VOLUME 8 ISSUE 2 2022

ISSN 2454-3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 8, No. 2, 362-371 (2022)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Prevalence of Contributing Factors in Water Borne Diseases of Achankovil River with Respect to Coliforms and Thermotolerant Coliforms

Parvathy Mohan[1]*, Johnson Baby[2], Prasad G.[3] and Biju A.[1]

[1]Department of Zoology, St. Stephen's College, Pathanapuram, University of Kerala, India
[2] Department of Zoology, Christian College, Chengannur, Kerala, India
[3]Department of Zoology, University of Kerala, Karyavattom, India

**Corresponding Author*

Received: 13th August, 2022; **Accepted:** 10th September, 2022; **Published online:** 20th September, 2022

https://doi.org/10.33745/ijzi.2022.v08i02.045

Abstract: Many people around the world struggle to get good drinking water and generating safe drinking water is thus very important for human development. Moreover, Water- borne diseases are recognized to be a great concern in many provinces over the globe. Studies concerning all forms of freshwater resources with special inference on the various contributing factors in water-borne diseases epidemiology and water pollution assume significance in this perspective. Thermotolerant coliforms including *Escherichia coli* were enumerated from the river water samples by employing the Manual on Analysis Microbiology. The same manual was also used to analyse the Total Coliforms. Statistical analysis of data was carried out by SPSS software version 20. The prominent role of major contributing factors in context with the chance of water pollution in terms of Total coliforms and thermotolerant coliforms has been validated. The seasonal changes in the quality of water with an increase in coliform counts during the monsoon season may affect the water treatment system set up for public distribution of drinking water. The findings can be used as a significant element in various activities that focus on the sustainable use of freshwater and diminishing the risk of waterborne diseases.

Keywords: Achankovil, Bacteria, Water, Thermotolerant coliform count, Total coliform count

Citation: Parvathy Mohan, Johnson Baby, Prasad G. and Biju A.: Prevalence of contributing factors in water borne diseases of Achankovil river with respect to coliforms and thermotolerant coliforms. Intern. J. Zool. Invest. 8(2): 362-371, 2022.
https://doi.org/10.33745/ijzi.2022.v08i02.045

Introduction

Water scarcity has been noted as a swiftly growing concern over the globe, however, little is known about how it has extended over time (Mekonnen and Hoekstra, 2016). The increasing population rate and climate change followed by changing water consumption rates made keeping water use at a sustainable level more difficult (Gosling and Arnell, 2016). During the past few years, it is evident that freshwater scarcity is fetching a way of threat to the existence and sustainable development of the human population. Annual reports by World Economic Forum (Risks, 2015) have verified the water crisis as one of the major global risks with special inference on its impact over the human population.

Beyond the common factors behind the instigation of water scarcity, it is also critical to consider the various contributing elements including the presence of microbial consortia in freshwater as a prominent pollutant. For instance, the human populations will usually be under the threat of severe water-borne diseases once they consume the microbial consortia contaminated water. In this point of view, the coliform bacteria, specifically *Escherichia coli* has been witnessed to be a significant candidate in water contamination studies (Ashbolt, 2004). Usually, the coliforms are unlikely to cause illness, but their occurrence in drinking water indicates that pathogens could be present in the system. The presence of coliforms in water may thus indicate the presence of potential pathogens that can cause water-borne disease.

One of the prime sources of bacterial contaminants especially the coliforms worldwide is the wastes generated by dense human settlements which find their destination in surface waters (Edokpayi *et al.,* 2017). Flowing water bodies provide a suitable environment for the multiplication of microorganisms in the wastes due to the availability of nutrients they receive from surface runoff (Jamieson *et al.,* 2004). In addition to the availability of nutrients, following bacteriological parameters have been taken up in this context; Total Coliforms (TC) and Thermotolerant coliforms (T-coli). Moreover, sewage discharges in freshwaters thus become the major source of fecal contamination (Grabow, 1996). Achankovil River is one of the major rivers in Kerala on which a large number of people depend as their freshwater source. There are many pump houses along the river for purifying the river water for public supply. According to ENVIS Centre, Kerala (2021), the current water requirement of river basins for domestic use is $38Mm^3$. Various temples including 'Achan Kovil' along the river are used by a large number of devotees during the famous Sabarimala pilgrimage. People also use the river water directly for bathing, washing utensils, bathing animals, etc. Bacterial contamination of river water can therefore cause direct health issues to the people who live in the basin. For this reason, vigilant assessment and monitoring are required to manage river pollution to avert any imminent bacterial outbreak. Based on the above mentioned facts and perspectives, the current investigation has been intended to find out the contributing factors in context with the chance of water pollution based on Total coliforms and thermotolerant coliforms during the Pre-monsoon, Monsoon and Post-monsoon seasons.

Materials and Methods

Sample Collection:

Surface water samples were collected once a month in the morning hours from eight stations along Achankovil River. Samples were collected in sterilized glass bottles, kept in an icebox and brought to the Cashew Export Promotion Council of India (CEPCI) laboratory, Kollam for analysis. The stations were selected covering physiographically upstream, midstream and downstream of the river. Achankovil (AKL) and Konni (KON) belongs to upstream, Omalloor (OMR), Konathumoola (KML), Kaippuzha (KPZ), and Attuva (ATV) belongs to midstream region and Pallippad (PPD) and Veeyapuram (VPM) comes under downstream portion. Station locations finalized by GPS readings are depicted in Figure 1.

Analytical Parameter:

Water samples brought to the CEPCI laboratory, Kollam were analyzed for Total Coliforms (TC) and Thermotolerant coliforms.

Analytical Methods:

Total Coliforms:

Total coliforms are gram-negative, rod-shaped, non-spore-forming aerobic and facultative bacteria that ferment lactose at 35-37^{0}C with the

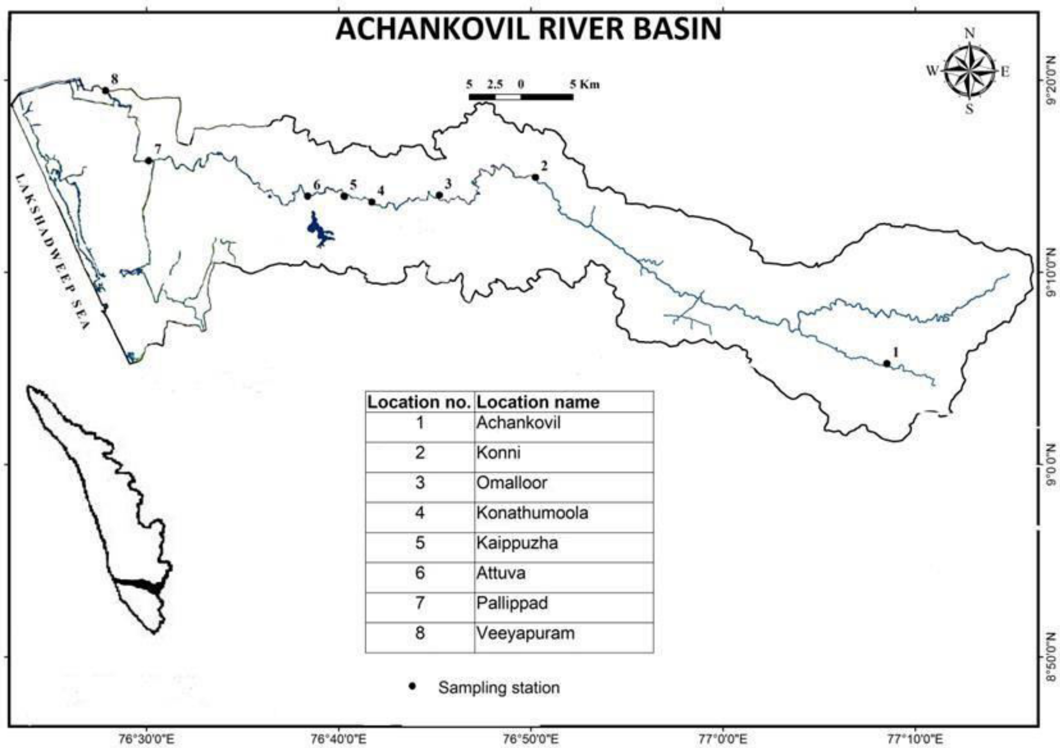

Fig. 1: Location Map of Achankovil River Basin.

production of acid and gas within 24-48 h of incubation. They can grow in high concentrations of bile salts. Total Coliforms were analyzed following Manual on Analysis Microbiology (MOAB/AP/DW2) by 5 tube MPN method (Edberg, 1990) using MacConkey broth double strength (DS) and Single Strength (SS) and Brilliant Green Lactose Bile broth-2% (BGLB) and Butterfield's Phosphate buffer solution (pH 7.2) (BIS, 1981). The gas formed in the inner vial of MacConkey broth indicated a positive presumptive test and gas production in BGLB broth tubes on the transfer of inoculum from presumptive tubes after incubation at 36 ± 1°C for 24 to 48 h indicated confirmation of total coliforms.

Thermotolerant Coliforms:

Thermotolerant coliforms and *E. coli* were enumerated from the river water samples by employing the Manual on Analysis Microbiology (MOAB / AP / DW 3) by 5 tube MPN method (BIS, 1981). They were confirmed on gas production after inoculating positive presumptive tubes on MacConkey broth into BGLB 2% broth tubes and incubating at 44.5±0.5°C for 24 h.

E. coli were confirmed after the BGLB positive tubes were inoculated into tryptone broth and incubated at 44.5±0.5°C for 24 h. Positive tubes were confirmed for Indole production by the formation of pink colour in Tryptone broth on the addition of Kovac's reagent and formation of yellow colour for negative tubes.

Data Analysis:

Statistical analysis of data was carried out by SPSS software version 20. ANOVA (Two-way) was done to appraise the significant difference in analysed factors.

Results

Total Coliforms:

Thermotolerant coliforms and *E. coli* are the subsets of the total coliform group that ferments lactose at higher temperatures. During lactose fermentation, coliforms produce b-galactosidase enzyme. Though the total coliforms were generally viewed as belonging to the genera *Escherichia, Klebsiella, Citrobacter* and *Enterobacter,* the group includes a more heterogeneous range of genera

Table 1: Monthly Total Coliform counts (MPN/100 ml) in Achankovil River basin

Months	Stations							
	AKL	KON	OMR	KML	KPZ	ATV	PPD	VPM
Oct	1600	1600	1600	1600	1600	1600	1600	1600
Nov	1600	1600	1600	1600	1600	1600	1600	1600
Dec	1600	300	1600	1600	1600	1600	1600	900
Jan	1600	1600	500	1600	1600	1600	1600	1600
Feb	1600	1600	1600	1600	1600	1600	1600	1600
Mar	1600	1600	1600	1600	1600	1600	240	1600
Apr	1600	1600	1600	1600	1600	240	350	1600
May	1600	1600	280	1600	1600	1600	1600	1600
Jun	1600	1600	1600	1600	1600	1600	1600	1600
Jul	1600	1600	1600	1600	500	1600	1600	1600
Aug	1600	1600	1600	1600	900	1600	1600	1600
Sep	1600	1600	1600	1600	1600	1600	1600	1600
Total mean	**1600±0**	**1492±375**	**1398±473**	**1600±0**	**1450±361**	**1487±393**	**1383±509**	**1542±202**
F value	**0.761**							
p value	**0.621**							

AKL-Achankovil, KON-Konni, OMR-Omalloor, KML-Konathumoola, KPZ- Kaippuzha, ATV-Attuva, PPD-Pallippad, VPM-Veeyapuram

including *Serratia* and *Hafnia* (WHO, 2017). Bureau of Indian Standard stipulates that there should not be any coliform bacteria in 100 ml of drinking water (BIS, 2012). This group comprises both fecal and environmental species which can also survive and grow in water distribution systems, especially when biofilms are present. The monthly and seasonal variation in MPN values of total coliform count is shown in Tables 1, 2 and Figures 2, 3, respectively.

Thermotolerant Coliforms:

The presence of thermotolerant coliforms (fecal coliforms) in water indicated fecal contamination. Fecal coliforms are considered indicators of the likely occurrence of pathogens in freshwaters and the possibility of waterborne diseases. Since, it is difficult to detect potential pathogens such as *Salmonella* sp., *Shigella* sp., diarrheagenic *E. coli, Giardia lamblia, Cryptosporidium parvum* and enteric viruses from water, fecal coliforms such as thermotolerant coliforms, enterococci and *E. coli*

are employed as the prime indicators of fecal contamination (USEPA, 2002). Monthly and seasonal MPN of thermotolerant coliforms is shown in Tables 3, 4 and Figures 4, 5.

In order to combat the threatening effects as reported in this investigation, the authors have provided significant ways concerning the awareness towards the population inhabited in the study area (Fig. 6). Pie diagram shows the number of people involved in each station for the awareness class. Awareness class were delivered to representatives of Panchayath members, Kudumbasree CDS members, social members and local inhabitants. A pamphlet prepared in vernacular language that contains the causes, impacts and mitigation of river pollution especially in terms of Microbial pollution was

Table 2: Seasonal mean Total Coliforms (MPN/100 ml) in Achankovil River basin

Stations	Seasons			Annual mean	F value	p value
	PRM	MON	POM			
AKL	1600±0.00	1600±0.00	1600±0.00	**1600±0**	**0.761**	**0.621**
KON	1600±0.00	1600±0.00	1275±650	**1492±375**		
OMR	1270±660	1600±0.00	1325±550	**1398±473**		
KML	1600±0.00	1600±0.00	1600±0.00	**1600±0**		
KPZ	1600±0.00	1150±548	1600±0.00	**1450±361**		
ATV	1260±680	1600±0.00	1600±0.00	**1487±393**		
PPD	948±755	1600±0.00	1600±0.00	**1383±509**		
VPM	1600±0.00	1600±0.00	1425±350	**1542±202**		
Total mean	**1435±445**	**1544±227**	**1503±316**			
F value	**0.893**					
p value	**0.414**					

PRM-Pre-monsoon, MON-Monsoon, POM- Post-monsoon

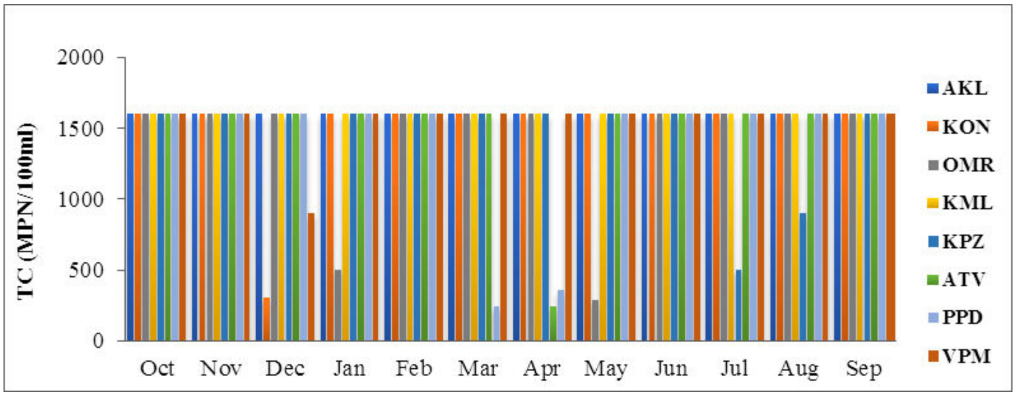

Fig. 2: Monthly Total Coliform counts in Achankovil River basin.

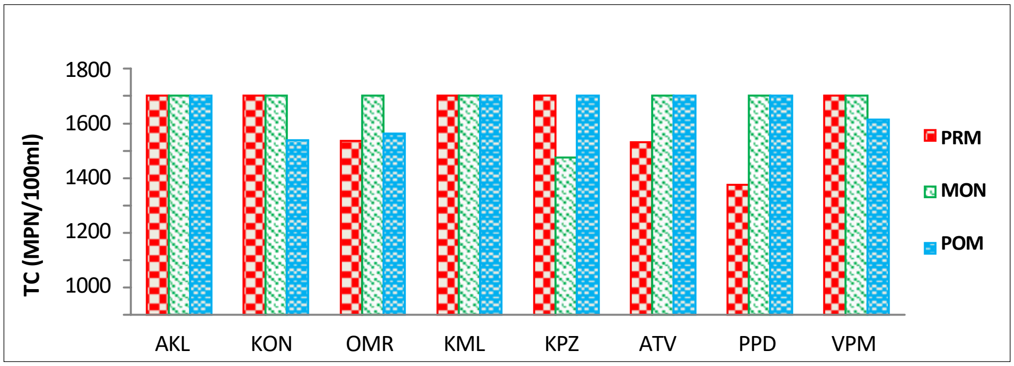

Fig. 3: Seasonal mean Total Coliforms in Achankovil River basin.

Table 3: Monthly Thermotolerant Coliform counts (MPN/100 ml) in Achankovil River basin

Months	Stations							
	AKL	KON	OMR	KML	KPZ	ATV	PPD	VPM
Oct	1600	1600	1600	1600	1600	1600	1600	1600
Nov	110	45	426	1600	170	1600	1600	80
Dec	220	9	1600	900	22	1600	1600	9
Jan	130	1600	500	1600	300	1600	1600	1600
Feb	27	500	1600	1600	1600	1600	1600	1600
Mar	145	1200	1600	1600	500	1600	240	1600
Apr	50	900	1600	50	900	240	212	1600
May	1600	500	170	1600	500	500	1600	1600
Jun	1600	1600	1600	1600	1600	240	1600	27
Jul	130	1600	1600	240	80	350	300	280
Aug	1600	1600	1600	200	90	500	1600	900
Sep	1600	1600	900	300	220	1600	1600	1600
Total mean	**734±766**	**1063±644**	**1233.0±565**	**1074±679**	**632±631**	**1086±640**	**1263±611**	**1041±726**
F value	**1.507**							
p value	**0.179**							

AKL-Achankovil, KON-Konni, OMR-Omalloor, KML-Konathumoola, KPZ-Kaippuzha, ATV- Attuva, PPD-Pallippad, VPM-Veeyapuram

Table 4: Seasonal mean Thermotolerant Coliforms (MPN/100ml) in Achankovil River basin

Stations	Seasons			Annual Mean	F value	P value
	PRM	MON	POM			
AKL	456±765	1233±735	515±725	**734±766**	**1.507**	**0.179**
KON	775±340	1600±0	814±908	**1063±644**		
OMR	1243±715	1425±350	1032±657	**1233.0±565**		
KML	1213±775	585±678	1425±350	**1074±679**		
KPZ	875±519	498±738	523±727	**632±631**		
ATV	985±718	673±627	1600±0	**1086±640**		
PPD	913±793	1275±650	1600±0	**1263±611**		
VPM	1600±0	702±702	822±899	**1041±726**		
Total mean	**1007±648**	**999±674**	**1041±705**			
F value	**0.041**					
p value	**0.960**					

PRM-Pre-monsoon, MON-Monsoon, POM- Post-monsoon

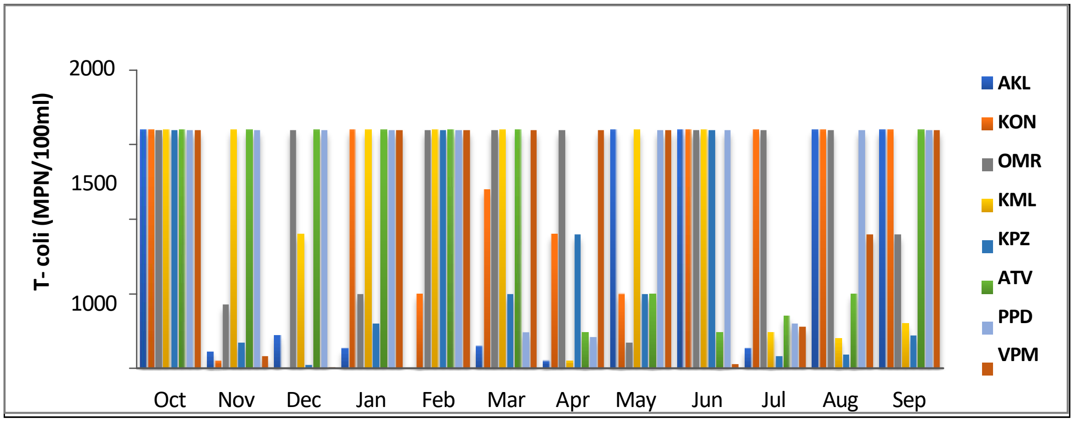

Fig. 4: Monthly Thermotolerant Coliform counts in Achankovil River basin.

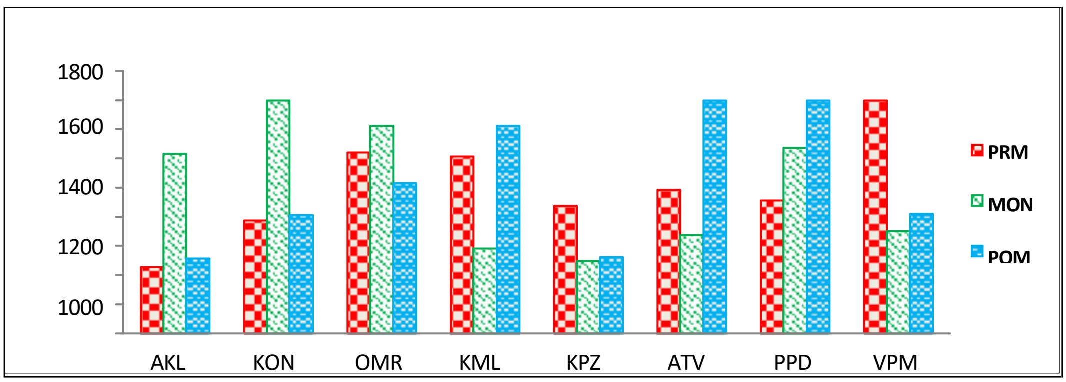

Fig. 5: Seasonal mean Thermotolerant Coliforms in Achankovil River basin.

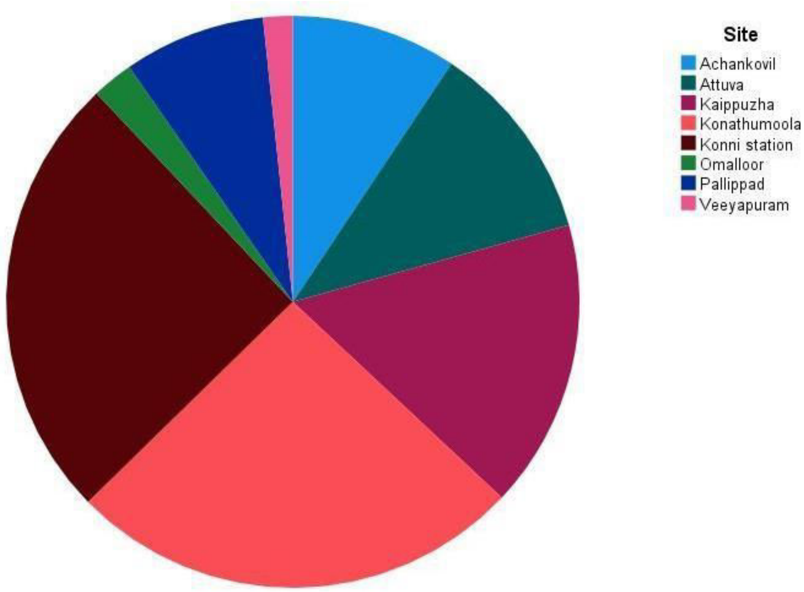

Fig. 6: Awareness among the inhabited population.

distributed among the participants. A total of 300 people were participated from 8 stations.

Discussion

The present investigation has clearly validated the prominent role of major contributing factors context with the chance of water pollution, total coliforms and thermotolerant coliforms in a monthly and seasonal variation perspective. As found in this investigation, a previous study by Bagade and Belagali (2013) also reported TPC, that including all forms of microorganism's variation between different sites in Karnataka state of India which revealed the chance of water contamination by different kinds of microbial populations including Yeast cells, *Rhizopus*, *Mucor*, *Streptococcus* spp, *Penicillium*, *Fusarium*, *Bacillus* spp., *Monococcus* spp., fecal Coliforms, *Actinomycetes*, and *E. coli*.

Since the number of bacterial pathogens present in fecal matter is considerably low and testing for all probable pathogens in drinking water is difficult and expensive, analysis of total coliforms which are present in large numbers in the fecal matter provides an easy and inexpensive way to understand the bacterial contamination in water. Total coliform counts in the present study were generally higher with negligible variation among stations. The lowest monthly Total coliforms (240MPN/100ml) was recorded from both Attuva station in April and Pallippad station in March whereas many stations recorded the maximum MPN value (1600MPN/100ml) in different months. Comparatively, the higher seasonal count was noted during monsoon and lowest at pre-monsoon. This revealed that organic wastes and sewage were drawn at many stations temporally along the length of the river by surface runoff. The presence of coliforms at Achankovil, the upstream station might also be due to contamination contributed from the tourism activities at Kumbavaratti and Manalar waterfalls near the sampling site and contamination from wild animals apart from the natural population. However, two-way ANOVA did not show variation among stations or seasons.

An earlier study by Jalal and Sanalkumar (2012) in the Achankovil River basin reported an increase in total coliforms from monsoon (0.6×10^3 CFU/ml) to post- monsoon (6.6×10^3 CFU/ml) season. Compared to the present values, higher values (46000 MPN/100 ml) of total coliforms associated with the Sabarimala pilgrimage were reported from the Pampa River (Sajudeen, 2013). Varying counts of total coliforms compared to the present study were reported from other parts of the country also. Comparatively lower TC values were reported from Bhima River (120 MPN/100 ml) in Karnataka State, Indrayani River, Pune (12-22 MPN/ml) and Chenab River (1 to 240 MPN/100 ml) (Jagtap, 2014; Dutta and Khajuria, 2016). TC counts between 1136 and 1880 CFU/100 ml were reported from Densu River, Ghana (Karikari and Ansa-Asare, 2009). According to the Bureau of Indian Standard (BIS, 2012) and the WHO (1997) that stipulate an acceptable limit/guideline value of nil total coliforms per 100 ml drinking water, the river water is unfit for human consumption without adequate treatment. WHO (2000) cites examples of recreational standards for total coliforms in bathing waters as <500 MPN/100 ml in 80% of the samples in Europe, 1000 MPN/100 ml in Japan, and <1000/100 ml in 80% of the samples in the USA. Considering these standards, the values obtained indicated that most of the sites under study are unfit for recreation. While considering the abovesaid facts and the findings from this investigation it is clear that the seasonal changes in the quality of water with an increase in coliform counts during monsoon season may affect the water treatment system set up for public distribution for drinking water. This implies that proper disinfection and monitored treatment is required for using Achankovil River water for drinking purpose.

Though the thermotolerant coliforms usually present in human and animal feces belong to the genera *Escherichia*, *Citrobacter, Enterobacter,* and *Klebsiella*, they may consist of bacterial species such as *Enterobacter cloacae* and *Citrobacter freundii*, which are inhabitants in soils and waters rich in nutrients and decaying vegetative matter (Hachich *et al.*, 2012). Monthly thermotolerant coliform counts in the present study varied from the lowest (9 MPN/100 ml) at Konni and Veeyapuram in December to the highest of MPN (1600 MPN/100 ml) at many stations in different months. Higher seasonal value was noted during post-monsoon compared to the other two seasons might be because of the influence of Sabarimala pilgrimage during the same. Two-way ANOVA did not show any variation among stations or seasons. Considering the BIS standard that stipulates zero thermotolerant coliforms per 100ml drinking water (BIS, 2012), direct consumption of Achankovil River water poses risk to human health. According to the guidelines set by WHO (2004) for fecal indicator bacteria in bathing waters, the Achankovil River water at most of the times was not fit for even bathing purposes during the study period.

The fecal coliform, especially the *Escherichia coli*, is noted to be a historical organism usually used for the fecal pollution detection in water environments. Precisely, the presence of *E. coli* validates the possible contamination water resources by more harmful pathogens of human origin. The *E. coli* is noted to be one of the most prevalent animal pathogens responsible for a wide spectrum of illness. The primary origin of the pathogen may mainly consist of water sources that are contaminated with fecal matter (Olsen *et al*., 2002). Such kinds of circumstances are primarily contributing to the emergence of various illness including cholera, typhoid and dysentery over the globe. Due to these reasons, as illustrated in the Fig. 6, the authors have conducted an awareness camp for the inhabitants in the current study area based on the findings from the investigation. Such kinds of awareness among the population will help the scientific community as well as the environment and the inhabitants of the corresponding region to combat the threatening effects instigated by the pathogens of microbial consortia towards humans (Ramírez *et al*., 2019). While considering a worldwide perspective, it was estimated that about 2 million people are under the threat of infections every year. Previous investigation has also validated the prominent role of fecal coliforms like *Escherichia coli* in the development and propagation of waterborne illness (Gimelli *et al.*, 2018). Considering the findings of this study, above discussed facts and BIS standard that stipulates zero thermotolerant coliforms, it was found that direct consumption of water from the study area poses risk to human health. Disinfection and treatment are highly required before considering the river water for the potable purpose. Moreover, the awareness camp conducted in the study region based on the above-discussed facts and findings could definitely be recognized to be the prominent and initial approach for the practical implementation of research concepts for better health.

Conclusion

In this study the prominent role of major contributing factors instigating the threat to the human population through water-borne diseases has been investigated. The poor sanitation measures opened the way for the augmenting population of microbial consortia. The presence of Thermotolerant coliforms like *E. coli* in water resources offers an indication concerning the possible existence of other kinds of pathogenic microorganisms including the hepatitis and salmonella. Hence, research targeting the aforesaid concerns could be recognized as the prime way to combat the threats instigated by the microbial consortia in human population, especially the water-borne illness such as typhoid, cholera and dysentery. The results from this investigation can be treated as a significant element in various challenges that focus on the preservation of freshwater thereby maintain reducing the water scarcity and better health of the human population.

References

Ashbolt NJ. (2004) Microbial contamination of drinking water and disease outcomes in regions. Toxicology 198: 229-238.

Bagade N and Belagali S. (2013) Microbial quality of lakes around Dharwad City Karnataka, India. J Environ Sci Eng. 55: 317-332.

BIS. (1981) Methods of sampling and microbiological examination of Water. IS:1622. Indian Standard. Reaffirmed 1996, 2003 to 2005. Edition 2.4. Bureau of Indian Standards. New Delhi.

BIS. (2012) Drinking water specification (Second Revision). IS:10500. Indian Standard. Bureau of Indian Standards. New Delhi, 1-5.

Dutta S and Khajuria M. (2016) Quantitative microbial analysis in the river Chenab at Akhnoor, Jammu. Ecoscan 10: 607-609.

Edberg SC, Allen MJ, Smith DB and Kriz NJ. (1990) Enumeration of total coliforms and *Escherichia coli* from source water by the defined substrate technology. Appl Environ Microbiol. 56: 366-369.

Edokpayi JN, Odiyo JO and Durowoju OS. (2017) Impact of wastewater on surface water quality in developing countries: a case study of South Africa. Water Quality: Chapter 18. Intech Open Science, Open minds, pp. 402-410.

ENVIS Centre: Kerala (2021) Water: State of Environment and Related Issues, ENVIS Centre, hosted by Kerala State Council for Science, Technology and Environment and Sponsored by Ministry of Environment, Forests & Climate Change, Govt. of India. http://www.kerenvis.nic.in/Database/WATER_820.aspx.

Gimelli FM, Bos JJ and Rogers BC. (2018) Fostering equity and wellbeing through water: A reinterpretation of the goal of securing access. World Dev. 104: 1-9.

Gosling SN and Arnell NW. (2016) A global assessment of the impact of climate change on water scarcity. Clim Change 134: 371-385.

Grabow W. (1996) Waterborne diseases: Update on water quality assessment and control. Water SA. 22: 193-202.

Hachich EM, Di Bari M, Christ APG, Lamparelli CC, Ramos SS and Sato MIZ. (2012) Comparison of thermotolerant coliforms and *Escherichia coli* densities in freshwater bodies Braz. J Microbiol. 43: 675-681.

Jagtap PB. (2014) Study of water quality of Bhima river water at Tulapur. Dist. Pune, Maharashta, India. Int J Res Biosci Agricult Technol. 2(2): 154-163.

Jalal FN and Sanalkumar MG. (2012) Hydrology and water quality assessment of Achencovil river in relation to pilgrimage season. Int J Sci Res. 2: 1-5.

Jamieson R, Gordon R, Joy D and Lee H. (2004) Assessing microbial pollution of rural surface waters: A review of current watershed scale modeling approaches. Agric Water Manag. 70: 1-17.

Karikari A and Ansa-Asare O. (2006) Physico-chemical and microbial water quality assessment of Densu River of Ghana. West Afr J Appl Ecol.10(1). doi: 10.4314/wajae.v10i1.45701.

Mekonnen MM and Hoekstra AY. (2016) Four billion people facing severe water scarcity. Sci Adv. 2: e1500323.

Olsen SJ, Miller G, Breuer T, Kennedy M, Higgins C, Walford J, McKee G, Fox K, Bibb W and Mead P. (2002) A waterborne outbreak of Escherichia coli O157:H7 infections and hemolytic uremic syndrome: implications for rural water systems. Emerg Infect Dis. 8(4): 370-375.

Ramírez AS, Ramondt S, Van Bogart K and Perez-Zuniga R. (2019) Public awareness of air pollution and health threats: challenges and opportunities for communication strategies to improve environmental health literacy. J Hlth Commun. 24: 75-83.

Risks G. (2015) World economic forum. Insight Report. 10th Edition. http://www3.weforum.org/docs/WEF_Global_Risks_2015_Report15. Pdf.

Sajudeen P. (2013) A study on the Pamba river pollution and its possible treatment strategies. Ph.D. Thesis, MG University.

USEPA. (2002) Implementation guidance for ambient water quality criteria for bacteria. United State Environmental Protection Agency, EPA 823-B-02-003.

WHO. (1997) Guidelines for Drinking Water Quality. Volume 3: Volume 3 Surveillance and control of community supplies. Geneva: 234.

WHO. (2000) Monitoring Bathing Waters - A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes. Edited by Jamie Bartram and Gareth Rees. WHO. London: 311.

WHO. (2004). Guidelines for drinking-water quality: incorporating first addendum. Vol. 1, 3rd ed. Recommendations. World Health Organization. Geneva: 540.

WHO. (2017) Guidelines for drinking-water quality: fourth edition incorporating the first addendum. World Health Organization, Geneva: 631.