Arsenic contamination of groundwater in Ghazni and Maidan Wardak Provinces, Afghanistan

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SUMMARY: In Afghanistan, Arsenic (total As) and Fluoride (F^-) contamination are an issue of current drinking water supply systems where users have been using groundwater sources. Arsenic contamination is the major environmental health management concerns especially in Ghazni and Maidan Wardak provinces in WASH sector. Increasing human activities and haphazard urbanization have modified the cycle of heavy metal, non-metal and metalloids. The As contaminated groundwater used for drinking can cause adverse effect of human health of study area. The water quality study with 746 samples from drinking water points (DWPs) have been carried in Khwaja Omari district and center of Ghazni province and Jaghato district of Maydan Wardak province results show that 61% of drinking water points samples exceeded the value of the WHO guideline of 10 µg/L of As, and 38% of analyzed water samples exceeded the Afghanistan drinking water quality standard (DWQS) of 50 µg/L of As.

1 INTRODUCTION

The inhabitants of study areas are heavily dependent on groundwater containing elevated level of arsenic (As). Therefore, an understanding of the occurrence, behavior, and sources of As along with other water quality parameters in the DWPs is essential to implement drinking-water supply schemes.

The study carried out analyzing physical and chemical parameters integrates data sets from UNICEFE, ECHO funded projects and National Groundwater Monitoring Wells networks to understand the spatial distribution of As concentration along with the hydrochemistry of groundwater in study areas.

The WHO guideline for As in the drinking water is 10 µg/L (WHO, 2004), however the Afghanistan drinking water quality standard (DQWS) is 50 µg/L (ANSA, 2013). This study focuses the distribution and occurrence of high As concentration in the drinking water points of study areas, but there are no clinical information regarding to the health effect of high As content drinking water.

2 METHODS/EXPERIMENTAL

2.1 Description of study area

The study area is located in the south direction of Kabul and geographically, it is situated between latitude 33.39776 - 33.84776 and longitude 68.26683 - 68.61683 (Figure 1). It covers total area of about 6788 km^2 with population of about 844,765 (Polhill, 1982)[3]. It has semi- arid climate with major fluctuation in day- and night-time fluctuations. The winter is characterized by low temperatures of less than -20 ºC while the summer is dominated by high temperatures of more than 35 ºC. The rainfall and snowfall are the main source of groundwater and surface water, and the area receives an average 200 mm rainfall [4]. There are number of seasonal rivers and abandoned channels which are flowing water in rainy seasons.

Groundwater flow direction is from north mountains front hydrogeolgical boundaries (upstream) to south flood plain (downstream) along the Ghazni seasonal river (Uhl &Tahiri, 2003; US Army, 2009).

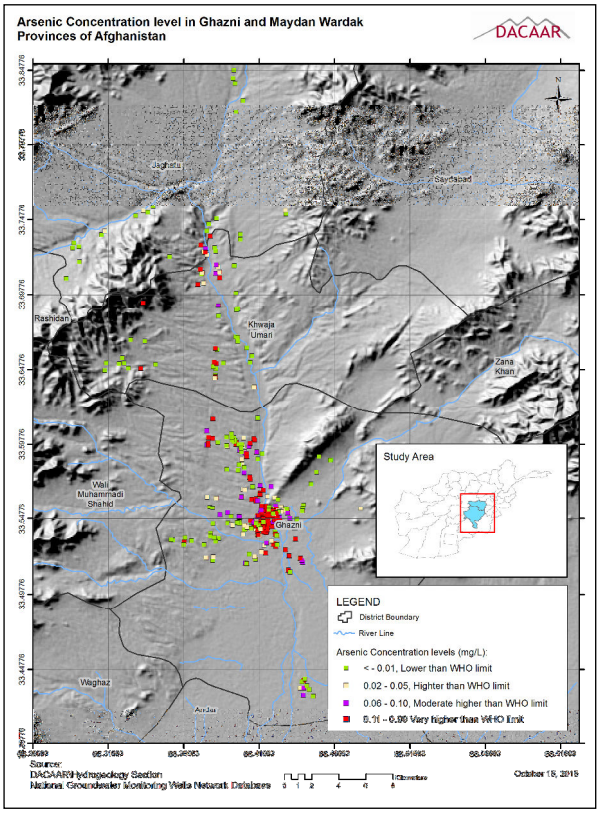

Figure 1: Location of study area and the spatial distribution of arsenic in groundwater samples

2.2 Sampling and field measurement

In total 764, drinking water points (DWPs) including hand pump tube wells and dug wells were collected

and tested on-site for measurement of As concentration and physico-chemical parameters like temperature, pH and electrical conductivity (EC) using digital Arsenator and pH/conductivity meter (Figure 1). 106 out of 764 water samples were sampled for chemical analyses.

Before collection of samples, each hand-pump was flushed for about 10 minute. The samples were then collected in sterilized 500 mm polyethylene bottle according to the DACAAR's water sample collection procedure. All samples were immediately shipped to the laboratory and stored to the refrigerator at 4° C in the dark until analysis. The water samples were analyzed for 34 parameters. The analytical data quality was ensured through col-lection of duplicate samples chemical analysis and comparison. The ionic charge balance of each sam-ples was < 5%.

3 RESULTS AND DISCUSSION

3.1 Distribution pattern of arsenic

Arsenic concentration in the DWPs of study area is mostly geologic occurrence and its spatial distribution is irregular trough the study areas. 61% of drinking water points samples exceeded the value of the WHO guideline of 0.01 mg/L of As, and 38% of analyzed water samples exceeded the Afghanistan drinking water quality standard (DWQS) of 0.05 mg/L of As. The spatial distribution of As concentration in the drinking water points is shown in the Figure 1.

3.2 Correlation among various water quality parameters

For understanding the hydrogeochemistry of As in the groundwater, the correlation coefficient (r) of As with pH (r = -0.18), Ca^{2+} (r = -0.214), Mg^{2+} (r = -0.176), Na^{+} (r = 0.025), EC (r = 0.049), SO_4^{2-} (r = -0162), K^{+} (r= 0.152), Cl^{-} (r = -0.032), HCO_3^{-} (r = -0.104), Mn^{2+} (r = 0.140), total Fe (r = -0.301), NO_3^{-} (r = 0.139), NH_4^{+} (r = - 0.290), SiO_2 (r = 0.156) and F^{-} (r = 0.058) were plotted by scatter plots using AquaChem 2014.1 software. The observed correlation of As with other water quality parameters indicated complex hydrochemical processes which contribute to mobilization of As in groundwater of the study area. The correlation between SO_4^{2-} and pH is negative, which would be the result of sulfide oxidation. The influencing hydro- chemical may be dissolution of Fe- and Mn-oxide and sulfide dissolution.

3.3 Hydrochemical statistical analysis

The 106 sampled chemical tested data were analyzed statistically and the result is shown in Table 1.

Table 1 Water quality statistic analysis results

No	Elements	Unit	Statistics				Acceptable Limit	
			Count	Min.	Max.	Mean	WHO	NDWQS
1	As	mg/L	106	0.000	0.99	0.037	0.01	0.05
2	Conductivity	µS/cm	106	145	2440	1020	1500	3000
3	pH		106	6.33	8.52	7.43	6.5 – 8.5	6.5 – 8.5
4	ORP	mV	106	0	291	136		
5	Temp	°C	106	6.50	20.8	24.8		
6	Fe^{++}	mg/L	106	0.00	0.30	0.06	0.3	0.3
7	Mn	mg/L	106	0	0.08	0.00	0.4	
8	Cl^{-}	mg/L	106	2.5	500	138.2	250	250
9	PO_4^{---}	mg/L	106	0.02	1.80	0.51		
10	HCO_3^{-}	mg/L	106	115	1170	451		
11	NO_3^{-}	mg/L	106	4.20	127.20	41.91	50	50
12	Na^{+}	mg/L	106	24	570	172	200	200
13	K^{+}	mg/L	106	12	90	17		
14	Ca^{++}	mg/L	106	14	200	75		70
15	Mg^{++}	mg/L	106	11	190	43		30
16	Cu	mg/L	106	0.1	0.8	0	2	2
17	SO_4^{--}	mg/L	106	3	248	70	250	250
18	F^{-}	mg/L	106	0.02	2.40	0.71	1.5	1.5
19	NH_4^{+}	mg/L	106	0.1	0.9	0	1.5 - 3.5	
20	Mn^{++}	mg/L	106	0.0	0.8	0.00	0.05	

4 CONCLUSIONS

The As contamination in the DWPs of study area is mostly geologic in origin and its distribution is patchy. Nearly 61% (459 out of 746) of the water samples from the DWPs exceeded the WHO guideline of 10 µg/L of As, and 38% (261 out of 746) of analyzed water samples exceeded the Afghanistan drinking water quality standard of 0.05 mg/L of As.

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