Special Edition on "Frontiers of Biosciences in Sustainable Development (FBSD)"
CIBTech Journal of Zoology ISSN: 2319–3883; http://www.cibtech.org.htm
2023 Vol.12/S1, pp.206-214/Nusrat et al.
***Research Article** (Open Access)*

BIOMONITORING OF ADYAR ESTUARY CHENNAI, INDIA THROUGH BIODIVERSITY DYNAMICS OF MEIOFAUNA

Nusrat Abkar[1], *Ghousia Nisha[1], Mehrajuddin War[2]
[1]Department of Zoology, JBAS College for women, Chennai-18,
[2]Department of Zoology, The New College, Chennai-14
**Author for Correspondence: ghousiasirajuddin@gmail.com*

ABSTRACT
Estuaries are dynamic and productive systems, besides supporting important ecological functions and services, resources provided by estuaries have been a target of human exploitation, compromising estuarine ecological integrity. Furthermore, human induced impacts and their negative effects on estuarine systems triggered the attention towards the need for monitoring, assessing and managing ecological integrity to promote the long-term sustainability of these systems. The behaviour and physiology of different meiofaunal taxa, such as foraminiferans, nematodes and copepods, can provide vital information on how organisms respond to these challenges and can provide a warning signal of anthropogenic impact. Meiofauna samples were collected by using a stainless steel corer with an inner diameter of 3.57 cm which comes to 10 cm^2 surface areas. Three sites for collection were selected Site I, II and III. In general, higher density of meiofauna was recorded at site I (1529.33±353.67) of Adyar estuary followed by Site II (1161.53±252.47) and Site III (1041.87±311.13) Ind./10 cm^2. Further, it is inferred from the present study that in sites II and III, lesser diversity and density of meiofauna might be due to the retention of pollutants in soil sediments rendering unfavourable conditions for their growth and survival. The sustainability of estuarine biodiversity is vital to the ecological and economic health of coastal regions. It is important, therefore, to have techniques that enable society to assess the degrees of exposure of estuaries to anthropogenic toxic contamination and the significance of this exposure to the ecology of the biota living there, especially the effects on biota of commercial significance. Due to great abundance, low mobility, rapid replication, short-life cycle and extreme sensitivity to entering materials, meiofauna are most appropriate bio-indicators for assessing the health of marine environment. Scientific studies of the Adyar estuary require a comprehensive and holistic approach taking into consideration the topography, tidal flow, water quality and assessment of flora and fauna like meiobenthos, zooplankton and macro biota which could be a pointer toward the successful assessment of the status of the Adyar estuary. Moreover, this study suggests that more exploration of the meiofaunal community will allow us to understand how the community patterns influence the ecosystem functioning in Adyar Estuary.

Keywords: *Meiofauna, Adyar Estuary, Bioindicators, Pollution Assessment*

INTRODUCTION
Estuaries are the areas of high productivity, crucial in the life histories of many fishes, invertebrates and birds. The sustainability of estuarine biodiversity is vital to the ecological and economic health of coastal regions. On the other hand, estuarine ecosystems are exposed to toxic anthropogenic effluents transported by rivers from remote and nearby conurbations and industrial and agricultural concerns. It is important, therefore, to have techniques that enable society to assess the degrees of exposure of estuaries to anthropogenic toxic contamination and the significance of this exposure to the ecology of the biota living there, especially the effects on biota of commercial significance. The temperature variation is one of the factors in the swamp and estuarine system, which may influence the physico-chemical characteristics and also influence the distribution and abundance of flora and fauna (Manikannan *et al.*, 2011).
Estuaries have high ecological value, but often are modified in ways that substantially degrade their environment quality and thus their capacity to provide benefits to people. A distinguishing feature of estuaries

is their water diluted by freshwater drainage river mouths are good example where tidal influx causes salinity fluctuations that can range from normal seawater to freshwater (Gadhia *et al.*, 2013). Meiofauna (small interstitial animals and protists living in aquatic sediments) are ubiquitous. Owing to their high abundance and diversity, widespread distribution, rapid generation times and fast metabolic rates, meiofaunal organisms are important contributors to ecosystem processes and functions, including nutrient cycling and provision of food to higher trophic levels, among others (Woodward, 2010, Schratzberger and Ingels, 2018). Benthic meiofauna are important members of coastal ecosystems and estuaries that feed on micro alga and bacteria, affect the primary production cycle and bio-mineralization and other parts of benthic metabolism (Patricio *et al.*, 2013). Extreme environments characterized by one or more environmental parameters, permanently close to the lower or upper limits for life, cover more than 50% of the Earth's surface (Zeppilli *et al*., 2018). The discovery of abundant and well adapted meiofaual communities in several environments with extreme condition has provided new insights into ecology and physiology of species thriving in challenging setting (Danovaro *et al.*, 2010). The behaviour and physiology of different meiofaunal taxa, such as some foraminiferans, nematodes and copepods species, can provide vital information on how organisms respond to these challenges and can provide a warning signal of anthropogenic impact.

MATERIALS AND METHODS

In present research, marine estuary sediment samples were collected from Adyar estuary during September, 2022 at three sites. Sampling was done between 5.00 pm to 6.00 pm.

2.1 Collection Site:

2.1.1 Adyar Estuary:

The Adyar River, which originates near the Chembarambakkam Lake in kanchipuram district, is one of the three rivers which winds through Chennai, and joins the Bay of Bengal at the Adyar Estuary. The 42.5 kilometre long river contributes to the estuarine ecosystem of Chennai. The Adyar estuary encloses the sand bar which may be closed or open depending on the tidal action and seasons. It also represents a higher saline zone and may have either highly polluted or moderately polluted states due to the tidal influence.

Meiofauna samples were collected, following the methodology of Altaff *et al*., (2004) by using a stainless steel corer with an inner diameter of 3.57 cm which comes to $10cm^2$ surface areas. Three sites for collection were selected Site I (away from Estuary starting point), Site II (Nearer to Estuary Mouth) and Site III (at the start of Estuary). In the field, this corer was pushed upto 15 cm into soil and samples were collected with minimal disturbance.

2.2 Sampling Instrument:

2.2.1 Corer:

Corer is the best-suited and recommended sampling instrument for the collection of meiofaunal samples. The advantage of the corer are that it covers a defined area, it is easy to operate, and samples can be collected with minimal disturbances. The corer designed for the present study is made up of stainless steel corer and has a total length of 42.3 cm and 3.57 cm in inner diameter. It covers a total surface are of 10 $cm^{2.}$

2.3 Meiofauna Separation Method:

Meiobenthos are known to adhere the sand particles and some gentle force is required to separate them without any damage. In the present investigation, decantation methods are adopted for faunal separation.

2.3.1 Decantation Method:

Sediment is placed in a 2L plastic cylindrical bottle. Tap water was added upto ¾ th volume of the bottle, stoppered and inverted for several times. The bottle is left undisturbed for less than one minute to allow the sand particles to settle and then the supernatant is sieved through 62µm sieve and this procedure is repeated for 5 times. Prior to subjecting the live sample for separation they were treated with weak formalin to narcotize the animals.

2.3.2 Preservation

Meiofauna separated from both the methods were preserved in 5% formalin with 1% Rose Bengal stain.

2.4 Identification and Quantification

The major and minor meiofaunal taxa were identified following Higgings and Thiel (1988) and Altaff *et al*., (2004). The meiofauna was quantified using Sedgewick Rafter counting chamber.

2.5 Statistical Analysis

Statistical analysis was done using Microsoft excel, SPSS version 10 software and Statistica version 6.0.

RESULTS AND DISCUSSION

In the diversity studies conducted on the meiofauna at the three sites of Adyar estuary, 19 groups of Meiofauna were recorded belonging to Foraminiferans, Turbellarian, Nematoda, Ciliate, Gnathostomulida, Rotifer, Gastrotrichs, Sipuncula, Polychaetes, Oligochaetes, Archiannelids, Ostracods, Cyclopoid, Harpacticoid, Isopod, Halacarid, Collembolans, Insecta, Holothurians. In addition to this, unidentified species were also recorded. The Number of meiofaunal species recorded in stations I, II, III were 18, 17, and 17 respectively. The meiofaunal diversity, density and distribution of Adyar estuary includes freshwater, estuarine and marine species (Table 1 and figure 1 &2).

Table 1: Density of meiofaunal groups (Mean ± SE) from Adyar Estuary at three sites.

S.No	Groups	Site 1	Site 2	Site 3
1	**Foraminiferans**	118.00±26.00	115.67±20.33	168.00±42.00
2	**Turbellarian**	145.33±32.67	133.88±29.12	215.33±57.67
3	**Nematoda**	600.67±52.33	340.67±53.33	227.33±70.67
4	**Ciliate**	5.67±3.33	-	2.67±3.33
5	**Gnathostomulida**	133.67±34.33	103.67±23.33	113.67±26.33
6	**Rotifer**	11.33±9.67	23.67±3.33	13.67±12.33
7	**Gastrotrichs**	10.00±5.00	5.67±3.33	2.73±1.33
8	**Sipuncula**	11.33±9.67	8.33±6.67	13.67±3.33
9	**Polychaetes**	10.00±3.00	16.87±9.13	6.67±3.33
10	**Oligochaetes**	200.00±36.00	125.67±25.33	71.51±25.49
11	**Archiannelids**	55.00±15.00	21.67±9.33	-
12	**Ostracods**	20.67±12.33	64.00±10.00	47.33±14.67
13	**Cyclopoid**	17.33±13.63	13.33±6.67	11.33±6.67
14	**Harpacticoid**	25.00±10.00	27.63±3.37	35.00±1.00
15	**Isopod**	-	7.63±3.37	10.33±1.67
16	**Halacarid**	10.00±2.00	20.33±6.67	27.67±13.33
17	**Collembolans**	57.33±11.67	-	-
18	**Insecta**	45.67±22.33	42.33±10.67	69.59±17.41
19	**Holothurians**	9.00±5.00	11.39±9.61	6.13±5.87
20	**Nauplius**	-	-	-
21	**Others**	43.33±27.67	80.00±17.00	10.33±5.67
	Total	**1529.33±3±53.67**	**1161.53±252.47**	**1041.87±311.13**

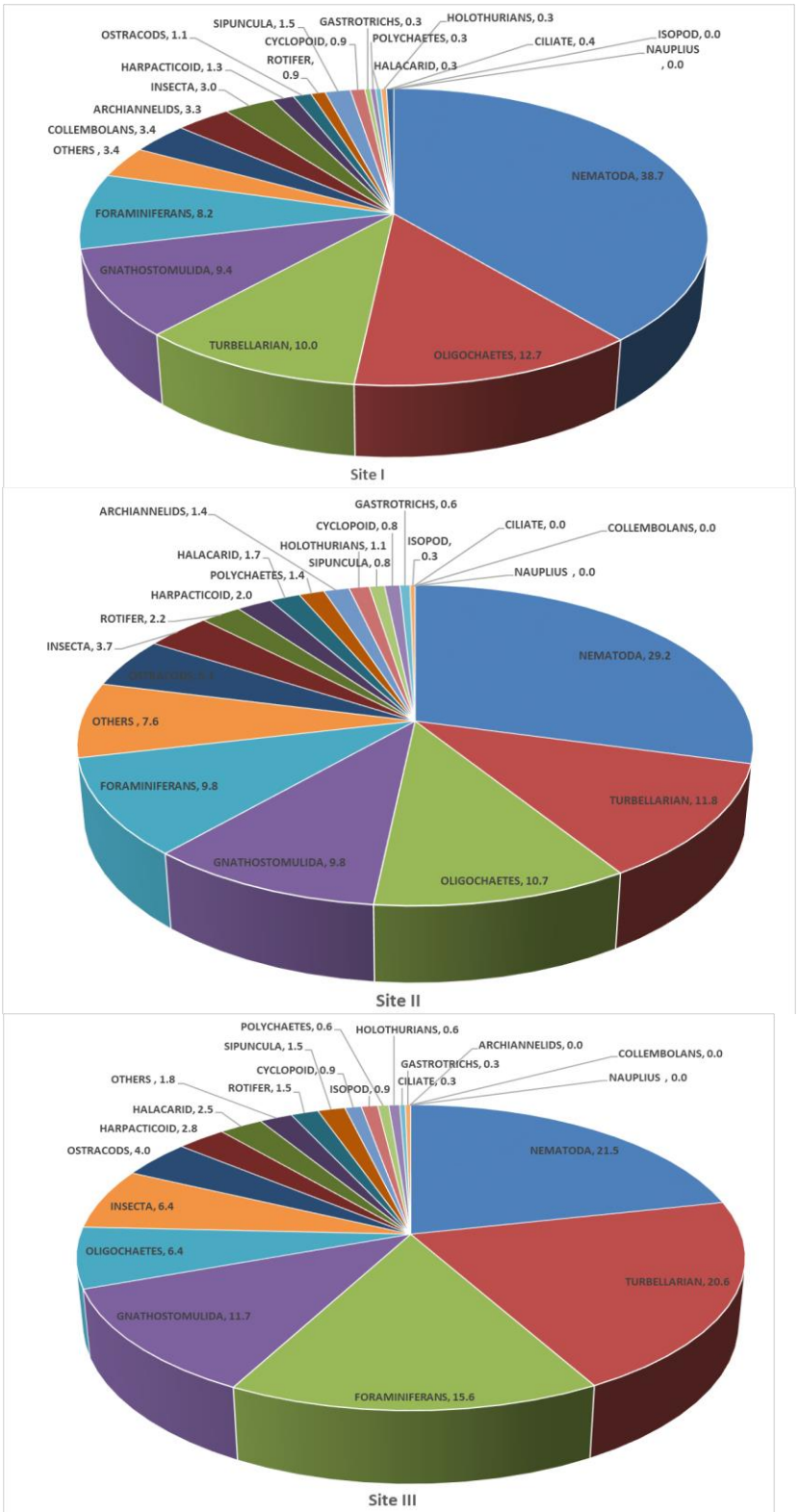

Figure 1. Percentage Composition of Meiofaunal Groups collected at three Site from Adyar Estuary

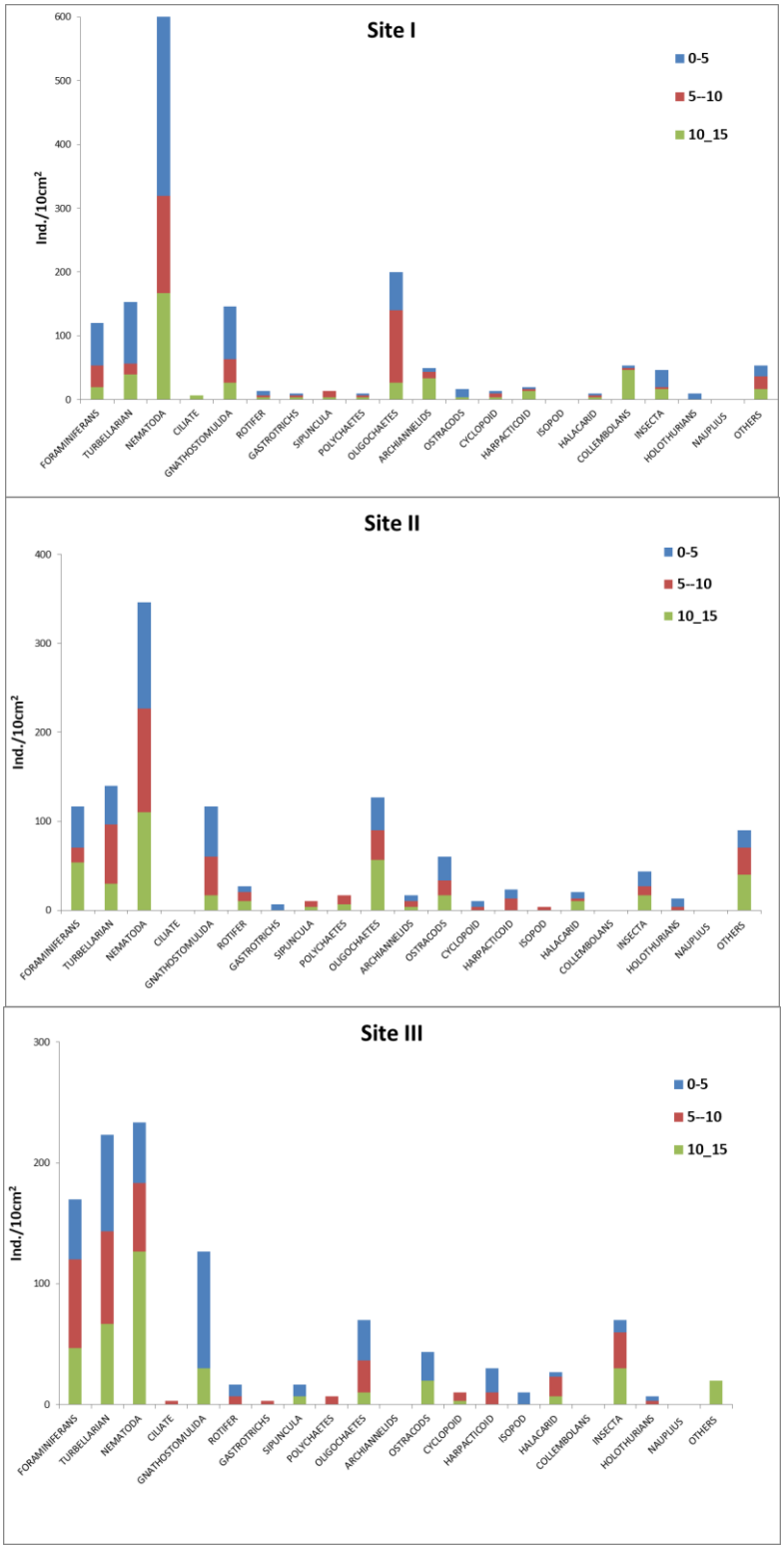

Figure 2: Vertical distribution of Meiofaunal Groups from various depths (0-15 cm) at three sites collected from Adyar Estuary

Meiofauna are known to be sensitive indicators to pollutants. Because their large numbers, relatively stationary life habitats and short lifecycles helps to assess the effects of contaminant within a short duration. Species diversity is a simple and useful measure of a biological system. Redding and Cory (1975) found a high level of agreement between species diversity and the nature of the environment and, hence, regarded the measure of species diversity as an ecologically powerful tool.

With regard to the diversity of meiofauna, in the present study, nineteen groups were recorded from the three sites of Adyar estuary. Nematodes, Oligochaetes, Turbellarians, Gnathostomulida and Foraminiferans occurred in higher density than other meiofaunal groups in Adyar estuary. The Number of meiofaunal groups recorded in sites I, II and III were 18, 17 and 17 respectively. The meiofaunal diversity of Adyar estuary includes freshwater, estuarine and marine species. Of the three sites, higher diversity of meiofauna was recorded in site I (18 groups) than in site II (17 groups) and III (17 groups). Dominant meiofaunal assemblages evidence the tolerance of foraminiferans and nematodes. However, these taxa were affected by decreased abundance at impacted sites compared to other fauna (Roa *et al.*, 2022). Within an ecosystem, the species diversity and abundance of benthic organisms vary, primarily due to abiotic and biotic factors. Bioturbation influences the benthic organisms by the availability of oxygen, nutrients, increasing sediment mixing depth, and also increasing the flux of nutrients from the sediment to the overlying water column (Arya *et al.*, 2022).

It is observed that diversity and abundance of meiofauna is high in estuarine and coastal regions than in the sediments of freshwater habitats, and this may be the reason for the difference in the diversity of meiofauna of the sites of Adyar estuary. Further, it is inferred from the present study that in sites II and III, lesser diversity of meiofauna might be due to the retention of pollutants in soil sediments. The low diversity of meiofauna in station III can also be due to the low salinity of this station. It is reported that higher diversity of meiofauna is recorded from estuarine and marine waters than from freshwater (Giere, 1993), which is in agreement with the present study. Abundance of foraminifers (Bernstein *et al.*, 1978), nematodes (Hasemann, 2006) and harpacticoid copepods (Thistle, 1978) indicates that they may be important for creating habitat heterogeneity for meiofauna. Low meiobenthic biodiversity and presence of tolerant taxa, such as nematodes, have often correlated with high organic matter concentrations, high levels of contaminants and low oxygen content (Trannum *et al.*, 2004; Steyaert *et al.*, 2007) which is in agreement with the present study. Efficient implementation of nematodes-based indices for ecological quality assessment requires fundamental knowledge on their biodiversity and functional patterns along with the drivers that generate these patterns (Kasia *et al.*, 2021)

Among the meiofaunal groups of Adyar estuary, nematodes, oligocheates and turbularians were most dominant as indicated by their percentage composition. Results suggested higher polluted state of III and II sites as they are more polluted when compared to site I. Different groups of meiofauna not only differ in their size and morphology but also show variation pertaining to their life-cycle strategies like food and feeding habits, life span, reproductive potential and development. These features of meiofaunal groups exert many beneficial attributes towards the productivity of the benthic system. All the three sites of Adyar estuary recorded occurrence of foraminifers denoting contribution of this group in combating the pollutants. Of the metazoans meiofauna, nematodes are by far the most dominant taxon in terms of both densities and biomass but are often equaled by foraminifera (Moodley *et al.*, 2000). Diversity, density and distribution of meiofauna showed variation in the three sites of Adyar estuary, which is mostly due to a combination of many factors like availability of food, inter and intra-species competition, climatic and water chemistry parameters as well as predation pressure. Similar to the present study, Soltwedel (1997) reported that the differences in food availability, both quantitative and qualitative, appear to be an important factor controlling total abundance and the faunal composition of the metazoan meiobenthos at the taxonomic level. Richer communities are tending to develop in shallower areas where there is a higher overall input of organic matter.

In the present study, higher density of meiofauna was recorded in site I of Adyar estuary than the other two sites. Many environmental changes induced by anthropogenic activities may lead to a reduction in benthic species richness, abundance and biomass (Holmer *et al.*, 2007). Such a condition is also observed in the

present study. This is mainly due to oxygen depletion associated with biochemical oxygen demand and the formation of toxic products in anoxic sediments (Gray *et al.*, 2002). Monitoring of biological parameters rather than chemical ones is important as it gives the bioavailability rather than the absolute concentration of pollutants (Giere, 1993). Due to human activities, estuaries have become one of the most polluted aquatic environments (Chapman and Wang, 2001). Changes in the community structure of meiofauna have been widely used to identify the effects of anthropogenic contamination on aquatic environments (Munawar *et al.*, 2003). In addition to these kinds of disturbances, the Adyar estuary experiences frequent changes in the concentration of pollutants and salinity, which results in forming a unique type of meiobenthic community structure. Gray and Delaney (2008) reported that the contaminant impacts may also be assessed in a variety of ways and within the aquatic pollution.

The use of faunal diversity as indicator of environmental health, is the most effective, advantageous and cost-effective approach. Benthic infaunal monitoring is widely accepted as the fundamental step to most recent interdisciplinary studies of contaminant effects on ecosystems (Susanta and Tridip, 2018).). Not only in pollution monitoring, meiofauna also plays important roles in benthic community processes such as bioturbation (organic decomposition, nutrient cycling, redistribution of organic material, oxygenation of the sediment) and an effective link in food web. In conclusion it may be said that the meiofauna either appears to consist of more than one population or has a continuously changing species composition with depth. Deposition of sediment in large dose caused severe changes rather than the type of sediment or the degree of contamination in nematode assemblage structure (Dhivya and Mohan, 2013: Ghosh and Mandal, 2021: Roa *et al.*, 2022)

The Adyar estuary have been subjected to great ecological stress due to anthropogenic activities like discharge of untreated sewage and effluents, encroachments etc. Scientific studies of the Adyar estuary require a comprehensive and holistic approach taking into consideration the topography tidal flow, water quality and assessment of flora and fauna like zooplankton and meiobenthos and macro biota which could be a pointer toward the successful assessment of the status of the Adyar estuary.

REFERENCES

Altaff, K, Naveed MS.and Sugumaran J (2004). Meiofauna of Chennai coast of bay of Bengal with special reference to sampling and extraction methods. *Convergence*, 6(1- 4) 61-91.

Arya DB, Salom Gnana Thanga Vincent and Prince Godson S (2022). Benthic biotopes: abiotic and biotic factors in the sediment, Editor(s): Prince S. Godson, Salom Gnana Thanga Vincent, S. Krishnakumar, *Ecology and Biodiversity of Benthos*, Elsevier, Pages 21-31.

Bernstein BB, Hessler RR, Smith R and Jumars PA (1978). Spatial dispersion of benthic Foraminifera in the abyssal Central Pacific. *Limnology Oceanography*, 23:401–416.

Chapman PM and Wang F (2001). Assessing sediment contamination in estuaries. *Environmental Toxicology Chemistry.* 20: 3–22.

Danovaro, R (2010). *Methods for the study of Deep-sea Sediments, Thier Functioning and Biodiversity*. Boca Raton, MA: CRC Press Taylor & Francis Group. doi: 10.1201/9781439811382

Dhivya P and Mohan PM (2013). A review on meiofaunal study in india. *Journal of the Andaman Science Association*, 18(1):1-24

Gadhia M & Bengani R and Ansari E (2013). Seasonal Variations in Physico-Chemical Characterstics of Tapi Estuary in Hazira Industrial Area. *Our Nature*, 10:1-10 10.3126/on.v10i1.7811.

Ghosh M and Mandal S (2021). Disentangling the Effect of Seasonal Dynamics on Meiobenthic Community Structure from River Matla of Sundarbans Estuarine System, *Indian Frontiers Marine Science*, 1:1-20.

Giere O (1993). *Meiobenthology: The Microscopic Fauna in Aquatic Sediments*. Springer- Verlag, Berlin, 316.

Gray NF.and Delaney E (2008). Comparison of benthic macroinvertebrate indices for the assessment of the impact of acid mine drainage on an Irish river below an abandoned Cu-S mine. *Environmental Pollution,* 155:31-40.

Gray SC, Sturz A, Bruns MD, Marzan R, Dougherty D, Law HB, Brackett JE and Marcou M (2002): Composition and distribution of sediments and benthic foraminifera in a submerged caldera after 30 years of volcanic quiescence. *Deep-Sea Research,* 50: 1727-1751.

Hasemann. C., 2006. Kleinskalige Heterogentität in der arktischen Tiefsee: Einfluss kleiner Kaltwasser - Schwämme auf die Diversität benthischer Nematoden-Gemeinschaften. B*er Pol- Meeres forsch,* 527:1–323.

Higgins RP and Thiel H (1988). Introduction to the Study of Meiofauna, Smithsonian Institute Press., Washington, D.C, .1-488.

Holmer M, Marba N, Diaz-Almela E, Duarte CM, Tsapakis M and Danovaro R (2007). Sedimentation of organic matter from fish farms in oligotrophic Mediterranean assessed through bulk and stable isotope ([delta] 13C and [delta] 15N) analyses. *Aquaculture,* 262: 268–280.

Kasia Sroczyńska, Paula Chainho, Soraia Vieira and Helena Adão (2021). What makes a better indicator? Taxonomic vs functional response of nematodes to estuarine gradient, *Ecological Indicators,* 121:107-113.

Moodley L, Boschker HTS, Middelburg JJ, Pel R, Herman PMJ and Deckere E (2000). Ecological significance of benthic foraminifera: 13C labelling experiments. *Marine Ecological Programme Series,* 202:289–295.

Munawar M, Munawar IF, Dermott R, Johannssen OE, Lynn D, Munawar SF and Niblock H (2003). An integrated assessment of the ecosystem health of a protected area: Fathom Five National Marine Park, Lake Huron. *Aquatic Ecosystem Health and Management,* 6:185–204

Patrício J Adão H, Neto JM, Alves AS, Traunspurger W, Marques JC (2013). Do nematode and macrofauna assemblages provide similar ecological assessment information? Ecological Indices, 14:124–137

Rao MN, Gaikwad S, Ram A, Pradhan UK, Sautya S, Kumbhar, Udayakrishnan PB Siddaiha V (2022). Effects of sedimentary heavy metals on meiobenthic community in tropical estuaries along eastern Arabian Sea. *Environ Geochem Health.* https://doi.org/10.1007/s10653-022-01239-3

Redding JM. and Cory RL (1975). Macroscopic benthic fauna of three tidal creeks adjoining the Rodhe river, Maryland. *U.S. Geol. Survey-water Resource Invest,* 39:1-28.

Schratzberger M and Ingels J (2018). Meiofauna matters: the roles of meiofauna in benthic ecosystems. *Journal of Experimental Marine Biology Ecology,* 502: 12-25.

Soltwedel, T (1997). Meiobenthos distribution pattern in the tropical East Atlantic: Indication for fractionated sedimentation of organic matter to the sea floor? *Marine Biology*. 129:747–756. doi: 10.1007/s002270050217

Steyaert M., Moodley,L, Nadong T, Moens T, Soetaert K, Vincx M (2007). Responses of intertidal nematodes to short-term anoxic events. *Journal of Experimetal Marine Biology and Ecology,* 345 (2):175-184

Susant KC and Tridip KD (2018). Relevance of Meiobenthic Research: Indian Perspectives. *Marine Biology Oceanography*. 1(4). EIMBO.000523.2018. DOI: 10.31031/EIMBO..01.000523

Thistle D (1978): Harpacticoid dispersion pattern: Implications for the deep sea diversity maintenance. *Journal of Marine Research* 36: 377-397.

Trannum HC, Olsgard F, Skei JM, Indrehus J, Øveras S and Eriksen J (2004). Effects of copper, cadmium and contaminated harbour sediments on recolonisation of soft-bottom communities. *Journal of Experimental Marine Biology Ecology,* 310:87-114.

Woodward G (2010). Integrative ecology, volume 43: from molecules to ecosystems. *Advances in ecological research.* Academic Press, London

Zeppilli D, Leduc D, Fontanier C, Fontaneto D, Fuchs S and Gooday AJ (2018). Characteristics of meiofauna in extreme marine ecosystems: a review. *Marine Biodiversity*, 48: 35–71. doi: 10.1007/s12526-017-0815-z