EVALUATION OF DRINKING WATER QUALITY OF SELECTED TUBE AND OPEN WELL WATER FROM THE RURAL AREAS OF ERODE, PERIYAR DISTRICT.

By

J. REVATHI
Reg. No. 92PLS07

A THESIS SUBMITTED TO
THE AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN (DEEMED UNIVERSITY) COIMBATORE-641 043
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN LIFE SCIENCES.

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CERTIFIED AS BONAFIDE RESEARCH WORK.

26/4/94	25/4/94	
Signature of the Head of the Department	Signature of the Dean of the Faculty	Signature of the Guide

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Introduction

INTRODUCTION

Water plays an important role in fulfilling human needs. Water is basically used for their drinking purpose. Clean drinking water is an essential human requisite for the sustenance of life.

Drinking water must be of good quality and does not contain any impurities and disease causing micro-organisms. It is however, not essential to have physically or chemically pure water. The presence of some minerals in water is required to give some taste to water and they also assist in food assimilation (Rangwala, 1984).

The vast majority of the population in urban areas take drinking water, piped from central sources such as municipal treatment plants. Water from such municipal treatment plants is of good quality and does not contain any impurities and disease causing organisms.

Most of the people living in rural areas are not accessible to drinking water from the treatment plants.So they take water for drinking purpose only from the natural water resources.

Water resources may occur in two forms such as

i. surface water and

ii. ground water resources

Surface water resource includes river, lake, stream and pond etc. Most of these resources may be polluted by the discharge of untreated industrial effluents into the body of them. Water is used as a cooling agent in thermal power stations and the resultant heated water is discharged into the surface water systems leading to thermal pollution.

All industrial, municipal and agricultural developments lead to the contamination of surface water systems. This impairs the quality of water and its suitability for domestic and industrial use.

Ground water is extremely used as a source of potable water since

i. In some areas, surface water supplies are insufficient, unavailable or require extensive purification and treatment and

ii. Ground water is almost an unstinted source of water and is superior to surface water because or low contamination of free from enteric pathogens.

Wells and springs are the two ground water resources (Fair *et al*. 1960), but it is generally available in the form of wells. There are two kinds of wells; shallow and deep. Majority of wells in India are of shallow type and cause health hazard to the community if they are not made sanitary.

Wells may also be classified on the basis of their construction into dug wells and tube wells. Dug wells are generally more than 2ft in diameter and not over 50 ft in depth. Bored and drilled wells are generally used in hard ground and rock and may be sunk to the depths measuring hundreds and even thousands. Tube wells are successful sources of drinking water in many parts of India.

Though the ground water is considered as free of pathogens since it is protected by impervious strata, this protection is frequently not available and it is becoming polluted with increasing frequency and this polluted water is a source of numerous diseases.

Pollution of the water resources is a significant and rapidly increasing threat to health, well-being and prosperity of the people, and to the quality of the environment (Emmanuel Somers, 1977). Faulty waste disposal practices endanger ground water quality (Lokohman, 1979).

Pollution of the ground water by seepage from sewerlines and industrial effluents may increase the concentration of organic, inorganic and toxic materials.

Nitrate concetration in drinking water is considered important for its adverse health effects.Nitrates are reported to be the most common cause of ground water degradation in many regions of the world (El - Hinnawi and Hashmi, 1987). Higher concentration of nitrates in drinking water may cause methaemoglobinaemia in infants. (Ozha et al. 1993). Presence of higher concentration of fluoride in drinking water leads to fluorosis.

Several epidemiologial studies have evaluated the possibility of a link between drinking water contamination and cancer in human populations (Cantor et al. 1985).

Contamination of drinking water leads to the introduction of micro-organisms which may cause water related or water borne diseases such as cholera, salmonellosis, shigellosis, Infectious hepatitis, Gastroenteritis and Amoebic dysentry. Micro organisms present in drinking water includes Vibrio comma, Salmonella, Shigella etc. The common indicator of microbial pollution are Coliform, Faecal coliform. E.coli, Faecalstreptococci, Closteridium, Pseudomonas aeruginosa, Lactobacillus etc.

Among these, Faecal coliforms and E.coli correlate better with faecal contamination in water (Geldreich , 1978 ; Feng and Hartman , 1982).

Reports on these water borne disease outbreaks show that contaminated ground water supplies were responsible for 50 % of the outbreaks (Crawn and Mc Cabe, 1973).

With the multiplicity of uses of water resources and the increasing threat of pollution, it comes as no surprise that several areas of government are involved in establishing criteria and recommanding standards, for drinking water.

The standard prescribes the requirement for the essential and desirable characteristics required to be tested for ascertaining the suitability of water for drinking purposes. The presence of organic and inorganic chemicals in drinking water above the prescribed limits may create health hazards.

Hence, the present investigation is taken to evaluate the drinking water quality of selected tube and open well water from the rural areas of Erode.

Review of Literature

REVIEW OF LITERATURE

Our forebears probably learned by experience which springs or streams were suitable for drinking purposes. In some parts of the world today a source of water of any kind may be attractive if there is no alternative and the need is great. However, in our civilized society potable water of an acceptable and reliable quality is demanded as a right. Though majority of surface waters require some form of treatment before they are considered as attractive and acceptable to the population, some sources of water, particularly those from underground sources may be suitable for direct consumption without treatment. Hence several attempts were made to study the quality of well water and its suitability for drinking purposes.

For the present study, the available literature was reviewed under the following heads.

i. Studies on physico-chemical quality
ii. Studies on bacteriological quality

i. Studies on physico-chemical quality.

Olaniya et al. (1969) studied the quality of ground water in Jaipur city and found that except a few cases, in the majority, alkalinity, hardness, chloride, sulphate and total dissolved solids were present within the limit recommended for drinking water. Phirke et al. (1969) reported that water from majority of the hand pumps from Delhi contained chemical substances within the limits of tolerance.

Sivakumar and Ramamoorthy (1977) stated that the well waters in Madurai had pH within the admissible range, total solids exceeding the permissible limit, hardness higher than 300 mgl^{-1} and chloride content in the range from 200 to 400 mgl^{-1} Madurai waters are probably getting their chlorides from septic tank effluents or seepage from sewage channels or from garbage and solid waste dumps.

Olaniya et al. (1978) reported that sewage along with mineral water percolates through soil strata and increases the total dissolved solids, organic matter and bacterial loads of the underground water sources. The pollution of the well water is generally related to distance of the well from sewage channel.

Studies on the quality of well water in Udaipur district showed that they were free of any chloride and sulphate. About 74% of the samples contained the chloride concentration less than 200 mgl^{-1} and 98.4% of the samples had less than 1000 mgl^{-1}. Sulphate was found less than 200

mgl^{-1} in 96% of the samples. The distribution of total dissolvd soild (TDS) was not uniform in this district (Gupta, 1981).

The effluents discharged from the tanneries located in North Arcot district have caused serious deterioration in the ground water quality and consequent reduction of quantity and quality of agricultural products. Moreover the chloride content also was high (601.8 mgl^{-1} to 3115 mgl^{-1}) far in excess than the maximum available concentration of 355 mgl^{-1} (Srinivas et al. (1984).

Brar et al. (1984) revealed that out of 315 well waters from Delhi, 60% of the water samples were found to be fit for drinking and 38% was marginal and 3.8 percent was unfit for even irrigation.

Hardness of the water reflects the nature of geological formations with which the water is in contact.Calcium present in water is mainly due to the passage of ground water through or over the deposits of limestone, delomite, gypsum and gypsiferrous materials (Manivasakam, 1985).

Handa (1986) studied the hydrogeo chemical zones in a few places in India and indicated that the chemical composition of ground water was affected by the use of fertilizers.

Ajmal and Raziuddin (1986) reported that pH and the electrical conductivity of hand pump samples from Aligarh ranged between 7.00 - 8.30 and 98.00 — 218.30 micro mhos cm^{-1} respectively. Most of the wells had very high amount of chloride exceeding the prescribed limit. The sulphate concentration was within the limit. The total hardness was also found to be above the prescribed limit. Total alkalinity reported was within the range of 200-356 mgl^{-1}

Ground water passing through any land fill exhibited a significant increase of total dissolved solids mainly due to increase of calicum, and sulphate concentrations. The leaching of soil nutrients into the groundwater system and the increased recharge due to irrigation have opposite effects on groundwater chemistry (Karnath, 1987)

According to Pitchai and Govindan (1988), the water quality of majority of the bore wells from Madras was found to be satisfactory. Deep bore wells situated in hard rock formations in general exhibited a much poorer water quality compared to those in sedimentary rock formations.

Gupta (1988) suggested that the calcium and sulphate ions showed negative correlation with water level, thus indicating lesser degree of penetration of pollutants at depths, in Udaipur district.

Patel and Tiwari (1989) found that the quality of tube well waters collected from Rourkela was somewhat better than that of dug-well water.

A higher nitrate-nitrogen concentration was reported in the groundwater under the irrigated coastal plain soils treated with poultry manure (Weil et al. 1990). Gangal and Zutshi (1990) reported that the ground water pollution is due to the seepage of industrial effluents.

A water quality study carried out by Naidu et al. (1990) in Tirupati and Tirumala showed that there was no significant variation in water quality with change in season.

The study carried out by Harish Chandra et al. (1991) in Allahabad city showed that the values of various parameters for drinking water samples from tubewells and hand pumps ranged between desirable and maximum permissible limits. A high level of Cd was found in some of the drinking water samples.

Pradhan and Tiwari (1991) studied the concentration of 10 trace metals in the groundwaters of Rourkela and found that they were much below the permissible limits for drinking water.

Study of groundwater pollution in and around Ujjain city showed that the degradation in groundwater quality is mainly due to disposal of industrial and municipal sewage waste (Patel, 1991).

Water samples from dug and tube wells near Noiyyal river in Tiruppur had the values of several parameters above the permissible limits for drinking water; being the impact of industrialisation and improper waste disposal. (Ramaswamy and Rajaguru, 1991).

Chemical analysis of groundwater samples from Nagaur district showed that fluoride and nitrate concentrations increased with increasing salinity. (Gupta, 1991).

Studies on the groundwater quality of South Madras revealed that there were a few locations where the groundwater was not suitable even for irrigation purposes (Elango et al. 1992).

Water samples from borewells and openwells located in the vicinity of sewage courses in Hubli city area had a high concentration of Na, Ca, Cl, TDS and total hardness; being the impact of sewage on groundwater quality. (Hedge et al. 1992).

Ozha et al.(1993) reported high concentration of nitrates in groundwaters of Churu and Barmer districts of

Rajasthan. Presence of nitrates in groundwater and its relationship with other physico-chemical constituents of water was studied in the Medchal Block of Andhra Pradesh by Vijay kumar et al. (1993).

ii. Studies on bacteriological quality.

Literature available on the bacterial quality of groundwater in India is limited.

Bacteriological quality of drinking water in rural India (79% of the sample)gave an appreciable limit on bacterial count (Battacharjee et al. 1989).

Srivatsava and Singh (1989) on Eastern Ghats (Karaput) implicated that among the 13 openwells, the coliforms were present in all samples, whereas in 12 wells faecal coliforms were present.

The main source of drinking water in Shrimpur Municipal Council area of Ahmednagar district of Maharashtra State (India) is borewell water. The bacteriological survey showed that 38.35% of borewell samples were found contaminated with faecal coliforms, 18.68% were positive for E.Coli (Vaidha et al., 1990).

Chatterjee (1992) reported the presence of faecal coliforms in surface water systems.

Bacteriological analysis of 44 hand pump water samples from gastroenteritis affected areas showed that 16.2% hand pumps were contaminated with 10 coliforms per 100 ml. (Pathak et al. 1993).

With this background, the present investigation attempts to evaluate the drinking water quality of selected tube and open well water from the rural areas of Erode, Periyar district.

Methodology

MATERIALS AND METHODS

For the present study, 3 samples of water were collected from the following sources in the three villages of Erode, Periyar district, Tamil Nadu, during December 1993.

1. Bore well - Karukkampalayam (Fig. 1)
2. Open well - Subbarayavalasu (Fig. 2)
3. Bore well - Lakkapuram, Modakkurichi Main Road. (Fig. 3)

Collection of water samples

For purpose of uniformity, the samples were collected between 4 and 5 p.m. and were analysed in the laboratory.

i. Water for physico-chemical analysis

The samples were collected in a new, hard, white and first quality jerry cans of 2.5 litres capacity. Water was drawn in the cans after carefully rinsing them 3 or 4 times with the water to be sampled.

Water from the tap, pumped from the borewell was collected after opening the tap fully and allowing the water to run to waste for atleast two minutes in order to flush the interior of the nozzle and to discharge the stagnant water in the service pipe. Similarly sample from the open well was collected after wasting the first few buckets of water. Then water was drawn into the jerry can leaving some air space. Cans were closed properly and labelled giving the details of source and date of collection. Then they were brought to the laboratory to carry out the physico-chemical analysis.

2. **Water for iron test**

Water was collected in a small glass stoppered bottle containing α-α Bipyridyl solution to prevent the oxidation of ferrous iron to ferric state. Water was taken only upto the neck of the bottle without allowing overflow.

3. **Water for bacteriological analysis**

Stoppered glass bottles were fully wrapped in paper, sterilized and used for collecting water samples. After reaching the sampling station, the upper part of the wrapper just below the neck portion was cut around and removed along with the stopper. Water was drawn into the bottles following the same procedure used for the collection of water for physico-chemical analysis. After the collection of the sample, bottles were stoppered along with the original wrapper. The wrapper was tied around the neck of the bottle. Then the bottles were labelled clearly on the wrapper on its lower portion and were brought to the laboratory in a box with plenty of ice.

Preservation of water samples

For physico-chemical analysis, the water samples were stored at room temperature and for bacteriological analysis they were stored at 4° c.

In order to ascertain the quality of water, the water samples were subjected to various tests. These tests were categorised as

I. Physical test

II. Chemical test

III. Bacteriological test

The analysis were carried out based on "Standard methods of American Public Health Association" (1980).

I. Physical Test

Colour

The colour of the sample was visually observed

Odour

The odour of the sample was noted by directly smelling the sample.

Turbidity

The turbidity was estimated with the help of Jackson candle method and was presented as number of Jackson turbidity units.

Temperature

Temperature was measured at the sampling station itself, using mercury filled centigrade thermometer (0 to 50° c). The readings were made by dipping the thermomter in water for 2 minutes before constant readings were obtained.

II. Chemical Test

Hydrogen ion concentration

A direct reading pH meter was used.

Conductivity

Electrical conductivity was estimated by a direct reading conductivity meter, and was presented in micromhos/cm (reciprocal megaohms/cm^3).

Estimation of total solids

A known volume (250ml) of the sample was taken in a preweighed silica crucible and the sample was evaporated to dryness using a water bath. After complete evaporation the final weight of the crucible was taken. The total solids present in the sample was calculated by using the formula.

$$\text{Total solids (mg/l)} = \frac{\text{(Final - Initial) weight of crucible} \times 1000}{\text{Volume of the sample}}$$

Estimation of alkalinity

Phenolphthalein alkalinity was estimated with the help of a titrating method against 0.02N sulphuric acid using phenolphthalein as indicator (0.1% alcoholic solution).

After finding phenolphthalein alkalinity, methyl orange alkalinity (total alkalinity) was estimated by continuing the same titration adding methyl orange as indicator.

Estimation of hardness

Total hardness of the sample was estimated by EDTA Titrimetric method.

i. Carbonate and non-carbonate hardness

Carbonate and non-carbonate hardness were estimated using the below mentioned formula.

When the hardness is numerically greater than the sum of bicarbonate and carbonate alkalinity (methyl orange alkalinity), the amount equal to the alkalinity is carbonate hardness and the excess amount is non-carbonate hardness.

Carbonate hardness = Alkalinity

Non-carbonate hardness= Total hardness - Alkalinity

If the hardness is equal to or less than the sum of the carbonate and bicarbonate alkalinities, all the hardness is carbonate hardness and there is no non-carbonate hardness.

Carbonate hardness = total hardness.

Non - carbonate hardness = 0

ii. Calcium and Magnesium hardness

Calcium hardness was estimated by EDTA Titrimetric method.

Magnesium hardness = Total hardness - Calcium hardness.

Estimation of chloride

Estimation of chloride was performed with the help of a titrating method against silver nitrate using potassium chromate as indicator.

Estimation of fluoride

Flouride in the sample was estimated by SPADNS method.

Estimation of nitrogen

i. Ammoniacal nitrogen

The free ammonia was measured by Direct Nesslerisation method.

ii. Albuminoid nitrogen

Following the distillation of ammonia nitrogen, the albuminoid nitrogen was estimated by Nesslerisation method, in the presence of a strongly alkaline potassium permanganate solution.

iii. Nitrate nitrogen

Nitrate nitrogen present in the sample was measured by Phenol Disulphonic acid method.

iv. Nitrite nitrogen

Nitrite nitrogen in the sample was analysed qualitatively by Diazotisation method.

Estimation of oxygen absorbed

Oxygen absorbed by the sample in 4 hours was estimated by conducting Tidy's test.

Estimation of iron

Total iron in the sample was estimated by Thiocyanate method.

Ferrous iron in the sample was estimated by α-α Bipyridyl method.

Estimation of manganese

Manganese in the sample was estimated by Persulphate method.

The presence of sulphate and phosphate were qualitatively tested.

i. Sulphate - Gravimetric test.

ii. Phosphate - Ammonium molybdate test.

Microscopical Examination

The water sample was centrifuged and the sediment was examined microscopically for the presence of plant and animal life.

iii. Bacteriological test

For bacteriological analysis the following tests were conducted.

1. Total count or agar plate count test - for total colonies per ml. on agar at 37° C.

2. B-coli test - for Most Probable Number (MPN) of coliform bacteria per 100 ml.

3. IMViC test - for the identification of coliform bacteria.

Results and Discussion

RESULTS AND DISCUSSION

Water that is free of disease-producing micro organisms and chemical substances deleterious to health is called potable water. Drinking water is perhaps, together with the air we breathe, a unique commodity in that the general population is normally permitted no freedom of choice; so the assurance that the water available for drinking is of the highest quality, is of paramount importance. The underground sources namely wells and springs, provide most of the water for individual homes in rural areas.

In the present study, the physico-chemical and bacteriological characters of three well water samples were analysed to evaluate their potability. The results of physic-chemical and bacterioligical analysis of sample I, II and III are given in table-1 WHO (1971, 1985) and ISI (1991) standards for drinking water prescribing the desirable and maximum permissible limits of physical and chemical parameters are mentioned in table-2 for comparison.

Physical parameters

Colour

Colour is a common constituent of many natural waters and it is caused by metallic substances such as iron and manganese compounds, humus materials, peat, tannins, algae, weeds and protozoans. An undesirable appearance is produced by colour in water. The determination of colour is rapid and is useful in detecting a change in character of the water. In the present study, all the three water samples were found to be colourless, which indicates that the three water samples are not contaminated with any of the above mentioned substances.

Odour

No water can be quite satisfactory for domestic and industrial purposes if it possess any odour. (Manivasakam, 1985). The usual requirement of water sample is that they should not contain any objectionable odour. In the present study, all the three water samples were found to be odour less; hence they are agreeable for drinking.

Turbidity

Turbidity is the most important physical parameters associated with the satisfactory appearance of the water samples. The cloudy appearance developed in water due to turbidity is aesthetically unattractive. In the present study, the Jackson turbidity units recorded were 2, 2 and 1 for sample I, II and III respectively. These values are found to be within the desirable limit of 5 Jackson units recommended by WHO and ICMR (1975) standards.

Temperature

The test for temperature of water has no practical meaning, in the sense that it is not possible to give any treatment to control the temperature in any water supply project. In the present study, the temperature was recorded as 24°C for all the three water samples. The desirable temperature of potable water is 10°C while temperature of 25°C is considered to be objectionable (Rangwala, 1984). When compared to this standard, the temperature recorded for the three water samples are within the permissible level prescribed for potable water.

The above mentioned physical parameters are mainly concerned with the appearance of the drinking water. The appearance of drinking water is very important to ensure its complete acceptance; water which is clear, bright, sparkling and free of suspended solids is generally preferred for drinking. The three water samples analysed are clear, bright, odourless, free of suspended solids and hence preferable and aesthetically attractive for drinking.

Chemical Parameters

Hydrogen ion concentration (pH)

The pH values of the three water samples were found to be very close to 7.0. pH value of 7.8 was recorded for sample II and pH value of 7.9 was recorded for sample I and III.

Similar values were recorded for graoundwater samples by Anuja Singh and Wadhwani (1987), Gangal and Zutshi (1990), Naidu et al. (1990), Harish Chandra et al. (1991), Ramaswamy and Rajaguru (1991) and Elango et al. (1992).

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. The pH value of potable water is important in that it is likely to give rise to off-taste (Goodman, 1980) and affect the mucous membrane beyond the desirable limit (ISI, 1991).

In the International standards for drinking water prescribed by WHO, the highest desirable level quoted is 7.0 to 8.5 while, the maximum permissible level is given as 6.5 to 9.2. The Indian standard quotes the desirable limit as 6.5 to 8.5.

In the present study, the pH values of the three water samples studied, fall within the highest desirable level of 7.0 to 8.5 prescribed by WHO and therefore found to be agreeable for drinking.

Electrical Conductivity

Electrical conductivity was found to vary for the three water samples. The values were 900 µs/cm, 1200 µs/cm and 700 µs/cm for sample I, II and III respectively at 20° C. Since conductivity varies directly with the temperature of the sample, the result is usually reported at 20° C. This parameter for drinking water was analysed by Harish Chandra et al. (1991) and was found to vary between 382.0 and 1723μs/cm.

Guide values for electrical conductivity is included in the EEC Directives. 1000 micro siemens/cm at 20° C appears as the guide value in the surface water Directive. 400 micro siemens/cm at 20° C appears as the guide value in the drinking water for Human consumption Directive. These values are considered to be reasonable to prevent the undue corrosion of distribution mains, domestic plumbing and terminal fittings (Goodman, 1980).

In the present study, the values obtained for conductivity seem to be high as compared to the above mentioned guide value of 400μs/cm for human consumption.

This parameter is of little importance when other parameters with more relevant application to public health considerations are compiled with satisfactorily (Goodman, 1980). Based on this, we consider that the high value obtained for conductivity in the persent study will not affect the quality of the drinking water samples.

Total solids

The concentration of total solids within the desirable limit of 500 mg/l was obtained in the case of sample III (453 mg/l). The other two samples were observed to have a value above 500 mg/l; 594 mg/l for sample I and 760 mg/l for sample II. These values are within the maximum allowable limit suggested by WHO standard.

Alkalinity

Total alkalinity was measured as 304 mg/l for sample I, 445 mg/l for sample IIand 286 mg/l for sample III. Phenolphthalein alkalinity was estimated as zero for the three samples. These values are within the maximuim permissible limit (600 mg/l) of drinking water recommended in the Indian standard. The values in the same range were obtained for drinking water by Harish Chandra *et al*. (1991).

Hardness

The hardness of the three water samples ranged between 300 and 500 mg/l. The values recorded were 356 mg/l, 430 mg/l and 316 mg/l for the samples I, II and III respectively. The values in the same range were obtained for ground water by Gangal and Zutshi(1990), Harish Chandra *et al*., (1991), Vijaykumar *et al*. (1993). The three samples recorded very low values for non-carbonate hardness (52 mg/l, 0 and 30 mg/l for sample I, II and III respectively).

Calcium and magnesium hardness were measured separately and the values were 152 and 204 mg/l for sample I 160 and 270 mg/l for sample II: 182 and 134 mg/l for sample III.

The hardness depends on the nature of geological formations with which the water is in contact and therefore ground water is generally harder than surface water (Manivasakam, 1985). The hardness is the soap-destroying power of water. The carbonate hardness is the temporary hardness and is mainly due to the presence of bicarbonates of calcium and magnesium. The non-carbonate hardness is the permanent hardness and is due to the presence of sulphates, chlorides and nitrates of calcium and magnesium. It requires special treatment of water softening.

The limits given in the WHO standards are 100 to 500 mg/l of $CaCO_3$. Indian standard on the quality of drinking water quotes 300 mg/l as the desirable limit and 600 mg/l as the maximuim permissible limit. The maximum hardness permissible in the Russian water quality criteria is 350 mg/l. This value is considered as the upper limit on the ground that greater hardness would affect the taste of water. (Goodman, 1980).

The hardness of the three water samples evaluated in the present study for drinking water quality range between 300 and 500mg/l and are found to be within the permissible limit of WHO and Indian Standards. A close examination of hardness values shows that they lie around 350 mg/l and this reveals that even the taste of the water samples is not affected by hardness. Since hardness is found to be within the permissible limit of WHO and ISI standards, the value recorded for carbonate, non-carbonate, calcium and magnesium hardness are not discussed separately.

Chloride

The chloride content of the three water samples were very low, 62 mg/l, 96 mg/l and 56 mg/l for sample I, II and III respectively, when compared to WHO and ISI standards.

Similar reports were made by earlier workers. A low concentration of chloride in drinking water, that is, below 200 mg/l was reported by Harish Chandra et al. (1991). Similarly low levels in ground water were reported by Patel (1991) and in surface water by Sanjeev Majoo (1991). Only in few cases, the level exceeded the desirable limit (Harish Chandra et al. 1991).

The concentration of chloride in natural waters varies from a few milligrams to several thousand milligrams per litre. Chlorides in drinking water are generally not harmful to human beings. However higher concentrations may affect persons suffering from diseases of heart and kidneys

(Manivasakam, 1985). Consumption of water high in chloride may affect infants and young children by damaging their delicate kidney tissues because of high osmatic pressure caused by high concentration of salts. It is therefore important that the chloride content of drinking water should be kept as low as possible (Goodman, 1980).

From the above, it is clear that a low concentration of chloride is desired and also safe for drinking. In the present study also, the chloride concentration is found to be very low, and hence the three water samples are considered to be agreeable and safe for drinking.

Fluoride

The concentration of fluoride was found to be 1.1 mg/l, 2.2 mg/l and 0.9 mg/l for sample I, II and III respectively. WHO, ICMR and ISI standards quote 1.0 mg/l as the highly desirable limit and 1.5 mg/l as the maximum permissible limit. In the present study, sample III has the desirable quantity of fluoride, sample I has the permissible level of fluoride and sample II has fluoride concentration exceeding the maximum permissible limit.

Generally in the United Kingdom a standard of 1.0 mg/l is adopted. 1.0 mg/l is considered to be sufficient to have a beneficial effect upon the incidence of dental caries in children. Thus when flouride is added artificially to drinking water the concentration is raised to this optimum level of 1.0 mg/l(Goodman, 1980).

From the above, it is clear that sample I and III have the optimum level of fluoride. (Values close to 1.0 mg/l).

No other naturally occuring inorganic constituents in drinking water has been given so wide importance as has been given to fluoride. Several reports on the concentration of fluoride in drinking and ground water were made by earlier workers. Elevated fluoride levels in water samples were reported by Harish Chandra et al. (1991), Gupta (1991), Benbi et al. (1991) and Gupta et al. (1993).

In the present study also, an elevated level was recorded for sample II.

This elevated level of fluoride may lead to effects associated with high fluoride content. Mottled enamel particularly in children of age group 7 to 12 years consuming water having fluoride level above 1.5 mg/l has been confirmed in many studies. Osteosclerosis and crippling skeletal fluorosis have been reported with waters containing fluoride level of 3 to 10 mg/l. In extreme cases even thyroid or kidney changes have also been reported as toxic effects of fluoride above 20 mg/l (Mehta and Ghosh, 1988).

On the contrary, physiology of human skeleton unaffected by fluoride level upto 8.0 mg/l has also been reported (WHO, 1970). Epidemiological studies in areas where concentration of fluoride in water were naturally high have rarely shown adverse health effects (National Research Council, 1977). In Western Rajasthan also no apparent physiological effects has been reported where water contain upto 2.0 mg/l of fluoride (Ram Gopal and Ghosh, 1985).

From this,it is concluded that the high value of 2.2 mg/l will not cause any noticeable effect to affect the potability of sample II.

Nitrogen and its compounds

In the three water samples, the ammoniacal nitrogen was absent, albuminoid and nitrite nitrogen were negligible.

Nitrate nitrogen was estimated as 9.0 mg/l, 6.0 mg/l and 2.0 mg/l for sample I, II and III respectively. When converted to nitrates, the values were found to be 39.87, 26.58 and 8.86 mg/l respectively for sample I, II and III, and none of the samples exceeded the desirable limit of 45 mg/l recommended by WHO and Indian standards.

Hence all the three samples are potable with regard to nitrogen compounds.

Unaffected natural water sources have been found to contain only low levels of nitrates - rain water 3.52 mg/l, tube well water 4.40 mg/l, dug well water 26.40 mg/l (Sunil Kumar Saxena and Kavitha Mehra, 1991).

Based on this, we consider that among the samples, sample II has the value similar to that of the unaffected water source.

Oxygen absorbed.

The values for oxygen absorbed ranged below 0.5 mg/l, that is,0.16 mg/l, 0.44 mg/l and 0.40 mg/l for sample I, II and III respectively. A water sample can be regarded satisfactory when Tidy's figure is in the range of 0.5 to 1.0 mg/l (Manivasakam, 1985).

In the present study, as the values are found below 1.0 mg/l, we consider that the samples contain very low amount of organic and inorganic matter and therefore they are found to be agreeable for drinking.

Trace metals -Iron and Manganese.

These trace metals were absent in the water samples.

Sulphates and Phosphates

Sulphates and phosphates in the samples were found to be negligible.

Hence the samples are fully fit for human consumption with respect to trace metals and sulphates and phosphates.

Microscopical Examination

Microscopic examination of water samples is important to study the presence of plant and animal life. On microscopic examination sample I was found to contain sand grains and sample III, sand grains and some amorphous matter. No plant or animal life was reported. The sample II, in addition to sand grains and amorphous matter, showed the presence of two algae, namely, Navicula (Clean - water and filter clogging algae) and, Melosira (filter clogging algae).

All the three water samples are found to be potable as they contain no animal life. The presence of algae in sample II indicates that the water is not as clean as it ought to be for drinking.

Bacteriological Parameters

Many diseases can be transmitted by microbiological agents in water system. Bacteria, viruses and protozoans are all known to cause disease; therefore water quality must be maintained such that these diseases are not transmitted. It is important to observe whether disease agents are present in a water system and at what level. The examination of water for the presence of bacteria is very important.

Total count or agar plate count

Plate counts are useful in determining the efficiency of operations employed in water treatments for removing or destroying organisms.

In the present study, the values obtained for the total colonies per ml. or agar at 37° C is 1400 (Fig. 4), 5200 (Fig. 5) and 1800 (Fig. 6) for sample I, II and III respectively.

For potable water, the total count should not exceed 100 per ml. (Rangwala, 1984). When compared to this standard, all the three samples are found to exceed the total count level prescribed for drinking water quality.

However, the plate count stndards have not been suggested for water, because water with a few pathogenic bacteria is obviously more dangerous than water containing many saprophytic bacteria. Based on this we consider that the high value obtained for total colonies in the present study will not affect the quality of drinking water samples.

B-coli count

Microbial water quality is not commonly determined by testing for specific microbial pathogens, but by testing for the presence and concentration of some indicator organisms. The indicator organism is, an organism that would be indicative of the presence of pathogens in the water.

Total coliforms, faecal coliforms and faecal streptococci are the bacterial groups most commonly used as indicators of faecal contamination.

In the present study, the Most Probable Number (MPN) of coliform bacteria per 100 ml is 550, 1800 and 170 for sample I, II, and III respectively.

The British Ministry of Health (1969) suggests standards based on presumptive coliform count that water regarded as highly satisfactory contains less than one coliform/100 ml, satisfactory contains one or two coliforms/ 100ml, suspicious contains 3 to 10 coliforms/100 ml and unsatisfactory contains more than 10 coliforms/100 ml.

When compared to these standards, the above three water samples studied, exceeded the value of 10 coliforms/100 ml.

As the standards are recommended for piped water supply entering the distribution system, we consider that the comparison with these standards is not possible for raw and untreated water samples.

According to ISI (IS2296: 1974), the tolerance limit of coliform organisms for inland surface waters for use as raw water for public water supply is not more than 5000/100ml. In the present study, the total coliform values in the three water samples are found to be within the prescribed limits of Indian standard and therefore they are considered to be agreeable for drinking.

Nature of coliform bacteria isolated

The nature or type of coliform bacteria isolated was E.coli III for sample I, E.Coli - II and Klebsiella aerogenes - I for sample IIand E-coli I and II for sample III.

E.coli is referred to as the Colon bacillus because it is the predominant facultative species in the large bowel. Its presence in a water supply usually indicates continuing faecal contamination. Members of Klebsiella are also gram negative bacteria which are considered second to E.coli.

In the present study, the nature of coliform bacteria isolated suggests the possibility of faecal contamination.

The coliform is a general tern for facultative gram-negative rods that inhabit the intestinal tract of man and other animals without usually causing disease . (Davis et al. 1980).

From this view it is clear that the presence of E-coli and Klebsiella aerogenes in the three water samples will not cause noticeable disorders to the users and hence the samples are found to be agreeable for dinking.

Looking to the physico-chemical and bacteriological characters of the water samples, individually and collectively, it is evident that the water from the three wells is suitable for drinking. However, the water from the open well (Sample II) having high electrical conductivity, a higher concentration of fluoride and high values of total colonies and coliform bacteria may pose health hazard to human beings and therefore necessary preventive measures have to be taken to safeguard the open well water used for drinking. From the study, it is clear that the borewell water is more suitable for drinking than the openwell water.

TABLE I

Phisico-chemical and bacteriological parameters of three samples of well water from Erode. (in mg/l.)

S.No.	Parameters	Sample I	Sample II	Sample III
	Physical Parameters			
1.	Colour	Colourless	Colourless	Colourless
2.	Odour	Odourless	Odourless	Odourless
3.	Turbidity(Jackson turbidity units.)	2	2	1
4.	Temperature	24° C	24° C	24° C
	Chemical Parameters			
5.	Hydrogen ion concentration [pH]	7.9	7.8	7.9
6.	Electrical conductivity (micromhos/cm)	900	1200	700
7.	Total solids	594	760	453
8.	Alkalinity			
	i) Phenolphthalein	0	0	0
	ii) Methyl Orange	304	445	286
9.	Total hardness as $CaCo_3$	356	430	316
	i) Carbonate hardness as $CaCo_3$	304	430	286
	ii) Non-carbonate hardness as $CaCo_3$	52	0	30

contd..

S.No.	Parameters	Sample I	Sample II	Sample III
	iii) Calcium hardness as $CaCo_3$	152	160	182
	iv) Magnesium hardness as $CaCo_3$	204	270	134
10.	Chloride	62	96	56
11.	Fluoride	1.1	2.2	0.9
12.	Nitrogen and its compounds			
	i. Ammonia nitrogen	0	0	0
	ii..Albuminoid nitrogen	0.03	0.05	0.07
	iii.Nitrate nitrogen	9.0	6.0	2.0
	iv.Nitrite nitrogen	Nil	Trace	Nil
13.	Oxygen absorbed in 4 hours (Tidy's test)	0.16	0.44	0.40
14.	Total iron	0	0	0
15.	Ferrous iron	0	0	0
16.	Manganese	0	0	0
17.	Sulphate	Trace	Trace	Trace
18.	Phosphate	Trace	Trace	Trace

contd..

S.No.	Parameters	Sample I	Sample II	Sample III
19.	Microscopical Examination	Sand -grains	Navicula, Melosira, Sand grains, Amorphous -matter	Sand -grains Amorphous -matter.
	Bacteriological parameter.			
20	Total colonies per ml.on agar at 37° C	1400	5200	1800
21.	MPN (Most probable number) of coliform bacteria per 100 ml.	550	1800	170
22.	Nature of Coliform bacteria isolated	E.Col.III	E.coli-II Klebsiella -aerogenes I	E.coli-I and II

TABLE 2

The desirable and maximum permissible limits prescribed by WHO and ISI for the physico-chemical parameters of drinking water (in mg/l).

S.No.	Parameters	Permissible limits of WHO		Permissible limits of ISI	
		Highest desirable	Maximum	Highest desirable	Maximum
1.	Colour(Hazen units)	5	50	5	25
2.	Odour	unobjection able	Unobjection able	Unobjection able	Unobjec-tionable
3	Turbidity	5(JTU)	25	5 (NTU)	10
4.	Hydrogen ion concentration (pH)	7.0	8.5	6.5	8.5
5.	Electrical Conductivity (micromhos/cm)	Guideline value.	400	--	--
6.	Total solids	500	1500	500	2000
7	Alkalinity	-	-	200	600
8.	Total hardness	300	600	300	600
9.	Chloride	200	1000	250	1000
10.	Flouride	1.0	1.5	1.0	1.5
11.	Nitrate nitrogen	10	--	10	-
12.	Nitrate	-	-	45	100

contd..

S.No.	Parameters	Permissible limits of WHO		Permissible limits of ISI	
		Highest desirable	Maximum	Highest desirable	Maximum
13.	Iron	0.3	1.0	0.3	1.0
14.	Manganese	0.1	0.5	0.1	-
15.	Sulphate	200	400	200	400

Note: JTU- Jackson turbidity units.

NTU- Nephalometric turbidity units.

Fig.I

The bore well at Karukkam palayam village.

Fig.II
The open well at Subbrayavalasu Village.

Fig.III
The bore well at Lakkapuram Village.

Fig.IV

Total colonies per ml. on agar at 37 °C for sample I.

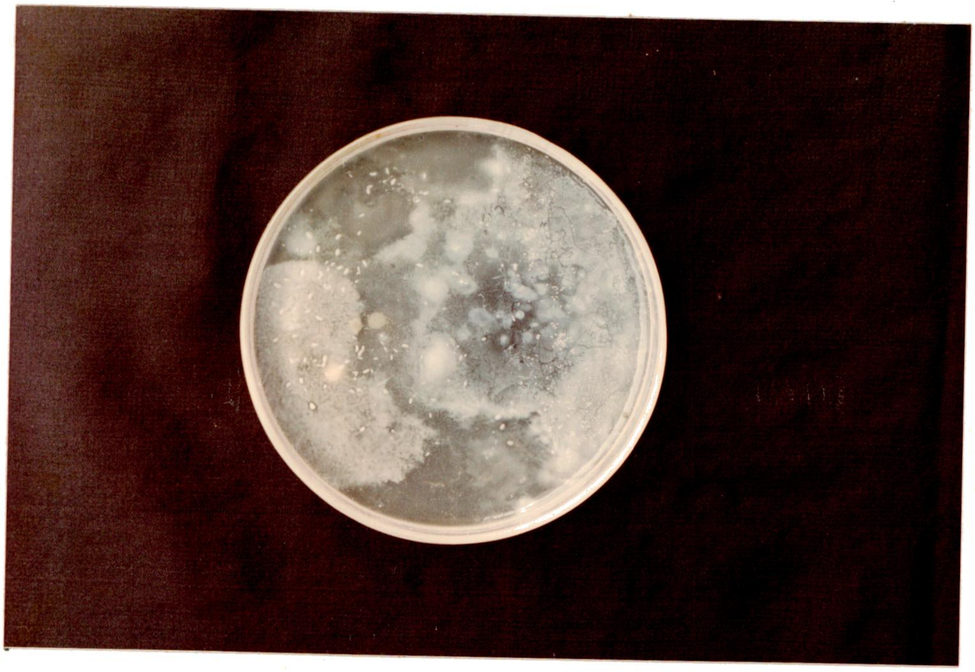

Fig. V

Total colonies per ml on agar at 37°C for Sample II.

Fig.VI

Total colonies per ml on agar at 37°C for Sample III.

Summary and Conclusion

SUMMARY AND CONCLUSION

People in rural areas use bore well and open well water for drinking. In the present study, the physical, chemical and bacteriological quality of selected tube and open well water from the rural areas of Erode were analysed to assess their suitability for drinking.

The physical parameters analysed were colour, odour, turbidity and temperature. The three water samples were colourless, odourless and free of suspended solids.

The chemical parameters analysed were pH, electrical conductivity, total solids, alkalinity, hardness, chloride, fluoride, nitrogen compounds, absorbed oxygen, iron, manganese, sulphates and phosphates.

For sample I and III, except electrical conductivity, all the other chemical parameters were within the prescribed limits of ISI and WHO standards for drinking water.

For sample II, except electrical conductivity and fluoride concentration, the other paramaters were within the prescribed level of ISI and WHO standards.

On microscopic examination, the three samples were found to be free of animal life. Sample II showed the presence of two algae, Navicula and Melosira.

Total colonies per ml, MPN of coliform bacteria per 100 ml. and the identification of coliform bacteria were the bacteriological parameters analysed. The presence of coliform bacteria in the three water samples indicated faecal contamination but their values were within the prescribed limits of ISI standard.

Hence, it has been concluded that, all the three water samples are found to be suitable for drinking and borewell -water is preferred to open well water.

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