INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 18, No. 6, p. 251-257, 2021

RESEARCH PAPER OPEN ACCESS

Determination of arsenic level in groundwater of Kandhkot City

Hafizullah Mazari*[1], Mushtaque Ali Jakhrani[1], Sanaullah Ansari[1], SafeullahBullo[1], Sahrish Memon[1], Amjad Hussain Soomro[1], Shahid Ali Jakhrani[2], Khalid Ahmed Bhutto[1]

[1] *Institute of Chemistry, Shah Abdul Latif University, Khairpur, Sindh, Pakistan*

[2] *Department of Zoology, Shah Abdul Latif University, Khairpur, Sindh, Pakistan*

Key words: Arsenic, Kandhkot, Groundwater, GF-AAS

http://dx.doi.org/10.12692/ijb/18.6.251-257 Article published on June 30, 2021

Abstract

Water is an essential component for the survival of humans and animals. Due to industrialization, water is being contaminated with varying polluting agents, arsenic (As) contamination is one of them. An exclusive study was carried out for the determination of arsenic in groundwater of Kandhkot city using microwave-assisted digestion followed by atomic absorption spectrometry (GF-AAS). For that, a total of 112 groundwater samples were collected from different sampling points on basis of the wards from Kandhkot city during the year 2017 followed by ISO sampling method. Results exposed that maximum concentration of arsenic in groundwater was found 23.0 µgL-1 in ward-11 & 13, while in ward-02, ward-03, ward-04, ward-06, ward-08, and ward-15 the concentration was within the permissible limits of WHO (10 µgL-1). The minimum and maximum mean concentrations of arsenic were found 6.4 µgL-1 and 13.8 µgL-1 respectively. Out of 112 groundwater samples of Kandhkot city, 35 samples were found above the permissible limits which become the (~39% of total samples). The human subject study indicated that in UC-3, UC-4, UC-1, and UC-2 of total 135, 84, 73, and 68 people were suffering from various diseases, possibly due to contamination of Arsenic in their groundwater. Hence, water can be used for drinking purposes with caution. Human health risk in ward-09, ward-10, ward-11, ward-12 and ward-13 index were found 0.86, 0.80, 0.88, 0.76 and 0.78 respectively. In the rest of the wards, risk values were found below the Risk limit of (0.66). The people of high health risk index can be affected by carcinogenic diseases. It was concluded that groundwater of Kandhkot city of wards 9 to 13 is not fit for drinking purposes on the basis ADI calculation.

* **Corresponding Author:** Hafizullah Mazari ✉ mazari.hafeez@gmail.com

Introduction

Water is an essential component and building block to sustain life. Water is considered an economic development indicator for third world and developed countries. Water has essential usages of biochemical reactions in the body, drinking, and home usage (Braune & Xu, 2008). Water is the essential ingredient of earth's oceans, lakes, and streams and the liquid of most living organisms and vital for the growth of life, still though it provides no organic nutrients or calories. Its chemical name is H2O. It is useful for the growth of animals, plants, and man. In an ecosystem, the most abundant component of life is water. For the growth and survival of life on earth, all living organisms need water. Water is an important compound which is regulating the climatic changes in the environment and shaping the land for essential uses of human beings as well as another living organism. This is one of the most important compounds that profoundly influence life. Growth in population, industrial, and agriculture development increases the need for water across the world. Recent reports of UNICEF and WHO have revealed 748 million people around the world lacking access to safe water resources and over 2.5billion people suffering a shortage of water supply (Supply& Programme 2014).

Contaminated water affects its economic development, quality, social prosperity, and human health (Ma L *et al.,* 2014). Good quality of water society needs for drinking and to avoid health risks they pay extra cost for drinking water (Shah MT 2012; Shah MT 2014). Arsenic with atomic number 33 and their symbol is As. In nature, it is the 12th most common element. Throughout earth's crust arsenic extensively dispersed and normally originated in organisms, rocks, piles of earth, ambiance, and natural water. The occurrence of arsenic in the atmosphere is also associated with anthropogenic activities with about 60% (Khan M U 2015).

Heavy metals such as arsenic contamination in groundwater are an enormously serious problem (Gul N *et al.*, 2015; Muhammad S *et al.*, 2011; Begum. S *et al.*, 2015; Khan S *et al.,* 2015). The surrounding pollutants are extremely movable and find their ways to bring up in the resources of drinking water such as surface water and groundwater. The groundwater contains dug-well, tube-well, springs, and bore well and surface water such as lakes, streams, and rivers (Khan S 2013; Muhammad S. 2010 & 2011). Groundwater is having much more chances of heavy metal contamination as compared to surface water because sources of surface water are liable only for microorganisms. That's why the majority of populations utilize groundwater as a principal resource for their life.

Millions of people gone through to death due to waterborne diseases while drinking polluted water across the world. Pollution in water is due to the use of metal-based fertilizer in crops. It might result in an increased level of toxic elements in the reservoir of freshwater. Every biotic is endured and originated on water. It is an important element for the development and living of humans such as agriculture and industries. Thus, enormous quantity and quality of water required human beings (Shah MT 2012; Shah MT 2013). Actually, the continuous growth of the world population has been based on the resources of water development.

Through different toxic materials, water is being polluted that may be inorganic and organic. Especially transition metals can cause health hazards to the public. Throwing away from home waste and industrial influent directly pollute water in Pakistan (Fakir Md. 2016). Arsenic (As) pollution is the most important anxiety, in collecting with various contaminations in Pakistan. From rocks and soils, it is naturally occurring elements (Seema Anjum Khattak, *et al.,* 2016; Yi Huang, 2016; Ung-Duck Park, *et al.,* 2016; Rahman *et al.,* 2016). The occurrence of inorganic arsenic in water may be caused by cancer in humans (Wu, Y. *et al.,* 2004). Due to inorganic arsenic, various kinds of cancer can happen for example bladder, skin, kidney and lung, liver, and prostate cancer (Eleni P 2013; Chen, *et al.,* 2013). Furthermore, contamination of arsenic in drinking water may because of various diseases such as thickening, nausea, vomiting, diarrhea, partial paralysis, abdominal pain, headaches, muscle pain, diabetes, cardiovascular, skin lesion, depression blindness, and kidney failure, etc. (Lei Hang 2015; Milton, *et al.,* 2012). In numerous kinds of literature reported that many countries are contaminated by inorganic arsenic which is a risk assessment to human health (George *et al.,* 2012; Pesola *et al.,* 2015, Flanagan, *et al.,* 2012). Due to arsenic contamination, many areas of Pakistan's groundwater are polluted. The objectives of the current study were to estimate sufficient contamination of arsenic from inorganic in groundwater of Kandhkot @ Kahmore city with the help of known protocols.

Material and method

Description of the study area

Kandhkot is the city of district Kashmore in the province of Sindh, Pakistan. The city is distributed in 04 union councils, 16 wards. The city has a population of around 2, 01637, which comes to be one-third of the whole population of the district Kashmore @ Kandhkot. It is the district headquarters of Kashmore @ Kandhkot and connected with railway track and by road service with other areas such as Baluchistan and Punjab provinces.

Sampling

The samples were collected in acid-washed 1.5L polyethylene bottles from hand pumps. Before collecting samples, a hand pump was run fast for 5 minutes to remove sand and insoluble impurities, as well as depth water, must be obtained to contain desired elemental quantities (Shar G.Q *et al.,* 2014). Water was obtained from hand pumps having depth 40-050 feet. Four UCs, 16 wards of Kandhkot city were selected to acquire water samples of hand pumps used in houses to draw water from the ground with depth 40 to 50 feet. The method of collection of water samples from different points of Kandhkot was done with the help of a global positioning system (GPS) in 2017. A total of 112 samples were obtained from all UCs, wards of Kandhkot city. Samples were shifted to the laboratory to protect them from the atmosphere and kept at room temperature to avoid their pH and temperature. Experimental work was carried out for checking their chemical parameters in the laboratory.

Chemicals and reagents

The standard solution was prepared from reagents purchased from Merck (Darmstadt, Germany) and diluted with de-ionized water for the required concentration of ppm solution for the detection of arsenic.

Instrumentation

This study was conducted using the latest techniques of analysis such as Graphite Furnace atomic absorption spectrometer was used by the Perkin Elmer system 6000 devices through the Zeeman effect backdrop amendment system to measure the contamination of arsenic in water. This technique provides a simple and précised measurement of quantitative and qualitative analyses of metals present in different samples of water (Fisher, Tu, & Baldocchi, 2008).

Microwave digestion method

500mL of water samples were put in PTFE flask, then flasks were closed and subjected to microwave irradiation in closed vessel microwave digestion system using Milestone Ethos D model (Sorisole-Bg, Italy). Digestion program of the microwave oven was applied at 100 W (2 min), at 250 W (6 min), at 400 W (5 min), at 550 W (8 min), and ventilation for 8 min. The contents of the flasks were cooled and then diluted to 10mL with (0.2 M) HNO3. Similarly, reagent blanks were also made by the same procedure. The microwave digestion method has superior it to conventional digestion method because it takes less time to digest water sample as well as it has less chance of evaporation of elements so more accurate extraction of elements from samples than in conventional method. It also uses less acid for digestion (Guven & Akinci, 2011).

Results and discussion

According to results obtained in the current study, the maximum concentration of arsenic was found 23.0 µg/L from ward-11 & 13 and the minimum was 3.1 µgL-1 from ward-05 and ward-06. However, in Ward-2, ward-3, ward-4, ward-6, ward-8, ward-15, and ward-16 the concentration of arsenic was found within the safe limit recommended by WHO (10 µg/L).

A comparative study of data from the groundwater of Khairpur city indicates that maximum concentration with 315 µgL-1 (Muhammad Qasim Mazari *et al.,* 2017) and the study area results were found slightly lower than Khairpur as mentioned in table. 2. Out of 112 groundwater samples of Kandhkot city, 35 samples were found above the permissible limits which become the (~39% of total samples).

In Pakistan, more than 40% of populations bear the arsenic contamination in water. Hence, the nation of Pakistan has more risk exposure to arsenic. More than 20% of people living in Punjab are suffering from higher pollution of arsenic in either ground or surface water sources but tolerate a higher quantity of arsenic in industrial areas (Azizullah *et al.*, 2011). In Sindh, people are suffering from 16-36%, exposing a high level of arsenic up to 315 µg/L in some areas of groundwater (Jakhrani *et al.*, 2011).

Arsenic also causes a hazardous effect on the population in the northern areas of Pakistan, where 25% of people face the perilous effect of arsenic (Azizullah *et al.*, 2011). Water is being deteriorated and not safe for drinking purposes in populous areas of Pakistan like Karachi, Lahore, Peshawar, and various other cities due to various anthropogenic activities. In comparison to the quality of groundwater of Kandhkot city is much better and safe than other cities of Pakistan especially in Punjab province, where groundwater is contaminated more and unsafe for people due to the high concentration of arsenic. Many studies have reported a high concentration of arsenic in different cities such as Dera Gazi Khan (1–29 µg/L), Rahim Yar Khan (20–500 µg/L), Bahawalpur (0.5–59 µg/L), Muzaffargarh (0.01–900 µg/L), Multan (0–50 µg/L), Lahore (0–50 µg/L) Faisalabad (1.0–23 µg/L) and Sheikhupura (5–76 µg/L) as shown in Table. 2.

Table 1. Arsenic (µg/L) level in groundwater of different wards of Kandhkot city.

Sample No.	Ward-01	Ward-02	Ward-03	Ward-04	Ward-05	Ward-06	Ward-07	Ward-08	Ward-09	Ward-10	Ward-11	Ward-12	Ward-13	Ward-14	Ward-15	Ward-16
1	6.0	5.5	6.4	7.2	4.1	3.1	7.2	6.2	21	20	9.1	15	23	18.5	9.5	6.1
2	12.4	6.2	7.1	7.1	4.0	4.2	15	6.3	11	12	11.4	13	13	9.5	6.0	7.3
3	7.0	5.0	8.0	7.0	4.2	4.1	7.5	3.1	11	11.5	12	13.5	13	9.4	6.0	8.1
4	7.1	4.2	7.0	7.0	4.1	4.3	7.4	3.5	12	11	22	17	8.0	6.0	9.5	7.1
5	7.0	4.1	6.1	6.0	11.0	9.4	7.0	5.0	11.4	10.5	23	17	8.0	6.0	9.0	7.0
6	8.1	4.2	7.5	5.5	11.0	9.1	6.5	5.1	20.2	10	15	12	18.1	9.5	6.5	8.0
7	8.1	9.0	10	6.0	3.1	7.5	4.3	7.0	11	11.3	11	11.5	8.0	6.0	6.5	8.4
Mean	7.9	5.5	7.4	6.5	5.9	5.9	7.9	5.2	13.9	12.3	14.8	14.1	13.1	9.3	7.6	7.4
STDV	1.8	1.5	1.1	0.6	3.1	2.3	2.9	1.3	3.9	2.9	4.8	1.9	5.0	3.8	1.4	0.6

In the upper part of Dadu, groundwater quality was found polluted with arsenic contamination. The level of arsenic in the water of Dadu was reported in the range of 8–67 µg/L. The groundwater quality of Jamshoro was also reported with the contamination of the arsenic level with 13.0–106 µg/L. The research was also conducted on the groundwater assessment of Tando Allahyar, Thatta, and Karachi, where a higher concentration of arsenic was reported 0.04–300 µg/L, 10–200 µg/L, and 1–80 µg/L, respectively. The study concluded that 39% of groundwater samples have exceeded the limit of WHO permissible level and found unsafe for drinking purpose. Furthermore, these results confirm the worsening situation of groundwater quality of Punjab and other cities of Sindh province, where a higher level of arsenic found in groundwater and people has been suffering from various diseases caused by arsenic contamination.

Table 2. Concentration of Arsenic in different cities of Pakistan.

Province	City	As (µg/L)	References
Punjab	Dera Gazi Khan	1–29	Malana&Khosa, (2011)
	RahimYar Khan	20–500	Mahar*et al.* (2015)
	Muzffargarh	0.01–900	Nickson, *et al.*(2005)
	Bhawalpur	0.5–59	Aziz, (2001)
	Multan	0–50	Farooqi, *et al.* (2007).
	Lahore	0–50	Akhan, F*et al.* (2006).
	Faisalabad	1.0–23	Rahman, A.*et al.* (2006).

Province	City	As (µg/L)	References
	Sheikhupura	5–76	Abbas & Cheema, (2015)
Khyber Pakhtunkhwa	Peshawar	5–20	Shakirullah *et al.* (2004)
	Nowshera	0.01–17.58	Khan M *et al.* (2015)
Sindh	Khairpur	0.24–315.6	M. Jakhrani,*et al.* (2009)
	Gambat	0.01–126	M. Jakhrani *et al.*, (2011)
	Nawab Shah	10–200	Kandhro *et al.* (2016)
	Dadu	8–67	A. Memon *et al.*., (2016)
	TandoAllahayar	0.04–300	Majidano, *et al.*(2010)
	Matiari	0.05–50	UqailiN. *et al.*., (2012)
	Jamshoro	13–106	Baig L.*et al.*., (2009)
	Thatta	10–200	Rubab *et al.* (2014)
	Karachi	1–80	A. Rahman, B. Lee, &*et al.* (1997)
	Larkana	0.01–17	A H Kori, M. A.Jakhrani (2018)
	Kandhkot	3.1 - 23	Current Study

When comparing the concentration of arsenic in groundwater of Kandhkot city with other countries, it is a much lower level of 3.6 to 23 µg/L in some wards. In East Asian countries, a high level of arsenic in groundwater of Inner Mongolia, Thailand, Burma, Vietnam, and Cambodia have been reported. The arsenic contamination in groundwater of Asian countries is shown in Table 3.

Table 3. Arsenic concentration in ground water of different parts of world.

Country	Concentration µg/L	Reference
India	2000	Kumar & Shah, 2006
Bangladesh	$4^{*}10^{4}$	Guo *et al.*, 2001
Inner	4000	Berg *et al.*, 2001
Mongolia,	3100	Lin *et al.*, 2013
China	1800	Kim, Chanpiwat, Hanh,
Vietnam	114	Phan, &
Taiwan	350	Sthiannopkao, 2011
Thailand	3500	
Burma		
Cambodia		

Human health risk assessment

The health risk assessment was calculated by using the calculation of Arsenic daily intake method as mentioned in the literature.

Arsenic daily intake (ADI)

According to literature, total arsenic intake was anticipated using formula (Baig *et al.,* 2009). ADI is equal to mean arsenic concentration in groundwater multiply with daily water intake and divided by the mean weight of the body.

The daily water intake was assumed 3.0 to 3.5 liters while 65, 28kg bodyweight of common people respectively. The results of arsenic daily intake are shown in table 20-24. Human health risk assessment of total Arsenic indicated that the people of ward-09, 10, 11, 12, and ward-13 are at risk of chronic arsenic poison due to arsenic in their groundwater, in the rest of the wards, the index was low as mentioned in table 4.

Table 4. Arsenic daily intakes from drinking water of different UCs of Kandhkot city.

Sample No:	Ward -01	Ward-02	Ward-03	Ward-04	Ward-05	Ward-06	Ward-07	Ward-08	Ward-09	Ward-10	Ward-11	Ward-12	Ward-13	Ward-14	Ward-15	Ward-16
Arsenic Mean (µg/L)	9	6.5	8	6.3	07	6.2	9.5	05	16	15	16.5	14.2	14.5	12	7.5	7.3
ADI	0.48	0.35	0.43	0.34	0.37	0.33	0.51	0.26	0.86	0.80	0.88	0.76	0.78	0.64	0.40	0.39
Risk limit	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66

Conclusion

It has been concluded that the maximum concentration of arsenic was found 23.0 µgL-1 in ward-11 & 13, while in ward-02, ward-03, ward-04, ward-06, ward-08, and ward-15 it was within the permissible limits of 10 µgL-1 as proposed by WHO. The human subject study indicated that in UC-1, UC-2, UC-3, and UC-4 of total 73, 68, 135, and 84 people were suffering from various diseases respectively. It may be due to the contamination of Arsenic in groundwater.

Moreover, a positive correlation of the Arsenic level with human health study was noted. It was deduced from the study that water can be used for drinking purposes with caution. Keeping in view of the results obtained in this study, it can be concluded that the groundwater of Kandhkot city is not safe for drinking purposes based on (ADI report) except wards-09, 10, 11, 12, and 13. Therefore, it may cause health problems for local inhabitants and pose future complications for Kandhkot community, if they continue drinking unsafe water. Hence, it is recommended to Pakistan state and particularly Sindh government to pay special attention and protect people from contaminated water and improve solid waste management to keep groundwater of Kandhkot city safe for the future as well as increase awareness among farmers to use chemicals(pesticides) sparingly to keep water safe.

Acknowledgement
I am highly thankful of Institute of Chemistry, Shah Abdul Latif University, Khairpur, Pakistan that provided chemicals and instrumentations to carry out this work for scientific purpose.

References

Abdul Hameed Kori, Mushtaque Ali Jakhrani, Sarfaraz Ahmed Mahesar, Ghulam Qadir Shar, Muhammad SaqafJagirani, Abdul Raheem Shar & Oan Muhammad Sahito. 2018 Risk assessment of arsenic in ground water of Larkana city Geology, Ecology, and Landscapes. Volume 2, Issue-**1,** p. 8-14

Begum S, Shah M T, Muhammad S. 2015. Role of mafic and ultramafic rocks i drinking water quality and its potential health risk assessment, Northern Pakistan. Journal of Water Health. Volume **13,** Issue 4, 1130-1142.

Braune E, Xu Y. 2008. Groundwater management issues in Southern Africa: An IWRM perspective. Water S A, Vol. 34, Issues **6,** 699-706.

Fakir Md. Yunus, Safayet Khan Priyank. 2016. A Review of Groundwater Arsenic Contamination in Bangladesh: The Millennium Development Goal Era and Beyond International Journal of Environmental Research and Public Health 15 February. Volume **13,** issue 2, p. 215.

Gul N, Shah MT, Khan S. 2015. Arsenic and heavy metals contamination, risk assessment and their source in drinking water of the Mardan district, Khyber Pakhtunkhwa, Pakistan. Journal Water Health. Volume **13,** Issue 4, 1073-1084

Jameel Ahmed Baig, Tasneem GulKazi, Mohammad BalalArain, Hassan Imran Afradi, Ghulam Abbas Kandhro, Raja Adil Sarfraz, Mohammad Khan Jamal, Abdul Qadir Shah. 2009. Evaluation of arsenic and other physico-chemical parameters of surface and groundwater of Jamshoro, Pakistan. Volume 166, Issues **2(3),** 30 July 2009, Pages 662-669.

Khan MU, Malik RN, Muhammad S. 2013. Human health risk from heavy metal via food crops consumption with wastewater irrigation practices in Pakistan. Chemosphere, Volume **93,** Issue 3, p. 2230-2238.

Khan MU, Malik RN, Muhammad S. 2015. Health risk assessment of consumption of heavy metals in market food crops from Sialkot and Gujranwala Districts, Pakistan. Human Ecological Risk Assessment Volume **21,** Issue-2, 327-337.

Khan S, Shah I A, Muhammad S. 2015. Arsenic and heavy metal concentrations in drinking water in Pakistan and risk assessment; a case study. Human Ecological Risk Assessment. Volume **21,** Issue-10, 20-31.

Ma L, Qin X, Sun N. 2014. Human health risk of metals in drinking-water source areas from a forest zone after long-term excessive deforestation. Human Ecological Risk Assessment Vol. **20,** Issue **5,** p. 1200-1212.

Muhammad S, Shah MT, and Khan S. 2011. Health risk assessment of heavy metals and their source apportionment in drinking water of Kohistan region, northern Pakistan. Journal Micro Chemistry. Volume **98,** Issue 2, 334-343.

Muhammad S, Shah MT, Khan S. 2010. Arsenic health risk assessment in drinking water and source apportionment using multivariate statistical techniques in Kohistan region, northern Pakistan. Food Chemistry Toxicol.Volume-48, Issue **10,** p. 2855-2864.

Seema Anjum Khattak, David Polya, Liaqat Ali and Tahir Shah M. 2016. Arsenic exposure assessment from ground water sources in Peshawar Basin of Khyber Pakhtunkhwa, Pakistan. Journal of Himalayan Earth Sciences Volume **49,** No. 1, pp. 68-76.

Shah MT, Ara J, Muhammad S. 2012. Health risk assessment via surface water and sub-surface water consumption in the mafic and ultramafic terrain, Mohmand Agency, Northern Pakistan. Journal of Geochemistry Explor. Vol. **118,** 60-67.

Shah MT, Ara J, Muhammad S. 2012. Health risk assessment via surface water and sub-surface water consumption in the mafic and ultramafic terrain, Mohmand Agency, Northern Pakistan. Journal of Geochemistry Explore. Vol. **118,** 60-7.

Shah MT, Ara J, Muhammad S. 2014. Potential heavy metal accumulation of indigenous plant species along the mafic and ultramafic terrain in the Mohmand agency, Pakistan. CLEAN-Soil, Air, Water Volume **42,** Issue 3, 339-346.

Who/Unicef. 2014. Joint Water Supply, Sanitation Monitoring Programme. Progress on Drinking Waterand Sanitation. Volume. 11 issues **8,** 8137.

Wu Y, Li W, Sparks DL. 2015. The effects of iron (II) on the kinetics of arsenic oxidation and sorption on manganese oxides. Journal Colloid Interface Sciences. Volume **457,** 319-328.

Yi Huang and Chihiro Inoue. 2016. Arsenic contamination of groundwater and agricultural soil irrigated with the groundwater in Mekong Delta, Vietnam Environmental Earth Sciences Volume **75,** Issue-9 article number 757.