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Physio-Chemical Parameters of Waste water and Ground water in District Faisalabad-Pakistan

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Objective: The aim of this cross-sectional study was to assess the physio-chemical parameters and the selected heavy metal concentrations among the selected industrial waste water and drinking ground water sources in Faisalabad, Pakistan. **Methods:** After ethical approval from the University Ethical Review Committee; sixty (n=60) samples were collected both from the industrial waste water effluents and fifteen (n=15) from the nearby drinking ground water sources. All the samples were collected analyzed for the selected physio-chemical parameters of PH, TDS, EC, Na, K, Ca, Mg, Cl, and F; and for the selected heavy metals of Zn, Fe, Pb, Ni, Cr, Cu, Mn and As. Finally, data was analyzed and presented in form of tables. **Results:** All the waste water samples and drinking ground water samples had increased concentration of all the selected physio-chemical parameters and the selected heavy metal concentrations, according to WHO & Pakistan EPA permissible exposure limits level guidelines. **Conclusion:** From the results it was concluded that the selected physio-chemical parameters and the selected heavy metal concentrations in waste water samples and drinking water samples were high as compared to the national and international permissible exposure limits. Moreover, the local industries resulted in contamination of drinking groundwater sources.

Keywords: Physio-Chemical **(Non-MeSH),** Waste Water **(MeSH),** Underground Water (**MeSH),** Heavy Metals **(MeSH),** WHO **(MeSH),** Pak-EPA **(Non-MeSH)**

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INTRODUCTION

Globally, the discharged wastewater is considered as the main determinants of water pollution and in most of the developing countries can produce up to 30–70 mm3 of wastewater per person per year [1]. In most of the circumstances the waste water is not completely treated and thus resulting a high risk for the people who rely on such water shed bodies and thus proves detrimental. Owing to lack of or improper wastewater treatment facilities, wastewater and its effluents are often discharged into surface water sources, which are receptacles for domestic and industrial wastes, resulting to pollution [2].

Many studies had found that improperly treated waste water proves hazardous and has impacts on the physio-chemical characteristics and poses a health risk to several communities who are using these sources for domestic purposes [2-3]. Moreover, over population and industrialization are the prime reason for water shortage [4]. The source of drinking water for people of Pakistan is from ground water and surface water as lakes, reservoirs and rivers etc. Our natural resources are polluting because of runoffs from agricultural land. These runoffs contain different toxic chemicals which seep down into the fresh water reservoirs and cause high impact on ground water [5]. Study revealed that sewage sludge composed of various metals which may enter into the groundwater and the concentration of these metals are much higher in sludge than the ground water. But persistent discharge can drop the water and soil quality [6-7]. Sewage waste water irrigation cause changes in physical and chemical properties of soil like salt solubility and alkalinity [8].

Sewage water discharge into the soil cause long term contamination of ground water. Heavy metal from sewage water discharge enters into the soil and seep down into the ground water. It may include multiple metal contaminants like Pb, Cu, Zn, Ni, Cd, Mn, Cr, As [9]. Heavy metals found in ground water pose serious health threats to human. Higher concentration of cadmium and lead found in ground water causes serious health threats and potential non-carcinogenic risks to humans [10]. Heavy metal accumulates in water bodies due to various physical and chemical phenomenon [11]. A study was conducted in Cairo on Hydro chemical assessments of surface Nile water and ground water in an industry area, and revealed that ground water was not suitable for drinking and even need treatment prior to use for irrigation [12]. Heavy metals pose serious threats to human health. It has been found that miscarriages and stillbirth rate increase in women who were exposed to heavy metal like mercury, arsenic, lead, chromium and cadmium [13]. Tube well water of Punjab, Pakistan contaminated with various anions and heavy metals including Fe, Cr, Pb, Na^+, HCO_3, SO_4^{2-}, and As as an international study results clearly revealed that contaminated ground water posing serious human health threats [14].

Pakistan being a developing country and its industrial sector is expanding. Due to industrialization, the prevalence of environmental and occupational hazards were on rise and thus poses great risk to the population, thus this study was carried out in Faisalabad, Pakistan; to study the physio-chemical characteristics of waste water and underground water sources and industrial effluents and to compare it with water quality parameters of Pak-EPA and WHO guidelines.

MATERIALS &METHODS

After taking approval from the Ethical Review Committee of Bahria University Islamabad, Pakistan; the Department of Earth & Environmental Sciences, across sectional comparative study was conducted in the main city of Faisalabad Pakistan, from March to September 2018; in which a total of n=75 samples, were collected from the selected industrial sites and the adjacent drinking water sources. Initially, n=60 waste water samples were collected from six points of industries i.e. Inlet, Sedimentation Tank, Biological Tank, Outlet and External Drains. Moreover, then for comparison, n=15 samples were collected from the available drinking water sources i.e. hand pumps, tube wells, motor pumps and pressure pumps. All the n=75 samples were analyzed for physio-chemical parameters of PH, TDS, EC, Na, K, Ca, Mg, Cl, and F; and heavy metal parameters of Zn, Fe, Pb, Ni, Cr, Cu, Mn and As. The measurements of TDS in water samples were carried

out according to the standard methods of APHA and Ukah BU et al., 2018 by the filtration process. The TDS of the water samples were determined by the gravimetric method, in which the filtrate was heated in oven at above 100°C, till complete evaporation of water and then the residue revealed the TDS concentrations [15-16]. Chemical analysis includes the on-site analysis (pH, turbidity, and conductivity) and in-laboratory analysis (TDS and TSS). For the analyses of selected heavy metals such as Zn, Fe, Pb, Ni, Cr, Cu, Mn and As were carried out based on ASTM standards using Flame Atomic Absorption Spectrometer [17]. Finally, data was analyzed and presented in form of tables.

RESULTS

The physic-chemical analysis of waste water samples (n=60), Faisalabad, Pakistan; was shown in Table I. The heavy metals concentrations of wastewater samples (n=60) Faisalabad, Pakistan; was shown in Table II. The Physio-chemical Analysis of drinking ground water samples (n=15) Faisalabad, Pakistan; was shown in Table III; and the Heavy Metals Concentration in Drinking Water Samples (n=15), Faisalabad, Pakistan; was shown in Table IV.

Location	PH	TDS (mg/l)	EC (µs/cms)	Na	K	Ca	Mg	Cl^-	F^-
Inlet	11.12	4750	3.16	479	56	138	3.56	659.37	14.7
Sedimentation Tank (a)	11	4650	3	472	57	150	3.59	581.38	13.1
Sedimentation Tank (b)	10.53	3980	2.85	419	54	135	4.17	545.93	12.9
Biological Tank	5.4	3780	2.92	418	53	127	4.19	723.18	13.5
Outlet	5.7	3460	3.02	425	54	117	4.02	581.38	15
Drain	11.21	5325	3.6	619	57	31.7	2.9	1106.04	25
NEQS	6-8.5	3500	ND	ND	ND	ND	ND	1000	10

Table I. Physio-Chemical Concentrations of Wastewater Samples (n=60), Faisalabad, Pakistan

TDS = Total dissolved Solids, EC= Electrical conductivity Na = Sodium, K = Potassium,
Ca = Calcium, Mg = Magnesium, Cl = Chloride, F= Fluoride,
NEQs= National Environmental Quality Standard

Location	Concentrations (mg/L)							
	Zn	Fe	Pb	Ni	Cr	Cu	Mn	As
Inlet	0.27	2.88	1.5	2.5	1.47	3.56	4.09	3.98
Sedimentation Tank (a)	0.22	2.43	1.04	2.09	1.43	3.59	4.31	3.1

Sedimentation Tank (b)	0.17	2.21	1.21	2.04	1.43	4.17	4.37	3.21
Biological Tank	0.18	2.08	1.25	2.04	1.42	4.19	4.6	2.9
Outlet	0.59	2.08	1.04	2.05	1.4	4.02	4.5	4.79
Drain	2.09	1.4	0.8	1.5	1.3	2.9	4.05	6.22
Pak-EPA	**5**	**2**	**0.5**	**1**	**1**	**1**	**1.5**	**1**

Table II. Heavy Metals Concentrations of Wastewater Samples (n=60) Faisalabad, Pakistan

Zn = Zinc, Fe= Iron, Pb= Lead, Ni= Nickel,
Cr= Chromium, Cu= Copper, Mn= Manganese, As= Arsenic

Location			**Concentration (mg/L)**											
	PH		**TDS**		**Na**		**K**		**Ca**		**Cl^-**		**F^-**	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Hand Pump	6.5	6.9	2880	3740	617	830	55	440	147	3750	794	1290	3.5	4.9
Tube Well	6.7	7.1	460	3790	60	800	8	350	27	3520	113.4	1305	3.7	5.2
Motor Pump	6.5	6.9	3070	3640	635	704	46	72	144	244	375.7	1361	4.1	5
Pressure Pump	6.6	6.8	3160	3810	674	740	65	77	171	203	1035	1312	4.3	4.5
WHO Limits	**6.5-8.5**		**<1000**		**200**		**12**		**75**		**250**		**1.5**	

Table III. Physio-chemical Analysis of Ground Water Samples (n=15) Faisalabad, Pakistan

TDS = Total dissolved Solids, Na = Sodium, K = Potassium, Ca = Calcium,
Mg = Magnesium, Cl = Chloride, F= Fluoride

Location	**Concentration (mg/L)**													
	Zn		**Fe**		**Pb**		**Ni**		**Cr**		**Cu**		**Mn**	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max	Min.	Max.	Min.	Max.

Hand Pump	0.03	0.09	0.06	0.81	0.01	0.08	0.01	0.4	0.13	0.47	1	5	0.12	0.95
Tube Well	0.02	0.14	0.01	0.13	0	0.09	0.01	0.03	0.01	0.04	0.5	1.1	0.02	0.4
Motor Pump	0.01	0.4	0.12	0.81	0.01	0.2	0.01	0.08	0.25	0.44	0.95	5	0.05	1
Dug Well	0.01	0.05	0.45	0.92	0.04	0.12	0.01	0.08	0.31	0.4	2.5	5	0.03	0.23
WHO Limits	**3**		**0.3**		**0.01**		**0.02**		**0.05**		**2**		**0.5**	

Table IV. 4. Heavy Metals Concentration in Drinking Water Samples (n=15), Faisalabad, Pakistan

Zn = Zinc, Fe= Iron, Pb= Lead, Ni= Nickel,
Cr= Chromium, Cu= Copper, Mn= Manganese, As= Arsenic

DISCUSSION

Our study results showed that the pH of waste water gradually reduces throughout process and found within permissible limit provided by Pak EPA i.e. 6-8.5. In outlet TDS reduces to 3460 while EC increased by 3.02. Comparing with EPA standards it was found that TDS of water moving out of outlet within permissible limits i.e. 3500 mg/L while there were no standards provided for EC of waste water. In our research study, so many physical and chemical parameters were identified as was reported by an international study showing that the waste water had more than 132 types of different chemicals [18]. According to an international research study, it was found that the PH, TDS and electrical conductivity of the waste water samples was increased as was verified by our research study with high concentration of TDS and EC [19].

Chloride and fluoride have significance in our body within certain limit. Results showed that on entering through inlet chloride and fluoride found in concentration of 659 mg/L and 15 mg/L, respectively. These concentrations continue to reduce in sedimentation tank where chloride found 546 mg/L and fluoride found 13 mg/L. Waste water at discharge point had concentration of 581 mg/L and 15mg/L of chloride and fluorides, respectively. The results were then compared with PAK EPA standards; and thus, revealed that throughout the process fluorides concentration high while chlorides concentration was found within permissible limits; as was shown in Table I. Moreover, our study results, found that the concentration of total organic compounds, potassium, NH3, calcium, sodium, nitrogen and Fe were increased in the ground water samples and thus were verified and found in many international studies [20-21].

The concentration of Fe remains same in outlet i.e. 2.08 mg/L while there was considerable increased in concentration of Zn i.e. 0.59, indicating intrusion of contamination from nearby source but the concentration of Zn was very low as compare to EPA PELs of 5.0 mg/L. Pb and Ni found in concentration of 1.5 mg/L and 2.5 mg/L at inlet source and then in sedimentation rank, concentration reduced to 1.04 mg/L and 2.09 mg/L for Pb and Ni respectively. PAK-EPA standards for Pb and Ni are 0.5 mg/L and 1.0 mg/L; and thus, were found higher in concentration than permissible limits. Many national and international studies found high and permissible limits of various heavy metals as was supported and found in our study (Table II),with higher concentrations of Cu, Zn, Cd, Ar, Mn, Pb, Cr, Fe, Mg, Ni and Hg [19, 22-24].

The underground water analysis showed that pH of all samples was found within permissible limits. Total Dissolve Solids (TDS) value for various samples of hand pumps, tube wells, and motor pump were greater than EPA permissible limit i.e. <1000 mg/L. In an international study, published in Journal of Exposure & Health, 2016, reported higher concentrations of Chlorine, calcium, magnesium, and potassium as was revealed in our research findings [21].According to EPA and WHO; Na and K permissible limit; the ground water was highly contaminated with K, Na, and Ca; as was shown in Table III. Moreover, the concentrations of Cl and F were also more than EPA permissible limits of 250 mg/L for Cl and 1.5 mg/L for F. Our study results, found that the concentration of total organic compounds, potassium, NH3, calcium, sodium, nitrogen and Fe were increased in the ground water samples and thus were verified and found in many international studies [20-21].

Zn and Fe concentrations ranged from 0.03 to 0.9 mg//L and 0.06 to 0.81mg/L, respectively. Moreover, the Pb and Ni concentrations were above the permissible exposure limits (PELs) in all samples and thus posed greater risk on human health and environment. The results clearly showed that in ground water sample most of the metals found above the EPA & WHO PELs. Moreover, in open wells, Zn, Cr and Mn were found within permissible limit. Nickel contamination may cause protein disorder affecting human health; as was shown in Table VI. Thus, nickel binds protein may cause allergies and cancer [25,26]. Many national and international studies found high and permissible limits of various heavy metals as was supported and found in our study with higher concentrations of Cu, Zn, Cd, Ar, Mn, Pb, Cr, Fe, Mg, Ni and Hg [19, 23-24]

CONCLUSIONS

It was concluded that selected physio-chemical parameters and heavy metal concentrations in waste water samples and drinking water samples were high as compared to the Pakistan EPA standards and WHO PELs guidelines. Moreover, the local industries resulted in contamination of drinking groundwater sources and thus strict guidelines should be followed regarding industrial waste water treatment and adequate management of their effluents. Furthermore, future studies are required for long-term monitoring of underground water bodies along with awareness and mass education of public regarding water sources utilization.

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