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Risk Based Evaluation and the Exposure of Dissolved Trace Metals by Average Daily Dose in Drinking Water of District Jamshoro

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Abstract: Health risk exposure caused by the dissolved pollutants like dissolved trace and heavy metal and arsenic like carcinogenic factors which is being included in fresh water from different sources of pollution like Manchar lake. These effluents discharge is continued in Indus river that is highly contaminated water coming from Main Narra Valley Drain (MNVD) and MNVD carries a discharge of industrial wastes. The risk of metals on human health was evaluated in this study using Hazard Quotient (HQ) of As, Cd, Ni, Zn,Cu,Mn,Fe,Co three different sources in dry and wet phases. Order of contamination in Phase 1 HQ AS > Co > Cd > Cu > Ni > Zn > Mn and phase 2 HQ Cd > Co > Cu > Mn > Ni > Zn > Fe shows phase wise variation revealed contamination variation with adverse potential health effects. Carcinogenic Risk of As was observed higher than 10-6 in samples suggesting potential adverse health effect on local residents of District Jamshoro.

Key Words: Risk assessment. Hazard quotient, Surface water, Ground water, Jamshoro

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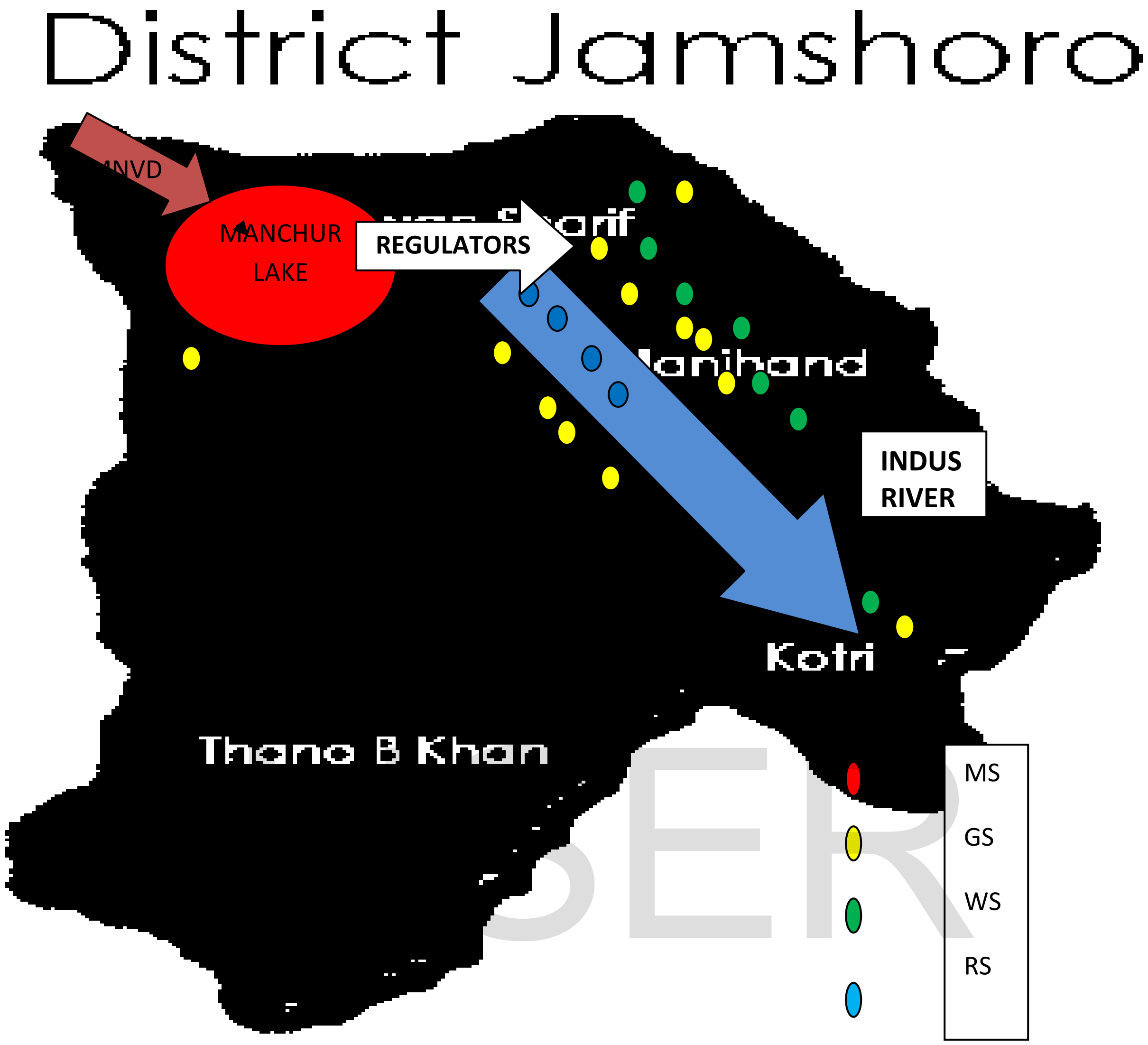
1. Introduction

Although some heavy metals (e.g., Cu, Mn and Cr) ar e essential for human but their presence in excess amount may be toxic (Armendariz et al., 2015; Espín et al., 2014). On the contrary, some metals (e.g., As, Hg, Cd and Pb) are highly toxic at a very low concentration with no known benefit for human health (Kavcar et al., 2009; Saha and Zaman, 2013). When entering into the environment, these metals can disrupt not only the aquatic ecosystem but also the human health (Quandt et al., 2010; Saha et al., 2016). Human health risk assessment is an effective approach to determine health risk levels posed by various contaminants of metals (Wu et al. 2010)., HQ Suggests the probability of adverse health effects (Leung et al. 2008). This method has been applied to assess the potential adverse health effects exposing to contaminated water (Hartley et al. 1999, Kumar et al., 2015, 2016, Rahman et al., 2015, Jain et al., 2010, Krishna et al., 2009, Zhou et al., 2008, Buschmann et al., 2007, 2008, Agusa et al., 2006,Katsoyiannis and Katsoyiannis, 2006, Frisbie et al., 2009, Sun et al. 2007, Kavcar et al. 2009, Wu et al. 2010).there are many reported methods which are being practiced to determine health quotient of dissolved metals like CDI(oral)(Kumar M et al, 2017, Avingo P et al. 2011, weng X et al. 2011,Muhammad S et al 2011, Muhammad S et al 2010) ,CDI(dermal)(Narottam Saha et al. 2017, Jiang et al.2015, Giri S et al. 2015, Alves et al. 2014,Amaya et la. 2013, Qu et al 2012, Zahida K 2011, Li et al.2010, Zeng et al. 2009, Leung et al. 2008, kim EY et al.2004, wyatt et al. 1998)and ADD (average daily dose) (Alves et al. 2014, kavcar et al. 2009, Nguyen et al 2009, Chrostowski et al. 1994). This Study was carried out to estimate Health impacts of drinking water of district Jamshoro, for that purpose Health Quotient of oral has been analyzed of eight metals Co, Cd, As, Mn, Ni, Cu, Fe, Zn Exposure and risk assessments were carried out on the basis of US EPA guideline.

2. Material and Methods

The study stretched from Manchar Lake to Jamshoro city along with the Indus catchment through Indus highway. Approximately the distance covering is more than 160km area. Water samples were collected from selected villages and major populated areas of Sehwan, Lucky shah saddar, Aamri, Chhachhar, Sann, Manjhand, Jamshoro and kotri. In the present study, 68 water samples were collected in two phases with a gap of three months (August 2013, November 2013). Water samples were collected from Manchar lake, Canals, River, Water Supply Schemes, and ground water and analyzed at Institute of Biochemistry and Hitech Research Lab University of Sindh. In Phase one we collected 2 samples from Manchar Lake (M), 9 samples from River (RS), 6 samples from water supply schemes (WS), 2 from Canals (MC), and 15 Ground Water Samples (GS) and For Phase Two we collected 1 from Manchar lake (M) 2 from Canals (MC), 9 from river (RS), 6 from Water Supply Schemes (WS) and 15 from Ground water samples (GS).



2.1.Sampling and pretreatment

The sampling network was designed to cover a wide range of the whole district including surface and ground water origins. For each sampling site, fresh surface water samples river (RS) and municipal water (MS), Manchar lake with its regulators (M, MS) and Ground water samples were collected. The collections of samples were performed by using Van Dorn plastic bottles (1.5 L capacity) and were kept in well-stoppered polyethylene plastic bottles previously soaked in 10% nitric acid for 24 h and rinsed with ultrapure water. All water samples were stored in insulated coolers containing ice and delivered on the same sampling day to the laboratory for analysis.

2.2. Methodology

Arsenic was measured with Merck Arsenic Kit for 0.01-0.5 mg/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 (Yu, G., et.al 2007).Other metals like Cd, Zn, Ni, Mn, Cu, Co, Fe were measured by using model number (AAS-PEA-700) Perkin Elmer flame atomic absorption spectrometer (Memon, ah., et.al 2016).

2.3. Exposure assessment

Through several pathways including food chain, dermal contact, and inhalation Arsenic enters into a human body but all others are negligible in comparison with oral intake (ATSDR, 2000). According to following formula (US EPA, 1998), the average daily dose (ADD) through drinking water intakes is calculated.

$$ADD = C \times IR \times ED \times EF / BW \times AT$$

Where C represents the As concentration in water (mg L^{-1}), IR water ingestion rate 2 (L day^{-1}), ED exposure duration (assumed 67 years), EF exposure frequency (365 days $year^{-1}$), BW, body weight (70 kg) and AT average life time (24,455 days), respectively.

2.4. Human health risk assessment

Both the chronic and carcinogenic risk levels were also assessed in this study by using the following equations

(I) HQ=ADD/RfD

(II) CR = ADD × CSF

Where HQ is the health quotient and it was considered that health risk will generally occur when the value of HQ is greater than one (Khan et al., 2008). RfD, CR and CSF stands for reference daily dose, cancer risk and Cancer slope factor respectively. According to US EPA (2005) database, the value of CSF is 1.5 mg kg^{-1} day^{-1} for As. The value of CR less than 10^{-6} is considered as a carcinogenic limit, however according to the national standards and environmental policies, these standards of CSF and CR may be changed (US EPA, 2000; WHO, 2004).

Table 1 Reference dose for different metals (Wu et al. 2009, IRIS 2009)

Element	RfD mg/kg/day

Cu	0.04
Fe	0.3
Mn	0.02
Ni	0.02
As	0.0003
Cd	0.0005
Co	0.003
Zn	0.3

3. Results and Discussions

In many countries like Bangladesh, India, China, Vietnam, Nepal and Myanmar Arsenic (As) is recognized as a big threat to public health (Islam-Ul-Haque et al. 2007). Over 10-50 ppb arsenic contaminated water has been exposed in Sindh province it is about 16–36% of the population (Ahmad, Kahlown, Tahir, & Rashid, 2004). Some types of cancers like lung, liver, skin and bladder cancer have been found due to Arsenic exposure and known as a carcinogen in humans (Kapaj, Peterson, Liber, & Bhattacharya, 2006). Manchar lake (Sindh) the biggest Asian lake is the main source of water for domestic, irrigation and fishing purposes which is polluted by As due to main Nara valley drain. Chronic health impact of arsenic varies with source type and phase wise.

Table 2 Mean value of Phase 1 and Phase of different metals

Mean (ppb)	Fe	Mn	As	Cd	Co	Ni	Zn	Cu
Phase 1	642.72	35.29	34.11	0.769	146.77	28.14	123.69	35.3
Phase 2	3418.46	599.78	38.03	102.97	171.19	293.38	935.47	258.49
WHO	300	500	10	3	NF	20	3000	2000

In both phases mean values observed more than WHO limits which are shown in table 2. It also showed that mean value of phase 2 is higher than phase 1 which reflects contamination variation burden of both phases. In phase one Manchar and its outlet samples, Health Quotient is more than one which is not a significant figure in both phases. ADD of Manchar with its outlet is 2.86E-04 mg/kg-d minimum and maximum is 1.43E-03 mg/kg-d in phase one, In Phase 2 Minimum ADD is 0.00E+00 mg/kg-d and 7.14E-04 mg/kg-d is maximum,

From the River samples, HQ in both phases got more than one which reflects health concerns regarding the source of drinking and factors of contamination which are present in its surrounding. ADD minimum is 7.14E-04 mg/kg-d and maximum 1.43E-03 mg/kg-d present in both phases. Water supply scheme samples HQ is less than one in both phases which is a significant sign and reflects decrease impacts of river contamination on water supply. ADD maximum in phase 1 and phase 2 is 2.86E-04 mg/kg-d and 1.43E-04 mg/kg-d, Minimum

2.86E-04 mg/kg-d and 1.43E-04 mg/kg-d respectively. Ground source samples HQ determined more than one in both phases in the maximum range which also raises the concerned about the impact of contamination. ADD in both phases varies in minimum range 2.86E-04 mg/kg-d and 7.14E-04 mg/kg-d but maximum range in both phases is 1.43E-03 mg/kg-d and 1.43E-02 mg/kg-d respectively.

Table 3 Minimum and maximum values of both Phases Health Quotient and Average daily dose of arsenic

As	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	BW 70 HQ				BW ADD 70 kg mg/kg-d			
S.Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M& MC	9.52E-01	4.76E+00	0.00E+00	2.38E+00	2.86E-04	1.43E-03	0.00E+00	7.14E-04
RS	9.52E-01	4.76E+00	4.76E-01	4.76E+00	7.14E-04	1.43E-03	7.14E-04	1.43E-03
WS	4.76E-01	9.52E-01	4.76E-01	4.76E-01	1.43E-04	2.86E-04	1.43E-04	1.43E-04
GS	9.52E-01	2.38E+01	9.52E-01	2.38E+01	2.86E-04	1.43E-03	7.14E-04	1.43E-02

ADD values of current As study were lower than those in Bangladesh drinking water (5.00E_02 – 5.00E_01 mg kg^{-1} day^{-1}) reported by Karim 2000 and in Vietnam drinking water (5.00E_03 – 4.39E_01 mg kg^{-1} day^{-1}) by Nguyen et al. 2009 but more than kohistan region north Pakistan drinking water. Surface water contaminated with As had ADD values ranged from 0.00 mg/kg-d to 5.61E_05 mg kg^{-1} day^{-1} and while the people who consumed groundwater had ADD values ranged from (5.50E_07 - 4.64E_04 mg kg_1 day_1) by Muhammad et al 2010. Which reflects area variations in an average daily dose of Arsenic, with respect to impact on the local water drinking communities and involvement of contamination sources.

Table 4 Minimum and maximum values of both Phases Carcinogenic Health Quotient of arsenic

Cancer Risk As	Phase # 1		Phase # 2		Normal HQ
	BW 70 HQ				
S.Station	Minimum	Maximum	Minimum	Maximum	
M &MC	4.29E-04	2.14E-03	2.14E-04	1.07E-03	
RS	4.29E-04	1.07E-03	2.14E-04	1.07E-03	10^{-6} - 10^{-4}
WS	4.29E-04	1.07E-03	2.14E-04	4.29E-03	
GS	4.29E-04	1.07E-02	4.29E-04	1.07E-02	

Cancer risk CR potential of As values vary with the sample source type and phase wise. In our study result had revealed that irrespective to phases and sources type samples observed with less than 10^{-6} which shows a potential carcinogenic health risk for the local communities which had used these sources for the drinking purpose. The reported CR index by Karim (2000), Nguyen et al. (2009) and Muhammad et al (2010) for drinking water in Bangladesh, Vietnam and kohistan Pakistan respectively that the CR index of the study area was found lower than reported by this study which also reflects the area wise burden of contamination.

Cobalt required for normal body functions as a metal component of vitamin B12 is also one of the required metals and needed (Strachan et al 2010). However, abnormal thyroid artery, polycythemia, over-production of red blood cells (RBCs) and right coronary artery problems can cause by high intake of Co via consumption of contaminated food (Robert et al 2003).

Table 5 Minimum and maximum values of both Phases Health Quotient and Average daily dose of cobalt

Co	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	BW 70 HQ				BW ADD 70kg mg/kg-d			
SS.Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M &MC	8.21E-01	4.14E+00	1.85E+0	3.90E+00	8.63E-03	1.24E-02	5.56E-03	1.01E-02
RS	8.95E-01	2.46E+00	8.48E-01	3.19E+00	7.43E-04	1.46E-03	7.71E-05	1.31E-03
WS	9.33E-01	1.09E+00	9.43E-01	2.25E+00	4.06E-03	2.06E-03	6.75E-03	1.23E-03

GS	9.24E-01	7.84E+00	3.33E-01	7.76E+00	4.57E-03	1.20E-02	8.36E-04	1.16E-02

Health concerns and its chronic impact on local drinking communities determined by the health quotient of Manchar lake with its regulators. In phase 1 minimum value found less than one which is safe but maximum value found insignificant. In phase 2 minimum and maximum values had found more than one which shows more health concerns in phase 2 than phase 1. ADD minimum 8.63E-03 mg kg^{-1} day^{-1} - 5.56E-03 mg kg^{-1} day^{-1} and maximum 1.24E-02 mg kg^{-1} day^{-1} - 1.01E-02 mg kg^{-1} day^{-1} phase wise respectively found. River samples Health Quotient in all samples minimum value is an significant range but maximum values are more than one. ADD minimum is 7.43E-04 mg kg^{-1} day^{-1} - 7.71E-05 mg kg^{-1} $day^{-1}$and maximum is 1.46E-03 mg kg^{-1} day^{-1}- 1.31E-03 mg kg^{-1} day^{-1} in both phases respectively, Water supply schemes HQ also found significant in both phases minimum value but insignificant in maximum values of both phases. ADD minimum is 1.23E-03 mg kg^{-1} day^{-1} - 4.06E-3 mg kg^{-1} day^{-1} and maximum is 2.06E-03 mg kg^{-1} day^{-1} - 6.75E-03 mg kg^{-1} day^{-1} phase wise respectively. Ground water samples HQ also found < 1 which is also a significant and safe sign for drinking in both phases minimum values and maximum observed in insignificant range. ADD minimum 4.57E-03 mg kg^{-1} day^{-1}- 8.36E-04 mg kg^{-1} day^{-1} and maximum is 1.20E-02 mg kg^{-1} day^{-1}- 1.16E-02 mg kg^{-1} day^{-1} in both phases respectively observed.

Nickel allergy in the form of contact dermatitis, lung fibrosis, cardiovascular diseases, kidney problems and cancer of the respiratory tract and variety of adverse effects can be caused by Nickel compounds (McGregor et al. 2000; Oller et al., 1997; Seilkop and OLLER, 2003)

Table 6 Minimum and maximum values of both Phases Health Quotient and Average daily dose of Nickel

Ni	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	BW 70 HQ				BW ADD 70kg mg/kg-d			
S.Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M & MC	1.50E-02	3.67E-01	8.27E-02	7.47E-01	3.00E-04	3.66E-03	1.65E-03	1.49E-02
RS	4.14E-02	4.23E-01	9.76E-01	1.16E+00	7.43E-04	3.29E-03	3.89E-04	1.31E-02
WS	5.57E-02	0.00E+00	4.14E-03	1.46E-01	0.00E+00	1.11E-03	8.29E-05	1.67E-02
GS	0.00E+00	0.00E+00	1.29E-02	1.16E-01	0.00E+00	0.00E+0	2.57E-04	1.11E-02

Health impact of drinking water of Jamshoro by the nickel contamination exposure had variations with respective sources. In Manchar Lake and its regulators is less than one found in both phases which is a significant. ADD minimum 3.00E-04 mg kg^{-1} day^{-1} - 1.65E-03 mg kg^{-1} day^{-1} and maximum is 3.66E-03 mg kg^{-1} day^{-1} - 1.49E-02 mg kg^{-1} day^{-1} with respect to both phases. River HQ in both phases also found less than one means significant river impact showed in minimum value of both phases but insignificant in phase 2 maximum value. ADD

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minimum 7.43E-04 mg kg^{-1} day^{-1} - 3.89E-04 mg kg^{-1} day^{-1} and maximum is 3.29E-03 mg kg^{-1} day^{-1} - 3.29E-03 mg kg^{-1} day^{-1} with respect to both phases found. Water supply scheme samples also showed significant HQ in both phases. ADD minimum 0.00E+00 mg kg^{-1} day^{-1} - 8.29E-05 mg kg^{-1} day^{-1} and maximum 1.11E-03 mg kg^{-1} day^{-1} - 1.67E-02 mg kg^{-1} day^{-1} in phase 1 and 2 respectively. Ground water samples HQ reflects significant relation also in both phases and ADD minimum 0.00E+00 mg kg^{-1} day^{-1} - 2.57E-04 mg kg^{-1} day^{-1} and maximum is 0.00E+00 mg kg^{-1} day^{-1}- 1.11E-02 mg kg^{-1} day^{-1} respectively in both phases. That reflects more ADD in phase 2 than Phase 1.

Zn toxicity causes a sideroblastic anemia (S. Strachan et al 2010). Chronic impacts of Zn in both phases measured by Health Quotient to determine contamination burden in drinking water.

Table 7 Minimum and maximum values of both Phases Health Quotient and Average daily dose of zinc

Zn	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	BW 70 HQ				BW ADD 70kg mg/kg-d			
S.Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M & MC	2.38E-03	3.71E-03	3.05E-03	2.52E-01	8.57E-04	1.11E-03	9.14E-04	7.55E-02
RS	9.52E-04	1.17E-01	7.99E-02	1.14E-01	4.00E-04	3.51E-02	9.87E-03	1.13E-02
WS	7.62E-04	0.00E+00	9.27E-02	1.28E-01	7.32E-04	1.43E-04	7.86E-03	1.23E-02
GS	8.57E-04	1.24E-03	2.86E-04	1.18E-01	5.71E-04	6.31E-02	8.57E-05	1.05E-02

HQ of Manchar lake with its outlet regulators had found significant less than one in both phases, minimum and maximum value reflects safe in sense of Zn toxicity. ADD minimum 8.57E-04 mg kg^{-1} day^{-1} - 9.14E-04 mg kg^{-1} day^{-1}, and maximum 1.11E-03 mg kg^{-1} day^{-1} - 7.55E-02 mg kg^{-1} day^{-1} had found in phase 1 and 2 respectively. River Health Quotient also found less than one as a significant value. ADD minimum 4.00E-04 mg kg^{-1} day^{-1} - 9.87E-03 mg kg^{-1} day^{-1} and maximum 3.51E-02 mg kg^{-1} day^{-1} - 1.13E-02 mg kg^{-1} day^{-1} observed in both phases respectively. water supply schemes samples in both phases also reflects significant result HQ < 1 and ADD minimum 7.32E-04 mg kg^{-1} day^{-1} - 7.86E-03 mg kg^{-1} day^{-1} and maximum 1.43E-04 mg kg^{-1} day^{-1} - 1.23E-02 mg kg^{-1} day^{-1} observed in both phases. Ground water samples HQ had found in significant relation too in phase1 and phase 2 and ADD minimum 5.71E-04 mg kg^{-1} day^{-1} - 8.57E-05 mg kg^{-1} day^{-1} and maximum is 6.31E-02 mg kg^{-1} day^{-1} - 1.05E-02 mg kg^{-1} day^{-1} in both phases respectively.

Cadmium from a toxicity point of view, there is a great concern about this element. Cadmium is a toxic metal causing both acute and chronic toxicity in humans. Acute gastrointestinal problems, such as vomiting and diarrhea may cause due to Intake of cadmium (Nordberg, 2004) kidney damage may cause while chronic exposure to cadmium for a long time (Barbier et al., 2005),problems in reproduction (Frery et al., 1993; Johnson et al., 2003; Piasek and Laskey, 1999), damage to bone (Kazantzis, 1979) and cancer (Waalkes et al.,1988). Both chronic and acute health effects in living organisms can cause due to Cd exposure (J.Y.J. Barbee et al 1999).

Table 8 Minimum and maximum values of both Phases Health Quotient and Average daily dose of cadmium

Cd	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	BW 70 HQ				BW ADD 70kg mg/kg-d+L794			
S.Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M & MC	0.00E+00	0.00E+00	0.00E+00	2.02E+01	0.00E+00	0.00E+00	4.00E-03	1.01E-02
RS	0.00E+00	0.00E+00	2.55E+00	1.22E+01	0.00E+00	0.00E+00	6.10E-03	1.28E-03
WS	0.00E+00	0.00E+00	8.40E-02	7.40E+00	0.00E+00	0.00E+00	4.20E-05	1.37E-03
GS	2.02E-02	1.45E+00	2.29E+00	2.64E+01	0.00E+00	7.25E-04	6.75E-03	1.32E-02

Cadmium Potential Chronic Health impacts from the samples of Manchar lake and its regulators is below the < 1 HQ which is a significant sign in both phases except maximum value of phase 2 reflects contamination with potential health concerns and ADD minimum and maximum in phase 1 is zero and phase 2 Minimum 4.00E-03 mg kg^{-1} day^{-1} and maximum is 1.01E-02 mg kg^{-1} day^{-1}. River samples Health Quotient also found in significant figure in phase 1 but insignificant in phase 2. Minimum and maximum value showed contamination burden variation phase wise and health risks. ADD in first phase is zero and in phase 2 minimum 6.10E-03 mg kg^{-1} day^{-1} and maximum is 1.28E-03 mg kg^{-1} day^{-1}. water supply scheme is also found safe for drinking in both phases values except the maximum range of phase 2 and ADD minimum is zero in phase 1 and phase 2 minimum 4.20E-05 mg kg^{-1} day^{-1} and maximum is 1.37E-03 mg kg^{-1} day^{-1}. Ground water samples HQ is also in a significant range below one in both phases minimum values. But showed HQ > 1 in both phases maximum value. ADD minimum 0.00E+00 mg kg^{-1} day^{-1} - 6.75E-03 mg kg^{-1} day^{-1} and maximum is 7.25E-04 mg kg^{-1} day^{-1} - 1.32E-02 mg kg^{-1} day^{-1} respectively in both phases.

Cu Cancer can be induced has already been proven to be a factor(Kosaka et al. 2007) diarrhea and other gastrointestinal symptoms can be caused because of High concentrations of Cu in drinking water (Knobeloch et al. 1994).

Table 9 Minimum and maximum values of both Phases Health Quotient and Average daily dose of copper

Cu	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	BW 70 HQ				BW ADD 70kg mg/kg-d			
S.Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M & MC	9.14E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.14E-04	0.00E+0	0.00E+0
RS	6.86E-02	3.07E+00	9.03E-01	2.83E+00	6.86E-04	3.07E-02	9.03E-03	2.11E-03
WS	8.57E-02	0.00E+00	0.00E+00	3.02E+00	0.00E+00	8.57E-04	3.02E-02	1.34E-02
GS	8.57E-03	0.00E+00	5.83E-01	6.77E+00	0.00E+00	8.57E-05	5.83E-03	1.03E-02

Chronic Health Impact of Copper from the Manchar and with its regulator samples is less than one HQ found which is a significant in both phases. ADD minimum 0.00E+00 mg kg^{-1} day^{-1} - 0.00E+00 mg kg^{-1} day^{-1} and maximum is 9.14E-04 mg kg^{-1} day^{-1} - 0.00E+00 mg kg^{-1} day^{-1} in phase 1 and phase 2. River sample HQ of Cu also find significant and ADD minimum 6.86E-04 mg kg^{-1} day^{-1} and maximum is 3.07E-02 mg kg^{-1} day^{-1} in phase 1. In phase 2 is .2.11E-03 mg kg^{-1} day^{-1} minimum and 9.03E-03 mg kg^{-1} day^{-1} maximum observed. water supply scheme samples HQ of Cu also determined in a significant manner < 1 and ADD minimum 0.00E+00 mg kg^{-1} day^{-1} - 3.02E-02 mg kg^{-1} day^{-1} and maximum 8.57E-04 mg kg^{-1} day^{-1} - 1.34E-02 mg kg^{-1} day^{-1} in phase 1 and 2 phase. Ground water samples HQ < 1 found in all analyzed samples which shows no health concerns regarding Cu contamination and ADD minimum 0.00E+00 mg kg^{-1} day^{-1} - 5.83E-03 mg kg^{-1} day^{-1} and maximum is 8.57E-05 mg kg^{-1} day^{-1} - 1.03E-02 mg kg^{-1} day^{-1}respectively in both phases.

Severe disorders in nervous system and brain as the main target site caused by Mn exposure and excessive doses (Crossgrove and Zheng, 2004) with symptoms similar to those of Parkinson's disease in its worst form, may lead to a permanent neurological disorder (Barbeau, 1984; Inoue and Makita, 1996)

Table 10 Minimum and maximum values of both Phases Health Quotient and Average daily dose of manganese

Mn	Phase # 1	Phase # 2	Phase # 1	Phase # 2

	BW 70 HQ				BW ADD 70kg mg/kg-d			
S.Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M & MC	0.00E+00	0.00E+00	0.00E+00	3.95E+00	0.00E+00	0.00E+00	7.91E-02	3.43E-02
RS	0.00E+00	0.00E+00	5.03E-01	6.71E+00	0.00E+00	0.00E+00	8.58E-02	1.34E-01
WS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GS	0.00E+00	0.00E+00	3.00E-02	6.06E+00	0.00E+00	0.00E+00	6.00E-04	1.21E-01

Mn Potential Chronic Health Impact on the drinking water consumers of all the sources Manchar Lake and Outlets, River, Water Supply Schemes, ground water samples found in significant range HQ less than one showed safe for drinking but phase 2 maximum values of all the sources found insignificant reflects phase variation health impact on the drinking water communities about Mn contamination. Average Daily Dose of all the type of sources identified 0 in phase but in phase 2 is as minimum and maximum Manchar with outlets 7.91E-02 mg kg^{-1} day^{-1} - 3.43E-02 mg kg^{-1} day^{-1}, River 8.58E-02 mg kg^{-1} day^{-1} - 1.34E-01 mg kg^{-1} day^{-1}, water supply schemes 0.00E+00 mg kg^{-1} day^{-1} - 0.00E+00 mg kg^{-1} day^{-1}, Ground water samples 6.00E-04 mg kg^{-1} day^{-1} - 1.21E-01 mg kg^{-1} day^{-1}.

Fe It is a less common condition elevated concentrations in natural water resources over exposure, but like cancer several serious health problems can be caused (Beckman et al., 1999; Perkily et al., 2001), diabetes mellitus (Allergic et al., 2001; Perkily et al., 2001; Perez de MacClare's et al., 2000), diseases like liver and heart (Mailman et al., 2001; Rasmussen et al., 2001; Yang et al., 1998) as well as disorders of neurodegenerative (Berg et al., 2001; Sayre et al., 2000). Diarrhea and lowered appetite in animals have been also associated (Pulls 1994).

Table 11 Minimum and maximum values of both Phases Health Quotient and Average daily dose of iron

Fe	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	BW 70 HQ				BW ADD 70kg mg/kg-d			
S. Station	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
M & MC	2.10E-02	2.30E-01	3.06E-02	4.43E-01	6.29E-03	6.51E-02	9.19E-03	1.33E-01
RS	7.60E-03	1.14E-02	9.52E-04	1.90E-02	4.43E-03	1.54E-03	2.86E-04	2.76E-01
WS	8.57E-03	3.81E-03	5.71E-03	5.18E-01	2.57E-03	1.14E-03	7.26E-04	1.55E-01
GS	1.35E-04	1.62E-02	9.33E-03	2.65E+00	8.00E-03	1.87E-01	5.48E-03	1.01E-01

Health Quotient of Iron in all type of sources found as a < 1 which is a significant in phase 1 as well as phase 2. Except for phase 2 maximum value which is insignificant and also like other parameters reflects health concern of phase 2 sampling than phase 1. which may be due to the less fresh water flow as compare to indulgent of contamination. Average Daily Dose of Iron Phase 1 had given in minimum and maximum range. Manchar Lake and Regulators 6.29E-03 mg kg^{-1} day^{-1} - 6.51E-02 mg kg^{-1} day^{-1}, River 1.54E-03 mg kg^{-1} day^{-1}-

4.43E-03 mg kg^{-1} day^{-1}, water supply schemes 1.14E-03 mg kg^{-1} day^{-1}- 2.57E-03 mg kg^{-1} day^{-1}, Ground water 8.00E-03 mg kg^{-1} day^{-1} - 1.87E-01 mg kg^{-1} day^{-1} I phase 2 Manchar Lake and Regulators 9.19E-03 mg kg^{-1} day^{-1} - 1.33E-01 mg kg^{-1} day^{-1}, River 2.86E-04 mg kg^{-1} day^{-1} - 2.76E-01 mg kg^{-1} day^{-1}, water supply schemes 7.26E-04 mg kg^{-1} day^{-1} - 1.55E-01 mg kg^{-1} day^{-1}, Ground water 5.48E-03 mg kg^{-1} day^{-1} - 1.01E-01 mg kg^{-1} day^{-1}.

4. Conclusion

This study was conducted in two phases to determine water quality potential chronic health impacts of district Jamshoro.Study revealed that all the metals in phase 1 found < 1 HQ which is a significant figure and safe drinking according to US EPA Guideline except as, Co and some samples of Cd where HQ found > 1 reflects the burden of contamination of these metals in phase 1 and health concern with respect to an average daily dose as well, Phase 2 found more potential health concern HQ and ADD than phase 1 with all metals except as and Co.As Health concerns increased in phase 1 reflects its contamination and Cd in phase 2 which may be due to lack of fresh water flow in rivers, Carcinogenic Risk as Health Quotient found beyond the normal range in all the samples than Vietnam, Bangladesh and kohistan studies which are an awakening finding of this study. Bangladesh, Vietnam and kohistan Pakistan, CR index of the study area was found lower than those reported in this study, which also reflects the area wise burden of contamination, ADD of As in this study reported lower than in Vietnam, Bangladesh and more than Kohistan regions north Pakistan.

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