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DIVERSITY OF MACROBENTHIC INVERTEBRATES IN THE INTERTIDAL ZONE OF BRGY. TAGPANGAHOY, TUBAY, AGUSAN DEL NORTE, PHILIPPINES

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***Abstract*— Macrobenthic invertebrates in the intertidal zone of Barangay Tagpangahoy, Tubay, Agusan del Norte, a mining identified area, were assessed. One sampling was done during low tide on May 5-6, 2009. Transect-quadrat method was used in an approximately 75,000 m^2 study area. Three hundred twenty six individuals belonging to 39 species were found in the area. These samples belong to three phyla namely: Mollusca, Echinodermata, and Arthropoda. The top three most abundant species found were mollusks. These are *Planaxis* sp., *Nerita* sp., and *Isognomonisognomon* with the relative abundance value of 18.71%, 12.27%, and 8.90% respectively. Most of the macrobenthic fauna were arranged in a clumped distribution pattern, while the rest were dispersed uniformly. About 69.93% of the total numbers of individual present in the area were found in rocky substrate. Meanwhile, about 13.80% were found in the sandy-rocky substrate; 10.43% were found in the sandy substrate; and only about 5.83% were found in the sandy-muddy-rocky substrate. The species diversity of the area is 3.00, which is relatively higher compared to reports from other related studies. The values of pH, salinity and temperature taken were within the normal range of these characteristics of marine water.**

Index Terms*— *Agusan del Norte, Brgy. Tubay, diversity, intertidal zone, macrobenthic invertebrates, Philippines

I. INTRODUCTION

Macrobenthic invertebrates are an extremely important part of the marine ecosystem [1]. Over the 95% of the known marine species are considered benthic. These include epifauna which live on or move over the surface of a substrate [2]. They have the ability to attach to the firm substrate and/or can move freely along the seafloor. The other group belongs to the infauna, inhabitants that live within the sediments instead on the bottom sediments [2,3].

These organisms live in all types of marine substrates from soft oozes to rocky bottoms. They are big enough to be seen with the naked eye, though some can be very small. The main groups of aquatic macro invertebrates are worms, snails, crustaceans and insects. Macrobenthic invertebrates have well- known sensitivity and quick responses to environmental degradation. These organisms act as biological indicators [4]. Biological indicators are organisms whose presence, absence or condition provides information about the environmental quality [2, 5].

Macrobenthic invertebrates are links in the aquatic food chain. They help maintain the health of water ecosystem by eating bacteria and decaying plants and animals. In otherwise stable communities, sudden changes in their species composition and relative abundance signal poor health of significant disturbance of the system [6].

Different groups of macro invertebrates have different tolerances to pollution, which means they can serve as useful indicators of water quality [7]. These organisms are differently sensitive to fluctuations of many biotic and abiotic factors. Such organisms have specific requirements in terms of physical and chemical conditions. Consequently, the changes in the macro invertebrates' community structure have been commonly used as an indicator of the condition of an aquatic system [8]. Changes in the presence or absence, numbers, morphology, physiology or behavior of these organisms can indicate that the physico-chemical conditions of the water are beyond their preferred units [9]. The open sea and the intertidal ecosystems are vulnerable to different kinds of major pollutants coming from several destructive anthropogenic activities [3].

The diversity and abundance of macrobenthic invertebrates therefore can be used as an indication to water's health [10]. This is because these organisms possess a wide range of responses to stressors, such as pollutants that affect water quality. Healthy water or good water quality is characterized by the absence of sewage sludge, industrial wastes, garbage, toxic substances, radioactive wastes, construction materials, and oil [11]. This pollution has degraded macrobenthic invertebrates and even other marine organisms. The decrease in number of some of these invertebrates and/or the increase in few indicate poor water quality and inability to support life adequately [12].

Barangay Tagpangahoy is a small barangay situated at Tubay, Agusan del Norte, Philippines and can be found east of Butuan Bay. Few kilometers away from the barangay are mining companies, which are actively operating. Pollutants coming from the wastes of these industries might affect both the open sea and the intertidal ecosystems. The presence of mining activities is predicted to create an impact on the macrobenthic community in a particular area, but the impact cannot be properly evaluated without baseline data. At present, there is no study on macrobenthic invertebrates in the intertidal zone of the barangay. There is a pressing need to survey the macrobenthic invertebrates to evaluate whether the intertidal zone of Barangay Tagpangahoy still supports important species. This study is an assessment on the macrobenthic invertebrates in the area in terms of species diversity, composition and abundance. The research output will serve as baseline data that will help residents know the possible effects of current human activities, particularly mining activities in the area; and encourage the Local Government Units (LGUs) to come up with measures to help

conserve and preserve the environment, as well as the different species present.

II. MATERIALS AND METHODS

A. Study Area

Barangay Tagpangahoy is a small area situated at Tubay, Agusan Del Norte, Philippines (Fig. 1). It is located east of Butuan Bay, near mining companies which are actively operating (Fig 2). It is a coastal barangay composed of ninety households. Only about thirteen houses are settled in front of the intertidal zone. The intertidal zone is located 09 ^{0}14 '29.6'' North Latitude and 125 ^{0}30' 30.5'' Longitude. The whole stretch of the intertidal zone was used as the sampling area and is about 750m in length.

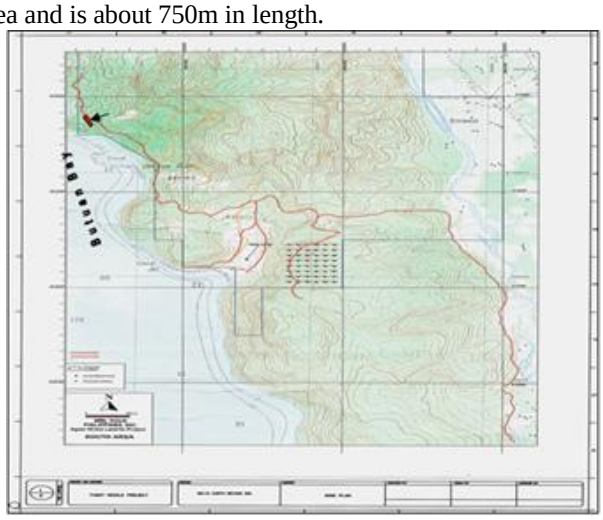

Fig. 1. **Map Showing Barangay Tagpangahoy, Tubay Agusan del Norte.**

Fig. 2. **Map of Tubay, Agusan del Norte, Philippines.**

B. Establishment of the Sampling Site

Sampling and data gathering were conducted from May 5 to 6, 2009 during low tide. The transect-quadrat method was employed during the sampling. Fifteen transect lines were established, from the low tide mark to the edge of the intertidal area. The whole stretch of the intertidal zone was used as the sampling area and is about 750m in length. The transect lines were laid perpendicular to the shore, which were 50 m apart. Laying of transect lines depended on the topography of the intertidal zone. Transects 1-4 were about 80m long each; transect 5 was about 90m; transects 6-11 were about 100m each; transect 12 was 90m; transect 13 was 80m; and transects 14 and 15 were about 60m. A 0.25m^2 quadrat was laid alternately 1m away from the transect lines at 5 m interval.

C. Collection and Preservation of Samples

All surface macrobenthic invertebrates found within the quadrat were counted and recorded. Representative samples were collected and placed in pre-labeled plastic bags for identification in the laboratory. Necessary safety precautions were employed in handling or hand picking of the samples. The representative samples collected were washed with sea water and transferred into plastic containers and preserved using 5% formalin solution. Echinoderms collected were sun dried. Mollusks with shells were extracted from the shells; and the shells were thoroughly washed and sun dried.

D. Determination of Physico-Chemical Parameters and Zonation Pattern

The water temperature, salinity and pH were taken in situ per quadrat using a laboratory thermometer, refractive salinometer and portable pH meter respectively. Substrate type was also noted and recorded. The identification of the substrate was based on the description of Smith [3]. Spatial distribution of macrobenthic invertebrates in terms of quadrat-distance from shore was determined. This was done by examining the trend of the number of individuals belonging to different phyla present in the intertidal zone at various distances from the shore.

E. Identification and Documentation

Identification of the preserved organisms was performed in the Science Laboratory of Xavier University, Cagayan de Oro City. The representative samples were identified on the basis of their external morphology using various taxonomic keys including the Encyclopedia of Shells by Peter Dance and Echinoderms in the Philippines by Schoppe [9]. Photographs of the study area and the establishment of transect lines and quadrats were taken during field sampling. Dorsal and ventral orientations of the collected representative species were documented to highlight their physical characteristics.

F. Identification and Documentation

Species diversity indices, relative abundance, dominance, evenness and distribution pattern were determined using PAST version 1.74.

III. RESULTS AND DISCUSSION

A. Species Composition and Relative Abundance

A total of 326 macrobenthic invertebrates belonging to 39 species were found within the 300 quadrats laid in the intertidal zone or 4-5 individuals / m^2 (Table I). These organisms belong to three different phyla; Mollusca, Echinodermata and Arthropoda with densities of ~ 4 individuals / m^2, 1 individual/ 2m^2, and 4 individuals/ 100 m^2 respectively. Thirty one species identified belong to Phylum Mollusca; 7 species to phylum Echinodermata, and 1 species to phylum Arthropoda. The top three most abundant species all belong to Phylum Mollusca: *Planaxis* sp. with relative abundance of 18.71% (~ 1 individual / m^2), *Nerita* sp. with relative abundance of 12. 27% (1 individual/ 2 m^2), and *Isognomon isognomon* with a relative abundance of 8.90% (~ 4 individuals/ 10 m^2).

Among the three phyla, Phylum Mollusca had the highest relative abundance value of 87.73%, followed by Phylum Echinodermata with a relative abundance of 11.35%. Phylum Arthropoda had only 0.92%.

Like many previous studies, the molluscs were found to be the most abundant. A mollusk, *Eutheria dira*, was also found to be the most abundant in the intertidal zone of Magting Mambajao, Camiguin in the year 2000 [13], Poblacion, El Salvador, Misamis Oriental last 2005 [14]. Abundance of mollusks in the intertidal zones simply imply that interactions between molluscan species is significant and that each species is well adapted to the variations of the physical factors experienced by organisms in the intertidal zone.

TABLE I. NUMERICAL AND RELATIVE ABUNDANCE OF MACROBENTHIC SPECIES

Species number	Species Name	No. of individuals	Relative abundance
Phylum Mollusca			
1	*Acmea saccharina*	25	7.67
2	*Anadara sp.*	3	0.92
3	*Angaria sp.*	17	5.21
4	*Astraea sp1.*	6	1.84
5	*Astraea sp2.*	5	1.53
6	*Cantharus sp.*	1	0.31
7	*Cellana concillata*	9	2.76
8	*Cellana sp.*	10	3.07
9	*Cerithium chemnitzianum*	1	0.31
10	*Cerithium sp.*	6	1.84
11	*Chione sp.*	2	0.61
12	*Conus canonicus*	5	1.53
13	*Conus sp.*	1	0.31
14	*Conus textile*	1	0.31
15	*Cypraea sp1.*	1	0.31
16	*Cypraea sp2.*	1	0.31
17	*Drupa grossularia Roding.*	4	1.23
18	*Isognomon isognomon*	29	8.90
19	*Nerita sp.*	40	12.27
20	*Pinna sp.*	2	0.61
21	*Planaxis sp.*	61	18.71
22	*Strombus labiatus*	5	1.53
23	*Strombus luhuanus*	2	0.61
24	*Thais sp.*	5	1.53
25	*Timoclea ovata*	13	3.99
26	*Trochus lineatus*	5	1.53
27	*Trochus niloticus*	2	0.61
28	*Trochus sp.*	7	2.15
29	*Turbo sp.*	15	4.60
30	*Unidentified species of oyster*	1	0.31
31	*Vexillum plicarum*	1	0.31
Subtotal		**286**	**87.73**
Phylum Echinodermata			
1	*Astropectin polyacanthus*	1	0.31
2	*Culcita novaeguineae*	1	0.31
3	*Diadema setosum*	11	3.37
4	*Echinometra mathaei*	11	3.37
5	*Linckia laevigata*	7	2.15
6	*Macrophiotrix longipeda*	5	1.53
7	*Ophiolepis sp.*	1	0.31
Subtotal		37	**11.35**
Others			
1	*Pagurus arcuatus*	**3**	**0.92**
Total		**326**	**100**

B. Species Diversity, Evenness and Dominance

Species diversity, dominance, and evenness were determined and presented in Table II. The macrobenthic community in the area was more diverse compared to the reports of other related studies such as those conducted by Santiago [15], in the marine sanctuary of Goso-on Carmen, Agusan del Norte in 2002 and Obuyes [16] in the marine sanctuary of Burnay Gitagum, Misamis Oriental in 2007 who reported values of species diversity of 0.82 and 2.83 respectively. However, this is lesser compared to the study of Quiblat [17] in the intertidal zone of Guinsiliban, Camiguin Province in 2004 who reported diversity index value of 3.13.

TABLE II. DIVERSITY OF MACROBENTHIC SPECIES IN THE INTERTIDAL ZONE OF BARANGAY TAGPANGAHOY, TUBAY, AGUSAN DEL NORTE

Indices	Value
Shannon (H)	3.00
Dominance (D)	0.08
Evenness (E)	0.51

C. Distribution Pattern

The distribution patterns of the reported species are presented in Table III. Results indicate that 18 out of 31 Molluscan species displayed clumped distribution. In the animal world, this is the most common dispersion type [3,18]. The individuals found in the intertidal zone occurred in groups. This is maybe the result of spatial variation in habitat availability or rather limited powers of dispersion. As the data suggest, most of those that display clumped distribution pattern were those that confine to rocks as their habitat. Since the intertidal zone is subjected to daily variations of tides, these organisms also are much well adapted to changes in temperature of the area. Temperature in intertidal zones vary widely with the ebb and flow of the tide [3,19].

Another pattern of distribution exhibited by the macrobenthos in the study area is the regular or uniform distribution. Thirteen out of thirty one in this distribution pattern, individuals are distributed uniformly and are more or less evenly spaced. This is usually the result of some form of competition such as territoriality [20]. This simply suggests that such organisms have direct interactions with each other; and between individuals in a population. This relationship could be due to an aggressive social interaction.

No macrobenthic invertebrate in the area were found to display the random distribution pattern. Random spacing or unpredictable dispersion occurs in the absence of strong attractions or repulsions among individuals in the population [20].

D. Zonation Pattern

Fig. 3 shows that macrobenthic species under Phylum Mollusca were found in all distances from the shore up to the edge of the intertidal zone. They were most abundant at 0 - 35 m from the shore. However, species such as *Isognomon isognomon* and *Angaria* sp. were found numerous 95 - 100m from the shore, attached to rocks. Echinoderms were found abundant at distances 20 - 55m from the shoreline. On the other hand, hermit crabs, the only Arthropod were found 10m from the shoreline.

Nerita sp., *Planaxis* sp., and the limpets were most abundant on areas 0 - 20m from the shoreline. These organisms were found largely restricted to the surfaces of rocks in the intertidal zone. These archeogastropods are noted

to be grazers who are common inhabitants of the rocky intertidal zone such as the study area.

TABLE III. DISTRIBUTION PATTERN OF MACROBENTHIC SPECIES

Phylum Mollusca	Coefficient of dispersion	Distribution pattern
1. *Acmea saccharina*	0.41	regular
2. *Anadara sp.*	1.57	clumped
3. *Angaria sp.*	1.50	clumped
4. *Artraea sp1.*	2.07	clumped
5. *Astraea sp2..*	2.45	clumped
6. *Cantharus sp.*	0.96	regular
7. *Cellana conciliate*	2.81	clumped
8. *Cellana sp.*	3.13	clumped
9. *Cerithium chemnitzianum*	0.96	regular
10. *Cerithium sp.*	1.36	regular
11. *Chione sp.*	0.95	regular
12. *Conus canonicus*	3.32	clumped
13. *Conus sp.*	0.96	regular
14. *Conus textile*	0.96	regular
15. *Cypraea sp1.*	0.96	regular
16. *Cypraea sp2.*	0.96	regular
17. *Drupa grossularia Roding.*	1.83	clumped
18. *Isognomon isognomon*	1.66	clumped
19. *Nerita sp.*	4.90	clumped
20. *Pinna sp.*	2.05	clumped
21. *Planaxis sp.*	4.40	clumped
22. *Strombus labiatus*	2.45	clumped
23. *Strombus luhuanus*	0.95	regular
24. *Thais sp.*	1.59	clumped
25. *Timoclea ovate*	1.46	clumped
26. *Trochus lineatus*	2.45	clumped
27. *Trochus niloticus*	2.05	clumped
28. *Trochus sp.*	3.30	clumped
29. *Turbo sp.*	4.29	clumped
30. *Unidentified sp. of oyster*	0.96	regular
31. *Vexillium plicarum*	0.96	regular

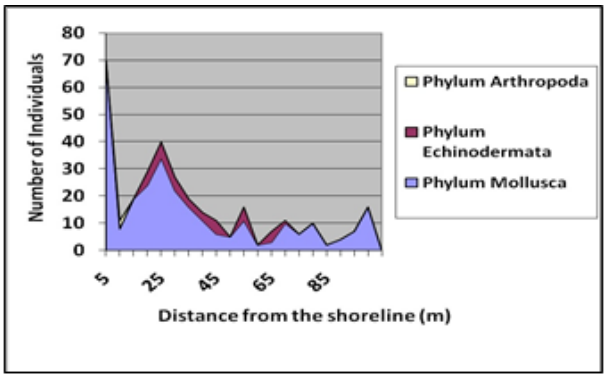

Fig. 3. **Zonation of Macrobenthic Invertebrates of Barangay Tagpangahoy, Tubay, Agusan del Norte.**

E. Physico-chemical Parameters

Measures of the physico-chemical parameters of the sea water in the study area were recorded. The values of temperature in each transect line ranged from 28 to 30 ^{0}C with the average value of 29 ^{0}C. These values of temperature are within the normal values for marine water. Salinity on the other hand, ranged from 34 to 36 ppt with an average value of 35 ppt. These values of salinity are still within the normal limits for sea water. pH values ranged from 8.10- 8.26. Its average is 8.18 across transect lines. These are also within the normal range of the pH of marine water. [20,21].

F. Substrate Type

The macrobenthic invertebrates were found in all different types of substrates in the area. The intertidal zone is mostly rocky. But most of the organisms were found in the rocky and sandy-rocky substrates. Some were found in the sandy substrate and few were found in the sandy-muddy-rocky substrate. The sandy-muddy-rocky substrate occurred in transects 12 and 13; in quadrats near the spring water source. *Trochus* species which are reportedly mud dwellers and vegetarians were found in this substrate where species of sea grasses also grew. *Strombus labiatus* were also found in such substrate but attached to the rocks.

Most of the mollusks were found on the rocky and sandy-rocky substrates in the area. On near shore rocks, planaxis, limpets, and nerites were most abundant. Few molluscan species were confined to the sandy-rocky substrate. These were found in quadrats about 25m from the shore and beyond, in a very minimal number. The edge of the intertidal zone is about 90% rocky where *Isognomon isognomon, Angaria species and Astraea species* were found.

Only few macrobenthos were found on the sandy substrate, as the intertidal zone of Barangay Tagpangahoy is mostly rocky. Echinoderms were found mostly on sandy-rocky substrate while the lone species of Arthropod (hermit crab) present there were found on rocky substrate. Fig. 4 shows the abundance of macrobenthic invertebrates according to phylum per substrate type.

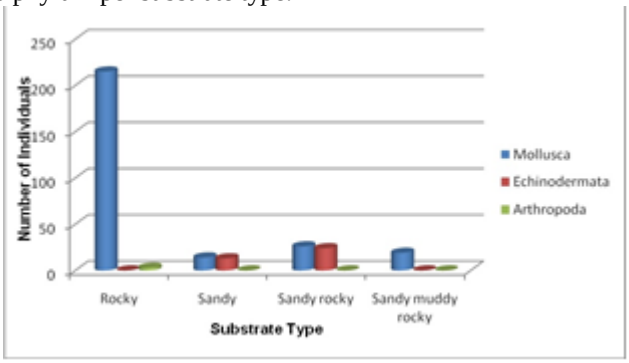

Fig. 4. **Abundance of macrobenthic invertebrates according to phylum per substrate type.**

IV. CONCLUSION

Macrobenthic invertebrates were found in the intertidal zone of Barangay Tagpangahoy, Tubay, Agusan del Norte, Philippines. These organisms belong to Phylum Mollusca, Phylum Echinodermata, and Phylum Arthropoda. Mollusks were the most abundant organism, followed by Echinoderms and Arthropods having the least value of relative abundance. The macrobenthic community in the area had greater diversity compared to other areas but less than the diversity reported by other studies. Clumped distribution was the most common pattern of dispersion, followed by the uniform pattern of distribution. No species was found to exhibit the random pattern of distribution. The macrobenthos in the area were found in all four different substrate types found in the area: rocky, sandy, sandy-rocky, and sandy-muddy-rocky substrates. Based on the results obtained, Barangay Tagpangahoy's intertidal zone can still support life

sufficiently, and the diversity of the indicator organisms (the macrobenthic invertebrates) is still high. Regular follow up studies on the macrobenthic invertebrates in the area is recommended, such as doing the sampling for four quarters of the year with corresponding rainfall data and physico-chemical parameters, including the heavy metal contamination. This will be necessary to monitor possible changes in the biotic community and alert the residents for possible interventions.

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