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Assessment of Meiofaunal Community Structure in Heavy Metal Containing Sediment of Tapi River, India

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Abstract— Meiofauna is a vital constituent of freshwater systems because it helps in the biomineralization of organic matter, increases nutrient restoration, works as food intended for higher trophic levels, and shows high sensitivity to environmental changes. The study was undertaken to understand the meiofaunal community composition concerning heavy metals (Cu, Zn, Ni, Pb, Cd) in sediment at different sites of the Tapi River. During the study total of 44 species of 6 groups of the meiofaunal community were identified i.e., Copepoda, cladocerans, rotifers, nematodes, Oligochaeta, and Ostracoda. Among these groups, nematodes were most abundant in both seasons and Ostracoda was reported least dominant at all the sites. According to heavy metal concentration meiofaunal community composition also differed.

Keywords— Meiofauna, heavy metals, seasonal variation, sediment, Tapi River

I. INTRODUCTION

Meiofauna has been considered as a most important metazoan part of the benthic environment because of its high abundance and rapid turnover rates. Meiofauna is mostly found in and on soft sediments, but also on and among epilithic plants and other types of substrate (e.g., animal tubes) [1]. Even though, meiofauna is a well-recognized as plentiful and ubiquitous part of benthic communities [2]. Its production is equivalent to or else higher than macrofauna in shallow waters in the deep sea. It constitutes a high-quality food source for fishes, shrimps, and larvae of molluscs. Hence, it is an important constituent in the benthic food chain. In recent times, the role of meiobenthos and nematodes as indicators of ecological quality and their combination in impact as well as monitoring study has been esteemed, being essential to be aware of the distribution patterns of these communities. In the scope of the growing responsiveness of the risk, human activities characterize aquatic ecosystems; there has been a improvement in environmental policies, primarily focused on the ecological quality consideration [3].

Several papers have analyzed the value of freshwater ecosystems as an vital part of human cultures. Despite the fact that they occupy only about 1 % of the Earth's surface, equally lotic and lentic environments are essential to society. However, they are being conquered to exceptional levels of human interruption with the variable prevalence in waters, sediments, and biota [4]. Heavy metals obviously materialize in both terrestrial and freshwater sediments. Amongst heavy metals, some, such as iron, are essential element and important for maintenance of all biological processes [5]. Though, at high concentration, particular elements, include lead, copper or, zinc can be toxic for the natural aquatic ecosystem[6]Various groups of organisms have been proposed as bio indicators or bio monitors [7] to test these environmental changes. along with the macrofaunal organisms, fishes, mussels, gastropods or plants are typically used for this function[8][9][10]. Moreover, numerous meiofaunal groups are also incorporated as custodian of human-induced changes in these freshwater environments, such as diatoms or nematodes [12][13]. The major cause of pollution of the river Tapi with the heavy metals is due to drainage releases coming from all villages as well as cities on the banks of the river and its tributaries. In the same way, heavy metals contamination also takes place due to small-scale industries, small brick industries, and farming runoff water comprising fertilizer and pesticides. The higher concentration of heavy metals in the ecosystem could be harmful due to their toxicity and increasing behaviours with serious public health implications [14].

II. MATERIALS AND METHODS

II.I. Study area

To fulfil the aims of the present study, three different sites along the stretch of the freshwater zone of Tapi River were selected based on the accessibility and point sources of pollution; Galteshwar is a reference site as it has the least interference from human activities, Utran as a site receiving sewage of the urban area and waste from the Gas based power station as a pollution source and Ashwanikumar as a site under the influence of pollution from cremation ground as well as domestic sewage.

II.II. Core collection

The sample collection from all three sites has been done on the same day of the last week of every month. Sediment samples have been collected by using a 30 cm long acrylic core of 7.5 cm diameter which has been pushed into mudflats up to 5cm and the sediments have been scooped out per m^2 area. A total of five core samples have been collected at different points and pooled together. At each sample site, two sediment samples have been collected, pooled, and stored in polythene bags.

II.III. Laboratory Processing

II.III.I Heavy metal analysis

At first the sediment samples were air-dried for ten days, then vegetables and debris materials removed from the sediment samples. The air dried sediment samples were grinded using a morter and pastle to get powder form and seiving was done to obtain a homogeneous mass. The 2 g of each powder sediment sample was digested following the standard procedure. Briefly, a 2 g of each sediment sample placed in a 50 ml crucible before the addition of 10 ml concentrated HNO_3. The mixture was placed on a hot plate for 30–45 min to allow for oxidation. After cooling, 2.5 ml of concentrated (70%) $HClO_4$ acid was added and the mixture was reheated on a hot plate until the digest became clear and semi dried. Thereafter, the samples were cooled and filtered through Whatman No. 42 filter paper. Finally, the solution was used for elemental analysis using atomic absorption spectrometry [15].

II.III.II. Extraction of Meiofauna

Every sample was washed with deionised water on a 300-µm–aperture sieve, and the material that passed through was caught on a 30-µm-aperture sieve. The meiofauna were removed from the 30-µm fraction [16][17]. Benthic organisms have been extracted using an isotonic solution of 7% NaCl [18]. It releases them from the particles and pours them off the water, and it has been constantly stirred up so the organisms have been dislodged. The first sediment sample has been poured through a 1 mm sieve to collect macrofauna. After those sediments have been settled down and supernatant has been poured through a 62-micron sieve to collect meiofauna. It had been preserved in 4% formalin in separate jars. Samples were stained with 2% rose bengal, and all were searched for meiofauna under a Labomed Vision 2000 Binocular microscope at 40X and 100X. Six groups of the meiofaunal community were identified and recorded i.e., copepod (5species), cladoceran, rotifer, nematode, Oligochaeta and Ostracoda.

III. RESULTS AND DISCUSSION

The presence of sensitive or tolerant meiofaunal taxa and nematode genera appears to be particularly informative in highlighting the state of sediment pollution and allows a better assessment of the spatial heterogeneity of environmental disturbance within each harbour [19]. During the study total of 44 species of 6 groups of the meiofaunal community were identified i.e., copepod (5 species), cladoceran (6 species), rotifer (6 species), nematode (19 species), Oligochaeta (5 species), Ostracoda (3 species). Among these groups, nematodes were most abundant in both seasons meiofaunal communities in the soil samples were assessed by examining the diversity of the Nematoda. It was found previously that nematodes were the most prevalent of the meiofaunal groups examined at one site in this study [20] and Ostracoda was reported least dominant at all the sites. Nematodes are typically found in organically rich, muddy sediment [21][22] and have been proposed to be representative of a community that is well adapted to disturbed conditions [23].

III.I. Cadmium

Cadmium and Nickel presented the lowest level during both seasons. Though, cadmium shows very high toxicity to both aquatic and terrestrial organisms even at low concentrations [24]. Average concentration of heavy metals in wet season and dry season is described in table no.1 and 2.

Copper and Zinc presented the highest level during both seasons. The cadmium concentration ranged from 1.37-7.6 mg kg-1and 2.11 to 4.77 mg kg-1 for wet and dry seasons respectively. A higher concentration was reported at site -1 during the wet season and a lower concentration was reported at site -3 during the dry season. At minimum value of Cadmium **Nematoda**(*Strongyloides sp., Protorhabditisspiculocrestata, Trichodorousobtusus),* **Rotifer** *(Brachionusfalcatus, Notholca sp.),* **Oligochaeta** *(Chaetogaster sp., Nais sp., Tubifex sp.),* **Cladocera** *(Daphnia lumholtzi, Macrothrix spinosa)* was reported during the study period. At maximum value of cadmium **Nematoda**(*Acrobeloidesapiculatus, Dorylaimus occidentalis, Pungentusangulosus),* **Rotifer** *(Keratellatropica),* **Oligochaeta***(Chaetogaster sp., Nais sp., Tubifex sp.),* **Cladocera***(Daphnia lumholtzi, Leydigiaacanthocercoides, Macrothrix spinosa),* **Copepoda***(Bryocamptus sp., Thermocyclop sp.)* were reported during the study period.

III.II. Copper

Copper concentration ranged from 57.82 - 102.27 mg kg-1 and 75.90 to 101.4 mg kg-1 for wet and dry seasons respectively. A higher concentration wasreported at site -1 during the wet season and a lower concentration was reported at site -2 during the wet season. At minimum value of Copper **Nematoda**(*Rhabditislongicaudata, Anaplectusgranulosus, Tripyla sp.),* **Rotifer** *(Lecane (Monostyla) bulla, Lecaneinopinata, Notholca sp.),* **Oligochaeta** *(Nais sp., Tubifex sp.),* **Cladocera** *(Leydigiaacanthocercoides, Kurzialongirostris),* were found during the study period. At maximum value of Copper **Nematoda** (*Acrobeloidesapiculatus, Dorylaimus occidentalis, Pungentusangulosus),* **Rotifer** *(Keratellatropica),* **Oligochaeta** *(Chaetogaster sp., Nais sp., Tubifex sp.),* **Cladocera***(Daphnia lumholtzi, Leydigiaacanthocercoides, Macrothrix spinosa)* were reported during the study period.

Table 1. Average concentration of heavy metals in wet season

Wet season	Heavy metals (mg kg^{-1})				
Sites	**Cd**	**Cu**	**Pb**	**Zn**	**Ni**
Site 1	7.86	102.27	125.35	46.66	29.88
Site 2	3.61	57.82	71.92	51.25	17.02
Site 3	1.37	101.41	33.85	106.84	35.23

Table 2. Average concentration of heavy metals in dry season

Dry season	Heavy metals (mg kg^{-1})				
Sites	**Cd**	**Cu**	**Pb**	**Zn**	**Ni**
Site 1	4.68	76.71	17.67	64.75	30.51
Site 2	4.77	75.90	16.58	77.00	21.38
Site 3	2.11	101.4	22.28	94.40	35.82

Table 3. Meiofaunal communities found during wet and dry season

Meiofaunal community	Number of species					
	Wet season			*Dry season*		
	Site-1	*Site-2*	*Site-3*	*Site-1*	*Site-2*	*Site-3*
Copepoda	4	4	5	4	4	4
Cladocera	5	4	3	6	4	4
Rotifera	5	5	6	4	5	6
Nematoda	7	8	6	12	6	9
Oligochaeta	5	3	4	5	3	5
Ostracoda	3	1	2	2	2	2

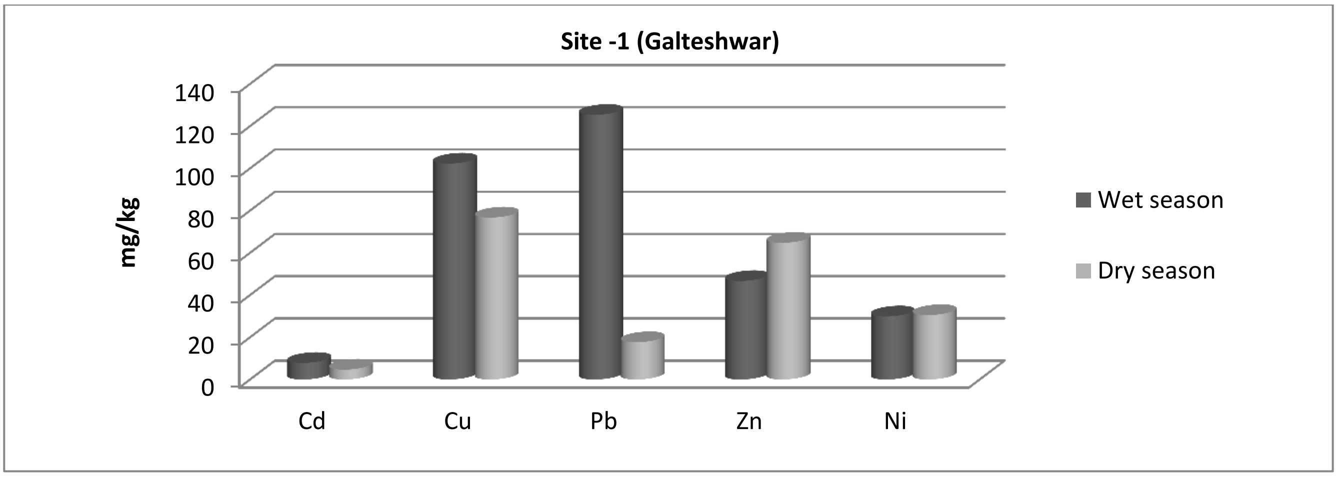


Figure 1. Comparison of average concentration of heavy metals in both seasons at site 1

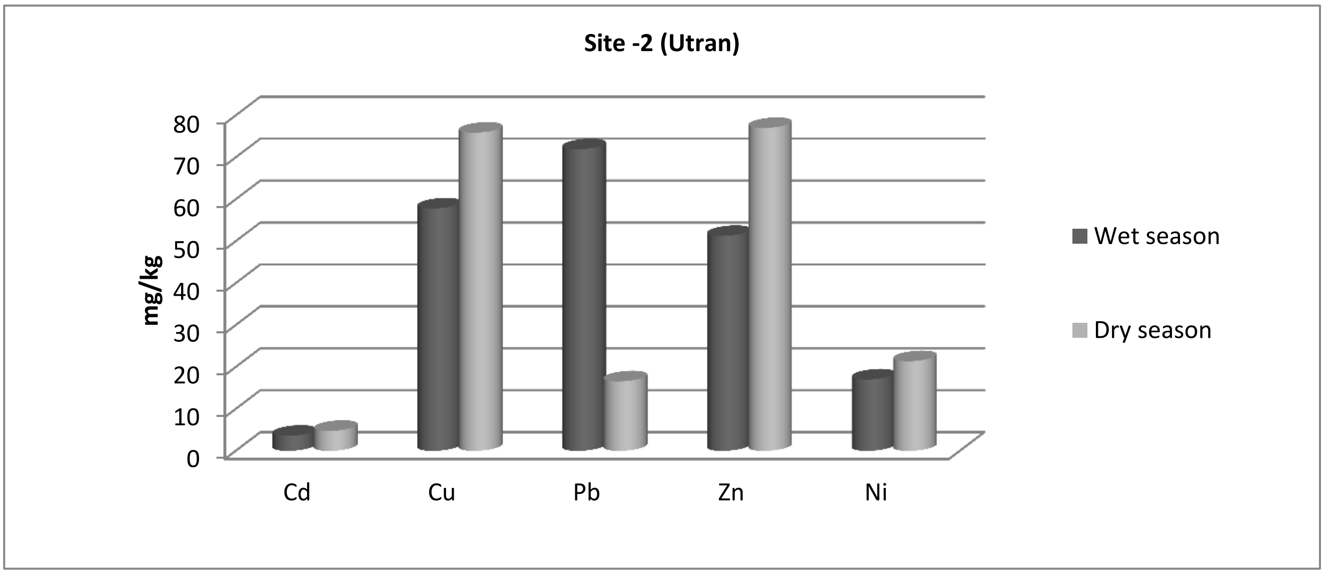


Figure 2. Comparison of average concentration of heavy metals in both seasons at site 2

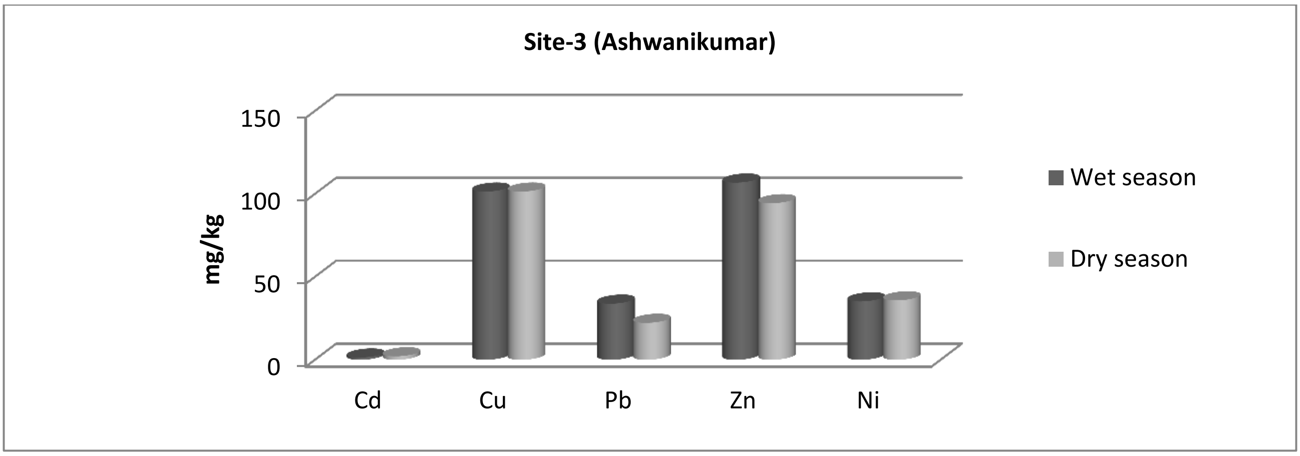


Figure 3. Comparison of average concentration of heavy metals in both seasons at site 3

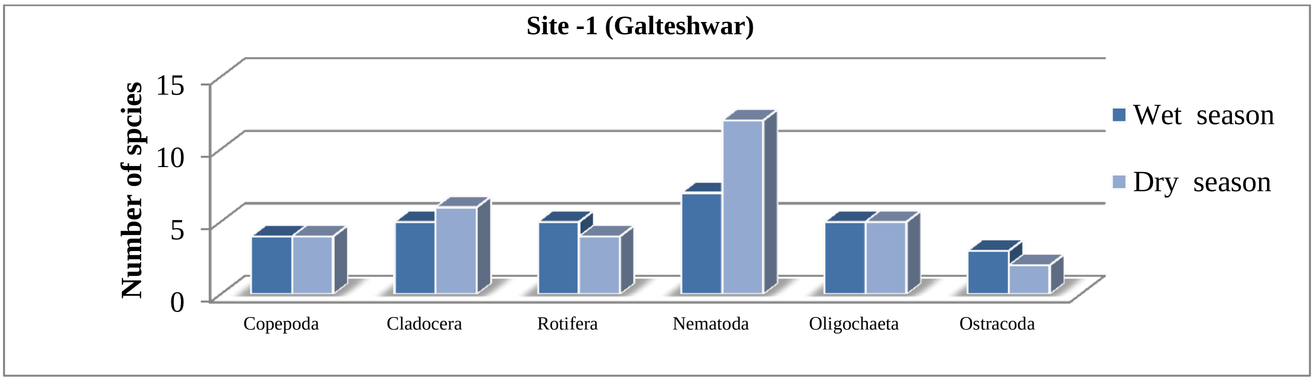


Figure 4. Comparison of average concentration of heavy metals in both seasons at site 1

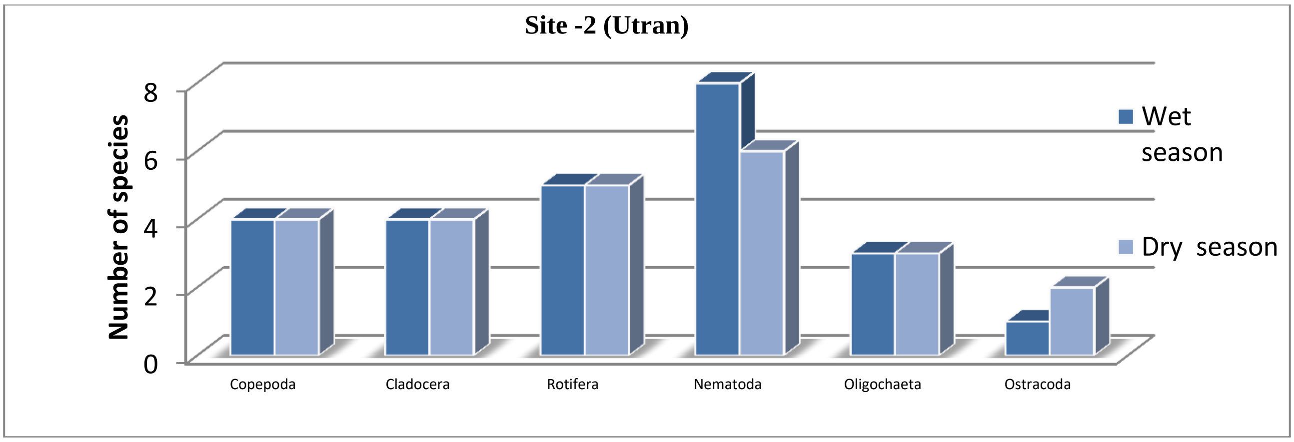


Figure 5. Comparison of species composition of meiofauna in both seasons at site 2

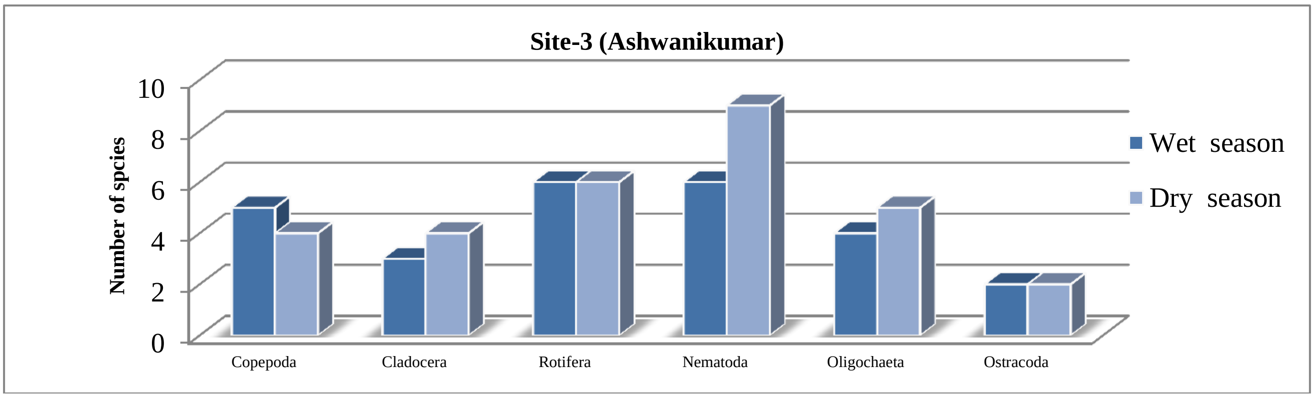


Figure 6. Comparison of species composition of meiofauna in both seasons at site 3

III.III. Lead

The toxicity level of Pb is so hazardous, even at a low concentration; it can cause a significant threat to the ecosystem [25]. The average Pb concentration at different sampling points was significantly different ranged from 33.85–125.35 mg kg-1and 16.58 to 22.28 mg kg-1 for wet and dry seasons respectively. A higher concentration was reported at site -1 during the wet season and a lower concentration was reported at site -2 during the dry season. At minimum value of Lead **Nematoda** (*Rhabditislongicaudata, Gracilacus latescens, Tripyla sp.)*, **Rotifer** *(Notholca sp.)*, **Oligochaeta** *(Tubifex sp., Clitellioarenarius),* **Cladocera** *(Daphnia lumholtzi, Leydigia acanthocercoides)*, **Protozoa** *(Arcella vulgaris, Centopyxis sp.),* **Copepoda** *(Paracyclopspoppei, Bryocamptus sp.)* was reported during the study period.At maximum value of Lead **Nematoda** (*Gracilacuslatescens, Tripyla sp.),* **Rotifer** *(Brachionus quadridentatus brevispinus, Brachionus forficula minor, Lecane (Monostyla) bulla*), **Oligochaeta** *(Nais sp.),* **Cladocera** *(Daphnia lumholtzi, Leydigiaacanthocercoides, Alonella excise)* were reported during the study period.

III.IV. Zinc

Zinc concentrations ranged from 46.66–106.84 mg kg-1 and 64.75 to 94.40 mg kg-1 for wet and dry seasons respectively. A higher concentration was reported at site -3 during the wet season and a lower concentration was reported at site -1 during the wet season. At minimum value of Zinc **Nematoda** (*Dorylaimus occidentalis, Anaplectusgranulosus),* **Rotifer** *(Brachionusquadridentatusbrevispinu, Lecane (Monostyla) bulla),* **Oligochaeta** *(Nais sp., Clitellioarenarius),* **Cladocera** *(Alonella excise),* **Protozoa** *(Arcella sp., Centopyxis sp.),* **Copepoda***(Bryocamptus sp., Nauplius larvae)* was reported during the study period.At maximum value of zinc **Nematoda** *(Mesodorylaimuslissus, Anaplectusgranulosus),* **Rotifer** *(Notholca sp.),* **Oligochaeta** *(Chaetogaster sp., Naissp.),* **Cladocera** *(Ceriodaphniacornuta, Alonella excise),* **Protozoa** *(Centropyxis sp., Diffugia corona),* **Copepoda***(Mesocyclopleukarti, Thermocyclop sp.)* were reported during the study period.

III.V. Nickel

Nickel concentration ranged from 17.02–35.23 mg kg-1 and 21.38 to 35.82 mg kg-1 for wet and dry seasons respectively. A higher concentration was reported at site -2 during the wet season and a lower concentration was reported at site -3 during the dry season. At minimum value of Nickel **Nematoda** *(Mesodorylaimus flexus, Monhysterastangnalis),* **Rotifer** *(Keratellatropica, Notholca sp.)*, **Oligochaeta** *(Chaetogaster sp.)*, **Cladocera** *(Leydigiaacanthocercoides),* **Protozoa** (*Diffugia corona),* **Copepoda** *(Mesocyclopleukarti, Nauplius larvae, Thermocyclop sp.)* were reported during the study period. At maximum value of Nickel **Nematoda** *(Mesodorylaimuslissus, Anaplectusgranulosus),* **Rotifer** *(Notholca sp.),* **Oligochaeta** *(Chaetogaster sp., Nais sp.),* **Cladocera (***Alonella excise* were reported during the study period.

Currently, there are no sediment quality guidelines (SQGs) in India for metal concentration in freshwater sediments and therefore the SQGs of the Canadian Council of Ministers of the Environment (CCME) for sediments in freshwater were employed in this study. The average concentration of all heavy metals cadmium, copper, lead, zinc, and nickel at all sites remained under the permissible limit according to ISQG/PEL guidelines.

Copepod was observed highest when cadmium concentration was reported minimum and zinc concentration was reported as maximum. While cladoceran was reported highest in number when lead was at the minimum level. The number of rotifer species was reported maximum when copper and nickel were at maximum levels. While rotifer species were decreased when lead was at least concentrated. The highest nematode species were identified during the dry season when zinc concentration was reported as a minimum and the lowest numbers of species were identified when lead was at a maximum level. Oligochaeta was reported at maximum when copper concentrations were highest while a lower number of species were reported when nickel and copper were at minimum concentration. Ostracoda species were reported maximum when the concentration of cadmium, copper, and lead was reported maximum. While the lowest numbers of species.

Table 4. Meiofaunal species identified from 3 sites in the sediment of the River Tapi

Species	*OccuranceNo.of sites*	*Curange (mgkg^{-1})*	*Cd range (mgkg^{-1})*	*Pb range (mgkg^{-1})*	*Zn range (mgkg^{-1})*	*Ni range (mgkg^{-1})*
Copepoda						
Mesocyclops sp.	1	65.5-125.7	0.11-18.2	2.4-311	26.46-88.1	21.3-37.4
Brayocamptussp	1	65.5-125.7	7.3-18.7	7.4-202	11.08-92.3	8.6-33.02
Thermocyclops sp.	2	84.5-102.4	0.23-7.3	11.36-89.2	75.3-136.2	26.32-41.3
Paracyclopspoppei	3	68.7-119.5	0.25-4.19	3.2-210	26.46-92.3	8.6-37.4
Nauplius larvae	2	84.5-102.5	0.11-7.3	7.4-311	11.08-136.2	21.3-41.3
Paracyclopspoppei	2	68.7-119.5	0.25-18.7	11.36-202	75.3-92.3	37.4-41.3
Bryocamptus sp.	1	65-125	4.19-18.7	2.4-89.2	93.6-136.2	26.32-37.5
Cladocera						
Ceriodaphniacornuta	1	65-125	0.11-18.2	11.36-89.2	11.08-136.2	8.6-37.4
Leydigiaacanthocercoides	2	84.5102.5	7.3-18.7	89.3-202	75.3-92.3	21.3-41.3
Macrothrix Spinosa	2	6.75-102.3	0.23-7.3	89.2-315	93.6-136.2	37.4-41.3

Alonella excise	3	84.5102.5	0.25-4.19	7.4-311	75.3-136.2	26.32-37.5
Daphnia lumholtzi	2	65.8-128.4	0.11-7.3	89.3-202	26.46-92.3	21.3-37.4
Ceriodaphniacornuta	1	65-125.3	0.25-18.7	7.4-311	11.08-136.2	8.6-33.02
Kurzialongirostris	1	65-125.3	4.19-18.7	11.36-89.2	93.6-136.2	26.32-41.3
Rotifera						
Brachionusfalcatus	1	65-125	0.11-18.2	3.2-210	75.3-136.2	21.3-37.4
Notholca sp.	2	84.5102.5	7.3-18.7	7.4-311	26.46-92.3	8.6-33.02
Keratellatropica	3	6.75-102.3	0.23-7.3	2.4-311	11.08-136.2	26.32-41.3
Testudinella patina	1	65-125	0.25-4.19	7.4-202	26.46-88.1	8.6-33.02
Platyiasquandricornis	2	84.5102.5	0.11-7.3	11.36-89.2	11.08-92.3	26.32-41.3
Notholca sp.	3	65.5-125.1	0.25-18.7	3.2-210	75.3-136.2	8.6-37.4
Trichocera sp.	1	65-125	4.19-18.7	7.4-311	26.46-92.3	21.3-41.3
Brachionusforficula	2	6.74-102.3	0.25-4.19	11.36-202	11.08-136.2	37.4-41.3
Lecaneinopinata	2	72.6-102.3	0.11-7.3	2.4-89.2	75.3-92.3	26.32-37.5
Lecane (Monostyla) bulla	3	72.6-102.3	0.25-18.7	3.2-210	93.6-136.2	37.4-41.3
Philodinacitrina	1	65.5-125.1	4.19-18.7	7.4-311	26.46-92.3	26.32-37.5
Brachionusquadridentatusbrevispinus	1	72.6-102.3	0.11-18.2	7.4-202	75.3-92.3	8.6-33.02
Nematoda						
Strongyloides sp.	1	65-125	0.23-7.3	89.2-315	26.46-92.3	37.4-41.3
Trichodorous sp.	1	6.75-102.3	0.11-18.2	11.36-89.2	11.08-136.2	26.32-37.5
Protorhabditis sp.	1	6.75-119.3	0.11-18.2	89.3-202	75.3-92.3	21.3-37.4
Rhabditislongicaudata	2	6.75-102.3	7.3-18.7	2.4-311	26.46-88.1	8.6-33.02
Protorhabditis	3	65.8-119.6	0.11-18.2	7.4-202	11.08-92.3	26.32-41.3
spiculocrestata	3	6.75-102.3	7.3-18.7	11.36-89.2	75.3-136.2	8.6-37.4
Diplocaster sp.	3	65.8-119.6	0.23-7.3	3.2-210	26.46-92.3	21.3-41.3
Aphelenchusavenae	2	6.75-102.3	0.25-4.19	7.4-311	11.08-136.2	37.4-41.3
Helicotylenchus sp.	1	65.6-125.2	0.11-7.3	11.36-202	75.3-92.3	26.32-37.5
Rhabdolaimus minor	3	6.75-102.3	0.25-18.7	2.4-89.2	93.6-136.2	21.3-41.3
Trichodorousobtusus	3	65.8-119.6	4.19-18.7	89.2-315	26.46-92.3	37.4-41.3
Anaplectusgranulosus	2	6.75-102.3	0.11-18.2	7.4-202	11.08-136.2	26.32-37.5
Tripyla sp.	2	6.75-102.3	7.3-18.7	89.3-202	11.08-92.3	37.4-41.3
Acrobeloidesapiculatus	1	6.75-102.3	0.23-7.3	2.4-311	75.3-136.2	26.32-37.5
Dorylaimus occidentalis	1	65.8-119.6	0.25-4.19	7.4-202	11.08-92.3	21.3-37.4
Pungentusangulosus	1	6.75-102.3	0.11-18.2	11.36-89.2	26.46-88.1	8.6-33.02
Mesodorylaimus flexus	1	65.9-102.5	7.3-18.7	3.2-210	11.08-92.3	26.32-41.3
Monhysterastangnalis	1	6.75-128.3	0.23-7.3	7.4-311	75.3-136.2	8.6-37.4
Mesodorylaimuslissus	3	72.6-102.3	0.25-4.19	11.36-202	26.46-92.3	21.3-37.4
Cylindrolaimusmelancholicus	2	72.6-102.6	0.11-7.3	2.4-89.2	11.08-136.2	8.6-33.02
Gracilacuslatescens	3	6.75-128.4	0.25-18.7	89.2-315	75.3-92.3	26.32-41.3
Achromadora sp.	3	65.3-119.5	4.19-18.7	3.2-210	93.6-136.2	8.6-33.02
Aprocelaimellus obscures	1	72.6-125	0.25-4.19	89.3-202	11.08-92.3	26.32-41.3
Oligochaeta						
Chaetogaster sp.	1	65.5-125.7	0.25-4.19	89.2-315	26.46-92.3	21.3-37.4
Nais sp.	1	6.75-102.3	0.11-7.3	2.4-311	11.08-136.2	8.6-33.02
Tubifex sp.	1	65-125	0.25-18.7	89.3-202	75.3-92.3	26.32-41.3
Clitellioarenarius	3	72.6-102.3	4.19-18.7	7.4-202	93.6-136.2	21.3-37.4
Aelosma sp.	3	65.5-125.7	0.25-4.19	7.4-311	11.08-92.3	8.6-33.02
Brachiurasowerbyi	3	65.5-125.7	0.11-7.3	89.3-202	75.3-136.2	26.32-41.3
Ostrapoda						
Chrissiahalyi	1	6.75-102.3	0.11-18.2	7.4-311	26.46-92.3	21.3-37.4
Cypris elongate	2	72.6-102.3	7.3-18.7	11.36-202	11.08-136.2	8.6-33.02
Cyprinotus aureus	1	65-125	0.23-7.3	2.4-89.2	75.3-92.3	26.32-41.3

Tripyla sp.

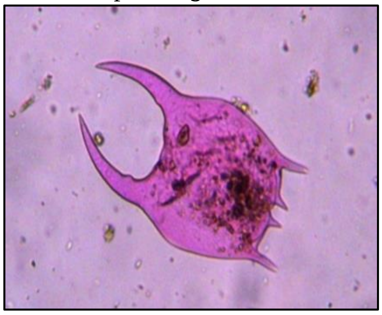
Rhabdolaimus minor

Helicotylenchus sp.

Anaplectusgranulosus

Trichodorus obtusus

Monhystera stagnalis



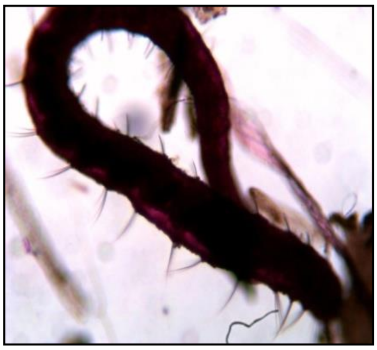
Brachionusforficula

Brachionusfalcatus

Keratellatropica

Platyiasquandricornis

Nais sp.

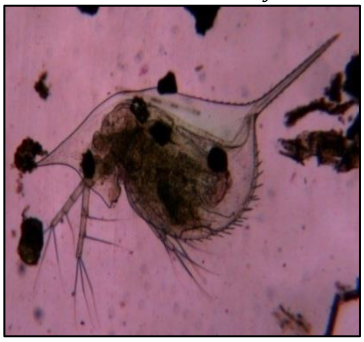


Aeolosoma sp.

Brachiurasowerbyi

Tubifex sp.

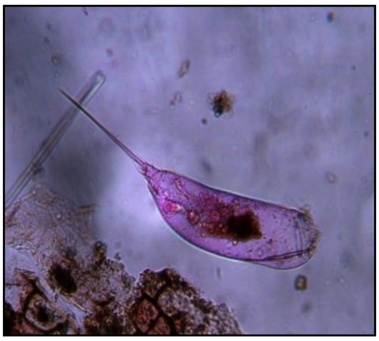
Kurzialongirostris

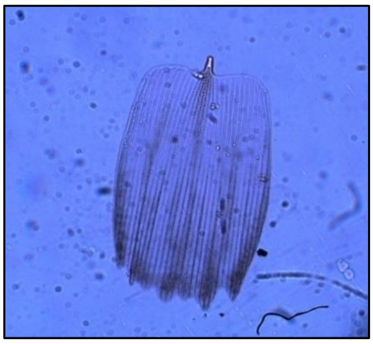


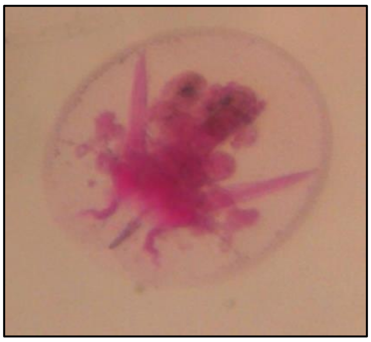
Daphnia lumholtzi

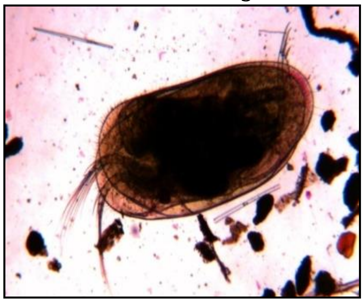
Thermocyclop sp.

Nauplius larvae


Trichoceraelongata


Notholca sp.


Testudinella patina


Chrissia halyi


Andonocypns serrato marginata


Cyprinotus aureus

Figure 7. Various meiofaunal species identified from the sediment of Tapi River

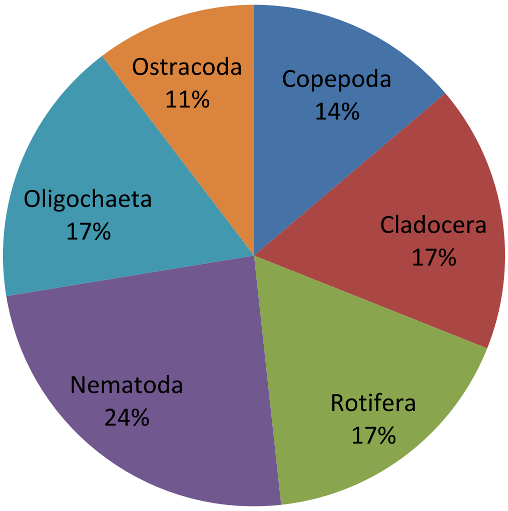


Figure 8. Graphical representation of dominancy in benthic faunal communities during wet season

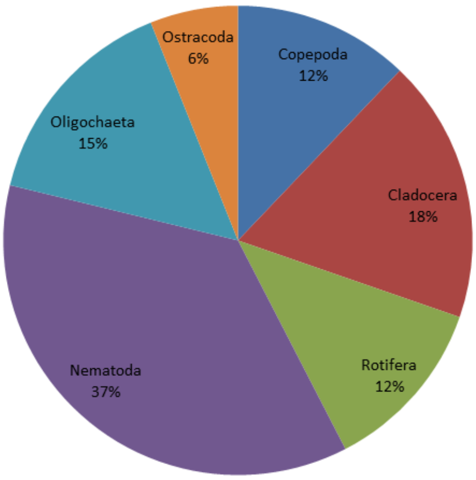


Figure 9. Graphical representation of dominancy in benthic faunal communities during dry season

Were reported at a minimum concentration of nickel and copper. Meiofaunal communities found during wet and dry season are described in table no. 3 and 4**.**

Copper and zinc concentrations were highest than other heavy metal concentrations at all the sites. The meiofaunal community was reported lower during the wet season than the dry season. It may be due to flowing off the nutrients downstream and also due to the rainfall number of organisms could be diluted.

IV. CONCLUSION

According to seasonal variation, changes in heavy metal concentration also affected the meiofaunal organisms. The study of meiofaunal diversity variation can be a useful tool for assessing the pollution pressure in aquatic ecosystems, as long as there are no confounding factors, such as differences in grains size and availability of food sources that disparagingly affect the richness and dispersal of these creatures. As studies over the past five decades have emphasized the important roles meiofauna play in benthic ecosystems, future studies will need to determine how reliable and prevalent these roles are. Observations can be implemented to understand the interactions of meiofaunal communities with environmental conditions. The presence of organisms having ecological and economical importance can be taken into consideration for further research.

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