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Assessment of drinking water quality in government schools in Virudhunagar District, Tamil Nadu, India

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***Abstract*---**Objective: The main objective of this study is to assess the quality of drinking water in hysical, chemical and bacterial aspects in government schools of Virudhunagar district, Tamil Nadu, India. Methods: The water samples appearance, colour, odour, turbidity, total dissolved solids, electrical conductivity, pH, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, iron, nitrate, chloride, fluoride, sulfate, phosphate and coliform bacteria were analysed using standard methods used by American Public Health Association and compared with standards of World Health Organization. Results: Of the 20 physico-chemical and microbiological parameters studied only three parameters which include a physical total dissolved solids 1148mg/l and two chemical parameters total hardness 558mg/l and chloride 366mg/l of school no.3 were above the guideline value of WHO. Conclusion: To recapitulate, in addition, these three parameters were based on taste consideration rather than health. There is no coliform bacteria were found in the drinking water. All the seven drinking water sampled at the government schools were safe during the study. Continuous monitoring of drinking water in all the schools is proposed to avoid undesirable water borne diseases and maintaining students' health.

***Keywords*---**water quality, physico-chemical factors, bacteria, hardness, total dissolved solids.

I. Introduction

Water is quintessential nutrient and principal chemical constituent of the body [1,2]. This vital nutrient water, present in each cell of our body and in various tissues and compartments and acts as a building material. As a carrier it transports nutrients and removes waste from the cells. Water acts as thermoregulation by evaporation of water from the skin through sweating. Water

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combined with other viscous molecules, forms lubricating fluids for joints, saliva, gastric and intestinal mucous secretion in the digestive system. Furthermore, apart from lubrication they maintain cellular shape and acts as shock absorber when performing exercise. In addition, amniotic sac or bag of water which is filled with amniotic fluid is chiefly contains water and act as cushion for fetus [3,2].

Many factors are responsible for the amount of water intake, including the amount of solids in the diet, air humidity, temperature, type of clothing worn, exercise performed, respiratory rate, health of individuals and during pregnancy and lactation [3,4]. In this regard, a daily water intake of 2.5 of water is required for an adult in a normal environment [3]. The body obtains water from other than drinking water includes beverages, foods and small amount from metabolic breakdown of food [5,3]. Water deficiency causes harmful effects to the body the outcome of water deficiency is dehydration. In general dehydration can be defined as loss of 1 % or more loss of body weight as a result of fluid loss from the body [5]. Water consumption negatively effect on urinary stone disease, cancers in breast, colon, and urinary tract, childhood and adolescent obesity, mitral valve prolapsed, salivary gland function, overall health in elderly stage [5]. Diarrhoeal diseases attributed to poor water supply, sanitation and hygiene account for 1.73 million deaths each year. Other diseases such as trachoma, schistosomiasis, ascariasis, trichuriasis, hookworm disease, malaria and Japanese encephalitis contribute to an additional burden of disease [6].

The quality of water is of vital importance for mankind and it is associated with human welfare. A good knowledge of the physico-chemical and microbiological qualities of water is necessary so as to guide its suitability for use. Thus, the present research work was conducted to assess the physical, chemical and microbiological aspects of water in the seven select government schools of Viruthunagar District.

II. Materials and Methods

Viruthunagar District is located in the south-western part of Tamil Nadu bounded by Ramanathapuram district in the east, Kerala in the west, Madurai and Theni district in the north, Sivagangai district in the northeast and Tirunelveli and Thoothukudi in the south. The district spread over 4283 sq.km and lies between 9°12'N to 9°47'N Latitude and 77°23'E to 78°25'E.

Collection of water samples

The water samples from the schools were collected using clean and sterlized plastic containers of two litre volumes for the estimation of water quality parameters. The collected water samples were taken immediately to analyse the physical, chemical parameters and microbial growth in the laboratory.

Methods

Physico-chemical characteristics such as colour (TCU), turbidity, total dissolved solids, electrical conductivity, pH, alkalinity, total hardness, calcium, magnesium, sodium, potassium, iron, nitrate, chloride, fluoride, sulfate and phosphate were estimated using standard methods of [7]. In addition, Microbial aspects total coliform group estimated using Multiple tube fermentation technique of [7].

III. Results and Discussion

The present study was conducted in seven different schools which are numerically names as school no.1 to school no.7 in Viruthunagar district of Tamil Nadu. A total of 20 parameters *viz.* appearance, colour, odour, turbidity, total dissolved solids, electrical conductivity, pH, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, iron, nitrate, chloride, fluoride, sulfate, phosphate and coliform bacteria were studied.

Appearance
The collections of samples from all the seven school during the study appeared very clear, transparent and without any visible particles (Table 1).

Colour
Generally, water is colourless however due to presence of coloured organic matter, metals such as iron and manganese may imparts colour to the drinking water [8]. Since all of the water cannot be ascertained accurately on the spot, most consumer rely on visual sense before consuming water, and inspects water for its transparency. The presence of algal flora in water discernible as green colour, excess of slit in brownish, organic matter and iron imparts a yellow hue to the water [9]. [8] recommended 15 true colour units (TCU) for drinking water. However, in the present analysis all the samples collected from the seven schools were colourless (Table 1).

Odour
Taste of drinking water too relies upon the impurities in water and linked with the odour [9]. Next to colour, consumption of water evaluated by smell and taste. Consumer relies on the olfactory sense for water consumption of water. Generally, municipal water chlorinated waters with phenol traces give very strong chlorophenol odour. In the present investigation all the seven school water samples were without smell (Table 1).

Turbidity
It is one of the water quality control methods. Turbidity in natural waters is caused by suspended matter like clay, slit, organic matter, phytoplankton and other microscopic organisms. This method is based on a comparison of the intensity of light scattered by the sample water. Scattering of light is dependent upon the size, shape, and refractive index of such particles [9]. High levels of turbidity can protect microorganisms from the effects of disinfection and can stimulate the growth of bacteria [8]. Turbidity makes the water unfit for domestic purposes, food and beverage industries, and many other industrial uses. In our samples the turbidity ranged from 0-1 NTU (Nephelometric Turbidity Units). All the samples were ranged between 0 to 1 NTU. Two samples school 5 and school 7 had only 0 (below detectable level). Among the samples school 3 had 1NTU and less than that school 6 (0.4 NTU), 4 (0.5 NTU), 1 (0.7 NTU) and school 2 (Table 1). all the samples were within the permissible value of 5 NTU [8].

Total Dissolved Solids
Water has property dissolve an array of inorganic and some organic minerals or salts [10]. Total dissolved solids in water are due to inorganic substances [8]

soluble materials [9]. They impart un-wanted taste and diluted color in appearance of water [10]. Based on taste consideration WHO recommend 1000mg/l also less than 600 taste generally considered good. The present study the TDS wavered from 22mg/l to 1148mg/l. The higher value of total dissolved solids found in school no. 3 (1148mg/l) and lower value found in school no. 7 (22mg/l) (Table 1). School no.3 had higher TDS were above the recommended value of WHO.

Electrical Conductivity

The ability of water to conduct an electric current is called electrical conductivity of water. The units of measurements denoted as µS/cm (Microsiemens Per Centimeter). There are positively charged ions as well as negatively charged ions. In addition, ions such as nitrates and phosphates are biologically important, they are being minor contributors to conductivity. Pure water is not a good conductor of electricity since electrical current is transported through with the rise of concentration ions. Hence, conductivity increases as water dissolves more ionic species. Solutions of most inorganic compounds are relatively behaved as good conductors reciprocally organic compounds conduct a current very poorly [7]. [11] pointed out that electrical conductivity had significant correlation with ten parameters such as temperature, pH, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, chloride and iron concentration of water. Hitherto, no guideline value was recommended by health organisations [12]. The electrical conductivity in the water samples of the schools analysed during the study period has been found to be fluctuating between 31 and 1640 µs/cm (Table 1). The EC were noted to be higher in school no.3 (1640 µs/cm) and lower in sample no.7 (31 µs/cm).

pH

pH of water refers to hydrogen ion concentration. The pH value range between 0 and 14 and the mean value 7 considered neutral less than and more than 7 acidic and basic in property respectively. Based on the pH value the solution is termed acidic or alkaline. The guideline value set by WHO [8] is between 6.5 and 8.5. However, no health-based guideline was promised by [13]. However, a less than 4 and more than 8.5 produces sour and alkaline taste. Lower value below 4 will produce sour taste; and a higher value above 8.5, an alkaline taste [9]. During the present study pH of the water samples ranged from 6.8 to 8.2. This indicates except School 7 rest of the water samples were alkaline during the study period (Table 1). However, all the water samples were within the guideline value proposed by WHO.

Total Alkalinity

Alkalinity is standard method for water quality measurements. Alkalinity is the presence of one or more ions in water including hydroxides, carbonates and bicarbonates [10]. The WHO standards tell the alkalinity only in terms of total dissolved solids (TDS) of 500 mg/l is good. However, above recommended level may cause unpalatable to human and cause scaling of water pipes. Total alkalinity of the samples ranged from 7-275 mg/l. These values were under the permissible limit of WHO standards (Table 1).

Total Hardness
The hardness of water is caused chiefly by calcium and to a lesser extent magnesium, and is often expressed as the equivalent quantity of calcium carbonate [8]. Temporary hardness (bicarbonates of calcium and magnesium) of water by mere boiling precipitated as normal carbonates by the loss of carbondioxide and leftover remains after boiling is permanent hardness due to the presence of sulfates, chlorides and nitrates of calcium and magnesium [9]. In the present investigation hardness of water samples followed similar pattern like alkalinity. The maximum hardness recorded n school no.3 (558mg/l) and minimum 6 mg/l (Table 1). According to [8] guideline value for hardness at 500 mg/l (as CaC03) is based on taste. Only school No.3 had the alkalinity slightly above the guideline value of WHO.

Calcium
Calcium is necessary in plant and animal nutrition and is a fundamental component of bones, shells, and plant structures. Calcium is fifth most abundant element 4.9 % on the earth crust [7]. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may cause rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases [10]. [13] elucidate that the drinking-water can be a contributor to calcium and magnesium intake and could be important for those who are marginal for calcium and magnesium. The hardness of drinking water is largely contributed by calcium and magnesium [8,14]. Therefore, calcium is one of the contributors to hardness separate guideline value was not recommended by WHO. In the present experiment, highest calcium content was recorded in school no. 3 (137mg/l) followed by school no.2, school no.1, school no.4, school no.6, school no.5 and finally school no.7 had 2 mg/l (Table 1).

Magnesium
The element occurs in most of the water along with calcium at lower ratio. They found in average abundance of 2.1 % in earth crust, in soil 0.03 to 0.84% in streams 4 mg/l and water bodies 5 mg/l [7]. It is an essential for proper functioning of living organisms and non-toxic at the concentrations generally met with in natural waters [10,9]. [15] recommends dietary intake of 350 mg/day magnesium for adult human beings. [14] stated that the decreased risk for cardiovascular disease has been related particularly high levels of magnesium in drinking water. Like calcium, magnesium is another contributor to hardness of water so separate value for magnesium not recommended by WHO. The magnesium value ranged 0 to 51mg/l. The maximum and minimum value recorded in school no. 3 and school no.7 respectively (Table 1).

Sodium
Sodium element is about occupies 2.5% earth crust and found in soil 0.02 to 0.62. In ground and stream water it is 5mg and 6.3mg per liter [7]. Sodium compounds are used in many applications, including caustic soda, salt, fertilizers, and water treatment chemicals. [10] stated that proper quantity of sodium in human body prevents many diseases like kidney damages, hypertension, headache etc. Soil permeability can be decreased due to high sodium ratio. Sodium salts in the form of sodium chloride are found in daily intake of foods and in drinking water. Hitherto, permissible limit has not been

proposed yet when it exceeds more than 200mg/l may change the palatability of food and water [13]. In the present investigation the highest sodium value measured in school no. 3 (148 mg/l) and lowest in school no.7 (3mg/l) during the study period (Table 1).

Potassium

Potassium or Kallium (in latin) is essential for living organisms and plants. Earth crust composed of about 1.84% and in soil sample ranged from 0.1 to 2.6 %. Likewise, in streams it is 2.3mg/l and ground water ranged from 0.5 to 10 mg/l [7]. About 110 to 140 grams of potassium found in the human body [10]and functions like heart protection, regulation of blood pressure, protein dissolution, muscle contraction, nerve stimulus are regulated. According to [13] potassium found in drinking-water at concentrations well below those of health concern. The recommended daily requirement is greater than 3000 mg [13]. Potassium values ranged from 1 to 13 mg/l. Repetition of values 5mg/l was found in three schools followed by 1mg/l in school no. 5 and no. 7. whereas, highest value of 13mg/l was observed in school no. 3 (Table 1).

Iron

Anaerobic groundwater may contain ferrous iron at concentrations up to several milligrams per litre without discoloration or turbidity in the water when directly pumped from a well. When it is exposed to atmosphere, however, the ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown colour to the water [13]. In addition, Iron also promotes the growth of iron bacteria, which oxidizes ferrous iron to ferric iron and in the process deposit a slimy coating on the piping. These iron bacteria in open undisturbed water bodies and in condition devoid of dissolved oxygen produce iridescent film or scum [16]. The permissible limit set for iron 0.3mg/l by [8]. At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures. There is usually no noticeable taste at iron concentrations below 0.3 mg/l, although turbidity and colour may develop. The iron content of water samples varied from 0 to 0.13mg/l. Highest dissolved iron was found in school no.3 (0.13mg/l) followed by school no.2 (0.07 mg/l), school no1 & no.6 had similar values of 0.06 mg/l, school no.4 (Table 1). Two samples of school no. 5 and no. 7 iron content was nil. These iron contents of water samples were within the permissible limits of WHO standards.

Nitrate

Nitrate is found naturally in the environment and is an important plant nutrient. It is present at varying concentrations in all plants and is a part of the nitrogen cycle. Nitrate can reach both surface water and groundwater as a result of agricultural activity (by means of fertilizers and manures) and anthropogenic activities [`17, 13]. In surface water nitrate can change surface runoff fertilizer, exploitation by phytoplankton and denitrification bacteria whereas ground water concentration shows comparatively slow and low. Although, nitrate is available form of dissolved nitrogen in groundwater. However, it can also be in the form of nitrite, nitrogen, nitrogen oxide and organic nitrogen. It is possible to examine the toxicological effects of nitrate in three stages. The toxicological effects of nitrogen have been addressed by [17]. When it exceeds 50 mg/l cause inflammation in digestive and urinary system. Nitrate a naturally available ion which are part of nitrogen cycle and important plant nutrient. Industrial waste and nitrogenous fertilizers are the known sources of nitrogen. Drinking-water can make a significant contribution to nitrate intake [13]. The WHO fixed 10mg/l as maximum permissible limit [8]. Nitrate content was found in all the water samples from the schools. Maximum of 9 mg/l in school no.3 and minimum of 1mg/l in school no. 5 (Table 1). The results indicate that the quantity of Nitrate within the permissible limit of WHO standards.

Chloride

Chlorides are the inorganic compound resulting from the combination of the chlorine gas with metal. Chlorine alone as highly toxic, and it is often used a disinfectant. According to [13] chloride should not be more than 250mg/l in drinking water. Environmental impact of chlorides are not affecting human health whereas the sodium part of the table salt has been linked to heart and kidney diseases [12,9] stated that chloride is harmless up to 1500 mg/l concentration but produces a salty taste over 250mg/l. [8] 250mg/l was set as guideline value for chloride content in water. Concentration above the limit can be detected by taste, frequent consumption consumer get accustomed to even low levels of chloride induced taste. Highest of 366 mg/l was detected in school no.3 followed by school no. 4 (49mg/l) , no1(40mg/l), no2 (38 mg/l), no.6 (36mg/l), no.5 (11mg/l) and no 7 (4 mg/l). Except school no.3 all the school drinking water were within the standards of WHO.

Fluoride

Fluoride is common element available in earth crust. They found in all water with its highest concentration in ground waters. Due to continuous erosion in the mountains fluoride is removed and transferred to lower plateau through streams and river to the sea. Owing to the reason, high mountain areas are low fluoride and sea being the high fluoride content. In addition, foot of high mountains hills and in areas with geological deposits of marine origin usually high fluoride content were observed in many parts of the world India is not an exception [18]. Fluoride is absorbed by vegetation from soil and water. For protection against dental caries some countries add fluoride with water or table salt. [13] recommend 1.5mg/l as guideline value in drinking water. The fluoride content of the water samples from various schools ranged between 0.2mg/l to 0.8mg/l. Highest fluoride content was in school no.3. Two schools no. 1 & 2 had similar value of 0.6mg/l. Similarly, 0.4 mg/l was observed in school no. 4 & no.6. Lowest of 0.2mg/l was observed in school no. 7. All the samples were within the limit of WHO standards.

Sulfate

Sulfate is widely distributed in natural waters in concentrations ranging from a few to several thousand milligrams per liter. According to [13] no health-based guideline is proposed for sulfate. However, the presence of sulfate in drinking-water may also cause noticeable taste and may contribute to the corrosion of distribution systems. In generally, considered that taste impairment is minimal at levels below 250 mg/l. Biological oxidation of reduced sulfur species to sulfate also increases its concentration [9]. In the present study none of the drinking water reached the maximum level of 150 mg/l all the samples were less than 50mg/l. Sulfates have little effect on taste. [8] reported 400mg/l based on the taste consideration. However no major negative impact on human beings have been reported [10]. Highest sulfate content was found in school no.3 (101mg/l) followed by same value of 30mg/l in school no. 2, no. 4 & no.6. then 27mg/l in school no.1, 5mg/l in school no. 5 and 2mg/l in school no 7. It clearly indicates that none of the samples were harmful and all the samples were within WHO standards.

Phosphate

Phosphorus occurs in natural waters and waste waters in the form of various phosphates. Phosphorus is essential for the growth of plants and animals. Surface waters seldom contain high concentration of phosphates and they are exploited by plants likewise ground water also contain considerable amount of phosphate. Rainfall washes the phosphate from the soil into nearby waterways. Phosphates are not considered as toxic to human or animals. However, excess extremely high level of phosphate digestive problem could occur [12]. Out of seven schools only five samples had phosphate content detected value ranged from 0.04mg/l to 0.11mg/l. Hitherto, there is no guideline value proposed by WHO.

20 Coliform Bacteria

Microorganisms will normally grow in water and on surfaces in contact with water as biofilms [19]. The microbiological aspects is of primary importance and must never be neglected or compromised. Ideally drinking water should be free from any microorganisms known to be pathogenic. For microbial aspects of studies coliform group of organisms are the known bacterial indicator for the drinking water. The term coliform organisms (total coliforms) refers to rod-shaped, non-spore forming, gram-negative bacteria that develop colonies with distinctive characteristics on specific media and capable of ferment lactose at 35°C to 37°C within 24hours ([8,7]. The bacteria which have the same properties as coliforms even at the temperature 44 or 44.5°C thermo tolerant features are called faecal coliform organisms they ferment lactose and other suitable substrate which also form indole from tryptophan are presumably *Escherichia coli* [8]. These bacteria are distributed globally in large numbers in the excreta of warm-blooded animals. There are laboratory methods are available for the confirmation of *E.coli* [7]. Presence of *E.coli* provides evidence of faecal pollution in water and beverages. Some of the coliforms are part of natural bacterial flora in water and proliferate in biofilms. So, coliform bacteria are used as indicators of general microbial quality [19]. In the present study all the samples from the seven schools no coliform bacteria was detected during the study.

Table 1. Physico-chemical and microbiological parameters of government schools in Virudhunagar district, Tamil Nadu, India

Parameters	School No.1	School No.2	School No.3	School No.4	School No.5	School No.6	School No.7
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour (TCU)	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless
Odour	None	None	None	None	None	None	None
Turbidity (NTU)	0.7	0.8	1	0.5	0	0.4	0
TDS (mg/l)	478	485	1148	361	62	361	22
EC (µS/cm)	683	693	1640	516	88	516	31

pH	7.7	7.9	8	8.2	7.9	7.6	6.8
Alkalinity (mg/l)	250	275	267	174	25	186	7
Hardness (mg/l)	263	275	558	168	30	145	6
Calcium (mg/l)	63	65	137	16	3	14	2
Magnesium (mg/l)	25	27	51	16	3	14	0
Sodium (mg/l)	48	43	148	45	6	53	3
Potassium (mg/l)	5	5	13	5	1	6	1
Iron (mg/l)	0.06	0.07	0.13	0.05	0	0.06	0
Nitrate (mg/l)	5	5	9	4	1	5	4
Chloride (mg/l)	40	38	366	49	11	36	4
Fluoride (mg/l)	0.6	0.6	0.8	0.4	0.2	0.4	0.2
Sulfate (mg/l)	27	30	101	30	5	30	2
Phosphate (mg/l)	0.04	0.04	0.11	0.04	0	0.04	0
Coliform	Nil	Nil	Nil	Nil	Nil	Nil	Nil

IV. Conclusion

To recapitulate, the present study evaluated of physical, chemical and microbiological properties of seven schools from Viruthunagar District was studied. There are 20 parameters include appearance, colour, odour, turbidity, total dissolved solids, electrical conductivity, pH, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, iron, nitrate, chloride, fluoride, sulfate, phosphate and coliform bacteria. Most of the parameters were within the permissible limits of WHO standards. Only three parameters total dissolved solids 1148mg/l. total hardness 558mg/l and chloride 366mg/l were above the standards of WHO. Although, these parameters guideline values were set based only on the basis of taste consideration. No coliform bacteria were recorded during the study period. Overall appearance, colour and odour were good during the present study.

Monitoring the drinking water quality is essential for determination of current status of hydrological condition of water. This will help us to avoid pollution, contamination and undesirable diseases. The awareness campaign of waterborne diseases and importance of safe water for human health should be commenced in schools. Protecting natural resources of water and checking for standards is generally good for human beings and domestic and wildlife.

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