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# Level of Arsenic in Ground Water and Its Impact on Human Health: A Case Study of Bahawalpur City, Pakistan

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**Abstract**

Access to clean and pure drinking water is basic human right. Poor drinking water quality causes many diseases including Cancer (Lung, Liver, Skin, and Kidney Cancer). The major goals of this study are to measure level of arsenic in groundwater and to find the relation of arsenic level in drinking water and water borne diseases in Bahawalpur City. This research work was based on both primary and secondary data. A cross sectional study was designed to check the drinking water quality and the spatial pattern of selected water borne disease (cancer). Groundwater samples were collected from 42 areas of the city of Bahawalpur. These samples were analyzed in PCRWR laboratory for Arsenic level. The data of cancer patients were obtained from the District Head Quarter Hospital and the patient's locations were marked by their addresses on Google maps. Water quality data and health data analysis through GIS techniques, Interpolation, IDW (inverse distance weighted), kernel density were used for diseases pattern and results were presented through maps. The results showed that the level of Arsenic was higher (55 to 80 ppb) than WHO standard (50 ppb). It has been observed that the drinking water quality has affected the public health as there were 319 Cancer patients. This study revealed that people were using As-contaminated groundwater for drinking purposes that caused water-borne diseases. There is an insistent need for a practical solution to supply the fine quality drinking water in the Bahawalpur City.

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## Introduction

An adequate supply of drinking water is one of the main prerequisites for a healthy life, but waterborne diseases remain a major cause of death in many parts of the world, especially in children, and it is also a significant economic constraint in many subsistence economies. Drinking water comes from two main sources: surface water (such as rivers and reservoirs) and aquifers. All water containing natural contaminants, inorganic contaminants that arise particularly in geological strata through which the water flows and to varying degrees, anthropogenic pollution by micro-organisms and chemicals. There are many sources of chemical contaminants in drinking water. However, the most important contaminants from the health point of view are naturally occurring chemicals that are typically found in ground water (Fawell, 2013).

Arsenic-contaminated water is a major cause of morbidity in many parts of the world, including the Indian subcontinent, particularly Bangladesh and Western Bengal, South America and the Far East. It is the only contaminant that has been shown to be the cause of cancers in people drinking As-contaminated water. Apart from skin cancer, lung and bladder, and probably the liver, arsenic is responsible for a series of adverse effects, including hyperkeratosis and peripheral vascular disease (Fawell, 2013). It is estimated that 1100 million people in the world use the unhygienic water. Around 4000–6000 children are dying each day because of the diseases associated with lack of access to safe drinking water, inadequate sanitation and poor hygienic conditions. Lack of access to improved drinking water is still a serious problem in large portions of Asia where an estimated 6750 lakhs people are without improved drinking water sources (Christine, 2006).

Mortality study in the field of arsenic exposure in Cordoba, Argentina showed an increased risk of bladder cancer in men and women during the period 1986-1991. It also showed countries with high exposure to arsenic have increased mortality due to lung and kidney cancer (Smith, 2000).

According to an approximation by Pakistan Council of Research in Water Resources (PCRWR), about 50% of urban water supply is poor for drinking and personal use. Almost 25.61% of Pakistan's 159 million residents have admittance to secure and satisfactory drinking water. The bigger part of the Pakistan's population is exposed to the risks of drinking insecure and impure water. As of 2005, more or less 38.5 million inhabitants did not have secure drinking water supply. By year 2015, if this tendency keeps on going, 52.8 million people will be depressed of secure drinking water (Kausar, 2011).

High arsenic has been found in many industrial cities in Punjab due to industrial and chemical waste discharge (Soomro *et al.*, 2011). Quality of groundwater in Bahawalpur is deteriorating. The ground water in the city has become saline and brackish and as a result not suitable for drinking purposes (Anwar and Bureste, 2011; Mohsin *et al.*, 2013). Arsenic in drinking water is considered environmental cause of cancer in the world and can affect human health (Smith *et al.*, 1992). Many researchers found that association between as exposure and cancer disease is positive (Kapaj *et al.*, 2006).

The major goal of the study are to compare the drinking water quality with WHO standards and to study the spatial pattern of water borne diseases in Bahawalpur City and to analyze the relation of drinking water quality and water borne diseases in Bahawalpur City.

## Material and methods

*Study area*

Area of Bahawalpur City is 2,372 km². Bahawalpur is located in the province of Punjab, Pakistan at 29°23′44″N latitude and 71°41′1″E longitude. Lodhran district is situated in the north and Hasilpur Tehsil is in the east, while Bahawalpur is bounded by Ahmad pur Tehsil in the west and Yazman Tehsil in the South (Fig. 1).

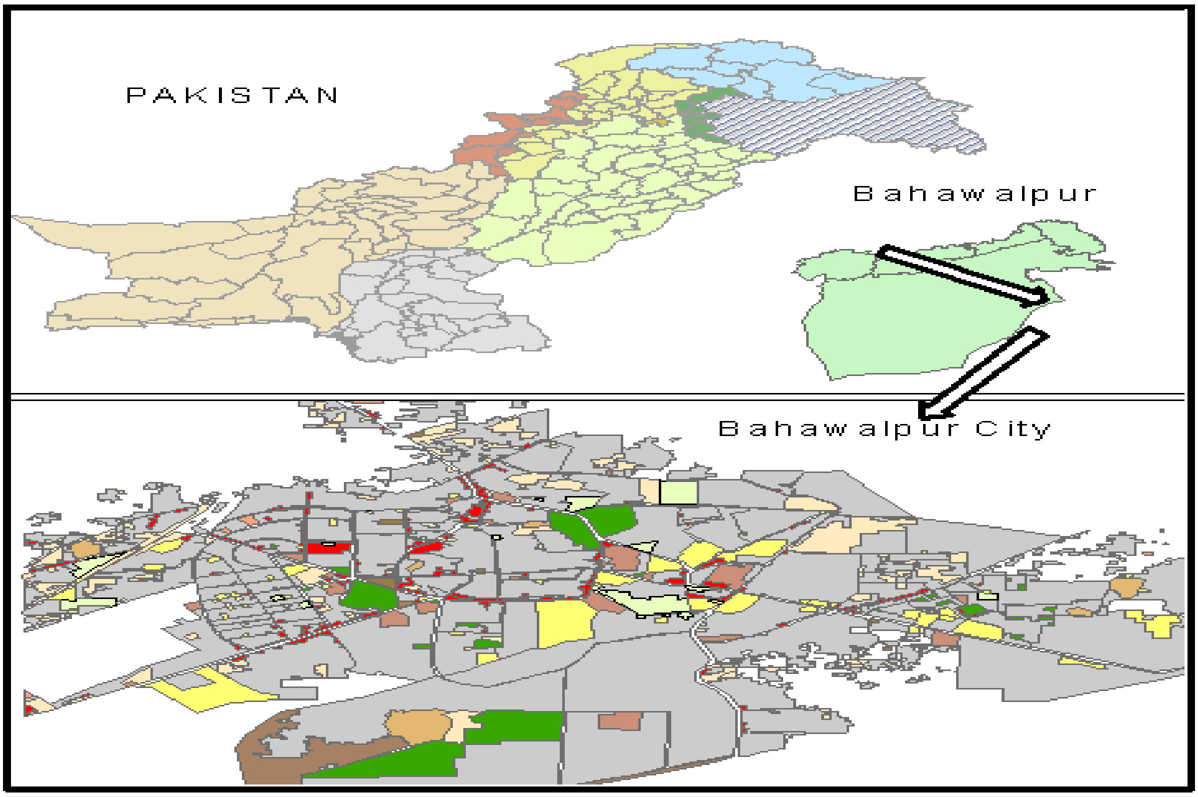


**Fig. 1.** Map of Study Area: Bahawalpur City.

The climate is extremely hot and dry in summer with cold and dry winter. The summer season starts from May and ends in September. The winter season starts from October and ends in March. The mean maximum temperature of the area is 44°C with mean minimum temperature 28°C. Dust storms are frequent during the summer season. Bahawalpur City processes less number of green spaces, parks and forest area. Due to the dry climate of Bahawalpur City, there is a great need of the high number of green spaces, parks and forest for a sustained growth of the city (Anwar, *et al.* 2015).

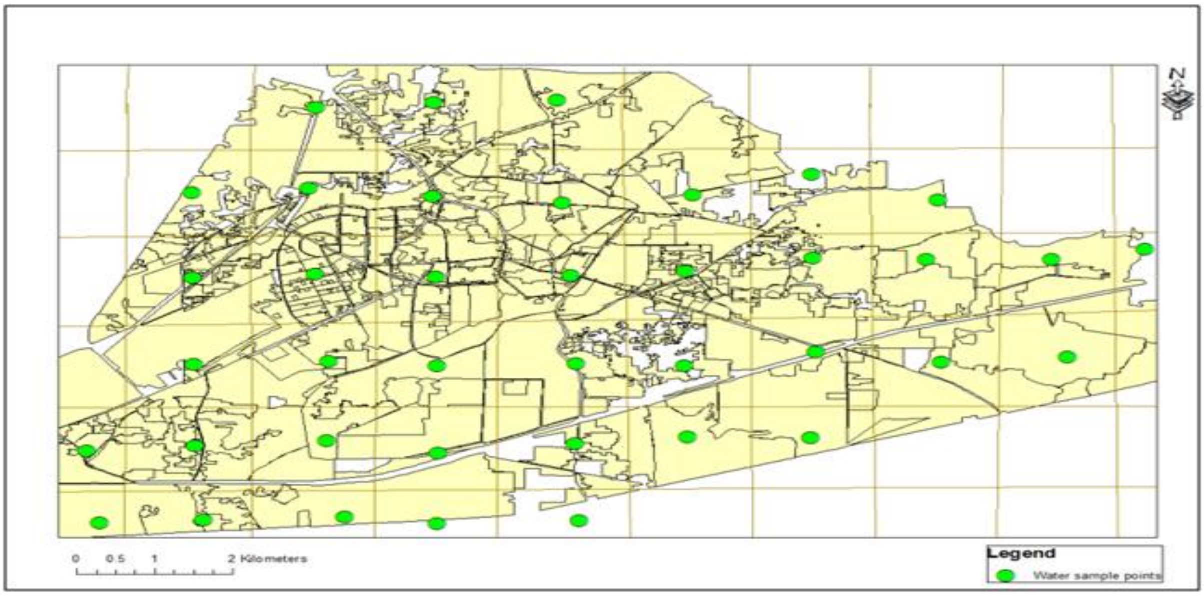


**Fig. 2.** Sampling sites in the study area.

*Collection of water sampling*

A cross sectional study was designed to check the drinking water quality and the spatial pattern of selected water borne diseases. The grid sampling techniques were used to collect the water sampling. The area of each grid is 2 Sq. Km. The area of Bahawalpur City was divided into 42 equal parts with the help of grids. The central point of each grid was the sampling point, as shown in Fig. 2.

*Sample analysis and WHO standards*

Water samples were tested in PCRWR laboratory for arsenic level. Atomic absorption method was used to determine the arsenic level in water sample. The results were compared with WHO standards.

*Secondary data collection*

The data of patients were obtained from the District Head Quarter Hospital and the patient's locations were marked by their addresses on Google maps. Health's reports of the selected water borne disease mainly focus on Cancer (Lung, Liver, Skin, and Kidney Cancer) were obtained.

*Mapping of arsenic level and density of patients*

Water quality data and health data analysis were presented by maps through GIS techniques, Interpolation, IDW (inverse distance weighted) and kernel density. GIS software (ArcGIS 10) was used in mapping arsenic level and patients' density in the study area.

## Results and discussion

*Arsenic level in drinking water*

Fig. 3 shows as level in different sites of Bahawalpur City. The results showed that the quality of drinking water is not in good conditions.

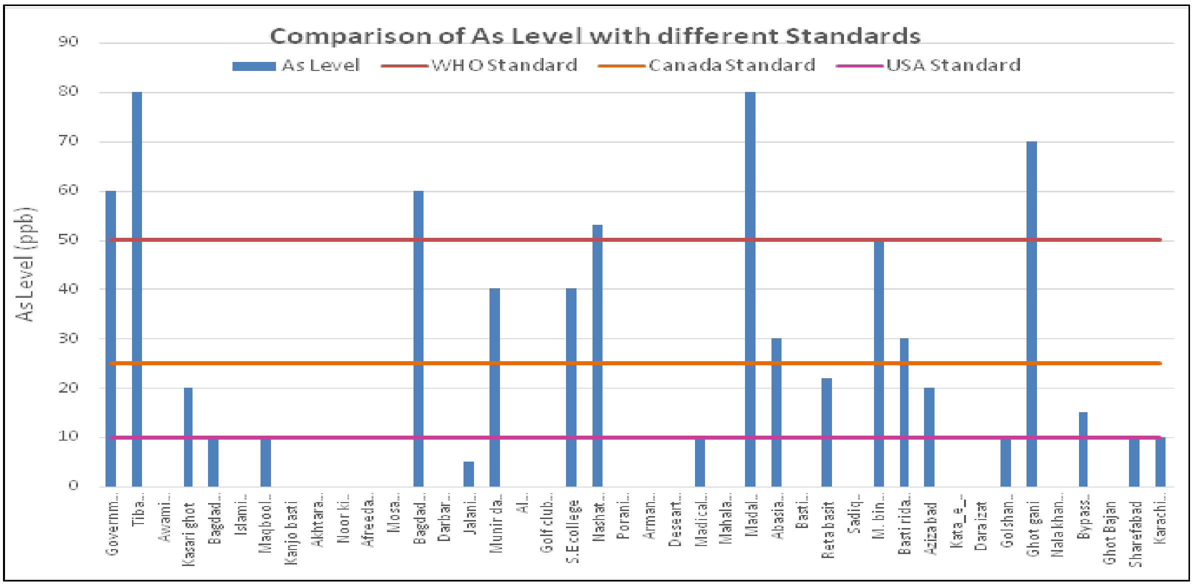


**Fig. 3.** Level of Arsenic in comparison with different standards.

The study also examines the relationship between the drinking water quality and health of the residents of the Bahawalpur City. The study also revealed the deficiencies in planning and management of the local Govt. of the Bahawalpur city.

The ground water analysis showed that the ground water quality is not good for human health because the level of Arsenic is very high in some areas of Bahawalpur City.

WHO standard for Arsenic level is 50 ppb but in some sites of study area arsenic level was 55 to 80 ppb that causes the Cancer (Lung, Liver, Skin, and Kidney Cancer). Tiba Badar Shar, Government Colony, Bagdad Station, Nashat Colony, Modal Town C, Ghani

Ghot had very high levels of Arsenic. Inorganic arsenic originates from minerals, industrial discharges and insecticides, whereas organic arsenic may come from industrial discharges, insecticides and biological action on inorganic arsenic (Chung *et al.* 2014).

Heavy application of agrochemicals, improper disposal of solid waste and sewage water were the major causes of water contamination (Khan *et al.*, 2012). Centeno *et al.* (2006) reported that as is a unique carcinogen and has adequate evidence of carcinogenic risk by both ingestion and inhalation. According to Rahman *et al.* (2003), patients that had premature death due to cancer had serious arsenical skin lesions in West Bengal, India. Shallow groundwater in urban areas was found to contain high as levels due direct contamination with industrial or agricultural chemicals. Geochemical evidence indicates that sorbed as is released to shallow groundwater due to reduction of hydrous ferric oxide (HFO) caused by pollutant organics from sewage (Nickson *et al.*, 2005).

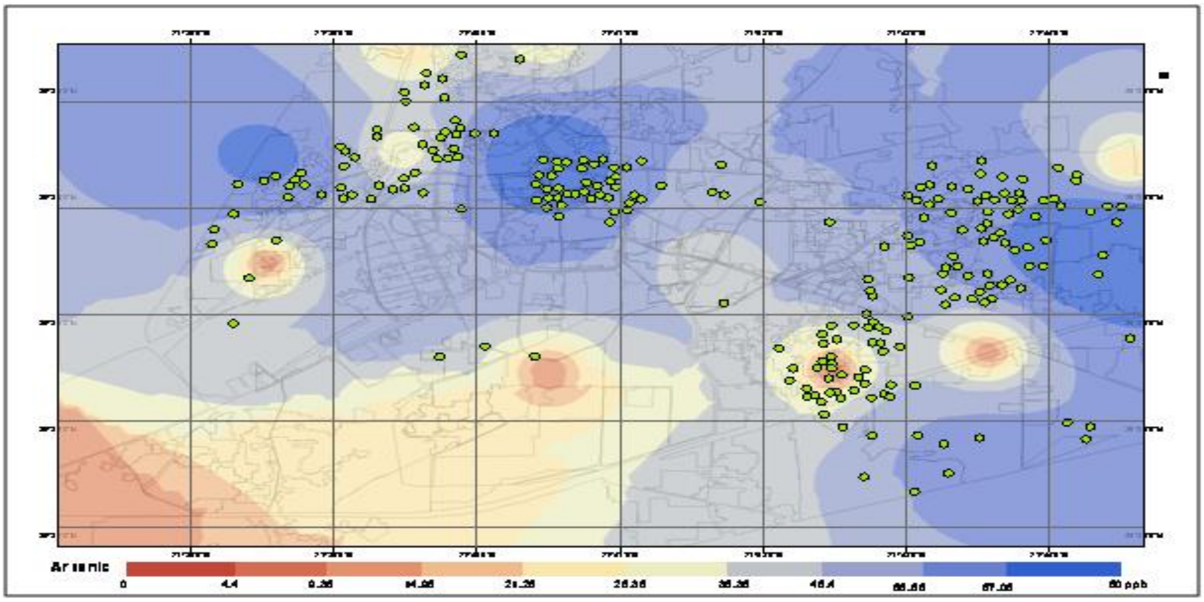

**Fig. 4.** Comparison the level of arsenic with cancer patients.

*Comparison the level of arsenic with cancer patients*

Fig. 4 shows comparison the level of arsenic with cancer patients in the study area. The level of the arsenic was high in east and north side of the study area. Groundwater samples of some sites had arsenic levels higher than WHO standard (55 ppb). These sites include Government Colony, Tiba Badar Shar, Bagdad Station, Nashat Colony, Modal Town-C and Ghani Ghot. The results showed that the level of Arsenic was 55 to 80 ppb while the permissible limit by WHO is 50 ppb. It has been observed that the drinking water quality has affected the health of the peoples as there were 319 Cancer patients were found. The arsenic caused the Cancer (Lung, Liver, Skin, and Kidney Cancer), and majority of cancer patients were located in Modal town C, Shadara, Basti rida of the North side, Jail road, Nashat colont, Mosa colony, Bagdad station, in the east of the study area. So the comparison showed the cancer patient's location was same in those areas where the arsenic level was high.

The cancer patient density was calculated and the density and cancer disease pattern in the study area are presented in map. According to a report (NRC, 2001), very low concentrations of Arsenic can cause deleterious health effects. There is greater risk to infants and children for both cancer and non-cancer effects due to greater intake of As via drinking water on the basis of body-weight.

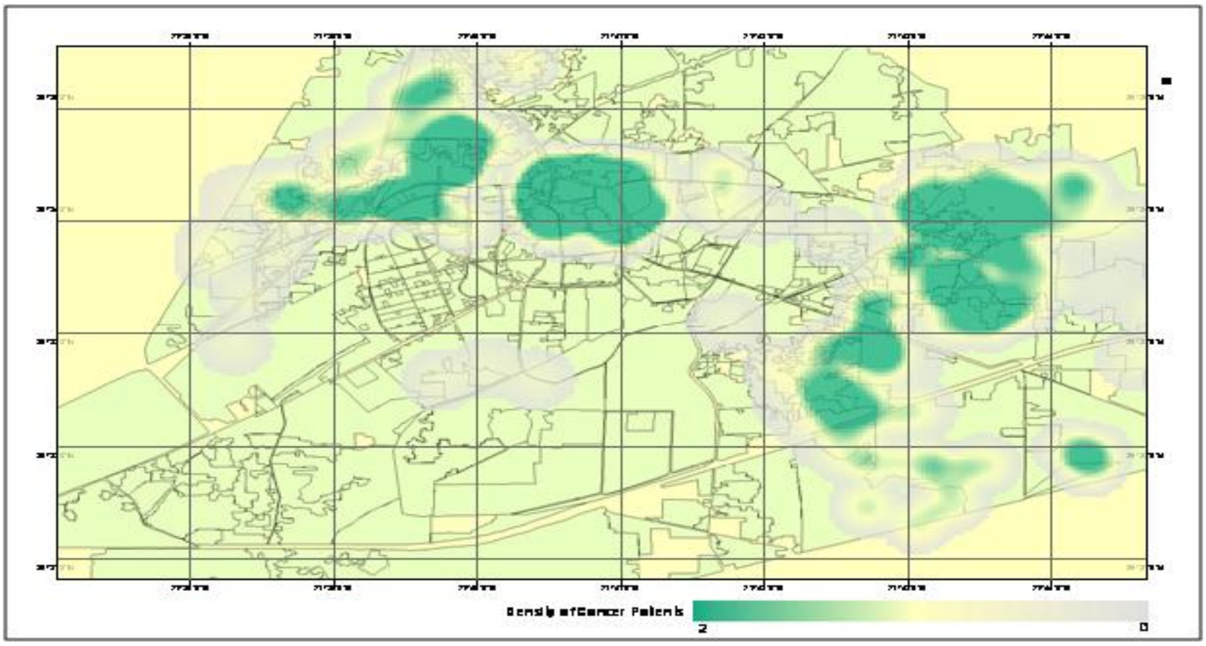


**Fig. 5.** Density of cancer patients.

Hopenhayn-Rich *et al.* (1998) found that there was significant increased mortality from lung cancer with higher arsenic ingestion. It is important to note that As guideline of 50 µg/L is not protective and safe. As a result guidelines have decreased in Canada (25 µg/L) and USA (10 µg/L). Attempts are made in Canada to lower guideline to ≤5 µg/L. Due to presence of high levels of As in groundwater, It is better to test groundwater sources used for drinking water. If arsenic levels are above 5 µg/L, It is better to do biological monitoring including measurement of arsenic in blood, urine, hair and toe nails. Sufficient evidences have been found to link lung and bladder cancers with ingestion of inorganic arsenic (Kapaj *et al.*, 2006).

The US EPA set As standard for drinking water at 50 µg/L in 1975 on the basis of a Public Health Service guideline originally established in 1942 (USEPA, 1996). According to US EPA (2002) lowering of the As standard from 50 to 10 µg/L could prevent deaths from lung, bladder, skin cancers and heart disease. The FAO guideline for As in groundwater was 50 µg/L, but many regulatory bodies in the world are considering to decrease it to 5–10 µg/L in view of recent incidences of As poisoning in the Indian subcontinent. The temporary WHO standard for arsenic in drinking water is 10 µg/L on the basis of $6\times10^{-4}$ excess skin cancer risk (60 times higher than the factor used to protect human health). WHO stated that as guideline should be 0.17 µg/L for health-based drinking water. In past less protective guideline was adopted due to lack of analytical techniques to determine very low as concentration (WHO, 1993; WHO, 1998; WHO 1999).

It was found that as standard of 50 did not remove the risks of lung, prostate and skin cancer from long-term exposure to low as levels in drinking water. There are several other non-cancer effects caused by as even at low levels including diabetes, cardiovascular disease and anemia, as well as developmental, reproductive, neurological and immunological disorders. It was recommended to In order to lower the safe drinking water limit to 5 µg/L to achieve the EPA's goal of protecting public health. It is slightly higher than technically feasible measurable level (3 µg/L) (NRC, 1999).

**Conclusion**

A monitoring study was conducted to measure arsenic level in groundwater in Bahawalpur and to relate contamination levels with cancer disease in the study area. The results showed that the arsenic level in some sites was higher than the WHO standard. It has been observed that the drinking water quality has affected the health of people and caused cancer disease in the study area. People of these areas are using contaminated drinking water that causes diseases. Further research is recommended to measure other contaminants including heavy metals and pesticides in the groundwater.

The Government and policy makers should formulate the policies towards the efficient handling of limited water resources and its quality. The government and NGOs should launch a media campaign to raise awareness about effects of poor quality of drinking water on public health. There is need of awareness campaign of importance of safe water for human health and waterborne diseases. Clean water supply should be given priority in the study area of Bahawalpur City.

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