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Original Article

MICROBIAL CONTAMINATION IN THE SEDIMENTS AND GROUNDWATER OF TUTICORIN CORPORATION, SOUTH INDIA USING GIS

[1]S. SELVAM, [1]A.ANTONY RAVINDARAN, *M.RAJAMANICKAM, *M.SRIDHARAN

[1]Department of Geology,V.O.Chidambaram College,Tuticorin -628008 Tamil Nadu, India, *Department of Earth sciences Pondicherry University Pondicherry-605014

Email: geoselvam10@gmail.com

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ABSTRACT

Objective: The present study investigates the diversity, and distribution of harmful microbes in sediments and groundwater of Tuticorin Corporation. The faecal pollution indicators such as, *Total coliform bacteria, Faecal coliform bacteria, Escherichia coli, Faecal streptococci* were investigated in the sediments and groundwater samples from 12 locations in the study area.

Methods: Groundwater and sediment samples were analyzed for total coliform bacteria (TC), faecal coliform bacteria (FC), E. coli (EC) and faecal streptococci (FS). Fecal and total coliform counts were performed using the standard membrane filtration technique.

Results: The results reveal that the sediments and groundwater samples were contaminated with *Total coliform bacteria, Faecal coliform bacteria, Escherichia coli, Faecal streptococci bacteria* in Thirespuram, Fishing old Harbour, Iniko Nagar, Mappillaiurani Beach and Annanagar. This is due to the mixing of industrial and domestic sewage through the Buckle channel and fishing activities in the study area. The spatial maps presented in the study clearly depicted the bacterial contamination pattern in the study area. The samples near to coastal areas are prone to microbial contaminations which indicate that the source of the contamination is due to anthropogenic pressure in the study area.

Conclusion: The proper installation of sewage treatment plant, draining of treated industrial effluence and creation of public awareness about the coilform bacteria pollutants are the solutions to protect the groundwater aquifers and also the sediments.

Keywords: Coliform bacteria, buckle channel, fishing activity, groundwater, sediments, Tuticorin

INTRODUCTION

The biological contamination in drinking water is a major problem of public health in developing world. The WHO estimates that about 1.1 billion people globally drink unsafe water and the vast majority of diarrhea disease in the world (88%) is attributable to unsafe water, sanitation and hygiene [1 and 2]. Several investigators have reported difficulties in using total and faecal coliforms to measure the sanitary quality of tropical waters, including the ability of the bacteria to multiply, to survive for long periods, and to occur in high numbers in the absence of any identifiable source of faecal pollution [3 and 4]. Fecal material from warm-blooded animals may contain a variety of intestinal microorganisms (viruses, bacteria, and protozoa) that are pathogenic to humans. For example, bacterial pathogens of the genera *Salmonella*, *Shigella*, and *Vibrio* can result in several types of illness and diseases in humans, including gastroenteritis and bacillary dysentery, typhoid fever, and cholera. Some investigators have suggested the sole use of E. coli as an indicator of fecal pollution as it can be easily distinguished from the other members of the fecal coliform group (e.g., absence of urease and presence of b-glucuronidase). Fecal coliforms display a survival pattern similar to that of bacterial pathogens but their usefulness as indicators of protozoan or viral contamination is limited. Coliform standards are thus unreliable with regard to contamination of aquatic environments with viruses and protozoan cysts. Coliforms may also regrow in the environment. Detection of E. coli growth in pristine sites in a tropical rain forest, suggest that it may not be a reliable indicator of fecal pollution in tropical environments [5, 6 and 7].

Study area

The study area (8° 43' - 8° 51' N latitude and 78° 5' - 78° 10' E longitude) falls in the east coastal belt of Tuticorin, Tamil Nadu, India and its relation to the highly developed industrial activities in the Figure 1. The area is highly industrialized, which is the main source of pollution. The waste products released from the anthropogenic activities like, poultry farms, chemical, pharmaceuticals, and other industries constitute the main cause for the degradation of water quality in the area. This study area, coastal tract, is underlined by the geological formations comprising of the crystalline Archaean complex, Tertiary and sub-recent to recent groups. The surface boundary, between the Archaean and the sedimentary strata is widening towards south from 2 km to 25 km from the coastline [8]. The tertiary to recent age sedimentary formations overlie the Archaean complex with a marked unconformity. The major rock types are Shell limestone and sand, Tuffaceous kankar, Sand- aeoline deposit. The average annual rainfall of the study area is 877 mm. Tuticorin city tremendous increases in human activities, urbanization and industrialization has disturbed the balance of the coastal environment [9]. The coastal ground waters are contaminated due to human activities, dumping of waste and discharge of domestic sewage into the coastal environment. All these could contaminate the coastal waters and render the beach unsuitable for recreational and fishing activities. Therefore, it is necessary to understand the magnitude of faecal pollution in the environment. The present study was undertaken to study the indicator bacteria such as total coliform bacteria, faecal coliform bacteria, Escherichia coli, faecal streptococci as indicators of fecal pollution of sediments and groundwater in the coastal environment.

MATERIALS AND METHODS

In the present study a total of 12 groundwater sample and 12 sediments samples were collected from industrial and coastal regions during the period from pre monsoon season from June 2012. Groundwater samples for microbiological examination were collected in non-reactive borosilicate glass bottles of 500 ml capacity each that had been cleansed and rinsed carefully, given a final rinse with distilled water and sterilized. Sediments samples from the intertidal zone were collected in sterilized polythene bags using

sterile spatula. Groundwater and sediment samples were analyzed for total coliform bacteria (TC), faecal coliform bacteria (FC), E. coli (EC) and faecal streptococci (FS). Fecal and total coliform counts were performed using the standard membrane filtration technique. The 100 ml water sample was filtered using 0.45 mm pore size, 47 mm diameter filter membrane as described by APHA 1998 [10]. The MPN method was used to determine the presence of gas producing lactose fermenters and most probable number of coliforms present in 100 ml of water.

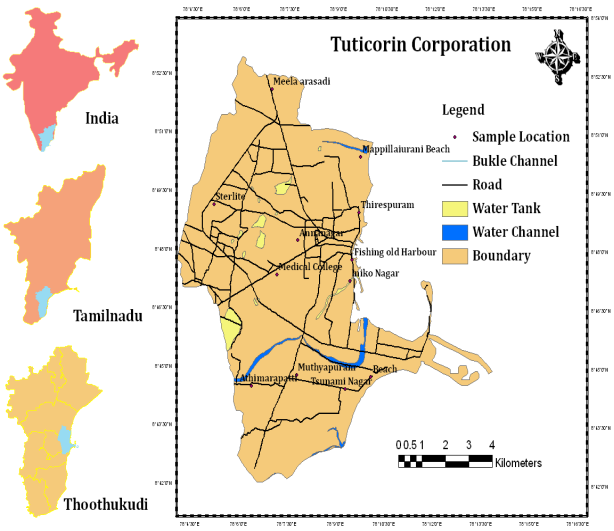

Fig. 1: Location map of the sampling site

Pour plate technique using Kenner faecal (KF) agar was employed for the estimation of faecal streptococcal count and typical colonies were counted after incubation at 37°C for 48 hours and expressed as colony forming unit (CFU) per ml or g of the sample [11, 12 and 13].

RESULTS

In pre monsoon seasons 24 samples collected from sediments and groundwater in the study area and analyzed for bacterial contamination. The analyzed parameters are presented in Table 1. The temperature of 12 groundwater samples measured in the field ranged from 24°C to 36°C (mean, about 30°C). Coliform organisms used in this study as indicators for water contamination were the most commonly used indicators for monitoring water quality.

The Total coliform bacteria in pre monsoon season ranges between 0-145 MPN ml^{-1} in groundwater and 0-153 MPN g^{-1} in sediment samples. For the groundwater and sediment samples, the highest value was recorded in the Thirespuram, Iniko Nagar, Mappillaiurani Beach from near coastal area and one sample from Annanagar, near buckle channel. In the Thirespuram, Iniko Nagar, Mappillaiurani Beach the high total coliform count may be the indicative of the presence of high organic compounds in the groundwater and sediments. Because this place is very close to so many number of fishing industries in this area. In Annanagar, the primary sources of these bacteria in groundwater and sediments are animal and human wastes.

These sources of bacterial contamination include surface runoff, pasture, and other land areas where animal wastes are deposited. Additional sources include seepage or discharge from septic tanks, sewage treatment facilities and natural soil /plant bacteria and buckle channel. The similar findings were also observed by different authors in different water bodies in India during pre-monsoon and post monsoon seasons [14, 15 and 16].

Table 1: It shows results of coliform bacteria in groundwater and sediment samples in the study area

Place	Groundwater				Sediments			
	TC MPN ml^{-1}	FC MPN ml^{-1}	EC MPN ml^{-1}	FS CFU ml^{-1}	TC MPN g^{-1}	FC MPN g^{-1}	EC MPN g^{-1}	FS CFU g^{-1}
Athimarapatti	Absent	Absent	Absent	Absent	1.6	Absent	Absent	Absent
Muthyapuram	2.3	12	06	07	Absent	Absent	Absent	Absent
Thirespuram	142	143	39	920	153	140	146	200
Tsunami Nagar	1.6	45	03	05	2.5	62	32	08
Fishing old Harbour	48	44	40	20	8	6.5	8.5	08
Medical College	0.6	Absent	2.0	Absent	Absent	Absent	Absent	Absent
Iniko Nagar	145	141	23	500	139	149	140	300
Meela arasadi	Absent	Absent	Absent	08	Absent	Absent	Absent	03
Beach	1.9	2.2	0.9	10	12.5	16.5	8.6	20
Sterlite	2.3	Absent	12	05	6.5	2.3	25	05
Mappillaiurani Beach	140	141	29	740	152	162	146	300
Annanagar	140	143	44	720	144	136	147	200

TC = Total coliform bacteria, FC = Faecal coliform bacteria, EC = Escherichia coli, FS= Faecal streptococci

DISCUSSION

Out of 24 samples, 08 samples from groundwater and 08 from sediment samples in pre monsoon period showed the presence of faecal coliform bacteria. The Faecal coliform bacteria ranges between 0-143 MPN ml^{-1} in groundwater and 0-162 MPN g^{-1} in sediment samples. Faecal coliform of groundwater and sediment samples had been presented as shown in Figure 2.

This figure clearly shows that a high level was recorded from coastal area. Thirespuram, Iniko Nagar, Mappillaiurani Beach and Annanagar were more affected from faecal coliform bacteria, which indicate the presence of fecal material from warm-blooded animals. The samples of sediments from coastal area presented higher level of faecal coliform bacteria compared to other area, where there is no mixing of domestic sewage. Earlier studies from India reported higher concentration of faecal coliform bacteria in sand than in water [17 and 18]. E. coli. (Escherichia coli) is a bacteria that colonizes the gastrointestinal tract of humans and other mammals shortly after birth and is considered part of our normal intestinal flora. Some types of E. coli, such as E. coli O157:H7 possess virulence factors and can cause diarrheal disease in humans, but the most types of E. coli are harmless.

E. coli levels were relatively low at groundwater samples, where it varied from MPN 0 to 44 ml^{-1}, but samples of sediments were also found to have high levels of bacteria ranges from MPN 0 to 147 g^{-1} in sediment samples. The seepage of E. coli is easier in sedimentary formation compared to hard rock terrain, [3] which supports the present study. The high contamination level of the majority of sediment samples from coastal area is surprising in view of the geology of the study area, the construction of the fishing industries, and local sanitation practices.

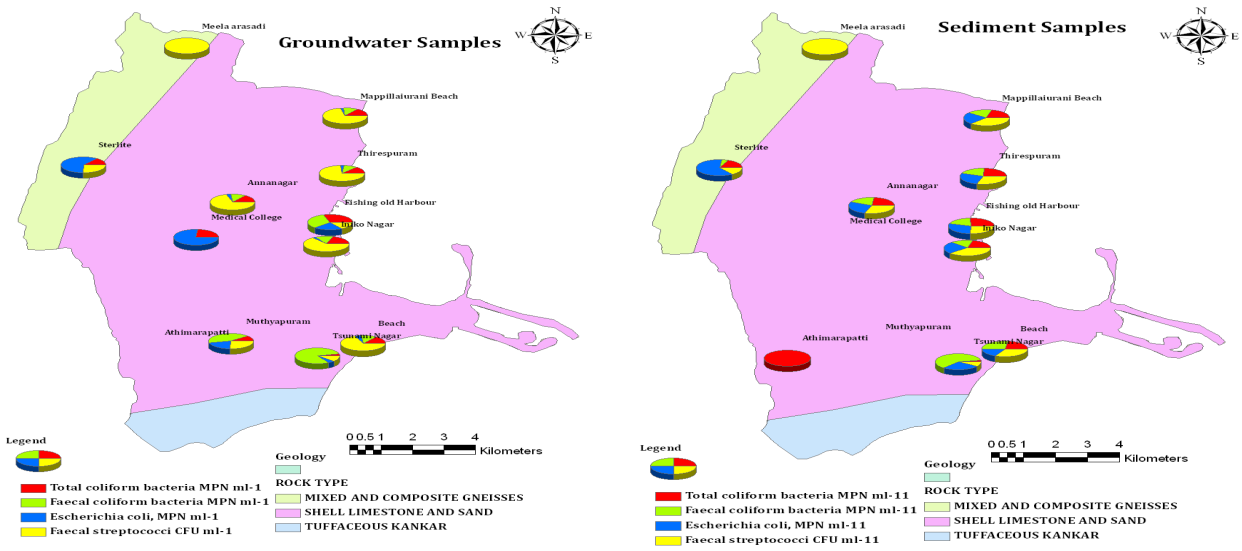

Fig. 2: Spatial distribution of coilform bacteria in groundwater and sediment samples in the study area

The fecal streptococci organisms present in water indicate that the water has been polluted with feces (sewage); their incidence was in parallel with the fecal coliform and has the same indicative power of the fecal coliform. Some environmental organizations believe that the fecal streptococci represent the true evidence for fecal coliform. This is because the differential die off for enterococci is not as great as that for E. coli. Fecal streptococci bacteria were detected in 10 of the groundwater samples with concentrations ranging from 10 to 920 CFU/100 ml^{-1} and 09 of the sediment samples within concentrations ranging from 0 to 300 CFU/100 g^{-1}. Compared to the groundwater samples, faecal streptococcal count was lesser in sediment samples and could not be detected at Athimarapatti, Muthyapuram, Medical College throughout the study. Faecal streptococcal count in sand samples was greater than earlier reports from Cherai beach, Kerala, Cochin backwaters and lesser than those reported from Bhavnagar coast. The sources of fecal streptococci bacteria are seepage or discharge from septic tanks, sewage treatment facilities and natural soil /plant bacteria in the study area [19 and 20].

Factor Analysis

The correlation coefficients between the log_{10} concentrations of the bacterial indicators in all the water samples studied are shown in Table 2. The close inspection of correlation matrix was useful because it can point out associations between variables that can show the overall coherence of the data set and indicate the participation of the individual chemical parameters in several influence factors, a fact which commonly occurred in hydrochemistry [17 and 19]. In the study area all the four indicators correlated reasonably well with each other.

Table 2: It shows Correlation matrix of bacteria in the groundwater and sediments of Tuticorin

Bacteria	Groundwater				Sediments			
	TC	FC	EC	FS	TC	FC	EC	FS
TC	1				1			
FC	**.982****	1			.965**	1		
EC	.829**	.802**	1		.966**	.958**	1	
FS	.950**	**.943****	**.762****	1	**.989****	**.982****	**.957****	1

**Correlation is significant at the 0.01 level (2-tailed) high coefficient values are marked in bold.

Inspection of Table 2 and the correlation matrix showed that the groundwater bacteria such as TC, FC, EC, FS which displayed lower concentration in the groundwater samples when compared to sediment samples, but groundwater than in the sediment samples were closely correlated.

The FS has been set up very good correlation among all other indicators in the study area. As seen from the table 2 higher correlation matrix (TC and FC, r= 0.982; FC and FS, r=0.943; EC and FS, r=0.762) in groundwater samples are due to anthropogenic activities like fishing waste and buckle channel human and animal waste percolated to the ground, and (TC and FS, r=0.989; FC and FS, r=0.982; EC and FS, r=0.957) in sediment samples are due to human and animal waste and direct discharge of wastes from fishing activities or other contaminants from the surrounding system. Direct or indirect contact with animal faecal material may be common and could result in transmission of diarrhoeal diseases with animal reservoirs, e.g., salmonella and campylobacter.

CONCLUSION

From this study, the spatial and temporal variations of coliform bacteria concentration along the Tuticorin coast have been investigated. The coastal tract of the study area is highly contaminated than the other part due to fishing activities and human/animal waste water discharges from buckle channels. The Buckle Channel, which flows through the heart of the town, is fast dying since the water flow has been blocked owing to indiscriminate dumping of wastes and disposal of sewage from houses and commercial establishments into it. The anthropogenic activities, which cause damaging effect on the groundwater and sediments due to the large quantities of fishing activities, fishing industrial and domestic sewage water discharge from buckle channels. Hence the study area is getting polluted by coilform bacteria. If the level of coilform bacteria continues to increase then the diarrheal diseases will also be increased. The proper installation of sewage treatment plant, draining of treated industrial effluence and creation of public

awareness about the coilform bacteria pollutants are the solutions to protect the groundwater aquifers and also the sediments.

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REFERENCES

1. Geldreich EE. Waterborne pathogens. In: Mitchel R (ed) Water pollution microbiology. Wiley, New York 1972; pp 207–241.
2. Mohandas C, Loka Bharati PA. Representation, Dispersion and variation of Bacterial Indicators in the coastal waters of Nagore (East Coast of India). Water Environment Research 2003; 75: 66-68.
3. Bermúdez M, Hazen TC. Phenotypic and genotypic comparison of Escherichia coli from pristine tropical waters. Appl Environ Microbiol 1988; 54: 979–983.
4. Jeevanandam M, Nagarajan R, Manikandan M, Senthilkumar M, Srinivasalu S, Prasanna MV. Hydrogeochemistry and microbial contamination of groundwater from Lower Ponnaiyar Basin, Cuddalore District, Tamil Nadu, India. Environ Earth Sci 2012; DOI 10.1007/s12665-012-1534-1.
5. Sugumar G, Chrisolite B, Velayutham P, Selvan A, Ramesh U. Occurrence and season variation of bacterial indicators of faecal pollution along Thoothukudi Coast, Tamil Nadu. Journal of Environmental Biology 2008; 29: 387–391.
6. Selvam S, Manimaran G, Sivasubramanian P. Cumulative Effects of Septic System Disposal and Evolution of Nitrate Contamination Impact on Coastal Groundwater in Tuticorin, South Tamilnadu, India. Research Journal of Pharmaceutical Biological and Chemical Sciences 2013; 4(4): 1207-1218.
7. Yates MV. Biomonitors of environmental contamination. In: Lederberg J, Ed.Enchyclopidia of Microbiology, Vol.1, San Diego: Academic Press 1992; 327-328.
8. Selvam S, Manimaran G, Sivasubramanian P. Hydrochemical characteristics and GIS-based assessment of groundwater quality in the coastal aquifers of Tuticorin Corporation, Tamilnadu, India. Applied water Sciences 2013; 3:145-159.
9. Selvam S, Manimaran G, Sivasubramanian P, Balasubramanian N, Seshunarayana T. GIS-based Evaluation of Water Quality Index of groundwater resources around Tuticorin coastal city, south India. Environmental Earth Sciences 2014; 71: 2847-2867.
10. APHA. Standard methods for the examination of water and wastewater. 20th edition, American public health Association, American water works association, Water environment federation 1998; Washington DC.
11. Vaidya SY, Vala AK, Dube HC. Bacterial indicators of faecal pollution at Bhavnagar coast. Ind. J. Microbiol 2001; 41: 37-39.
12. Rajurkar NS, Nongbri B, Patwardhan AM. Physicochemical and microbial analysis of Umian (Brapani) lake water. Ind. J. Environ. Protec 2003; 23:633 – 639.
13. Noble PA, Bidle KD, Fletcher M. Natural Microbial Community Compositions Compared by a Back-Propagating Neural Network and Cluster Analysis of 5S rRNA. Environ Microbiol 1997; 63: 1762–1770.
14. Radhakrishnan M, Balaguruathan R, Selvakumar N, Doble M, Kumar V. Bioprospecting of marine derived actinomycetes with special reference to antimycobacterial activity. Indian J.of Geo-Marine Sciences 2011; 40:407-410.
15. Selvam S, Manimaran G, Sivasubramanian P, Seshunarayana T. Geoenvironmental esource Assessment Using Remote Sensing and GIS: A case study from southern coastal region. Research Journal of Recent Sciences 2014; 3(1): 108-115.
16. Mmolawa PT, Willmore R, Thomas CJ, Heuzenroeder M W Temperate phages in Salmonella enterica serovar Typhimurium: implications for epidemiology. Int. J. Med. Microbiol 2002; 291: 633–644.
17. Selvam S. Use of Remote Sensing and GIS Techniques for Land Use and Land Cover Mapping of Tuticorin Coast, Tamilnadu. Universal Journal of Environmental Research and Technology 2012; 2(4) 233-241.
18. Powell KL, Cronin AA, Barrett MH, Sellwood J, Pedley S. Distribution of microbiological contaminants in Triassic sandstone urban aquifers. EA R&D Tech Rep P2-255/TR, July. Final Report to the Environ Agency, Bristol 2001; p 26.
19. Selvam S, Iruthaya Jeba Dhana Mala R, Muthukakshmi V. A Hydrochemical analysis and Evaluation of groundwater quality index in Thoothukudi district, Tamilnadu, South India. International Journal of Advanced Engineering Applications 2013; 2(3):25-37.
20. Straub TM, Chandler DP. Towards a unified system for detecting waterborne pathogens. J. Microbiol. Methods 2003; 53:185–197