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Research Paper

Potential use of nematode-copepod index in assessing pollution thresholds in selected coastal areas of Northern Mindanao, Philippines

Jomar C. Bagares, Alana Ashley B. Oco, Reyvah P. Genardino and Sonnie A. Vedra
Department of Marine Biology and Environmental Science, College of Science and Environment
Mindanao State University at Naawan, 9023 Naawan, Misamis Oriental, PHILIPPINES

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Abstract

Coastal areas are continuously deteriorating due to unregulated pollution sources from anthropogenic activities. These lead to subsequent loss of marine biodiversity and ecological integrity. The potential use of an index, as a pollution threshold derived from the ratio of nematode and copepods densities, is a promising tool that might be used to formulate effective coastal management strategies. Hence, a study was conducted to obtain an index based on pollution threshold level out of nematode and copepod density ratios. Collection of nematode and copepod specimens was done in selected coastal areas of Northern Mindanao using standard methods of collection and analysis of samples. Results showed that rural coastal areas had an index ranging from 0.53 to 6.07, which is below the pollution threshold level at 10. However, in the urban coastal areas, a three-fold increase of index was observed ranging at 30.53 to 38.79, which are above the pollution threshold level. This observation might be due to differing coastal utilization patterns that contribute various type, degree and magnitude of pollutants released into the coastal areas. The results of the study posed some urgent challenges to policy-makers in particular to actively monitor their coastal areas to sustain its economic and ecological importance for the present and future generations.

Keywords: coastal pollution threshold, nematodes, copepods, Northern Mindanao.

Introduction

Coastal ecosystems are integral parts of functioning and adjacent ecosystems such as the offshore marine ecosystems, terrestrial and riverine ecosystems[1]. To this, various anthropogenic activities are undertaken mostly in the coastal areas, and in turn, contributed significant amounts of pollution. One of the many components in the coastal sediments is meiofauna, where they are mainly dominated by nematodes and copepods. Meiofauna in general, are metazoan organisms measuring 30 µm to 1 mm. Their life histories and feeding habits differed from larger macrofauna indicating them as a well-defined entity [2]. The potential use of meiofauna as bioindicators of environmental health had started based on their ecology that closely linked to their soft-bottom habitats, particularly on various anthropogenic perturbations in aquatic ecosystems [3,4], as they reflect the quality of marine ecosystem in the food chain to organisms athigher trophic levels. They are highly abundant, ubiquitous, have short generation times, absence of a planktonic phase in their life cycles and have high metabolic rates [5]. These meiofaunal characteristics suggest a shorter response time and their higher sensitivity to anthropogenic disturbances in aquatic habitats [6,7]. Since the entire meiofauna population is dominated mainly by nematodes and copepods, their density ratios, which are translated into an index, can be used to determine the health status of the environment. Hence, this study was carried out to use its potential use as bioindicators of environmental health through coming up with an index to reflect pollution threshold levels.

Monitoring on the quality of aquatic ecosystems and the knowledge generated from this study can be used for further scientific investigations as coastal areas are more susceptible to destruction than other ecosystems as a result of the interrelated complex relationship of three interacting systems: the terrestrial ecosystem, the marine ecosystem and the anthropogenic system [8,9]. This is because management of coastal areas is less prioritized by the local government units since they prioritized developmental plans such as social and health services, infrastructure developments, economic and other project management. This impaired their legal mandate on coastal resources management as stipulated in RA 7160 or the Local Government Code of 1991. The rural coastal areas of Plaridel, Misamis Occidental, Initao, Libertad and Laguindingan in Misamis Oriental are concrete examples to have these undertakings, and mostly, the urbanized cities of Oroquieta, Iligan and Cagayan de Oro. These were the study areas where pollution threshold was established using the ratio of nematode and copepod densities.

Use of nematode to copepod ratio as tool for monitoring aquatic ecosystem condition was used [8], since they are mostly abundant but have differed sensitivity to stress. For instance, nematodes are less sensitive to environmental stress or pollution, and therefore, a high ratio indicates pollution such as oil spills, sewage and increasing organic enrichment [9,8]. Higher density of nematode in an urban coastal area was observed as an indicator of polluted (dirty) or disturbed environment[4] as a consequence of large amounts of organic matter[10]. Higher density of copepods which is an indicator of undisturbed (clean) environment was associated with coarser sediments[11,12].

Nematode-copepod index of 100 was proposed as a pollution threshold[9,15], however, other values were recommended [15], and were used in this study[15]. These were: (1) for sandy substrate, nematode-copepod index is higher than 10 and (2) in muddy substrate, nematode-copepod index would be higher than 40. The observed variations in the nematode-copepod ratio were based on (1) the different habitat requirements of nematodes and copepods, (2) the ability of each to exhibit monotonic response; and (3) degree of organic enrichment examined along a gradient[12,13,14,16].

Materials and Methods

Collection of sediment and specimens

Sediment samples were collected in selected coastal areas of Northern Mindanao, to wit: the rural coastal areas of Plaridel, Misamis Occidental, in Initao, Libertad and Laguindingan, Misamis Oriental, and in the urban coastal cities of Oroquieta, Iligan and Cagayan de Oro on years 2004, 2008, 2013, and 2014. Transect-plot method was employed to collect sediment samples. Two-replicate 5 m interval transect lines were laid parallel to the shoreline. Each transect line had three 1x1 m^2 quadrats at 100 m interval. A transparent plexiglass corer with a diameter of 5 cm and a height of 10 cm was used. Three independent cored sediment samples were collected in each quadrat and placed in labeled plastic containers, added with 5% buffered formalin and a few drops of Rose Bengal solution. All samples were left for two days to enhance absorption of the Rose Bengal stain[17,18].

Nematode and copepod density analysis

Stained specimens in the sediments were washed 10 times and the supernatant liquid was sieved into a 40 µm mesh sieve following the standard decantation method[18]. Sieved specimens of nematodes and copepods were transferred into separately labeled container with 5% buffered formalinand a few drops of Rose Bengal solution. Density is the number of individual nematodes and copepods identified at 8 cm depth level and was extrapolated to N 10 cm^{-2} using the formula specified in the International Biological Programme Manual: N 10 cm^{-2} = N cm^{-2} x 10, where: N = cm^{-2} = A/B, where A is the total number of individuals in a sample and B is the cross-sectional area of the corer, which is equal to D x H, where: D is the inner diameter of the corer and H is the height of the cored sample. An index was derived from the ratio of nematode over copepod densities, and was referred to the pollution threshold levels [11].

Results and Discussion

All four rural coastal municipalities, namely, in Plaridel, Misamis Occidental, in Initao, Libertad and Laguindingan in Misamis Oriental had attained pollution threshold levels below 10 that ranged from 0.53 to 6.07. This signified very low pollution impacts as indicated by relatively low index computed. As per observation, it might be due to minimal deposition of pollution from point and non-point sources. The index was derived from nematode densities ranging from 501 to 12,505 ind 10 cm^{-2} over copepod densities ranging at 276 to 5,393 ind 10 cm^{-2}.

Among the three urban cities sampled, only Oroquieta City in Misamis Occidentalthat attained an index of only 3.71. This value did not surpass the pollution threshold level more than 10. This could be due to the concerted efforts of the local government in protection and management of their river system and coastal areas. However, the industrialized cities of Iligan and Cagayan de Oro attained an index higher than 10, at 30.53 and 38.79, respectively. This is a three-fold increase of pollution threshold level. These values were obtained from nematode densities ranging from 17,037 to 17,767 ind 10 cm^{-2}, respectively over copepod densities at 558 and 458 ind 10 cm^{-2}, respectively in years between 2008 and 2014 (Table 1).

Table 1: Densities (ind 10 cm^{-2}) of nematodes and copepods in the coastal sediments of Northern Mindanao during specimen collections on 2004, 2008, 2013 and 2014

Sampling location	Year of collection	Author involved	Nematode density	Copepod density	Index
Plaridel, Mis. Occ.	2004	Vedra	501	276	1.81
Initao, Mis. Or.	2008	Vedra	12,505	2,060	6.07
Initao, Mis. Or.	2014	Bagares	2,890	5,393	0.53
Libertad, Mis. Or.	2014	Oco	3,131	611	5.12
Laguindingan, Mis. Or.	2013	Genardino	1,281	591	2.16
Oroquieta City	2004	Vedra	1,091	294	3.71
Iligan City	2014	Bagares	17,037	558	30.53*
Cagayan de Oro City	2008	Vedra	17,767	458	38.79*

*****Pollution threshold > 10 per Warwick (1981) level

The observed high densities of nematodes, an indicator of disturbed environment, particularly in the urban coastal areas could be related to the OMC-rich muddy substrates [10], mainly from untreated effluent discharges drained to canals, creeks and rivers.

Relatively higher densities of copepods in rural coastal areas, which could be an indicator of undisturbed environment, were associated with coarser sediments[14]and low in organic matter content. Their finer sediment habitats are crucial to their burrowing mode of life in the interstitial pore system [15]. Grain size distribution and organic matter load were governed by transport processes, primarily due to tidal inundation would determine the recruitment of organisms in terms of food quality [19]. High organic matter content(OMC) of the sediments compared to natural levels were attributed to high input of nutrients and organic matter from various human activities like sewage disposal [20], which was observed in the urban coastal areas. This high OMC concentration in sediments had contributed to relatively high pH due to the insufficiency of the atmosphere-water-sediment interface interactions, although exerted little influence on their densities [21].

The resulting difference in the pollution threshold levels among the coastal areas of Northern Mindanao suggests the extent of nematode and copepod adaptive interactions depending on the pollutants released into the sediments, residence time of the contaminating compound, and the biology of the interacting organisms[20]. This is mainly influenced by varying concentration of pollutants as amplified by the changes in the lunar cycles and tidal actions[10].

Conclusion

Results showed that rural coastal areas were less polluted and urban coastal areas were relatively polluted based on threshold levels derived from the ratio of nematode and copepod densities. Results of the studymight add knowledge and information to policy-makers to critically evaluate the extent of their conservation and management initiatives undertaken. Since specimen collection times differed, it is timely and imperative that regular quarterly sampling of nematodes and copepods be done to arrive at more conclusive and persuasive findings for a thorough and comprehensive data. Again, the main purpose is to provide collective efforts of all concerned stakeholders for coastal protection and management, that in turn, be translated into appropriate and effective options to gain back the economic and ecological benefits of coastal resources for the present and future generations.

Further study is recommended for in-depth ecological and sociological assessments to fully understand the interrelationships of nematodes and copepods as a function of changing water quality and sediment characteristics due to human-related waste generations and natural perturbations like tidal fluctuations and lunar cycle changes. This is because the nematode and copepod densities were used as an index of pollution threshold level determination, and that, without due considerations, results might be affected.

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