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Physico-chemical parameters and macrobenthic invertebrates of the intertidal zone of Gusa, Cagayan de Oro City, Philippines

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Abstract. Physico-chemical parameters and macrobenthic invertebrates of the intertidal zone of Gusa, Cagayan de Oro City, Philippines were assessed from March to May 2014. Water temperature, pH, salinity, dissolved oxygen, biological oxygen demand, and type of substrate were determined in the study were within the normal range. A modified transect-quadrat method was used in an approximately 14,000 m^2 of study area. Seven hundred twenty seven individuals belonging to 15 species were found in the area. These organisms belong to four phyla namely: Mollusca, Arthropoda, Echinodermata, and Annelida. The three most abundant organisms found were *Coenobita clypeatus*, *Ophiothrix longipeda*, and *Cypraea poraria* with relative abundance of 73.86%, 4.13% and 3.71% respectively. Most of the macrobenthic fauna identified exhibited a clumped pattern of distribution, while the rest are randomly distributed. The species diversity of the area is 1.19 which is very low compared to reports from related studies.

Key Words: abundance, diversity, environment, invertebrates, pollution, Philippines.

Introduction. Macrobenthic invertebrates are organisms that live on or inside the deposit at the bottom of a body of water (Idowu & Ugwumba 2005). They are easily visible to the naked eye with the lower range of body size at 0.5 mm but usually larger than 3 mm. In the coastal water ecosystem, they include several species of organisms, which cut across different taxa including Porifera, Annelids, Coelenterates, Mollusks, Crustaceans, Arthropods and etc. These organisms play a vital role in the circulation and recirculation of nutrients in aquatic ecosystems. According to Imevbore & Bakare (1970), organisms constitute the link between the unavailable nutrients in detritus and useful protein materials in fish and shellfish. Thus, most benthic organisms feed on debris that settle on the bottom of the water and in turn serve as food for a wide range of fishes.

Much of these macrobenthic invertebrates reside and inhabit intertidal zones of our coast areas. Intertidal environment is defined as the zone between high and low water surrounding the world's oceans, supports a rich and unique biota consisting almost entirely of marine organisms. Intertidal organisms are exposed to air on a daily basis, and so must avoid or tolerate environmental stresses rarely encountered in the subtidal (Esenowo & Ugwumba 2010).

Coastal areas are the interface between water draining from inland river basins and the oceans, and can therefore receive high concentrations of natural and anthropogenic materials, including minerals, soils, nutrients and organic matters. These wastes largely affect the species diversity, abundance and biomass, and structure of the benthic community (Müller et al 1995). As such, indicators of pollutants are benthic organisms for these organisms settle in the mudflat, contact the sediment directly and can respond quickly to changes in the habitats. Consequently, Gray (2000), proposed that benthic communities are indicator of ecological health of the ecosystem wherein, organisms detects pollutant over time.

Physical, chemical and biological qualities of water are some of the factors that influence species composition, diversity, productivity and physiological conditions of local populations of a body of water (Boyd 1979). Various studies on water quality and management using macrobenthic invertebrates in assessing the impacts of pollutants in marine environments have been published. One of of these studies are from Dance & Hynes (1980), wherein, existence and distribution of macrobenthic invertebrate are influenced mostly by the physicochemical quality of water and the nearest substrate of occupancy. Temperature, dissolved oxygen, pH and salinity have substantial effects on the life of marine organisms. As cited by Fabry et al (2008), one of the cause of global warming and ocean acidification is the rising of atmospheric carbon dioxide (CO_2) which consider as an important drivers of change in biological systems. In relation to the study conducted by Sithik et al (2009), momentary salinity are remarked by rainfall and evaporation. Furthermore, pH has a linear relationship with salinity.

Gusa, Cagayan de Oro City is a well-known urbanized barangay with plenty of residential subdivisions, commercial stores, industries, schools and a shipment port to name a few. Increased rate of development follows an increase of population which then results to high rate of consumption and thereby increasing the rate of waste production which are discharged in bodies of water. There are several studies conducted internationally and locally in Mindanao and even studies on disturbed and polluted marine environment and its effects on the macrobenthic invertebrates. According to the study of Mandal & Harkantra (2013), macrobenthos play a significant role in mixing sediments, flux of oxygen into sediments, mineralization, and cycling of organic matter. Furthermore, this idea was supported from the study conducted by Sany et al (2015), wherein, sediments, high sensibility to chemical contaminates, and the absorption and accumulation of different kinds of compounds such as heavy metals, which has a close relation in evaluating the environmental changes and chemical effects in macrobenthic organisms. Hence, the main aim of this study is to assess the macrobenthic invertebrates in the intertidal zones of Gusa, Cagayan de Oro City where port areas, human activities and industrial companies are its fullest. Thus, it specifically aims to: (1) determine the physico-chemical parameters on the established transect lines of the intertidal zone of Gusa, Cagayan de Oro City; (2) identify the macrobenthic invertebrates species present in the aforementioned site; (3) determine the relative abundance (RA) and species diversity of macrobenthic invertebrates.

Material and Method

Study area. The study was conducted in the intertidal zone of Gusa, Cagayan de Oro City from March to May 2014 (Figure 1).

The intertidal zone is roughly 300 meters from the National Highway with a geographic coordinates of 8°28'40.60" North 124°41'00.56" East; average elevation of 2 meters above sea level; and is roughly 4000 m^2. To the east of the study area is a river mouth from the Province of Bukidnon. To the west is the Port of Agora. The study area is near the port of Agora where much of industrial products are docked and is near to Villa Ernesto Subdivision Phase II. Much of the wastes coming from cargo ships are thrown and discarded in the coast, some wastes are carried to the sandy shore. The intertidal zone is mainly composed of sandy and rocky substrate. The rocky substrate is mostly covered with algae and sea grasses. Gravel, coarse, sand, fine and muddy sediments are readily observed from the shore to the intertidal zone.

Establishment of study area. A modified transect - quadrat method was employed in the study as shown in Figure 2. The shoreline of the study area extends approximately 400 meters divided by five (5) transect lines established. Each transect line is 80 meters apart from each other. A 1 X 1 meter quadrat were established 1 meter from the both sides of the transect and the quadrats were 5 meters apart from each other. The length of the transect line varied depending on the topography of the area.

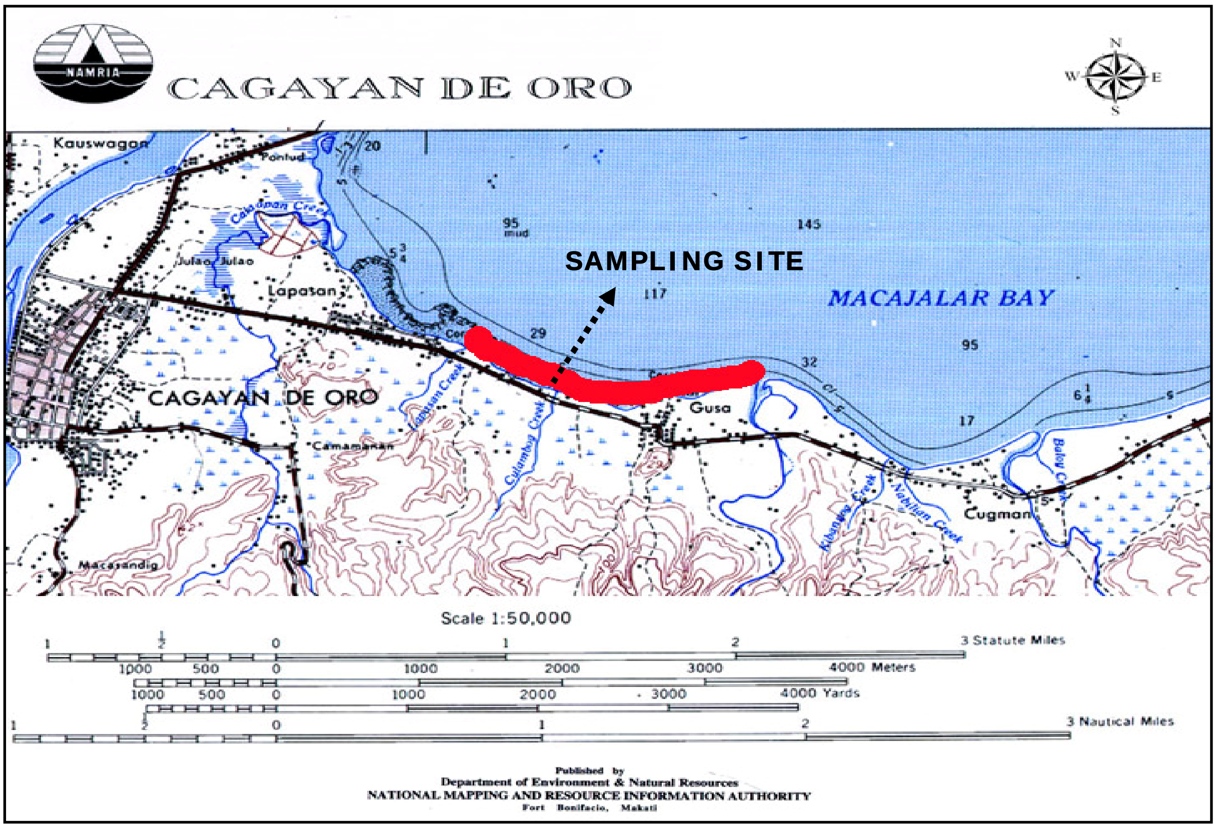

Figure 1. Map of Gusa, Cagayan de Oro City showing the area of study.

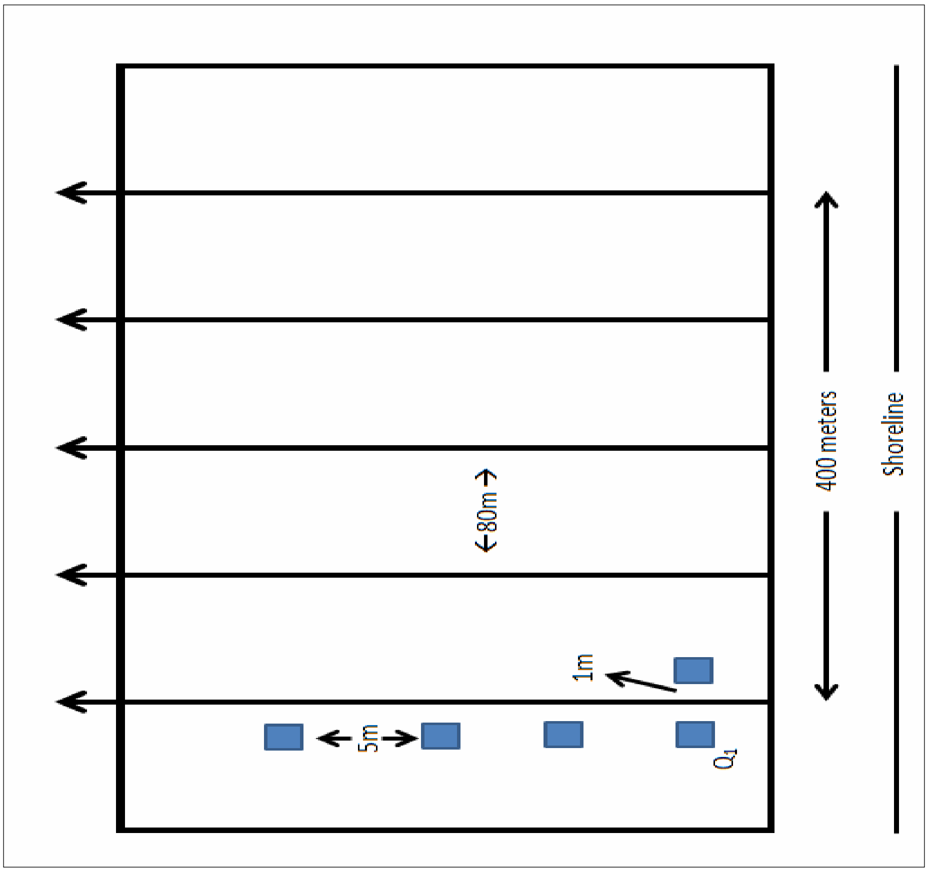

Figure 2. Establishment of transects and quadrats in the study area.

Determination of physico-chemical parameters. The physico-chemical parameters of the sea water were measured and identified which includes temperature, pH, salinity, dissolved oxygen (DO), biological oxygen demand (BOD), and substrate type. Temperature, pH, and salinity were determined in-situ using a mercury-in-glass thermometer, buffered electronic pH meter (Kent EIL 7020) and handheld salinity refractometer were used. BOD and DO were determined using titration method (APHA, AWWA, WEF 1999).

Collection and determination of macrobenthic invertebrates. All specimens collected were brought to the laboratory for identification and classification. Identification was based on morphological characteristic of each specimen, using several guides to identify collected samples (Nichols & Bartsch 1945; Springsteen & Leobrera 1986; Edward & Barnes 1994; Schoppe 2000; Abbott & Morris 1995; Dance 1992; De Bruyne 2003; Pechenik 2015).

Statistical analyses

Relative abundance. RA is the number of percent composition of an organism of a particular kind relative to the total number of organism in the area.

$$RA\ (\%) = \frac{\text{Number of individuals per species}}{\text{Total number of individuals}} \times 100$$

Pattern of distribution

Coefficient of dispersion (CD) = Variance/Mean

i. Variance= $\sum_n (\sum x) - (\sum x)\ \ln\ (n-1)$
   Where: n = no. of species
ii. Mean (x)= $\sum xn$
   Where: x = no. of species
   n = no. of quadrats

Where CD:

- Less than 1 (< 1) – regular;
- Greater than 1 (> 1) – clumping;
- Equal to 1 (=1) - random.

Shannon's Wiener function for diversity

$$H = -\sum(ni/n)\log n\ (ni/N) \text{ or } H = -\sum p_i\ (\ln p_i)$$

Where:

H = Shannon's index of general diversity;
n_i = no. of macrobenthic invertebrate of a species i; the abundance of species I;
N = Total no. of all individuals;
p_i = the RA of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community: $\frac{n_i}{N}$.

Results and Discussion

Physico-chemical parameters. Physico-chemical parameters were determined in the five (5) transects of the study area and are summarized in the Table 1.

The lowest mean temperature was recorded in transect 3 in May while the highest mean value was recorded in transect 1 in the month of April as shown in Figure 3.

Higher pH was recorded in the month March compared to April and May. The highest pH recorded was in transect 3 in the month of March while the lowest was in transect 2 in the month of April as shown in Figure 4. According to Esteves (1998), most marine environments exhibit pH values ranging from 6 to 8 which is also true to the results in this study. The pH of marine water is influenced by the concentration of carbon dioxide and organic substances dissolved in water.

The highest salinity was recorded in transect 4 in the entire duration of the study while the lowest was recorded in transect 1 in the month of March as shown in Figure 5.

The lowest mean DO was recorded in transect 5 in the month of May while the highest was in transect 3 in the month of March as shown in Figure 6. DO concentration is dependent on two primary reasons – water temperature and atmospheric pressure. DO decreases due to consumption of different organic processes, respiration of marine organisms, oxidation of metals (Esteves 1998).

The highest recorded BOD was in the month of April for all the transect lines while the lowest was in transect 1 in the month of May as shown in Figure 7.

Rocky substrate was observed in transects 1, 2 and 3, a muddy substrate in transect 4, and a sandy substrate in transect 5.

Table 1

Mean values of physico-chemical parameters of the five transect lines

Parameters	*Transect 1*	*Transect 2*	*Transect 3*	*Transect 4*	*Transect 5*
Water temperature (°C)	23.26±0.28	21.85±0.26	20.17±0.25	22.45±0.32	23.3±0.11
pH	7.32±0.64	6.98±023	8.32±0.05	8.11±0.13	7.87±0.43
Salinity (mg L^{-1})	28.90±0.21	29.78±0.45	30.05±0.12	31.01±0.33	30.21±0.03
Dissolved oxygen (mg L^{-1})	7.28±0.11	5.98±0.21	8.02±0.06	6.86±0.34	6.73±0.21
Biological oxygen demand (mg DO L^{-1})	13.44±0.32	13.33±0.14	13.16±0.12	14.07±0.43	14.21±0.11
Substrate type	Rocky	Rocky	Rocky	Muddy	Sandy

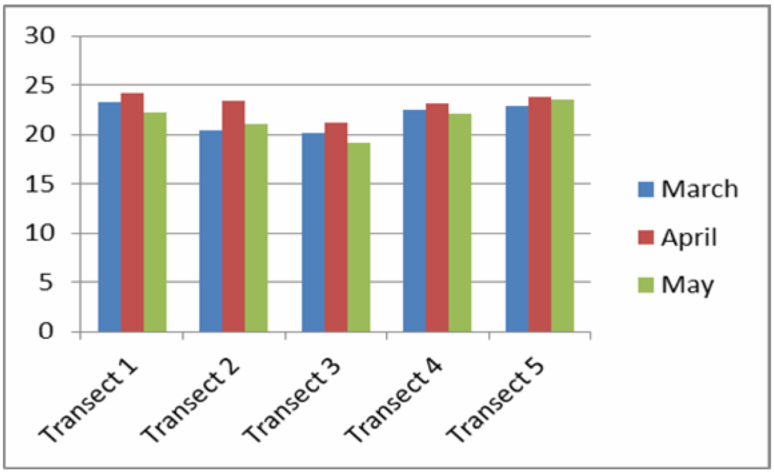

Figure 3. Monthly variation of temperature (°C).

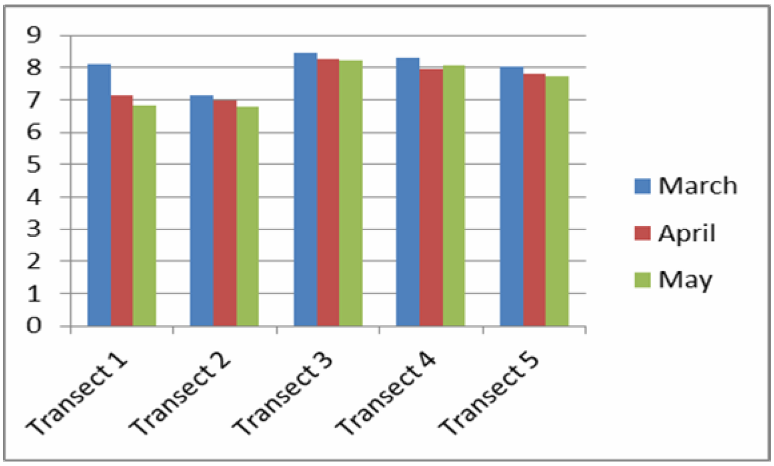

Figure 4. Monthly variation of pH.

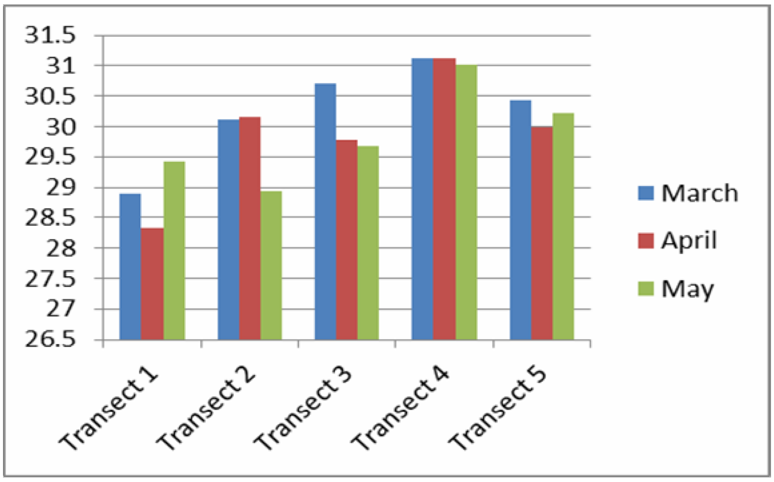

Figure 5. Monthly variation of salinity (mg L^{-1}).

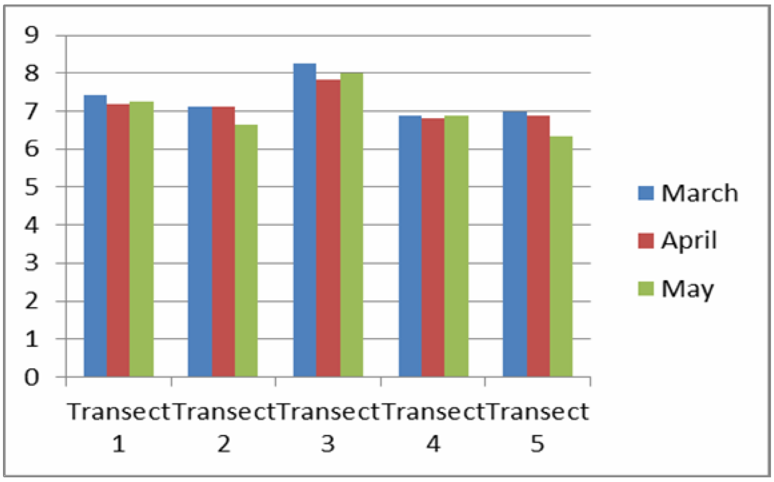

Figure 6. Monthly variation of DO (mg L^{-1}).

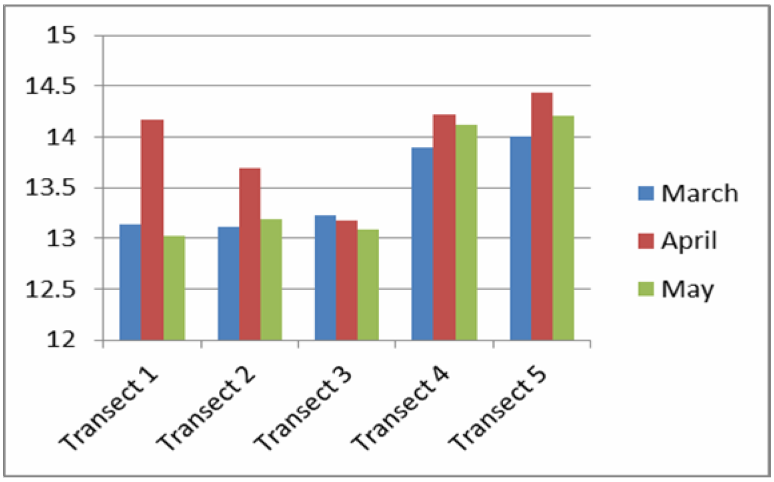

Figure 7. Monthly variation of BOD (mg L^{-1}).

Species composition. Fifteen (15) taxa of macrobenthic invertebrates were identified from the seven hundred and twenty seven individuals collected from 5 transects. These taxa belong to four phyla namely, Arthropoda, Mollusca, Annelida and Echinodermata as shown in Table 2. The number of recorded organism populations was generally low because of some ecological and environmental imbalances which come from the alterations of some essential factors which influence the abundance and distribution of the benthic communities as reported by George et al (2009). Some of the factors include the quality of water, substrate near the marine ecosystem and availability of food. In addition, high human activities were also noted around study area which may be a possible explanation to a low turn-out of organisms as shown in the study conducted by Ogbeibu & Egborge (1995) where high biodiversity is expected in ecosystems which are from anthropogenic activities. Phylum Arthropoda constituted the most abundant group with 537 organisms collected of which are *Coenobita clypeatus* under class Malacostraca, while Phylum Annelida has the least number of individuals, of which is a species of Polychaeta where 1 organism was collected and identified. One hundred and fifty nine (159) individuals under Phylum Mollusca were identified belonging to the 12 species out of 15 identified were collected, while Phylum Echinodermata had 30 individual recorded belonging to one species. While the least number of species identified and collected is under Phylum Arthropoda, Annelida and Echinodermata, all of which have only 1 taxon out of 15 identified and collected as shown in Table 2.

Table 2

List of identified macrobenthic invertebrates and their respective relative abundance

Taxon	*No. of individuals*	*Relative abundance (%)*
Arthropoda		
Malacostraca		
Coenobita clypeatus	537	73.86
Mollusca		
Gastropoda		
Cypraeidae		
Cypraea moneta	25	3.44
Cypraea poraria (juvenile)	27	3.71
Cypraea tigris	5	0.69
Cypraea asellus	1	0.14
Cypraea annulus	20	2.75
Trochidae		
Monodonta canalifera	11	1.51
Neritidae		
Nerita sp.	9	1.24
Pattelidae		
Cellana radiata	19	2.61
Murcidae		
Morula granulata	18	2.48
Buccinidae		
Engina sp. (juvenile)	10	1.37
Bivalvia		
Mactridae		
Tellinides timorensis	1	0.14
Polyplacophora		
Chitonidae		
Acanthopleura gemmata	13	1.79
Annelida		
Polychaeta	1	0.14
Echinodermata		
Ophiuroidea		
Ophiotrichidae		
Ophiothrix longipeda	30	4.13
Total	727	100.00

Relative abundance. Based from the collected data, Phylum Arthropoda (RA = 73.86%) is the most relatively abundant from the all the phyla. It is followed by Phylum Mollusca (RA = 21.87%), then Echinodermata (RA = 4.13%) and Annelida (RA = 0.14%) as shown in Figure 8. Phylum Arthropoda is the most represented phyla since crustaceans are generally filter feeders and are fed by the suspended particles found in the mud and rocky substrate (Tyokumbur et al 2002). Phylum Mollusca is next to Phylum Arthropoda in terms of number of individuals with 8 families having 159 individuals collected from 12 species out of 15. The results of the study is consistent with the results of the studies conducted in Camiguin (Penalosa 2010), in El Salvador (Sambaan 2005), and in Agusan del Norte (Santiago 2002) which shows that the three most abundantly represented phyla are Mollusca, Arthropoda, and Echinodermata. The dominance of mollusks may indicate high resource availability or lack of predators or both. A study conducted by Masese et al (2009) has shown that the dominance of a taxa is attributed to suitable abiotic factors, availability of food source, and lack of competition and/or predation. The top three (3) most abundant species from the five (5) transect lines sampled are *Coenobita clypeatus* (RA = 73.86%), *Ophiothrix longipeda* (RA = 4.13%) and *Cypraea poraria* (RA = 3.71%) (Figure 9). The molluscan species collected are less abundant compared to *Coenobita clypeatus* (Phylum Arthropoda) because this may be due to the gleaning activity of human beings living near the coast. These gastropods and bivalves under phylum mollusca are considered as edible for consumption thus, they are target to gleaners resulting to low number of abundance than the collected individuals belonging from the phylum arthropoda, as shown in Figure 8.

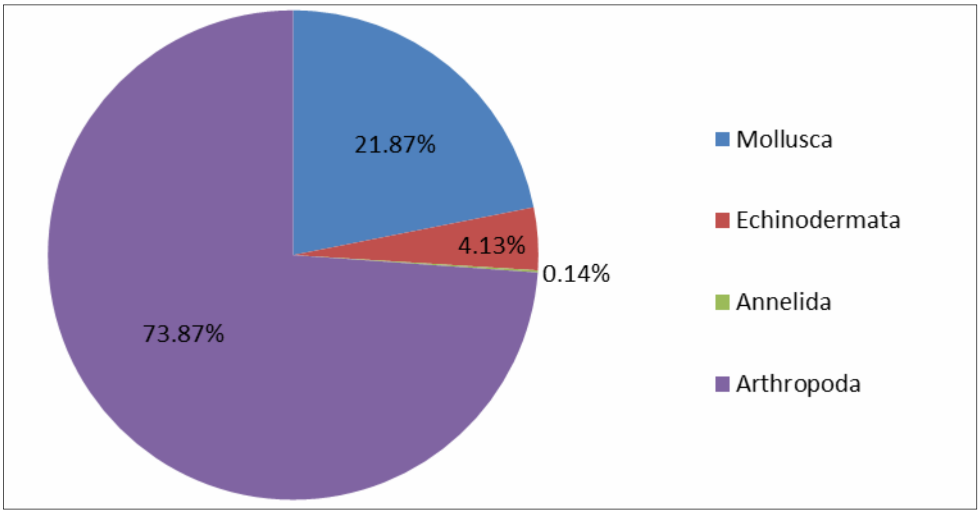

Figure 8. Relative abundance of each Phylum.

Even Arthropods are relatively abundant and dominating in the area with RA = 73.86%, still only one species was identified and collected under the phylum. These organisms are decapods that usually reside inside gastropod shell for protection. Since suitable intact gastropod shells are sometimes a limited resource, there is often vigorous competition among *C. clypeatus* individuals for shells. The availability of empty shells at any given place depends on the RA of gastropods shells that are matched for their size. At this case, specifically in transect 1-4, small sized *C. clypeatus* are readily observable competing for the scarce gastropod shells available. *C. clypeatus* that are seen and found in the area range from 10 mm to 80 mm. Due to less availability of big shells in the area, *C. clypeatus* with a shell that is too small cannot grow as fast as those with well-fitting shells, and is more likely to be eaten if it cannot retract completely into the shell. Most of these species hide under rock crevices and below sea grasses. While the least abundant species collected comes from the Phylum Annelida (RA = 0.14%) which is a species of Polychate. The low number of collected species may be due to the reason that annelids usually burrow and hide under rocks and sea grasses. In the transect lines that were sampled, the area was generally covered with sea grasses, rocks and algae, thus it may be the cause of low turnout of the number of species collected (RA) and that they are less represented (species diversity) under this phyla as shown in Figure 8. Polychates play an important role in the regular functioning of the benthic ecosystem (Hutchings 1998). Gambi & Giangrande (1986) found significant relationship and linkage between abundance of Polychates and sediment type and particle size which is consistent with this study. Polychates are generally abundant in muddy substrate, where in this study, majority of the substrate identified is rocky.

Phylum Mollusca has the most number of species coming from 3 classes under it. Class Gastropoda (RA = 19.94%) the most abundant class under the phylum is has six families; Cypraeidae (RA = 10.73%), Trochidae (RA = 1.51%), Neritidae (RA = 1.24%), Pattelidae (RA = 2.60%), Murcidae (RA = 2.48%) and Buccinidae (RA = 1.24%). The Family Cypraeidae has five species: *Cypraea moneta*, *Cypraea poraria, Cypraea tigris, Cypraea asellus* and *Cypraea annulus.* Of the 5 identified species, *C. poraria* is the most abundant and *C. asellus* is the least abundant. Most species collected under the family of Cypraeidae were adult except for one, *C. poraria*. The same holds true to all molluscans (except *C. tigris)* which are all mostly juvenile. This may be due to that these gastropods are mainly edible and are therefore target to gleaners. Under Class Bivalvia is *T. timorensis* (RA = 0.14%) an edible bivalve with a very low RA, the lowest in this phylum. This may be due to its edibility where gleaning activity that is very alive in the early morning and late afternoon and where they are targets. *Acanthopleura gemmata* (RA = 1.79%) under Class Polyplacophora has at least good number of collected samples relative to species under the phyla. Compared to Class Bivalvia which has the lowest RA and compared to Class Gastropoda which has the highest RA in the phyla, Class Polyplacophora has the average of the two classes, not so many and not so less. These chitons are not easily seen in the field, for they hide under rocks and sea grasses, this may be the cause why there is an average turnout of number of species collected.

Under Phylum Echinodermata, only one species has been identified, *Ophiothrix longipeda. O. longipeda* are very fast moving, regular in size and hard to collect. Most hide under rocks and sea grasses. They are readily observable, but once it has been touched, it moves very fast and hides under rocks, rock crevices and under seagrasses. They are averagely represented in terms of abundance, due to their hiding ability; it is hard to identify their presence or absence.

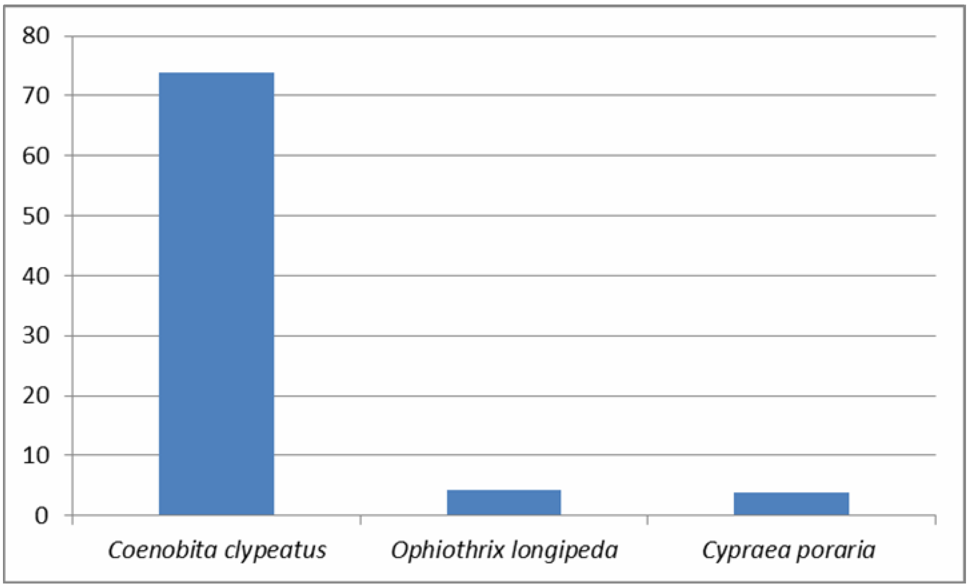

Figure 9. Three most abundant species.

Species diversity. The species diversity of the macrobenthic invertebrates in the five transect lines was computed and the results showed a species diversity of H = 1.19. The species diversity was a bit low compared to the studies conducted by Penalosa (2010), Sambaan (2005), and Santiago (2002). This is may be due to the various anthropogenic activities in the study area like improper waste disposal of residential areas, hotel and a ship port, which are all near the study area.

Coefficient of dispersion. The pattern of distribution of the macrobenthic invertebrates identified in the five transect lines is shown in the Table 3. All of the identified species exhibit a clumping distribution except for *Monodonta canalifera* and the species of Polychaeta. Phylum Echinodermata which is represented by *O. longipeda* exhibits clumping pattern of distribution because according to Schoppe (2000), *O. longipeda* are more mobile and clumped because of common food accessibility; they feed on the same thing and some exhibit competition, while *Coenobita clypeatus* exhibit clumping pattern of distribution because these decapods share one common resource among their kind, the scarce gastropod shells. Majority of the organisms identified, eleven out of fifteen, exhibit clumping patterns as a result of the spatial variation of habitat availability or rather the limited powers of dispersion (Medrano 2015). Some of these organisms exhibiting clumped pattern were those organism confined in a rocks as their habitats. Four organisms out of fifteen identified and collected exhibit random distribution pattern. Random spacing or unpredictable dispersion occurs in the absence of strong attractions or repulsions among individual organisms in the population (Campbell & Reece 2002).

Table 3

List of identified macrobenthic invertebrates and their respective coefficient of dispersion

Phyla	*Coefficient of dispersion*	*Pattern of distribution*
Arthropoda		
Malacostraca		
Coenobita clypeatus	1.44	Clumping
Mollusca		
Gastropoda		
Cypraeidae		
Cypraea moneta	1.52	Clumping
Cypraea poraria (juvenile)	1.23	Clumping
Cypraea tigris	1.37	Clumping
Cypraea asellus	1.00	Random
Cypraea annulus	1.54	Clumping
Trochidae		
Monodonta canalifera	1.00	Random
Neritidae		
Nerita sp.	1.6	Clumping
Pattelidae		
Cellana radiata	1.27	Clumping
Murcidae		
Morula granulata	1.19	Clumping
Buccinidae		
Engina sp. (juvenile)	1.33	Clumping
Bivalvia		
Mactridae		
Tellinides timorensis	1.00	Random
Polyplacophora		
Chitonidae		
Acanthopleura gemmata	1.36	Clumping
Annelida		
Polychaeta	1.00	Random
Echinodermata		
Ophiuroidea		
Ophiotrichidae		
Ophiothrix longipeda	1.7	Clumping

Conclusions. Physico-chemical parameters were measured and collected in the intertidal zone of Gusa, Cagayan de Oro City, Philippines. These are temperature, pH, salinity, dissolved oxygen, biological oxygen demand, and substrate type. All of these parameters are in normal level. Macrobenthic organisms were also collected and identified in the study. These organisms belong to Phylum Arthropoda, Mollusca, Annelida, and Echinodermata. Arthropods were the most abundant organisms, followed by Mollusca, Echinodermata and Annelida. Most of the organisms collected are pollution-tolerant. A low species diversity index was also noted which is attributed to a very high anthropogenic activities surrounding the area of study. It is also noted that majority of the organisms identified and collected exhibit clumping pattern which is due to limited powers of dispersion and availability of food and resources. Based on the results of this study, Gusa's intertidal zone can still support life and diversity sufficiently but regular follow studies must be conducted to further assess the status of the macrobenthic organisms.

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