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Assessment and public perception of drinking water quality and safety in district Vehari, Punjab, Pakistan

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ABSTRACT

Most of the developing countries including Pakistan have poor sanitary conditions which cause numerous diseases in human. Therefore, the present work aimed at evaluating the physicochemical and microbial contamination of drinking water in urban areas of three tehsils (Vehari, Mailsi and Burewala) of district Vehari based on occurrence of water-borne diseases. Forty-one water samples (six from tehsil municipal administration (TMA) water supply and 35 from electric pump) were collected from various locations of district Vehari for physicochemical and microbial analysis. In all the sampling sites pH (7.2–7.7), Phosphate (PO_4^{-3}) (0.00–0.94 mg/L), Sulphate (SO_4^{-2}) (0.00–172.8 mg/L), Magnesium (Mg^{+2}) (4.55–40.7 mg/L), Iron (Fe^{+2}) (0.00–0.09 mg/L), Copper (Cu^{+2}) (0.00–0.04 mg/L), Zinc (Zn^{+2}) (0.00–0.15 mg/L) and Manganese (Mn^{+2}) (0.00–0.01 mg/L) were found under WHO limits. Microbial contamination of *Eschrichia coli* and coliform were found in water samples of F-Block, D-Block and C-Block of tehsil Vehari. Results revealed that the values of certain parameters such as electrical conductivity (0.34–2.23 mS/cm), total dissolved solids (123–1430.4 mg/L), Sodium (Na^+) (55.5–327.5 mg/L), Calcium (Ca^{+2}) (7.1–115 mg/L), Potassium (K^+) (3.9–17.75 mg/L), Chloride (Cl^-) (0.00–479.25 mg/L), and Nitrate (NO_3^-) (0.59–12.14 mg/L) exceed WHO limits in Sharqi Colony, Lalazar, Health Colony, TMA Sharqi Colony, Y-Block, 9-11 WB, College Town and 13-WB areas of district Vehari. Moreover, the survey of the sampled area was also conducted to assess public perception regarding water quality, its treatment, sanitation practices and possible reasons for the occurrence of water borne diseases. The survey results showed that 48.6% of the respondents disagreed that drinking water of their area is good. Cross tab analysis exhibited that respondents from different gender (65.3%), marital status (65.3%) and family type (65.3%) did not treat drinking water before use. Peoples who were not satisfied with their drinking water quality reported more disease development (45.8%) compared to those who were satisfied (11.1%) with their drinking water quality.

1. Introduction

The world is full of innumerable natural resources. While some of these have been discovered with their benefits identified, many still remain to be unearthed. However, among all the known natural resources to man, water undisputedly continues to stand out as the most important of all. Water scarcity is currently confronting topographical issue and very soon every part of the world will be under crisis of water (Mohsin et al., 2013). Availability of good quality water is the basic right of every human being living on the earth. However, over 844 million people on the Earth have no access to good quality drinking water and about 2.3 billion people still lack access to adequate sanitation facilities (WHO and UNICEF, 2017). Around 6000 children die every day from diseases linked

Abbreviations: US EPA, United States Environmental Protection Agency; EU, European Union; EC, Electrical conductivity; TDS, Total dissolved solids; WB, West Bank; TMA, Tehsil municipal administration; WHO, World Health Organization.

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with lack of access to good quality drinking water, poor sanitation and hygiene (WHO and UNICEF, 2017). In developing countries like Pakistan, a greater percentage of rural and urban population lack access to safe drinking water as it is available to only 40–60% of its population (Hannan et al., 2010). Contamination of drinking water by seepage from stagnant water and leakage from septic tank contaminate the underground water with harmful microorganisms, which are responsible for the spread of many water-borne diseases. Surface water can have some sort of bacteria while groundwater is mostly safe, unless not contaminated with wastewater (Khan et al., 2013). It is believed that water supplies contaminated with human and animal feces cause serious infections in humans. Coliform genera include both fecal (specifically present in intestine and feces of warm blooded animals) and non-fecal origin. *E. coli* bacteria belong to fecal coliform group, are harmless but few strains like *E. coli 0157:H7* cause severe illness (Odonkor and Ampofo, 2013). Water-borne diseases are commonly found throughout the world but the condition is more aggravated in developing countries including Pakistan (Anwar et al., 2010). According to an estimate, 230,000 children die annually in Pakistan because of water-borne diseases (DigiTex, 2013).

Water being universal solvent dissolves various chemicals and impurities in it, during its hydrological cycle (Ilyas and Sarwar, 2003). Many metals and salts are also introduced to underground water through anthropogenic activities such as improper disposal of industrial wastes and indiscriminate use of fertilizers and pesticides during agricultural activities (Abbas et al., 2014). Many of chemicals dissolved in water are essential for human health to a specified amount (Midrar-Ul-Haq et al., 2005) but their higher amounts results in severe health problems. Trace metals such as calcium (Ca^{+2}), chromium (Cr^{+3}), copper (Cu^{+2}), iron (Fe^{+2}), magnesium (Mg^{+2}), potassium (K^{+}), sodium (Na^{+}), and zinc (Zn^{+2}) are required in a specific amount in the body, and their deficiency may cause retarded biological processes and functions, while their excess may cause toxicity (Rasool et al., 2016). Water is a source of essential mineral elements; these elements in combined form affect bone and membrane structure (Ca^{+2}, Fe^{+2}, Mg^{+2} and P), oxygen binding (Fe^{+2}), metabolic catalysis (Cu^{+2}, Mg^{+2}, Mn^{+2} and Zn^{+2}) and electrolyte balance (Cl^{-}, K^{+} and Na^{+}) (WHO, 2005). Potassium is required as a co-factor in many enzymes for protein synthesis, insulin secretion and carbohydrate metabolism (WHO, 2009). Potassium deficiency results in hypokalemia, however, its higher consumption had no adverse effect on human health (WHO, 2009). Normal concentration of Na^{+} in drinking water is beneficial for healthy adults, however: its higher intake can lead to high blood pressure (Shahid et al., 2015). Calcium excess may reduce the absorption of Fe^{+}, Zn^{+2}, Mg^{+2} and phosphate however, its deficiency can increase the risk of cancer, kidney stones, osteoporosis, cardiovascular diseases, diabetes and obesity (Sengupta, 2013).

Public awareness about drinking water quality plays important role in defining preventive measure against various diseases. In Lahore, majority of population (60%) had no knowledge of water-borne diseases (Malik et al., 2012). Scanty knowhow about water quality restrains people from adopting any water treatment measure which results in strong health impacts (Cairncross and Valdmanis, 2006). Income and education of the person strongly influence the adoption of proper source of drinking water and various water treatment measures to improve water quality and reduce disease development (Larson and Gnedenko, 1999). In three districts of Punjab province: Multan, Rawalpindi and Toba-Tek Singh reduction in diarrhea illness was observed where mother (female resident) had higher level of education (Kausar et al., 2011). In district Vehari, the installed TMA water supply wells and turbines are at depth of 350–400 ft (Anonymous, 2008) whereas, installation depth for hand pumps and electric pumps is generally shallow (80–110 ft). Shallow underground water present in unconfined aquifers is generally highly contaminated due to leaching of sewage (Anonymous, 2011b) and seepage of polluted water from river Sutlej and other surface water bodies (Missen, 2011) making its way from unsaturated zone to phreatic zone. Further, prevailing agricultural activities like pesticides and fertilizers application in the study area contribute in the contamination of underground water reservoirs (aquifers). Knowledge about public awareness regarding drinking water quality and their adopted sanitation practices is necessary to develop a link between water quality and disease development.

Therefore, the purpose of this study was to evaluate the physicochemical and bacteriological water quality and to determine the public awareness regarding drinking water quality and disease development and their adopted measures to reduce disease risks in district Vehari.

2. Materials and methods

2.1. Study area description

District Vehari is located between 29.36°′ and 30.22°′ N and 71.44°′ and 72.53°′ E (RDPI, 2010). It has borders with district Sahiwal and Khanewal on the northern side, district Pakpatan on eastern side, Bahawalpur and Bahawalnagar on southern side and district Lodhran on western side (Fig. 1) (Anonymous, 2011a). It is located at the right bank of river Satluj which has lower water discharge since its closure by India under Indus Basin Treaty due to which water table has depleted and reaches at a depth of 60–70 ft (Anonymous, 2011b). In the study area, electric and hand pumps were being used to draw ground water for drinking purposes. Vehari is relatively new district created in 1976. It is a low-lying riverine settlement located in southern Punjab, Pakistan. The total area of the district is 4364 km^2. It has three tehsils: Vehari, Burewala and Mailsi (Anonymous, 2011a).

2.2. Water sampling

Retrospective data about the water-borne diseases was collected from district and tehsil Head Quarters (DHQ and THQ) hospitals and other related health centers of district Vehari and reviewed to determine the prevalence of water-borne diseases in the study area. The areas having high disease ratio were selected for the collection of water sampling. In total, forty-one water samples were collected, thirty-five samples from hand pumps and electric pumps and six samples from TMA water supplies normally used for drinking purposes in district Vehari (Fig. 1). Water samples were collected in leak proof plastic bottles and preserved as described by Khan et al. (2013). Water from pumps and TMA supplies was allowed to run for couple of minutes (purging) and then collected in polyethylene bottles. The bottles were filled carefully without splashing, followed by emptying to ensure no air bubbles and gases and refilling in a same manner. All the sample bottles were properly sealed, tagged and immediately transported to laboratory for physicochemical analysis. However, some part of the samples was acidified with few drops of 5% nitric acid and stored in a separate bottle at 4 °C for metals analysis. For microbial analysis, water samples were collected separately in sterilized bottles and immediately shifted to laboratory for microbial analysis (*E. coli* and Coliform).

2.3. Physical analysis (color, pH, EC and TDS)

Physical analyses were performed in laboratory of Department of Environmental Sciences, COMSATS Institute of Information Technology (CIIT), Vehari. The pH and EC were measured by pH/EC