.65

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)

Table 5: Diversity indices of aquatic macroinvertebrates in the four study stations near mining area of Tubay, Agusan Del, Norte

Indices	Bugnam	MBR	Dumlao	Tagmamarkay
Taxa	5	7	8	16
Individuals	47	72	78	113
Dominance	0.4378	0.2573	0.4404	0.1249
Simpson	0.5622	0.7427	0.5812	0.8798
Shannon	1.056	0.7427	0.5596	0.8751
Evenness	0.5749	0.6682	0.4432	0.6735

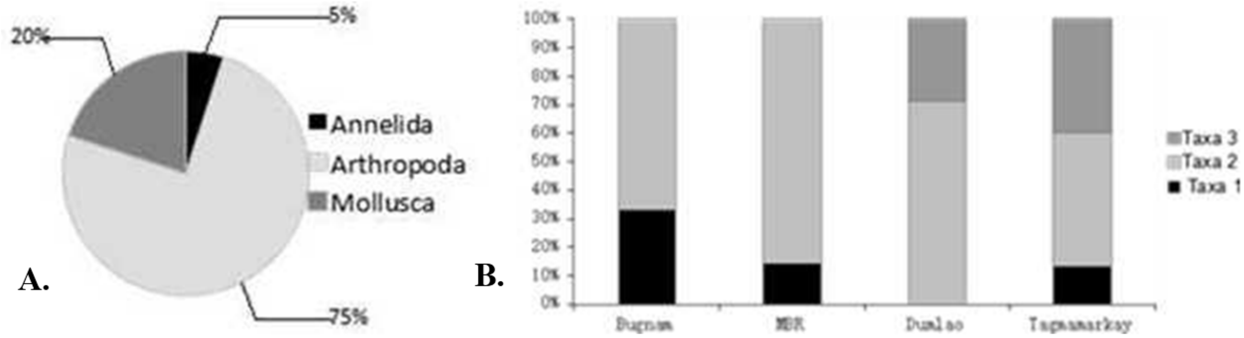

Fig 2: Percent (%) composition of major phyla of aquatic macroinvertebrates (A); and Taxa groupings of indicator macroinvertebrates in the four study stations in Tubay, Agusan Del Norte (B)

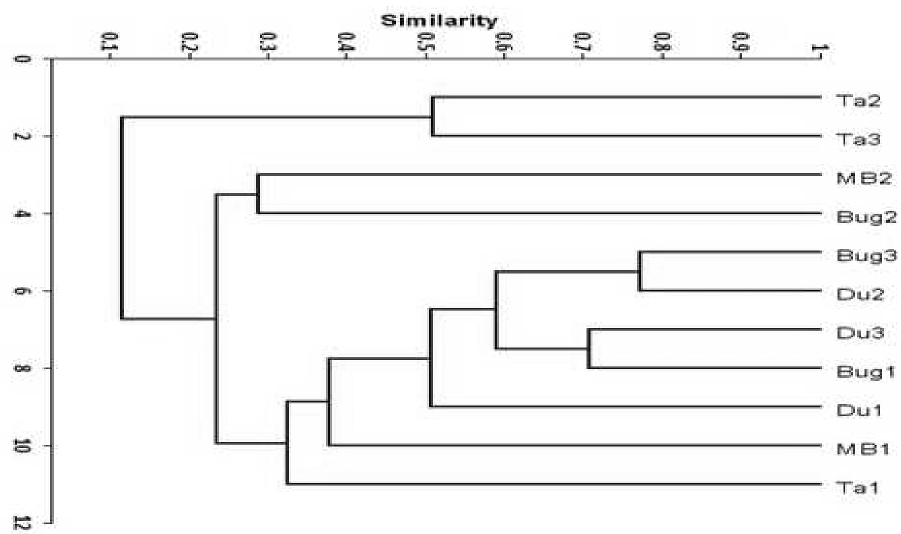

Fig 3: Dendogram of similarity of macroinvertebrate populations in the four study stations in Tubay, Agusan Del Norte, Philippines.

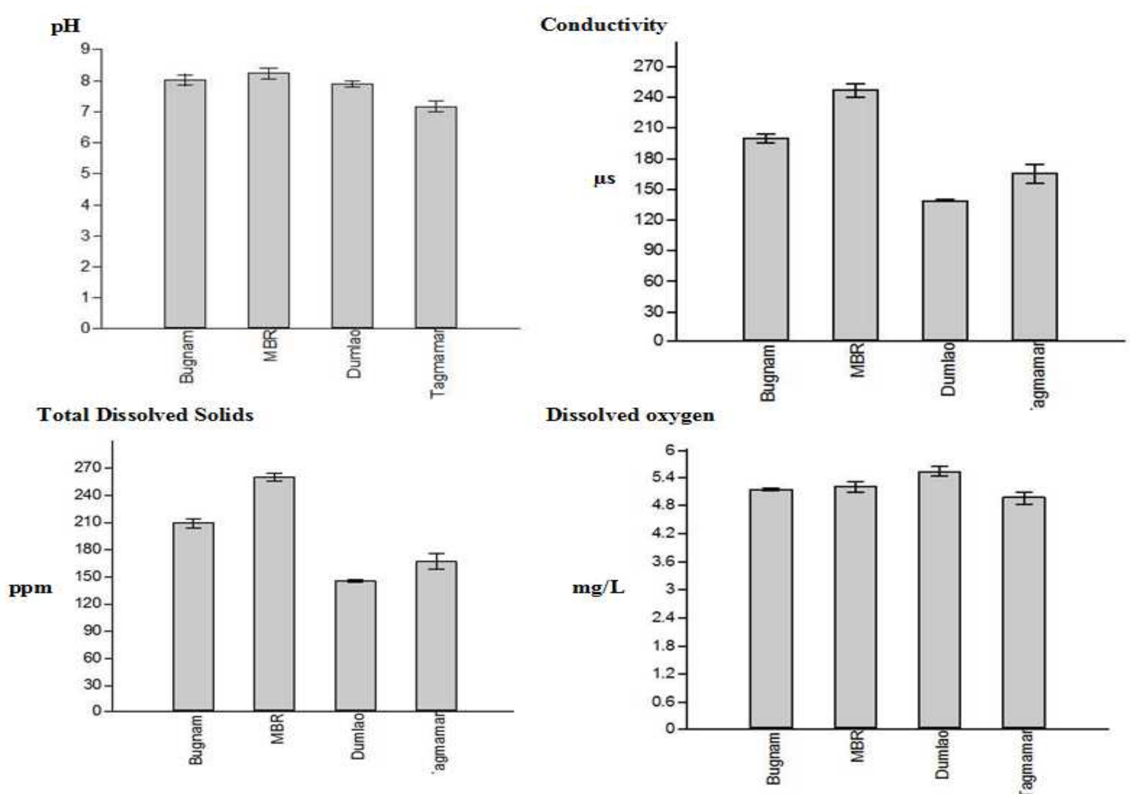

Fig 4: Physico-chemical parameters of the four study stations.

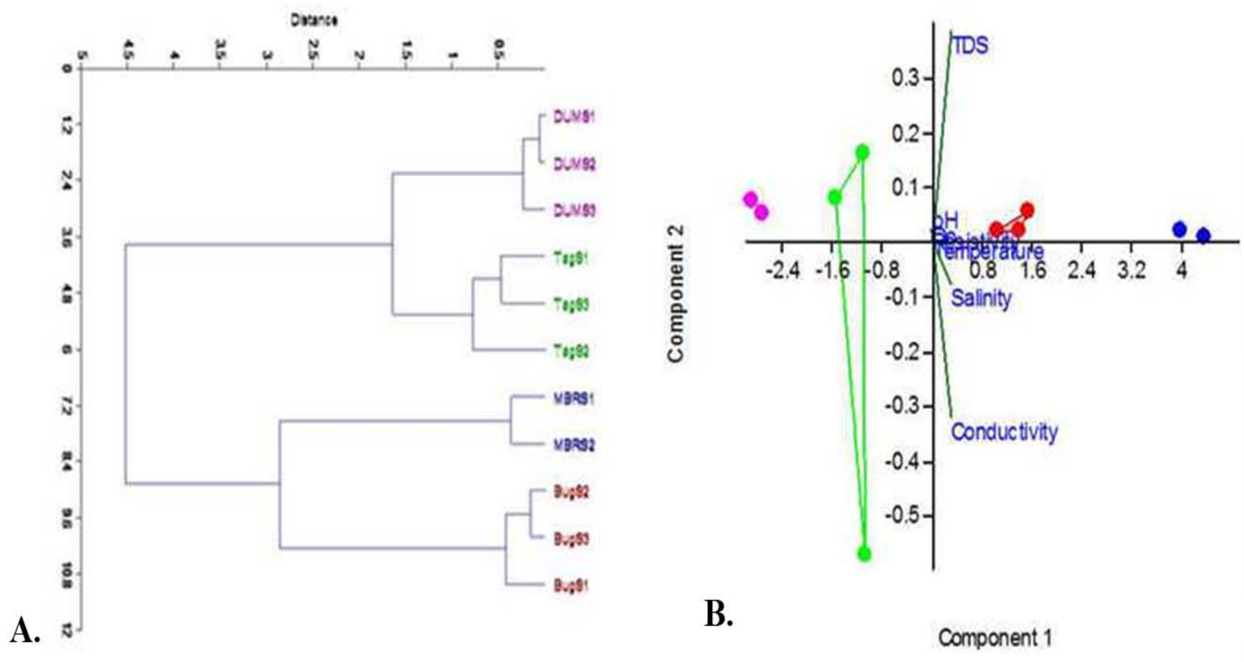

Fig 5: Multivariate relationship of study stations based on their physico-chemical features. A: Dendogram of similarity of study stations based on physico-chemical parameters; B: Principal component analyses (PCA) showing distinct groupings/relationships physico-chemical data for MBR (blue), Bugnam (Red), Dumlao (Pink) and Tagmamarkay (Purple).

Physico-chemical Assessment

Water quality of four sampling stations was characterized based on four physico-chemical parameters (Table 6), Figure 4). Data that has been collected showed that all study stations are within the standard limits as required by DENR Administrative Order No. 34 series of 1990 (DAO 90-34). Basic water quality parameters are generally the same in terms of temperature. Among the four study stations upstream MBR has higher level of pH and conductivity due to the presence of large boulders of rocks. Ideally, freshwater aquatic organisms prefer pH range "between" 6.5-8.0. The value of TDS range from 144-260 ppm, which was still as the prescribed limits of DENR. This is due to high dissolved salts of calcium, magnesium and iron [14] in the study station. Statistical analysis however, show that there were similarities in the physico-chemical features of the two nearest stations-Bugnam and upstream MBR and the other stations- Dumlao and Tagmamarkay. This similarity could be due to elevation, similarity in vegetation and shade of areas.

Table 6: Physico-chemical features of the four study stations within and nearest the premises of mining area (Mean±SEM).

Parameters	Bugnam	MBR	Dumlao	Tagmamarkay
pH (1-14)	8.017± 0.047	8.265± 0.044	7.887± 0.027	7.146± 0.471
Conductivity (µs)	199.31± 1.26	248.32± 4.87	138.27± 0.355	164.43± 4.059
Total Dissolved Solids (ppm)	209.22± 1.44	260.22± 4.41	144.88± 0.355	166.26± 3.759
Temperature (°C)	25.744± 0.047	26.117± 0.186	25.922± 0.149	25.889± 0.086
Dissolve Oxygen (mg/L)	5.144± 0.044	5.25± 0.0763	5.522± 0.795	4.956± 0.192
Standard Values for Freshwater				
DO	pH	TDS	Salinity	Conductivity
>5 mg/L	6.5-8.5	<1000 mg/L	<0.5 mg/L	<1500 (µs)/cm

Conclusion

Macroinvertebrate community and physico-chemical parameters were studied to assess habitat and water quality. Five important environmental variables such as temperature, dissolved oxygen, pH, total dissolved solids and conductivity were also recorded. These supported macroinvertebrate data and revealed that the water quality was still within acceptable limits that was implemented by DENR (DAO-90-34). Tagmamarkay had the most number of species and individual that was dominated by pollution tolerant from Taxa 3 and species that could live on moderate water quality Taxa 2 particularly *Thiara* and *Melanoides*. Taxa 1, the pollution sensitive species were also present in Tagmamarkay but in minimal number only. One *Hirudo* sp. from Hirudinidae family was collected at Tagmamarkay. Annelids were noted as species that could tolerate pollution. Water quality assessment based on pollution sensitive and pollution tolerant for all stations revealed a score ranging 4.5-5.28 indicating "average" water quality.

Aquatic organisms such as benthic macroinvertebrates are filter feeders and favor an environment that has a great supply of oxygen. Considering the health of organisms, improvement of the riparian habitat such as planting more native tree, shrubs and lesser disturbance in this buffer zone is highly recommended. Improvement of the riparian vegetation near the water bodies will eventually improve the quality of water and the diversity of aquatic macroinvertebrates.

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References

1. Wood PJ, Armitage PD. Biological Effects of Fine Sediment in the Lotic Environment. Environmental Management. Springer-Verlag New York Inc. 1997; 21:203-217.
2. Brinson MM, Bradshaw HD, Kane ES. Nitrogen cycling and assimilative capacity of an alluvial flood plain swamp. Journal of Applied Ecology. 1984; 21:1041-1057.
3. Wallace JB, Webster JR. The role of microinvertebrates in stream ecosystem. Annu. Rev. Entomol 1996; 41:115-139.
4. Barbosa FAR, Callisto M, Galdean N. The diversity of benthic macroinvertebrates as an indicator of water quality and ecosystem health: a case study for Brazil. Taylo and Francis and AEHMS. 1463-4988/01/ 2001; 4:51-59.
5. Hodkinson ID, Jackson JK. Terrestrial and Aquatic Invertebrates as Bioindicators for Environmental Monitoring, with Particular Reference to Mountain Ecosystem. Environmental Management 2005; 35:649-666.
6. Hellawell JM. Biological Surveillance of River. Water Research Center. Stevenage Laboratory, UK, 1978.
7. Lenat DR. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. J North Am Benthol Soc. 1988; 7:222-233.
8. Resh VH, Unzicker JD. Water Quality Monitoring and Aquatic Organism: the importance of species identification. Water Environment Federation. 1975; 47:9-19.
9. Duran M. Monitoring Water Quality using Benthic Macroinvertebrates and Physicochemical Parameters of Behzat stream in Turkey. Polish J of Environ. 2006; 15:709-717.
10. Whiles MR, Brook BL, Franzen AC, Dinsmore SC II. Environmental Auditing Stream Invertebrate Communities, Water Quality, and Land-Use Patterns in an Agricultural Drainage Basin of Northeastern Nebraska, USA. Environmental Management, Springer-Verlag New York Inc 2000; 26:563-576.
11. Muños CZ, Cantero CES, Ortega AS, Tercedor JA. Are Biological Indices BMPW and ASPT and Their Significant Regarding Water Quality Seasonally Dependent? Factors explaining their variations. Water Res. 1995; 29:285-290.
12. Tabacchi E, Correll DL, Hauer R, Pinay G, Tabacchi AMP, Wissmar RC. Development, maintenance and role of riparian vegetation in the river landscape. Freshwater Biology. 1998; 40:497-516.
13. Barbour MT, Gerritsen GE, Synder BD, Stribling JB. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Phytoplankton, Benthic Macroinvertebrates and Fish. Second Edition. EPA 841-B-99-002., U.S. Environment Protection Agency; Office of Water, Washington, D.C, 1999.
14. Pandey SK, Tiwari S. Physico-chemical analysis of ground water of selected area of Ghazipur City- A case study. Nature and Science 2009; 7:1545-0740.
15. SWAMP Bioassessment Procedures. Standard Operating Procedures for Collecting, 2007.
16. Armitage PD, Moss D, Wright JF, Furse MT. The performance of new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. Water Research 1983; 17:333-347.
17. Benthic Macroinvertebrates Samples and Associated Physical and Chemical Date for Ambient Bioassessments of California. Original Issue February, 2007. www.waterboards.ca.gov/swam.