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Original Research Paper

The Study of Water Quality of Tripunithura, a City Suburb of Ernakulam District in Kerala, India

M. P. Subin, C. T. Anitha and P. D. Sidhimol
Post Graduate Department of Botany, Sree Narayana College, Nattika-680 566, Thrissur, Kerala, India

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ABSTRACT

In the present study, physico-chemical and microbiological characteristics of different sources of surface and groundwaters in Tripunithura, a suburb of Ernakulam district, Kerala were determined during February 2011. The objective of the study was to asses the suitability of water for human consumption and other domestic purposes. Water samples from three different densely populated localities were collected and analysed for various parameters using standard methods. The physico-chemical parameters of home well water and pond water, with the exception of iron value in pond water, were satisfactory whereas bore well water and river water exhibited all the values as exceeding maximum permissible limit with a few exceptions of sulphate and dissolved oxygen in bore well water and nitrate in river water. The microbiological analysis revealed that with the exception of bore well water, all other waters fail to satisfy the prescribed standards set for drinking water. Therefore, the study revealed that the entire water samples investigated in the present study failed to qualify the prescribed standards for drinking water either in the physico-chemical aspects or in the microbiological aspects or both.

INTRODUCTION

Water is one of the essential natural resources for existence and development of life on the earth. Surface and groundwaters are the major sources to meet out the entire requirement. However, several factors like industrial and domestic wastes, discharge from agricultural practices, land use practices, rainfall pattern and infiltration rate, geological formation, etc. can affect water quality in a region (APHA 1975). The quality of water is getting vastly deteriorated mainly due to unscientific waste disposal, improper water management and carelessness towards the environment. This has led to the scarcity of potable water affecting human health (Agarkar & Thombre 2005). Increased anthropogenic activities in and around the water bodies can damage aquatic systems and ultimately microbiology and the physico-chemical properties of water. According to WHO (1984) 30 to 80% human diseases occurred due to impurities in water. Traditionally, the microbiological quality of drinking water is assessed by monitoring non-pathogenic bacteria of faecal origin (Rompre et al. 2002). Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards to ensure that it is palatable and safe for drinking and other domestic purposes (Tebutt 1983). Water can be obtained from a number of sources such as wells, ponds, rivers, lakes, etc. but unfortunately, clean, pure and safe water exists only briefly in nature and is immediately polluted by prevailing environmental factors and human activities, and hence water from most sources is unfit for immediate consumption without some sort of treatment (Raymond 1992). Consequent to the realization of the potential health hazards that may result from contaminated drinking water, causes for contamination of drinking water from any source is, therefore, of primary importance because of the danger and risk of waterborne diseases (Edema et al. 2001). Therefore, any water sources must be thoroughly analysed and studied before being used for domestic purposes.

Tripunithura is a densely populated city suburb in Ernakulam district in Kerala, which is reeling under acute shortage of potable water, especially during summer season, despite having a number of surface and groundwater resources. The present situation in Thripunithura attracts the attention to the urgency for investigating the causes and suggestion remedies. In the present study, an attempt has been made to analyse the physico-chemical as well as the microbiological parameters of different water resources available in Tripunithura, to see whether these water bodies are suitable for drinking and for other beneficial purposes.

MATERIALS AND METHODS

Sampling: The water samples were collected from three different selected regions of Thripunithura during the month of February 2011. The location and source of water samples are given in Table 1.

Table 1: The location, source and code of water samples collected from Tripunithura.

Sl. No.	Location	Sample code & Source W1	W2	W3	W4
1	Mekkara	Home well	Bore well	Pond	River let
2	Puthyakavu	Home well	Bore well	Pond	River let
3	Petta	Home well	Bore well	Pond	River let

The water samples were collected in high grade plastic bottles of one litre capacity. Before collection, the plastic bottles were rinsed with distilled water and then thrice with respective water sample. During collection, care was taken to avoid trapping of air within the bottle by completely immersing the bottle within the respective water sample until the bottle is completely filled in with the water sample.

Parameters analysed: The samples collected were brought to the laboratory and analysed for pH, electrical conductivity (EC), dissolved oxygen (DO) and total dissolved solids (TDS) immediately. Other physico-chemical parameters like colour, odour, taste, turbidity, total hardness (TH), total alkalinity, biochemical oxygen demand (BOD), calcium, chloride, fluoride, magnesium, sulphates, iron and nitrates were analysed within 36 hrs of collection. Standard methods were adopted for the analysis of water samples (APHA-AWWA-WPCF 1989).

For microbiological examination, samples were collected in 250 mL sterile bottles, and analysis was carried out within 6 hours of sample collection using standard methods outlined in BIS (1981). The parameters studied include total plate count (TPC), total coliform bacteria and faecal coliforms (*E. coli*).

Comparison with BIS and WHO standards: The physico-chemical parameters analysed for water samples were compared with BIS (1992) for drinking water and microbiological parameters with WHO standards (1996) for drinking and bathing water. The data provided in Tables 2 and 3 is an average of three samples collected from three different areas under study.

RESULTS AND DISCUSSION

Colour, taste and odour: All the four water samples were found to be colourless. Regarding taste, water sample W2 and W4 tasted salty. The odour of all the samples was not objectionable.

pH: As the pH is related to a variety of different parameters, it is not possible to determine whether pH has a direct relationship with human health, but it is argued that pH has an indirect effect as it can affect water treatment processes (Aramini et al. 2009). In the present study the range of pH of different water samples was from 6.8 to 7.5 and all were well within the safer limits as per BIS standards (Table 2).

Total hardness: Total hardness of different water samples in the present study varied from 29 mg/L to 8600 mg/L. Generally, the hardness of water bodies increases as the concentration of calcium and magnesium salt in water increases, especially during summer season due to excessive evaporation. The maximum hardness was observed in water sample collected from bore well (W2) followed by river let water (W4), which was 8600 mg/L and 1403 mg/L respectively. These two values are much higher than the maximum permissible limit prescribed by BIS (1992). The remaining two water samples W1 and W3 showed hardness level well within the desirable limit.

Turbidity: According to BIS (1992), the desirable limit of turbidity in drinking water is 5 NTU and a maximum permissible limit is extended up to 10 NTU. The study showed that turbidity value range from 1 NTU to 4.67 NTU. Therefore, all the water samples were well within the desirable limit. The minimum value of turbidity was recorded in water samples collected from home well, whereas the maximum in bore well water.

Iron: The concentration of iron (as Fe) in different water samples varied from 0.41 mg/L to 28.44 mg/L (Table 2). With the exception of sample W1, all the water samples have iron concentration much above the maximum permissible limit for consumable water, whereas W1 has a value within the maximum permissible limit but above the desirable limit (0.41 mg/L). The intake of large amount of iron through drinking water can cause haemochromatosis, a condition in which normal regulatory mechanisms do not operate effectively, leading to tissue damage as a result of the accumulation of iron (Dillman et al. 1987). Besides this, when iron concentration in the domestic water supply exceeds permissible limit, it becomes objectionable for a number of reasons that are indirectly related to health (Cohen et al. 1960).

Chloride: Chloride is one of the important indicators of water pollution. The value of chloride concentration in water samples W2 and W4 under study was too much higher than the maximum permissible limit. It was 10978.97 mg/L in W2 and 6303 mg/L in W4. With respect to water samples W1 and W3, the chloride concentration was satisfactory as it lies within the desirable limit of BIS drinking water specification, and were 77.75 mg/L and 43.29 mg/L respectively. Sources of chloride pollution in water include fertilizers, sewage, effluents, farm drainage, salt and human and animal wastes. High chloride content can cause high blood pressure in people.

Nitrates: The high concentration of nitrates in drinking water is toxic (Gilli et al. 1984). It is regulated in drinking water primarily because high levels can cause methaemoglobinae-

Table 2: Physico-chemical characteristics of water samples collected from various sources in Thripunithura in Ernakulam district for comparison with drinking water specifications of IS: 10500, BIS (1992).

Sl. No.	Parameter	BIS-1992		Water Sample			
		DL	ML	W1 Home well	W2 Bore well	W3 Pond	W4 River
1	Colour	5	25	2	3.67	1	3
2	Odour	unobjectionable	-	unobjectionable	unobjectionable	unobjectionable	unobjectionable
3	Taste	Agreeable	-	agreeable	salty	agreeable	salty
4	Turbidity	5	10	1	4.67	2	3
5	pH	6.5-8.5	NR	7.2	6.8	7.01	7.5
6	TotalHardness	300	600	71.67	8600	29	1403
7	Iron	0.3	1.0	0.41	28.44	9.22	5.0
8	Chlorides	250	1000	77.75	10978.97	43.29	6303
9	Fluoride	1	1.5	0.02	0.12	0.02	0.06
10	Calcium	75	200	24.8	2480.33	8.33	217.67
11	Magnesium	30	100	1.95	633.09	2.05	263
12	Sulphates	200	400	9.63	5.84	12.7	946.0
13	Nitrates	45	100	1.86	1087	3.88	8.15
14	EC	-	-	154.66	3376	184.33	2123.67
15	Total Alkalinity	200	600	13.63	6.4	7.53	62.50
16	BOD	-	-	2.57	17.96	5.23	10.5
17	DO	-	-	7.5	16.4	6.8	4.3
18	TDS	500	2000	146	21013	220	10278.33

Desirable limit (DL); maximum limit (ML). All parameters are expressed in mg/L with the exception where colour in hazen units, turbidity in NTU and electrical conductivity in μmhos/cm.

mia or “blue baby” disease (Mccasland et al. 1985). It is reported that groundwater is often contaminated due to nitrogenous fertilizers and manures, and also often accompanied by pesticides used in agriculture (Munsuz & Unver 1995). It is also reported that nitrate concentration depends on the activity of nitrifying bacteria which in turn get influenced by presence of dissolved oxygen. In the present study values of nitrates indicate that with the exception of water sample W2, all other water samples have nitrate content well within the desirable limit. W2 sample exhibited a value of 1087 mg/L which is many times higher than the maximum permissible BIS guideline value of 100 mg/L.

Sulphate: Sulphate content of water samples varied from 5.84 to 946 mg/L. With the exception of river water, all the samples were within the desirable limit. Water sample W4 showed a value of sulphate 946 mg/L, which is very high above the maximum permissible limit of 400 mg/L. Sulphate above the permissible limit may cause gastrointestinal disorders and diarrhoea in human beings (Prasad et al. 2008).

Fluoride: The desirable limit for fluoride in drinking water is 1mg/L and the maximum permissible limit is 1.5 mg/L (BIS 1992). The excessive amount of fluoride in drinking water can cause fluorosis having disfigurement of teeth and deformities of bones (Kulshreshtha et al. 2004). The concentration of fluoride in the water samples varied from 0.02 mg/L to 0.12 mg/L. Therefore, all the water samples have fluoride well within the desirable limit.

Calcium and magnesium: The values of calcium and magnesium in the water samples varied from 8.33 mg/L to 2480.33 mg/L and 1.95 mg/L to 633.09 mg/L respectively. The water sample W2 has the maximum value in both the cases, which was followed by water sample W4, and all these values were greater than the maximum permissible limit as per BIS (1992). Water samples W1 and W3 have acceptable value. Venkata et al. (2006) reported high positive correlation between TDS-Mg, TH-Ca and TH-Mg. The present study also supports this observation, as there is a positive correlation between the values of magnesium, calcium, TDS and total hardness in different samples.

Total alkalinity: Alkalinity of water is related to the actual number of base components and can be thought of as the intensity of the pH. Alkalinity values were recorded in the range of 6.4 mg/L to 62.5 mg/L. The water sample collected from river let water exhibited maximum alkalinity, whereas minimum was noticed in bore well water. As per the BIS standards all the values were well within the desirable limit (Table 2). If the alkalinity is low it indicates that even a small amount of acid can cause a large change in the pH.

Total dissolved solids (TDS): Total dissolved solids of the water samples were in the range of 146 to 21013 mg/L. TDS is an important parameter for drinking water and water to be used for other purposes. According to BIS (1992), water containing TDS value up to 500 mg/L is considered desirable and a maximum permissible limit of 2000 mg/L under

Table 3: Microbiological data variation in the total plate count (TPC/mL), total coliform (MPN/100 mL) and faecal coliform (MPN/100 mL) of different water samples.

Sl.No.	Sample	Parameters		
		Total plate count (CFU/mL)	Total coliform (MPN/100mL)	Faecal coliform (*E. coli*) (MPN/100mL)
1	W1	10×10^2	113	2.00
2	W2	27×10^2	0.00	0.00
3	W3	66×10^3	257	3.00
4	W4	28×10^3	1320	127.0
Limit as per BIS (1992) / WHO (1996)		100/mL	0/100mL	0/100mL

Table 4: Water quality requirements for bathing waters of the European Economic Community suggested by WHO (1996 & 1998).

Sl.No.	Microbiological parameter	Guide value	Mandatory value
1	Total coliform/100mL	500	10,000
2	*E. coli*/100mL	100	2,000

unavoidable situations. In the present investigation the water sample W1 and W3 showed a range satisfactory and within the desirable limit. The water sample W2 recorded maximum TDS value followed by water sample W4, and both were too higher than the maximum permissible limit and are not at all suitable for human consumption.

Biochemical oxygen demand (BOD): BOD is the amount of oxygen required by the living organisms engaged in utilization and ultimate destruction or stabilization of organic matter in water (Hawkes 1963). It is an important indicator of water pollution. BOD value of water samples in the present study varied from 2.57 to 17.96 mg/L. As per BIS the maximum desirable limit of BOD for drinking water is 5 mg/L. Here, it is observed that the BOD value of water sample W2 and W4 are above the maximum desirable limit, and are 17.96 mg/L and 10.5 mg/L respectively. The higher BOD values of these samples clearly indicate pollution and imply high demand for oxygen to support life processes which may be attributed to the percolation of wastewater loaded with biodegradable material.

Dissolved oxygen (DO): Generally, an increased values of BOD and COD indirectly indicate decrease in DO values. Deficiency of DO gives bad odour to water due to anaerobic respiration of organic matter (Sallae 1974). In the present investigation, with the exception of bore well water (W2), DO values of all the water samples were comparatively lower and the higher value of DO in water sample W2 may be because of comparatively low organic matter content.

Electrical conductivity (EC): EC measures the ability of water to conduct an electrical current, and it is directly related to TDS (Aydin 2007). The present study showed that EC values of various samples range from 154.66 to 3376 μmhos/cm. Water samples W1 and W3 exhibited a reasonable values, whereas samples W4 and W2 have higher values of 2123.67μmhos/cm and 3376 μmhos/cm respectively. The higher values of these samples may be due to high TDS value and the higher concentration of ionised substances present in the samples due to pollution by industrial effluents, domestic wastes, agricultural water, etc. (Aramini et al. 2009). It clearly indicates that samples W2 and W4 are unfit for human consumption.

The physico-chemical analysis of water samples, collected from surface and groundwater sources, shows that among the nine essential characteristic parameters for drinking water studied here, colour, odour, pH, turbidity and fluorides have satisfactory values considering the entire samples together as per BIS (1992). Among these nine desirable parameters, total alkalinity is the only common parameter which shows desirable value in all the samples. The rest of the essential and desirable characteristic parameters analysed, i.e., total hardness, chlorides, calcium, magnesium, sulphate, nitrate, TDS, EC, BOD and DO, water samples W1 and W3 were identified as having values within the desirable limit, with the exception of iron where sample W3 exceeded the maximum permissible limit, whereas sample W1 is above the desirable limit but within the excessive limit. With respect to the water samples W2 and W4, with the exception of sulphate and DO values in W2 and nitrate values in W4, all the parameters exceeded the maximum guideline value prescribed by BIS (1992). Water samples collected from bore well and river let are salty.

Microbial status: An estimation of bacterial production is a crucial step in understanding quantitatively the function and contribution of bacteria in material cycling within the given aquatic habitats (Azam et al. 1990). Assessment of indicator bacteria namely coliform bacteria is a convenient way to evaluate potability and sanitary condition of water bodies. *E. coli* and *Enterococcus* species are traditionally used as hygiene indicator bacteria, and methods for their detection are essential for drinking water regulations all over the world.

As per the results of the present study shown in Table 3, the total bacterial load as evident from total plate count (TPC), water samples collected from pond indicated highest bacterial load (66×10^3/mL) followed by river let water (28×10^3/mL), bore well water (27×10^2/mL) and home well water (10×10^2/mL). The total coliform count per 100 mL of different water samples ranged from 0 to 1320 MPN/100mL. Coliform bacteria will not likely cause illness. However, their presence in drinking water indicates that disease-causing organisms could be in the water system. The water samples collected from bore well showed no coliform count whereas all other water samples collected including home well, pond and river let were found to fall in higher range than the standard limit for drinking water. Water samples W1, W3 and W4 were identified as having the presence of faecal coliform bacteria *E. coli*. There was no count for *Escherichia coli* in water sample W2. Confirmation of faecal coliform bacteria or *E. coli* in a water sample indicates recent faecal contamination of either human or animal origin, which may pose an immediate health risk to anyone consuming the water (Okonko et al. 2008). Therefore, water samples W1, W3 and W4 give clear indication of poor water quality as they are exceeding the drinking water permissible microbiological counts suggested as per BIS (1992) and WHO (1996) standards.

As per the suggested WHO (1996, 1998) values of total coliform bacteria and *E. coli* per 100 mL water for the purpose of bathing and swimming (Table 4), the water samples W1, W2 and W3 are safe for bathing purposes as their microbial values are lying within the guide value. With respect to W4, both total coliform and *E. coli* count exceeded guide value but lying within the mandatory value.

CONCLUSION

The high level of many physico-chemical characteristics of water sample (W2) or microbiological parameters (W1 & W3) or both together (W4) render all the water samples unfit for human consumption though they can be used for other purposes. The water should meet the different quality specifications depending on the particular use. The microbiological and physico-chemical quality adversely affected the quality of various water sources of Tripunithura. The sources of pollution include agricultural practices, infiltration of irrigation water, infiltration of sewage effluents, construction activities, farm animals, septic tank, etc. Therefore, people in these areas have high potential risk of getting waterborne or sanitization related diseases under situations when they are forced to use these resources. Therefore, it is recommended that water from these sources is to be used for drinking only after pretreatment like boiling, chlorine disinfection, filtration, reverse osmosis, electrodialysis, etc. based on the situation demand. In conclusion, effective preventive measures are to be taken immediately to save these water resources of Tripunithura as it is an area of faster development and dense population.

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