Science Letters
2016 | Volume 4 | Issue 2 | Pages 131-134

RESEARCH ARTICLE OPEN ACCESS

Risk Assessment of Dissolved Trace Metals by Chronic Daily Intake in Drinking Water of District Jamshoro, Pakistan

Amjad Hussain Memon[1]*, Allah Bux Ghanghro[1], Taj Mohammad Jahangir[2], Hussain Ahmed Abro[3], Irshad Ghanghro[2]

[1]Institute of Biochemistry, University of Sindh, Sindh, Pakistan
[2]Hitech Research Laboratory, University of Sindh, Jamshoro, Sindh, Pakistan
[3]Beijing University of Chemical Technology, Beijing, China

Abstract
This study was conducted to observe probabilistic health burden of water samples collected season wise from Manchar Lake, river Indus, water supply schemes and ground water from different locations of Jamshoro, Sindh, Pakistan. The health burden was analyzed using USEPA standard methods to measure chronic and carcinogenic health quotients (HQ) of different metals such as As, Cd, Ni, Zn, Cu, Mn, Fe and Co in wet (phase 1) and dry (phase 2) seasons. The results declared that in phase 1 HQ of As and in phase 2 HQ of Cd indicated more adverse potential health effects. In addition, the carcinogenic risk of As was observed higher than the standard USEPA level in some samples. The HQ of other metals was increased in phase 2 compared to phase 1, reflecting more potential adverse health effects on local residents of District Jamshoro in the dry season. This study revealed the probabilistic chronic impact of different metals and carcinogenic impact of dissolved As on drinking water consumers.
Keywords Arsenic, hazard quotient, risk assessment, trace metals.

Received February 08, 2016 **Accepted** May 11, 2016 **Published** August 15, 2016
***Corresponding author** Amjad Hussain Memon **E-mail** ahmemon05@gmail.com **Tel** +92-333-2778622

To cite this manuscript: Memon AH, Ghanghro AB, Jahangir TM, Abro HA, Ghanghro I. Risk assessment of dissolved trace metals by chronic daily intake in drinking water of district Jamshoro, Pakistan. Sci Lett 2016; 4(2):131-134.

Introduction

Rapid growth of population, land development along the river Indus basin and urbanization caused water pollution and environmental deterioration [1]. One sixth of humanity (1.1 billion people) doesn't have access to fresh water within one kilometer from their home [2]. Unreachable safe and adequate water supplies are playing important role in ongoing poverty and economic costs that increased household expenses in poor residential peoples due to poor health and enhanced need for water purchasing and/or energy with time expended in collection [3]. If actions will not be taken for the basic human need of safe water, in 2020 as many as 135 million people will be dying from these diseases and 76 million will die from preventable water-related diseases [4]. To evaluate the possible risks of unsafe water, human health risk assessment is an effective approach to determine the health risk levels posed by various contaminants [5],which has been applied to assess the potential adverse health effects exposing to contaminated water [5,8]. Although ingestion is considered to be the primary route of exposure to chemical contaminants in drinking water, the aim of this study was to determine the level of trace metals in drinking water of Jamshoro and to evaluate the health risk associated with exposure to these trace metals via oral ingestion.

Materials and Methods

Study area

In this study, the water samples were collected from Manchar Lake, river Indus, water supply schemes and ground water sources from Jamshoro city, Sindh, Pakistan along with the Indus catchment through Indus highway covering the distance of 160 km. Samples were collected from selected villages and major populated areas likeSehwan, Lucky shah saddar, Aamri, Chhachhar, Sann, Manjhand, Jamshoro, kotri and so on. In the present study, 65 samples were collected in wet (phase 1) and dry (phase 2) seasons with a gap of three months. The water samples were analyzed at Institute of Biochemistry and Hitech Research Laboratory, University of Sindh, Sindh, Pakistan.

Table 1 The detail of water sample collection sources and number of samples collected in phase 1 and phase 2.

Sr. No.	Sample sources	Phase 1	Phase 2
1	Manchar lake	5	4
2	Water supply schemes	6	6
3	Indus river	7	7
4	Ground water sources	15	15

Arsenic was measured with Merck Arsenic Kit for 0.01-0.5mg/L. This test generates arsenic hydride which reacts with the mercury bromide present in the analytical strip to form a yellow brown mixed arsenic mercury halogenide. The concentration of arsenic was measured by visual comparison of the reaction zone of the analytical test strip with scales of fields of color [9]. Other metals like Cd, Zn, Ni, Mn, Cu and Co were measured by using Perkin Elmer atomic absorption spectrometer (AAS-PEA-700).

Exposure and risk assessment

The following equation is a representative of chronic daily intake exposure:

$$CDI = C \times DI / BW \quad (1)$$

CDI is the chronic daily intake measured in µg/kg/d, where C is the drinking water contaminant concentration (ppb), DI is the average daily intake rate of drinking water (l/d) and BW is body weight (kg). The DI and BW are standard values according to USEPA.

Non-carcinogenic risk, hazard quotient (HQ) was calculated by using the following equation [10]:

$$HQ = CDI / RfD \quad (2)$$

Where RfD, stand for reference dose (µg/kg/d)is a standard value according to USEPA for different metals as shown in Table 1.

The cancer risk associated with ingestion exposure was calculated using the following equation [11]:

$$R = CDI \times SF \quad (3)$$

Where R is the excess probability of developing cancer overall lifetime as a result of exposure to a contaminants (carcinogenic risk). According to the USEPA, risk (R) values greater than one in a million (10^{-6}) are generally considered unacceptable; however, according to national standards and environmental policies this acceptable level may change and may be as high as 10^{-4} [12,14] and for non-carcinogenic, normal value is HQ<1 and exposed population is assumed to be safe [15]. The S factor and RfD values employed in this study were obtained from the website (http://www.epa.gov/iris/subst/0278.htm).

Table 2 The reference dose (RfD) of different metals as suggested by the US Environmental Protection Agency (USEPA).

Metal	RfD (µg/kg/d)
As	0.3
Zn	300
Mn	20
Co	3
Cu	10
Cd	0.5
Ni	20
Fe	300

Results and Discussion

Health quotient (HQ) is used to determine the impacts of metals on human health and is calculated by daily intake, body weight, and standard values given by USEPA called as reference dose. HQ suggests the probability of adverse health effects and HQ>1 considered as a hazard for the weight of 70 and 15 kg [16]. Ingestion was reported to be the most important route of exposure to trace metals [17].The results of this study showed that for HQ As of 70kg in phase 1, water samples which were found beyond the normal range were 1 of Manchar Lake, 4 of fresh water and 7 of ground water. In phase 2, 2 samples from Lake Manchar, 5 from river Indus and 7 from ground water samples identified with HQ>1. HQ As 15 kg weight phase I showed 2 samples of Lake Manchar, 12 of river Indus and 6 of grounds water samples and in phase 2, all samples were lying in the normal range except seven samples observed with HQ>1. Mn HQ of phase 1 of 70 and 15 kg weight were observed less than one in all the samples because the readings were below the detection limit. In phase 2,number of samples which were observed more than the normal limit of HQ were 1 from Manchar Lake, 2 from river Indus and 2 were from ground water samples and in phase2, 2 samples were from Manchar Lake, 3samples from river Indus and 4from ground sources showed HQ>1.

For Ni, HQ of phase1 70 kg weight, all samples had HQ<1 and in phase 2, one sample from each respective source, Lake Manchar, river Indus and ground water had HQ>1 that may cause chronic health impact for the drinking communities. For 15 kg weight, Ni HQ phase 1 observed that only 1Lake Manchar sample was found with HQ more than normal limit and in phase 2, 2samplesofLake Manchar, 8 of river Indus, 1 of water supply source and 10 ground water sources were observed with HQ more than the normal range. For Zn HQ for the 70 kg weight phase 1, all the samples had HQ>1 and same for phase 2. For 15 kg HQ phase I, HQ were <1 in all samples and in phase 2, only 1 Lake Manchar sample and 2 ground sources had HQ>1. For Cd HQ 70 kg phase1, only one ground water sample had HQ>1 and others had values below detection limit. In phase 2, except 5 ground water samples, all samples were beyond the limit of HQ which showed health concerns of Cd. For the 15 kg phase I, only one sample was with HQ>1 while other samples had values below detection limit. In phase 2, except 5 ground water sources, all samples had HQ>1.

Table 3 The concentration of different metals in water samples collected from different sources in two phases.

Metals	Phase 1		Over limit samples	Phase 2		Over limit samples	WHO (ppb)
	Minimum	Maximum		Minimum	Maximum		
Arsenic	5	250	13	5	500	12	10
Cadmium	0	25.38	1	1.47	462.8	24	3
Cobalt	45	823	-	2.7	814	-	NF
Copper	24	1076	1	74	2368	1	2000
Zinc	5	2210	1	3	3429	5	3000
Nickel	10.49	296	7	2.9	835	27	20
Manganese	0	1200	1	21	4700	8	500
Iron	40	6530	15	10	22500	19	300

NF = not found

Table 4 Carcinogenic Health Quotient (HQ) of arsenic for two body weights (BW).

Sampling sources	BW70HQ				BW15HQ				Normal HQ
	Phase 1		Phase 2		Phase 1		Phase 2		
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
Manchar lake	4.29E-01	2.14E+00	1.07E+00	2.14E+00	1.10E+00	5.50E+00	2.75E+00	5.50E+00	>1.00E 10^{-6}
River Indus	4.29E-01	1.07E+01	2.14E-01	1.07E+00	5.50E-01	5.50E+00	5.50E-01	2.75E+00	
Water supply scheme	4.29E-01	4.29E+00	2.14E-01	2.14E-01	5.50E-01	1.10E+00	5.50E-01	5.50E-01	
Ground water	2.14E-01	4.29E+00	4.29E-02	2.14E+01	5.50E-01	2.75E+01	5.50E-01	5.50E+01	

For Co HQ 70 kg in phase 1, samples which were analyzed with HQ>1 were 2 from Lake Manchar, 3 from the river Indus, 1 from water supply schemes and 3 from ground water. For phase 2, 2 samples were from Lake Manchar, 5 from the river Indus, 2 from water supply schemes and 8from ground water showed HQ>1. For 15 kg HQ phase 1, all samples had HQ>1 and for phase 2, HQ except 3 ground water samples, all samples showed HQ>1. For Cu HQ phase 1 and phase 2 70kg, all samples were within normal range except one ground water sample. For phase I of 15 kg, all samples had HQ<1 and in phase 2, 10 from the river Indus, 3 from water supply schemes and 4 from ground water had HQ more than one, which may cause chronic health impacts for consumers.

The HQ of Fe also varied for 15 kg and 70 kg in phase 1 and phase 2. According to the above results, HQ of different metals reflects that for the 70 kg phase 2, HQ in majority of the samples was found higher than the normal range as compared to phase I. Similar results were observed for 15 kg HQ which might be due to the short fresh water flow in the river Indus from upper stream and effect of Lake Manchar pollutants and others like home sewerages.

Carcinogenic risk was measured by slope factor only for As which reflected the impact of contamination in the sense of cancer causing agent for the consumers. According to Chen and Liao [18] and Obiri et al. [19], carcinogenic risk is defined as the incremental probability that an individual will develop cancer during one's lifetime due to chemical exposure under specific scenarios with level between 10^{-6} and 10^{-4}which is carcinogenic potential risk level [19,20]. Previously, the contamination exposure and impacts on drinking water of Johi district, Sindh, Pakistan were described where the HQ (carcinogenic) was observed more than the limit from the identified As contaminated water samples [21]. The results of our study also showed potential health carcinogenic concern for the consumers of drinking water of Jamshoro. Our research showed threat and alarming warning to take the serious steps for the local consumers to keep them protected from such kind of carcinogenic threats. It showed that HQ of 70 kg and 15 kg were more on health concern from metal contaminations especially in phase 2.

Conclusions

HQ calculated for 70 kg was found higher in phase 2as compared to phase1. HQ varied in an order Co>As>Cu>Ni>Cd>Mn>Zn in phase 1 and Cd>As>Co>Ni>Cu>Mn>Zn in phase 2. Our research results emphasized to take the serious steps for the local consumers to keep them protected from such kind of carcinogenic threats. It is compulsory to provide them clean drinking water, especially during the dry season when fresh water is not flowing through river Indus.

References

[1] Sumok P. River water quality monitoring: sharing Sarawak experience. In: Proc. 6th Sabah Inter-agency tropical ecosystem (SITE) research seminar, Kota Kinabalu, Malaysia 2001; 4, 13–14.

[2] World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICF). Global

water supply and sanitation assessment Report, WHO/UNICEF, Geneva/New York; 2000.
[3] United Nations Development Programme (UNDP). Human development report, Oxford University Press, New York, USA; 1999.
[4] Gleick PH. Dirty water: Estimated deaths from water-related disease 2000-2020, Pacific institute research report, August 15, 2002.
[5] Wu B, Zhang Y, Zhang X, Cheng S. Health risk from exposure of organic pollutants through drinking water consumption in Nanjing, China. Bull Environ ContamToxicol2010; 84:46–50.
[6] Hartley WR, Englande AJ, Harrington DJ. Health risk assessment of groundwater contaminated with methyl tertiary butyl ether (MTBE). Water Sci Technol 1999; 39:305–310.
[7] Sun F, Chen J, Tong Q, Zeng S. Integrated risk assessment and screening analysis of drinking water safety of a conventional water supply system. Water Sci Technol 2007; 56:47–56.
[8] Kavcar P, Sofuoglu A, Sofuoglu SC. A health risk assessment for exposure to trace metals via drinking water ingestion pathway. Int J Hyg Environ Health 2009; 212:216–227.
[9] Yu G, Sun D, Zheng Y. Health effects of exposure to natural arsenic in groundwater and coal in china: An overview of occurrence. Envi Health Persp 2007; 15:636-642.
[10] United States Environment Protection Agency (USEPA). Guidance for performing aggregate exposure and risk assessments. Office of Pesticide Programs, Washington, DC; 1999.
[11] Patrick DR. Risk assessment and risk management. In: Patrick, DR (Ed.) Toxic Air Pollution Handbook; 1994.
[12] Keith S. Environmental hazards: Assessing risk and reducing disaster. New York, New York, USA: Routledge; 2001.
[13] United States Environment Protection Agency (USEPA). Water quality standards, establishment of numeric criteria for priority toxic pollutants for the state of California;2000. at:/http://www.epa.gov/fedrgstr/ EPA-WATER/2000/May/Day18/w11106.htmS,September 2006
[14] World Health Organization (WHO). Guidelines for drinking-water quality, third ed., Recommendations. World Health Organization, Geneva; 2004.
[15] Khan S, Cao Q, Zheng YM, Huang YZ, Zhu YG. Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing China, Environ Pollut 2008; 152:686–692.
[16] O'Rourke MK, van de Water PK, Jin S, Rogan SP, Weiss AD, Gordon SM, Moschandreas DJ, Lebowitz MD. Evaluations of primary metals from NHEXAS Arizona: distributions and preliminary exposures. J Expo Anal Environ Epidemiol 1999; 9:435–445.
[17] Leung AOW, Duzgoren-Aydin NS, Cheung KC, Wong MH. Heavy metals concentrations of surface dust from e-waste recycling and its human health implications in Southeast China. Environ Sci Technol 2008; 42:2674–2680.
[18] Chen SC, Liao CM. Health risk assessment on human exposed to environmental polycyclic aromatic hydrocarbons pollution sources. Sci Total Environ 2006; 366:112–123.
[19] Obiri S, Dodoo DK, Okai-Sam F, Essumang DK. Cancer health risk assessment of exposure to arsenic by workers of AngloGold Ashanti–Obuasi Gold Mine. Bul Environ Contam Toxicol 2006; 76:195–201.
[20] Liao CM, Chiang KC. Probabilistic risk assessment for personal exposure to carcinogenic polycyclic aromatic hydrocarbons in Taiwanese temples. Chemosphere 2006; 63: 1610–1619.
[21] Memon AH, Lund GM, Channa NA, Shah SA, Younis M, Buriro F. Contaminants exposure and impacts on drinking water of Johi subdivision of Sindh, Pakistan. Sci Lett 2016; 4:78-83.