

Economic Impact Assessment of Brackish Groundwater in Kirana Hills Region, District Chiniot, Pakistan[†]

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Abstract: Good quality water is the basic need of every citizen. Contaminated water not only affects our health but also damages household items such as sanitary materials. The purpose of this study is to assess the economic impact of high Total Dissolved Solids (TDS) groundwater in Kirana hills region of district Chiniot. In order to evaluate the economic impact in areas of different TDS levels of water, a survey was conducted. The survey form comprised fifteen questions related to health impact, laundry, cooking and sanitary issues. Results of data collected from the respondents of very hard water area indicated that the water causes digestive, skin and hair related diseases. According to the survey, in very hard water areas, washing clothes with groundwater makes them look rough, dull or stained. However, people living in hard water areas responded that the water is relatively better for laundry. Overall residents of very hard water area and hard water area bear costs of rupees 73,850 and 16,200 per five years respectively. By provision of good quality water and taking measures to clean the groundwater, problems can be resolved as the quality of water is positively correlated with the quality of our lives. A collective effort by government and society can minimize the loss by installing appropriate filtration techniques.

Keywords: Kirana hills, GIS, water analysis, economic impact, district Chiniot.

Introduction

Water is generally known as a universal solvent as it can dissolve almost anything. When water moves through the rocks and soil it dissolves some impurities like calcium and magnesium, holding them in a solution. Once the water has an adequate amount of these minerals along with metals present such as sulfate, chloride, aluminum, barium, iron, zinc and manganese, it ends up as hard water. These divalent cations in combination with anions in the water constitute stable salts (Pallav, 2013). The degree of hardness depends on the amount of calcium and magnesium in the groundwater. Contaminated water is not only hazardous to health but also damages the infrastructure at the domestic and industrial level (Browett. et al., 2012).

The main focus of our current study includes the economic loss incurred at household level due to brackish groundwater (> 2000 TDS) in the Kirana hills region of district Chiniot. As good quality municipal supply water is inadequate, most of the population depends on groundwater for domestic use. Previous studies have revealed that groundwater of this region has generally high TDS and is close to the exposed rocks (Ahmad *et al.*, 2016).

According to McGowan, (2000), water having calcium carbonate concentrations less than 17 mg/L is considered 'soft' while 17-60 mg/L, 60-120 mg/L, 120-180 mg/L and more than 180 mg/L is considered slightly hard, moderately hard, hard and very hard respectively. According to Ahmad *et al.* (2016) no sample from study area was found within soft to

moderately hard water category. Only 2.5% of groundwater samples were found to be hard and remaining 97.5% samples belonged to very hard water category. According to the permissible range set by WHO (2008), 30% of the area has groundwater within the permissible range (500mg/L) while water quality of 70% of the area has a hardness in non-permissible range. According to EPA (2001), the criteria scaling effect or clogging starts at the total hardness of 200mg/L. High TDS water can cause damage to sanitary items such as taps, marble floors, showers, geysers and boilers (Browett., et al., 2012). This study assesses the economic burden on the households.

Study Area

The town of Rabwah is the main focus of this research and is situated in the Kirana hills region of district Chiniot. It is surrounded by Precambrian rocks to the north and Chenab river in the east. The Kirana hills are mostly composed of meta-sediments and igneous rocks of Precambrian age represented by quartzite, slates and phyllites (Chaudhry et al., 1999).

The municipal water supply is generally inadequate, therefore, the local population has to rely on private wells. The level of TDS is very high in the northern and central part of the area, which is close to the exposed rocks, whereas it gets lower away from the hills (Ahmad *et al.*, 2016).

Materials and Methods

The research survey was conducted through a structured questionnaire to evaluate the economic

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impact of hard water related to sanitary problems. Keeping in view the results of the chemical analysis conducted by Ahmad *et al.*, 2016 (Fig. 1), the study zone was divided into hard water and very hard water areas. The questionnaire respondents were local residents, plumbers and sanitary shopkeepers. Based on the questionnaire, the cost of the cleaning, repairing and replacement of appliances was computed to estimate the annual economic loss due to hardness of water. There were 140 observations, out of which 102 households were in very hard water area and 38 in the hard water area.

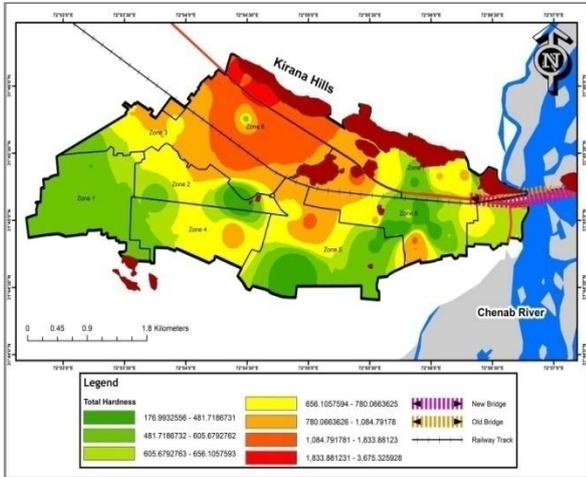


Fig.1 Zone map of the study area (after Ahmad et al., 2016).

Results and Discussion

The average value for total hardness in the water samples was 804.4 mg/L which is higher than the admissible standards of WHO (Ahmad *et al.*, 2016). 12.50% area of the town of Rabwah contains hard water and the remaining 87.50% contains groundwater categorized as very hard water. Out of 10,679 homes, about 18.14% (1938 homes) are within hard water area while 81.85 % (8741) homes are located in very hard water area.

Water Use Purpose

According to the survey 87.50% respondents from very hard water area use water for household and only 14.63% people use water for drinking. While 85.36% respondents from hard water area consume water for drinking and 12.50% use for household only (Fig. 2).

Health Impact

According to the respondents of very hard water area, the water quality is not good but due to inaccessibility of sufficient potable water they have to use it, which causes digestive (90%), skin (92.5%) and hair related issues (88.3%). Mostly, respondents from hard water area expressed that they have no issue with water quality but some of them reported that they have to face digestive problems (17.07%), dull hair (12.19%), itchy dry skin (7.31%) and eyes irritation (7.31%) (Fig. 3). Although hard water has no adverse health effect

but can cause a laxative effect, if the level of magnesium and sulfate exceeds the range (~250 mg/l each) in drinking water (Pallav, 2013). Hard water and skin ailments are also correlated with each other in form of ‘eczema’ which causes loss of moisture in the skin (WHO, 2011).

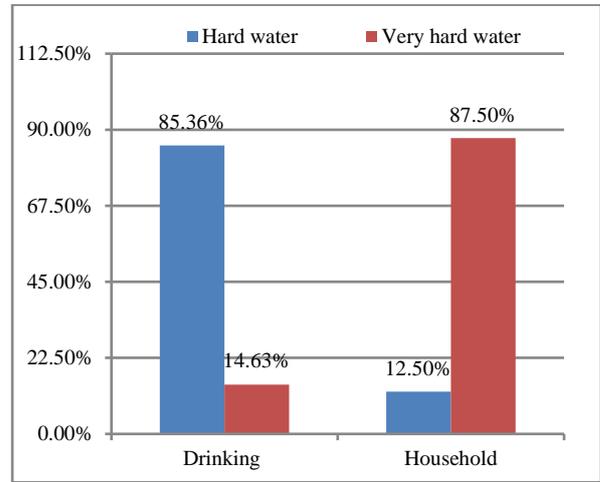


Fig. 2 Water use purpose.

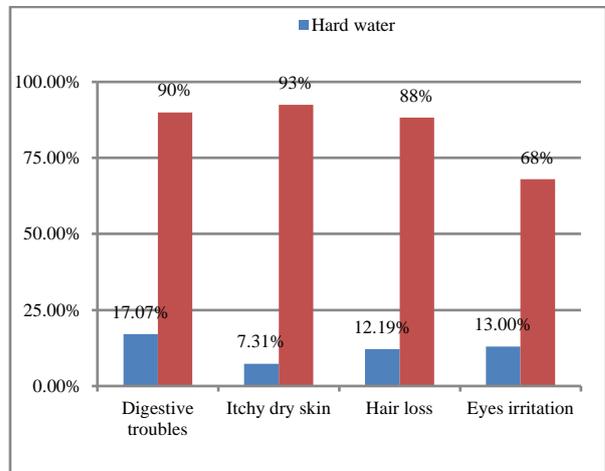


Fig. 3 Impacts of contaminated water on health.

Laundry Issues

People from very hard water area expressed that clothes turn rough (82.5%), dull (84.1%), stained (67.5%), life span reduction (80.8%) and the detergent doesn’t wash out completely (85.8%). The prime reason is the presence of calcium and magnesium carbonate in the water that causes the fabric to become stiff and harsh, leaving a film on fabrics. No precipitate is formed when the carbonate-built detergents are used in soft water. The reaction of soap with calcium in hard water causes sticky curds to form which creates problems (Konstadinos et al., 2015).

Around 90.25% respondents from hard water areas told that water in the area is good for laundry. Only a few respondents (9.75%) argued that it causes stiffness (9.75%), dullness (7.31%) and detergent completely washing off (7.31%) (Fig. 4).

have plastic taps of 5 years durability. The data

Table 1. Details of sanitary items in an average household.

Items	Material	Average No. Home	Basic life	Percentage of respondents	
				Very hard water area	Hard water area
Taps	Nickel coated	5	5 years	58%	44%
	Plastic	5	5 years	42%	56%
Muslim Shower	Nickel coated	2	5 years	100%	100%
Overhead shower	Nickel coated	2	5 years	43%	43%
	Plastic	2	5 years	59%	57%
Toilet watertank	Plastic	2	5 years	100%	100%
Toilet Flush	Ceramics	2	unlimited	100%	100%
Sink inkitchen	Steel	1	unlimited	100%	100%
Wash basin	Ceramics	2	unlimited	100%	100%
Geyser	Steel	1	More than 5 years	100%	100%
Washing machine	Plastic	1	More than 5 years	100%	100%

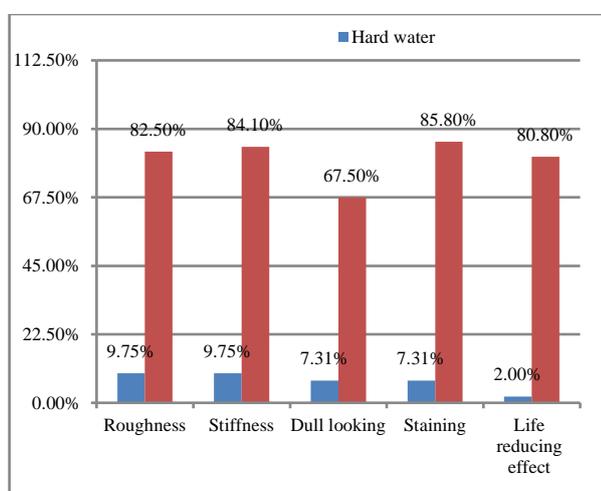


Fig. 4 Laundry issues.

Cooking Issues

The level of hardness in the water has a great impact on fuel consumption, appearance and taste of food (Murali et al., 2009). Almost 92.5% respondents from very hard water and 4.87% from hard water areas believe that food takes a longer time to cook, if they use groundwater in the area resulting in the consumption of extra fuel. Moreover, quality of groundwater affects the taste of food.

Sanitary Issues

The survey showed that 58% of people living in very hard water area have installed nickel-coated taps while 42% have plastic material taps. On average there are five taps in each home with a basic life cycle of 5 years. On the other hand in the hard water area, 56% of residents have installed nickel-coated taps and 44%

mentioned in the table below presents the sanitary materials used, which include taps, Muslim showers, overhead showers and flush water tanks that are nickel coated or plastic. The kitchen sinks and geysers have a steel body; washing machines have a plastic body while the toilet and wash basins have ceramic material (Table 1).

Average Replacement Expenses

According to the survey carried out, the residents change their taps twice a year due to the deposition of materials from water in very hard water areas. The plumbers report that the taps get clogged with particles of salt resulting in a shorter operating life. The people living in very hard water area pay 6100 rupees per year for replacement of taps, overhead showers, and Muslim showers. This cost becomes 25,300 rupees during the span of 5 years by the end of their life (Table 2). The residents living in hard water area on the other hand only pay 5100 rupees every 5 years for replacing sanitary accessories (Table 3). Most of the residents have installed sanitary accessories that are nickel coated, which results in rusting of the material and clogging in the shower holes, however, accessories made of plastic do not rust off (FM article).

Labor Cost

The residents of very hard water area pay 3200 rupees as labor charges per year on top of the replacement costs which equals to 16000 rupees for every 5 years (Table 4). On the other hand, residents of hard water area pay 1200 rupees as labor charges per year and 6000 rupees for every 5 years on top of the replacement costs (Table 5).

Table 2. Average replacement expenses in the very hard water area.

Items	Material	No. of replacements	Replacement expenses / item (average)	Replacement expenses/year	Replacement expenses for items for 5 years
Taps	Nickel coated	2/ year	350	3500/-	17500/-
	Plastic	2/year	150	1500/-	7500/-
Muslim Shower	Nickel coated	1/year	300	300/-	300/-
Overhead shower	Nickel coated	Once in 5 years	500	500/-	500/-
	Plastic	Once in 5 years	300	300/-	300/-

Table 3. Average replacement expenses in hard water area.

Items	Material	No of replacements	Replacement expenses / item (average)	Replacement expenses / item / year	Replacement expenses /average item / year	Replacement expenses /average item / 5year
Taps	Nickel coated	1/ year	350	No	No	1750/-
	Plastic	1/year	150	No	No	750/-
Muslim Shower	Nickel coated	1/year	300	No	No	600/-
Overhead shower	Nickel coated	None	500	No	No	1000/-
	Plastic	None	300	No	No	1000/-

Table 4. Labor cost in the very hard water area.

Items	Material	Replacement labor/item	Replacement labor/ item/year	Replacement labor cost for 5 items	Replacement labor cost for 5 years
Taps	Nickel coated	100/-	200/-	1000/-	5000/-
	Plastic	100/-	200/-	1000/-	5000/-
Muslim Shower	Nickel coated	100/-	200/-	400/-	2000/-
Overhead shower	Nickel coated	100/-	200/-	400/-	2000/-
	Plastic	100/-	200/-	400/-	2000/-

Table 5. Labor cost in the hard water area.

Items	Material	Replacement labor/item	Replacement labor/ item/year	Replacement labor cost for 5 items	Replacement labor cost for 5 years
Taps	Nickel coated	100/-	100/-	500/-	2500/-
	Plastic	100/-	100/-	500/-	2500/-
Muslim Shower	Nickel coated	100/-	100/-	200/-	1000/-

Average Repair Expenses

While studying the other option for households to get repairing of the accessories, we found that the residents of very hard water area have to bear expenses of 4850 rupees per year and in total 24250 rupees for 5 years. The repairing cost is almost slightly less than the replacement cost, that is why most people choose to

completely change their sanitary items rather than repairing. Moreover, the cost of the geyser repairing is around 2500 rupees, which needs to be done every year (Table 6). According to plumbers, the hard water causes scaling and blockage of pipes when the salts accumulate in the geyser tanks, leading to damage of the tank.

Table 6. Average repair expenses in very hard water area.

Items	Material	No of replacements	Replacement expenses / item(average)	Replacement expenses / item / year	Replacement expenses /average item / year	Replacement expenses /average item / 5year
Taps	Nickel coated	250	2	500/-	2500/-	10000/-
	Plastic	100	2	200/-	1000/-	5000/-
Muslim Shower	Nickel coated	100	2	200/-	400/-	2000/-
Overhead shower	Nickel coated	150	2	300/-	600/-	3000/-
	Plastic	150	2	300/-	600/-	3000/-
Toilet water tank	Plastic	250	2	250/-	250/-	1250/-
Geyser	Steel	2500/-	Once after 2-3 year	2500/-	---	2500/-
Washing machine	Plastic	900	Once after 2-3 year	400	---	400/-

Table 7. Comparative analysis of expenses.

Category	1 year (Before)		5 years (Before basic life)	
	Very hard water area residents	Hard water area residents	Very hard water area residents	Hard water area residents
Average replacement expenses	6100/-	-----	30,500	5100/-
Labor cost	3200/-	1200/-	16000/-	6000/-
Average repair expenses	4850/-	-----	27350/- including geyser	5100/-
Total	14150/-	1200/-	73,850 including geyser	16200/-

Conclusion

The results show that the expenditure/maintenance cost is higher in very hard water areas in contrast to places with hard water. Almost 82% population is bearing annual losses in the form of household item deterioration due to contaminated water, while only 18% population has access to relatively better quality water. This study will create awareness in the local community and provide basic information for the administration to install water softening plants or other water purification systems for the local population to reduce the economic loss. Moreover, this study will also help the local residents to understand the importance of investing in a water purification systems in their homes.

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