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Health Risk Assessment of Arsenic Contaminated Ground Water of Taluka Moro, District Naushahro Feroze, Sindh, Pakistan

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Abstract: This study is to report the occurrence of arsenic (As) in ground water samples of Taluka Moro, District Naushahro Feroze and to compute the health risk assessment of As. Total 52 groundwater samples collected from 17 union councils (UCs) of taluka Moro. The quality of groundwater assessed by analyzing the concentration of As and other physicochemical parameters. The results revealed that in 27 samples As was not detected, 13 samples contain As level within WHO permissible limit (10 ppb) whereas only 12 samples showed the As content above allowable limits of WHO. The maximum As concentration observed was 90 ppb in samples collected from UC lett and Moro city. Physico-chemical parameters such as pH, Total Dissolved Solids (TDS), electric conductivity (EC), sulfate, phosphate, calcium (Ca) and magnesium (Mg) determined in all samples. pH values in the water samples were found within WHO permissible limit, while TDS and EC result exceeded the WHO limits in eight samples. The reveals of sulfate, phosphate, Ca and Mg presented a similar trend to that of TDS and EC. Health risk assessment was calculated using formulae proposed by USEPA. Average daily dose (ADD), cancer risk (CR) and hazard quotient (HQ) value also figured. The study concluded that due to consumption of As-contaminated groundwater and high cancer risk values, the people of UCs Lett, Deparja, Moro city, Khalos, Kot Satabo, Jatoi, Lalia, Gachero, Kenchi Jageer, Manaheen and Fatoo Bala are at cancer risk.

Key words: As · Contamination of water · Groundwater · Health Risk Assessment · Cancer Risk · Physico-chemical · Moro

INTRODUCTION

The occurrence of arsenic (As) in groundwater is a significant public health concern due to its carcinogenic and persistent nature. According to the United Nation World assessment program [1], about 140 million people in more than 70 countries are severely affected by groundwater pollution of As. The maximum permissible limit proposed by WHO for As in drinking water is 10 ppb and has also declared As a "major public health issue" that must handle on the emergency basis [2].

Arsenic is mobilized in nature by many factors including degradation of biological activities, volcanic eruption, weathering of rocks [3]. The anthropogenic activities; such as the use of Hebrides, insecticide, fossil fuel combustion, mining, smelting, use of additives in poultry and livestock feeds [4, 5]. According to literature survey, it has reported that 7-10 millions of people living in different countries of the world, such as Bangladesh, Vietnam, Magnolia, Chile, Mexico, China, India, Argentina, Taiwan and Pakistan highly exposed to As due to consumption of As-contaminated groundwater [6]. Due to use of As-contaminated water, people in South and East Asian region have been affected by skin, lungs, kidney and bladder cancer [7-9].

Arsenic has associated with various systemic effects like cardiovascular diseases, skin disorders and neurotoxicity. Arsenic exists in two primary forms as soluble in water: Arsenite (As+3) and arsenate (As+5). Both the forms cause acute and chronic toxicity to a wide variety of organisms including humans [10]. In an environment, the concentration of arsenic varies being lowest in the air particularly in remote and rural areas whereas; it is highest in industrial settings [11]. According to a report of the Pakistan Council of Research in Water Resources [12] after India and Bangladesh, now

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Pakistan is also facing a growing threat of arsenic contamination in drinking water. During surveys and studies conducted by PCRWR on sub-soil water analysis in collaboration with UNICEF, groundwater was declared 'dangerous' having Arsenic contamination above the permissible level of WHO guideline (10 ppb) in the Punjab districts and Sindh. The Government of Pakistan has promulgated National Drinking Water Quality Standards (NDWQS) of Pakistan in the year 2010 and prescribed the permissible level as 50 ppb in the country [13]. The general geochemical conditions that lead to mobilization of arsenic into groundwater characterized by one or more of the following features: reducing (6–8) environments, arid oxidizing environments with elevated pH [1, 9, 10].

In Sindh province, Pakistan, As affected District include Khairpur [14], Nawabshah [15], Tando Allahyar [16], Dadu [17] and Jamshoro [18].

Health risk assessment, the study has attracted the attention of Environmental scientist nowadays, because environmental pollution in water bodies especially heavy metals has affected human life badly [19, 20]. According to literature, health risk assessment, carcinogenic and chronic effects of As can be calculated using estimated daily dose (ADD), Hazard quotient (HQ) and cancer risk (CR) formulas [21, 22].

Various researchers have studied different metals in groundwater of Naushahro Feroze, but no any study has conducted on arsenic that poses a severe health risk. The first study which was carried out to assess As concentration in groundwater samples of Taluka Moro, District Naushehro Feroz and to calculated Health risk assessment in this area of Sindh province.

MATERIALS AND METHODS

Brief Description of Study Area: The study area is Taluka Moro, District Naushahro Feroze, Sindh, Pakistan. Taluka Moro consists of 17 UCs and located in North of District Dadu, district Jamshoro is at the west side and district Nawabshah is at South, from Taluka Moro to Naushahro Feroze. Its distance is approximately 18 kilometers and it's about 12 kilometers away from river Indus. While its population is 2, 65, 251 approximately (as per record of Revenue department-2017). The drinking sources of Taluka Moro based on water supply schemes and groundwater through hand pumps and tube wells. According to technical assessment survey report of Pakistan Council of Research in Water Resources (PCRWR), only five water supply schemes out of total 24 in district Nauoshahro Feroz are functional and rest of 19 projects are nonfunctional due to unavailability of funds and use of groundwater by local people. The people living in taluka Moro consume groundwater for drinking as well as agriculture purposes in forms of hand pumps and tube wells [23]. The GIS map of the study area detailed in Fig. 1.

Chemicals: Arsenic Trioxides, Sodium Boro-hydride, Hydrochloric acid and Nitric Acid were purchased from DAEJUNG Chemicals and Metals, Korea. Sodium hydroxide was purchased from Merk, Germany.

Sample Collection: Total 52 samples collected from 17 Union Council of Taluka Moro. All the sample were collected in duplicate from hand pumps, electric motors and tube wells with depth ranging from 20 to 200 meters by using white plastic bottles. The samples for As analysis were preserved by adding a few drops of nitric acid and were correctly sealed at the sampling site. The latitude and longitude were recorded using a Global Position System (GPS) at time of sampling the collected. Samples preserved at 4-degree centigrade before analysis.

Sample Preparation and Analysis: The preserved samples were pre-concentrated by adding 1 ml of HNO3 in 1 liter of a water sample. The samples (1 liter) then placed a hot plate and the volume reduced to 100 ml. Finally, it was filtered using Whatman filter paper and analyzed for As content.

The As content in samples were analyzed using Hydride Generation-Atomic Absorption Spectrometer method (HG-AAS). In brief, the 1000 ppm standard prepared by Arsenic trioxide and further diluted to 0.2, 0.4, 0.6, 0.8 and 1 ppm to make a calibration curve on equipment. Sodium-Boro-hydride solution (2%) was prepared separately in 0.5% Sodium-hydroxide. The calibration curve is drawn by running standard As solutions and a linear regression equation obtained, the samples were acidified using Hydrochloric acid and were analyzed for As content in triplicate using HG-AAS, model AI1200, Aurora company, Canada.

Measurement of Physico-Chemical Parameters: The Physico-chemical parameters also measured for collected groundwater samples. The parameters included were pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Calcium (Ca+), Magnesium (Mg+), sulfate and phosphate. TDS and EC were recorded using HACH company conductivity meter and pH was measured using a pH meter of WTW, Germany. Ca+2 and Mg+2 measured

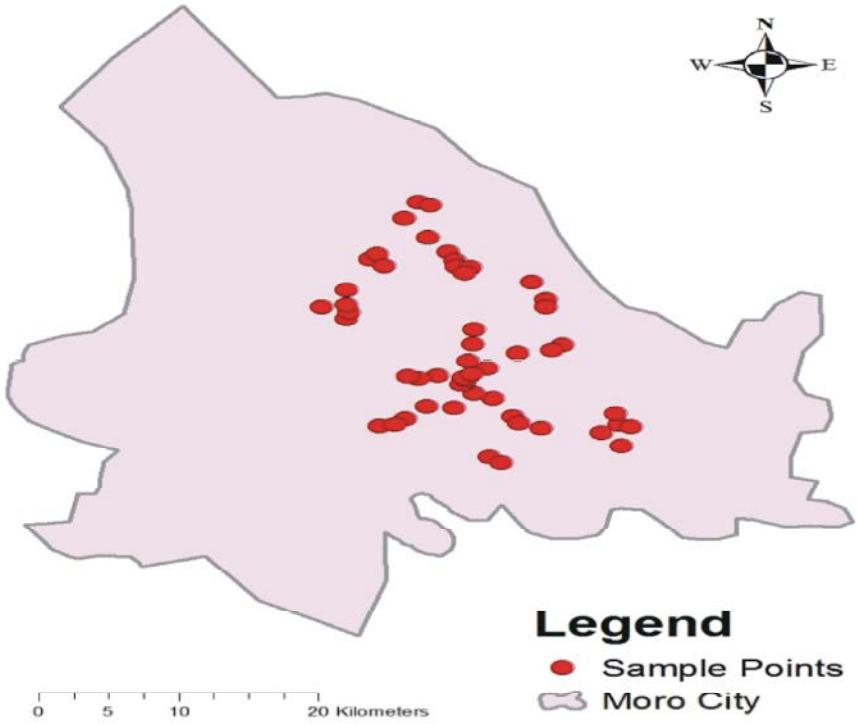

Fig. 1: Arc GIS Map of sampling locations of study area

by titration method. Sulfate was analyzed by turbidimetric method [24] and Phosphate was determined by Molybdo-Vanadate spectrophotometric method [25] using UV/Visible spectrophotometer, UV-1800, Shimadzu, Japan.

Health Risk Assessment of Arsenic: The aim to calculate risk assessment was to the estimated level of the population of Taluka Moro exposed to As through As-contaminated water. In this study, the USEPA derived model [26] for Health risk assessment was applied to calculate the effect of As exposure to individuals health. For this purpose, the Estimated Daily Intake (ADD) for As via consumption of hand pump and tube wells computed according to the following proposed equation.

$$ADD = CxIRxEDxEFxAT/BW$$

Where, C, IR, ED, EF, BW and AT represents the concentration of As in water (mg/l), water intake (3 l/day) the , exposure duration (assumed 67 years), exposure frequency(365 days/year), body weight (72 Kg) average lifetime (24455 days) respectively.

The assessment of carcinogenic and chronic risk level, the Hazard Quotient (HQ) calculated. Usually, HQ calculated by the formula given,

$$HQ=ADD/RFD$$

Where RFD is an oral reference dose (0.0003 mg/Kg/day) for As proposed by [27]. Similarly, Cancer Risk (CR) for groundwater of Moro computed by formula,

$$CR = ADDxCSF$$

Where CSF is a cancer slope factor for As which is 1.5 mg/kg according to USEPA.

Statistical Analysis: All the statistical parameters such as mean, median and relative standard deviation were determined using Microsoft Excel, version 2010. Arc GIS version10.2 was used to make the map of the study area. Cluster Analysis (Dendrogram) and correlation metric study were conducted using the statistical package for social sciences (SPSS) version 22.

RESULTS AND DISCUSSION

Arsenic Concentration in Ground Water, Taluka Moro: The effect of As concentration in groundwater samples of Taluka Moro represented in Table 1. The As results divided into 17 UCs and sample IDs given to each sampling location. Arsenic concentration varied dramatically ranging from below detection limit (BDL) to 90 µg/l. The As was not detected in 27 samples out of

Table 1: Represents mean As concentration in groundwater samples of 17 UCs of Taluka Moro

S#	Address	Sample ID	X- Longitude	Y-Latitude	As µg/L (mean)
		Lundki UC			
1	Village Near Hafiz Ali Murad Mast	VHAMM	68.01633	26.64207	BDL
2	Village Liaque Zardari	VLZ	68.02942	26.62284	BDL
3	RO Office WAPDA	ROW	68.0126	26.67284	BDL
		Khairah UC			
4	Village Photo Zardari	VPZ	68.08665	26.60657	BDL
5	Village Rahib Buriro	VRB	68.09799	26.61437	BDL
6	Village Muhammad Buriro	VMB	68.09556	26.62613	BDL
		Kehkat UC			
7	Village Mehro Kalhoro	VMK	68.10533	26.61204	40
8	Village Saifal Shahi	VSS	68.09906	26.59275	BDL
9	Village Ali Muhammad Zardari	VAMZ	68.04777	26.61076	BDL
		Khalso UC			
10	Village Lundo	VL	68.03336	26.61602	BDL
11	Village Hunainabad	VH	68.01424	26.58103	40
12	Village Muhammad Khan Solangi	VMKS	68.02178	26.57496	BDL
		Gachehro UC			
13	Dargah Kamal Shah	VDKS	67.96026	26.62044	BDL
14	Dargah Makhdoom Shah	DKMS	67.94402	26.6127	BDL
15	Link Road	LR	67.95353	26.61438	BDL
		Dal Chand UC			
16	Village Muhammad Rahim Chand	VMRC	67.97435	26.6335	BDL
17	Village New Gachehro	VNG	67.99183	26.63238	1
18	Village Khan Muhammad Khaskheli	VKMK	68.00474	26.64696	10
		Fatoo Bala UC			
19	Lalu Machi	LM	67.98103	26.66552	BDL
20	Village Hashim Solangi	VHS	67.96905	26.66242	5.7
21	Village Sahib Khan Chandio	VSKC	67.96229	26.6646	3
		Daris UC			
22	Daris Road	DR	68.00086	26.68095	BDL
23	Village Ghullam Hyder Kario	VGHK	68.00372	26.69802	BDL
24	Village Gareebo Behan	VGB	68.00484	26.71306	BDL
		Manaheen UC			
25	Village Mooso Khoso	VMK	68.04187	26.7626	BDL
26	Peer Saedi	PS	68.05094	26.74466	2.2
27	Village Bachal Khokhar	VBK	68.05105	26.7371	BDL
		Kanchi Jageer UC			
28	Village Duro Behan	VDB	68.06118	26.69746	2
29	Village Sher Khan Behan	VSKB	68.05434	26.69237	BDL
30	Village Wadpagya	VW	68.03245	26.68869	BDL
		Lalia UC			
31	Village Junalo	VJ	67.90622	26.73709	BDL
32	Village Imam abad	VIA	67.92269	26.72436	BDL
		Kot Satabo UC			
33	Village Gul Muhammad Siyal	VGMS	67.92383	26.7312	BDL
34	Village Puran	VP	67.92229	26.73944	80
35	Village Ahmed Khan Almani (Pako goth)	VAKA	67.92238	26.75443	61.3
		Deparja UC			
36	BHU Hospital Deparja	BHU	67.93802	26.78622	5
37	Dargah Sain Nazar Muhammad	DSNM	67.94255	26.79157	18
38	Village Meer Hassan mari	VMHM	67.94642	26.77934	BDL

Table 1: Continued

		Lett UC			
39	Village Gul Muhammad Bhatti	VGMB	67.95999	26.82895	10
40	Village Murad korejo	VMK	67.96866	26.84514	90
41	Village Letnagar	VL	67.97666	26.8423	2
		Diloo Shah UC			
42	Village Thorha	VT	67.97505	26.80913	3
43	Govt: P.H.S. School New Jatoi Mosque	GPHS	67.9874	26.79359	2
44	Village Kamil Jarwar	VKJ	67.99256	26.78473	2
		Jatoi UC			
45	Link Road Jatoi Deparja	LRJD	67.99291	26.77887	4
46	Village Manak Khan Khoso	VMKK	68.0021	26.77743	10
47	Jatoi Grid Station	JGS	67.99873	26.77139	5
		Moro City			
48	Near Gachehro Road Moro	GRM	67.99744	26.65704	40
49	Gachehro Road Near Saban Chowk Moro	GRSCM	67.99632	26.65662	15
50	Near National Bank Moro	NNBM	67.99889	26.66121	BDL
51	Soomro Muhalla Moro	SMM	67.99779	26.66301	90
52	Near Midway Hotel	MW	68.0028	26.66727	1

Note: BDL= Below Detection Limit, UC= Union Council

52 samples, whereas in 13 samples the detected concentration of As was found within permissible limits of WHO (10µg/l). Total 12 samples of whole samples showed As concentration above WHO guideline values.

The maximum average concentration of As observed was 90 µg/l in samples of Village Murad Korejo (VMK) and Soomro Muhalla Moro (SMM). Such as high concentration of As in these two samples represents the serious level of As contamination in groundwater of these study areas. The samples with As contents crossing the WHO guidelines showed minimum As-concentration of 15 µg/l in sample GRSCM. While the As content observed in remaining samples were 40 µg/l (VMK), 40 µg/l (VH), 61.3 µg/l (VAKA) and 18 µg/l (DSNM). Among groundwater including hand pumps and tube wells, As is one of the hazardous species that originate from anthropogenic as well as natural sources [18]. According to previous studies, it has reported that the As contamination has badly affected the groundwater quality of Sindh [28]. The situation of As contamination in hand pump and tube well groundwater samples from neighboring cities of Taluka Moro, Taluka Moro is also worst, for instant the maximum As concentration observed in Khairpur city was 315 µg/l [14], Nawabshah city 200 µg/l [15] and Dadu city was 67 µg/l respectively due to enormous use of pesticides and fertilizer in agricultural lands [17].

Physico-Chemical Characteristics: The hand pump, electric motor and tube well samples of Taluka Moro analyzed for physicochemical characteristics. The parameters included pH, TDS, EC, sulfate, Phosphate, Calcium and Magnesium. The result of the physio-chemical parameters summarized in table 2. The TDS was observed ranging from 210 mg/l to 5610 mg/l. The maximum TDS observed was a groundwater sample of MKS, UC Khalso (5610 mg/l). Only 8 samples out of 52 showed TDS value higher than the permissible limit of WHO(1000 mg/l). pH values in all the samples were within the WHO guideline values (6.5-8.5) and ranged from (7.29 to 8.12). Sulfate values observed were minimum 29 mg/l and maximum 201mg/l, whereas the Phosphate values measured as below detection limit (BDL) to maximum 2.94 mg/l in a sample of Junalo, UC Lalia.

Health Risk Assessment: Health risk assessment data of water samples is summarized in table 3. The results of samples are divided in 17 Unions Councils (UCs) including Moro City. Risk assessment values were calculated from mean result of samples in each UC. The average estimated daily intake (ADD) value for As content observed in 5 UCs were zero. The minimum ADD values were find in UC Fatoo Bala that was 0.0000278 mg/Kg per day, whereas the maximum values of 0.001963 mg/Kg per day was observed at UC Lett. The highest values of ADD represents As contamination UC Lett.

The values of target hazard quotient (HQ) presented in table 3. The HQ values are shown in Table 3. The HQ values or UCs of Moro, followed almost same tends like ADD values, the HQ values in 5 UCs observed were zero, because of the As values found below the detection limit in all samples of those 5 UCs. Similarly, in remaining

Table 2. Shows results of Physico-chemical parameters of sample of Taluka Moro.

S#	Sample ID	pH	TDS mg/L	E.C µS/cm	Phosphate mg/L	Sulfate mg/L	Calcium mg/L	Magnesium mg/L
1	VHAMM	7.94	1430	2850	1.51904	142.9063	100	36
2	VLZ	7.92	210	420	0.66190	33.92187	60	22
3	VAMZ	7.49	590	1190	1.09047	124.2344	60	22
4	VPZ	7.69	360	710	0.51904	49.93750	80	29
5	VRB	7.48	3260	6530	1.23333	196.0313	280	101
6	VMB	7.58	400	800	1.04285	49.39062	100	36
7	VMK	8.12	890	1790	0.56666	159.8594	60	22
8	VSS	7.68	600	1210	1.47142	140.7188	100	36
9	VL	7.84	330	660	1.51904	29.15625	60	22
10	VH	7.94	3580	7170	1.32857	187.43750	120	43
11	VMKS	7.60	5610	11230	1.47142	201.2656	240	86
12	DKS	7.40	1820	3650	1.80476	175.0156	460	166
13	DKMS	7.73	400	810	1.42381	61.81250	100	36
14	LR	7.59	770	1550	1.70952	166.3438	180	65
15	VMRC	7.64	1050	2110	1.51904	129.8594	140	50
16	VNG	7.62	1460	2920	1.80476	124.7031	160	58
17	VKMK	7.99	730	1630	1.28095	144.0781	80	29
18	LM	7.61	370	700	1.80476	117.5156	120	43
19	VHS	7.37	590	1180	0.94761	153.2188	220	79
20	VSKC	7.65	410	820	1.80476	120.3281	260	94
21	DR	7.73	7600	1510	BDL	161.18750	280	101
22	VGHK	7.59	1260	2520	BDL	160.4844	160	58
23	VGB	7.45	480	960	BDL	121.3438	140	50
24	VMK	7.68	600	1200	BDL	159.7031	180	65
25	PS	7.52	630	1260	BDL	141.5781	140	50
26	VBK	7.59	640	1280	BDL	141.3438	200	72
27	VDB	8.05	230	470	BDL	40.95312	100	36
28	VSKB	7.66	520	1040	BDL	127.75000	100	36
29	VW	7.57	610	1220	BDL	137.12500	140	50
30	ROW	7.49	470	940	BDL	62.04687	180	65
31	VIA	7.63	780	1550	BDL	150.7188	160	58
32	VGMS	7.76	360	720	BDL	39.62500	80	29
33	VP	7.59	1050	2100	BDL	141.6563	240	86
34	VJ	8.05	270	540	2.94761	16.73437	60	22
35	VAKA	7.80	870	1730	BDL	161.9688	60	22
36	BHU	7.62	810	1620	BDL	182.5156	80	29
37	DSNM	7.53	860	1730	BDL	139.8594	260	94
38	VMHM	7.55	540	1070	BDL	142.6719	220	79
39	VGMB	7.70	730	1450	BDL	146.0313	160	58
40	VMK	7.48	410	820	BDL	87.12500	200	72
41	VL	7.43	500	990	BDL	146.18750	200	72
42	VT	7.66	790	1570	BDL	157.2813	200	72
43	GPHS	7.41	650	1290	BDL	158.2969	60	22
44	VKJ	7.29	730	1470	BDL	163.5313	280	101
45	LRJD	7.40	700	1400	BDL	151.9688	240	86
46	VMKK	7.83	340	670	BDL	92.67187	180	65
47	JGS	7.58	380	760	BDL	76.42187	140	50
48	GRM	7.53	1080	2160	BDL	149.1563	160	58
49	GRSCM	7.61	700	1400	BDL	169.8594	200	72
50	NNBM	7.30	960	1930	BDL	137.75000	240	86
51	SMM	7.71	530	1060	BDL	144.0781	200	72
52	MW	7.59	1640	3310	BDL	168.6094	280	101

Note: BDL= Below Detection Limit

12 UCs the minimum HQ values observed was in UC Fatoo Balal (0.0925) and the highest HQ value measured was 6.542 in UC Lett. The most top HQ was due to most upper As content in groundwater samples and also due to its high RFD values. The people of UC Lett are therefore at chronic health risk due to consumption of groundwater with high As concentration.

Table 3: Shows Average daily dose (ADD), hazard quotient (HQ) and Cancer risk (CR)

UC No	Union Council Names	As in mg/ l	ADD (mg/kg. day)	HQ	CR
1	Khairah	0	0	0	0
2	Kahkat	0	0	0	0
3	Khalso	0.013	0.000541667	1.805555556	0.000361111
4	Deparja	0.013	0.000541667	1.805555556	0.000361111
5	Diloo Shah	0	0	0	0
6	Lalia	0.003667	0.000152792	0.509305556	0.000101861
7	Gachero	0.0029	0.000120833	0.402777778	0.0000806
8	Daris	0	0	0	0
9	Manaheen	0.00073	0.000030416	0.101386667	0.0000203
10	Fatoo Bala	0.000667	0.00002779	0.092633333	0.00001853
11	Lundki	0	0	0	0
12	Lett	0.0471	0.0019625	6.541666667	0.001308333
13	Kot Satabo	0.0077	0.000320833	1.069444444	0.000213889
14	Dal Chand	0.034	0.001416667	4.722222222	0.000944444
15	Kenchi Jageer	0.0023	0.0000958	0.319333333	0.00006387
16	Jatoi	0.0063	0.0002625	0.875	0.000175
17	Moro City	0.0292	0.001216667	4.055555556	0.000811111

Table 4: Pearson correlation coefficient values of As with other physico-chemical parameters

Parameters	As	pH	TDS	EC	Sulfate	Phosphate	Ca	Mg
As	1							
pH	0.1169	1						
TDS	0.02134	-0.0429	1					
EC	0.02138	-0.0398	0.9999	1				
Sulfate	0.116	-0.3412	0.54182	0.5422	1			
Phosphate	-0.2307	0.29118	0.251422	0.25316	-0.1583	1		
Ca	0.02479	-0.5541	0.31684	0.315743	0.47044	-0.10345	1	
Mg	0.02479	-0.5541	0.31684	0.315743	0.47044	-0.10345	1	1

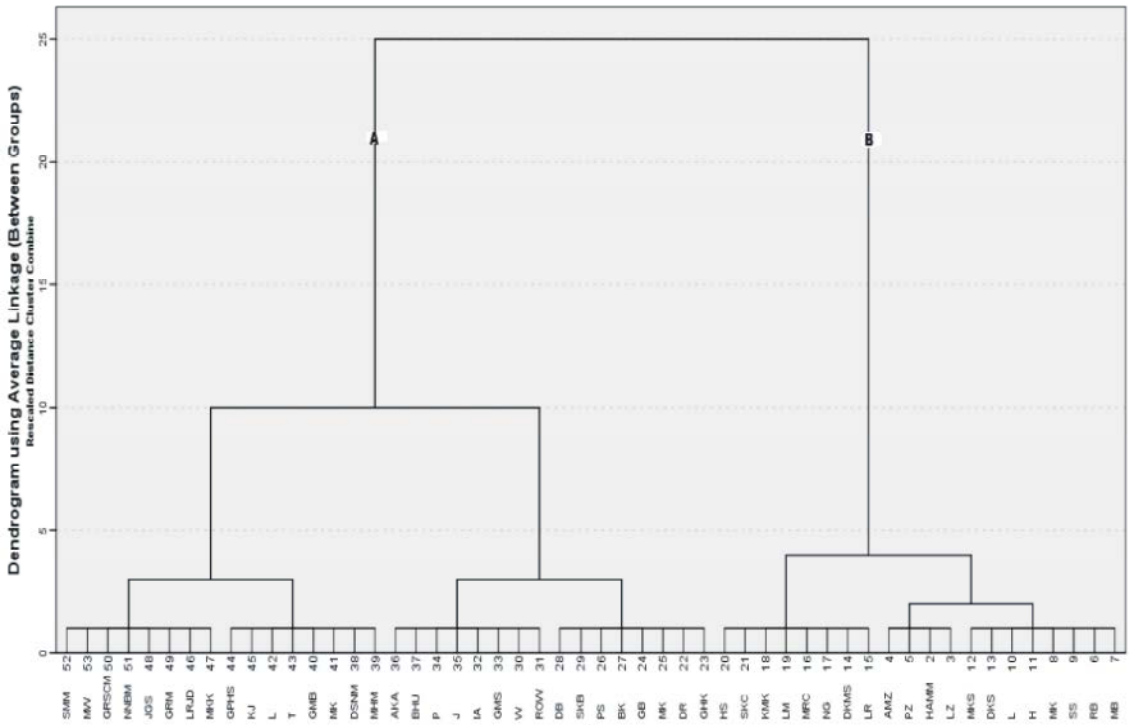

Fig. 2: Dendogram represents the similarity in As concentration between sampling location

Cancer Risk: The average Cancer Risk (CR) values for groundwater samples of UCs Lett, Dal Chand, Moro city, Khalso, Deeparja, Kot Satabo, Jatoi, Lalia, Gachero, Kenchi Jageer, Manaheen and Fatoo Bala city were exceed the safe limits proposed by USEPA. According to USEPA, CR values higher than 10-6 are considered significant. But the values observed revealed that groundwater of some UCs of more poses an elevated cancer risk due to As contamination groundwater. The results are shown in Table 3.

Correlation of As with Physico-Chemical Parameter: The correlation of As values measured with other Physico-chemical parameters such as pH, TDS, EC, Sulfate, Phosphate, Ca+ and Mg+, as shown in Table 4. The arsenic represents weak positive correlation with all the parameters except phosphate. The phosphate only shows the negative correlation with As concentration.

Hierarchical Cluster Analysis: The Hierarchical cluster analysis (HCA) recognizes the group of samples having similar water quality parameters (29). In cluster analysis, similar results fall in the same class and dissimilar into other class (30). The HCA presented in a graph known as the Dendrogram, which divides the samples into groups and sub-groups. The Dendrogram for As concentration in groundwater samples of Taluka, Moro in fig (2) this is divided into two primary group named A and B. Both A and B groups are further divided into two sub-groups. Group A is relatively larger than B, which consist of the sampling sites. All samples containing high As concentration grouped into group A. The group is of the samples in which As was not detected.

CONCLUSION

The study concluded that the majority of the hand pump and tube well samples collected from Taluka, Moro represented As concentration in safe WHO guideline values. In 27 samples of total 52 samples As was not detected. Only 12 samples showed As concentration above the permissible limit of WHO guideline. It was observed through this study that the peoples of UCs Lett>Dal chand> Moro city>Khalso, Deeparja>Kot Satabo>Jatoi>Lalia >Gachero>Kenchi jageer>Manaheen>Fatoo Bala are at risk of cancer due to consumption of As-contaminated water. The ADD, HQ and CR values for UCs Lett, Dal Chand, Moro city, Khalso, Deeparja, Kot Satabo, Jatoi, Lalia, Gachero, Kenchi Jageer, Manaheen and Fatoo Balal observed to higher than proposed safe limits of USEPA and 5 UCs are in the limit of USEPA.

REFERENCES

1. UN WWAP, 2009. United Nations World Water Assessment Programme. The World Water Development Report 3: Water in a Changing World. UNESCO, Paris, France. Retrieved 18 May, 2011.
2. Nguyen, V.A., S. Bang, P.H. Viet and K.W. Kim, 2009. Contamination of groundwater and risk assessment for arsenic exposure in Ha Nam province, Vietnam. Environment International, 35: 466-472.
3. Mukherjee, A. and A.E. Fryar, 2008. Deeper groundwater chemistry and geochemical modeling of the arsenic affected western Bengal basin, West Bengal, India. Applied Geochemistry, 23(4): 863-894.
4. Haque, I.U., D. Nabi, M.A. Baig, W. Hayat and M. Trefry, 2008. Groundwater arsenic contamination – A multidirectional emerging threat to water scarce areas of Pakistan. Proceedings of the 6th International Groundwater Quality Conference held in Fremantle Western Australia. IAHS publication, 324: 24-30.
5. Jadhav, S.V., E. Bringas, G.D. Yadav, V.K. Rathod, I. Ortiz and K.V. Marathe, 2015. Arsenic and fluoride contaminated ground waters: A review of current technologies for contaminants removal. Journal of Environmental Management, 162: 306-325.
6. Smedley, P. and D. Kinniburgh, 2002. A review of the source, behavior and distribution of arsenic in natural waters. Appl. Geochem., 17(5): 517-568.
7. Frisbie, S.H., R. Ortega, D.M. Maynard and B. Sarkar, 2002. The concentrations of arsenic and other toxic elements in Bangladesh's drinking water. Environ. Health Perspect., 110: 1147-1149.
8. Schmoll, O., G. Howard, J. Chilton and I. Chorus, 2006. Protecting Groundwater For Health: Managing the Quality of Drinking-water Sources. World Health Organization. IWA Publishing, London, UK.
9. Rahman, M.M., R. Naidu and P. Bhattacharya, 2009. Arsenic contamination in groundwater in the Southeast Asia region. Environ. Geochem. Health, 31: 9-21.
10. Kitchin, K.T., 2001. Recent advances in arsenic carcinogenesis: modes of action, animal model systems and methylated arsenic metabolites. Toxicology and Applied Pharmacology, 172: 249-261.

11. Bhumbla, D.K. and R.F. Keefer, 1994. Arsenic Mobilization and Bioavailability in Soils.
12. PCRWR, 2003. Arsenic Contamination in Groundwater of Southern Punjab0, Pakistan Council of Research in Water Resources Ministry of Science and Technology. Islamabad.
13. National Drinking Water Quality Standards (NDWQS), 2010. Ministry of Environment. Government of Pakistan http://www.waterpakistan.com/2010- drinking-water-standards-pakistan.
14. Jakhrani, M., K. Malik, S. Sahito and A. Jakhrani, 2011. Analytical investigation of arsenic and ioron in hand pump and tube-well groundwater of Gambat, Sindh, Pakistan. Pakistan Journal Chemistry, 1(3): 140-144
15. Kandhro, A.J., N.A. Samoon, J.H. Laghari, A.M. Chandio and A.H. Yousfani, 2016. Assessment of arsenic and essential metal ions in the quality of groundwater sources of Taluka Daur, District Shaheed Benazeer Abad, Sindh, Pakistan. Journal of Peoples University of Medical and Health Sciences, 6(1): 1-8.
16. Majidano, S., G. Arain, D. Bajaj, P. Iqbal and M. Khuhawar, 2010. Assessment of ground water quality with focus on arsenic contents and consequences. Case study of Tando Allahyar District in Sindh Province. International Journal of Chemical and Environmental Engineering, 1(2): 54-63.
17. Memon, A.H., G.M. Lund, N.A. Channa, S.A. Shah, M. Younis and F. Buriro, 2016. Contaminants exposure and impacts on drinking water of Johi subdivision of Sindh, Pakistan. Science Letter, 4(1): 78-83.
18. Baig, J.A., T.G. Kazi, M.B. Arain, H.I. Afridi, G.A. Kandhro, R.A. Sarfraz and A.Q. Shah, 2009. Evaluation of arsenic and other physico-chemical parameters of surface and ground water of Jamshoro, Pakistan. Journal of Hazardous Materials, 166(2): 662-669.
19. Ravenscroft, P., H. Brammer and K. Richards, 2009. Arsenic in North America and Europe. Arsenic Pollution: A Global Synthesis, pp: 387-454 DOI: 10.1002/9781444308785.
20. Alkarkhi, A.F., A. Ahmad, N. Ismail and A.M. Easa, 2008. Multivariate analysis of heavymetals concentrations in river estuary. Environ. Monit. Assess., 143: 179-186.
21. Kavcar, P., A. Sofuoglu and S.C. Sofuoglu, 2009. A health risk assessment for exposure to trace metals via drinking water ingestion pathway. International Journal of Hygiene and Environmental Health, 212: 216-227.
22. Caylak, E., 2012. Health risk assessment for arsenic in water sources of Cankiri Province of Turkey. CLEAN - Soil, Air, Water, 40(7): 728-734.
23. Tahir, M.A., M.K. Mari and F. Hasan, 2010. Technical Assessment Survey Report of Water Supply Schemes, Pakistan Council of Research in Water Resources (PCRWR).
24. USEPA, 1986. Method 9038-6 “Sulfate Turbidimetric Method” Revision.
25. APHA, 1992. method 4500-P C“ Vanadomolybdophosphoric Acid Colorimetric method for Phosphate” 18 edition.
26. US Environmental Protection Agency (USEPA), 1998. Arsenic, inorganic. United States Environmental Protection Agency, Integrated Risk Information System (IRIS), (CASRN 7440- 38-2). http://www.epa.gov/iris/subst/0278.htm
27. US Environmental Protection Agency (USEPA), 2005.Guidelines for carcinogen Risk assessment. Risk Assessment Forum, Washington, DC, EPA/630/P-03/001F
28. Sanjrani, M.A., T. Mek, N.D. Sanjrani, S.J. Leghari and H.T. Moryani, 2017. Current Situation of Aqueous Arsenic Contamination in Pakistan, Focused on Sindh and Punjab Province, Pakistan: A Review. J. Pollut Eff Cont 5: 207. doi: 10.4176/2375-4397.1000207
29. Guler, C., G.D. Thyne, J.E. McCray and K.A. Turner, 2002. Evaluation of graphical and multivariate statistical methods for classification of water chemistry data. Hydrogeology Journal, 10: 455-474.
30. Chen, K., J.J. Jiao, J. Huang and R. Huang, 2007. Multivariate statistical evaluation oftrace elements in groundwater in a coastal area in Shenzhen, China. Environ. Pollut., 147(3): 771-780.