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APPRAISAL OF WATER QUALITY OF TAPI RIVER IN REFERENCE TO BACTERIOLOGICAL AND PHYSICO-CHEMICAL PROPERTIES

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ABSTRACT

Present paper deals with the annual variations in Bacteriological and physicochemical quality of Tapi River, Surat, and Gujarat. The bacterial genera isolated were identified using Bergey's manual of determinative bacteriology. The concentrations of Nitrate, Nitrite, and phosphate were recorded higher at the downstream sites with depletion of Dissolved oxygen concentration throughout the year. Bacterial counts were recorded highest during the summer season. Presence of various bacterial genera, including some pathogens and fecal indicators viz., Escherichia, Klebsiella, Enterobacter, Streptococcus, Salmonella, Shigella, Citrobacter, Vibrio etc. were observed. It is also observed that bacteria from Gammaproteobacteria group were frequently distributed throughout the year. The Tapi River water quality monitoring brought out that human interference and anthropogenic activities, as well as agricultural practices, significantly alter natural properties of water resources.

KEYWORDS: *Bacteriological, Pathogens, Physico-Chemical, Tapi River, Water Quality*

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INTRODUCTION

As being an important source of development and urbanization, water is an essential constituent of life. The physical and chemical conditions of water resources can influence the community composition and abundance of microbes as they exhibit different responses to such conditions. Rivers are an essential ecosystem as they are sources of water for drinking, recreation as well as fisheries purposes. In addition, industrialization, colonization and agricultural activities take place in adjacent areas of the river and waste discharge into stream make the river an active ecosystem. Surface waters are exposed to higher nutrient load as a result of agricultural practices, wastewater discharge, sewage discharge etc. Many authors have reported that Indian river systems are polluted mainly because of human interference (Borade *et al,* 2014; Dubey et al., 2014; Sangani and Manoj, 2017; Shanmugam *et al*,, 2016; Sood et al., 2010).

One of the key factors, as well as indictor of water pollution, is the microbial contamination. Rivers are often used as receiving bodies of urban wastewaters from the cities those are situated on their banks. With broad functional diversity, microbial communities of the polluted river also include some pathogenic bacteria which are harmful to human and livestock (Abraham, 2010).

Considering the importance, inadequacy, and vulnerability of ecosystems, continuous monitoring of the quality of water and pollution status of water bodies is must be required.

Tapi River has valuable importance in the development of Surat city. Agricultural and Industrial developments as well as human interference and anthropogenic activities significantly put pressure on the ecology and shape the bacterial diversity of the water bodies. However, environmental variables that affect the bacterial composition may vary according to location and time. To better understand how human activities perturb the natural water body conditions, it is necessary to completely understand the seasonal and annual dynamics of river water quality and microbial interactions. Therefore, the present study was carried out to study the physicochemical water quality of the Tapi River in reference to bacterial composition and abundance.

MATERIAL AND METHODS

The water samples were collected from three different sites by River Tapi, Surat, Gujarat, India during the month of March'15 to February'16 at monthly intervals. Sampling sites selected for the study were as follows.

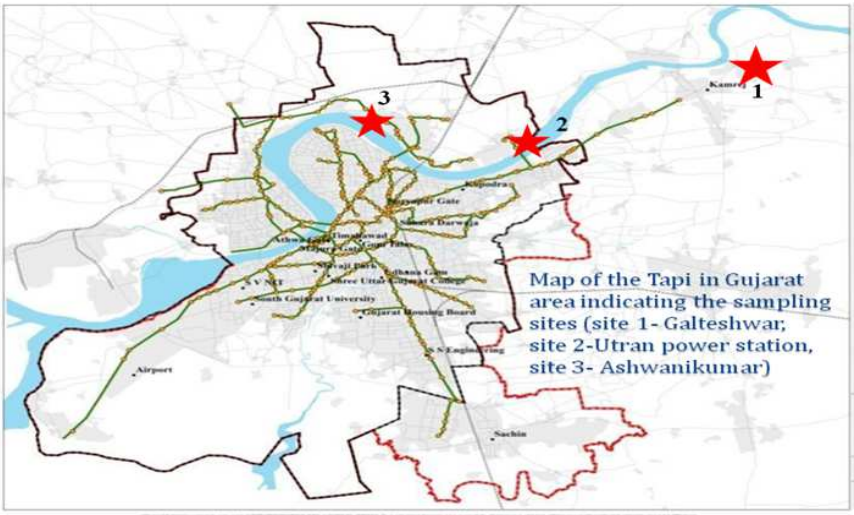

Figure 1: Map of Tapi River Indicating Sampling Sites

- Galteshwar (Freshwater Zone, up-stream, fewer disturbances)
- Utran (Freshwater Zone, Inlet of domestic sewage, anthropogenic pollution)
- Ashwanikumar (Freshwater Zone, Inlet of domestic sewage, Anthropogenic pollution and cremation ground drainage)

The samples were collected in sterile containers and transported to the laboratory for further analysis. The physicochemical parameters such as pH, temperature, Dissolved Oxygen, Nitrate and Phosphate of water samples were measured using standard methods (APHA, 2005; Trivedy & Goel, 1986). pH and Temperature were recorded immediately. Dissolved oxygen was fixed at the site itself.

In bacteriological studies, a serial dilution of each sample was made and 0.1ml of each diluted samples was plated onto nutrient agar (Hi-Media) plates to determine Total Viable Count (TVC). The results were expressed as Colony Forming Unit (CFU) per unit volume (mL), enumerated after 48 h of incubation. Depending on the variations in colony morphology or colony characteristics, the isolates were separated and stored on nutrient agar slants at 4°C for further analysis.

The isolates were identified by using standard morphological, cultural, biochemical and physiological characteristics as per the *Bergey's Manual of Determinative Bacteriology*(Holt *et al.*, 1994).

RESULTS AND DISCUSSIONS

Resulting Values of physicochemical and microbiological parameters analyzed for collected samples are represented in Table-1. The results of bacteriological examination of collected samples are shown in Table-2. The statistical summary of physicochemical and microbiological parameters is tabulated in Table-3.

The pH of the water samples ranged from 7.2 to 8.6 with an average value of 7.8. Minimum pH was recorded at galteshwar in April-2015 and February-2016 whereas maximum pH at Utran in October-2015 was noticed. Almost pH values were remained alkaline throughout the year with slight variations which indicate the high buffering capacity of the river ecosystem. Temperature of river water was recorded comparatively higher in June-2015 and lower in January-2016 with range between 17.7˚C to 28.4˚C because of seasonal variation. Concentration of Dissolved Oxygen ranged from 5.7 to 8.9 mg/l with an average value of 6.87mg/l. Depletion in DO at downstream sites is observed.

Table 1: Monthly variations in water quality parameters of Tapi RIver at 3 selected Sites; G: Sampling Site at Galteshwer, U: Sampling Site at Utran, Ak: Sampling Site at Ashwinikumar

Month	Temperature			pH			Dissolved Oxygen			Nitrate-NO3			Nitrite-NO2			Phosphate-PO4		
	G	U	Ak	G	U	Ak	G	U	Ak	G	u	Ak	G	U	Ak	G	U	ak
Mar-15	27.5	27.8	28	7.35	8.12	8.02	6.12	5.74	5.89	2.053	3.76	2.912	0.87	1.088	1.534	0.084	0.127	0.215
Apr-15	28	28.5	29	7.2	7.75	7.82	7.32	6.89	5.57	1.179	1.709	6.545	1.07	1.787	1.98	0.026	0.064	0.069
May-15	27	27.3	27.5	8.25	8.31	7.99	7.13	6.5	6.7	2.359	9.907	6.406	1.652	1.678	1.749	0.187	0.428	0.405
Jun-15	28.8	28.8	28.9	7.59	7.69	7.79	7.52	6.51	6.89	1.608	7.933	2.178	1.757	2.373	2.396	0.128	0.296	0.268
Jul-15	26	26.5	26	7.38	7.75	7.6	6.28	7.09	6	0.548	3.768	2.989	1.558	2.137	1.221	0.088	0.42	0.363
Aug-15	24.7	26	25	7.45	7.64	7.87	12.36	8.71	8.31	1.359	3.137	2.653	0.106	0.496	0.679	0.187	0.231	0.278
Sep-15	21.5	22	22	7.89	8.1	8.21	6.08	5.87	6.48	1.782	4.427	7.166	0.026	0.046	0.05	0.005	0.149	0.079
Oct-15	25	25.2	25.5	8.43	8.64	8.78	7.7	7.29	7.89	2.748	3.82	6.874	0.019	0.022	0.049	0.067	0.134	0.349
Nov-15	22	22.4	22.5	8.06	8.23	8.54	7.8	6.28	5.47	2.759	4.692	6.416	0.042	0.061	0.05	0.093	1.68	1.39
Dec-15	23	23	23.2	7.22	7.83	7.67	7.5	7.9	7.29	2.766	5.747	6.033	0.018	0.044	0.043	0.016	0.219	0.029
Jan-16	17.7	18.1	18.2	7.37	7.59	7.43	7.7	7.09	6.08	1.894	3.604	7.187	0.016	0.028	0.057	0.013	0.037	0.006
Feb-16	21	21.2	21.6	7.2	7.39	7.16	7.09	6.08	5.67	2.014	3.13	2.872	0.027	0.039	0.035	0.061	0.182	0.08

Nitrate and phosphate are very important nutrients for the growth of bacteria as well as they affect the flora and fauna of freshwater ecosystem. Values of Nitrate ranged from 0.548 mg/l to 9.907 mg/l with annual average value 3.86 mg/l. Phosphate concentration in water ranged from 0.005 mg/l to 1.68 mg/l with average value 0.23 mg/l. Highest phosphate concentration was recorded in Sept-2015. Major possible sources for phosphate may be fertilizers used in agricultural fields and detergents used in households, whereas decomposition of organic waste, oxidation of nitrite, disposal of higher organic matter etc. can be the sources of Nitrate in river water.

Table 2: Values of Total Viable Count (CFU/ml) of Collected Samples from 3 Sites

Month	Galteshwar	Utran	Ashwanikumar
Mar-15	7.5×10^5	5.5×10^5	12.9×10^5
Apr-15	5.0×10^5	9.7×10^5	11.7×10^5
May-15	3.0×10^5	5.0×10^5	8.0×10^5
Jun-15	3.5×10^5	5.8×10^5	10.1×10^5
Jul-15	2.3×10^5	4.1×10^5	7.6×10^5

Table 2: Contd.,

Aug-15	5.0×10^5	10.6×10^5	11.3×10^5
Sep-15	3.4×10^5	4.1×10^5	7.6×10^5
Oct-15	2.4×10^5	3.9×10^5	6.6×10^5
Nov-15	3.6×10^5	4.9×10^5	8.6×10^5
Dec-15	3.0×10^5	5.5×10^5	8.3×10^5
Jan-16	2.8×10^5	7.5×10^5	9.3×10^5
Feb-16	5.6×10^5	6.8×10^5	10.1×10^5

Table 3: Statistical Summary (Average ± SE,) of Physico-Chemical and Bacteriological Parameters

Parameters	Galteshwar	Utran	Ahwanikumar
Temp.(˚C)	17.7-28.3 (24.31±0.95)	18.1-28.3 (24.67±0.95)	18.2-28.4 (24.69±0.93)
pH	7.2-8.43 (7.62±0.12)	7.39-8.64 (7.92±0.1)	7.16-8.58 (7.89±0.12)
DO(mg/l)	6.08-8.9 (7.26±0.23)	5.74-8.71 (6.83±0.25)	5.47-8.31 (6.52±0.27)
Nitrate(mg/l)	0.548-2.766 (1.92±0.2)	1.709-9.907 (4.64±0.65)	2.178-7.187 (5.02±0.6)
Nitrite(mg/l)	0.016-1.757 (0.6±0.21)	0.022-2.373 (0.82±0.27)	0.035-2.396 (0.82±0.26
Phosphate(mg/l)	0.005-0.187 (0.08±0.02)	0.037-1.68 (0.33±0.13)	0.006-1.39 (0.29±0.11)
TVC(CFU/ml)	230000-750000 (380000±44723.48)	390000-1060000 (633846.2±72566.15)	660000-1290000 (913076.9±55205.65)

The microbial load of the river in terms of CFU/ml was tending to be high and varied throughout the year. Values ranged from 2.3×10^5 to 1.29×10^6 CFU/ml during the study period. A trend of higher TVC at the downstream sites viz. Utran and Ashwanikumar as compare to Galteshwar were revealed. Sewage and domestic waste discharges, as well as anthropogenic interferences, could be the possible reason. The lowest microbial load was observed in October-2015 and highest was in March-2015. Dissolved Oxygen was found to be higher during August-2015 and lower during March-2015 which indicates the negative correlation between TVC and DO. Further statistical analysis can be done to find out the correlation between them. Seasonal comparison when taken into consideration, Bacterial abundance was observed higher during summer while lower during monsoon. Krishna J.M. (Krishna, 2012) studied the Physico-chemical and Bacteriological quality of Kaveri River at Kudige, Karnataka and found the similar results. Higher nutrient concentration can also be the reason for the higher bacterial load. Research suggested that abundance of bacteria in freshwater ecosystem is related to the concentration of ammonia, nitrate, and phosphate as they can cause eutrophication in freshwater and it affects the bacterial abundance as well as community structure (Kumari *et al.*, 2011; Liu *et al.*, 2015; Staley *et al.*, 2015).

Bacterial isolates identified during the study period are belonging to 20 different genera i.e. *Escherichia, Klebsiella, Pseudomonas, Enterobacter, Acinetobacter, Azotobacter, Bacillus, Staphylococcus, Streptococcus, Streptomyces, Proteus, Flavobacterium, Salmonella, Shigella, Vibrio, Enterococcus, Citrobacter, Pantoea, Nostoc, Oscillatoria* etc. from 5 different phyla i.e. *Gammaproteobacteria, Firmicutes, Cyanobacteria, Bacteroides* and *Actinobacteria*. Members of *Gammaproteobacteria* were predominated in term of both diversity as well as an abundance, whereas least abundant organism was *Flavobacterium* from *bacteroides* phylum. The presence of Members from the coliform group including *Escherichia, Klebsiella, Salmonella, Shigella, Enterobacter, Enterococcus* etc. indicates the presence of fecal contamination in water which deteriorates the water quality and makes it unsuitable for drinking and domestic purposes without treatment.

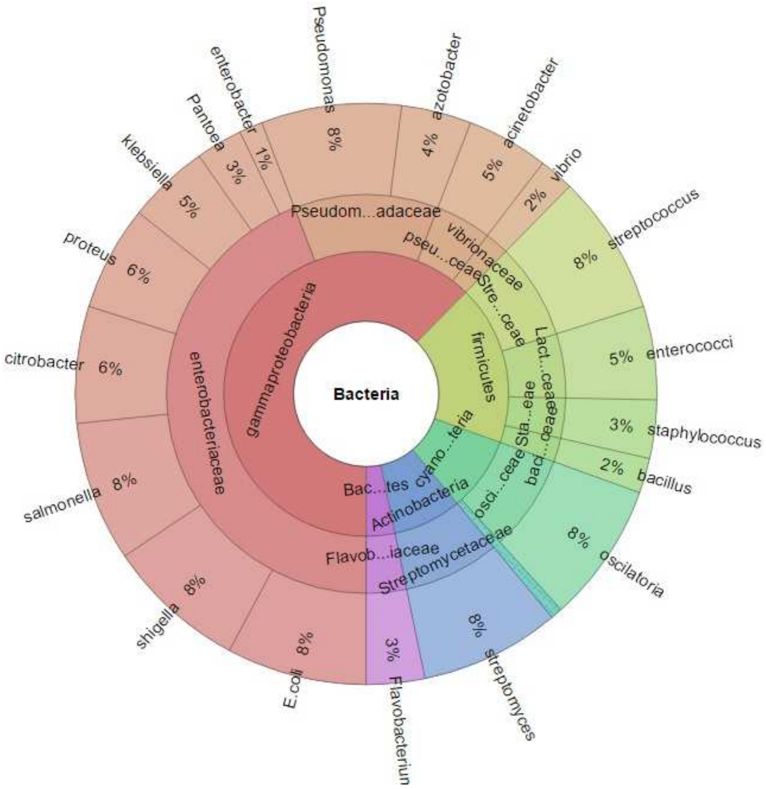

Figure 2: Frequency of Bacterial Community Distribution throughout the Year in Tapi River

Table 4: Bacterial Isolates and their Impact on Human Health

Bacterial Genera	Pathogenic Impact
Escherichia	*E.coli* infected from feces contaminated water can cause bloody diarrhea, some strains can cause severe anemia, kidney failure, other can cause urinary tract infections
Pseudomonas	*p.aeruginosa* is one of the most common cause of pneumonia and urinary tract infection. Bacteriemia with *Pseudomonas* can cause very low blood pressure that can lead to failure major organs
Klebsiella	*K. pneumoniae* infection can progress into severe infections leading to pneumonia, bloodstream infections, wound infections, urinary tract infections, and meningitis.
Enterobacter	*Enterobacter* infections can include bacteremia, lower respiratory tract infections, skin and soft-tissue infections, urinary tract infections (UTIs), CNS infections, and ophthalmic infections.
Acinetobacter	Generally consider as nonpathogenic but Some strains of *Acinetobacter* have been associated with respiratory infections, wound infections, bacteremia, secondary meningitis, and urinary infections
Azotobacter	Nonpathogenic to human.
Bacillus	Some species are pathogenic including *B. anthracis* causes anthrax, and B. cereus causes food poisoning
Proteus	*Proteus* includes pathogens responsible for many human urinary tract infections
Staphylococcus	Common cause of skin infections, including abscesses, respiratory infections such as sinusitis, and food poisoning.
Streptococcus	Some species are nonpathogenic while some are responsible for pink eye, meningitis, bacterial pneumonia, endocarditis, erysipelas, and necrotizing fasciitis.
Streptomyces	Infrequent pathogens. Some species cause mycetoma in human and plants.
Flavobacterium	Known to cause disease in freshwater fish at lower temperatures. Nonpathogenic to human.
Salmonella	Strains of *Salmonella* cause illnesses such as typhoid fever, paratyphoid fever, and food poisoning.
Shigella	*Shigella* is one of the leading bacterial causes of diarrhea worldwide.
Vibrio	Pathogenic *Vibrio sp.* include *V. cholerae* are the causative agent of cholera. Other can cause foodborne illnesses

Table 4: Contd.,

Enterococcus	Species of *Enterococcus* are causative agents of urinary tract infections, bacteremia, bacterial endocarditis, diverticulitis, and meningitis.
Citrobacter	Generally nonpathogenic except responsible for infections of the urinary tract and infant meningitis and sepsis.
Pantoea	Opportunistic pathogen
Nostoc	Imparts typical unpleasant smell to water
Oscillatoria	Imparts typical unpleasant smell to water

In addition, the presence of Pathogenic bacteria such as *Vibrio, Klebsiella, Pseudomonas, Staphylococcus, Streptococcus, Salmonella* etc. indicates poor water quality and seek attention as it causes diseases and can be harmful to the rural communities' people who use the river water directly without treatment for the domestic use as well as drinking purpose. The impact of these bacteria on human health has been discussed in Table-4. Consumption of such untreated contaminated water is responsible for waterborne sickness because of the presence of pathogens and more research in direction of drinking water treatments and development of new technologies is required.

CONCLUSIONS

Overall, it can be concluded that higher bacterial abundance, pollution, and human anthropogenic activities are affecting the water quality of the Tapi river ecosystem. Moreover, frequent distribution of pathogens and opportunistic pathogens require attention and further research is needed in order to understand the risk to the rural communities who rely primarily on them as the only source of domestic water supply and to take the required steps in the account for the removal of such pathogens from the water before use.

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