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Bacteriological and Physicochemical Properties to Assess Quality of Open Dung Well Water in Selected Laksham Veedu Colonies in Thrissur District, Kerala

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ABSTRACT

The bacteriological and physicochemical properties of open dung well water in selected 'Laksham veedu" colonies belonging to four different grama panchayaths in Thrissur district,Kerala have been studied to assess potability of water and the impact due to seasonal variation on the water quality. An average of three wells was selected from each 'Laksham veedu" colony and their properties were analyzed using standard methods during the pre monsoon and post monsoon season. Different parameters viz., pH, electrical conductivity, turbidity, total hardness, total alkalinity, calcium, magnesium, chlorides, sulphates, nitrates, total dissolved solids, iron, total coliforms, fecal coliforms, fecal streptococci, FC:FS ratio etc. were determined and have been compared with IS:10500 specifications for drinking water to see the quality and suitability. The investigation revealed, around 75% of open dung wells studied have polluted water due to various factors like poor sanitization measures, lack of waste management, dumping of solid wastes, lack of proper septic tank etc. and found unfit for human consumption. The intensity of pollution tended to increase during post monsoon season compared to pre monsoon.

KEYWORDS Laksham veedu colony, open dung well water quality, bacteriological and physicochemical property

INTRODUCTION

Water can be considered as the soul of the nature as life is supposed to have originated from water and as it is the most essential requirement of all lives. Water is a dynamic system, containing organic, inorganic, living, nonliving and soluble as well as insoluble substances. Any change in the natural quality may disturb the equilibrium of the system and would become unfit for drinking and other domestic purposes.

'Laksham Veedu' housing colonies in Kerala built in 1972 under the `Laksham Veedu' scheme for the underprivileged sections. The major problem noticed and faced by these colonies includes limited area and increasing population together with lack proper drainage system, improper sanitization measures, leach pit latrine system, careless waste disposal and dumping, practice of sewage disposal using soak pits etc. Major source of water for drinking and other domestic purposes within the colony premises is generally open dung wells and because of above said problematic factors, there is every possibility for pollution of these water sources and serious threat to the people who use this. Considering the above situation, the present author has tried to study the quality of open dung well water collected from certain selected Laksham Veedu' colonies in Thrissur district. The study aimed to see whether these sources are satisfying the standards prescribed by Bureau of Indian Standards [BIS] for drinking water and to see whether these well water sources are fit for human consumption. The study also aims to see the impact of seasonal variation during the year on the intensity of water pollution.

MATERIALS AND METHODS

Open dung wells belonging to four different "Laksham veedu" colonies under four different gramapanchayaths in the Thrissur district were selected for the assessment of water quality and the impact of seasonal variation. After conducting a survey, three wells were selected for the study from each colony and averages were taken. Details of water samples collected are given in table 1. Water samples were collected during the pre monsoon (April-May) and post monsoon (August-September) season of 2014 and this was done with a view to obtain a comparable data in different seasons. Water samples were collected in high grade plastic bottles of one liter capacity for physicochemical parameters. Before collection, the plastic bottles are rinsed once with distilled water and then thrice with respective water sample. For bacteriological examinations, water samples were collected in 250 ml pasteurized sterile bottles (at 121°C).

Physicochemical Parameters:

Physicochemical parameters such as turbidity, electrical conductivity [EC], pH, total hardness [TH], total alkalinity [TA], calcium, magnesium, chlorides, sulphates, nitrates, iron, total dissolved solids [TDS], dissolved oxygen [DO], biochemical oxygen demand [BOD] etc have been studied using standard methods (American Public Health Association [APHA], 2005).

Bacteriological Parameters:

Water samples were analyzed for bacteriological parameters like total coliforms [TC] count, fecal coliforms [FC] count, fecal streptococci [FS] count and FC:FS ratio. TC count was assessed by multiple fermentation tube method (APHA, 2005). FC count was determined by inoculating tenfold serial dilution of each water samples on turgitol-7 agar plates and FS count on KF - streptococci agar plates. The plates were incubated at 37 °C for 24 hr and the count per 100 ml was determined (APHA, 2005).

Comparison with BIS IS: 10500 (2012)

Physicochemical and bacteriological parameters of water samples analyzed have been compared with BIS, IS: 10500 specifications (2012).

RESULT AND DISCUSSION

The results obtained from the physicochemical analysis of selected open dung well water samples collected from four different 'Laksham Veedu' colonies are depicted in table 2.

Turbidity:

Desirable and maximum permissible limit of turbidity in drinking water set by BIS (2012) is 1NTU and 5NTU respectively. The turbidity values in the analyzed water samples varied from 0.1 NTU to 0.5 NTU during the pre monsoon season and 0.1

NTU to 0.8 NTU during the post monsoon season. The highest turbidity was noticed in the water sample ODW1 (Padiyur) during both the seasons whereas the lowest in ODW3 during the pre monsoon and both ODW3 and ODW4 during the post monsoon season. The results reveal all the water samples are safe in this respect.

Electrical Conductance [EC]:
Considerable variation in the Electrical Conductance [EC] value was observed in the studied water samples which range from 100µS/cm to 2300µS/cm during the pre monsoon season and 100µS/cm to 2600µS/cm during the post monsoon season. The highest EC value was recorded in ODW1 and lowest in ODW4, during both the seasons. The higher EC value of water samples ODW1and ODW2 may be due to corresponding higher level correlation significance with total dissolved solids, total hardness and total alkalinity and which may be attributed to comparatively higher concentration of chlorides, magnesium, nitrates etc in the water samples (Mahajan, Khare & Shrivastava, 2005).

pH:
pH of well water samples ranged from 6.51 to 7.28 during the pre monsoon season and 6.95 to 7.91 during the post monsoon season. The desirable pH range prescribed by BIS (2012) is 6.5 to 8.5. The study indicates the pH value of all the water samples are within the permissible limit and safe. Water samples collected from Eariyad (ODW2) was slightly basic in nature whereas that collected from Maala (ODW3) and Koratty (ODW4) was slightly acidic. The highest pH during the pre monsoon season as well as post monsoon was observed in ODW2 and it was 7.28 and 7.91 respectively whereas the lowest pH in ODW3 (6.51) and ODW4 (6.95) during the pre monsoon and post monsoon respectively.

Total Hardness [TH]:
Total hardness [TH] of water samples varied from 22 mg/l to 505.5mg/l during the pre monsoon season and 23mg/l to 765mg/l during the post monsoon season. Highest TH level was recorded in ODW1 and was above the desirable limit during the pre monsoon season (505.5mg/l) but exceeded the maximum permissible limit during the post monsoon season (765mg/l). TH value recorded in ODW2 was safe during the pre monsoon; however it became undesirable but within the maximum permissible limit during the post monsoon season (318mg/l). ODW3 and ODW4 are safe. Higher TH value with respect to ODW1and ODW2 in the investigation may be the result of comparatively higher concentration of carbonate and non-carbonate hardness causing cations which could be resulted from seepage of domestic sewage through the soil, liming and fertilizer applications, sedimentary rocks in the underground etc.

Total Alkalinity [TA]:
Total alkalinity [TA] values were recorded in the range of 14mg/l to 198.5mg/l and 17mg/l to 327mg/l during the pre monsoon and post monsoon season respectively. The desirable and maximum permissible limit of TA in drinking water according to BIS (2012) is 200mg/l and 600mg/l respectively. The water sample collected from Padiyur (ODW1) exhibited maximum alkalinity compared to all other water samples in both the seasons and was above the desirable limit during the post monsoon season. This may be associated with comparatively higher concentrations of chlorides and other ions present in water, imparted by the poor waste management and percolation of sewage effluent. All other water samples have acceptable value.

Calcium (Ca) and Magnesium (Mg):
The values of Calcium (Ca) and Magnesium (Mg) in the water samples varied from 4mg/l to 84.8mg/l and 0.49mg/l to 70.95mg/l respectively during the pre monsoon season and varied from 3.9mg/l to 53.6mg/l and 0.32mg/l to 41.6mg/l respectively during the post monsoon season. The study shows highest Ca and Mg value was recorded in ODW1 during both the season. None of the water samples analyzed showed a value of Ca and Mg exceeding maximum permissible limit, however it was exceeding the desirable limit of Ca in ODW-1during the pre monsoon season and Mg in ODW1 during both the seasons and ODW2 during the pre monsoon season. All other values are well within the safer limit for both Ca and Mg as per BIS. The undesirable level of Ca and Mg in the water samples may be due to the leaches from solid waste dumped area or sedimentary rocks in the underground or it may be due to some agricultural practices and liming in that area. Ca and Mg are the two principal cations associated with hardness in drinking water. Higher concentrations of Ca in water cause the formation of concretion in the body and may cause intestinal diseases and stone formation (Dhembare, Ponde &Singh, 1998).

Chlorides (Cl):
The values of Chloride (Cl) concentrations in the open dung well water samples varied from 19.15mg/l to 517mg/l during the pre monsoon season and 8.67mg/l to 609.12mg/l during the post monsoon season. With the exception of ODW4 water sample, all the samples recorded more Cl value during the post monsoon season compared to pre monsoon season. ODW1 during both the season and ODW2 during the post monsoon season exhibited Cl concentration which exceeds desirable level but within the maximum permissible limit whereas other samples are well within the desirable limit. The highest Cl concentration was recorded in ODW1 and the lowest in ODW4. The excessive Cl in potable water is not particularly harmful to human however there is report that at concentration above aesthetic objective, Cl content imparts undesirable tastes to water (World Health Organization [WHO], 1984), may cause corrosion in the distribution system and may also harm growing plants (McConnell & Lewis, 1972). The higher concentration of Cl in ODW1and ODW2 can be attributed to the heavy discharge of sewage waste (Pettyjohn, 1972), leaches from solid waste dumping, sea water intrusion etc (National Research Council of Canada [NRCC], 1977).

Sulphate (SO_4):
The maximum desirable limit of Sulphate (SO_4) in drinking water is 200mg/l and maximum permissible limit is 400mg/l (BIS, 2012). SO_4 content of water samples in the study varied from 26mg/l to 41mg/l and 0.3mg/l to 45.2mg/l respectively during the pre monsoon and post monsoon season. No SO_4 content was detected in ODW4 during both the season and ODW3 during pre monsoon. The data clearly reveals that all the water samples have SO_4 value well within the safe limit.

Nitrate (NO_3):
As per BIS (2012), water containing Nitrate (NO_3) value up to 45mg/l is considered as desirable limit. The study shows only the sample ODW2 collected during post monsoon season from Eriyad recorded NO_3 value slightly above desirable limit (46.93mg/l) whereas all other water samples are safe. The excessive presence of NO_3 in ODW2 may be due to leaches from solid waste dumping and domestic sewage and agricultural runoff, which dissolve in rain water and leaches into the ground water (Zutshi & Khan, 1998).

Iron (Fe):
The concentration of Iron (Fe) in different well water samples varied from 0.27mg/l to 0.60mg/l during the pre monsoon season and 0.29mg/l to 0.68mg/l during the post monsoon season. Drinking water containing Fe value up to 0.30mg/l is considered desirable. When the Fe concentration in the domestic water supplies exceeds 0.3 mg/l, it becomes objectionable for a number of reasons that are indirectly related to health (Cohen, Lamphake, Harris & Woodward, 1960). Highest Fe value was recorded in ODW2 which exceeded the desirable limit during both the seasons. All other water samples are safe. The result shows a slight increase in Fe concentration during post monsoon period compared to pre monsoon.

Total Dissolved Solids [TDS]:
Total Dissolved Solids [TDS] value up to 500mg/l is considered

desirable for drinking purposes and a maximum of 2000mg/l is permissible under unavoidable situations. TDS was recorded in the range of 98mg/l to 1136mg/l during the pre monsoon season and 97mg/l to 1442mg/l during the post monsoon season. Water samples ODW1 and ODW2 are having TDS value which exceeded the desirable limit but within the maximum permissible limit whereas others are within safe limit. The water sample collected from Padiyur (ODW1) exhibited highest TDS value compared to all other water samples while the minimum was exhibited by Koratty (ODW4). The most important aspect of TDS with respect to drinking water quality is its effect on taste (Bruvold & Pangborn, 1966). The drinking water containing TDS more than 500 mg/l can cause excessive scaling in water pipes, water heaters, boilers and household appliances (Tihansky, 1974). Undesirable levels of TDS in ODW1 and ODW2 may be impacted by the dissolution of higher concentrations of chlorides, calcium, magnesium, sulphates, organic and other inorganic particles which resulted from the discharge of sewage and dumping of solid wastes (Mahananda, Mohanty & Behera, 2010).

Dissolved Oxygen [DO]:

Dissolved Oxygen [DO] values in the present study recorded in the range of 3.1mg/l to 5.2mg/l during the pre monsoon and 3.4mg/l to 5.9mg/l during the post monsoon season. An average of 5.0mg/l of DO is considered desirable for drinking water (Alberta Environment, 1977). ODW3 and ODW4 water samples have desirable DO level. However, ODW1 and ODW2 have DO level less than 4.0mg/l and found undesirable and this may be due to high oxygen demand resulting from high organic and inorganic pollutants received by water bodies (Osibanjo & Adie, 2007). Highest DO value was recorded in ODW4 whereas the lowest value in ODW1.

Biochemical Oxygen Demand [BOD]:

Generally the drinking water would be safe if Biochemical Oxygen Demand [BOD] value lies less than 1mg/l. The values of BOD in the present study varied from 2.9mg/l to 7.8mg/l during the pre monsoon season and 2.6mg/l to 7.0mg/l during the post monsoon season. This clearly indicates undesirable level of BOD in studied water samples and this may be attributed to the percolation of waste water loaded with biodegradable compounds (Pitchammal, Subramanian, Ramadevi & Ramanathan, 2009). The highest BOD value during the pre monsoon was recorded in both ODW1and ODW2 however it was ODW2 alone during the post monsoon season. The lowest BOD value was recorded in ODW4.

Bacteriological Properties

The bacterial contamination in water caused either directly or indirectly by human or animal excreta is one of the most common and widespread health risk associated with drinking water. A convenient way to evaluate potability and sanitary conditions of water bodies is through assessment of indicator bacteria. The result obtained from the bacteriological analysis of selected well water samples in different seasons are given in table 3. According to BIS guidelines, total coliform (TC), fecal coliform (FC) and fecal streptococci (FS) counts should be zero per 100ml of water which is used for drinking purpose.

The present study revealed about 75% of the "Laksham veedu" colony selected for the study having open dung well water sources failed to meet the bacteriological quality in both the season. TC and FC detected in ODW1, ODW2 and ODW3 and the count were above the permissible limits. TC and FC count ranged from 7 to 68/100ml and 3 to 25/100ml respectively during the pre monsoon season and 28 to 440/100ml and 12 to 150/100ml respectively during the post monsoon season. With respect to FS, their presence not detected in ODW4 during both the season and ODW2 during the pre monsoon season while others not satisfied the BIS permissible limit. FS count ranged from 4 to 11/100ml and 4 to 70/100ml respectively during the pre monsoon and post monsoon season. FC: FS ratio (fecal index) was found in the range of 2.27 to 4.25 and 2.14 to 4.46 in pre monsoon and post monsoon season respectively, which indicating a mixed type of pollution due to animal and human fecal contamination and which may pose an immediate health risk to anyone consuming the water (Okonko, Adejoye, Ogunnusi, Fajobi & Shittu, 2008). Investigation clearly reveals only water sample collected from "Laksham veedu" colony Koratty (ODW4) found free from bacterial contamination. The contamination of water samples collected from Padiyur (ODW1), Eariyad (ODW2) and Maala (ODW3) may be due to the leakages from septic tank, leaches from pit latrine system, cattle farming, seepage of domestic sewage through the soil etc in the colony area. Further, the data reveals the situation is more worsening during the post monsoon season, as the counts of TC, FC and FS bacteria recorded during the pre monsoon season have tended to increase (table 3). The increased count during the post monsoon season could be due to higher ground water level and poor filtering action of soil followed by more percolation of pollutants. This observation is in conformity with the previous findings of Chitanand, Gyananath, and Lade (2008) who found significant increase in the concentration of indicator organisms in the public bore wells of Nanded city during monsoon season.

CONCLUSION

The excessive level of many physicochemical and bacteriological parameters with respect to water samples ODW1, ODW2 and ODW3 compared to BIS IS:10500 specifications for drinking water render them unfit for human consumption, however the water sample ODW4 which was collected from 'Laksham Veedu' colony belonging to Koratty grama panchayath was found safe. The presence of fecal contamination in water sample ODW1, ODW2 and ODW3 indicates potentially dangerous situation which require immediate attention. The study further concludes that regular water quality monitoring of water bodies is highly necessary for maintaining a safe and reliable source. Well water should be tested a minimum of once per year and this allow us to properly address the specific problems of water and guide us to treat our water sources, if required, before being used up for drinking and other domestic purposes.

TABLE-1
Details of open dung well water

Sample code and open dung well	"Laksham veedu" colony [LVC] and Gramapanchayath	Remarks
ODW1	LVC –Padiyur	Open dung well water collected from 3 different wells from each "Laksham veedu" colony and averages were taken after analysis
ODW2	LVC -Eariyad	
ODW3	LVC -Maala	
ODW4	LVC –Koratty	

TABLE- 2
Physicochemical parameters of open dung well water collected from selected "Laksham Veedu" colonies during pre monsoon and post monsoon seasons in the Thrissur district

Parameter (mg/l)	BIS IS 10500: 2012 guidelines		Open dung well water sample							
	DL	MPL	Pre monsoon				Post monsoon			
			ODW1	ODW2	ODW3	ODW4	ODW1	ODW2	ODW3	ODW4
Turbidity (NTU)	1.0	5.0	0.5 ±0.2	0.3 ±0.1	0.1 ±0	0.2 ±0	0.8 ±0.1	0.5 ±0.1	0.1 ±0	0.1 ±0
EC (µS/cm)	800	-	2300 ±400	1400 ±270	200 ±60	100 ±16	2600 ±580	1500 ±200	250 ±50	100 ±12
pH	6.5	8.5	7.05 ±0.11	7.28 ±0.07	6.51 ±0.08	6.52 ±0.06	7.45 ±0.14	7.91 ±0.1	7.54 ±0.08	6.95 ±0.08
Total hardness	300	600	505.5 ±19.5	260.0 ±6	22.0 ±1	28.0 ±2	765.0 ±32	318.0 ±11	118.0 ±20	23.0 ±1
Total alkalinity	200	600	198.5 ±13.5	120.0 ±7	14.0 ±1	18.0 ±1	327.0 ±28	198.0 ±8	48.6 ±15	17.0 ±1
Calcium (as Ca)	75	200	84.8 ±7.3	59.2 ±6.4	8.0 ±0.2	4.0 ±0.3	53.6 ±6.8	33.6 ±2.8	5.3 ±0.3	3.9 ±0.2
Magnesium (as Mg)	30	100	70.95 ±6.35	35.22 ±2.8	0.49 ±0.06	4.37 ±1.03	41.6 ±4.65	19.18 ±1.85	0.32 ±0.05	2.45 ±0.36
Chloride (as Cl)	250	1000	517.0 ±27.3	191.5 ±4.63	24.89 ±1.94	19.15 ±0.76	609.12 ±27.81	272.64 ±11.54	43.46 ±3.12	8.67 ±0.93
Sulphate (as SO_4)	200	400	26.0 ±1.81	41.0 ±2.36	ND	ND	32.6 ±1.34	45.2 ±3.12	0.30 ±0.03	ND
Nitrate (as NO_3)	45	NR	29.75 ±1.87	42.08 ±4.58	24.80 ±2.15	17.72 ±1.18	31.42 ±1.72	46.93 ±3.7	28.34 ±0.96	18.28 ±0.8
Iron (as Fe)	0.3	NR	0.28 ±0.01	0.60 ±0.05	0.27 ±0.00	0.29 ±0.01	0.30 ±0.01	0.68 ±0.03	0.29 ±0.02	0.30 ±0.03
TDS	500	2000	1136 ±116	620 ±41	102 ±10	98 ±12	1442 ±219	732 ±56	231 ±18	97 ±9
DO	5.0	-	3.1 ±0.2	3.2 ±0.2	5.0 ±0.1	5.2 ±0.3	3.4 ±0.1	3.8 ±0.3	5.1 ±0.1	5.9 ±0.1
BOD	1.0	-	7.8 ±0.3	7.8 ±0.2	5.6 ±0.2	2.9 ±0.1	6.4 ±0.2	7.0 ±0.2	5.3 ±0.2	2.6 ±0.1

DL- Desirable limit; MPL –Maximum permeable limit; ND- Not detected

TABLE- 3
Bacteriological parameters of open dung well water collected from selected "Laksham Veedu" colonies during pre monsoon and post monsoon seasons in the Thrissur district

Parameter (mg/l)	BIS IS 10500: 2012 guidelines	Open dung well water sample							
		Pre monsoon				Post monsoon			
		ODW1	ODW2	ODW3	ODW4	ODW1	ODW2	ODW3	ODW4
TCC/100 ml	0/100ml	46 ±8	7 ±2	68 ±12	0.00 ±0	185 ±18	28 ±7	440 ±38	0.00 ±0
FC/100ml	0/100ml	17 ±5	3 ±1	25 ±4	0.00 ±0	79 ±12	12 ±5	150 ±32	0.00 ±0
FS/100ml	0/100ml	4 ±1	0.00 ±0	11 ±2	0.00 ±0	18 ±3	4 ±1	70 ±6	0.00 ±0
FC: FS ratio	-	4.25	ND	2.27	ND	4.39	3.0	2.14	ND

ND- Not defined

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