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During and Post Flood Health Impacts of Dissolved Metals on Adjacent Area of Manchur Lake, District Jamshoro, Sindh, Pakistan

Amjad Hussain Memon[1*], Allah Bux Ghanghro[1], Taj Mohammad Jahangir[2], Muhammad Younis[1,3], Gul Muner Lund[1,4]

[1]Institute of Biochemistry, University of Sindh, Jamshoro, Sindh, Pakistan

[2]Hi-tech Research Lab, University of Sindh, Jamshoro, Sindh, Pakistan

[3]The key Laboratory of Development Genes and Human Diseases, Institute of Life Sciences, Southeast University, Sipailou 2, Nanjing, 210096, China

[4]School of Life Sciences, Northeast Normal University, Changchun, Jilin, China

Abstract
Aim of this study was to analyze phase wise contamination burden on water samples of Manchur Lake and its regulators with the closer one source of water supply scheme and ground water source. It was observed that concentration of metals found higher than world health organization (WHO) level. In phase 2, silica, sulphur, arsenic, cadmium was found higher, which reflects heavy burden of lake contamination and its Chronic and carcinogenic health impacts on surrounding area determined by average daily dose (ADD) Health Quotient method of metals, bacteriological contamination has been observed in both phases especially in phase 2, due to low fresh water flow but no any dermal Health Quotient(HQ) impact identified findings with previous studies in Nanjing China and Karachi Sindh, Pakistan. Lake contamination impact also identified in its adjoining areas like nearby water supply scheme sample and Ground water source which can be overcome by proper gate regulations and fresh water flow from the upstream of Indus River or controlling the flushing of contaminated water into Lake by MNVD.
Keywords: Manchur Lake, average daily dose, health quotient, ground water.

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Introduction

One of the most versatile ecosystem of the world considered are Lakes but they are more sensitive to anthropogenic impacts and environment pollution. Main source of Manchur Lake Sindh contamination is Main Nara Valley Drain (MNVD) that one is a main source of arsenic contamination which have been observed in this lake in previous studies. It is a largest Asian Lake and chief source of water for irrigation, household, and fishing purposes [1,2]. Indus River polluted it considered as a fact and with the discharge of Manchur lake pollution becomes further distinct during the periods of low flow [3]. It is thought that global load of disease, morbidity, mortality, socio-economic disruptions will be increased in floods and especially in low-resource countries will place a continuing stress on health services, where most major floods occurs vulnerability is the utmost [4,5] chronic and carcinogenic[6,7]. In years 2002–2011, developing versus high resource regions worldwide, the ratio of deaths linked to floods to be approximately 23 to 1 counted by the Centre for Research on Epidemiology of Disasters [8]. Chemicals releasing as trigger from the flood water which are already stored in environment. Population which exist in industrial or agricultural areas of flood-impacted having toxic exposure-related health impacts. Diseases which caused by such kind of contamination exposures causes diseases are gastrointestinal, neurological, liver, kidney, cancer and cardiovascular [9,10]. United States reports [11] and South Asia [12] exacerbation of ARIs exposed, rashes of skin and earache are widespread complaints of post-flood and mainly common type of infectious disease happening after floods were the upper respiratory infections (ARIs) [13]. Aim of this study was to identify the impact of Manchur lake contamination and its burden on nearby adjoining areas.

Material and Methods
Study Area
The study stretched From Manchur Lake along with adjoining areas. In present study 30 samples were collected in both phases (August 2013, November 2013) with gap of three months. Samples were analyzed at Institute of Biochemistry and Hitech Research Lab University of Sindh. Each phase had 15 samples, location of samples were Manchur Lake (M), Manchur Lake canals, nearby water supply schemes to lake (WS) and Ground

water supply schemes and ground water (GS) sources (**Table 1**).

Table 1: Phase wise sample numbers

Sr. No	Sources	Phase 1	Phase 2
1	Manchur Lake	3	3
2	Manchur Lake Canals	4	4
3	Indus River	3	3
4	Water supply Scheme	3	3
5	Ground water	2	2

Sampling and pretreatment

The sampling network was designed to cover a wide range of determinates of the Manchur Lake and its nearby river source, water supply scheme and ground water. The collections of samples was performed by using sterilized van dorn plastic bottles (1.5 L capacity) and were kept in well-stopper 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 and analysis [37].

Appearance, color and odor were identified by senses and turbidity by Hianna Turbido meter, electric conductance (EC), Total dissolve salts (TDS) and Power of Hydrogen(pH) measured by conductivity and pH Meter, Arsenic was measured with HACH Arsenic kit (EZ arsenic test kit 2822800) Hach Company USA 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, Calcium hardness (Ca Hardness),Chloride (Cl), Alkalinity measured by titration, Calcium (Ca) and Magnesium (Mg) measured by formula method, Silica and Sulphte measured by double beam Spectrophotometer, other metals like Cadmium (Cd), Zinc(Zn), Nickel (Ni), Manganese (Mn), Copper (Cu), Cobalt (Co), Iron (Fe), Potassium (K), Sodium (Na) were measured by using Perkin Elmer atomic absorption spectrometer (AAS-PEA-700). Microbiological analysis of samples was performed to detect the total coliform load by most probable number (MPN) method [15].

Risk assessment

Equation 1 was used as per US Environmental Protection Agency [16-18] which was accustomed to estimate the chronic daily intake of ingestion and dermal absorption pathways [19].

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

Concentration of trace metal in water (CW) μg/L
Body weight (BW)kg   70   [19]
Ingestion rate (IR) /day   2.2   [18]
Exposure frequency) Days/year or events/year 365 [18]
Skin − surface area cm2   18000   [19]
Conversion factor (CF) L/cm3   1/1,000   [18]

Average time (AT)Days   25,550 [18,19]
Permeability coefficient (Kp)cm/hr 2 9E − 4 (Ni) 1.00E − 3 (As) 1.10E − 0 (Cd), 1 9E − 3 (Cu), 4 9 E − 4 (Co), 2 9E − 3 (Cr), 1 9 E − 3 (Mn) 1 9 E − 3 (Fe)[19]
ABSd: Dermal Absorption Factor (unit less); 0.001 meant for every element, Apart from arsenic , designed for arsenic 0.03   [20]

To know personage exposures to every trace metal deterministic exposure assessment involved using CDI, the hazard quotient (HQ) is considered by means of the subsequent formula [21] to approximate non carcinogenic risk

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

When HQ < 1 opens elements population is hypothesized to be secure [22].

Health Quotient by Average Daily Dose

Throughout numerous ways of average daily dose (ADD) are as food chain, dermal touch and inhalation. Arsenic enters into human body but all others are negligible in comparison with oral intake [23]. Consistent with subsequent equation [24] 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 [24] generally, the HQ can be calculated as following.

$$HQ = ADD / RfD$$

When the HQ values were >1 the health risk is generally occurs [22].

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 toward [25] US EPA (2005) database.

By USEPA guideline larger than one into a million (10^{-6}), CR value was commonly measured important. Though as the national standards and environmental policies this standard could change [26, 27].

Results and Discussion

Electric conductance increased in phase 2 than phase 1 as compare to WHO suggested 1562 μS/cm normal value. In water supply scheme EC have also been found increased in Sehwan sample as compare to others sample stations because it closer one and first one water supply scheme from Manchur which also indicate impacts of Manchur effluents. Manchur lake sample shows high EC in phase 1 than phase 2 due to the outlets were closed at that time due to flood conditions. Phase 1 Sehwan river sample showed less EC due to closed gate of Manchur regulators as compared to Phase 2 when outlets of Manchur Lake were open.

Remaining Ground water samples also reflects variation with the phase wise sampling, samples related to Manchur lakes found high concentration in phase 1 than phase 2, this phase wise variation demonstrated that TDS correlates with water flow [29,30] and due to open of Manchur regulating canals towards Indus river. TDS of ground water samples also varies with the climate change and location, GW 1 Sample which was closer to lake indicates high concentration of TDS, it means ground water source have also been contaminated with the lake water. Salinity reflecting phase 1 was found less contaminate because of heavy flow of water in flood condition and lake effluents gates were closed but Manchur [MS] samples show more salinity in phase 1 because source discharges of pollutants were closed. Water supply scheme samples have been found normal in phase 1 than phase 2 due to lakes gates were open discharging its contaminants in river.

Salinity found increased RS Samples in phase 2 from the point where lake water meets with river at Sehwan, which also puts effects on water supply scheme of Sehwan, same like ground water sources near to Lake Village Mola Bux have been found more contaminated, Samples from Manchur Lake found lightly more pH in phase 1 may be because of highly storage of water in lake and gates were closed in flood conditions, Phase 1 as taken in flood season showing more turbidity than Phase 2 as present, Manchur lake and outlets samples shown more Hardness due to contamination source was closed, ground water samples which were near to lake shows high concentration of total hardness, number of samples of the Lake outlets, water supply schemes, rivers, ground water samples especially which were near to lake (as a source of contamination) shows more Total Hardness level than WHO Standard limit, which might be due to lake itself contamination and shortage of water from upper sides and Lake regulating gates were open which also put impacts on other sources. Because, storage amount of contaminate water and gates were closed of lake in phase 1 so chloride level in Manchur lake sample was found higher and less in phase 2 due to gates were open and contamination were releasing, which also put impacts in other sources and Cl level found increased as compare to phase 1, Manchur lake samples shows more concentration in phase 1 but less in phase 2 except samples from Aral Wah, which reflects more Ca hardness might be due to settling of contaminants, narrow passage of regulator or any other link of contamination joined like bathing or washing there. In phase 1 all other sample sources like river and water supply schemes are under the normal range but ground water samples specially those which taken near to lake found more contaminated in both phases.

In Phase 1 all the Samples from lake, danastar, aral, river and water supply schemes indicates within normal 200mg/L limit, which may be due to the heavy flow of water in flood seasons but in phase 2 except Manchur lake samples which may be due to settling its contaminants all other samples from surface water sources are normal in range, it has been found increased magnesium in Manchur sample ground water sample near to Manchur also shows high contamination of Mg, Phase 2 found more concentrated which may be due to Manchur source was open and shortage of water also sources shows extended value of Mg, samples from Aral Wah, Manchur-River Link found light increase in concentration than permissible limit, samples from Manchur lake and Aral Wah showed increased amount of sodium concentration and some ground water samples which may be high TDS in these samples in phase 1 but in phase 2 samples from Manchur, Danastar, Aral Wah, and sample from Manchur-River link shows much increased concentration of Na than phase 1.

Ground water sample indicated increased amount of sodium it might be due to adsorption on fine sediment in case of high evaporation process of fluctuation in Na concentration attributed [31]. Samples from Manchur Lake analyzed have high concentration of SO_4 and danastar sample but not the Aral Wah sample due to gates were closed Gates were open of lake's regulators so high amount of sulphate found from Manchur, Danastar, Aral Wah and sample where Manchur touches the River and Ground Sources which is closed to lake, Manchur and River samples in phase 1 increased amount of silica in samples found due to the flood water and inter linked with turbidity of water, ground sample reflecting more silica Concentration than permissible which was taken near to lake may be due to lake contamination, During Flood season more concentration of arsenic observed which may be due to floods water was rich of arsenic or

environment pollution or field pesticides involvement in flood water. Aral Wah showing 50 ppb in stagnant water of lake, Sehwan River analyzed to caring arsenic content more than normal WHO limit which shows itself flood contamination. Water supply schemes show 10ppb of arsenic which is impact of river water itself, sources which are closer to Lake Source like village Mola Bux (GS) ground source.

In Phase 2 samples found in exceed limit than WHO, Manchur shows more contamination of Arsenic in phase 1 it might be during phase I MNVD discharge was stored and gates were closed due to flood conditions. Manchur Lake shows fluctuation of contaminations during different periods also Contamination in lake of Manchur have been found zero in 1995 [32].But, in 2008, 97.5-28.9ppb founded by researchers [1]. Danastar and aral wah showing amount of arsenic more than WHO Limit. River samples like Manchur-River link 50ppb identified, Ground Source also found highly contaminated as 100 ppb in both phases, manchur lake sample and Danastar. which is closer to lake shows more k level than Aral Wah which was in normal value due to gates were closed in phase 1, In phase 2 Gates of lake became opened K increased from Manchur to river link, water supply scheme sample of Sehwan is more than permissible range which may be due to close station of Manchur lake and ground source as well.

Phase 2 shows upper concentration of Zinc in water due to water shortage and polluted water overload from the MNVD and Other sources of water pollution and less flow of water to run off the pollutants. There is no any concentration found in all sources of drinking water in Phase 1 except one Ground water source which is nearer to Manchur Lake, GS might be due to seepage impact of contaminated lake water on the Ground Sources which is found higher than normal value. In Phase 2, samples of Manchur and danstar outlet, Manchur/River link, Ground Source and water supply scheme found contaminated more than permissible limit, Increased number of contaminated samples is prominent clue of contamination of drinking water due to shortage of fresh water discharge in Indus River and Heavy flow of contamination sources, Cu found normal in both phases except phase 1 lake sample and phase 2 lake/river sample, In Phase 1 all other samples found below detection limit it may be because of increased water flow due to flood condition and this metal considered as trace metal.

Mn concentration detected more in Phase 2 as one from Manchur and Aral Wah, this phase wise variation may be due to contamination of Manchur Lake itself and low fresh water involvement shows inflected concentration with the all fresh water samples even water, Iron acceptable WHO Limit is 0.3 mg/L. In both phase, all source of samples found in increased limit than WHO.

Iron detected more than normal range in all type of sources may be due to the low flow of fresh water and high intake of contaminated water from Polluted sources and its impact reaches to the ground sources and water supply schemes as well in phase 2. Co concentration increased in Phase 1 in all type of samples which may be due to the contamination of flood water than phase 2 except ground source. Lake sample and ground source near to lake shows increased concentration more than 400 ppb, in phase 1 lake was also getting fresh water from the upper mountains flow, it may be the fresh water of flood was rich in Co content, in phase 2 danastar, aral regulators, Manchur/river link. Ground source contains more concentration than phase 1 except water supply scheme sample, Ni found higher in ground source, River/Manchur sample, water supply scheme and aral wah sample in phase 2 which may be due to same reason low fresh water flow and high amount of contamination sources involvement (**Table 2**).

Bacterial contamination as shown in **Table 3** was observed as serious issue in both phases, all fresh water samples were found contaminated. Samples, which were more turbid or from stagnant water are the main reason of contamination. Drinking source which found linked with sewerage system due to sewerage plant absence in the villages or improper drainage system. All waste materials were directly dumped or flowed into the river which was the main reason for the contamination of all water samples, except ground water samples due to the more depth of boring and saline nature of the water.

Cancer Risk CR Potential of As shown in **Table 5** varies with the sample source type and phase wise, in our study result had revealed that irrespective to phases and sources type all samples found more than 10^6 which shows a potential carcinogenic risk health risk for the local communities which had using these sources for the drinking purpose. For drinking water in Bangladesh [33], Vietnam [34] and Kohistan, Pakistan [35] reported respectively CR index.

Chronic health impact of arsenic HQ **Table 6** varies with source type and phase wise. In phase 1,Manchur and its outlet sample's Health Quotient is more than one which is insignificant figure in both phases and ADD range wise of Manchur with its outlet is 2.86E-04mg/kg-d minimum and maximum is 1.43E-03mg/kg-d in phase 1 and phase 2 minimum ADD is 0.00E+00mg/kg-d and 7.14E-04mg/kg-d was maximum. Our As study found lower than in Bangladesh drinking water

Table 2: Mean value of different parameters in Phase wise comparisons

	Conductivity µS/cm³		Salinity (ppt)		TDS (ppm)		pH		Turbidity (NTU)	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Maximum	8500	9000	4.7	4.8	5440	5760	7.94	8.3	450	269
Mean	3798	4250	2.05	2.25	2430.88	3108.84	7.32	6.88	245.37	142.12
Minimum	312	1383	0.1	0.7	192	885.1	6.9	7	122	63

	Total Hardness (ppm)		Cl (ppm)		Ca Hardness (ppm)		Mg (ppm)		Ca (ppm)		Alkalinity (ppm)	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Maximum	2240	2190	1373	1896	720	830	219.3	221.78	288.57	393.38	450	545
Mean	856	1167.5	773.36	1093.77	331.25	481.25	88.30	139.58	132.72	208	220.62	278.75
Minimum	150	800	31.9	436.03	70	300	9.72	97.2	28.05	120.24	130	135

	Na (ppm)		SO₄ (ppm)		Silica (ppm)		Arsenic (ppb)		K (ppm)		CO (ppm)	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Maximum	1400	820	5102	5322.4	28.8	8.87	100	100	53.1	60.5	453	489
Mean	1082	1385.8	726	1141.93	373.75	537	105.77	152.85	149.78	240.56	266.87	319.58
Minimum	35	41.8	36.7	189.79	1.39	1.84	10	5	4.28	5.8	86.2	43

	Ni (ppm)		Zn (ppm)		Cu (ppm)		Fe (ppm)		Mn (ppm)		Cd (ppm)	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Maximum	257	523	70	519	32	74	6530	9674	0	2767	25.38	236.2
Mean	839	749.21	1954.92	2218	134.64	182.59	71.92	85.95	69	102.28	268.69	283.86
Minimum	10.49	57.9	8	32	0	0	90	321.7	0	407	0	3.8

Table 3: Phase wise microbiological analysis data all samples of Manchur Lake, its canals, water supply schemes and Indus River found positive except ground water samples.

		Phase 1		Phase 2	
Sr. No	S. Station	Coliform	Total coliform	Coliform	Total coliform
1	M	+	+	+	+
2	MC	+	+	+	+
3	GS	–	–	–	–
4	RS	+	+	+	+
5	WS	+	+	+	+

Table 4: Reference dose for different metals [17, 28]

Sr. No.	Element	RfD mg/kg/day
1	Cu	0.04
2	Fe	0.3
3	Mn	0.02
4	Ni	0.02
5	As	0.0003
6	Cd	0.0005
7	Co	0.003
8	Zn	0.3

Table 5: Maximum values of carcinogenic Health Quotient

	Cancer Risk As	Phase # 1	Phase # 2
Sr. No	S. Station	BW 70 HQ	
1	M1	4.29E-04	1.07E-03
2	M2	4.29E-04	NC
3	MC1	4.29E-04	1.07E-03
4	MC2	2.14E-03	2.14E-04
5	GS1	4.29E-03	0.00E+00
6	RS1	2.14E-03	2.14E-03
7	WS1	4.29E-04	2.14E-04

Table 6: Dermal Reference dose for different metals [18] RfD [dermal] µg/kg/day

Sr. No	Element	RfD mg/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
7	Co	0.003
8	Zn	0.3

(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 found more than Kohistan region north Pakistan surface drinking water contaminated with As had ADD values ranged from (0.00mg/kg-d to 5.61E_05 mg kg^{-1} day$^{-1)}$ while the people who consumed groundwater had ADD values ranged from (5.50E_07 - 4.64E_04 mg kg_1 day_1) by S. Muhammad et al [2010] which reflects area wise variations in average daily dose of Arsenic and impact on local communities and involvement of contamination in water drinking sources. Health concerns and chronic impact on local drinking water of communities by the Co Health Quotient of Manchur and its regulators is as in phase 1 as min value found less than one HQ in all samples which is safe but max value found insignificant means more than one HQ in all samples. In phase 2 minimum and maximum values had found more than one HQ in all samples which shows more health concerns in phase 2 than phase 1.

ADD in phase 1 and 2 is minimum (8.63E-03mg kg^{-1} day^{-1} - 5.56E-03mg kg^{-1} day^{-1} and maximum 1.24E-02mg kg^{-1} day^{-1}- 1.01E-02mg kg^{-1} day^{-1}) phase wise respectively found, Health impact of drinking water of district Jamshoro by the nickel contamination exposure had variations with respective sources. In Manchur Lake and its regulators is less than one HQ found in phase 1 and 2 which is a significant and ADD minimum (3.00E-04mg kg^{-1} day^{-1} - 1.65E-03mg kg^{-1} day^{-1}, maximum 3.66E-03mg kg^{-1} day^{-1} - 1.49E-02mg kg^{-1} day^{-1}) with respect to both phases, Zn HQ of Manchur 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 and ADD minimum (8.57E-04mg kg^{-1} day^{-1} - 9.14E-04mg kg^{-1} day^{-1} and maximum 1.11E-03mg kg^{-1} day^{-1} - 7.55E-02mg kg^{-1} day^{-1}) had found in phase 1 and 2, respectively.

Cadmium potential chronic health impacts from the samples of Manchur lake and its regulators is below the < 1 HQ which is a significant sign in both phases except maximum value of phase 2 as HQ more than one reflects contamination with potential health concerns and ADD minimum and maximum in phase 1 is zero and phase 2 minimum (4.00E-03mg kg^{-1} day^{-1} and maximum is 1.01E-02mg kg^{-1} day^{-1}). Chronic health impact of copper from the Manchur and with its regulator samples is less than one HQ found which is a significant in both phases and ADD minimum (0.00E+00mg kg^{-1} day^{-1} - 0.00E+00mg kg^{-1} day^{-1} and maximum 9.14E-04mg kg^{-1} day^{-1} - 0.00E+00mg kg^{-1} day^{-1}) in phase 1 and phase 2, Mn Potential Chronic Health Impact on the drinking water consumers of all the sources, Manchur lake with outlets, river, water supply schemes, ground water samples found in significant range HQ less than one showed safe for drinking but in phase 2 maximum values of all the sources found insignificant reflects phase variation health impact on the drinking water communities of Mn contamination.

Average daily dose of all the type of sources identified zero in phase 1 but in phase 2 is as minimum and maximum Manchur with outlets (7.91E-02mg kg^{-1} day^{-1} - 3.43E-02mg kg^{-1} day^{-1}), Health Quotient of Iron in all type of sample sources Found as a < 1 HQ which is a significant in phase 1 as well as phase 2 except phase 2 maximum values which is insignificant. like other parameters health concern HQ of phase 2 found more (insignificant) in samples 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, Manchur Lake and Regulators 6.29E-03mg kg^{-1} day^{-1} - 6.51E-02mg kg^{-1} day^{-1}Average daily dose.

Chronic health impacts of trace and toxic metals on dermal a measured by USEPA Recommended formula **Table 7**. Dermal health quotient of all the type of sources in **Table 8** all samples with respect to different metal found less than one HQ means no any dermal carcinogenic risk assisted. The findings of this study are found in agreement with the previous studies of [Wu et al. 2009] and [36] reported that HQ dermal found lower than the HQ oral and HQs dermal of trace metals in drinking water were lower than unity, suggesting that these pollutants could pose minimum hazard to local residents in Nanjing, China and Karachi, Pakistan.

Conclusion
Our study revealed the impact of effluents on drinking water of community in flood season as well as in dry season. Dry season found more hazardous or contaminated season in sense of metal load and other parameters on the community those are using it for drinking purpose. It was observed that the drinking water sources which are closer to Lake have more impact of effluents like ground source, Manchur/River Link and closer water supply scheme. Manchur lake contamination is found to be decreased in phase 2 than phase 1 (Flood season) except arsenic and few samples of cobalt, river water, water supply schemes, ground water samples have been found more contaminated in phase 2 than phase 1(may be due to Aral Wah regulator was open during this season), arsenic, cadmium, zinc, copper, iron and nickel presence has been found randomly in sample sources with more concentration in phase 2. It showed HQ

ingestion found more as health concern, especially in phase 2 due to short fresh water flow in river and effect of lake pollutants, home sewerages and others. Carcinogenic potential health concern risk of arsenic have been found positive in all the samples with respect to phase wise, HQ As found HQ indicate low or no effect, average daily dose (ADD) of arsenic (As) in this study reported lower than Vietnam, Bangladesh and more than Kohistan region north Pakistan. Bangladesh and Vietnam Carcinogenic Risk (CR) index found lower than those reported in this study, which also reflects the area wise burden of contamination, bacteriological contamination found in both phases positively except ground sources have observed more causing factor in children diseases.

Table 7: Phase wise comparison of Dermal Health Quotient Maximum values of Different metals

Phase 1	Dermal HQ						
S. Station	Cu	Cd	As	Mn	Ni	Zn	Fe
M1	0.00E+00	0.00E+00	3.64E-04	0	5.80E-06	5.80E-05	8.00E-06
M2	3.98E-07	0.00E+00	3.64E-04	4.00E-07	2.80E-06	4.50E-05	8.00E-06
MC1	0.00E+00	0.00E+00	3.64E-04	0	1.40E-06	3.70E-05	8.00E-06
MC2	0.00E+00	0.00E+00	1.82E-03	0	0	3.70E-05	7.00E-07
GS1	0.00E+00	4.16E-04	3.64E-03	0	0	1.04E-04	2.164E-05
RS1	0.00E+00	0.00E+00	1.82E-03	0	0	0	5.137E-07
WS1	0.00E+00	0.00E+00	3.64E-04	0	0	1.193E-05	2.983E-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
M2	NC	NC	NC	NC	NC	NC	NC
MC1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.77E-05	1.82E-03
MC2	0.00E+00	2.30E-03	9.09E-04	0	6.40E-07	1.63E-04	1.50E-05
GS1	0.00E+00	1.67E-03	3.64E-03	0	1.127E-06	7.74E-04	1.989E-07
RS1	9.20E-07	0.00E+00	1.82E-04	0	5.778E-06	4.46E-04	1.066E-06
WS1	0.00E+00	1.20E-03	1.82E-04	1.229E-05	3.535E-06	3.29E-03	1.226E-07

Table 8: Phase wise min and max values of chronic health Quotient and average daily dose of different metals

		Phase # 1		Phase # 2		Phase # 1		Phase # 2	
		BW 70 HQ				BW 70 ADD mg/kg-d			
S. No	Metals	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
1	As	9.52E+00	9.52E-01	9.52E+00	4.76E-01	1.43E-03	2.86E-04	2.86E-03	7.14E-04
2	CO	4.31E+00	8.95E-01	4.66E+00	4.10E-01	1.29E-02	8.63E-03	1.01E-02	9.57E-03
3	Zn	2.38E-03	7.62E-04	2.10E-01	3.05E-03	2.00E-03	8.57E-04	1.48E-02	9.14E-04
4	Cu	0.00E+00	9.14E-02	0.00E+00	2.11E-01	0.00E+00	9.14E-04	0.00E+00	2.11E-03
5	Fe	6.22E-01	8.57E-03	2.41E-01	9.21E-01	1.87E-01	4.43E-03	1.33E-01	9.19E-03
6	Ni	1.83E-01	1.50E-02	1.51E-01	8.27E-02	3.66E-03	3.00E-04	1.11E-02	8.63E-03
7	Cd	0.00E+00	1.45E+00	2.02E+01	7.40E+00	0.00E+00	7.25E-04	1.01E-02	6.75E-03
8	Mn	0.00E+00	0.00E+00	3.95E+00	1.71E+00	0.00E+00	0.00E+00	3.43E-02	7.91E-02

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