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Physico-Chemical and Bacteriological Characteristics of selected potable water samples of Kanyakumari district

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Abstract
Water samples collected from three different borewell and three different openwells of Kanyakumari district were subjected to physico-chemical and bacteriological analysis. Various physico-chemical parameters, such as turbidity, electrical conductivity, pH, total alkalinity, total hardness, calcium, chloride, nitrate, iron, fluoride, phosphate and magnesium were studied and compared with WHO water quality guidelines. Electrical conductivity, alkalinity, total hardness, iron and fluoride of the selected potable water were not in agreement with the WHO guidelines. Steps should be taken to monitor the quality of drinking water used by the people to ensure their health.

Keywords: Potable water, physico-chemical parameters, human health, microorganisms, feacal pollution

Introduction
Potable water is the fundamental need of man to sustain life. Water serves as lubricant, regulates the body temperature and provides the basis for the body fluids and metabolism[1] . Water, which is essential to all forms of life makes about 50–97% of the weight of all plants and animals [2-3]. Drinking water should be suitable not only for human consumption but also for washing/showering and domestic food preparation because chemical and other constituents of the water would give rise to economical damage as well[4] .About 20% of the world's population lack access to safe drinking water[5] .The quality of surface water is constantly changing in response to daily, seasonal, and climatic rhythms. The quality of surface water also depends on the equilibrium between the physical, chemical, and biological characteristics of the surrounding environment[6-7] .The proportion of available but polluted water is continuously increasing as a result of changes in the modes of industrial activities, agricultural production, and increasing urbanization[8] .The safety of drinking water can be monitored to determine whether the water supply system is being operated correctly, implying that the water is safe for drinking or not. Indicator microorganisms survive better and longer than the pathogens with a uniform and stable properties and may easily be detected by standard laboratory techniques[9] . Ideally, drinking water should not contain any microorganisms known to be pathogenic or any bacteria indicative of faecal pollution. Detection of faecal indicator bacteria in drinking water provides a very sensitive method of quality assessment and it is not possible to examine water for every possible pathogen that might be present[10] .The objective of this work is to evaluate the bacteriological and physico-chemical parameters of the drinking water used by different stations of Kanyakumari district which acts as the main source of drinking water to local people.

Sample collection:
Water samples used for study were collected from six different drinking stations of Kanyakumari district. These samples were collected using pre-cleaned polyethylene bottle (1 liter capacity) for each and labeled accordingly as thus - openwell (S1-Karavilai); openwell (S2-Kurumbanai); borewell (S3-Amanakkanvilai); borewell (S4-Anjugramam); borehole (S5-Pudukudiyeruppu) and openwell (S6-Aloor).
The physical parameters like of EC and turbid was observed. The chemical parameters like pH was measured using a portable pen type pH meter, Total dissolved solids, calcium, iron, fluoride, chloride, Total Hardness, nitrate, sulphate and phosphate were analyzed following the standard methods[11] .

Bacteriological examination

The membrane filtration method of water analysis was used. Membrane filter of 47mm and pore size of 0.45µm were used[12] .100ml of water samples were filtered and the bacteria isolated was identified using standard methods[13]. MacConkey agar was used for the isolation of coliforms. Colonies that appeared on the plate were counted by marking the bottom of the plate, those that produce a plate count of between 30 and 300 colonies per plate [14].

Table 1: Physico-chemical parameters of different locations

PARAMETERS	S1	S2	S3	S4	S5	S6	WHO [17]
Turbidity (mg/l)	**7**	0.25	0	0	**77.5**	2.75	5
Electrical conductivity (micS/cm)	1560.5	900.5	1481	640.75	1691	860	200
pH	6.1	8	7	6.8	6.6	7.7	6.5-8.5
Alkalinity (mg/l)	72	136	304	272	328	308	200
Total hardness (mg/l)	320	176	400	156	292	172	80-120
Calcium (mg/l)	85	56	144	37	96	32	200
Chloride (mg/l)	448	172	320	28	320	68	250
Nitrate (mg/l)	0	5	10	8	8	1	50
Iron (mg/l)	0.8	0	0	0	6.78	0.27	0.3
Fluoride (mg/l)	0.2	0.1	0.4	0.4	0.2	1	1
Phosphate (mg/l)	0.03	0.51	0.03	0.03	0.02	0.02	0.5
Magnesium (mg/l)	26	9	10	15	12	22	50
Faecal coliform per 100ml	TNTC	150	TNTC	TNTC	TNTC	TNTC	70

Table 2: Correlation coefficient between physicochemical parameters of different locations

Parameter	Turbidity	EC	pH	Alkalinity (mg/l)	Total hardnes (mg/l)	Ca (mg/l)	Cl (mg/l)	NO_3 (mg/l)	Iron (mg/l)	Fl (mg/l)	PO_4 (mg/l)	Mg (mg/l
Turbidity	1											
EC	**0.59**	1										
pH	-0.34	-0.60	1									
Alkalinity	0.37	-0.04	0.14	1								
Total hardness	0.21	0.86	-0.54	0.01	1							
Ca	0.24	**0.80**	-0.39	0.107	**0.962**	1						
Cl	0.33	**0.92**	-0.62	-0.396	**0.841**	**0.75**	1					
NO_3	0.24	0.08	-0.01	0.578	0.271	0.48	-0.09	1				
Iron	**0.99**	**0.60**	-0.36	0.353	0.222	0.24	0.34	0.22	1			
Fl	**0.91**	0.53	-0.43	**0.600**	0.304	0.36	0.22	**0.54**	**0.90**	1		
PO_4	-0.241	-0.32	**0.66**	-0.475	-0.369	-0.21	-0.15	-0.03	-0.25	-0.43	1	
Mg	-0.183	0.03	-0.4	-0.360	-0.063	-0.33	0.16	-0.841	-0.160	-0.31	-0.47	1

Results and discussion

The physico-chemical analysis carried out for the different sites has been presented in (Fig.1). Turbidity is one of the foremost parameter for the acceptability of drinking water quality. Turbidity depends on a number of factors such as the size, shape, and refractive index of the clay, colloidal particles and the micro-organisms[15] . Concerned to different water samples; station 5 showed quite high range while remaining all water samples showed satisfactory level. WHO, guidelines for turbidity are < 5 NTU. The observed values of water samples varied from 0 to 78 NTU. The consumption of high turbid water would be a health risk due to microorganism[16] .

The total dissolved solids (TDS) consist mainly of bicarbonate, carbonate, sulphate, chloride, nitrates and other substance. The TDS ranged from 448 to 1183mg/l in the sampling sites. The desirable limit of TDS is 500mg/l[17] .The huge amount of dissolved solids present in the water is a consideration for its suitability for domestic use only and not for drinking purpose [15] . Electrical conductivity is a measure of water capability to transmit electric current and also it is a tool to assess the purity of water. Electrical conductivity ranged from 640 to 1691micS/cm. The EC ranged 300 to 1200 µmhos/cm in the drinking water samples Khed industrial areas[15] .

The determination of pH in water is very important as it plays a role in the growth of flora and fauna of the aquatic body and also indicates whether the water is safe for drinking and irrigation purpose[18] . The pH did not show remarkable differences between sampling sites except station S1(6.1). The range for pH in water for domestic use is 6.5 to 8.5[17] . The value of alkalinity provides an idea of natural salts present in water. In the present investigation alkalinity ranged from72 to 328 mg/l. Concerned to different water samples ; station 3,4,5 and 6 showed concentration above permissible limit by ISI (200mg/l). High range was found in monsoon season [15]. Alkalinity is itself not harmful to human beings [19] . Hardness in water is due to natural accumulation of salts from contact with soil and geological formation or it may enter from direct

pollution by human activities[15] . In the present study hardness ranged from 100 to 750mg/l. The water is soft when the range of hardness is in between 0-69mg/l, and it is considered medium when it ranges from 70- 120 mg/l, the range from 120- 180mg/l is considered hard, when it is above 181mg/l it is considered very hard and when it is above 300mg/l it causes adverse effect on domestic use[18] . In the selected station S2, 4 and 6 is considered to be hard, S5 is considered to be very hard and S1 and 3 is considered to cause adverse effect on domestic.

The suitability of water resources for the drinking and irrigational use in agriculture is depending upon salt concentration, especially chloride content[18] . Chloride usually occurs as NaCl, $CaCl_2$ and $MgCl_2$ in widely varying concentrations, in all natural waters. They enter water by solvent action of water on salts present in the soil, from polluting material like sewage and trade wastes. Chlorides when reaches concentration above 250mg/l; imparts an unacceptable taste to waters although no adverse effect have been observed on human beings regularly consuming water with much higher concentrations of chloride[20] . Station S2, 4 and 6 had the chloride content within the permissible limit of WHO. In the present investigation, the chloride content ranged from 28 to 448 mg/L. Sample1 had the chloride content above the permissible limit. Nitrate is an effective plant nutrient and is moderately toxic. Nitrate concentration in the study sites ranges from 0 to 10 mg/l. Values were well below (50mg/l) the WHO permissible limits of nitrate in drinking water. Iron is an essential element in human nutrition. Iron in ground water is normally present in the ferrous or bivalent form (Fe^{++}). It is a rare element required by both plants and animal. Iron in water may be present in varying qualities depending upon the geological area and other chemical component of the water way. Iron is an essential element in human nutrition[21] . In the samples S2, S3, S4 and S6 iron content were lower than (0.3mg/l) recommended by WHO[17] . Station 1(0.8) and 5(6.78) mg/l had iron content above the permissible limit declared by WHO.

The fluoride concentration was very low in all drinking water samples except S6 (1mg/l)[22] . The fluoride content ranged from 0.1 to 1mg/l. A limit of 1 mg/L has been prescribed by WHO[17] . Epidemiological evidences imply that fluoride concentrations in excess of 1.0 mg/l carry an increased risk of dental fluorosis and progressively higher concentrations (>1.5 mg/l) lead to increased risk of skeletal fluorosis [23] . The concentration of phosphate in groundwater is usually low, but various chemical processes in soil strata may induce the mobility of phosphate in subsoil and ground water[24]. The values ranged between (0.02 – 0.51 mg/l) in the present study. All the values were within the (0.5mg/l) WHO [17] permissible limit except S2.

Bacteriological studies showed that station 1,3, 4 and 5 showed infinite number of feacal coliform colonies in the water sample. This may be due to the leakage of septic tanks. Faecal coliform exceeding the limit indicates recent contamination of the water sources with faecal matter and hence the possible presence of intestinal pathogens [25] . All the three samples taken from bore well were contaminated with fecal coliform bacteria when compared to open well. The station 2 and 6 showed the bacterial count of 150 and 70 per 100ml respectively. According to WHO[10] *E. coli* or *Faecal coliform* should not be present in drinking water. Poor sanitary practices could be one of the main causes of indicator bacteria from faeces being introduced into stored water [25] .

The correlation co-efficient between various physicochemical parameters were calculated and presented in the Table 2. An appreciable significant negative correlation have been recorded for pH verses EC, alkalinity verses EC, total hardness verses pH, chloride verses pH, magnesium verses nitrate. A significant positive correlation have been recorded for EC verses turbidity, calcium verses EC and total hardness, chloride verses EC, total hardness and calcium, iron verses turbidity, EC, fluoride verses turbidity, alkalinity, nitrate, iron and phosphate verses pH.

Conclusion

Water samples were not in agreement with the WHO guideline on the basis of their physicochemical characteristics like EC, alkalinity, total hardness, iron and fluoride. The concerned authorities should take steps to monitor the quality of drinking water used by the people to ensure their health.

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