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Full Length Research Paper

Assessment of water quality and its effects on the health of residents of Jhunjhunu district, Rajasthan: A cross sectional study

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Achieving efficient, effective and cost effective water purification methods for the community is the key to human survival and development, as water management is a current global concern. Water is the basic resource necessary for sustaining all human activities, so its provision in desired quantity and quality is of utmost importance. Water pollution affects drinking water, rivers, lakes and oceans all over the world, which consequently harms human health and the natural environment. The present cross-sectional study is focussed on measuring the quality of drinking water in rural areas of Jhunjhunu district, Rajasthan and its effects on human health as told by the people living in these areas. Various analyses including physical, chemical and microbiological assessment were carried out on the water samples collected from the villages. The samples were found to have high pH, indicating alkalinity of the water samples, and high chromium content. Microbiological quality was also questionable in most of the cases. On the contrary to these findings, majority of people living in these areas were not suffering from various water borne diseases. So the study argues about the need and importance of water purification and water management systems in current times.

Key words: Water quality, chromium, cross sectional study, microbiological.

INTRODUCTION

Water covers over 71% of the earth's surface and is a very important natural resource for people (National Environment Research Council, 2007). Yet, only 2.5% of the earth's water is fresh and thus suitable for consumption. Not only that, but of that 2.5%, more than two-thirds is locked away in glaciers and not particularly able to help meet the growing demands of society (Ward, 2003). It is the fundamental right of every individual to get pollution free water. Water pollution affects drinking water, rivers, lakes and oceans all over the world, which consequently harms human health and the natural environment. Water pollution include sewage and waste water, industrial waste, oil pollution, marine dumping, atmospheric deposition, radioactive waste, underground storage leakages, global warming, eutrophication etc. (Gambhir et al., 2012).

Water pollution may not cause immediate effect on the health of the individual but can prove fatal in the long run. Heavy metals from industrial processes can accumulate in nearby lakes and rivers, proving harmful to the marine animals, other animals consuming this toxic water and humans using animal products. Toxins in industrial waste can cause immune suppression, reproductive failure or acute poisoning. Microbial pollutants from sewage often result in infectious diseases like cholera and typhoid fever which are the primary cause of infant mortality (Water Pollution Guide, retrieved from http://www.water-pollution.org.uk/economy.html). Water pollution can be

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Table 1. Indian data and statistics.

Year	No. of diarrhoeal deaths in 0-6 years	No. of diarrhoeal deaths in 6+ years
2006	1,68,896	3,15,818
2011	1,81,986	3,40,296
2016	1,95,046	3,64,716

Source: National Commission on Macroeconomics and Health, Ministry of Health and Family Welfare, Government of India, 2005).

damaging to the economy as it can be expensive to treat and prevent contamination. Waste that does not break down quickly accumulates in the earth's waters and eventually makes its way to the oceans (Water Pollution Guide) Table 1.

Diarrhoeal diseases represent a major health problem in developing countries and also a high risk to travellers who visit these countries. Conservative estimates place the global death toll from diarrhoeal diseases at about two million deaths per year (1.7 to 2.5 million deaths), ranking third among all causes of infectious disease deaths worldwide (World Health Organization, 2012). Most of these deaths occur in children under five years of age. An average morbidity attack rate of 3.2 episodes of diarrhoea per year per child has been reported, but in some settings in developing countries, this number can be as high as 12 episodes per year per child (World Health Organization, 2012) Table 1.

Evidence has been accumulating for long-term consequences of such heavy disease burden in early childhood, on physical and mental development of children that may eventually translate into costly impairment of human fitness, and productivity at an adult age. Moreover, outbreaks of cholera, shigellosis and typhoid fever most often occur in resource-poor countries, adding to the burden of disease among the most vulnerable such as refugees, internally displaced populations and groups living in shanty towns (World Health Organization, 2012).

Water pollution can be prevented by stopping pollutants from contaminating nearby waters. There are a number of water treatments to prevent pollution such as biological filters, chemical additives and sand filters. These simple techniques cost money to maintain, but prevention is much cheaper than cleaning up water pollution that has already occurred (World Health Organization, 2012). Keeping the above facts in mind, this study was carried out to assess the water quality of villages of Jhunjhunu district, Rajasthan and its effect on the health of individuals pertaining to water borne diseases.

METHODOLOGY

Study area

A cross-sectional study was carried out in villages Bangothri khurd, Bangothri kalan, Chapra to assess the health status of the individual pertaining to water borne diseases in the rural areas of Rajasthan.

Study tool

In total, 200 participants were interviewed with the help of a self designed pre-tested semi-structured questionnaire. Prior to the interview, informed consent was obtained from the participants. Questionnaire was designed to elicit descriptive accounts of the informants' everyday life, water usage, water storage habits, personal hygiene habits and experiences with diseases. Data collected was statistically analyzed using Statistical Package for Social Sciences (SPSS 10).

Study period

The study was carried out in a period of 4 months that is, August, 2009 to November, 2009. The study started with the collection of water samples from the villages, with the help of sterilised test tubes. For the microbiological sampling, water samples were brought to the laboratory in clean sterile test tubes and analysed within 24 h. These samples were taken from common water sources, that is, from where the whole village gets its water supply. So, testing water samples from these common sources like water tank, tube wells, wells, and common water taps, would serve the purpose and save resources.

To ascertain the physical, chemical and microbiological quality of drinking water of the selected villages, a total of 9 water samples were collected, one from the households (selected randomly), one from common taps (selected randomly) and one from the water tanks of each village. The household sites were chosen randomly using a random sampling technique. Physical parameters were measured directly at the water surface by conventional methods. Standard photometric analysis was employed for determination of chemical concentration of copper, chromium and Zinc. Microbiological assessment using Nutrient agar and MacConkey agar were used for presumptive and confirmed coliform counts, using the colony count and most probable number techniques.

RESULTS

The age distribution of people interviewed is given in Table 2. The education status of the population is given in Figure 1. According to the data collected, most of the subjects were illiterate (41%) or below metric pass (38%), so the level of literacy was very poor among the subjects under study.

Monthly income of the subjects

Majority of the subjects (65.0%) were from lower

Table 2. Age distribution of the subjects.

Age group	Percentage
16-20	10.5
21-25	28.5
26-30	17.0
31-35	14.5
36-40	10.0
41-45	5.5
46-50	5.0
51-55	2.5
56-60	6.5

socio-economic group, earning a monthly salary of 0 to 5,000 rupees only. Mean salary of the studied population was Rs. 5,175 only.

Sources for drinking water

Various sources for drinking water were tap (15.5%), well (13.0%), tube well (13.0%), and community water source supply (58%). Methods used for purification of drinking water included boiling (4.0%) and muslin cloth (7.5%), while 88.5% did not use any method for purification of drinking water.

Storage of drinking water

During storage of drinking water also, they did not use any precaution particularly. About 92.5% stored water in earthenware pots, 6.5% in stainless steel containers, 0.5% in plastic buckets as indicated in Figure 3. Most of them did not use any separate glass for taking out water from the containers in which water was stored. Inhabitants of the village, especially children, did not use basic hygiene measures like washing hands before taking out water from the storage container. Most of the villagers informed that they wash their water-storage utensil once a month while some of them washed it onceevery 2 to 3 months. Most of them were not aware of various precautions to be taken before and after storing water and to prevent water-borne diseases.

Medical illness of the subjects

About 20% suffered from medical illnesses like diarrhoea, vomiting, headache, stomach ache, dizziness, fever etc. while 80% did not have any such symptoms as shown in Figure 2.

Laboratory results

Physical, chemical and microbiological test results are shown in Table 3. Most probable numbers (MPN) is a suitable and widely used method to determine the extent of microbiological quality of water. Most of the villages showed infinite number of microbial content, with the worst being Chapra village. This might be due to the favourable conditions like temperature, pH etc. High value of MPN indicates that water is not suitable for drinking purpose. Most bacteria grow between pH 4 to 10 and exhibit optimum growth in the range of pH 6.5 to 7.5.

DISCUSSION

The villages Chapra, Bangothri Kalan and Bangothri Khurd have around 472, 476 and 550 households, respectively. The district has a population of 2,139,658 (2011 census), an area of 5,926 km², and a population density of 361 persons per km². Jhunjhunu district is supplied by mainly Sekhawati basin, and north western part falls under the basin, that is having inland drainage (Ministry of Water Resources, Government of India, 2008). Depth of ground water is between 20 m to 100 m, mostly observed in areas located to the west of Aravalli ranges covering Barmer, Jalore, Jhunjhunu, Sikar, Nagaur, Churu, Jaisalmer, Sirohi, Jodhpur, Bikaner, Jaipur, Hanumangarh and Dausa districts, served mainly by Kantli River (Ministry of Water Resources, Government of India, 2008). The region receives an annual rainfall of about 300 to 500 mm (Government of Rajasthan, 2009). As shown in the result of the above study also, the ground water is alkaline type, having pH value more than 7.

In India, majority of the rural population (approximately 72%) does not use any method of water disinfection and have no sanitary toilets (74%) (International Institute for Population Sciences (IIPS) and Macro International, 2007). Open air defecation is also a common practice among villagers, and may lead to contamination of the water supply system resulting in outbreaks of diarrheal diseases (Bora et al., 1997; Sarkar et al., 2007). According to the above study also, majority of villagers (88.5%) did not use any method for purification of drinking water and had poor knowledge about the need and availability of safe drinking water.

The commonest form of disinfection in rural India is single-point chlorination, using bleaching powder. However, this may not be effective because of the possibility of multiple sites of contamination (Propato and Uber, 2004). Alternative point-of-use disinfection methods such as solar water treatment (Kang et al., 2006; Rose et al., 2006) or point-of-use chlorination (Arnold and Colford, 2007) and storage of water in narrow-mouthed vessels (Mintz et al., 1995), need to be explored. Considering the contamination of all water samples at the household level, end-user disinfection with chlorine is likely to be more effective in such settings (Clasen et al., 2006) and it should be according to the WHO standards (World Health Organization, 1993). It has been estimated that diarrheal morbidity can be reduced by an average of 6 to 20% with

Table 3. Physical parameters.

Characteristic	Chapra villages	Bangothri khurd	Bangothri kalan
Taste	Agreeable	Agreeable	Agreeable
Odour	Unobjectionable	Unobjectionable	Unobjectionable
Temperature (°C)	26.5	27	27.5
Turbidity	No turbidity	No turbidity	No turbidity
Clarity	Clear	Clear	Clear
Chemical assessment			
pH	8.763	8.232	8.367
Heavy metal			
Copper (ppm)	Nil	Nil	Nil
Chromium (ppm)	0.117	0.110	0.078
Zinc (ppm)	0.258	0.277	0.233

Microbiological assessment		
Villages	**Nutrient agar (Colonies/100 ml of water)**	**Mckonkey agar (Colonies/100 ml of water)**
+Control	Infinite	Infinite
-Control	Nil	Nil
Chapra village	Infinite	Infinite
Bangothri Khurd	8	Nil
Bangothri Kalan	Infinite	8
Pond water	Infinite	Infinite

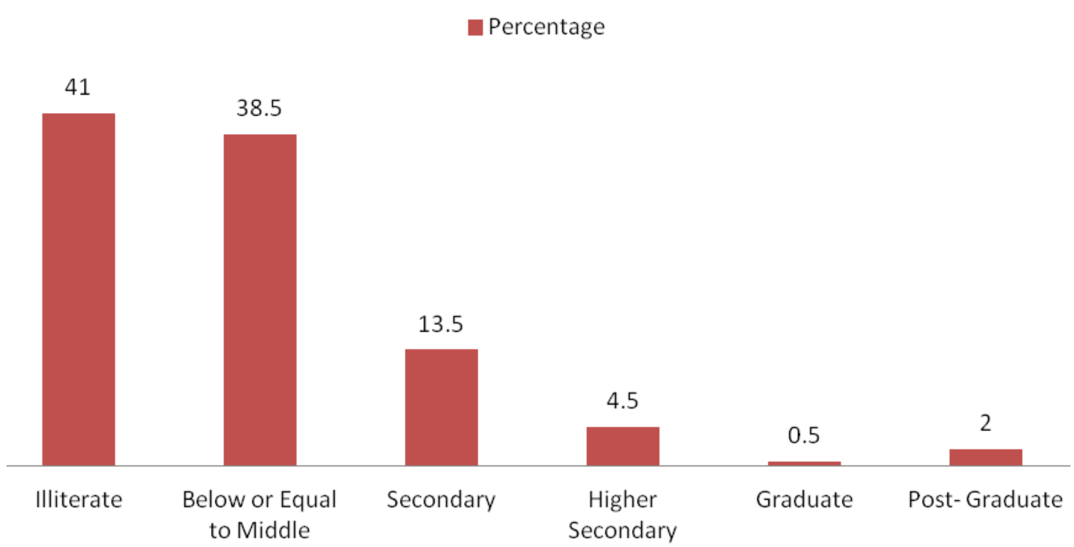

Figure 1. Educational status of the subjects.

improvements in water supply and by 32% with improvements in sanitation (World Health Organization, 2004). Educating people and mass media campaigning can be used to popularize these methods. However, sustainability of these methods over longer periods or cost-effectiveness in rural India is still questionable. In the present study, use of chlorine for water purification was not prevalent.

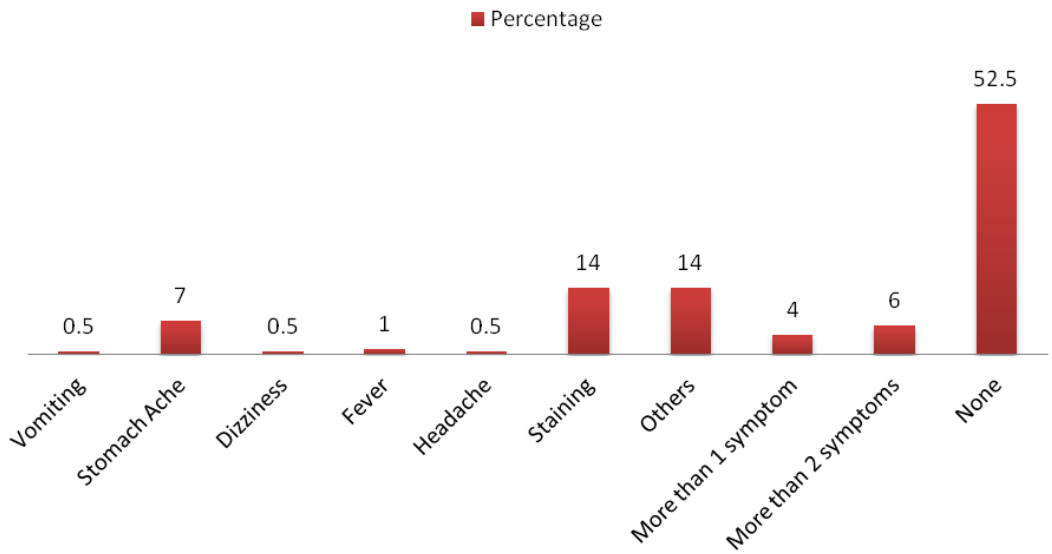

Figure 2. Past medical history of the subjects.

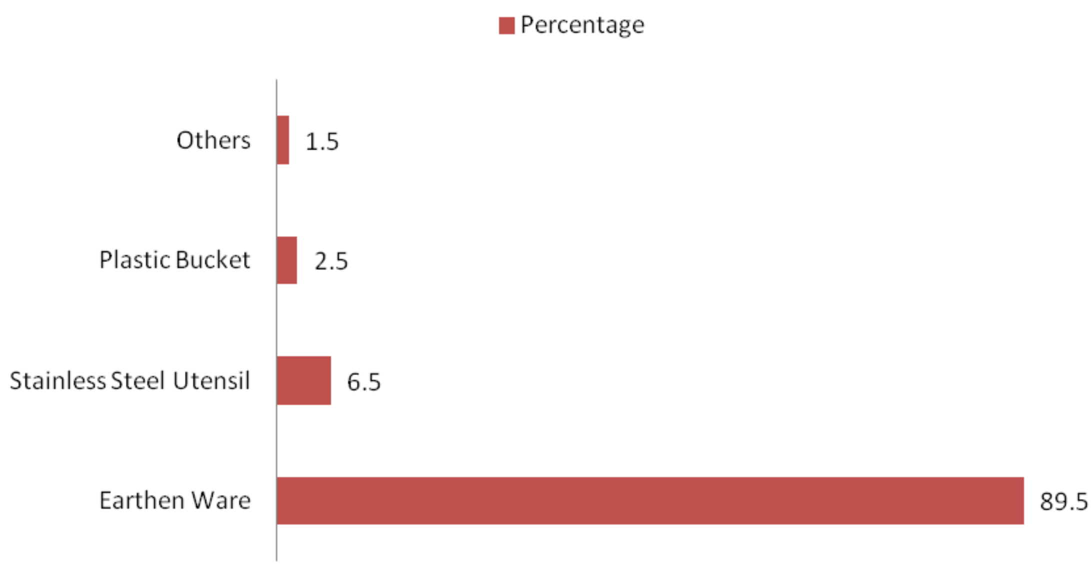

Figure 3. Storage of drinking water.

The study villages had no organized sewage system, open drains were common site and there was localized collections of waste water. Animal faecal matter was interspersed around houses (where animals were tethered), and on the streets. Children were seen defeca-ting on the streets. Also at certain points, faeces were visible in the sewage drains and around the loca-lized waste water collection spots. There was no system for collection and disposal of garbage. In certain places, garbage was inseparable from human and animal faeces, so the chances of diarrheal diseases were even more, but on the contrary 80% of people living in these villages did not report any symptom of diarrheal diseases. The reasons for this may be that they have developed immunity towards various water-borne bacterial and viral infections. The other reason could be that people are unaware about these symptoms, their relevance and why reporting these symptoms is important. So their ignorance about these symptoms and diseases could have been responsible for under reporting of the same.

The study also indicated that the accumulation of heavy metals over large areas and long periods of time resulting in gradual damage to living organisms necessitates careful monitoring of the input, movements and effects of such pollutants (Ida, 2012). Other studies also came out with similar results like a study of drinking water quality of desert affected area of Jhunjhunu district in Rajasthan which was carried out to find out water pollutants and to test the suitability of water for drinking and irrigation purpose in study area. In this study, it was found that nitrate fluoride and total dissolved solids (TDS) were higher, and water of study area was found to be hard (Literature Review).

In the study on heavy metal contamination in ground water at outer skirts of Kota city, Rajasthan India, researchers analyzed 72 ground water samples for determination of contamination level of Fe, Pb, Ca, Zn, Mn, Cr, and it was found that lead and chromium concentrations were high (Patil and Ahmed, 2011).

Zinc

Zinc is a very essential micronutrient in human being but if at very high concentrations, it may cause some toxic effect. Zinc compounds are astringent corrosive to skin, eye and mucous membranes. They cause special types of dermatitis known as "Zinc pox". Zinc is also irritating to digestive tract, causing nausea and vomiting. The maximum permissible concentration of zinc in drinking water is 15 ppm according to World Health Organization (WHO). The values of zinc content in all water samples of the study were below the maximum permissible limit according to WHO (1996) norms (Patil and Ahmed, 2011).

Chromium

Chromium is also essential to organisms as a micronutrient, in traces from fat and carbohydrate metabolism. Chromium is also more harmful in its lower oxidation state (III). Chromium and chromates are potential carcinogens. The limit of chromium in drinking water is 0.01 ppm according to WHO. The values of chromium content in all water samples were higher than maximum permissible level according to WHO (1996) norms. This is a serious health risk and should be looked upon by the concerned authorities (Patil and Ahmed, 2011).

The limitations of study are the low sample size of the study; fluoride, chlorine and other heavy metals levels were not tested due to resource constraints. Long term effects of these results were not studied in the sample population.

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