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Research Article

Well Water Quality Analysis-Physical, Chemical & Microbiological Parameters of Water Samples From Ernakulam District, Kerala, India

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ABSTRACT

The present study has been carried out to assess the quality of groundwater resources of Ernakulam district, Kerala, India. The sample was collected from five target areas, which include Edathala, Nedumbassery, Perumbvoor, Eloor and Paravur points in Ernakulam district and analyzed for pH, TDS, alkalinity, total dissolved solids, total hardness, dissolved oxygen, chlorides, iron and presence of *Coliforms* (based on MPN index) as well. On analyzing the MPN of *Coliform* levels, it was found that *Coliform* bacteria contaminated all the samples except S4 and is not suitable for drinking purposes. A well water sample taken from Perumbavoor was highly contaminated with a *Coliform* content of 2400 CFU/mL. The well waters exhibited TDS (average values from 19–181 mg/L), total hardness (6.2–87 mg/L), alkalinity (2.5–80 mg/L), pH (5.1–7.2), turbidity (0.1–7.5 NTU), chloride (8–31 mg/L), dissolved oxygen (6.67–8.27) and total iron as Fe (0.08-0.72 mg/L). The total iron content and turbidity from sample S5 exceeded the maximum permissible limits and all other parameters were within the acceptable limit for drinking purposes.

Keywords: Groundwater quality, Physicochemical parameters, Microbiological quality.

INTRODUCTION

India is rich in water resources, being endowed with a network of rivers and blessed with snow cover in the Himalayan range that can meet a variety of water requirements of the country.[1] It can be found as surface water in lakes, streams, rivers, ponds, shallow aquifers, oceans, seas, ice caps, glaciers, etc., and as ground water that can be acquired as spring water, well water, and borehole water.[2] Water has a remarkable capacity to absorb heat and is crucial to the metabolic processes of both plants and animals as well as to their physiology.[3]

Even though groundwater is assumed to be one of the safest drinking water sources, it certainly is not safe and impervious to microbial contamination.[4] Industrialization, urbanization and extensive agricultural activities are the potential causes for the degradation of the quality and quantity of groundwater,[5-7] and any decline in water quality could have an impact on both human and agricultural health. Runoff from informal settlements and sewage plant discharges are two major variables impacting the microbiological quality of surface waters. *Fecal coliforms* are the most common indicator organisms used to evaluate microbiological quality. Total *coliform* count indicates a degree of pollution in water.[8] Reports have shown that the presence of *coliform* in groundwater can be an indicator of fecal contamination.[9-12]

Pathogenic microorganisms contaminating the water is now a major global problem. The main causes of bacteria in the aquatic environment are the disposal of human waste and municipal waste water through sewage and drainage ditches systems. Human pathogenic bacteria, particularly members of the *coliform*, can inhabit fishes and aquatic environments.[13] Increased levels of *F. coliforms* provide a warning of

Failure of the water distribution system and possible contamination with other pathogens such as *Escherichia coli, Shigella* spp., *Salmonella* spp., *cholera*, etc.[14] Water becomes unsafe for human consumption or usage when it contains pathogenic or disease-causing microorganisms. The consumption of unhygienic drinking water and the uses of unsafe water for daily purposes lead to the prevalence of diseases like diarrhea, typhoid, cholera and bacillary dysentery among the population.[15]

In India, roughly 80% of rural water supply for domestic uses is met from groundwater.[16] In addition, because of the filtering nature of the soil and frequent long residence time underground, groundwater is commonly much cleaner than surface sources. The groundwater of Kerala is getting contaminated by various effluents and anthropogenic activities.[17] Groundwater contamination problems are detected in many parts of the state, including groundwater of various river basins of Kerala was assessed by CWRDM.[18,19] groundwater of Karakulam Grama Panchayat,[20] Kazhakuttam block[21] of Thiruvananthapuram district, coast of Ernakulam district by Sreekesh *et al.*,[22] etc. The major ground water quality problems of groundwater of Alappuzha were reported to be due to chloride, TDS and fluoride.[23]

Consumption of water contaminated with hazardous chemicals or pathogenic microorganisms poses serious health threats or various waterborne diseases. It is estimated that about 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water.[24] Although the Bureau of Indian Standards (BIS) has fixed the quality standards for drinking water, most of the drinking water sources are below the standards due to excess pollution.[25] For the effective maintenance of water quality, we need continuous monitoring of the water body. No specific work has been done so far to assess the ground water quality status of this area. The current study examines the physicochemical and biological indicators of water quality collected from five different areas in Ernakulam district in the month of December 2022. The chemicals parameters used were pH, TDS, alkalinity, chloride, turbidity, odor, taste, iron and dissolved oxygen (DO). The study also aimed to assess the suitability of the well waters for domestic purposes. So an investigation on the existing water bodies and its quality is necessary from the point of view of identifying area with high pollution and suggesting treatment measures so that water can be brought into potable levels.

MATERIAL AND METHODS

Study Area

The state usually receives a tremendous amount of rain water, about 2,800–3,200 mm of rain every year. There are 44 rivers and 34 backwaters, mostly in the form of lakes and ocean inlets and others are fresh water lakes. Besides this, the state is blessed with numerous streams, about 18,600 ponds and over 70 lakhs dug wells. Kerala is one of the most dug well density areas in the world.[26]

For this study, water samples were collected from five target areas: Edathala, Nedumbassery, Perumbavoor, Eloor, and Paravur. Due to the area's high population density, the research of the water quality for these places is seen as being of utmost importance. The drinking water source of the people around this place is mainly ground water from wells, which are prone to pollution by the leachate to canal water in the surrounding areas. The study area and sampling locations are given in Fig. 1 and Table 1.

Sample Collection

Water samples were collected from four wells separately on 10th December 2022 between 8.00 to 9.00 am for chemical and microbiological analysis. Samples were brought to the laboratory in pre-cleaned polythene bottles of 1L capacity. Samples were kept cool in darkness until the chemical analysis is completed. Samples for microbiological analysis were placed in sterilised vials. There was 20 mm of empty space in the bottle, which allowed for efficient shaking.

Chemical Analysis

The collected samples were analyzed for various parameters like pH, TDS, alkalinity, chloride, total hardness, turbidity, odor, taste, iron and DO. Analytical-grade chemicals and doubly distilled water were used for the analysis. The water quality parameters were analyzed in accordance with the American Public Health Association[27] and the quality parameters were followed as suggested by the BIS.[25]

Table 1: Sampling sites

Sample no	*Sampling point*	*Longitude, latitude*
S1	Edathala	10.06979, 76.368657
S2	Perumbavoor	10.095631, 76.440153
S3	Eloor	10.073884, 76.312384
S4	Nedumbassery	10.157698, 76.331672
S5	Paravoor	10.180289, 76.197105

pH of the samples were determined using pH meter. Turbidity was measured using turbidity meter. Total dissolved solids were measured using a conductivity meter. Total iron was estimated by UV-visible spectrophotometer and chloride was analyzed by argentometric titration. Total alkalinity was measured by acidimetric titrations and dissolved oxygen by a titrimetric method using sodium thiosulphate solution. The total hardness of the water samples was estimated using complexometric titrations.

Microbiological Analysis

For microbiological examination, five samples of water were gathered one at a time from every section. The instances were gathered in glasses that had been previously sanitized and carried in ice cases to the lab within inside shortest amount of time to prevent mistakes because of the growth of microorganisms. The most probable number (MPN) technique was used for the determination of total coli forms (TC) and fecal coli forms (FC).

Most Probable Number (MPN)

*Coliform*s were counted using the MPN multiple-tube fermentation approach. Three 10 mL, three 1-mL, and three 0.1 mL quantities of the proper dilution of water samples were inoculated in the corresponding nine fermentation tubes for the presumptive test for *coliform*s. Inverted Durham tubes were also placed in lactose broth to detect gas generation. The test tubes were inoculated and incubated for 48 hours at 37℃, and those with air bubbles were validated by plating on eosin methylene blue agar (EMB) at 37°C for total *coliform*s. The MPN test can be finished in three steps:

Presumptive Test of MPN

The presumptive test is a *coliform* bacteria detection method that is specific. An inverted gas vial is placed in a lactose fermentation broth, and measured aliquots of the water to be analyzed are added. Due to the fact that these bacteria can use lactose as a source of carbon (other intestinal organisms are not), using this media makes it easier to discover them. Bile salt, a surface tension depressant, is also present in the lactose fermentation broth, employed in order to inhibit the growth of organisms other than *coliform* bacteria. Water aliquots of 10 mL, 1-mL, and 0.1 mL are added to the lactose medium tubes for inoculation. There are a minimum of three groups in the series, each with three tubes of the designated media. The sensitivity increases with the number of tubes per group. The color change in the tube shows bacteria growth in the water samples (Fig. 1).

Confirmed Test of MPN

The purpose of this test is to verify the existence of *coliform* bacteria in cases where a positive or questionable presumptive test result is

obtained. From such an assumed tube, a loopful of growth is placed into a tube containing brilliant green lactose bile (BGLB), 25 broth (or another lactose broth) and incubated for 48 hours at 35°C. Lactose functions as a selective agent in the medium. A Durham tube to measure the generation of gas is also included in the broth tube. A loopful of growth from a positive tube is streaked into an EMB agar plate, which is then incubated at 35°C for 18 to 24 hours. *E.Coli* and *Enterobacter aerogenes*, two common *coliform* bacteria, grow well on this. Total *coliform* in brilliant green bile lactose broth is given in Fig. 2.

Completed Test of MPN

This test assists in verifying suspicious and, if desired, confirmed positive test results. A lactose broth tube and the surface of a nutritional agar slant were infected with a typical *coliform* colony obtained from an EMB agar plate. After that, they were incubated for 24 hours at 35°C. A gram stain was prepared from the organisms on the nutrient agar slant and the broth was examined for the formation of gas after a full day. It is certain that there are *coliform*s in the water sample if the organism is a rod that is non-spore forming, gram-negative and releases gas in the lactose tube. The completed test of MPN for all the samples are given in Fig. 3.

RESULTS AND DISCUSSION

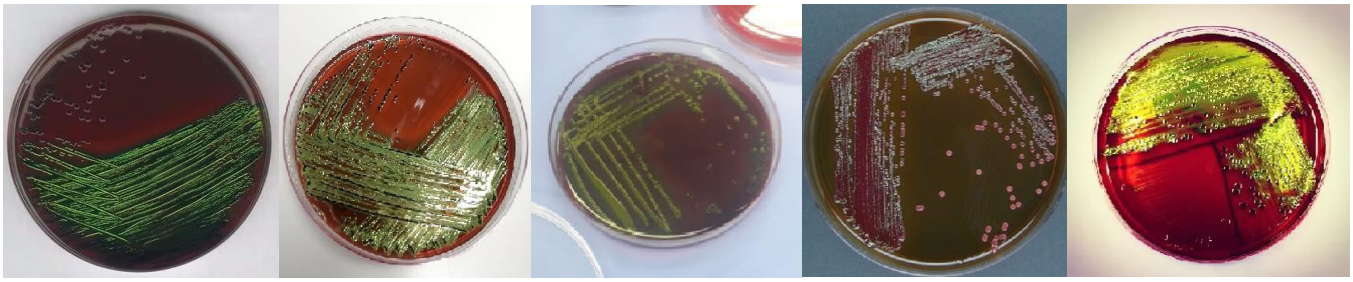
Physicochemical Parameters

The well water samples collected from five target areas were analyzed. The analysis of ground water samples includes the determination of inorganic constituents and bacteriological studies. Results of the physicochemical analysis are given in Table 2 and Figs 4 and 5.

Turbidity in water indicates the presence of pathogens, bacteria and other metal contaminants like lead, iron, mercury etc., which are harmful to human health. The desirable rate of turbidity is 1 NTU with a permissible rate upto 5 NTU for the drinking water. All the water samples except 5 are within the permissible range. The turbidity of the well water sample from Paravur is 7.5 NTU. The increase in turbidity may be due to soil contamination by soil particles.[28] Flood water might be a cause for the increase in turbidity of the water sample collected from the Paravur region. High turbidity can interfere with disinfection and water treatment process and that can provide a medium for microbial growth and contamination. Iron, algae and other suspended particles can increase the turbidity of surface water during the summer season. The increase in turbidity of sample 5 can be attributed to the presence of iron and other suspended pollutants.[29] The pH scale measures how evenly hydrogen and hydroxyl ions are distributed throughout water. In many different forms of geochemical equilibrium or solubility calculations, the pH of water gives crucial information. The ideal pH range required for drinking water is between 6.5 and 8.5 as per BIS, 2012, USPH and ICMR.[25,30] The pH of the studied water samples ranged from 5.1 to 7.2 as shown in Table 2. The pH of all the samples except 1, 2 and 4 are within the permissible range. Water samples from sampling stations 1 and 4 are slightly acidic. Low pH can cause a sour taste to drinking water. Low pH can cause corrosion and acidic water may leach metals like Pb, Mn, Cu, Fe etc., present in the soil. In such circumstances, the water becomes toxic for human beings depending on the concentration of leached metals. Total dissolved solids (TDS) is a measurement of the

S1 S2 S3 S4 S5

Fig. 1: Presumptive MPN test



S1 S2 S3 S4 S5

Fig. 2: Total *coliform* in brilliant green bile lactose broth

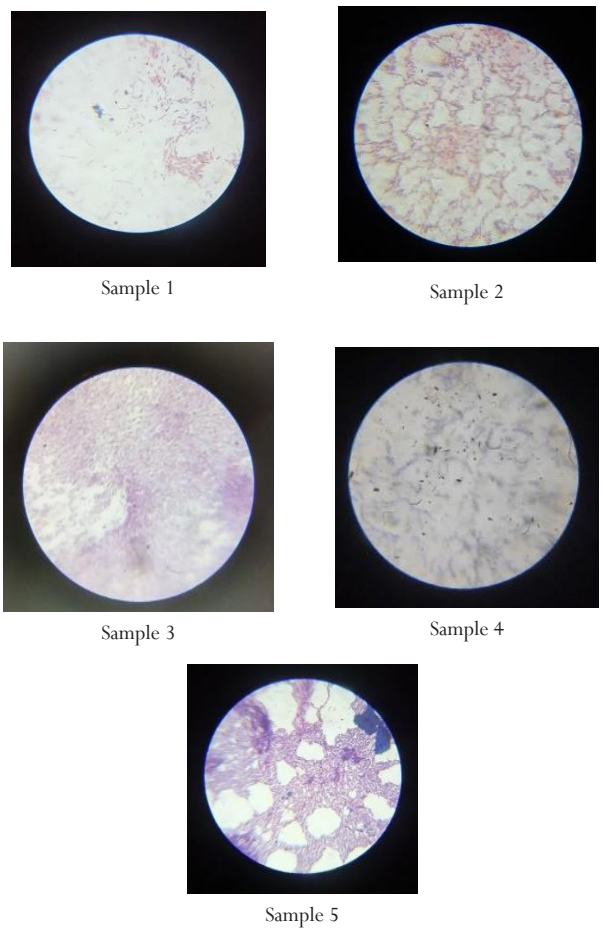


Fig. 3: The completed test of MPN for the samples S1-S5

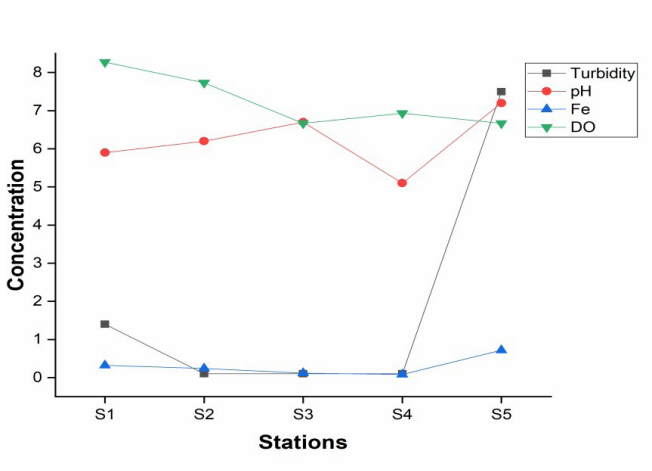


Fig. 4: Variation of turbidity, pH, Fe and DO from various sources

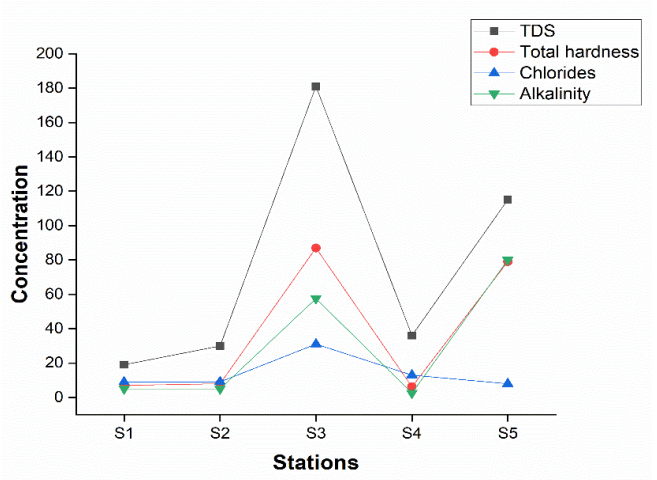


Fig. 5: Variation of TDS, hardness, chlorides and alkalinity from various sources

total amount of all inorganic and organic substances, whether they be in the form of molecules, minerals, or microscopic suspended grains. TDS up to 500 mg/L is the greatest desired level and up to 1,000 mg/L is the highest permissible level, according to WHO specifications. The study shows that all the well waters have TDS values below 500 mg/L and the sample from station 3 shows a maximum TDS value of 181 mg/L.

The carbonate alkalinity of all the samples is below the desirable limit of 200 mg/L. Lower alkalinity values suggest the absence of hardness and contaminants like chloride, calcium and magnesium in the well water of Ernakulam district. Alkalinity values for all the samples vary from 5 to 80 mg/L. The total hardness studied for all the samples ranges from 6.2 to 87 mg/L. Thus all the water samples are considered as soft as prescribed by BIS. From the results, it is clear that the presence of chloride is also very low, which is in agreement with the hardness and alkalinity of water samples. The increase in iron concentration can cause an increase in turbidity and also an unpalatable metallic taste to drinking water. The iron concentration of all the samples is within the desirable limit of 1 mg/L.

Dissolved oxygen determines the organic matter content in water bodies. More organic concentration can lead to lesser DO. Lower DO gives a bad odor to water due to the anaerobic respiration of organic matter.[31] Dissolved oxygen is high for sample 1 and low for samples 3 and 5. It can be due to the low organic matter content in S1 compared to other water samples.

Statistical Analysis

Correlation analysis of the physico-chemical parameters was performed using SPSS software, version 20, Table 3. The result shows that there are positive correlations between Fe and turbidity (0.965), hardness versus TDS (0.958) and alkalinity versus hardness (0.958). In the present study hardness can be considered as a water quality indicator parameter to potentially facilitate the rapid and cost-effective monitoring of ground water because of their correlation with other physicochemical characteristics.

Biological Parameters

Coliform bacteria belong to a broad group that includes numerous species. *Coliform* bacteria are generally not harmful. Numerous *coliform* species can be found in the soil, however they're not created by nature in the subsurface. *F. coliform* or *E. coli* is the target of this test. Such bacteria are signs that the water in the well has been contaminated with animal excrement contact, a serious risk for spreading illness.

Microbial analysis revealed that faecal *Coliform* contamination was observed in all samples except 4 (Table 4).

Table 2: Comparison of water quality characteristics resultsobserved in the present study with the scientific standards set by various regulatory agencies

Sample parameters	*Water quality standards*				*S1*	*S2*	*S3*	*S4*	*S5*
	BIS	*USPH*	*WHO*	*ICMR*					
Turbidity	1	-	5	2.5	1.4	0.1	0.1	0.1	7.5
pH	6.5–8.5	6–8.5	6.5–9.2	6–8.5	5.9	6.2	6.7	5.1	7.2
Total dissolvedsolids	500 mg/l	500	1000	500	19	30	181	36	115
Total iron as Fe	0.3 mg/l	0.3	0.3	1	0.32	0.24	0.12	0.08	0.72
Total hardness as $CaCO_3$	200 mg/l	-	300	300	7.0	8.0	87	6.2	79
Chloride as Cl	250 mg/l	250	250	200	9.0	9.0	31	13	8.0
Alkanity as$CaCO_3$	200 mg/l	-	200–600	200	5.0	5.0	57.5	2.5	80
Dissolvedoxygen	-	4–6	4–6	-	8.27	7.73	6.67	6.93	6.67

Table 3: Correlation coefficient of physicochemical parameters of ground water

	Turbidity	*pH*	*TDS*	*Fe*	*Hardness*	*Chloride*	*Alkalinity*	*DO*
Turbidity	1							
pH	0.666	1						
TDS	0.237	0.684	1					
Fe	0.965**	0.694	0.111	1				
hardness	0.5	0.825	.958*	0.389	1			
Chloride	-0.408	0.165	0.778	-0.521	0.571	1		
alkalinity	0.724	0.877	0.84	0.623	.958*	0.316	1	
DO	-0.326	-0.361	-0.755	-0.106	-0.738	-0.489	-0.71	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed)

The highest value for total *coliform* count was found in sample 2. According to the World Health Organization, a zero count of *E. coli* per 100 mL of water is considered safe for drinking. A count of 1 to 10 MPN/100 mL is regarded as low risk; 11–100

MPN/100 mL is medium risk. The well water bacterial contamination may be due to improper disposal of organic garbage from septic tanks or pits.[32] Many studies reported in coastal Kerala also recorded the presence of *Fecal coliform* contamination.[32-37] Water samples were gathered from various places in order to investigate the existence of *coliform*s and determine the reasons behind their presence in the water. By analyzing the report, out of 5 water samples, 4 of them are non-potable because of the presence of *coliform*s in the well water.

Table 4: Total *coliform* count of water samples (Source: APHA [37])

Parameters	*Results*	*Normal range*
S1	240 CFU/mL	<1 CFU/100 mL
S2	2400 CFU/mL	<1 CFU/100 mL
S3	240 CFU/mL	<1 CFU/100 mL
S4	NIL	<1 CFU/100 mL
S5	21 CFU/mL	<1 CFU/100 mL

CONCLUSION

The above-mentioned study demonstrated that the varied outcomes from five separate groundwater stations were compared with those set forth by the WHO, ICMR, and BIS. The total iron content and turbidity from sample S5 exceeded the maximum permissible limits and all other parameters were within the acceptable limit of drinking purposes, indicating that groundwater from all stations should be used for drinking according to the physical and chemical parameters. According to microbial studies, 4 out of 5 wells, water was contaminated with total *coliform* bacteria and is not potable. The present study of well water in Ernakulam district reveals that all the water samples except sample 4 are unsuitable for drinking purposes and outdoor bathing without proper disinfection and water treatment.

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CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

1. Gangwar S, *Int. J. Inform. Comput. Technol.*, 2013; **3**:851-856.

2. Chandra S, Singh A, Tomar PK, et.al. *Chem. Sci. Trans.,* 2012; **1(3)**:508-515.
3. Golterman HL, Clymo RS, Ohnstad MAM, et al.1978. Methods for Physical and Chemical Analysis of Freshwaters, vol. 8. Blackwell Scientific Publications, Oxford.
4. Andrade L, Boudou M, Hynds P, Chique C, Weatherill J, O'Dwyer J, et.al. *Sci. Total Environ.* 2022;**840**:156311.
5. Arumugam T, Kunhikannan S, Radhakrishnan P, et.al. *Int. J. Environ. Pollut.* 2019; **66(1- 3)**:187-211.
6. Nath AV, Selvam S, Kumari J, Nithya Y, Pitchaimani S, et.al, *Environ. Monit. Assess.* 2023; **195(2)**:316.
7. Paul R, Prasanna MV, Gantayat RR, Singh MK, et.al. *SN Appl. Sci.* 2019; **1**:1-4.
8. 8. Rai H, Hill G. **Arch. Hydrobiol**. 1978; **81(4)**:445-461.
9. Taylor CB. Coli-aerogenes bacteria in soils. *Epidemiol. Infect*. 1951; **49(2-3)**:162-168.
10. Mead GC, *Proc. Soc. Wat. Treat. Exam.,..}* i. 1966, 207-221.
11. Clark JA, Pagel JE, Can. *J. Microbiol*. 1977; **23(4)**:465-470.
12. Jyothylakshmi K, Abraham KM, Nandakumar S, Kumar MS, et.al. *Int. J. Adv. Sci. Res.*2020; **11**:203-6.
13. Saha ML, Nessa M, Khan MR, Islam MN, Hoque S, et.al. *Bangladesh J. Bot*. 2012 ; **41(1)**:55-60.
14. Tallon P, Magajna B, Lofranco C, Leung KT, et.al. *Wat. Air and Soil Poll.* 2005; **166**:139-66.
15. Moe CL, Rheingans RD. *J. Water Health.* 2006; **4(S1)**:41-57.
16. Moench M, 1996. Groundwater policy: Issues and alternatives in India. International Irrigation Management Institute, IIMI Country Paper, India, 2, 61.
17. Shaji E. Groundwater quality of Kerala–Are we on the brink. In Proceedings of Disaster Risk Vulnerablity Conference, Mahatma Gandhi University, Kerala, India 2011; 188-191.
18. CWRDM, Environmental monitoring programme on water quality, Report submitted to KSCSTE, 2009; p 174
19. CWRDM, Water quality status of Thiruvananthapuram district Kerala. In: Report submitted to centre for development studies, Thiruvananthapuram, 2017; p 32
20. Jaya DS, Deepthi GP, *Int. J. Geol. Environ. Eng,* 2015; 9**(10)**:1209–1213.
21. Binoj Kumar RB, Divya MP, *J. Geol. Soc. India.* 2012; **80**:48–56.
22. Sreekesh S, Sreerama Naik SR, Rani Seema, et.al. *J. Clim. Change,* 2018; **4(2)**:51–62
23. Harikumar PS, Madhavan K, Khan AB, et.al. *Ecol. Environ. Conserv.* 2000; **6**:245-9.
24. World Health Organization, Guidelines for drinking water quality, 3 rd Edn., WHO, Geneva, 2006
25. Bureau of Indian Standards, Indian Standards Drinking Water Specifications IS 10500, BIS, New Delhi, 2012
26. Geethu KV, Preethi V, Arun PR, Narasimha PN, et.al. *InInt. Symp. Integr. Water Resour. Manag*. 2014; 202-207.
27. APHA, Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association/ American Water Works Association/ Water Environment Federation, Washington DC, 2005.
28. Bordalo AA, Savva-Bordalo J, *Water Res.* 2007; **41 (13)**:2978-2986.
29. Sajeesh AK, Pulikkal AK, Aqua *Water Infrastruct. Ecosyst. Soc.* 2022; **71**:1325-1331.
30. USPH, Drinking Water Standards, P.H.S. Pub. U.S. Department of Health, Education and Welfare, Washington, 1962; 965-978.
31. Sallae AJ, Fundamental Principles of Bacteriology, 1974.
32. Harikumar PS, Kokkal K, Environmental Monitoring Programme on Water Quality: Report. Kerala State Council for Science, Technology and Environment; 2009.
33. Calvert P, Andersson I. The compost toilet: A positive experience in Kerala, India. Global Environment Sanitation Initiative, 2000.
34. Laluraj CM, Gopinath G, DineshKumar PK, Appl. Ecol. Environ. Res, 2005, **3(1)**:133-139.
35. Panicker S, Basi E, Alexander PK, Ravindran PC,et.al. Assessment of bacteriological quality of potable water and evaluation of water purification technique. Proceedings of 12th Kerala Science Congress, Kerala State Council for Science, Technology & Environment, (2000); 75-76
36. Varghese J, Jaya DS, *Indian J. Environ. Prot*, 2009; **29(5)**:430-4.
37. APHA (1998) Standard Methods for the Examination of Water and Wastewater.

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