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A Comparative Analysis of Microbiological Parameters of Pampa River and Achankovil River with Reference to Sabarimala Pilgrim Season

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Abstract

Management and conservation of riverine ecosystems are of special importance as rivers are under constant threat of degradation of their ecological quality due to natural as well as anthropogenic reasons. Congregation of people in river basins catalyses the degradative process by introducing anthropogenic factors into the system. The present study focuses on the evaluation of microbiological pollution status of Achankovil River and Pampa River, with reference to the Sabarimala pilgrimage, from July 2017 to June 2018. Site wise and seasonal variations were studied. Water quality was analysed using the presence of bacterial colonies as indicators of pollution. Total heterotrophic bacteria, total coliform bacteria and *E.coli* were counted using standard microbiological procedures. Microbiological contamination in Pampa river was found to be highest during Sabarimala pilgrimage season than the other seasons considered. Achankovil river showed high microbial contamination in both pilgrimage season and after pilgrimage season.

Keywords: Pampa River, Achankovil River, Sabarimala Pilgrimage season, Coliform bacteria

1. Introduction

Rivers are lifelines of biological, socio-cultural and economic progress of a country. They supply water essential for day-to-day activities, agriculture and industrial activities. The ever-increasing demand for water leads to its over-extraction and over-exploitation, leading to depletion and degradation of the resource. Natural, as well as anthropological factors, add to the degradation of riverine ecosystems. There is a countless number of bacteria, virus, and other microorganisms in water. Total coliforms are a group of bacteria commonly found in the soil, vegetation and untreated surface water (Partha, 2014). Faecal coliform bacteria, a subgroup of the total coliform bacteria, are mostly found in the intestine and faecal matter. River water, as well as sewage discharges, showed the presence of *Escherichia coli* and coliform bacteria (Ramaiah *et al*., 2004; Ramteke and Tewari, 2002). The biological characteristics of water influence human health, and quality of water are essential in controlling diseases that are caused by microbes of human origin (Metcalf and Eddy, 2003). Total coliform and faecal coliform counts are the most widely used bacteriological procedures for assessment of the quality of drinking and surface water (Mcdaniels *et al*., 1985). McLellan *et al*. (2001) stated the benefits of these indicator bacteria in checking the health of the aquatic system. The presence of faecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the faecal material of man or other animals (Hysko *et al.*, 2010), which can lead to short term and long-term health hazards. Major pathways of contamination include water from septic system connections, wastewater treatment discharge points, urban stormwater system, and runoff from livestock housing or manure storage, runoff from agricultural areas as well as direct deposition of animal droppings (Ritter *et al* ., 2002). About 3.4 million humans, mostly children, die due to water-related diseases as per the documentation by the World Health Organisation. According to the reports of UNICEF (2014) and WHO (2010), over 2.6 billion people lack access to clean water, which results in 2.2 million causalities annually, of which 1.4 million are children, and this can be reduced by 4% approximately by improving the quality of available water.

Analysis of water quality and microbiological monitoring parameters is essential to preserve and protect the riverine ecosystem. Pampa river and Achankovil river are a significant source of water in Pathanamthitta district. In addition to this, they are part of the rich cultural heritage of these rivers. Thus every single action towards conservation, preservation and rejuvenation of these rivers counts. The objectives of the study are to assess the water quality of the Pampa river and Achankovil river by analyzing microbiological parameters during different seasons and to analyze the anthropogenic impact of Sabarimala pilgrimage on these two rivers.

2. Materials and Methods

The study was conducted at three sites each from two major rivers, Pampa and Achankovil, in Pathanamthitta district. The sites selected were Cherukolpuzha (site-I), Chengannur (site-II) and Mannar (site-III) segments of Pampa River and Thumpamon (site-I), Kochalumood (site-II) and Veeyapuram (site-III) of Achankovil River. The period of study was from July 2017 to June 2018. These areas were selected for collection of samples as these areas show congregation of pilgrims en route to Sabarimala. The study was carried out in three seasons:

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Monsoon-Before Sabarimala Pilgrimage Season (BP) (July to October 2017), Post Monsoon -Pilgrimage Season (P) (November 2017 to February 2018) and Summer – After Pilgrimage Season (AP) (March 2018 to June 2018). The microbiological parameters of samples were done by using standard methods adopted by APHA (2012). A dilution factor of 10^{-1} through serial dilution was attained for the samples to enumerate total viable count, total coliform, and *E. coli*. Nutrient agar, Tergitol-7 agar and Mac Conkey agar were used for the enumeration of bacteria, respectively. The procedure of media sterilization and preparation of culture plates were conducted for enumeration. The plates were incubated at 25°C (Total heterotrophic bacteria), 35°C (Total coliform) and 44.5°C (*E. coli*) for 24hours in a bacteriological incubator, for allowing the growth of bacteria colonies. Lactose fermenters were identified as greenish yellow colonies with yellow zone while lactose non-fermenters as red colonies surrounded by blue zones (ISO, 1990) in case of total coliforms. White colonies were identified as total heterotrophic bacteria, and pink colonies surrounded a zone of acid precipitated bile were identified as *E.* coli. Bacteria colonies were counted with the help of Digital Colony Counter. Descriptive statistics were conducted, and the statistical significance of differences ($p<0.05$) was determined by analysis of variance (ANOVA) using software MS Excel (version 7.0).

3. Results and Discussion

Results of this study show that presence of the total heterotrophic bacteria and total coliform bacteria in all the three sampling sites of Pampa River is higher during the Sabarimala pilgrimage season (post-monsoon season) than other seasons. The microbiological quality of water is the health indicator to spot polluted sites and also to estimate the extent of pollution and hence the detection and enumeration of indicator organisms are of primary importance for the monitoring of the sanitary and microbiological quality of water (Gunnison, 1999). In Achankovil River, the total heterotrophic bacteria was found to be higher during pilgrim season, and total coliform is higher during the after pilgrimage season. The higher bacterial count could be due to the use of the river by pilgrims, mainly for sanitation purpose. The sampling sites which showed highest bacterial contamination during pilgrim season were Chengannur (294.84 CFU/ml in 10^{-1} dilution) of Pampa River and Kochalumood (296.16 CFU/ml in 10^{-1} dilution) of Achankovil River. The sites which showed lowest bacterial contamination during the pilgrimage season were Mannar (185.66 CFU/ml in 10^{-1} dilution) of Pampa River and Veeyapuram (201.2 CFU/ml in 10^{-1} dilution) of Achankovil River (Table.1).

Chengannur (site II) is a significant campsite of Sabarimala pilgrims and in this site total coliform bacterial population was high in all the three seasons. This can be due to increased anthropological interventions in this site during pilgrim congregation and also due to activities of the local population. Coliform bacteria are a reliable indicator of organic pollution because they are unable to survive in clean water beyond a limited time (Hiraishi *et al*., 1987). The comparatively lower bacterial count obtained during seasons other than the pilgrims season could be due to less anthropogenic disturbances. Dilution induced by rain can also be a factor.

With regard to statistical analysis of data of samples from the Pampa river, total coliform showed a significant difference between sites and between seasons. In the case of total heterotrophic bacteria, significant variation was shown between different seasons. In the case of *E.coli*, significant variation was shown between sites and between seasons ($p<0.05$). Significant variation was found in total coliform bacterial population between sites in Achankovil river. Total heterotrophic bacteria showed significant variation between seasons (Table 3 and 4). A comparative study conducted for the total heterotrophic bacterial population in the two rivers indicated significant variation between seasons and less variation between rivers. Total coliform bacterial count and *E.coli* count in the two rivers showed significant variation between rivers and no variation between seasons (Table.5). Total heterotrophic bacterial count and total coliform count were so high, making the water not suitable for drinking, domestic and other recreational purposes. As per the standards of drinking water quality set by WHO, the drinking water should be devoid of coliforms, and if present, will be below 10 MPN/100 ml (WHO, 1996). According to the CPCB (2008 and 2009) classification for 'class D' water bodies, the permissible limit for coliforms in surface water was 5000 MPN/100 ml.

E. coli can play the role of bio-indicator of the aquatic ecosystem, and its presence could reveal the quality of water. Usharani *et al.* (2010) had reported that the riverine ecosystem is contaminated by human excretory waste and domestic sewage, which contains *E. coli*, *Streptococci sp*. and *Bacillus sp*. In the present study, *E. coli* number was found to be highest in the pilgrimage season. The lowest value of *E.coli* population was observed before the pilgrim season. This trend was shown in sampling sites both in the Pampa river and Achankovil river (Table 1 and 2). During pilgrimage season, pilgrims camp at various stations along the riverside. Pilgrims use the river for multiple purposes, including sanitary activities. People lacking access to a toilet may use the riversides for open defecation, resulting in the high *E. coli* count. Mishra et al. (2009) has reported that discharge of sewage along with human and animal excreta and hospital refuge, open defecation near the bank, allowing of cattle and other human activities can contribute to increased bacterial load in river water. Marale *et al*. (2012) had reported the impact of activities of the pilgrim as well as local people in deterioration of Indrayani river, which resulted in increased the occurrence of water-borne diseases and other health hazards in pilgrims, local people and visitors. Study sites in both the rivers showed lowest bacterial contamination in the before pilgrim season. This can be due to the lesser density of the pilgrim population.

Pollution of these rivers is mainly attributed to anthropogenic impact, especially induced by the pilgrim population, which is evident from the values obtained with respect to the seasons. The geographical location of the

Table 1. Mean and Standard deviation of various microbiological parameters of Pampa River (CFU/ml in 10^-1 dilution)

Bacterial colony	Sites	Seasons		
		Before Pilgrimage	Pilgrimage	After pilgrimage
Total Heterotrophic Bacteria	I	24.2±0.63	252.83±0.24	214±0.16
	II	42.17±0.47	294.84±0.72	236±0.62
	III	56.5±0.70	185.66±0.34	153.33±0.36
Total Coliform Bacteria	I	10.45±0.61	37.13±0.48	31.2±0.37
	II	31.5±0.87	59.83±0.76	52.5±0.68
	III	20.6±0.43	25.6±0.16	27.5±0.88
E.coli	I	2.3±0.37	4.51±0.58	2.5±0.59
	II	7.3±0.26	15.83±0.85	12.5±0.21
	III	5.8±0.31	2.66±0.63	4±0.60

Table 2. Mean and Standard deviation of various microbiological parameters of Achankovil River (CFU/ml in 10^-1 dilution)

Bacterial colony	Sites	Seasons		
		Before Pilgrimage	Pilgrimage	After pilgrimage
Total Heterotrophic Bacteria	I	80.5±0.61	264±0.85	216.33±0.51
	II	30.66±0.73	296.16±0.30	275.5±0.41
	III	61±0.34	201.2±0.65	181.83±0.14
Total Coliform Bacteria	I	9±0.32	17.5±0.61	19±0.33
	II	6.5±0.64	8.5±0.67	10.61±0.63
	III	9.33±0.50	24.61±0.29	26.2±0.13
E.coli	I	3.66±0.63	9.16±0.71	9±0.59
	II	2.33±0.50	5.33±0.80	3.43±0.61
	III	5.66±0.64	18.66±0.17	9.35±0.52

Table 3. Variance in microbial population among sites and seasons in Pampa river

Pampa river				
Parameters	**comparison**	**F**	**P-value**	**F-crit**
Total heterotrophic bacteria	Between sites	2.107739	0.237058	6.944272
	Between seasons	27.60967	0.004562	6.944272
Total coliform bacteria	Between sites	11.79229	0.021027	6.944272
	Between seasons	7.835894	0.041346	6.944272
E.coli	Between sites	11.79229	0.021027	6.944272
	Between seasons	7.835894	0.041346	6.944272

Table 4. Variance in microbial population among sites and seasons in Achankovil river

Achankovil river				
Parameters	**comparison**	**F**	**P-value**	**F-crit**
Total heterotrophic bacteria	Between sites	1.51617	0.323534	6.944272
	Between seasons	22.74478	0.006533	6.944272
Total coliform bacteria	Between sites	7.096437	0.048341	6.944272
	Between seasons	6.516605	0.055148	6.944272
E.coli	Between sites	4.616944	0.091358	6.944272
	Between seasons	4.187058	0.104494	6.944272

Table 5. Variance in the microbial population in Pampa river and Achankovil river with respect to different seasons

Pampa river and Achankovil river				
Parameters	**Comparison**	**F**	**P-value**	**F-crit**
Total heterotrophic bacteria	Between rivers	0.406727	0.588909	18.51282
	Between seasons	110.6094	0.00896	19
Total coliform bacteria	Between rivers	26.18069	0.036138	18.51282
	Between seasons	1.477696	0.403601	19
E.coli	Between rivers	24.36338	0.038679	18.51282
	Between seasons	4.045323	0.198203	19

sites in addition to the size of the pilgrim congregation adds to the adverse impact of anthropogenic activities. Both these rivers are polluted as indicated by the presence of coliform bacteria and *E. coli*. Patra *et al.* (2009) has reported *E. coli* as the most reliable indicator of faecal contamination in water. By comparing these two rivers, microbial count (total heterotrophic bacterial count) showed significant variations with regard to seasons, i.e., before the pilgrimage and during the pilgrimage seasons. Vignesh *et al*., (2012) reported that factors such as organic matter in faecal content, bathing of human and livestock, waste from sewage and septic tank could increase the TVC values. The increased organic load enhances the bacterial load in water due to factors like mass bathing and religious activities (Sharma *et al*., 2014). Semwal and Alkolkar (2006) studied the Gangetic river sites and found the reason behind microbial contamination is due to mass bathing and holy dip by pilgrims. Byamukama *et al*. (2000) attributed raw sewage from slums, industrial effluents, and discharges from a sewage treatment as reasons for bacterial load in Nakivubo channel in Uganda, indicating the impact of various types of anthropogenic activities in the degradation of qualities of aquatic ecosystems. Sood *et al*. (2008) in their seasonal microbiological analysis done along the Ganga river reported that in Uttarakhand the lower part of the river face threat due to anthropological factors, mostly associated with religious rituals and bacterial indicator of faecal origin was reported from many points along the river. The major source of these bacteria to the riverine ecosystem is thus anthropogenic. The sites studied along the Pampa river, and Achankovil river is subjected to human activities as reported in these studies, which points to human interventions in increasing the microbial contamination of river water.

The present study investigated the degradation of two major rivers en route to Sabarimala- Pampa River and Achankovil River- with regard to water quality. Comparative analysis of water quality in Pampa River and Achankovil River, using various indicator bacteria revealed that there was a pronounced variation in water quality of these two rivers with respect to variation in season. Pampa River is highly contaminated, especially during Sabarimala pilgrimage season than the other seasons. Achankovil River shows microbial contamination both in pilgrimage season and in after pilgrimage season. This is due to the congregation of pilgrims even after the pilgrimage season. The ecological pressure induced by anthropogenic factors such as the use of the river for sanitary purposes, lack of scientific methods of disposal of municipal wastes, discharge of waste materials directly to the river from the makeshift commercial holdings during the pilgrim season, is beyond the self-rejuvenation capacity of the rivers. Scientific river management strategies are to be implemented for rejuvenation and resilience of the riverine ecosystem. Stringent efforts are needed to mitigate the damage such as regular environment impact assessments, strict enactment of laws, proper sanitation facilities for pilgrims to avoid open defecation, setting up of new water treatment plants and also by conducting proper awareness programs and training.

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