RESEARCH ARTICLE OPEN ACCESS

Assessment of physicochemical and bacteriological drinking water quality of different sources of H.D. Kote town, Mysore district.

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ABSTRACT
Water is essential to sustain the life. Water samples have collected from a different urban area of H. D. Kote town of Mysore district from different sources such as hand pump, public taps, and stored household drinking water. Physico-chemical and microbiological characteristics of the water samples were analysed following the standard methods to evaluate the quality of drinking water. All physic-chemical parameters are within the permissible limit to WHO. The microbiological analysis shows that that t nearly 53 % of the samples were observed with coliform contamination. The significant difference among water sources regarding total plate count was observed, where stored household water has relatively higher compared to tap and borewell water exceeding the standard limit. Both hand pump and the tap water were not detected with any *E. coli* contamination whereas 80% of the household stored water samples have shown *E. coli* contamination. The presence of significant counts of coliforms in stored household water indicates post poor sanitation and existence of human activities. Attention should be given to the collection, storage, and management by additional treatment to maintain and prevent excessive microbial growth
Keywords: Tap water, hand pumps, *E. coli*, coliform.

I. INTRODUCTION

Water is an extremely essential and play a vital role in human life. All people have the right to have access to drinking water in quantities and of a quality equal to their basic needs (WHO, 1997). About 780 million people do not have access to clean and safe drinking water, and nearly 2.5 billion do not have the proper sanitation.Therefore, water quality control is a top-priority policy agenda in many parts of the world [WHO, 2011].Sources of water include mainly surface, ground, and rainwater, which are supporting drinking water supply. Many chemicals found in drinking water sources may cause adverse human health effects, affect the acceptability of water and lower the effectiveness of water treatment. The chemical constituents present in drinking water cause health risk only after a prolonged period of exposure, which is different from the risk resulting from microbial contamination. It can be argued that chemical standards for drinking-water are of secondary consideration in a supply subject to severe bacterial contamination (WHO 1996). Though water is a colourless and tasteless, the quality depends on the various inorganic or organic chemical constitutes, dis in fectants, microo rganisms and their concentration. Ideally drinking water should not contain any pathogenic microorganisms or any bacteria indicative of faecal pollution. One of the common contaminants of drinking water is coliform bacteria which are used as an indicator of water quality to assess the potential public health risk of drinking water, and their absence or presence is key elements of most drinking water quality guidelines. Among coliforms, detection of *Escherichia coli* provides definite evidence of faecal pollution; in practice and the detection of thermotolerant (faecal) coliform bacteria is an acceptable alternative (WHO 1997). The water from the source is treated in different processes where microbes and other substances are removed in the treatment plant and then distributed through the pipeline to the point of use. In many places, underground water is supplied without treatment. The principal objective of municipal water is the production and the distribution of safe water that is fit for human consumption. It is essential and necessary to test the quality of water at a regular time interval before it is used for different purposes like drinking, domestic, agricultural or industrial use. Drinking water should meet standards set by WHO before consumption if these conditions are not met the water is said to be non-potable.Water may be contaminated with pathogens at the source, but contamination may also occur during distribution, transportation, or handling in households or other working places (WHO, Genthe *et al*., 1997), improper protection of water collection and storage containers and unhygienic conditions contribute to contamination at home (Nath *et al.,* 2010).

In India, the majority of the houses water to be collected and then stored for use at home for 24 hrs or till the next collection. Although such system can supply water for excellent quality, there is a considerable deterioration to occur because of the amount of handling involved during supply and consumption (Andrew et al., 2004). Microbial contamination of domestic drinking water during and after collection from the source even where the water sources are uncontaminated has been recognised as one of the problems, such post-source contamination results in poorer water quality in storage vessels within households (Stephen et al., 2004). The purpose of the study is to assess the physicochemical parameter along with total bacteria and coliforms in a different point of sources such as hand pumps and taps at the point of use and also stored household water.

II. MATERIALS AND METHODS

1.1. Study area:

Water samples were collected from the urban area of H.D Kote town (Mysore district). H. D. is a talukheadquarters of Mysore district. The population of the taluk is 12, 045 (Census 2001). There are four reservoirs namely, Kabini, Nugu, Hebbala, and Taraka. The main water source to this city is Kabini and ground water. There is one ground level reservoir with the capacity 50, 000 Gallons. The water supplied to the city is around 2.84 MLD. Surface water is treated and distributed whereas the groundwater is distributed untreated.

1.2. Collection of water samples

Water samples were collected according to the WHO standard method, and transported to the laboratory in an ice bath and processed withing 6 hrs. For microbiological analysis the samples were collected in an autoclaved container containing 2-3 drops of sodium thiosulphate to inactivate the chlorine used in water treatment.

1.3. Physico-chemical water analysis

For the analysis of phys icochemical parameters, samples were collected in clean plastic containers previously washed and was rinsed with water to be collected. Physico-chemical parameters were analysed by following standard methods of APHA, 2005. The following parameters have been performed; Chlorine level was measured on the spot of the collection using the readily available kit (Aqua check, Himedia, Mumbai). pH : Electronic method, Temperature: Mercury thermometer, Conductivity (µs/cm) : Electrical conductivity using conductivity meter, Turbidity: Turbidometric method, Total Hardness (mg/l) : EDTA Titrimetric method, Erichrome Black T, Calcium (mg/l) : EDTA Titrimetric method, Magnesium (mg/l) : Calculated from magnesium hardness, Alkalinity (mg/l) : Titrimetric method using Bromo Cresol Green indicator using 0.1 N HCl, Total Phosphorous (mg/l) : Stannous chloride – colorimetric method, Nitrate (mg/l): Use of brucine sulphate and sulphonic acid develop the colour. The intensity of yellow color was determined calorimetrically. Sodium (mg/l) and potassium: Flame photometric method at 569 nm wavelength, Chloride (mg/l) : Arganometric titration method.

1.4. Enumeration of Bacterial number by MPN and plate method

Bacterial identification was performed by, Multiple-Tube (MPN) Fermentation Technique (3 test tube set); which involves inoculation of inoculum with the ten-fold difference between each set. The test tube of each set containing Lauryl tryptone sulphate and Durham's tube were inoculated with different dilutions of the water sample and incubated at 37°C for 24 to 48 hrs. After the incubation period, the tubes were observed for gas production, the number of the positive tubes were recorded and compared with standard MPN table. Positive cultures were inoculated on both media like the Brilliant green agar and EMB agar. The organisms were identified up to the species level by biochemical tests using biochemical identification kit (Himedia).

1.5. Statistical analysis

Inter-relationshipsbetween phys icoche mical parameters were examined using Statistica ver. 6.0 and analysis tool pack in Microsoft Excel. Analysis of variance (ANOVA) was carried out to indicate sign ificant variation between the parameters.

III. RESULTS AND DISCUSSION

3.1 Physico-chemical parameters

In the studied area, the sample collected from different sources of water used for drinking purposes were colourless, odourless, tasteless and free from turbidity and excess salts.

3.1. 1Temperature pH, and Electrical Conductivity (EC)

The important phys icoche mical character is tics of water samples analyzed have been shown in Table-1, and the values were compared with standard parameters of WHO and Indian standard Table-1. The temperature of the water samples was in the range from 26.0-29.9°C. The pH of the water is a measure of the acid–base equilibrium of drinking water. In most of the natural waters, pH is controlled by the carbon dioxide–bicarbonate–carbonate equilibrium system. In this study, pH was ranged from 6.23-7.63, which are within the range prescribed by WHO (APAH standard 1995). Maintaining the proper pH in drinking water is important because it can affect the degree of corrosion of metals as well as disinfection efficiency, it may have an indirect effect on health (WHO, 1996). The Electrical Conductivity (EC) of samples range between 268-1568 (µ mho/cm) and a few hand pump samples shown higher than the permissible limit. The EC value is directly proportional to the concentration of ions in the water or total dissolved matter.

3.1.2 Total Dissolved Solid (TDS), Alkalinity, Hardness, and Turbidity

The Total dissolved solid, hardness, alkalinity and turbidity are also important parameters of water quality whether it is to be used for any purposes like domestic, industrial or agricultural purposes. The level of TDS decides the quality of drinking water and since it is an important factor to aquatic life in keeping the cell density balanced. TDS of the samples ranged from 180-1245 mg/L. WHO and USPH prescribed TDS value is less than 500mg/L, whereas ICMR permissible limit is 1500 mg/L. 87% of the samples analyzed had more than the maximum permissible limit of WHO but are below the maximum limit of ICMR. Water with high TDS has normally affected the taste and cause the high alkalinity or hardness. The TDS concentration is a secondary drinking water standard, therefore, is regulated because it is more of a visual rather than a health hazard. The hardness of water is due to dissolved calcium and magnesium salts from soil and aquifer minerals containing limestone or dolomite . The total hardness of the samples ranges between 60-630 ppm, while WHO and Indian standards permit any value less than 500mg/L. In few samples of a hand pump, the total hardness exceeds beyond the maximum acceptable limit. The alkalinity of water is defined as the ionic concentration, which can neutralize the hydrogen ions. The bicarbonate alkalinity ranges between 100-400 mg/L, which is expressed as a total alkalinity. The alkalinity value of all the samples was within the permissible limit of 600ppm. However, the little abnormal value of alkalinity is not harmful to human beings. Turbidity in water is due to suspend and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms.The turbidity of the samples lies between undetectable range to 1.92 NTU in the study area.

3.1.3 Chloride, Calcium, Magnesium and Potassium

The chloride content of the samples lies between 42.60-160.93 mg/L. Chlorides are the inorganic compound resulting from the combination of the chlorine gas with metal (Manoj Kumar and Avinash Puri, 2012), and it is normally the most dominant anion in water. In the present study; the chloride content of all the samples have been found to be in the permissible range i.e. 250-mg/L according to ICMR. The high amount of chloride in water results in corrosion and pitting of iron plates or pipes. In the interim, small amounts of chlorides are required for normal cell functions in plant and animal life. Maximum permissible limit of calcium and magnesium in drinking water is 100mg/L and 50mg/L as suggested by USPH and WHO; 75mg/L and 50mg/L as advised by ICMR, respectively. In the area studied the content of calcium and magnesium in potable water range from12.02-148 mg/L and 14.00-155.43 mg/L, respectively. Both calcium and magnesium are essential for human body development and also for normal function. As calcium is also a part of bones and teeth, it also plays a role in neuromuscular excitability (decreases it). Magnesium is essential as co-factor for enzyme activity including glycolysis, ATP metabolism, transport of elements such as Na, K and Ca through membranes.

3.1.4 Total Phosphate, Nitrate, Potassium and Sodium.

Sodium and potassium content of all the sampling sites ranged between 2.27 to 5.66 mg/L and 22.02 to 180.6 mg/L, respectively. The concentration of the nitrate and phosphate of the drinking water samples ranged from ND range to 0.9 mg/L and 5.60 to 27.2 mg/L, respectively. These are essential nutrients for the growth of phytoplankton and microbes in the aquatic environment.

3.3 Significant correlation

Interrelationship studies between different variables are very helpful tools in promoting research and opening new frontiers of knowledge. The study of correlation can reduce the range of uncertainty associated with decision making (Devi and Prem Kumar, 2012).

Physico-chemical Correlation

When, all the three types of sources of drinking water was correlatedamong the various water quality parameters. Total hardness showed significant positive correlation with EC (0.963, $p<0.001$) but near significance with alkalinity. The magnesium concentration significantly correlated with EC (0.963, $p<0.001$) and TH (0.963, $p<0.001$) but it also relate with total hardness and magnesium but they are insignificant. TDS concentration is positively influenced by EC (0.991, $p<0.001$), TH (0.963, $p<0.001$) Ca (0.576, $p<0.05$) and Mg (0.963, $p<0.001$) with significant. As mentioned above chlorides is normally the most dominant anion in water it showed significant positive with EC (0.721, $p<0.01$), alkalinity (0.535, $p<0.05$), total hardness (0.795, $p<0.01$), magnesium (0.795 , $p<0.01$) and TDS (0.739, $p<0.01$). Total phosphate and potassium positively correlated with EC (0.566, $p<0.05$) and Calcium (0.783, $p<0.01$), respectively. 28.94 % of the total alkalinity is influenced by nitrate concentration in water samples. High EC values were observed at 29% of the sampling points with reference to WHO standards, indicating the presence of high amount of dissolved inorganic substances in ionized form.

3.2 Microbiological water quality of the water samples.

Out of 15 samples collected from hand pumps, public taps, and stored household water, 53 % of the samples were observed with coliform contamination. *E. coli* contamination was not detected in the water collected from the hand pumps. Among household water samples all the samples were observed for coliforms contamination and 80% with *E.coli* contamination. Tap water sample analysis revealed that 60 % of the water had coliform contamination, but not detected with *E.coli* contamination. The significant difference among water sources regarding total plate count was observed, where stored household water has relatively higher compared to tap and borewell water exceeding the standard limit. When ANOVA run between the water samples collected for both MPN and CFU. MPN did not show any significant difference between the samples, but CFU showed significant ($p=0.0002$) between the samples.

Hand pump water recorded zero level of *E.coli* count. The contamination of the household water was significantly greater when the bacteria count of source water was low. According to the drinking water standards, the bacteriological content of drinking-water leaving treatment plants should contain only very low levels of heterotrophic microorganisms. The coliform contamination in the few tap water samples but not in all the samples indicates the cross contamination of the water in the distribution system could be due to leaky pipes or the organic and inorganic nutrients present in pipeline supporting the bacterial multiplication. Most of the microorganisms developing within the distribution network are harmless except *Legionella* and *Mycobacterium avium*complex (WHO). And also the total coliform counts are not necessarily a measure of fecal pollution because it has other species of the four *Enterobacteriaceae* genera *Escherichia*, *Klebsiella*, *Enterobacter* and *Citrobacter* which give positive coliform results (Cabral 2010), and these organisms are of less health concern comparable with *E. coli*. In the study though 90%, tap water had coliform contamination, only 13% of the sample was detected with *E. coli*. Stored household water quality depends on the source, but with a comparison with the point of use the stored household water has a high density of bacterial contamination and the coliform contamination was above the WHO recommended limit. The low level of residual chlorine of both stored household water and tap water indicate the loss of chlorine level as the water travels in the pipeline to a distance till the point of use and increase in the storage duration. Free chlorine is unstable in aqueous solution, and may decrease rapidly, particularly at warm temperatures and exposure to intense light or agitation. Hence, when water leaves the treatment plant residual, free chlorine of about 1 mg/l is needed for health reasons, and such level should be maintained at points of consumption (Momba, 2006). The lack of detectable levels of chlorine residuals in stored household drinking-water compared with piped water leads to the post-contamination. The presence of significant counts of coliforms in stored household water indicates post poor sanitation and existence of human activities. The temperature of the stored water was nearly 30^0C; this high temperature can also favor the growth of organisms in water resources (Muyima and Ngcakani F, 1998). Several previous reports were stating on the worse bacteriological quality of stored household water than water from the source (Dissanayake et al., 2004). Other studies are reporting on; higher compliance for piped water than from household water containers (Momba, 2006). However post water quality can be improved by promoting better water handling, storage, and treatment.

IV. CONCLUSION

The study concludes that all the physicochemical parameters of the water samples collected from a hand pump, tap water, and household stored water were within the recommended range of WHO and safe for drinking water. But the deterioration in the microbiological quality of water at point-of-collection and use indicate a contamination after collection. The decline in water quality during collection and storage indicate the poor sanitation and existence of unhygienic human practices. The results indicate that the individual householder is responsible for the pollution. Attention should be given to the collection, storage, and management by additional treatment to control the quality of the treated water in a distribution system and stored household water to prevent excessive microbial growth and any associated occurrence of larger life forms (AWWA, 1999).

ACKNOWLEDGEMENT

The author Roopavathi C is thankful to the University Grand Commission-Rajiv Gandhi National Fellowship (UGC-RGNF), New Delhi, for providing financial assistance.

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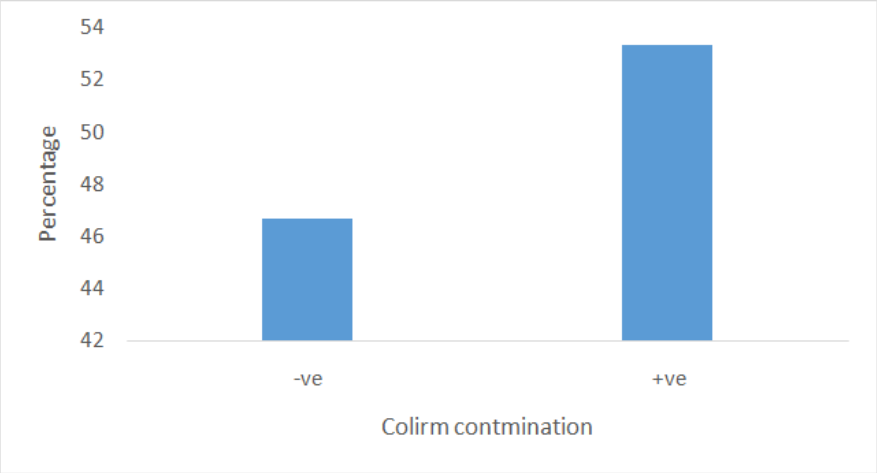

Figure 1: Percentage contamination of water samples with coliforms

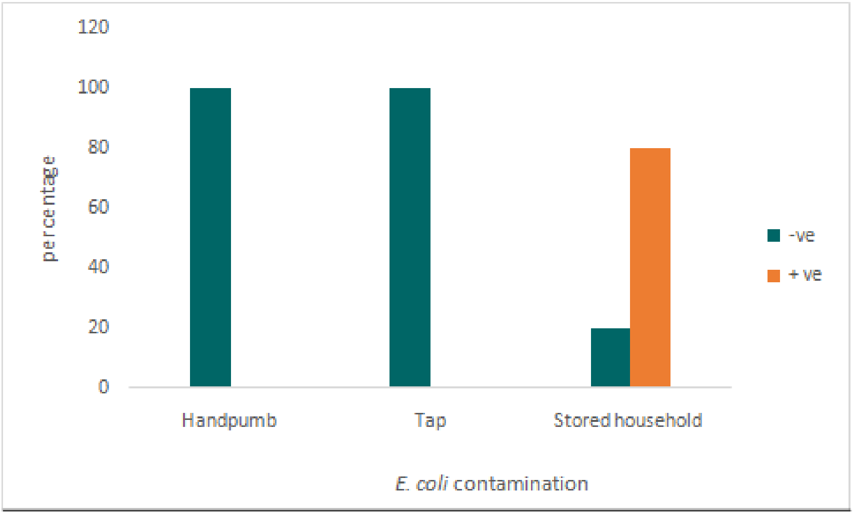

Figure 2: *E.coli* contamination of different water samples.

Tables

Table 1: Physico-chemical drinking water quality of H.D. Kote Town, Mysore District

	Hand pump	**Tap water**	**House hold water**	**WHO**	**Indian Standard**
TEMP (°C)	26.40±0.34	26.60±0.19	26.54±0.11	-	-
pH	7.01±0.57	6.91±0.42	6.63±0.38	6.5-8.5	
EC (µs)	1443.20±218.82	940.80±358.44	938.40±435.82	1000	-
TA (mg/L)	430.00±67.82	320.00±122.93	212.50±69.44	-	600
TH (mg/L)	574.00±56.07	308.00±148.98	302.00±161.02	500	600
Ca^{2+} (mg/L)	80.96±48.32	52.10±31.27	65.73±40.75		
Mg^{2+} (mg/L)	139.56±13.80	74.83±36.21	73.29±39.06	50	100
Turbidity (NTU)	0.10±0.03	4.08±5.27	0.47±0.83	5	5
TDS (ppm)	966.80±159.47	617.80±227.04	617.00±282.60	1000	2000
Chloride (mg/L)	130.17±18.02	51.12±6.80	68.63±32.53	200	250
TP (mg/L)	15.84±7.75	17.15±7.98	16.10±7.44	-	5
K^+ (mg/L)	60.62±67.76	9.92±6.92	26.22±29.11	15	-
Na^{2+} (mg/L)	4.11±0.89	4.32±1.69	4.47±0.97	200	-
NO_3^{2+} (mg/L)	0.61±0.26	0.58±0.23	0.26±0.02	10	45

WHO-World Health Organization; Temp.-temperature; EC-Electrical conductivity; TA-total alkalinity; TH-total hardness; TDS-total dissolved solid; TP-total phosphate

Table 2: Significant correlation coefficients values among the physic-chemical water quality parameters at H.D. Kote town

All	**Temp.**	**pH**	**EC**	**TA**	**TH**	**Ca^{2+}**	**Mg^{2+}**	**Turbidity**	**TDS**	**Chloride**
pH	0.468	-	-	-	-	-	-	-	-	-
TA	-	-	0.465		-	-	-	-	-	-
TH	-	-	0.963*	0.487	-	-	-	-	-	-
Ca^{2+}	-	-	0.519	-	0.524	-	-	-	-	-
Mg^{2+}	-	-	0.963*	0.488	0.999*	0.520	-	-	-	-
TDS	-	-	0.991*	0.470	0.963*	0.576*	0.963*	-	-	-
Chloride	-	-	0.721*	0.535*	0.795*	0.362	0.795*	-0.314	0.739*	-
TP	-	-0.462	0.566*	-	0.482	0.258	0.482	0.345	0.486	-
K^-	-0.501	-	-	-	0.393	0.783*	0.389		0.336	0.456
NO_3^{2+}	-	-	0.325	0.538*	0.371	-	0.373	-	0.347	-

n=15, *Indicates the significance ($p>0.05$), without a star are near significant. (-)Temp.-temperature; EC-Electrical conductivity; TA-total alkalinity; TH-total hardness; TDS-total dissolved solid; TP-total phosphate