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Investigation of Anthropogenic Influences on Aquatic Ecosystems Quality along the Cuddalore Coastal Area, Southeast Coast of Tamil Nadu, India

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Abstract: The water quality of different aquatic ecosystems viz., Effluent discharging and non-discharging sites of Uppanar estuary, Vellar estuary and Pitchavaram mangrove forest in Cuddalore coastal area, Southeast coast of TamilNadu, India were examined using selected physicochemical and microbiological indicators. The physicochemical characteristics such as pH, Temperature, salinity, ammonia, nitrate, total nitrogen, inorganic phosphate, total phosphorus, silicate and dissolved oxygen (DO) were examined. The microbiological indicators like total heterotrophic bacterial count (THB), *Salmonella* spp. *Shigella* spp. and *Klebsiella* spp. also were enumerated from collected water and sediment samples with using appropriate selective medium. Total heterotrophic counts were found in the range of 10.3×10^{-4} – 14.0×10^{-4} CFU/ml in water and 26×10^{-6} – 41.2×10^{-6} CFU/ml in sediment samples. The *Salmonella* spp. was only recorded in water samples of station II. The population of *Shigella* spp. ranged from 11×10^{-2} – 30×10^{-2} CFU/ml. *Klebsiella* spp. in water and sediment samples are depicted as 12×10^{-2}–40×10^{-2} CFU/ml and 10×10^{-3}–50×10^{-3} CFU/g respectively. The results of bacteriological studies revealed that THB and pathogenic bacterial densities were higher in sediments compared to water sample and were substantially high and much beyond the permissible limit of World Health Organization (WHO).

Key words: Bacteria · Coastal zone · Estuarine ecosystem · Sediment · Physico-chemical characteristics · Pollution indicator

INTRODUCTION

Estuaries can be defined as tidally influenced transition zones between marine and riverine environments. An estuarine ecosystem is being threatened by the indiscriminate disposal of sewage, industrial waste and other human activities, which affects its physicochemical and microbiological quality [1, 2]. These disposal wastes carry enormous level of microbial pathogens, trace elements, heavy metals and pesticides to the estuarine ecosystem. The total life of the world depends on water for the maintenance of life, irrigation, industries, hydroelectric power and disposal of sewage etc., [3]. Hence the hydrological study is very much essential to understand the relationship between its different trophic levels and food webs. The environmental conditions such as topography, water movement, stratification, salinity, oxygen, temperature and nutrients characterizing particular water mass is also determining the composition of its biota [4]. The population of *Salmonella, Shigella* and *Klebsiella* spp. are constantly found in environmental samples and typically spread faecal contaminated drinking water or food or by direct contact with an infected person [5]. Most of the *Salmonella, Shigella* and *Klebsiella* like organisms are pathogenic to human and other living creatures and spread the disease like typhoid, gastroenteritis, pneumonia, urinary tract infection, dysentery etc., [6].

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The disease causing above pathogens are serious threat to public health. Prevention of river pollution requires effective monitoring of physicochemical and microbiological parameters [7, 8]. The quality of surface water including lakes and rivers depends on their physical, chemical and biological properties [9]. The bacteriological and physicochemical examination of estuarine water bodies has a special significance in pollution studies, as it is direct measurement of deleterious effect of pollution on human health. The value of the evaluation of water quality by bacterial indicators is of great importance and has been a subject of many investigations attempting to identify the most reliable indicator group as an indication of the presence of pathogens and what levels of indicator will ensure satisfactory water quality. Appropriate and effective administrative measures that should be taken into account may be considered in order to improve water quality and reduce public health risk. The present study assessed the quality of estuarine ecosystems in selected sites of Southeast coast of Tamil Nadu, India with the help of pollution indicator bacteria and other measured physicochemical parameters.

MATERIALS AND METHODS

Sampling Points and Sample Collection: Four stations were selected viz. Station I - Non effluent discharging sites of Uppanar estuary, station II - effluent discharging sites of Uppanar estuary (Lat.11° 42'N; long 79 ° 49' E), station III- Vellar estuary (Lat.11°29'N; Long 79° 46' E), Station IV - Pitchavaram Mangrove forest (Lat.11°29'N; Long.74° 49 'E) (Fig 1). The sampling was carried out during the month of February 2011, which is covered post monsoon seasonal. The surface water sample was collected using pre cleaned, acid washed polyethylene bottle and sediment sample was collected by ziplock cover. After collection, the samples were transported to laboratory with the help of ice box and stored in 4°C until further processing.

Physicochemical Measurements: The physicochemical characteristics included in our study are pH, Temperature, salinity, ammonia, nitrate, total nitrogen, inorganic phosphate, total phosphorus, silicate and dissolved oxygen (DO). All these tests were performed using standardized methodology [8]. Atmospheric and surface water temperature was measured in the field itself using a mercury filled centigrade thermometer. Salinity was measured by using Salino-refrectometer (Model: REF201/211/201bp). The collected water samples were done to preliminary analysis of pH was measured by pH paper and was again checked by Elico pH meter (Model: EI 601). DO and BOD were measured using Winkler's method.

Pollution Indicator Assay: A total heterotrophic bacteria count (THB) was performed using the spread plate method in Nutrient agar (Hi Media). *Salmonella, Shigella, Klebsiella* like organism were enumerated by adapting

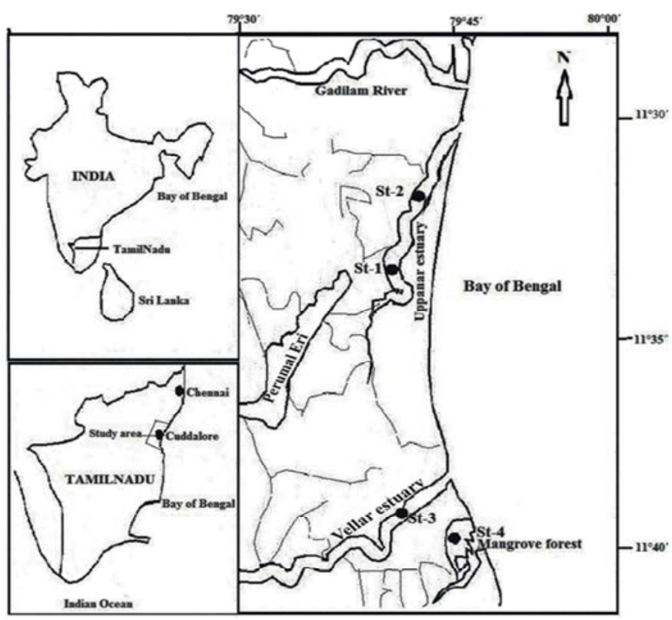

Fig. 1: Geographical position of sampling area

Table 1: Details of specific culture media used for quantitative bacterial analysis

S. No	Bacterial type	Culture medium	Interpretation
1	THB counts	Nutrient agar	All colonies counted
2	*Salmonella* spp	XLD agar	Pink dark black centred colonies counted
3	*Shigella* spp	XLD agar	Pink colonies counted
4	*Klebsiella* spp	XLD agar	Mucoid/ Yellow colour colonies counted

spread plate method using selective media, xylose lysine, deoxy cholate agar medium (Hi media). All the experiments were performed in duplicates. After inoculation, all the plates were incubated at 37°C for 24-48 h. typical colony morphology characteristics of different bacterial groups were noted and an initial enumeration of pathogenic pollution-indicator bacteria was completed according to the media manufacturer's guide (Table 1). For the confirmation of indicator bacterial species, staining technique and biochemical characterization (IMVic, nitrate, oxidase, catalase, citrate, H_2S) were performed according to Bergey's manual.

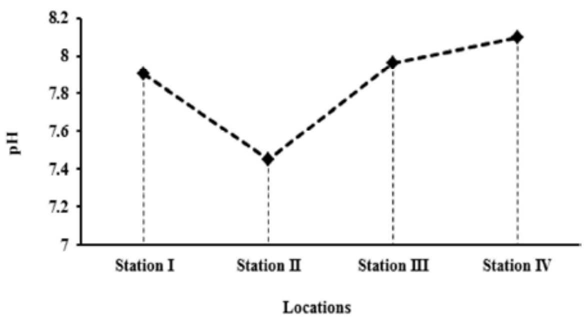

Fig. 2: pH values in study area

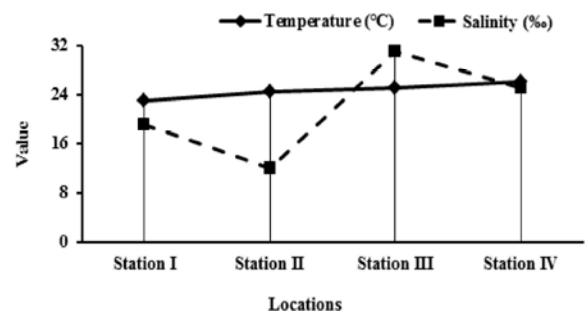

Fig. 3: Salinity and temperature in study area

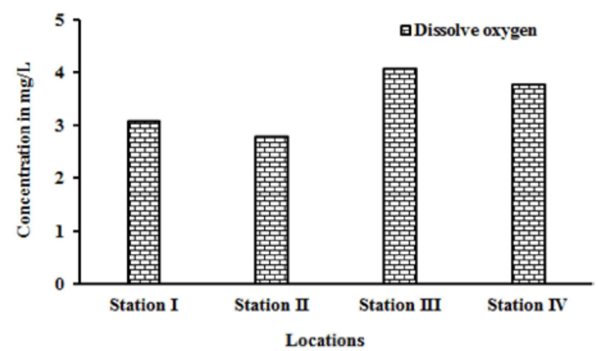

Fig. 4: Dissolved oxygen in study area

RESULTS AND DISCUSSION

The physicochemical characteristics of different stations of the study sites have been presented in (Table 2 and Fig. 2-4). The temperature in the study area is varied from 23 to 26 where maximum at station IV and minimum at Station I. Temperature is main factor, which influences chemical, physical and biological characteristics of water bodies [4] and also affecting growth and survival of microorganisms [9]. Salinity and pH ranged between 12 to 31 ‰ and 7.45–8.1 respectively. Salinity is profoundly influences the abundance and distribution of the microorganism in the estuarine environment [9]. Dissolved oxygen ranged between 2.8 to 4.1 mg/l where maximum at station III and minimum at station II. The highest recorded DO values was recorded at station III which is may be due to the minimum discharge of effluent and human activities while the lowest DO was recorded at station II where maximum discharge effluent and other anthropogenic activities. Dissolved oxygen is main criteria to assess the quality of

Table 2: Physico-chemical characteristics of waters collected from various stations of the study area

S. No	Parameters	Station I	Station II	Station III	Station IV
1	pH	7.9	7.45	7.96	8.1
2	Temperature	23	24.5	25	26
3	Salinity (%0)	19	12	31	25
4	Dissolve oxygen µm/l	3.1	2.8	4.1	3.8
5	Nitrate µm/l	1.21	3.23	2.72	0.72
6	Ammonia µm/l	2.59	10.76	4.03	7.95
7	Phosphate µm/l	0.6	2.685	0.50	0.41
8	Silicate µm/l	7.61	35.2	4.03	11.59

Table 3: Distribution of pollution indicator bacteria along the study area

	THB**		*Salmonella* spp.		*Shigella* spp.		*Klebseilla* spp.	
Locations	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment
Station I	12.5×10^{-4}	32.9×10^{-6}	-	-	15×10^{-2}	-	40×10^{-2}	50.4×10^{-3}
Station II	14.0×10^{-4}	41.2×10^{-6}	10×10^{-2}	-	11×10^{-2}	25×10^{-3}	22×10^{-2}	10×10^{-3}
Station III	11.2×10^{-4}	26×10^{-6}	-	-	30×10^{-2}	40×10^{-3}	12×10^{-2}	30×10^{-3}
Station IV	10.3×10^{-4}	28×10^{-6}	-	-	-	-	-	-

*THB – Total Heterotrophic bacteria

an aquatic system [4]. The highest concentrations of nitrate (3.232µm/l), ammonia (10.762 µm/l), phosphate (2.685 µm/l) and silicate content (35.2 µm/l) were observed at station II. These higher concentrations could be attributed to rain fall, washing out of effluents from industries, fertilizers from agricultural lands and domestic sewage flow. The elevated nutrient content can accelerated eutrophication in the stream which will potentially affect the water quality of river in terms of decreased oxygen and water clarity, pH fluctuations and increased algal bloom including toxin releasing blue green algae [10]. The lower concentrations of nitrate (0.71 µm/l), ammonia (7.95 µm/l), phosphate (0.41 µm/l) and silicate content (11.59 µm/l) were observed at station IV. The lowest concentration of trace metals were recorded in Station IV may be due to the least anthropogenic activities. The overall physicochemical characteristics data suggested that station II (effluent discharging sites of Uppanar estuary) adversely affected by anthropogenic activities compared to other stations.

The distribution patterns of different enteric bacteria in the water and sediment samples at various stations are illustrated in table (Table 3). The total heterotrophic bacterial (THB) population was varied between 10.3×10^{-4} – 14.0×10^{-4} CFU/ml in water and 26×10^{-6} – 41.2×10^{-6} CFU/ml in sediment samples. The minimum THB level in water samples was recorded in stations IV and the maximum THB population was recorded in station II. The same results were observed in sediment samples. Mahalakshmi *et al.* [11] recorded THB load in Uppanar estuarine sediments were ranged from 11.3×10^{-3}-3.0×10^{-6} CFU/g and water were 10.5×10^{-3} -3.2×10^{-6} CFU/ml and revealed that the Uppanar estuarine region is highly polluted with pathogenic microbes. The total heterotrophic bacterial count can be reliable indicator of water quality since the number of bacteria present depends on the degree of contamination [12]. The *Salmonella* spp. was totally absent in the water and sediment samples at all stations and only recorded in water samples of station II as 10×10^{-2}. The population of *Shigella* spp. ranged from 11×10^{-2}–30×10^{-2} CFU/ml in the study site. The minimum number (11×10^{-2} CFU/ml) of *Shigella* spp. was reported in station II and maximum (30×10^{-2} CFU/ml) was recorded in station III. The distribution patterns of *Klebsiella* spp. in water and sediment samples are depicted as 12×10^{-2} – 40×10^{-2} CFU/ml and 10×10^{-3}–50×10^{-3} CFU/g respectively. The population of S*higella* spp*, Salmonella* spp *and Klebsiella* spp. was not recorded in station IV. The overall studies revealed that population of pathogenic bacteria are high in sediment samples compared to water in all stations. Sediments act as reservoir for pathogenic microorganisms and may enhance their survival by reducing exposure to stressors such as sunlight and predation or by increasing the availability of nutrients [13-15].

The present study revealed that temperature and pH is profoundly influences the abundance and distribution of the microorganism in the estuarine environment. The ranges of THB level in all stations depends on temperature and pH. THB range is decreased level when the of temperature and pH values is increased level in among station. The amount of DO that a given volume of water can hold is a function of water temperature and the amount of other substances dissolved in the water [16]. When comparing the microbiological qualities of water at among the stations, SIPCOT (station II) were the mostly contaminated (Figure 6 and 7) due to highest population of pathogenic bacteria and were much beyond the permissible limit of World Health Organization (WHO). The microbiological quality of estuary is controlled by human activities [17]. The present study shown that water quality of station II has severely polluted compared to other stations. The station IV was less polluted environment. Both bacterial indicators and physic-chemical characteristics of estuarine ecosystems revealed that Uppanar estuarine is highly polluted. Previous studies reviewed that the anthropogenic impact in this region (station II) is very high [18].

The correlation coefficients (r) value was analysed between the physic-chemical parameters and indicators bacterial strains in various stations (I to IV) of study area

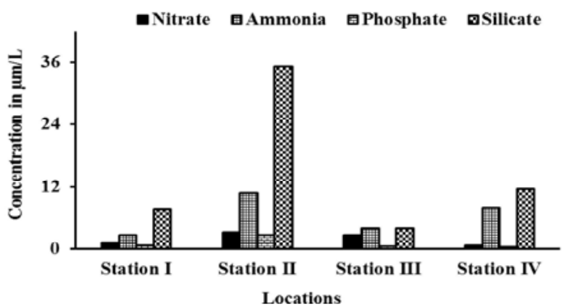

Fig. 5: Distribution of nitrate, ammonia phosphate and silicate (µm/L) content in study area

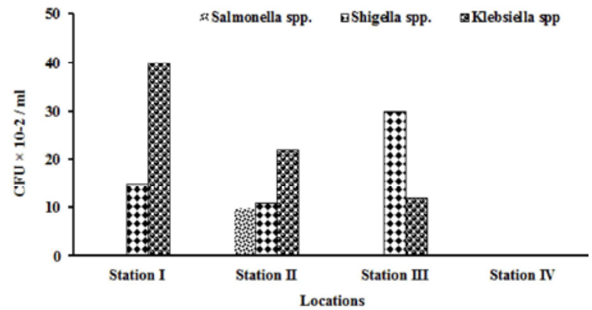

Fig. 6: Population density in water samples of study area

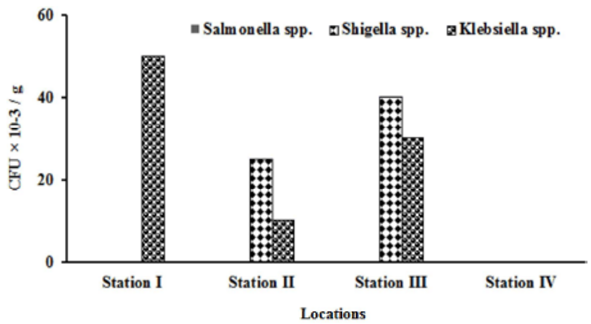

Fig. 7: Population density in sediment samples of study area

Table 4: Correlation co-efficient(r) between physic-chemical parameters and pollution indicator bacterial population

		Water													Sediment			
Parameters		AT	WT	pH	S	DO	NO_3^-	NH_3	PO_4^{3-}	SiO_4^{4-}	THB	SLO	SHLO	KLO	THB	SLO	SHLO	KLO
Water	AT	1.00																
	WT	0.891	1.00															
	pH	0.999	0.874	1.00														
	S	0.849	0.517	0.868	1.00													
	DO	0.894	0.593	0.91	0.9958	1.00												
	NO_3^-	-0.82	-0.99	-0.797	-0.391	-0.47	1.00											
	NH_3	-0.65	-0.24	-0.679	-0.954	-0.92	0.097	1.00										
	PO_4^{3-}	-0.98	-0.78	-0.985	-0.94	-0.97	0.682	0.794	1.00									
	SiO_4^{4-}	-0.89	-0.58	-0.904	-0.997	-1	0.463	0.927	0.964	1.00								
	THB	-1	-0.89	-1	-0.853	-0.9	0.814	0.657	0.98	0.892	1.00							
	SLO	-0.97	-0.76	-0.979	-0.951	-0.98	0.657	0.815	0.999	0.973	0.97	1.00						
	SHLO	-0.09	-0.53	-0.053	0.45	0.366	0.646	-0.7	-0.12	-0.38	0.08	-0.15	1.00					
	KLO	-0.94	-0.99	-0.932	-0.629	-0.7	0.961	0.367	0.857	0.689	0.94	0.839	0.411	1.00				
Sediment	THB	-0.93	-0.67	-0.947	-0.982	-0.99	0.56	0.879	0.988	0.994	0.94	0.993	-0.27	0.767	1.00			
	SLO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00		
	SHLO	-0.38	-0.76	-0.342	0.1698	0.079	0.84	-0.46	0.177	-0.09	0.37	0.143	0.956	0.659	0.022	0	1.00	
	KLO	-0.05	-0.5	-0.016	0.4831	0.401	0.617	-0.72	-0.15	-0.41	0.05	-0.19	0.999	0.376	-0.31	0	0.945	1.00

S – Salinity; AT – Atmospheric temperature; WT – Water temperature, DO – Dissolved oxygen; THB – Total Heterotrophic Bacteria; SLO – *Salmonella* Like organisms; SHLO – *Shigella* like organisms; KLO – *Klebseilla* like organisms

are illustrated in Table 4. The trace element relationship reveals a contradictory status where atmospheric temperature, water temperature, pH, DO, salinity does not show any significant relationship with trace metal distributions. The negative correlation was found between the trace metal and atmospheric temperature, water temperature, pH, DO, salinity. The positive correlation was found among the atmospheric temperature, water temperature, pH, DO, salinity. The THB, *Salmonella* spp. and *Klebsiella* spp. were positively correlated with trace elements but *Shigella* spp. were negatively correlated with trace elements in water samples. The perfect positive correlation (r=0.999) was found among the atmospheric temperature and pH. The week negative correlation (-0.016) was among the pH and KLO. The SLO does not correlate with other parameters. The perfect negative correlation (r=-1) was found between atmospheric temperature and pH with total heterotrophic bacteria.

CONCLUSIONS

The study aims to understand the physicochemical characteristics and concentration of bacterial indicators in the study area and also understand the impacts of point and nonpoint sources of pollution on the water quality of microbial features. Both bacterial indicators and physicchemical characteristics determine that quality of estuarine waters. The overall data indicates that stations II is adversely impacted by anthropogenic material. Dominance of pathogenic bacterial genera in study area suggests that they may be explored as indicators. The investigation of physicchemical parameters is shown that occurrence of pollution indicator bacterial population depends on the parameters. The present study revealed that the physicochemical parameters are likewise enriched in the polluted sites. This enrichment of these parameters can employ a considerable influence on the pollution indicator bacterial population. Anthropogenic activities were found to have greatly impacted negatively on the quality of the estuarine ecosystem. This study may be initiate the effective measures could be adopted to prevent spread of disease through the agency of water and to save the water body from decline.

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