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Water Supply Schemes and its Probabilistic Health Impacts on Communities of District Jamshoro, Sindh, Pakistan

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Abstract
Water is very important for life survival. It also plays its role as an indicator of the life presence. On the other hand water becomes life threatening and hazard when it contaminated by the industrial wastes, home sewerages and other things. The main focus of this study is to determine contaminants burden on the water supply schemes. Manchar Lake is considered as a main source of contamination of the water supply schemes by Indur River water. Season wise wet and dry session comparative study of the sources was carried out with the gap of three months. It was observed that dry season had more burdens of contaminants than wet season. Chronic, carcinogenic and dermal Health Quotient of some metals was found under normal range in water supply scheme samples. Whereas Samples collected from lake and lake/river link were observe highly contaminated in both phases. It may be due to the contaminants impact of lake water becomes diluted when it reached to water supply schemes or due to the dilution or settlements of contaminants because of long distance between lake and water supply schemes. It was also observed that water supply schemes closer to lake observed more contaminated than the distance one
Keywords: Health Quotient, water supply schemes, contaminants, industrial wastes.

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Introduction

Water considered as important to human life and the basic unit of nutrient. Main role of water in the body is digestion, transportation, adsorption of food, nutrients use, and waste or toxin elimination from body. It also plays an essential role in foodstuffs preparation[1]. From total amount of water only 0.08% of the world's freshwater are easily accessible and being exploited by humans [2]. About 1.1 billion people that is the total one sixth of humanity haven't access on fresh water within one kilometer from their home[3]so that unreachable safe and inadequate water supplies also playing their role in ongoing poverty, economic costs, enhancing need for water purchasing, poor health, increased household expenses, and/or energy with time expended in collection [4]. If actions will not be taken for the essential needs of human for the safe water in 2020 than 135 million people will be die by preventable water-related diseases, 76 million will die from water related diseases and about 34-76 million people will quit the life [5]. It is also estimated roundabout 2 billion deaths each year by water borne diseases in 2006 recorded. Worldwide around 1 billion people lack proper drinking water, thus a paramount importance matter is that purity and cleanliness of the water be ensured. Human sewage is more typical contamination of water resources specifically from human fecal pathogen and parasites [2]. Due to poor water and sanitation, the greatest health burden beard by children each year deaths caused 1.73 million and put in disability over 54 million. Diarrheal global disease caused a total equivalent to 3.7% of the disease burden because of lack water supply, sanitation and hygiene relation. So diarrheal disease on global scale becomes 6th highest disease which is principally avertable [6].Our study area district Jamshoro's soil Composition is quaternary alluvial deltaic sediments resultant from rocks of Himalaya. Major area of district is situated at Kirthar offshoots, having quaternary and tertiary volcanic rocks with thermal springs [7,8]. Lakes are considered as a one of the most versatile ecosystem of the world but they are more sensitive to anthropogenic impacts and environment pollution [9]. Manchar Lake is largest Asian lake situated at district Jamshoro. Source of contamination which contaminated lake is Main Narra Valley Drain (MNVD) and water discharged in Indus River. In the developing countries Rivers in the urban areas are on the end point of discharges effluents from industries [10]. Due to indiscriminate discharge of unprocessed municipal and waste water of industries Indus River polluted it considered as a fact and pollution becomes further distinct during the periods of low flow with the increased discharge of Manchar lake water [11]. Factors of water pollution are environmental deterioration due to increase stress on river caused by urbanization, quick growths of population and land development beside river basin [12]. This study designed to measure impact of lake contaminants on water supply schemes and there consequences probabilistic health impacts on the water consuming communities.

Materials and Methods

Study Area

The study stretched From Manchar Lake along with adjoining areas water supply schemes. 20 samples were collected in both phases (August 2013, November 2013) with gap of three months. Analysis of samples was carried out in the Institute of Biochemistry and Hitech Research Lab University of Sindh. Phase I collected in wet season and Phase II was in the dry season. Samples collection points were, one sample from Manchar Lake (M), one from the point where contaminated water mix with River/Manchar(R/M) point and eight samples from water supply schemes in each respective phase.

Sampling and pretreatment

The collections of samples was performed by using Van Dorn plastic bottles (1.5 L capacity) and were kept in well-Stoppard 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. Physical parameters like Appearance, color, odor identified by senses. Turbidity measured by Hianna Turbido meter. Electrical Conductance, pH and Total Dissolved Solids measured by conductivity and pH meter [13]. Arsenic analyzed with Merck Arsenic Kit for 0.01-0.5 mg/L. The concentration of arsenic was measured by visual comparison of the reaction zone of the analytical test strip with scales of fields of color [14]. Total Hardness, Ca Hardness, Cl, Alkalinity measured by titration, Ca and Mg measured by formula method, Silica and Sulphate measured by Double Beam Spectrophotometer Model 6850 of Jenway scientific[15].Other metals like Cd, Zn, Ni, Mn, Cu, Co, Fe, K and Na were measured by using Perkin Elmer atomic absorption spectrometer (AAS-PEA-700). Microbiological Test of Coliform and Total Coliform identified by MPN (Most Probable Number) Method [16].

Risk assessment

Equations 1 taken from of US Environmental Protection Agency [17,18,19] accustomed to estimate the chronic daily intake of ingestion and dermal absorption pathways [20].

$$\text{CDI (dermal)} = \text{CW} \times \text{SA} \times \text{Kp} \times \text{ABSd} \times \text{ET} \times \text{EF} \times \text{ED CF} / \text{BW} \times \text{AT} \quad \text{Eq} = 1$$

Concentration of trace metal in water (CW)	μg/L		
Body weight (BW)kg		70	[21]
Exposure frequency(EF) days/year		365	[19]
Skin surface area (SA)	cm2	18000	[21]
Conversion factor (CF)	L/cm3	1/1000	[19]
Average time (AT)	Days	25,550	[19,21]

Permeability coefficient (Kp): $\frac{\text{cm}}{\text{hr}}$

$2\ 9E-4$ (Ni), $1.00E-3$ (As) $1.10E-0$ (Cd), $1\ 9E-3$ (Cu), $1\ 9\ E-3$ (Fe), $4\ 9\ E-4$ (Co), $2\ 9E-3$ (Cr), $1\ 9\ E-3$ (Mn) [21]

ABSd: dermal absorption factor (unit less); 0.001 meant for every element apart from arsenic , designed for arsenic is 0.03 [22]

Reference dose for diverse metals [19]

RfD (dermal) μg/kg/day

(1) Cu	0.015
(2) Fe	45
(3) Mn	0.8
(4) Ni	5.4
(5) As	0.000123
(6) Cd	0.00001

To guess personage exposures to every trace metal deterministic exposure assessment involved using CDI the hazard quotient (HQ) is considered by means of the subsequent formula [20] to approximate non carcinogenic risk.

$$HQ = CDI / RfD \qquad Eq = 6$$

When HQ < 1 opens elements population is hypothesized to be secure [23].

Health Quotient by Average Daily Dose

Throughout numerous ways as food chain, dermal touch and inhalation arsenic enters into human body but all others are negligible in comparison with oral intake [24]. Consistent with subsequent equation [25] average daily dose (ADD) during drinking water ingestion is considered.

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

Where C represents the Sample concentration in water (lg L^{-1})

IR Water ingestion rate 2 (L day^{-1})

ED Exposure duration (unspecified 67 years)

EF Exposure frequency (365 days $year^{-1}$)

BW Body weight (70 kg)

AT Average life time (24,455 days)

Mutually chronic and carcinogenic hazard levels were also assessed in this study, through subsequent formula [25] generally, the HQ can be calculated.

$$HQ = ADD / RfD$$

When the HQ values were >1 the health risk is generally occurs [23].

Using following formula cancer risk (CR) was considered:

$$CR = ADD \times CSF$$

Cancer slope factor (CSF) meant for As is 1.5 mg kg^{-1} day^{-1} according [26]US EPA (2005) database.

CR value was commonly measured important. According to USEPA guideline larger than one into a million values (10^{-6}) considered to be safe. Though as the national standards and environmental policies this standard could change [27,28] (**Table 1**).

Table 1: Reference dose for different metals [19,29].

Elements	Cu	Fe	Mn	Ni	As	Cd	Co	Zn
RfD mg/kg/day	0.04	0.3	0.02	0.02	0.0003	0.0005	0.003	0.3

Results and Discussions

Water Supply Schemes basically are water storage tanks from where water supplied to the household consumers. Indus River which is being polluted through the contaminated water of Manchar Lake and that river polluted water directly stored in water supply scheme tanks. This study was designed to measure the contamination impact on water supply schemes and to measure probabilistic health impacts of it on community. We observed that color of the lake sample was greenish due to presence of green algae in both phases and taste was highly saline because of increased level of TDS that's shows level of polluted dissolve solids into the water. Manchar/River sample was in turbid color and found more saline in phase II than phase I which may be due to the dry season. Water supply schemes samples in both phases found highly turbid which may also be due to the improper cleaning of storage tanks. In some samples algae also found especially in phase II and also observed change in taste which may be the short availability of water in dry season, long time storage of water or improper cleaning and care of storage tanks. Electric conductance analyzes elevated in phase II than phase I so that TDS level and salinity also detected increased respectively. In phase I almost all samples were in normal range of WHO except sample which collected from Lake. In phase II some samples observed increased in limits of WHO level 500mg/L. Lake/River link sample and water supply scheme which is nearby to lake reflect the lake contamination burden impact (**Table 2**).

pH of analyzed samples were in WHO level 6.5- 7.5 except lake sample and one water supply scheme sample of both phase. Turbidity of both phases was highly increased than WHO level < 5 NTU observed in all the samples but phase I was more turbid. Silica level varies in both phases but founds higher in phase I than Phase II it may be due to the phase I was the collected during the flood flow. Elevated level of silica effects directly on the lungs [30]. Humans predominantly absorbed Orthosilicic acid in bone, tendons, aorta, liver and kidney. Deficiency induces deformities in skull and peripheral bones, poorly formed joints, reduced contents of cartilage, collagen and disruption of mineral balance in the femur and vertebrae [30]. Alkalinity observed in normal level except Lake Sample. WHO range of Total Hardness in water is 400mg/L. two samples of water supply schemes and lake sample in phase I were more than the WHO limit. All samples of phase II were in more than WHO level. Ca Hardness WHO Range is 175mg/L shows $CaCo_3$ amount in water. All samples of phase I was under the normal limit except Lake Sample. In dry season almost all samples had range more than WHO limit. According to WHO standards the permissible range of magnesium in water should be 30 mg/l. In dry and wet season round about all samples were in exceed range than WHO limit. WHO Range of Cl is 250mg/L, in wet season two samples were more than the WHO limit. In dry season all samples found in increased limit than WHO range, that shows contamination variation in phase wise, According to WHO (1996) standards Ca permissible range in drinking water is 175 mg/l. In wet season all samples were in the normal limit but in the dry season all samples were in more than normal range. WHO standards the permissible .limit of potassium is 12 mg/L. Potassium is silver white alkali which is highly reactive with water. Potassium is necessary for living organism functioning hence found in all human and animal tissues particularly in plants cells. In wet season and dry season all samples were in WHO range. Samples collected from lake and river observed more than normal range. High concentration of sulfate may be due to oxidation of pyrite and mine drainage. WHO has established 250 mg/l as the highest desirable limit of sulfate in drinking water. In dry and wet season all were in limit of WHO except samples of lake. In dry season all were under the WHO limit except river sample that shows dilution impact of water from lake to water storage tanks. Sodium is a silver white metallic element and found in less quantity in water. Proper quantity of sodium in human body prevents many fatal diseases. According to WHO standards concentration of sodium in drinking water is 200 mg/L. In dry season all samples were in normal range but in phase II majority of samples level exceeded from normal WHO range. Arsenic (As) is recognized as a big threat to public health in many countries like Pakistan, Bangladesh, India, China, Vietnam, Nepal and Myanmar. WHO standard of arsenic is 10 ppb (μg/L). Arsenic cause a decrease in white and red blood cells production, gastrointestinal irritation, disrupt the heart rhythm, damage blood vessels and cause "pins and needles" sensation in hands and feet, Long time exposure to arsenic can cause melanosis, leukomelanosis, hyperkeratosis, cardiovascular disease, black foot disease, neuropathy and cancer, except one river sample in wet season all wherein normal range that one river sample may be due to the settlements of contaminants at lake-river link. In dry season except Lake Sample all had normal limit. Manchar Lake shows fluctuation of contaminations during different periods also Contamination in lake of Manchar have been found zero in 1995[31]. In Lake Sample observed contamination of arsenic in phase II which reflects impacts of dry season on its water chemistry. Acceptable concentration of Zinc according to WHO is 3 mg/L. All analyzed samples in wet and dry season found exceeded than normal range except few samples of phase II. Cadmium is considered as heavy metals acceptable WHO Range is 0.003mg/L. Cd were below detection limit in all sources of drinking water in Phase I wet season. In dry season cadmium contaminants found that reflects lake contamination impact on surface water sources. WHO limit of Cu is 2 mg/L which is considered as essential element. During wet season two samples and three samples of dry season observed more than WHO limit which shows fluctuation in phase wise. Manganese is considered as trace elements for human life; WHO Limit of Mn is 0.05 mg/L. In both phases manganese had range less than detectable limit except one sample of Lake in dry season. Iron acceptable WHO Limit is 0.3 mg/L in dry and wet season except two all samples observed were more than WHO limit. For animals and plants mutually its shortage and excess can be injurious [32]. It is a less common condition of prominent concentrations in normal water assets overexposure but like cancer quite a lot of solemn health evils can be caused [33,34], diabetic mellitus [34,35,36] ,diseases like liver ,heart [37,38,39] in addition to disease of neurodegenerative [40,41]. Diarrhea and lowered appetite in animals have been associated with High concentrations of Fe [42]. WHO Limit of Cobalt is 1000ppb. In both phases Co detected within normal range. Standard WHO Limit of Nickel is 0.02 mg/L, in wet season Ni detected only in two samples one of river and one was from water supply scheme both were exceeded from the limit of WHO. In dry season mostly all samples observed were crossing the permissible limit of drinking water reflecting contamination impact in dry season (**Table 3**).

In both phases microbiological contamination observed positive which shows severe bacteriological health concern especially in children and weak immune persons and caused hemorrhagic diarrhea. Microbial contamination observed may be due to the turbid water and improper cleaning or maintenance of water storage tanks (**Table 4**).

Table 2: Different parameter's mean value of water supply scheme and concentrations of lake and river samples

		EC (µS/cm^3)		TDS (mg/L)		Salinity (ppt)		pH		Turbidity (NTU)	
		Phase I	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
1	M2	4980	3430	3187	2195	2.7	1.8	7.06	8.3	270	177
2	RS1	312	3530	199.6	2259	0.1	1.8	6.95	8	450	269
3	WS MEAN	316.6	731	202.6	467.8	0.15	0.36	6.945	8	141.1	67.6
		Alkalinity (mg/L)		**Ca Hardness**		**Mg**		**Cl**		**Total Hardness**	
	Unit mg/L	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
1	M2	145	545	370	300	119	170.1	1302	1048	860	1000
2	RS1	160	190	90	550	14.58	116.6	31.9	1003	150	1030
3	WS MEAN	146.6	123.3	113.3	270	34.7	100.4	54.35	284.9	396.6	850
		SO_4 (mg/L)		**Si (mg/L)**		**Ca**		**K**		**Na (mg/L)**	
	Unit ppb	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
1	M2	1262	5102	2.34	8.87	148.2	120.2	48.4	45.4	36	700
2	RS1	22.9	816.3	6.26	3.96	36.07	220.4	4.28	43	35	167
3	WS MEAN	41	131.7	12.89	3.98	45.42	108.2	4.905	4.795	57.6	480.5
		CO		**Ni**		**Zn**		**Fe (mg/L)**			
	Unit ppb	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**		
1	M2	302	355	257	214	3000	2644	2410	2526		
2	RS1	94	335	0	302	0	299	155	9674		
3	WS MEAN	97.09	74.23	6.5	179.3	883.4	723.5	60	202.3		
		Mn		**As**		**Cd**		**Cu**			
	Unit ppb	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**		
1	M2	0	2767	10	25	0	353.8	32	0		
2	RS1	0	0	50	5	0	213.6	0	74		
3	WS MEAN	0	0	9.16	5	0	79.75	50	24.7		

Table 3: Phase wise Microbiological contamination

		Phase 1		Phase 2	
S.No	S.Station	Coliform	Total- Coliform	Coliform	Total- Coliform
1	M2	+	+	+	+
2	RS1	+	+	+	+
3	WS1	+	+	+	+
4	WS2	+	+	+	+
5	WS3	-	-	-	-
6	WS4	+	+	+	+
7	WS5	+	+	+	+
8	WS6	+	+	+	+

Table 4: Phase wise comparison of Dermal Health Quotient of Different metals

Phase 1				**Dermal HQ**			
S.Station	Cu	Cd	As	Mn	Ni	Zn	Fe
M2	3.98E-07	0.00E+00	3.64E-04	4.00E-07	2.80E-06	4.50E-05	8.00E-06
RS1	0.00E+00	0.00E+00	1.82E-03	0.00E+00	0.00E+00	0.00E+00	5.00E-07
WS1	0.00E+00	0.00E+00	3.64E-04	0.00E+00	0.00E+00	1.20E-05	3.00E-07
WS2	0.00E+00	0.00E+00	3.64E-04	0.00E+00	0.00E+00	0.00E+00	2.00E-07
WS3	0.00E+00	0.00E+00	3.64E-04	0.00E+00	0.00E+00	7.50E-06	2.00E-07
WS5	0.00E+00	0.00E+00	3.64E-04	0.00E+00	0.00E+00	1.00E-05	1.00E-07
WS6	0.00E+00	0.00E+00	3.64E-04	0.00E+00	0.00E+00	1.20E-05	2.00E-07
Phase 2				**Dermal HQ**			
S.Station	**Cu**	**Cd**	**As**	**Mn**	**Ni**	**Zn**	**Fe**
M1	0.00E+00	5.80E-03	9.09E-04	0.00E+00	2.40E-06	3.94E-03	8.40E-06
RS1	9.20E-07	0.00E+00	1.82E-04	0.00E+00	5.80E-06	4.46E-04	1.10E-06
WS1	0.00E+00	1.20E-03	1.82E-04	1.20E-05	3.50E-06	3.29E-03	1.20E-07
WS2	5.84E-06	2.12E-03	1.82E-04	0.00E+00	1.20E-06	4.10E-04	1.80E-05
WS3	1.31E-05	1.21E-03	1.82E-04	5.80E-06	1.20E-06	6.41E-04	1.70E-06
WS5	0.00E+00	2.03E-03	1.82E-04	0.00E+00	3.20E-08	1.45E-03	8.40E-08
WS6	0.00E+00	2.41E-05	1.82E-04	0.00E+00	1.90E-06	2.92E-04	1.30E-07

Dermal Chronic health quotient determines to analyze health impact of different metals on dermis. Health quotient of all the samples of different metals observed below the limit of one which is the normal limit and resemble with the previous studies which did on dermal health quotient in Nanjing china and Karachi [46,47],,that also shows safe metal concentration in drinking water with respect to dermal chronic impact (**Table 5**).

Table 5: Phase wise minimum and maximum values of chronic health Quotient and average daily dose of different metals of water supply schemes

Manchar (MS)	Phase # 1		Phase # 2		Phase # 1		Phase # 2	
	Body weight 70 kg HQ				BW ADD 70kg mg/kg-d			
Metals	Minimum	Maximum	Minimum	Maximu	Minimum	Maximum	Minimum	Maximum
As	4.76E-01	9.52E-01	4.76E-01	4.76E-01	2.86E-04	1.43E-04	1.43E-04	1.43E-04
CO	9.33E-01	1.09E+00	9.43E-01	2.25E+00	4.06E-03	2.06E-03	6.75E-03	1.23E-03
Ni	5.57E-02	0.00E+00	4.14E-03	1.46E-01	0.00E+00	1.11E-03	8.29E-05	1.67E-02
Zn	7.62E-04	0.00E+00	9.27E-02	1.28E-01	7.32E-04	1.43E-04	7.86E-03	1.23E-02
Cd	0.00E+00	0.00E+00	8.40E-02	7.40E+00	0.00E+00	0.00E+00	4.20E-05	1.37E-03
Cu	8.57E-02	0.00E+00	0.00E+00	3.02E+00	0.00E+00	8.57E-04	3.02E-02	1.34E-02
Mn	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe	8.57E-03	3.81E-03	5.71E-03	5.18E-01	2.57E-03	1.14E-03	7.26E-04	1.55E-01

Chronic health impact of different metals varies with phase wise, Chronic health impact of arsenic , 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 I and phase II is 1.43E-04mg/kg-d, minimum 2.86E-04mg/kg-d respectively, Health concerns and chronic impact on local drinking water of communities determined by the Co Water supply schemes HQ also found significant more less than one in phase I and II minimum value but insignificant in maximum values of both phases all samples and ADD minimum 1.23E-03mg kg^{-1} day^{-1}- 4.06E-3 mg kg^{-1} day^{-1} and maximum 2.06E-03mg kg^{-1} day^{-1} - 6.75E-03mg kg^{-1} day^{-1} phase wise respectively, Health impact of drinking water of district jamshoro by the nickel contamination expo sure had variations water supply scheme samples also showed significant HQ less than one in both phases and ADD minimum 0.00E+00mg kg^{-1} day^{-1} - 8.29E-05mg kg^{-1} day^{-1}, maximum 1.11E-03 mg kg^{-1} day^{-1} - 1.67E-02mg kg^{-1} day^{-1} in phase I and II respectively, Zn HQ water supply schemes samples in both phases also reflects significant result HQ < 1 and ADD minimum 7.32E-04mg kg^{-1} day^{-1} - 7.86E-03mg kg^{-1} day^{-1}, maximum 1.43E-04mg kg^{-1} day^{-1} - 1.23E-02mg kg^{-1} day^{-1} in both phases, Cadmium Potential Chronic Health impacts from the samples water supply scheme is also found safe for drinking in both phases values except maximum range of phase II. ADD minimum range in zero in phase I and phase II minimum is 4.20E-05mg kg^{-1} day^{-1} and maximum 1.37E-03mg kg^{-1} day^{-1} same found, Chronic Health Impact of Copper water supply scheme samples HQ of Cu also determined in a significant manner <1 and ADD minimum 0.00E+00mg kg^{-1} day^{-1} - 3.02E-02mg kg^{-1} day^{-1}, maximum 8.57E-04mg kg^{-1} day^{-1} - 1.34E-02mg kg^{-1} day^{-1} in phase I and II phase. Mn Potential Chronic Health Impact Average Daily Dose Of all the type of sources identified 0 in phase I but in phase II water supply schemes 0.00E+00mg kg^{-1} day^{-1} - 0.00E+00mg kg^{-1} day$^{-1,}$ Health Quotient of Iron water supply schemes 1.14E-03mg kg^{-1} day^{-1} - 2.57E-03mg kg^{-1} day^{-1}(**Table 6**).

Table 6: Phase wise minimum and maximum values of chronic health Quotient and average daily dose of different metals of River/ Manchar link and Manchar lake water

S.Station		Phase 1	Phase 2	Phase 1	Phase 2	S.Station		Phase 1	Phase 2	Phase 1	Phase 2
WS		BW 70 HQ		BW 70 ADD mg/kg-d		WS		BW 70 HQ		BW 70 ADD mg/kg-d	
As	MS	9.52E-01	2.38E+00	2.86E-04	2.38E+00	Zn	MS	2.86E-03	2.52E-01	8.57E-04	7.55E-02
	RS	4.76E+00	4.76E-01	1.43E-03	1.43E-04		RS	0.00E+00	2.85E-02	0.00E+00	8.54E-03
Co	MS	2.88E+00	3.38E+00	8.63E-03	1.01E-02	Cd	MS	0.00E+00	2.02E+01	0.00E+00	1.01E-02
	RS	8.95E-01	3.19E+00	2.69E-03	9.57E-03		RS	0.00E+00	1.22E+01	0.00E+00	6.10E-03
Ni	MS	3.67E-01	3.06E-01	7.34E-03	6.11E-03	Cu	MS	9.14E-02	0.00E+00	9.14E-04	0.00E+0
	RS	0.00E+00	4.31E-01	0.00E+00	8.63E-03		RS	0.00E+00	2.11E-01	0.00E+00	2.11E-03
Mn	MS	0.00E+00	1.71E+00	0.00E+00	3.43E-02	Fe	MS	2.30E-01	2.41E-01	6.89E-02	7.22E-02
	RS	0.00E+00	0.00E+00	0.00E+00	0.00E+00		RS	1.48E-02	9.21E-01	4.43E-03	2.76E-01

In **Table 6,** chronic health impact of different metal have been identified of the Manchar lake sample and sample of river/manchar link and observed that chronic health impact in the both samples. In the water supply scheme samples except HQ of Cu and Cd all others Health quotient was in the normal limit.

Conclusions

Our study revealed that season wise burden of contamination. Dry season had more burden of contaminants in the lake, lake/river and water supply schemes collected sample than wet season. Physical parameters found under the normal range in all water supply schemes except lake and lake/river sample. Cadmium contamination observed more than normal limit of WHO in phase II. Microbial contaminations were positive in the both season. Chronic health quotient of different metals in the water supply schemes was under normal level except of cobalt, cadmium and copper in few samples. In the Samples of lake and river/manchar link arsenic, cobalt, cadmium, copper and manganese were observed with HQ more than normal level. HQ variation in water supply schemes and lake/river samples may be due to dilution of contaminants or settlements due to long moving distance of water from lake to river and then water supply schemes. Arsenic carcinogenic health quotient of water supply schemes was under the normal range except lake and river samples. Chronic dermal health quotient also observed under the normal range in all samples which also have resemblance with the previous studies.

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