ORIGINAL ARTICLE

Health Effects from Exposure to Sulphates and Chlorides in Drinking Water

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ABSTRACT

This study was designed keeping in view the negative and harmful effects of high levels of Sulphates and Chlorides present in drinking water sources after investigating Sulphate and Chloride contents. Sadiqabad, Rahim Yar Khan, Khanpur and Liaqatpur cities of district RYK, Punjab, Pakistan were investigated for the Sulphate and Chloride levels in different drinking water sources.53 and 23 percent of Sulphate and Chloride samples respectively were found having values greater than the guideline value obtained from the whole district of Rahim Yar Khan. Health Survey was conducted in the areas with higher contents of Sulphates and Chlorides .Almost 55 percent of population confirmed laxative effect and taste problem. Suggestions to prevent health effects were given.

Key words: Health effects, sulphates, chloride, drinking water

INTRODUCTION

In Pakistan, most of the population relies on shared water sources. Whether it is ground water, nearby river, ponds or even harvested rainwater, these water sources are usually shared by both humans and animals. Human uses include purposes such as bathing, washing, laundering, cooking and drinking. These uncontrolled varieties of human and animal use potentially alter the quality of natural source waters significantly. This calls for the need for effective management that warrants the maintenance of the fitness for use of water resources on a sustained basis, achieving a balance between usage and environmental protection.

Globally the subject of contaminant levels in drinking water has been a long contentious issue. However, in Pakistan and other developing nations where relevant institutional capacities are either non-existent or fragile, robust surveillance and early warning systems for chemical contaminants rarely exist. In cases where they do, the focus is on water access and not water quality bearing in mind the peculiarity of the location. Whereas water supply is seen as a national issue, pollution is mainly felt at, and dealt with, at the local level. National governments, with few exceptions, have little information on the relative importance of various types of pollution (agriculture, municipal, industrial, animal husbandry, aquaculture, etc.) and therefore have no notion of which is of greatest economic or public health significance (Abbaspour, 2007). Consequently, it is difficult to develop a strategic water quality management plan or to efficiently focus domestic and donor funds on priority issues as quality surveillance. Our study is one of the few independent reports that attempt to evaluate the concentrations of chlorides and sulphates in drinking water sources in Pakistan with an attempt to provide by surveys, epidemiological linkages to suggest potential health effects from exposure to elevated levels of the chemicals in drinking water.

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MATERIALS AND METHODS

Rahim Yar Khan District has an area of 11,880 square kilometers and comprises four Tehsils, which are Liaqatpur, Khanpur, Rahim Yar Khan, Sadiqabad with a total population of more than 4.73 million in 2011. The district Rahimyarkhan lies between 27.40' - 29.16' N latitudes and 60.45' - 70.01' E longitudes. The climate of the district is hot and dry in the summer and cold and dry in the winter.

Water samples were collected from different water sources (hand pumps, tube wells, canals and public water supply systems) from cities of Sadiqabad, Rahimyarkhan, Khanpur and Liaqatpur during the period of 2010-11. Water quality determinations of sulphate and chloride contents were carried out in chemistry laboratories of Sadiqabad College of Technology Sadiqabad, and Agriculture Department, Punjab Pakistan. Chloride was measured by silver nitrate titration using a chromate indicator, and a chloride ion-selective electrode. Sulphate ion was precipitated in a hydrochloric acid medium with barium chloride to form $BaSO_4$ crystals of uniform size. Light absorbance of the $BaSO_4$ suspension was then measured by nephelometery using a turbidimeter.

Sulphate concentration was extrapolated with the help of a prepared standard curve (15).

With collaborative assistance received from a local non-governmental organization (SAWACO), a health survey was conducted in areas with high values of chlorides and sulfates. Volunteers assisted in the administration of questionnaires among population in polluted areas in 1st quarter of 2012. Results were analyzed to identify any health concerns related to the elevated levels of chloride and sulfates in source waters available for residents each considered community.

RESULTS

A total of one hundred and fifty one samples were analyzed during the study. This consisted of hand pumps (n=88), tube wells (n=54), surface water (Canals) (n=06) and public water supply system (n=03). Out of the 151 samples analysed, 47% has sulphate levels within guideline limits while 53 percent of the samples had values above the limits. The number of samples with sulphate levels within and above guideline values is presented in Fig. 1. Curiously, as in Table 1, sulphate concentrations of a sample was as high as 7760 mg/L for samples collected from hand pumps. Altogether, 6.7%, 18.5% and 25.2% respectively had sulphate values within the range 250-300mg/L, 300-500mg/L and > 500 mg/L respectively. Out of 151 samples analysed, 77 percent had chloride levels within guideline value (Fig 2). For samples that exceeded the guideline values, chloride concentration was relatively low (23%) (Table 2). However, high chloride levels of up to 3190 mg/L were detected in samples from hand pumps. On the whole, 4.0%, 9.3% and 9.9% respectively had sulphate values within the range 250-300mg/L, 300-500mg/L and > 500 mg/L respectively.

Results from the health survey revealed that prolonged exposure to excessive levels of chlorides and sulphates may be attributable to health effects in the sampled population. In areas where consistently higher than guideline values were observed, residents complained of gastrointestinal tract problems such as diarrhea, nausea, inflammatory bowel disease. Almost fifty five percent among survey reported diarrheal symptoms and consequent dehydration. From an analysis of our survey questionnaires, chloride concentrations in excess of about 250 mg/Litre was associated with detectable taste in water. Consumers can, however, become accustomed to concentrations in excess of 250 mg/Litre. Individuals moving into areas with high Sulphate concentrations from areas with low Sulphate concentrations in drinking water complained about health effects such as gastroenteritis. Although it was not possible to screen out the possibility of gastroenteritis resulting from other sources, for example bacterial infection; tourists, hunters and students not normally resident in Rahimyarkhan were generally more affected. Questionnaire response also revealed that water distribution system in the urban area is either un-adequate or has reached its full development. Physical observation revealed that there is no public water supply system in rural area considered in the study neither was there any water treatment plant. Consequently, most of population resolve to the use of groundwater through electric pumps or hand pumps.

Fig.1: Samples (%) with sulphate levels within (-ve) and above (+ve) guideline values

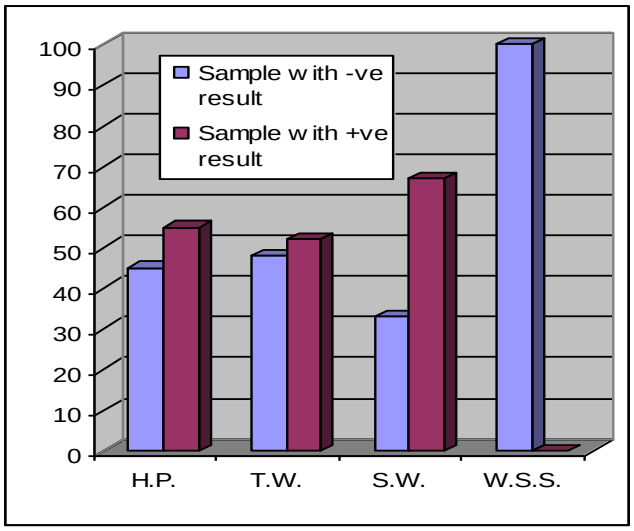

Fig. 2: Samples (%) with chloride levels within (-ve) and above (+ve) guideline values

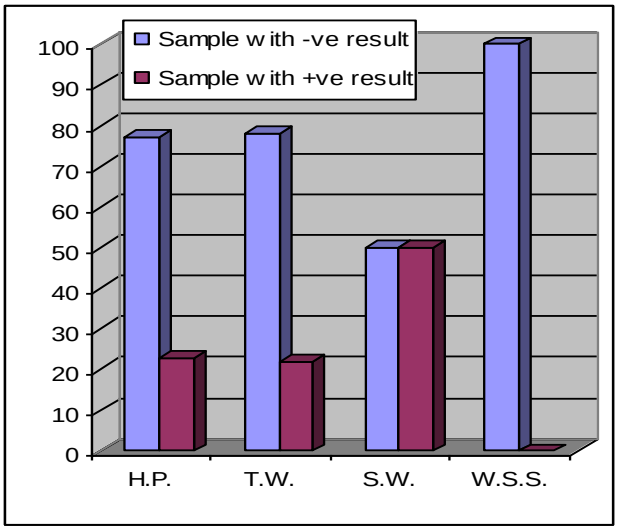

Table 1: Observed sulphate levels of different water samples

Sample source	Sulphate levels within guideline values	Sulphate levels higher than guideline values	Range (Mg/L)
HP	40(45.5%)	48(54.44%)	31.2-7760
TW	26(48.5%)	28(51.85%)	0-1990
SW	02 (33.33%)	04(66.67%)	180-413
WSS	03 (100%)	0	82.3-99.2

Table 2: Observed chloride levels of different water samples

Sample source	Sulphate levels within guideline values	Sulphate levels higher than guideline values	Range (Mg/L)
HP	68(77.27%)	20(22.73%)	14-3190
TW	42(77.78%)	12(22.22%)	18-780
SW	02 (50.00%)	03(50.00%)	35-56
WSS	03(100%)	0	148-405

DISCUSSION

Sulfates occur naturally in drinking water, usually as a combination of sulfur and oxygen. Some minerals present in soil also get dissolved and are ultimately released to groundwater as Sulfates. A number of health concerns regarding sulfate in drinking water have been raised because of reports that diarrhea may be associated with the ingestion of water containing high levels of sulfate. In the current study, high sulfate levels were observed especially in hand-pumps. In most developing countries, major settlements enjoy pipe borne water supply albeit erratic. In the rural communities, bore holes fitted with hand pumps serve as the main source of alternative 'potable' water. In an age where more and more emphases is suggested to be placed on the provision of hand pumps and wells for rural settlements, the results of this study thus gives cause for concern. High sulphate levels in drinking water as observed in the current study may be attributable to relatively shallow depth of wells attached to these pumps and the proximity to resources of pollution from human dwelling and animal yards. One striking observation in support of this assumption was the high sulphate levels from hand pumps on lands close to cattle feed lots and intensive agricultural sites in Punjab where chemical fertilizers were regularly applied.

There may be up to one percent sulfate present in gastric fluids. Normally, the body maintains a homeostasis between absorbed inorganic Sulphate, Sulphate compounds, and renal excretion; membrane transport and regulation contribute to this homeostasis. There have been a number of studies conducted to determine the toxicity of sulphate in humans. Chien et al. presented case reports of diarrhea in three infants exposed to water containing Sulphate (ranging from 630-1,150mg/L)[10]. However, there were other potential causes of the diarrhea in these infants like consuming infant formula with high osmolarity or the presence of microbial pathogens that were not thoroughly addressed by the investigators. Almost fifty five percent among survey reported diarrheal symptoms and consequent dehydration. These are mainly related to sulphate toxicity and due to these above mentioned effects patients having dehydration. Sulfates have a laxative effect that leads to dehydration especially infants are more prone to its effects. But with passage of time, people and young live stocks become acclimated to the sulfate and the symptoms disappear[9].

A survey conducted in North Dakota found a slight increase in the percentage of people (28%) who reported that their drinking water had a laxative effect when the drinking water contained 500 to 1,000 mg/L Sulphate compared to the percentage of people (21%) who reported a laxative effect from drinking water that contained <500 mg/L. Fifty one percent of people who consumed water with 1,000 to 1,500 mg/L reported a laxative effect. Arguably, the generally accepted concern is that which relates to greater risk from the laxative effects of sulfate when vulnerable populations experience an abrupt change from drinking water with low sulfate concentrations to drinking water with high sulfate concentrations. One such potentially sensitive population is infants receiving their first bottles containing tap water, either as water alone or as formula mixed with water. Another group of people who could potentially be adversely affected by water with high Sulphate concentrations are transient populations like tourists, hunters, and other temporary visitors who moves into areas with high Sulphate concentrations in the drinking water from areas with low Sulphate concentrations in drinking water[12].

It is suggested that most people may experience laxative effect when they drank water containing >1000 mg of Sulphate per litre[13,14]. However, like other ones, the current study may not be assertive about a statistically significant association between consumption of water with excessive sulphate levels and clinical syndromes experienced by the surveyed population. The science of sulphate levels in drinking water is itself rocked with inherent questions which still remain answered. Where reported studies suggest that a certain sulfate level would not be likely to cause adverse effects, existing data do not identify the level of sulfate in drinking water that would be unlikely to cause adverse human health effects.

Again with the assumption of acclimatization or adaptation to certain levels of sulphates in drinking water, findings on how long this takes is still yet to be published. Furthermore, in referring to the potential health effects of elevated sulfate levels in drinking water, one is quick to refer to vulnerable populations as being at risk, particularly infants. However, there are no dose-response studies to substantiate this partly because of the difficulty of locating a population of women feeding their infants formula mixed with unfiltered tap water containing high levels of sulfate. Consequently, it appears that there is not enough scientific evidence on which to base a regulation but a mere health advisory in places where drinking water has sulfate levels of >500mg/L, based solely on precautionary principle

Chlorides occur in surface and groundwater as a result of intrusion from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas (DNHW, 1978). Available data reveal that the mean chloride concentration in several rivers in the United Kingdom is in the range 11–42mg/litre during 1974–81 (Brooker and Johnson, 1984). Also evidence of a general increase in chloride concentrations in groundwater and drinking-water has been found (WHO, 1978). In developed nations, aquifers prone to seawater intrusion have been found to contain chloride at concentrations ranging from 5 to 460 mg/litre (Phelan, 1987), whereas contaminated wells in developing nations such as the Philippines have been reported to have an average chloride concentration of 141 mg/litre (Morales, 1987). Chloride levels in unpolluted waters are often below 10 mg/litre and sometimes below 1mg/litre (WHO, 1996)

However, high chloride levels of up to 3190 mg/L were detected in samples from hand pumps in our current study. Chloride in surface water and groundwater from both natural and anthropogenic sources, such as extensive use of Potassium fertilizer in which Potassium Chloride is used during production, landfill leachates, septic tank effluent, animal feeds, industrial effluents, and irrigation drainage. High values of Chlorides may also be due to extensive use of Sodium Chloride in production of industrial chemicals such as Caustic Soda, Chlorine, Sodium Chlorite and Sodium hypochlorite. The chloride ion is highly mobile and is transported to nearby watershed and river basins.

Usually, chloride concentrations in excess of about 250 mg/Litre can give rise to detectable taste in water, but the threshold depends upon the associated cations, a typical example being Sodium. The presence of sodium in drinking water is of significant health concerns. Therefore, the US Environmental Protection Agency (EPA) now requires drinking water to be monitored for sodium and public water suppliers are directed to report local health authorities any concentration above 250 mg/L. Chlorides in drinking water usually create taste and odor problems at concentrations exceeding 250 mg/L. In New Hampshire from 1983 to 2003 the NHDOT replaced more than 424 private wells contaminated by road salt at a cost of $3.2 million. Several public water supply wells have also been abandoned due to contamination[1,2]. Although excessive intake of drinking-water containing sodium chloride at concentration above 250mg/L has been reported to produce hypertension[3], this effect is believed to be related to the sodium ion concentration. Consumers may become accustomed to concentrations in excess of 250mg/L.

In humans, 88% of chloride is extracellular and contributes to the osmotic activity of body fluids. A normal adult human body contains approximately 81.7g chloride. On the basis of a total obligatory loss of chloride of approximately 530mg/day, a dietary intake for adults of 9mg of chloride per kg of body weight has been recommended for children up to 18 years of age, a daily dietary intake of 45 mg of chloride should be sufficient[4]. A dose of 1 g of sodium chloride per kg of bodyweight was reported to have been lethal in a 9-week-old child[7]. Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure[8]. Healthy individuals can tolerate the intake of large quantities of chloride provided that associated intake of fresh water. Little is known about the effect of prolonged intake of large amounts of chloride in the diet. As in experimental animals, hypertension associated with sodium chloride intake appears to be related to the sodium rather than the chloride ion[4]. However, adverse effects related to high chloride concentration are increased number of polymorhonuclear leukocyte and disturbed blood cell counts in full blood count analysis.

CONCLUSION

On a conclusive note, the current study revealed that higher than guideline levels of consumers of sulfates and chlorides in available drinking water in Rahimyarkhan. Consumers can however, become accustomed to concentrations in excess of 250mg/Litre. Individuals moving into areas with high Sulphate concentrations from areas with low Sulphate concentrations in drinking water complained about health effects such as gastroenteritis. Although

it was not possible to screen out the possibility of gastroenteritis resulting from other sources, for example bacterial infection; tourists, hunters and students not normally resident in Rahim Yar Khan were generally more affected. It is thus suggested that efforts be made to provide at least one laboratory in each city working in collaboration with health officials in district hospitals.

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