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Meiobenthic Diversity in Relation to Water Quality of Aamayizhanchan Canal of Thiruvananthapuram City, Kerala

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Abstract

Monitoring and assessment of meiobenthic fauna is essential to evaluate the health status of urban canals, especially those used as urban sewage discharge sites. An attempt was made to assess the diversity of meiobenthos of Aamayizhanchan Thodu, a freshwater first-order canal flowing through Thiruvananthapuram, the capital city of Kerala state, from January to April 2021. A total of 7 meiobenthic groups were identified, of which nematodes and foraminifera were registered from all stations with more abundance towards downstream reach. Ostracodes, oligochaetes, polychaetes, kinorynchs, and turbellarians are represented in the diversity and abundance of meiobenthos found higher in stations with higher salinity and from silty to sandy zones. Statistical analysis showed a significant ($P<0.05$) difference between stations in meiobenthic diversity and abundance. Despite the heavy effluent and municipal waste discharge to the canal, the meiobenthic diversity showed a significant relationship with water quality and canal water flow.

Keywords: Urban canal, Foraminifera, Nematodes, Benthos diversity, Municipal sewage canal

Introduction

Lower-order freshwater canals and rivulets confluence to form higher-order lotic systems, and if such systems are flowing through

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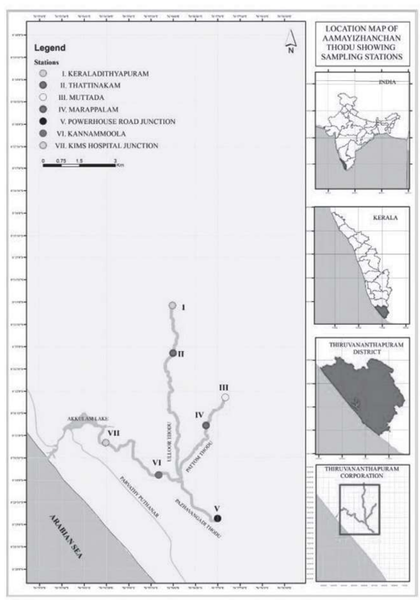
urban areas, the dependability of the population on water bodies will be at its zenith and the majority of the urban canals are in its pathetic condition due to urban sewage disposal. Hence, the services offered by such canals will be less, none other than sewage transport, which may not have any standards for water to be used for drinking or swimming compared to that used in agriculture or industry[1]. An aquatic ecosystem is found to be the utmost sink for pollutants. Contamination of these ecosystems is the outcome of anthropogenic activities, *viz*. urbanization, industrialization, and various agricultural activities. Overused pesticides and fertilizers and sewage from residential and industrial areas eventually accumulated in the aquatic environment, leading to the deterioration of the quality of water and the spread of health issues[2]. Water has an inherent capacity to revive contamination via natural phenomena such as rainfall, precipitation, etc. If the contamination rate is significantly higher, water loses its self-regenerating capacity and there comes the requirement of regular surveillance and controlling the pollution rate.

Aquatic invertebrates, especially benthic organisms, which have a cosmopolitan distribution, are now used widely for biological monitoring of ecological health worldwide owing to their small size, high abundance, rapid generation times, and absence of a planktonic phase[3]. Changes in their density, diversity, structure, and functioning may indicate alterations in the system, which act as biomarkers or monitoring tools for the health condition of lotic systems. Moreover, since the benthic community directly serves as food for organisms of higher trophic levels, their significance in trophic modeling of the system. In fact, a meiobenthic community of freshwater ecosystems contributes to bio-mineralization and nutrient cycling an equal or a level higher than that of a macrobenthic community[4]. Since there was no literature on the meiobenthic fauna of sewage-carrying canals, especially from Thiruvananthapuram (Kerala), the present study was undertaken to assess the meiobenthic diversity in relation to the water quality of Aamayizhanchan canal one of the main municipal sewage carriage canal flowing through the Thiruvananthapuram city, the capital city of Kerala State, south India.

Materials and Methods

Amayizhanjan Thodu, a first-order canal flowing through the Thiruvananthapuram City, Kerala state, covering a total distance of 21.34 km with three branches and debouches to the Arabian sea through Akkulam Kayal (estuary), was selected for the present investigation (Fig. 1). Seven stations *viz*. Station I, (Keraladityapuram; 8°33′55″N, 76°55′59″E), Station II (Thattinakam; 8°32′53″N, 76°55′59″E), Station III (Muttada; 8°31′51″N,76°57′10″E), Station IV (Marappalam; 8°31′13″N, 76°56′44″E), Station V (Powerhouse road junction; 8°29′8″N, 76°57′01″E), Station VI (Kannammoola; 8°30′07″N, 76°55′40″E) and Station VII (KIMS Hospital junction; 8°30′50″N, 76°54′29″E) were selected from both upstream and downstream stretches representing all three branches of the canal.

Fig. 1. Location map of Amayizhanchan Thodu/canal in Thiruvananthapuram, Kerala



The collection of water, sediment, and benthic samples was done on a monthly basis from January to April 2021. Water benthic sampling was done using a water sampler, Petersen Grab, respectively, during the early morning hours of the day and transported to the laboratory for further analysis after fixing it with chloroform. A total of 10 water quality parameters were estimated, of which temperature (^{0}C) and pH were measured in situ, and other parameters like alkalinity (ppm), hardness (ppm), total dissolved solids (TDS, ppm), biochemical oxygen demand (BOD, ppm), chemical oxygen demand (COD, ppm) and nutrients (Phosphate, sulphate and silicate, μg/L) were estimated at laboratory following spectrophotometric (Eutech) method. Grabbed sediment samples were sieved through different mesh sizes (40 – 500 micro sieves) to obtain meiobenthos, and they were identified into groups (phylum/class) using standard descriptions[5-17]. Both in-situ and laboratory analyses of the collected samples were done using standard procedures [18]. Analysis of variance (One Way ANOVA) and Kruskal Wallis ANOVA were used to compare water quality parameters and meiobenthic fauna, respectively, between stations, and Pearson's correlation analysis was employed to find out the relationship between meiofauna and water quality.

Results and Discussion

Meiobenthos can act as a marker for different parameters, especially health conditions or, in other words, the pollution status of any water body. Monitoring of meiobenthic diversity and abundance can predict the quality, especially during the summer season, where water flow/volume will be less, and biodiversity will be concentrated in the available water loggings. A water body that receives municipal wastes from a metropolitan/corporation area like Thiruvananthapuram will aggravate the situation and is essential to study such conditions to set baseline information and to check the pollution rate. Meiobenthic relationship with water quality parameters was estimated during the summer season of 2021 along Amayizhanchan canal, a sewage dumping canal of Thiruvananthapuram city.

Among the 10 water quality parameters analysed, the temperature was recorded using a thermometer in situ. The temperature at different stations manifested a range between 29.0 to 32.0^{0}C during January and February (Table 1). In February, Station III recorded 32.0^{0}C during morning hours, which may be due to the summer season and low water volume in the canal. Spatial comparison of surface water temperature registered a significant ($P<0.05$) difference between stations in which station I and IV registered low temperatures, which may be due to clear water at upper reaches in Station I and water mixing at the confluence of branches at station V, respectively. The water depth of the canal was less than a foot and restricted to small channels within the upper reaches canal, which may be one reason for elevated temperatures. The high temperature reported may be due to heat, which raises the temperature of surface water [19]. Rainfall may be the cause for the reduction in temperature in between, even though it is the summer season. Similar observations were reported for many aquatic bodies in Kerala[20].

Table 1: Analysis of variance (One Way ANOVA) of temperature, pH, alkalinity, and hardness of Amayizhanchan canal during summer 2021

Stations	Temperature (^{0}C)		pH		Alkalinity (ppm)		Hardness (ppm)	
	Mean	+ SD	Mean	+ SD	Mean	+ SD	Mean	+ SD
Station I	29.50	0.58	7.20	0.18	49.55	13.04	46.38	2.23
Station II	32.00	0.00	7.33	0.44	49.48	4.04	50.20	6.15
Station III	31.00	0.82	6.88	0.32	50.85	6.66	57.60	5.60
Station IV	29.50	0.58	6.98	0.15	52.58	12.78	53.13	3.05
Station V	31.00	0.00	6.63	0.21	95.63	29.59	68.33	6.66
Station VI	29.75	0.50	6.80	0.22	71.35	16.80	66.85	3.12
Station VII	30.75	0.50	6.43	0.74	87.15	17.23	81.28	12.83
F value	3.682*		2.78*		5.813**		3.933*	

* P < 0.05; ** P < 0.01

The pooled data on pH, alkalinity, and hardness are depicted in Table 1. pH, a good indicator of aquatic pollution, ranged from 6.4 to 7.8. Since the canal is a sewage-carrying canal, pH forms an important factor that governs the ecosystem as a heavy load of effluents is discharged into the system in the form of municipal sewage. In the present investigation, the lowest pH was reported at Station V in January, and the highest was at Station II in April. During January and February, the pH of seven stations was found to be acidic to neutral, whereas that in March and April was found to be neutral or basic, which may be due to rainfall surface water runoff and water volume development. The pH levels of water in Aamayizhanchan canal are within the standard limits of 6.5 to 9 for the protection of aquatic life[21] except for station V, which is devoid of vegetation, and reports suggest a pH of 7 to 9 for domestic use[22] and 6.5 to 8.6 for drinking use[23]. Station-wise comparison of pH showed a significant ($P<0.05$) difference with basic pH values in stations I and II as well as other stations, especially towards the lower reaches of the canal, showed acidic pH, which may be due to organic and inorganic pollution and effluents discharged to the water bodies. The titration alkalinity was also estimated, and the lowest value (38.6 ppm) was recorded at Station IV in March, and the highest was recorded at Station V in February. In January and February, Station V reported the highest alkalinity, followed by Station VII and Station VI. All other stations reported similar results with mild variations. In April, the highest alkalinity was recorded in Station VI followed by Station VI and Station VII. Similarly, the calcium and magnesium hardness of the water ranged (from 46.38 to 81.28ppm) within ISI standard water quality and registered significant differences ($P<0.05$) between stations with lower hardness along upper reaches and higher towards the lower reaches. Increment in hardness may be due to effluent and sewage discharge from urban areas, including hospital, industrial, agricultural, and household waste disposal along the course of flow. The hardness of water is also an important parameter that governs the distribution and abundance of biota, both in water as well as in sediments.

The total dissolved solids (TDS) of an aquatic ecosystem serve as the primary indicator of pollution as they increase with pollution from external sources. As it increases the density of the water, it also affects other physic-chemical properties of the water. In the present investigation, TDS ranged from 112 to 305ppm, lowest at Station II in February and highest at Station VII. Among the four months of sampling, Station VII recorded the highest value except for March. TDS registered a highly significant difference ($P< 0.01$) between stations with lower values in upper reaches and higher values in lower reaches of the canal with the highest value in station VII. Station VI registered a low value, which may be due to the dilution of water through volume development. In all lotic ecosystems, especially in rivers, the upper reaches are registered to have low TDS with clear and translucent water, which is an indication of pristine water. A high TDS value indicates pollution by extraneous sources [24]. It also indicates the presence of more ions and can induce an unfavorable physico-chemical reaction. Carbonate salts and agricultural runoff might be the increased levels of TDS. Water that has a total dissolved solids (TDS) content of less than approximately 600 mg/l is usually thought to be pleasant; water that has a TDS content of more than about 1000 mg/l is substantially and steadily less consumable [25].

Table 2: Analysis of variance (One Way ANOVA) of TDS, BOD, and COD of Amayizhanchan canal during summer 2021

Stations	TDS (ppm)		BOD (ppm)		COD (ppm)	
	Mean	± SD	Mean	± SD	Mean	± SD
Station I	136.50	10.79	23.13	3.45	67.75	6.85
Station II	123.25	11.09	21.68	2.49	47.88	7.12
Station III	144.50	2.08	31.28	5.31	73.85	23.30
Station IV	138.00	4.32	23.48	2.10	73.35	13.01
Station V	210.00	1.63	95.10	12.82	216.00	22.45
Station VI	180.75	7.50	29.10	3.93	167.00	25.85
Station VII	253.75	56.55	207.00	9.31	469.25	80.61
F value	18.179**		423.245**		74.199**	

* $P < 0.05$; ** $P < 0.01$

High biological oxygen demand (BOD) is an indication of purification, sometimes as it forms the quantity of oxygen used by microorganisms in the oxidation of organic matter. Any sewage canals should be monitored for BOD as it forms a prime factor in the health condition of the ecosystem. In the present study, the BOD ranged from 18.6 to 218.1ppm, with lower values reported at Station IV and Station II, respectively. High value registered at Station VII in February. BOD registered a highly significant (P<0.01) difference between stations with lower values in upper reaches and higher values in lower reaches of the canal, with the highest at station VII. As the sewage discharged into the canal, the BOD increased multifold due to purification and nutrient input. Several authors have suggested similar situations in sewage dumping canals in different parts of the world. The higher the BOD, the higher the demand for oxygen needed to support the life process [26]. A similar pattern was obtained in the case of chemical oxygen demand (COD). Station VI reported higher COD values during January and March. The range of COD was from 42 to 535ppm, with the lowest at Station II (April) and highest at Station VII (February). COD also registered a significant (P<0.01) difference between stations, with a lower value in station I and the highest value at station VII. As COD represents the amount of oxygen consumed when the water sample is chemically oxidized, the pollutants from sewage and other effluents increased the COD to an alarming level in the Amayizhanchan canal, especially along the lower stretches. Municipal wastewater discharge and industrial effluent can result in high BOD/COD values, which may negatively affect other water quality parameters, such as dissolved oxygen, thereby deteriorating the ecosystem.

Table 3: Analysis of variance (One Way ANOVA) of phosphate, sulphate, and silicate of Amayizhanchan canal during summer 2021

Stations	Phosphate (ppm)		Sulphate (ppm)		Silicate (µm/L)	
	Mean	± SD	Mean	± SD	Mean	± SD
Station I	2.92	1.00	4.85	2.52	166.83	11.76
Station II	3.73	0.55	5.75	3.79	165.03	9.30
Station III	2.86	1.23	4.93	1.73	19.87	2.18
Station IV	2.86	0.83	3.10	0.41	40.33	5.99
Station V	9.17	4.58	8.93	1.93	35.82	3.20
Station VI	4.59	2.20	5.73	3.15	7.48	2.87
Station VII	3.34	0.49	9.73	3.28	18.88	2.99
F value	4.906**		3.22*		466.875**	

* $P < 0.05$; ** $P < 0.01$

Nutrients are key factors of ecosystem dynamics that govern the primary productivity of the ecosystem, which is lacking in the present investigation as evidenced by the dark colour and foul odor of the system forming a municipal sewage canal. Three nutrients, phosphate, sulphate and silicate, were estimated spectrophotometrically and presented in Table 3. Phosphorous occurs in natural waters and waste waters, almost mainly as phosphates. Like nitrogen, phosphorous is also a growth-limiting nutrient that is essential to the growth of organisms. The phosphate range was from 1.05 (at Station III in March) to 12.57 (at Station V in February). In January, February, and March Stations V and VI showed greater values of phosphates. But in April, all the Stations exhibited a significant increase in phosphate concentration, with maximum in Station III and a minimum in Station VI. Phosphate registered a significant difference ($P < 0.01$) between stations with the highest value in station V, where maximum sewage disposal occurs from the heart of the city, and the Thampanoor, where hotel and domestic sewages are being discharged. Excessive use of phosphates in agricultural fields reaching the canal through runoff water might be the reason for this. Several authors made similar kinds of observations [27].

Sulphates are a bioavailable form of sulphur in natural waters, which is essential for primary productivity received through agricultural runoff and sewage discharge, which might be the higher content of sulphate in the present study. A decreased level of sulphate inhibits the growth of phytoplankton and there by productivity which was observed during March at Station II, whereas Station VII and III during March recorded the highest range (12.8ppm). Sulphate registered lower values and significantly ($P<0.05$) differed between stations with higher values in lower reaches, similar to the pattern of phosphate. Nutrient input from household discharge and agricultural waste runoff might be the reason for higher sulphate values in the lower reaches of the Amayizhanchan canal. Silicates are important nutrients for phyto- as well as zooplankton, especially shelled invertebrates. Apart from the degradation of silica-containing rocks, which results in the presence of silica in natural waters, animal and plant degradation also contributes to silica content in ecosystems. In the present study, the range of silicate was from 4.161µg/L (Station VI in January) to 184.2 µg/L (Station I in March). During the study period, Station I and II almost equally ranked highest silicate values, and the lowest was recorded at Station VI. Silicate also showed a significant ($P<0.01$) difference between stations with higher values in upper reaches and lower values in lower reaches, which may be due to the usage of benthic and aquatic animals for different purposes, including shell formation and metabolism.

Meiobenthic analysis resulted in 7 groups of invertebrates from the entire canal apart from unidentified/partly damaged organisms. Since unidentified organisms were kept for further molecular analysis, the data on the group is not included in the present study. Upper clear water stretches registered a lower abundance of meiofauna where, whereas lower stretches registered higher diversity and abundance of the organisms. Kruskal Wallis ANOVA showed a significant ($P<0.01$) difference between stations, with exceeding values in the lower reaches of the canal (Table 4). Nematodes (43%) were the largest group, followed by Foraminifera (18%), Oligochaeta (14%), Ostracoda (13%), Polychaeta (7%), Turbellaria (3%), Kinoryncha (2%). The meiofaunal abundance of the canal pooling at all stations is provided in Figure 2. The correlation of meiofauna with water quality parameters is provided in Table 5. Meiofanua registered a negative relationship with TDS as showed a positive relationship with BOD and phosphate content of the water, when data pooled for the entire stations and months. Even though the relationship was insignificant meiofana resulted in positive correlation coefficient with many water quality parameters.

Fig. 2: Meiofaunal abundance (%) of different stations in the Aamayizhanchan canal during summer 2021.

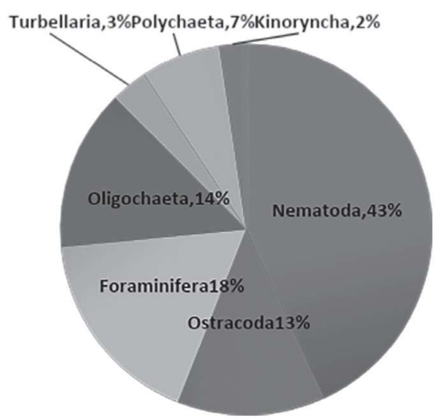


Table 4: Spatial variation in abundance of meiofauna of Amayizhanchan canal during summer 2021

Stations	Station I	Station II	Station III	Station IV	Station V	Station VI	Station VII	Kruskal Wallis H
Nematoda		2		35	94	78	126	212.5**
Foraminifera		12	14	2	15	26	31	
Ostracoda	9	10		16	38	29	34	
Oligochaeta	2	32	5	12	33	26	31	
Turbellaria		5		7	6	5	2	
Polychaeta	2		9	4	12	14	13	
Kinoryncha	2	1	3	4	3	1	4	

** $P < 0.01$

Conclusion

Meiobenthic fauna plays a major role in the lentic and lotic ecosystems as it performs bioturbation, thereby altering the sediment and water quality as well as forms an active role in trophic niche dynamics of the benthic community. Meiobenthos, with worldwide distribution, are widely used for biological monitoring or to evaluate the ecological health status of aquatic systems. Moreover, meiobenthos have economic and niche value as they are used for aquaculture, ornamental fish trade apart from its niche makeover. Due to extensive industrialization, urbanization, and various anthropogenic activities piled up, the rate of water pollution, which in turn affected the organisms over urban channels and rivulets as it forms the victim of effluent discharge. A total of ten water quality parameters and meiobenthic diversity were monitored for the Aamayizhanchan Canal during the summer months of 2021. Even though the water quality parameters, including three nutrients, registered normal values for upper reaches, lower reaches of the canal were polluted due to urban sewage disposal and pollution. A total of 7 invertebrate meiobenthic groups were reported and registered significant relationships with TDS, BOD, and phosphate. The meiofauna diversity and abundance increased towards lower stretches and warrants urgent attention to the health status of the canal.

Table 5: Multivariable Pearson's correlation for water quality parameters and meiofaunal abundance

Parameters	Temperature	pH	Alkalinity	Hardness	TDS	BOD	COD	Phosphate	Sulphate	Silicate	Meiofauna
Temperature	1										
pH	0.071	1									
Alkalinity	0.131	-.496**	1								
Hardness	0.102	-.684**	.790**	1							
TDS	-0.003	-.747**	.749**	.927**	1						
BOD	0.161	-.571**	.614**	.780**	.855**	1					
COD	0.035	-.671**	.644**	.856**	.929**	.959**	1				
Phosphate	0.145	-0.373	.394*	0.239	0.313	0.181	0.181	1			
Sulphate	0.196	-.756**	.437*	.549**	.661**	.626**	.648**	.559**	1		
Silicate	0.16	.575**	-.427*	-.647**	-.540**	-.392*	-.481**	-0.184	-0.225	1	
Meiofauna	-0.047	0.018	0.155	0.256	- 0.43*	0.666**	0.158	0.312*	0.027	-0.293	1

* $P < 0.05$; ** $P < 0.01$

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Conflict of Interest: Nil

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Ethical Statement: Authors hereby declare that **no** scheduled animal(s) has been harmed/mutilated/experimented for the present study. Since the study does not involve experimental study on animals, need not warrant an ethical clearance from a statutory body.

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