Original Research Article

A study on status of water contamination of the tube wells in a rural block of North 24 parganas district of West Bengal, India

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ABSTRACT

Background: In India, about 85% of rural drinking water supply depends on groundwater. National Sample Survey, 65th round showed that 55% of rural households were served by a tube well. But ground water pollution has drastically increased in last decade due to increased human activities. In India around 1.5 million children die of diarrhea and 37.7 million people are affected by waterborne diseases annually. The study was conducted to find out the prevalence of contamination of the tube well water and the factors associated with it.

Methods: A cross-sectional study was conducted in nine randomly selected villages of the Amdanga Block, North 24-Paraganas district, West Bengal. Water samples of 90 tube wells were tested for the bacteriological contamination using K020 HiH2S Test Strips (Modified) and factors associated with contamination were identified using logit model.

Results: The prevalence of tube well water contamination was estimated to be 45.6%. Bacterial contamination of water was found to be significantly (p<0.05) associated with the absence of casing, presence of bad odor in water, presence of habitation within 15 m area and presence of sanitary latrine within 15 m area of tube wells.

Conclusions: Ground water pollution is increasing because of human activities, suboptimal maintenance and poor environmental management around the sources. Routine surveillance of water sources, a sustainable system of maintenance and repair, and an effective waste management system in rural areas is required. Emphasis should also be given to household purification of water before consumption.

Keywords: Ground water, Tube well, Water contamination

INTRODUCTION

Drinking water is intended for human consumption and cooking purposes from a safe source. It includes water (treated or untreated) supplied by any means for human consumption.[1] Despite investments in water and sanitation infrastructure, many low-income communities in India and in other developing countries continue to be bereft of safe drinking water. While access to safe drinking water in India has increased over the past decade, the tremendous adverse impact of unsafe water on health continues. It is estimated that in India around 1.5 million children die of diarrhea alone and 37.7 million of people are affected by waterborne diseases annually.[2] Approximately 73 million working days are lost due to waterborne diseases each year which results in $600 million of economic burden in a year.[2] Access to safe drinking water remains an urgent necessity, as 30%

of urban and 90% of rural households still depend completely on untreated surface or groundwater.[3] Ground water is the water that seeps through rocks and soil and is stored below the ground.[4] It is used for domestic and industrial water supply and also for irrigation purposes all over the world.[5] In India, 92% groundwater extracted is used in the agricultural sector whereas the consumption in industrial and domestic sectors is 5% and 3% respectively.[2] Groundwater is preferable over surface water for a number of reasons. First of all, groundwater is reliable during drought, while surface water can quickly deplete. Groundwater is, in general, easier and cheaper to treat than surface water, because it tends to be less polluted.[6] But during last decade, ground water pollution has drastically increased of increased human activities.[7] Rural drinking water supply in India is to a large extent dependent on groundwater (about85%).[8] Data collected in 2008-09 for the 65th round of the National Sample Survey (NSS, July 2009) showed that 55% of rural households were served by a tube well, 12% by a well, and three per cent by a tap.[9] The major sources of groundwater pollution are principally the same as those of soil pollution and include landfills (waste dumps), accidental spills, agriculture, septic tanks, and atmospheric deposition. Dissolved pollutants move with the percolating soil water into groundwater, while organic liquid pollutants may reach the groundwater automatically. In addition, in areas where surface water infiltrates to groundwater, surface water pollution is a potential source of ground water contamination.[10] Due to these issues microbiological contamination of water still continues to be a widespread problem across the country and the major pathogenic organisms responsible for water borne diseases in India are bacteria (*E Coli, Shigella* and *V cholerae*), viruses (Hepatitis A, Polio Virus and Rota Virus) and parasites (*E histolytica, Giardia* and Hook worm).[2] In this background the following study was done to find out the prevalence of contamination of the tube well water and the factors associated with it.

METHODS

Study type and design

An observational, descriptive study of cross-sectional design.

Study setting

It was conducted in *nine r*andomly selected *[10% villages of total 81villages] villages of the Amdanga* Community Development *block* (of North 24-Paraganas district) which is the rural field practice area of the Department of Community Medicine, R.G.Kar Medical College, Kolkata, West Bengal from February to April 2016.

Sample size and sampling technique

The water quality assessments carried out in Kolkata in 2004 showed that 27.5% tube wells were bacteriologically contaminated.[11] Taking 27.5% as prevalence of water contamination with 95% confidence interval and 10% allowable error the sample size came out to be 76.56 tube wells. Considering that 10% of the tube wells may be derelict for last one month the sample size was calculated as 76.56+7.6 = 84.16 ~ 85. As the list of total number of tube wells in each village was not present during the sampling design it was decided to include equal number of tube wells from each village which came out as 85/9 = 9.44 tube wells/village. It was rounded off to *10* tube wells/village. Hence the final sample size of the tube wells to be studied became *90*. Nine villages were selected from the list of 81 villages by simple random sampling method.

Method of data collection and study tools

Tube wells from each selected village were chosen by random sampling. At first the center of the village was reached and one particular direction was selected by lottery method. Moving in that direction members of each successive household was asked about private possession of tube wells by them. An affirmative response by responsible member of the household was followed by brief introduction about the purpose of the study and obtainment of informed consent from that responsible respondent. Then an inspection of the tube well was carried out and relevant data were collected using a predesigned, pretested, semi-structured schedule. At last after proper hand washing and pumping out the water from tube well for one minute with the help of a second researcher, the water from the tube wells were collected in a sterile capped plastic container maintain all the aseptic measures. Finally the plastic container was placed safely inside the vaccine carrier containing four ice packs and the lid was closed firmly. Samples were also collected from common/community tube wells and relevant data were collected from the nearby households and users. Similar process was followed for collecting subsequent samples till the desired number of samples collected. Two vaccine carriers were used for collecting ten samples from one village. One such village was covered in one day and on the same day the samples were brought to the departmental laboratory for subsequent testing.

To test the bacteriological contamination of water, *K020 HiH₂S Test Strips (Modified) from HiMedia (HiMedia Laboratories Pvt Ltd., Mumbai, India)* were used. [12] The *HiMedia Test Strip (Modified)* is devised for simultaneous detection of *Salmonella, Vibrio* and *Citrobacter species*. Each Test Strip box contained ten sealed glass bottles and each bottle contained yellowish brown colored, rolled paper culture media. One such bottle was used for testing the water of each tube well. Water from the containers was filled into the bottles up to a particular arrow mark and shake gently maintaining all the aseptic precautions. Then the bottles were placed inside the incubator with temperature set at 37^0 C and the time was recorded. Then exactly after 48 hours the

incubator was opened and bottles were checked for presence of color change and growth. The interpretations are given in (Figure 1). After recording the findings the used culture bottles were sterilized in autoclave at 121 °C temperature and 15 psi above atmospheric pressure for 15 minutes and disposed into the yellow plastic containers for bio-medical waste management.
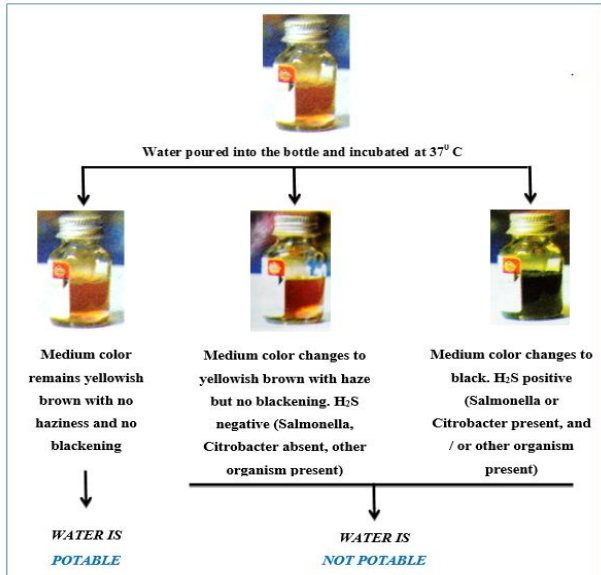
Figure 1: Flow diagram showing interpretations of color changes after 48 hours of incubation at 37^0 c.

Statistical analysis

Multinomial logistic regression was carried out to identify the factors responsible of bacterial contamination of water using the logit equation, i.e.

$$p[y = 1] = \frac{e^{(\beta 0+\beta 1 X1+\beta 2 X2............+\beta nXn)}}{1 + e^{(\beta 0+\beta 1 X1+\beta 2 X2............+\beta nXn)}}$$

Where, y is the presence of contamination. β1, β2,…βn are the coefficients of the explanatory variables and β0 is the intercept. *X1, X2,...Xn* are explanatory variables which includes characteristics of tube wells like condition of casing, connecting drain and platform, presence of slopping, bad odor and clogging of water, installing authority, duration of installation and requirement of repair. Surrounding environmental characteristics like presence of habitation, sanitary latrine, open field defecation, cattle shed, waste disposal area and water body within 15 meter diameter of the tube wells.[13]

Analyses were carried out using MS Excel 2010 spread sheet and SPSS version 20 software.

RESULTS

The mean (SD) distance of the study tube wells from the nearest cattle shed, waste disposal area and water body were 5.53 (4.12) meters, 14.92 (12.98) meters and 13.91

(11.94) meters respectively. 90.0%, 55.6% and 66.7% of the tube wells were found to be situated within 15 meters of the nearest cattle shed, waste disposal area and water body respectively. The mean (SD) distance from nearest habitation and sanitary latrine were 3.68 (2.40) meters and 3.89 (3.23) meters respectively. While one or more sanitary latrines were present within the 15 meters area of the tube wells in 96.7% of cases, practice of open field defecation within 15 meters area of the tube wells was reported in 15.6% of cases.

Almost $1/4^{th}$ (25.6%) of the tube wells studied were installed by respective panchayats and rests (74.4%) were installed by the villagers themselves (private ownership). While 76.7% (69 out of 90) tube wells were installed within ten years preceding the survey, the mean (SD) duration of installation was 6.83 (3.66) years. Majority (80.9%, 17 out of 21) of the tube wells installed more than ten years ago required repairing from time to time. While most (85.6%) of the tube wells provide water throughout the year, rests (14.4%) do get dry during the summer season. Description of different characteristics of study tube wells were given in Table 1.

As the block is not flood prone so history of inundation was absent. While water from all the tube wells was used for cooking, washing and bathing purposes, water from only 3 tube wells was not used for drinking purpose due to the strong bad odor of water as told by the users. Washing and bathing practices on the platform of the tube wells were reported in 88.9% and 87.8% of cases.

The water from 49 out of 90 tube wells studied was found to be potable i.e. no bacterial contamination detected (Figure 2).
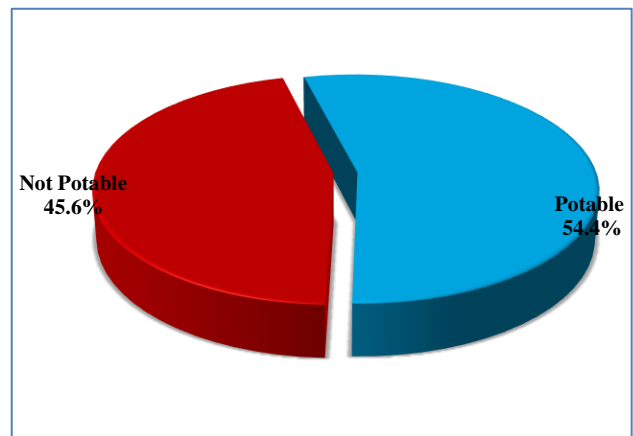
Figure 2: Proportion of tube wells found to produce potable water (n = 90).

Bacterial contamination of tube well water was found to be statistically significantly *(p<0.05)* associated with the absence of casing, presence of bad odor in water, presence of habitation within 15 m area and presence of sanitary latrine within 15 m area (Table 2). The odds (95% CI) of bacterial contamination for absence of

casing, presence of bad odor in water, presence of habitation within 15 m area and presence of sanitary latrine within 15 m area were 21.11(4.25 – 85.35), 5.05 (2.62 – 44.16), 1.68 (1.11 – 2.56) and 1.80 (1.18 – 2.85) respectively (Table 2).

Table 1: Profile of tube wells studied (n = 90).

		Present No (%)	Absent No (%)		Total No (%)
Casing		59 (65.6)	31 (34.4)		90 (100.0)
Platform		85 (94.4)	5 (5.6)		90 (100.0)
Slopping of platform	Present	60 (66.7)	NA	5 (5.6)	90 (100.0)
	Absent	25 (27.9)			
Condition of platform	Intact	24 (26.6)	NA	5 (5.6)	90 (100.0)
	Cracked	42 (46.7)			
	Broken in pieces	19 (21.1)			
Connecting drain		70 (77.8)	20 (22.2)		90 (100.0)
Type of drain	Kuccha	29 (32.2)	NA	20 (22.2)	90 (100.0)
	Pucca	41 (45.6)			
Clogging of water		52 (57.8)	38 (42.2)		90 (100.0)
Bad odor in pumped out water		15 (16.7)	75 (83.3)		90 (100.0)
History of inundation		0 (0.0)	90 (100.0)		90 (100.0)

Table 2: Multivariate logistic regression model results using water from tube wells detected as not potable as dependent variable, and different characteristics of the tube wells and surrounding environment as predictor variables (n = 90).

Variable	beta coefficient	SE beta	p value	Adjusted OR[#] (95% CI)
Habitation within 15 m area (present or otherwise)	1.521	0.214	*0.015*	1.68 (1.11 – 2.56)
Sanitary latrine within 15 m area (present or otherwise)	1.590	0.217	*0.007*	1.80 (1.18 – 2.85)
Open field defecation within 15 m area (practice present or otherwise)	1.652	1.271	0.194	5.21 (0.43 – 62.03)
Cattle shed within 15 m area (present or otherwise)	-1.549	1.256	0.217	0.21 (0.02 – 2.49)
Waste disposal area within 15 m area (present or otherwise)	0.790	0.877	0.368	2.20 (0.39 – 12.29)
Water body within 15 m area (present or otherwise)	0.670	0.886	0.450	1.96 (0.34 – 11.10)
Duration of installation (more than 10 years or otherwise)	1.410	1.031	0.171	4.10 (0.44 – 30.92)
Installing authority (self or otherwise)	-0.398	1.072	0.711	1.49 (0.08 – 5.49)
Repair (required time to time or otherwise)	1.228	0.804	0.127	3.41 (0.71 – 16.51)
Platform (absent/not intact or otherwise)	1.193	0.966	0.217	3.30 (0.49 – 21.88)
Casing (absent/not intact or otherwise)	3.307	0.949	*0.000*	21.11(4.25 – 85.35)
Slopping (absent or otherwise)	1.683	0.898	0.061	5.38 (0.93 – 31.29)
Connecting drain (absent/kuccha or otherwise)	1.381	0.903	0.126	3.98 (0.68 – 23.36)
Clogging of water (present or otherwise)	0.344	0.869	0.692	1.41 (0.26 – 7.74)
Bad odor (present or otherwise)	2.619	1.071	*0.045*	5.05 (2.62 – 44.16)
Intercept	-5.779	2.218	0.096	--------

-2 Log LR[@] = 64.038; Pseudo R- Square (Cox and Snell) = 0.487; LR Chi-Square, df, p* value = 60.016, 15, 0.000. #OR – Odds Ratio; LR@- Likelihood Ratio. Above model explained 48.7% of variance of water from tube wells being detected for bacterial contamination and the included explanatory variables contributed significantly to the model fit (p* 0.000).

DISCUSSION

The present study was conducted in the randomly selected villages of a rural block of West Bengal to assess the prevalence of tube well water contamination. Attempts were also made to identify the factors responsible for the same. In that regard, the tube well and its surrounding environment related factors as well usage practices were assessed. The prevalence of tube well water contamination was estimated to be 45.6%. A cross sectional community based study done by *Ray et al* during 2009-10 in two villages under Matigara block of Darjeeling district reported that 50% of rural water sources were contaminated at source point.[14] The *'Drinking water quality in the South-East Asia Region'* study published by WHO reported that water from 27.5% of the deep tube well in Kolkata city was bacteriologically contaminated.[11] Study done by *Mukhopadhyay et al* in Burdwan district during March-April 2013 reported that more than 50% of water samples contained fecal coliform and it indicated increasing pollution of groundwater by organic means.[15] The present study identified significant association between water contamination and absence of casing, and presence of habitation, and sanitary latrine within 15 meters of a tube well. It also probably indicates organic matter contamination of ground water. However according to Bureau of Indian Standards, drinking water should not be contaminated with fecal coliform.[1] As most of the groundwater coliforms come from the leaching of solid (human and animal excreta) and liquid wastes, sanitary risk of locating tube well/hand pump close to household toilets and accumulation of animal excreta near a drinking water source are the major risks in a typical rural settings.[3,16] According to *Martin* J, many tube wells in rural areas fail because they are overburdened and inadequately maintained.[17] The present study also identified that poor maintenance and absence of good sanitary practices around the tube well environment were significantly associated for water contamination. However even if the odds of the tube wells producing contaminated water and not having an intact platform, pucca connecting drain, peripheral slopping and presence of open field defecation within 15 meters area of tube well were 3.30, 3.98, 5.38 and 5.21 respectively, the association was not found to be statistically significant. According to a technical report of *Water Aid,* though open defecation was responsible for surface water contamination, animal wastes i.e. cattle excreta play a significant role in groundwater contamination in rural India in the absence of effective animal waste management.[16] The findings of the present study are similar with this.

CONCLUSION

Although the ground water is cleaner and less polluted as compared to surface water, the ground water pollution is increasing because of human activities, suboptimal maintenance of water sources, lack of monitoring and surveillance, and poor environmental management around the sources. The first step towards ensuring prevention and control of drinking water source contamination is to generate reliable and accurate information about water quality by routine surveillance of water sources by the relevant authorities to understand the risk of specific pathogens and to define proper control measures.

Recommendations

A sustainable system of maintenance and repair which will not only ensure availability and affordability of parts but also periodic inspection of the tube wells and replacement of parts that are damaged or show signs of deterioration is urgently required. An effective waste management system in rural areas is required along with intensified campaign against open field defecation. Finally, emphasis should also be given to household purification of water before consumption.

REFERENCES

1. BIS. Bureau of Indian Standards. Drinking Water Sectional Committee, FAD 25. Indian Standard Drinking Water- Specification (Second Revision). May 2012. Central Ground Water Board. Ministry of Water Resources, River Development and Ganga Rejuvenation. New Delhi. Available from http://www.cgwb.gov.in/Documents/WQ-standards.pdf. Accessed 12 Dec 2016.
2. Khurana I, Sen R. Drinking water quality in rural India: Issues and approaches. WaterAid India. 2008. Available from http://www.wateraid.org/~/media/Publications/drinking-water-quality-rural-india.pdf. Accessed 12 Dec 2016.
3. Srikanth R. Challenges of sustainable water quality management in rural India. Current Science. 2009 Aug 10;97(3):317-25.
4. Suhag R. Overview of ground water in India. PRS Legislative Research. New Delhi. Feb 2016. Available from http://www.prsindia.org/administrator/uploads/general/1455682937~~Overview%20of%20Ground%20Water%20in%20India.pdf. Accessed on 13 Dec 2016.

5. Dohare D, Deshpande S, Kotiya A. Analysis of groundwater quality parameters: A review. Research Journal of Engineering Sciences. 2014;3(5):26-31.
6. Sowrabha J, Narayana J. Assessment of ground water quality using for drinking purpose in Shivamogga Town, Karnataka, India. Int. J. Curr. Microbiol. App. Sci. 2014;3(12):381-8.
7. Manjit B, Sharma JK. Assessment of quality of ground water in some villages of Gurgaon district, Haryana (India)–focus on fluoride‖. Int. J. Innov. Res. Sci. Engg. Tech. 2014;3:11441.
8. Ahamed AJ, Ananthakrishnan S, Loganathan K, Manikandan K. Assessment of groundwater quality for irrigation use in Alathur block, Perambalur district, Tamilnadu, South India. Applied Water Science. 2013 Dec 1;3(4):763-71.
9. National Sample Survey, 65th round, National Sample Survey Organisation, Ministry of Statistics & Programme Implementation, Government of India, 2009.
10. Singh P, Shukla RK. Ground Water Quality mapping in Gorakhpur District. 11th ESRI India User Conference 2010. Available from http://www.esriindia.com/~/media/esri-india/files/pdfs/events/uc2010/papers/Parul%20Singh.pdf. Accessed 27 Nov 2016 Nov.
11. WHO. World Health Organization. Regional office for South-East Asia Region. Drinking water quality in the South-East Asia Region. New Delhi: Regional office for South-East Asia Region; 2010.
12. Khush RS, Arnold BF, Srikanth P, Sudharsanam S, Ramaswamy P, Durairaj N, London AG, Ramaprabha P, Rajkumar P, Balakrishnan K, Colford JM. H2S as an indicator of water supply vulnerability and health risk in low-resource settings: a prospective cohort study. The American journal of tropical medicine and hygiene. 2013;89(2):251-9.
13. Park K. Park's textbook of preventive and social medicine. 23rd ed. Jabalpur: M/s Banarashidas Bhanot; 2015. 710p
14. Ray K, Roy H, Chakraborty M, Biswas R. Exploratory Study on Water Quality and Sanitary Practice in Rural and Urban Communities of Siliguri, Darjeeling, West Bengal. Indian J Prev. Soc Med. 2011;42(2):199-203.
15. Mukhopadhyay S, Mukherjee R. Physico – Chemical and microbiological quality assessment of groundwater in adjoining area of Tamla Nala, Durgapur, District: Burdwan (W. B.), India. International Journal of Environmental Sciences. 2013;4(3):360-6.
16. Water Aid, Community-based water quality management in India. Technical report, 2008.
17. Martin J. Hand pumps for Rural Water Supply. University of South Florida. Available from: http://usfmi.weebly.com/uploads/5/3/9/2/5392099/2__hand_pumps_for_rural_water_supply_jenna_martin.pdf. Accessed 14 Dec 2016.