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Detection of Arsenic (As), Antimony (Sb) and Bacterial Contamination in Drinking Water

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ABSTRACT: Contamination of drinking water due to heavy metals and microbial growth is one of the most important concerns that have received attention locally and globally due to its toxicological effect on environment as well as on public health and is an emerging problem in District Quetta. Concentration of Arsenic (As) and Antimony (Sb) along with the bacterial contamination (Colony Forming Unit) in the drinking water of District Quetta were investigated with different parameters. The Atomic Absorption Spectroscopy (AASP) flame emission technique was used to analyze the concentration of heavy metals. Based on the study results, it was concluded that most of the drinking water samples were found fit for consumption with respect to the aesthetic and physiochemical water quality parameters but generally poor with respect to the bacterial contamination due to intermittent water supply, polluted sewerage pipes, leakage of pipes and contamination of shallow water tables due to human activities. Water samples collected directly from Tube (Bore) wells had less concentration of heavy metals than the water samples collected from Home (Tap) water. Antimony (Sb) was above the WHO standard limits in the drinking water of almost all the sampling areas. On average, the Antimony (Sb) (0.028±0.022 mg/L) was above the WHO standard limits while Arsenic (As) (0.006±0.0094 mg/L) was below the WHO standard limits.

Keywords: Water; Heavy Metals; Physiochemical; Microbial; Elements

INTRODUCTION

Water (H20) is an essential element for life and is vital for the survival of living organisms and plants (Alissa and Ferns, 2011). Water is the most widely distributed substance on earth; life would not have advanced without water on earth (Aydin *et al.*, 2013). Physically and apparently uncontaminated pure water is colourless, tasteless and odourless (Pappas, 2011).

The quality of drinking water is of greatest concern worldwide and access to safe drinking water is a major issue in developing and undeveloped countries. According to World Health Organisation (WHO) report, about 780 million people worldwide do not have access to adequate safe water; on consequences every year more than 2.2 million people from developing countries succumb to death from diseases that are mainly associated with the lack of access to safe drinking water (Berisha *et al*., 2013; WHO, 2014).

Access to safe drinking water is a major concern in Pakistan (Azizullah *et al.*, 2011). Only 25.61% population of the country have access to safe drinking water (Waseem *et al.*, 2014). The surface water resources of Pakistan mainly consist of flows of the River Indus and its streams that bring in about 138 million acre feet (MAF) of water every year. In Balochistan province, out of a total available potential of about 0.9 MAF of groundwater, over 0.5 MAF are already being utilized, thereby leaving a balance of about 0.4 MAF that can still be utilized, though some aquifers are already over exploited (Dil *et al.*, 2008; Kahlown and Majeed, 2002). The water resources of Balochistan province consist of surface water and ground water; the source being precipitation alone (Majeed and Ali, 2006).

For meeting drinking, domestic and irrigation requirements karezes, open wells and Tube (Bore) wells are used (Waseem *et al.,* 2014). Karezes are underground horizontal tunnels with vertical shafts/wells for ventilation and periodic cleaning. Open wells in different areas of the province are also used for utilization of groundwater. Tube wells are increasing with the current estimation of about 16,000 and ground water tapped from these tube well of different depths flows in pipes system to meet domestic and agricultural requirements (Tareen *et al*., 2013; Majeed and Ali, 2006).

Humans can act as hosts to the bacterial, viral, or protozoal organisms that cause waterborne diseases (Kotloff *et al*., 2013). About 1.1 billion people globally depend on water supplies that are at high risk of microbial and faecal contamination (Brain *et al*., 2014; Ye *et al*., 2013). According to WHO, 1.4 million people died from diarrhoeal diseases in developing countries in 2012 (GBD, 2015; WHO, 2014); children under the age of five years are the more susceptible group accounting for major part in deaths (Murray *et al*., 2012; Walker *et al*., 2013; Lanata *et al*., 2013). 88% of diarrhoeal disease is mainly attributed to unsafe water supply (WHO, 2014). Consumption of unsafe water annually causes 1.5 million cases of clinical hepatitis A (Jabeen *et al*., 2011).

Heavy metals are chemical elements with a specific gravity that is at least five times the specific gravity of water (Tareen *et al*., 2014). Small amounts of these elements are common in our environment and diet and are actually necessary for good health but large amounts may cause acute or chronic toxicity (Chen *et al.,* 2007). Arsenic (As) is a toxic element, carcinogenic to humans and is classified as Group 1 carcinogen by (IARC) International Agency for Research on Cancer (IARC, 2012). As the presence of heavy metals in water is safe up to certain limit but if it exceeds a certain limit it can cause harmful effect on human health and a long term exposure may also lead to death (Ullah *et al.,* 2009). Arsenic (As) and Antimony (Sb) consumption in drinking water is highly toxic and poisonous to normal body function (Islam *et al.,* 2012). Contents of Arsenic (As), Antimony (Sb) along with other metals need to be monitored in drinking water to avoid adverse health effects (Dastgiri *et al.,* 2010). Various techniques are used to remove arsenic from drinking water and coagulation is the most common and effective method. (Berisha *et al*., 2013; Rahbar *et al*., 2012; Cicchella *et al*., 2008).

The current study was conducted with the aim to detect the presence of Arsenic (As), Antimony (Sb) concentration and bacterial contamination in drinking water of District Quetta, Balochistan, Pakistan and to find correlation of different parameters with microbial growth and heavy metals.

MATERIALS AND METHODS

An analytical research study was conducted for the detection, assessment and evaluation of Arsenic (As) and Antimony (Sb) in drinking water from different areas of District Quetta. Presence of microorganisms (Bacterial Contamination) was also analysed. Tube (Bore) wells selected were of different parameters. Twenty four (24) water samples from different tube wells and homes (Tap) Water were collected in sterile falcon tubes. Clean and un-rusted tap were selected for the collection of water samples. Taps were allowed to flow for at least two (02) minutes before the collection of samples. Tube wells water samples were collected from tube well after allowing them to flow continuously for at least ten (10) minutes. Depth of each tube well was recorded; the tube wells were of different length ranging (650-1200 feet). The questionnaires were also filled about different parameters.

The collected water samples were processed in laboratory for presence of heavy metal contents. Water sample pH was measured by pH meter and water samples electric conductivity was measured with the help of conductive meter. The mean pH in water sample collected from tube well was 7.8±0.49 (7.1 to 8.4) in water samples taken from tube well whereas the mean pH in water sample collected from home was 7.7±0.44 (7.1 to 8.3). The mean conductivity in water sample collected from tube well was 120.8 µS±31.87 (79.3 µS to 165.3 µS) whereas the mean conductivity in water sample collected from home was 120.8 µS±31.72 (79.6 µS to 165.1 µS). All calculated samples pH and conductivity were according to standard pH and conductivity.

The collected water samples were kept in ice pots during transportation to the laboratory to avoid microbial contamination. The concentration of Arsenic (As) and Antimony (Sb) were analysed in water samples. Atomic Absorption Spectroscopy (AAS) flame emission technique was used for the detection of heavy metals presence and for sample analysis with the help of Nitrous oxide/Acetylene gases.

Bacterial contamination in water samples was analysed as quickly as possible within 2-4 hours of collection. Bacterial contamination was analysed on nutrient agar media. Colony Forming Unit (CFU) were counted and results were analysed in Microsoft excel and SPSS version 20.

RESULTS AND DISCUSSION

The results suggest that most of the drinking water samples in the surveyed area of Quetta district were found fit for consumption with respect to physicochemical and aesthetic water quality parameters but none of the samples were safe from bacterial contamination.

Generally in Pakistan the quality criteria of water is like foul smelling, bad tasting, brackish, coloured or turbid water to determine that it is not suitable for drinking. Although Arsenic (As) contents were below the WHO standard limits but Antimony (Sb) contents were above the WHO standard limits for drinking water in water samples collected from all the areas. Higher amounts of Arsenic (As) and Antimony (Sb) were calculated in water samples collected from home than in water samples collected directly from tube (Bore) well. The mean value of Arsenic (As) and Antimony (Sb) contents in water sample collected from tube well was 0.006±0.0094 mg/L (0.0001-0.027 mg/L) and 0.028±0.0218 mg/L (0.006-0.071 mg/L) respectively whereas the mean value of Arsenic (As) and Antimony (Sb) contents in water sample collected from home was 0.007±0.0092 mg/L (0.0005 to 0.028 mg/L) and 0.030±0.0239 mg/L (0.006-0.073 mg/L) respectively.

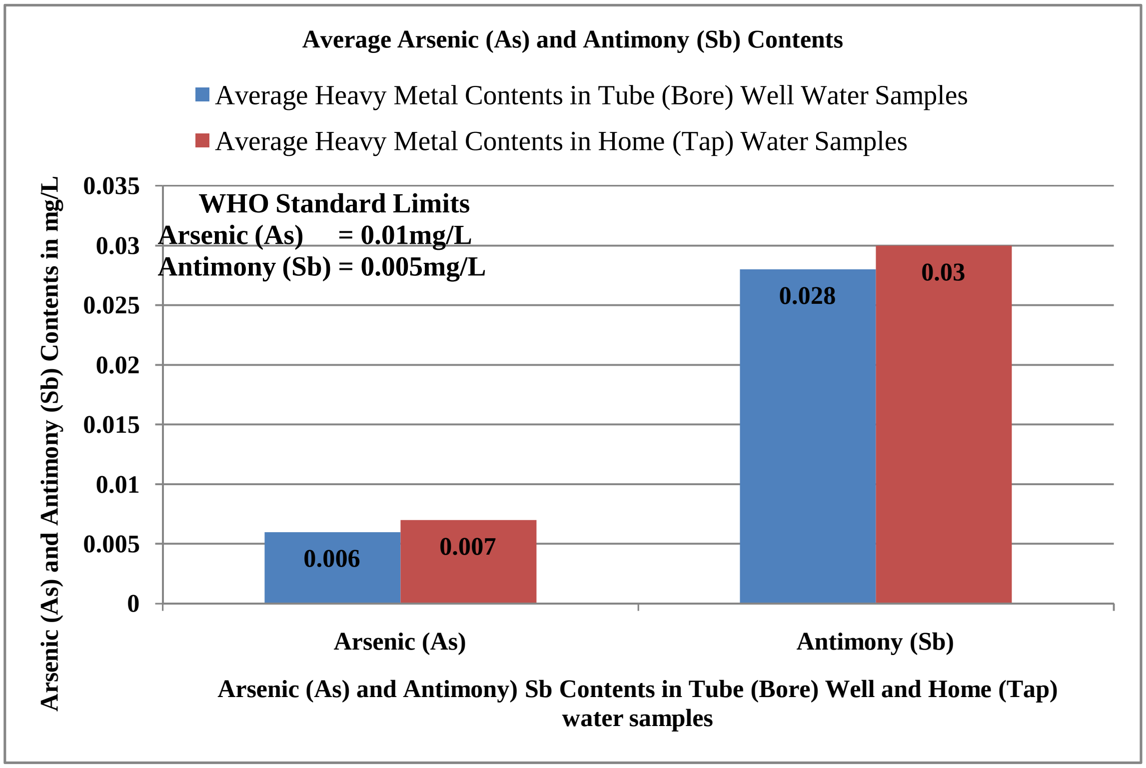

Fig. 1. Average Arsenic (As) and Antimony (Sb) Contents.

On average in water samples, the Arsenic (As) contents were below the WHO standard (0.01 mg/L), but the samples from three sampling areas (0.0121 mg/L), (0.0239 mg/L) and (0.0281 mg/L) were above WHO standard limits. Arsenic (As) was positively correlated (r = 0.0458) with the depth of tube well, functioning of the tube well (r = 0.4087) and negatively correlated (r = -0.44) with the pH of the water. According to study results Arsenic (As) contents were in less quantity in tube wells of shallow depth, higher amount in old tube well. Arsenic (As) were less in quantity at higher pH.

On average in water samples, the Antimony (Sb) contents were significantly above WHO standard limits (0.005 mg/L) in water samples collected from all areas counted as (0.073 mg/L), (0.032 mg/L), (0.034 mg/L), (0.006 mg/L), (0.035 mg/L), (0.008 mg/L), (0.009 mg/L), (0.052 mg/L), (0.069 mg/L), (0.025 mg/L), (0.013 mg/L) and (0.006 mg/L). At test value of 0.005 the mean for tube well sample was 0.027±0.021 (p=0.004) and 0.030±0.023 (p=0.004) for home (Tap) water samples. Antimony (Sb) was negatively correlated (r = -0.678) with the depth of tube well, functioning of the tube well (r = -0.216) and positively correlated (r = 0.8624) with the pH of the water. According to study results antimony contents were in greater quantity in tube wells of shallow depth and less in quantity in old tube well. The antimony (Sb) was high in quantity at higher pH.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Antimony in Tube Well Sample	12	.02750	.021807	.006295
Antimony in Home Sample	12	.03017	.023912	.006903

	Test Value = 0.005				
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference
					Lower
Antimony in Tube Well Sample	3.574	11	**.004**	.022500	.00864
Antimony in Home Sample	3.646	11	**.004**	.025167	.00997

Fig. 2. One Sample t test for Antimony (Sb) contents in Home (Tap) water and Tube (Bore) well water samples.

Water samples collected from all areas were contaminated with bacterial contamination. None of the samples were safe from bacterial contamination. Many reasons may be attributed including leakage of pipes (leakage in supply system) intermittent water supply, contamination of shallow water reservoirs due to human activities, unsealed tube wells and problem within the distribution system (pollution from sewerage pipes) (Knappett et al., 2012).The bacterial contamination was affected by different parameters. Many secondary sources may also be involved in ground water contamination including industrial pollution, Irrigation, flooding, fungicides, fertilizers, pesticides and untreated municipal waste (Tareen *et al.*, 2013). When bacterial contamination was correlated with the depth of tube well the correlation was r = -0.8594 which showed that the depth of tube wells had significantly negative correlation with bacterial contamination. According to study results bacterial contamination was higher in tube wells of shallow depth. Bacterial contamination was negatively correlated (r = -0.618) with the pH of water samples as at higher water pH less number of colony forming units (CFU) were counted.

Paired Samples Test

		Paired Differences			
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference
					Lower
Pair 1	Arsenic in Home Sample - Arsenic in Tube Well Sample	.0009417	.0013761	.0003972	.0000674
Pair 2	Antimony in Home Sample - Antimony in Tube Well Sample	.002667	.003701	.001068	.000315
Pair 3	Micro-Organism in Home Sample - Micro-Organism in Tube Well Sample	3.917	5.775	1.667	.247

		Paired Differences	t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference			
		Upper			
Pair 1	Arsenic in Home Sample - Arsenic in Tube Well Sample	.0018160	2.371	11	**.037**
Pair 2	Antimony in Home Sample - Antimony in Tube Well Sample	.005018	2.496	11	**.030**
Pair 3	Micro-Organism in Home Sample - Micro-Organism in Tube Well Sample	7.586	2.349	11	**.039**

Fig. 3. Paired t test for studied parameters.

When Colony forming units (CFU) were correlated with the functioning of the tube well, the correlation was (r = -0.151) which showed that the functioning of the tube well had significantly negative correlation with bacterial contamination. According to study results the contamination was less in old functioning tube wells. When Colony forming units (CFU) were correlated with the conductivity the correlation was (r = 0.6798) which showed that the contamination had significantly positive correlation with conductivity. The contamination Colony forming units (CFU) were negatively correlated with Arsenic (As) (r = -0.161) and Antimony (Sb) (r = -0.636) contents. According to study results Arsenic (As) and Antimony (Sb) contents were decreased by presence of Colony forming units (CFU) in water samples.

Water samples collected from tube (Bore) wells had less concentration of Arsenic (As), Antimony (Sb) and microorganisms (bacterial contaminations) than water sample collected from tap water (Home). Statistically significant difference between the Home (Tap) water sample and Tube (Bore) well water samples were associated. At 95% of confidence interval the p value was statistically significant for Arsenic (As) (0.037), Antimony (Sb) (0.030) and Bacterial Contamination (0.039). Study results have shown that Antimony (Sb) and Arsenic (As) have some antiseptic characteristics that has lead to decrease in presence of microorganisms in home water samples however further research is needed for the support of these results.

From the public health point of view, it is absolutely essential to establish regular monitoring and evolution system of all water resources and water points. Environmental Protection Agency (EPA) need to play an active role in water protection as most of the industries dispose there harmful wastes in water bodies and ground water, EPA should strictly enforce laws and regulations preventing such act. Alternate sources of water should be identified in the areas where the quality of source of existing water supply is questionable. Lower cost house hold water treatment technologies with low technical input should be used in the form of filter plants for controlling and treating water with biological, Arsenic (As) and Antimony (Sb) contamination. Farmers should use environmental friendly fertilizers and insect repellents in their farms. Substandard chemicals with impurities are used in water treatment plants which produce different health hazards so for this purpose strict quality control need to be ensured in the treatment plants (Tareen *et al*., 2014).

CONCLUSION

Based on study results, it is concluded that most of the drinking water samples in the surveyed area of Quetta district were found fit for consumption with respect to physicochemical and aesthetic water quality parameters but drinking water quality due to bacterial contamination in Quetta District is generally poor. None of the samples were safe from bacterial contamination. On average, Antimony (Sb) was above the WHO standard limits in the drinking water of almost all the areas of District Quetta. Water samples collected from tube wells had less concentration of Arsenic (As), Antimony (Sb) and bacterial contamination than water sample collected from Home (Tap) Water.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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REFERENCES

Alissa EM, Ferns GA. (2011). Heavy metal poisoning and cardiovascular disease. *Journal of toxicology*; 1-21.

Aydin ME, Ozcan S, Beduk F, Tor A. (2013). Levels of Organochlorine Pesticides and Heavy Metals in Surface Waters of Konya Closed Basin, Turkey. *The Scientific World Journal*; 1-6.

Azizullah A, Khattak MN, Richter P, Hader DP. (2011). Water pollution in Pakistan and its impact on public health. *A review Environ Int;* **37**: 479-497.

Bain R, Cronk R, Wright J, Yang H, Slaymaker T, et al. (2014). Fecal contamination of drinking-water in low- and middle-income countries: a systematic review and meta-analysis. *PLoS Medicine*; **11**(5): e1001644.

Berisha F, Goessler W. (2013). Investigation of Drinking Water Quality in Kosovo. *Journal of environmental and public health*; 1-9.

Chen Y, Factor LP, Howe GR, Graziano JH, Brandt RP, et al. (2007). Arsenic exposure from drinking water, dietary intakes of B Vitamins and folate, and risk of high blood pressure in Bangladesh: A population-based, cross-sectional study. *Am. J. Epidemiol*; **165**: 541–552.

Cicchella D, Vivo BD, Lima A, Albanese S, McGill RAR, et al. (2008). Heavy metal pollution and Pb isotopes in urban soils of Napoli, Italy. *Geochemistry*; **8**: 103–112.

Dastgiri S, Mosaferi M, Fizi MA, Olfati N, Zolali S, et al. (2010). Arsenic exposure, dermatological lesions, hypertension, and chromosomal abnormalities among people in a rural community of northwest Iran. *J. Health Popul. Nutr;* **28**: 14–22.

Dil AD, Qazi IA, Baig MA, Khan EA, Zaman S, et al. (2008). National Standards for Drinking Water Quality. Government of Pakistan. *Pakistan Environmental Protection Agency;* 2008: 1-25.

GBD. (2015). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet;* **386**(10010): 2287-2323.

IARC. (2012). A Review of Human Carcinogens: Metals, Arsenic, Fibres and Dusts. 100C. International Agency for Research on Cancer: Monographs on the Evaluation of Carcinogenic Risks to Humans.

Islam MR, Khan I, Attia J, Hassan SMN, McEvoy M, et al. (2012). Association between hypertension and chronic arsenic exposure in drinking water: A cross-sectional study in Bangladesh. *International journal of environmental research and public health;* **9**: 4522-4536.

Jabeen S, Mahmood Q, Tariq S, Nawab B, Elahi N. (2011). Health Impact Caused By Poor Water and Sanitation in District Abbotabad. *J Ayub Med Coll Abbottabad*; **23**: 47-50.

Kahlown MA, Majeed A. (2002). Water-Resources Situation in Pakistan: Challenges and Future Strategies. *Science Vision;* **7**: 33-45.

Knappett PSK, Mckay LD, Layton A, Williams DE, Alam MJ, et al. (2012). Unsealed Tubewells Lead to Increased Fecal Contamination of Drinking Water. *J Water Health*; **10**(4): 565-578.

Kotloff KL, Nataro JP, Blackwelder WC, Nasrin D, Farag TH, et al. (2013). Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): a prospective, case-control study. *Lancet;* **382**(9888): 209-22.

Lanata CF, Fischer-Walker CL, Olascoaga AC, Torres CX, Aryee MJ, et al. (2013). Child Health Epidemiology Reference Group of the World Health Organization and UNICEF. Global causes of diarrheal disease mortality in children <5 years of age: a systematic review. *PLoS One;* **8**(9):e72788.

Majeed A, Ali S. (2006). Water Management Practices in Baluchistan. *Pakistan Water Gateway*; 1-5.

Murray CJL, Vos T, Lozano R, Naghavi M, Flaxman AD, et al. (2012) Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. 2012. *Lancet*; **380**(9859): 2197–223.

Pappas G. (2011) Pakistan and Water: New Pressures on Global Security and Human Health. American journal of *public health*; **101**: 786-788.

Rahbar MH, Samms VM, Ardjomand HM, Loveland KA, Dickerson AS, et al. (2012). The role of drinking water sources, consumption of vegetables and seafood in relation to blood arsenic concentrations of Jamaican children with and without Autism Spectrum Disorders. *Science of the Total Environment;* **433**: 362-370.

Tareen AK, Sultan IN, Khan MW, Khan A. (2013). Determination of Heavy Metals found in different sizes of tube wells of District Pishin Balochistan, Pakistan. *Asian Journal of Science and Technology*; **4**(4): 17–21.

Tareen AK, Sultan IN, Parakulsuksatid P, Shafi M, Khan A, et al. (2014) Detection of heavy metals (Pb, Sb, Al, As) through atomic absorption spectroscopy from drinking water of District Pishin, Balochistan, Pakistan. *Int. J. Curr. Microbiol. App. Sci;* **3**(1): 299-308.

Ullah R, Malik RN, Qadir A. (2009) Assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. *African Journal of Environmental Science and Technology;* **3**: 430-436.

Walker CL, Rudan I, Liu L, Nair H, Theodoratou E, et al. (2013). Global burden of childhood pneumonia and diarrhoea. *Lancet*; **381**(9875): 1405-16.

Waseem A, Arshad J, Iqbal F, Sajjad A, Mehmood Z, Murtaza G. (2014). Pollution Status of Pakistan: A Retrospective Review on Heavy Metal Contamination of Water, Soil, and Vegetables. *Biomed Res Int;* 2014: 813206.

World Health Organization. (2014). Guidelines for drinking-water quality, 4th edition. (Last Accessed: October 2016).

Ye B, Yang L, Li Y, Wang W, Li H. (2013). Water sources and their protection from the impact of microbial contamination in rural areas of Beijing, China. *International Journal of Environmental Research and Public Health*; **10**: 879-891.