# Spatial distribution of marine invertebrates as bioindicator of water quality at intertidal zone of sandy shore habitat

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**Abstract:** Marine invertebrates successfully inhabited all types of marine ecosystem. The present study dealt with identification and determination of abundance of marine invertebrates at intertidal zone of sandy shore at Jazan University coast and Almarjan coast. The gastropod *Patella*, the prosobranch snails *Nerita*, *Littorina*, *Murex*, polyplacophore mollusk *Acanthochiton*, shells of cephalopod *Sepia*, the bivalve *Cardium*, isopod *Ligia*, cirriped *Balanus* and the macruran crab were defined at both investigated sites. Based on abundance data benthic invertebrates can be arranged at Almarjan coast as follows; *Balanus*> *Ligia* > *Nerita*> *Littorina*> *Murex*> bivalve *Cardium*> Crab> *Patella*> *Acanthochiton*> *Sepia*. Species richness was 10. At Jazan University coast *Balanus*> *Ligia*> *Nerita*> *Littorina*> *Murex*> crab> *Patella*> *Sepia*. Water quality criteria values; water temperature, pH, conductivity and oxygen concentration were normal at both studied sites. Species richness was 8. Data were discussed to highlight the possibility of using marine invertebrates as bioindicators for water quality at marine ecosystem.

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## 1. Introduction

Macrobenthic invertebrates play important ecological role in the marine ecosystem. They are intermediate link at the foodweb (Lee and Siok, 2006). They spend all their lives at the same habitat, so they can be a mirror for the water quality of their inhabiting area (Hadley, 2015 and Medrano, 2015).

Macrobenthic invertebrates are classified into epifauna and infauna. Epifauna are those live attached firmly to substrate or move freely over the surface including snails, *Patella*, chitons, arthropods and Echinodermata. Infauna are those invertebrates that live within the sediments such as crab, bivalves or polychaetes. Macrobenthos inhabit wide variety of substrates including soft oozes, muddy, sandy, sandy-rocky and rocky shores (Lee and Siok, 2006).

Several studies reported the success use of invertebrates as sentinel organisms or bioindicators for heavy metals, inorganic and some organic contaminants in freshwater and marine ecosystem' their presence or absence give information about water quality (Simkiss, et al., 1982, Simkiss and Mason, 1983, AbdAllah and Mostafa, 2002, AbdAllah, 2006, 2014 and 2017). Variation in acute and chronic toxicity of contaminants was shown among vertebrates and invertebrate animals. Caddisflies were studied as biomonitors for threshold metal toxicity affecting stream benthos (Rainbow, et al., 2012). Cladoceran *Daphnia* is very sensitive for aquatic pollutants (Ravera, 1972). It is commonly used as bioindicator for hazardous contaminants at biomonitoring stations.

Rare information was known about the macrobenthic invertebrates inhabiting littoral zones of sandy shores at Jazan coastal areas.

The present work aims to define the macroinvertebrates inhabiting intertidal zone of sandy shores at Jazan University coastal zone and Almarjan coastal area. Species richness, population density and diversity index were determined at both studied areas.

## 2. Materials and Methods

Intertidal zone of Jazan University coastal zone and Al-Marjan sandy shore were selected for the present study.

Alive healthy invertebrates belonging to different phyla were counted at 1m quadrates. The study was performed at the winter season; October-December, 2016. Counted invertebrate species were defined according to Hickman, et al., (2011).

Number of species were counted at intertidal zone of Al-Marjan sandy shore or Jazan University coast. Species richness was determined according to Tuomisto (2010).

Number of individuals were counted for each defined species at 1m quadrates as the population density. Relative abundance was determined as the percentage of number of individuals for each defined invertebrate sp. divided by the total number of individuals belonging to all invertebrate phyla.

Based on Shannon (1951). Diversity index was determined according to the following formula.

$$H' = -\sum_{i=1}^{R} p_i \log p_i$$

Where $p_i$ is the relative abundance of $i^{th}$ group.

Mann Whitney U-test was conducted to compare zooplankton abundance and water criteria at the intertidal zone of Jazan University and Almarjan sandy shore. Factorial Analysis of variance was employed to investigate the variation in population density between the two studied areas. XLSt at software program was used for statistical analysis. $P<0.05$ was used as the level of significance of examined statistical analysis.

## 3. Results

Table (1) showed means and standard deviations of measured physical and chemical water criteria at the intertidal zone of Jazan University coast and Almarjan coast. Water temperature recorded at Jazan University coastal area was 29.97 C±0.907(in the range 29- 30.8C), oxygen concentration; 13.46±2.05 mg/l (11.4-15.5) mg/l, pH; 8.083± 0.096 (7.98- 8.17) and conductivity was 59.1±0.795 (58.1-59.7) µs.

At Almarjan coast, water temperature recorded was 29.87±0.907(in the range 31.2, 30.1and 28.3 C). oxygen concentration; 14.2±2.05 mg/l (16.5, 12.6 and 13.5) mg/l, pH; 7.52± 0.096 (7.06, 7.49 and 8.01) and conductivity was 58.6 µs.

Table (1) Mean and standard deviation of water criteria of Almarjan and Jazan University coastal zone

| | Jazan University coast | AlMarjan coast |
|---|---|---|
| pH | 8.083± 0.096 | 7.52± 0.096 |
| Water temperature (´C) | 29.97 ±0.907 | 29.87±0.907 |
| Conductivity (µs) | 59.1±0.795 | 60.225± 4.158 |
| Oxygen concentration (mg/l) | 13.46±2.05 | 14.2±2.05 |

Mann-Whitney U test showed non-significant differences between water criteria (Table 1) determined at intertidal zone of Jazan University coast and Almarjan coastal area.

The gastropod *Patella*, the prosobranch snails *Nerita*, *Littorina*, *Murex*,, shells of cephalopod *Sepia*, isopod *Ligia*, amphipod cirriped *Balanus* and the macruran crab were defined at both investigated sites. Polyplacophore mollusk *Acanthochiton* and the bivalve *Cardium* were only defined at Al-Marjan sandy shore coastal area.

Species richness was 8 at Jazan University coast and 10 at Almarjan sandy shore.

Sediments of Jazan University coast are mixture of gravels, sands and rocks. Table (2) and Figs (1 & 2) show the population density, relative abundance of defined invertebrates at Jazan University coast

*Balanus* was the most abundant invertebrate at intertidal zone of Jazan University coast while the gastropod *Patella* was the least abundant species. Macoinvertebrates can be arranged as follows: *Balanus*> *Ligia*> *Nerita*> *Littorina*> *Sepia* shell> *Murex*> crab> *Patella*.

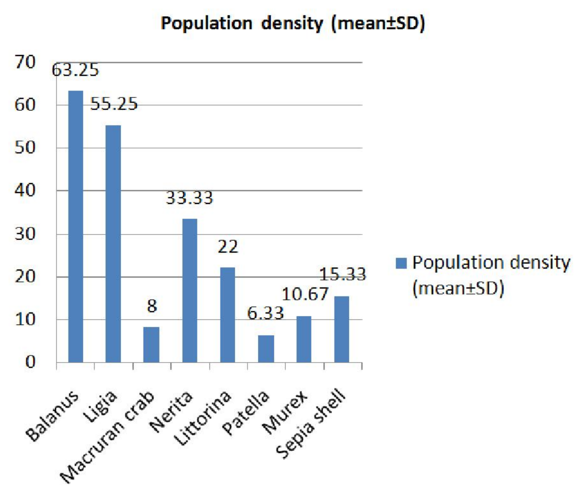


**Fig (1) Population density (individuals/m$^2$) and relative abundance of macroinvertebrates inhabiting intertidal zone of Jazan University coastal zone.**

**Table (2) Means and standard deviations of population density (individuals/m$^2$) and relative abundance of macroinvertebrates defined at Jazan University coast**

| | Species | Population density (mean±SD) | Relative abundance (%) | $p_i \log p_i$ | Taxonomy |
|---|---|---|---|---|---|
| 1 | *Balanus* | 63.25±8.098 | 29.53 | 0.422 | Cirriped, Arthropoda |
| 2 | *Ligia* | 55.25±6.021 | 25.8 | 0.364 | Isopod, Arthropoda |
| 3 | Macruran crab | 8±2.646 | 3.73 | 0.021 | Macrura, Arthropoda |
| 4 | *Nerita* | 33.33±7.234 | 15.56 | 0.186 | Prosobranch, Mollusca |
| 5 | *Littorina* | 22±6.782 | 10.27 | 0.104 | Prosobranch, Mollusca |
| 6 | *Patella* | 6.33±4.041 | 2.95 | 0.014 | Gastropoda, Mollusca |
| 7 | *Murex* | 10.67±4.041 | 4.98 | 0.035 | Prosobranch, Mollusca |
| 8 | *Sepia* shell | 15.33±5.033 | 7.16 | 0.061 | Cephalopod, Mollusca |
| 9 | Total | 214.16 | | | |
| 10 | average | 26.77±21.934 | | | |
| Shannon-Weiner Diversity index | | | | 1.207 | |

**Table (3) Means and standard deviations of population density (individuals/m$^2$) and relative abundance of macroinvertebrates defined at Al-Marjan coast.**

| Species | Population density (mean±SD) | Relative abundance (%) | $p_i \log p_i$ | Taxonomy |
|---|---|---|---|---|
| *Balanus* | 205±15 | 42.666 | 0.695 | Cirriped, Arthropoda |
| *Ligia* | 81.33±3.512 | 16.927 | 0.208 | Isopod, Arthropoda |
| Macruran crab | 20.33±3.786 | 4.231 | 0.026 | Macrura, Arthropoda |
| *Nerita* | 47.33±13.203 | 9.850 | 0.097 | Prosobranch, Mollusca |
| *Littorina* | 39.67±7.505 | 8.256 | 0.076 | Prosobranch, Mollusca |
| *Patella* | 12.33±3.786 | 2.566 | 0.0105 | Gastropoda, Mollusca |
| *Murex* | 24.33±3.055 | 5.064 | 0.036 | Prosobranch, Mollusca |
| *Sepia* shell | 18.5±4.795 | 3.850 | 0.022 | Cephalopod, Mollusca |
| *Cardium* | 14.33±2.516 | 2.982 | 0.014 | Bivalve, Mollusca |
| *Acanthochiton* | 17.33±2.082 | 3.607 | 0.0201 | Polyplacophora, Mollusca |
| Total | 480.48 | | | |
| Average | 48.05±89.457 | | | |
| Shannon-Weiner Diversity index | | | 1.889 | |

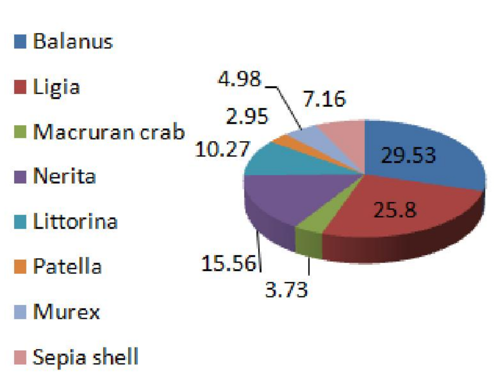


**Fig ( 2) Relative abundance of macroinvertebrates at intertidal zones of Jazan University coastal zone.**

**Population density and relative abundance at Almarjan coast**

Abundance (population density) and relative abundance of benthic macroinvertebrates at littoral zone of Almarjan sandy shore were tabulated at Table (3) and graphically represented at Fig (3 & 4).

*Balanus* was the most abundant invertebrate at Almarjan coast while the gastropod *Patella* was the least abundant species (Table 3 and Fig 4).

Macroinvertebrates can be arranged as follows: *Balanus*> *Ligia*> *Nerita*> *Littorina*> *Murex*> crab > *Sepia* shell > *Acanthochiton*> *Cardium*>*Patella* (Fig 3).

Factorial ANOVA showed high significant differences ($P<0.0001$) between macroinvertebrates abundance at Jazan University coast and Almarjan sandy shore coast.

Calculated Shannon-Weiner diversity index at Jazan University coast was 1.207(Table 2). At Almarjan sandy shore Shannon-Weiner diversity index was 1.889 (Table 2).

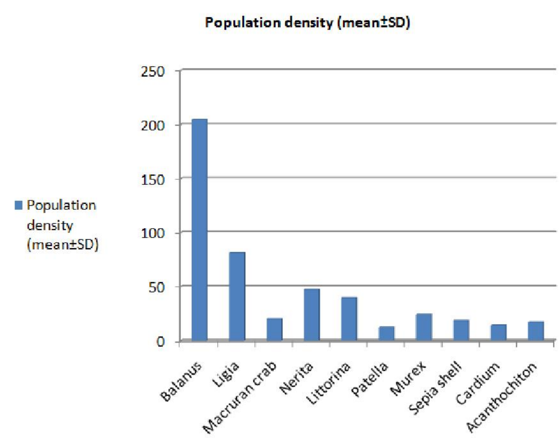


**Fig (3 ) Population density (individuals/m$^2$) of macroinvertebrates at intertidal zone of Al-Marjan coast.**

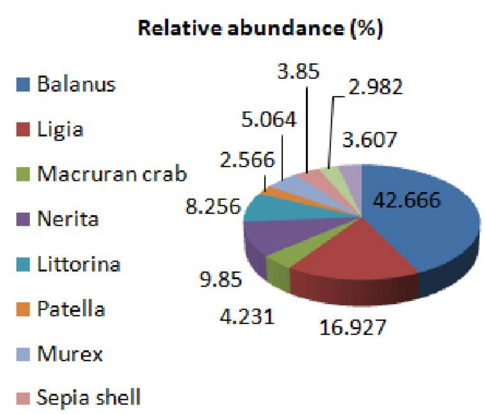


**Fig ( 4) Relative abundance of macroinvertebrates at intertidal zones of Al-Marjan coastal zone.**

## 4. Discussion

Good water quality was defined by Kindt [(1985) as that devoid from toxic substances, garabage, industrial wastes, sewage sludge, radioactive wastes and oil. The use of benthic organisms was suggested as bioindicators for good water criteria **[Reish, 1987** & Rombouts, etal. 2013) as they reflect the contamination status at the time of study and also at previous times.

Nkwoji, et al. (2010) reported the use of diversity and abundance of macrobenthos as bioindicators for water quality because of their variable response to hazardous contaminants. Hadely (2015) stated that the pronounced decrease or increase in population density of macroinvertebrates can be used as bioindicators for poor water quality. Arthropods and molluscs are well known with their resistance to environmental contaminants. They have successful detoxification mechanism changing hazardous contaminants into nontoxic compounds and storing them within their soft tissues (AbdAllah, 2006, 2017 & Rainbow, etal. 2012). The cirriped barnacle was the most abundant at both studied areas. The results are in accordance with the finding of Rainbow and White (1989) who found that the barnacle can accumulate dissolved zinc, copper and cadmium with no evidence of regulation and therefore might be the most abundant macrobenthic invertebrate at both studied areas. Higher diversity index was recorded at Al-Marjan coast (1.889), also, higher significant poplation density was recorded for invertebrates at Al-Marjan coast compared to Jazan University coast. This might be attributed to the physical nature of sandy shore habitat, where Jazan University coast contained both rocks, gravels and sand grains, while the sediments at Al-Marjan coast was totally from sand grains (Olga, etal., 2006 & Tang, etal., 2012).

Future studies are needed to investigate the effect of seasonal climatic changes on variation in spatial distribution and population density of macrobenthic invertebrates at sandy shore habitats.

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