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Research Article

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HEAVY AND TRACE METALS CONTAMINATION IN THE SOIL AND TAP WATER OF QASIMABAD, HYDERABAD, SINDH PAKISTAN

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ABSTRACT

This research intends to analyse the impacts of automobile exhaust pollutants on roadside soil anditscontamination in thewater supply network through faulty rusted pipes ofQasimabad town of Hyderabad City. Qasimabadis recently established in 1988 along the flood plains of River Indus. The results unveilthe causes of contamination and to propose the possible mitigations, the majority ofthe people consume drinking water through theunderground pipe network and tap water was found highly contaminated in the area due to the presence of heavy metals such as cadmium, chromium, iron and lead.

Key Words: Soil, Tap water, Heavy and trace metals

Introduction

The pollution in urban areas in the form of heavy and trace metals contaminate soil and water. This contamination may be the source of several fatal diseases in human beings and animals (Yisaet al., 2011). The term urban means modified ecosystem areas which are the results of human's anthropogenic activities and their settlements. Therefore, the modifications which are characterized to the chemical, biological and physical environments happen because of the large scale construction work (Taylor, 2007). Urban Environment consists of many major components which contribute to the urban sediment cascade and are sourced from a wide range of material. These components include street surfaces, gully pots, sewers, lakes, rivers, docks and canals. The term 'trace metal' refers to the metals that are present in the environment or in the human body in very low concentration, such as copper, iron and zinc, etc. Heavy metals are those metals whose densities are greater than water for five times such as cadmium, lead and mercury, etc. Metals are important to human health in many aspects (Baranowska, 1993),and some metals are essential for good health while their deficiency can cause various diseases (Yisa et al., 2011) . It is reported that metals such as Cobalt (Co), Copper (Cu), Iron (Fe), Nickel (Ni), and Zinc (Zn), are required to perform various functions such as physiological and biochemical functions and are considered as essential nutrients.

Pakistan is also in the list of developing countries. Further, its growing industrial sector accompanied by the rapid growth of road systems has been enhanced. In Pakistan, along with other sources; generally, the vehicles and stationary sources could be the possible sources,responsible for pollution in urban centres. The vehicles like automobiles, trucks, rickshaws, aircrafts run by internal combustion engines emanategaseous, heavy metals in air, road deposited sediments, soil and water. Power generating stations, industrial plants, brick kilns, construction projects are also considered as stationary sources (Khan, 1996).

Hyderabad is the second largest city of Sindh and eighth in Pakistan. It is an old denselypopulated, fast growing commercial city of the province. Its location is on the left side of Indus River. Qasimabad is its taluka and began to established in 1988. Most of the land of Qasimabad lies in flood plains of River Indus. Because of the unplanned establishment and its location in the flood plain of Indus River, may produce certain environmental challenges to the habitants. Besides the rapid growth in the number of vehicles and poor condition of roads which cause traffic jamsfurther deteriorate the surrounding conditions.This research work is designed to find out the heavy and trace metals in the tap water and roadside soil of Qasimabad, Hyderabad. Further, in the light of obtained results to suggest the causes of contamination and to propose the possible mitigations.

Geology, Geography and climate of area: The studied area lies on the east bank of Indus River (Fig. 1). Mostly alluvium,old and new, covers the area by deposition from river and overridden by raised terraces respectfully. The area is relatively flat except in the GanjoTakkar area. This area lies on Laki

Formation (Metting Limestone Member). However,in the southeast, the Ganjo Takar hills form Laki Limestone Member and Meting Shale Member.The studied area is semi-arid region almost with scorching summer and mild winter with scanty rain fall. In summer, the temperature rises up to 40^0 C, with breezy nights. Monsoon prevails from the month of June to September. Rains sometime become heavy and also cause flooding.

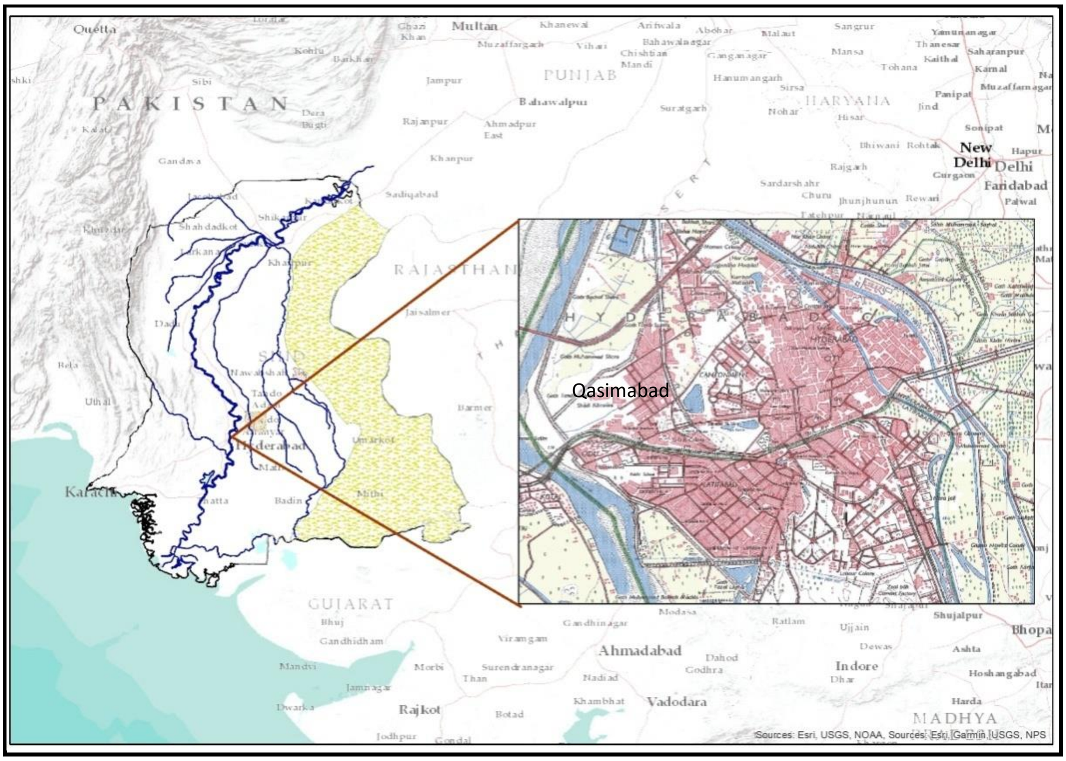
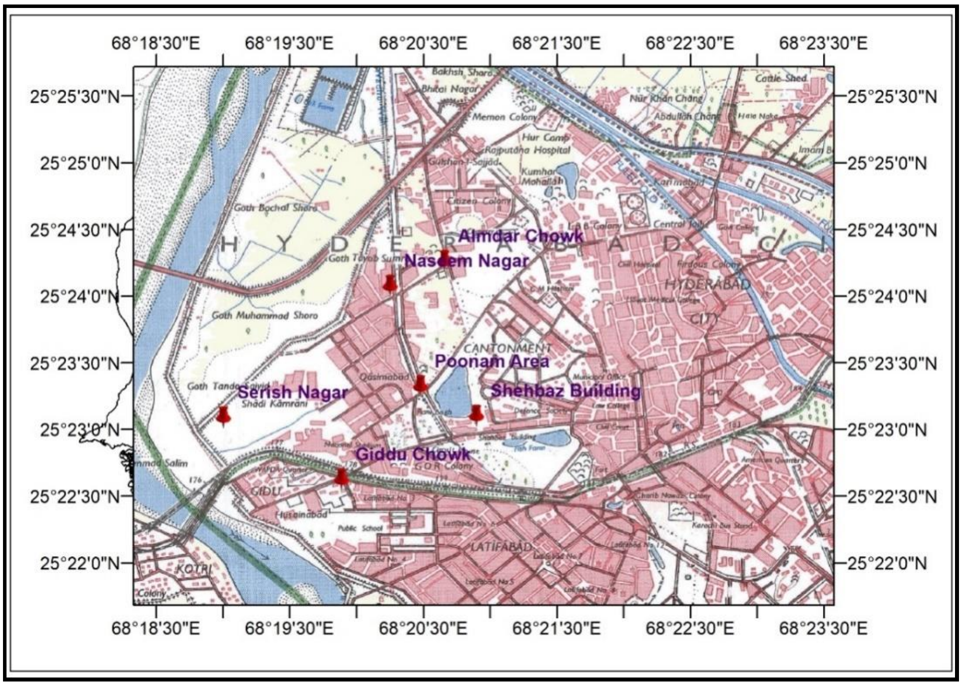


Figure. 1 Qasimabad Location Map (Study Area)

MATERIALS AND METHODS

Tap water and soil samples from six different sections (Naseem Nagar, Alamdar, Poonam, Serish Nagar, Shehbaz building and Giddu chowk) were collected. Water samples were analyzed physically and chemically, and for the determination of heavy and tracemetals,pH, electrical conductivity, total dissolved solids, turbidity,chloride,nitrate, sulphate, calcium, magnesium. Heavy and trace metals including iron, zinc, nickel, cadmium, chromium, cobalt, lead, manganese and copperwere analyzed. All physical and chemical parameters of water samples were analyzed at the Institute of Environmental Engineering & Management, Mehran University of Engineering & Technology, Jamshoro, Sindh. Heavy and trace metals were analyzed by using Atomic Absorption Spectrophotometer at the Hi Tech Resource Laboratory, University of Sindh, Jamshoro. Soil samples were obtained from all studied sites. Each location was dug for two feet from the surface and at a distance of one foot from the metaled road. Soil samples were pulverized to 200 mesh size before dried at 110^0 C for twelve hours. Then they were weighed two grams in porcelain crucible and then heated for four hours at 950^0 C. Glass bottles were used to keep the ignited samples for the determination of heavy and trace metals (iron, zinc, nickel, chromium, cobalt, lead) in the Hi Tech laboratory.

(Fig.2) Soil & Water Sample Location Map



Sample Location

RESULTS

Six heavy and trace metals were analyzed in soil samples (Ni, Pb, Zn, Cr, Co and Fe).In the studied areas, the range of Ni found in the soil samples is between 0.575 to 1.180 ppm, i.e., within the normal range for normal soils (Fig. 3, Table 1).The value of Pb found between 1.5 to 3.5 ppm in all studied sections, which is in the normal limits (Fig. 4, Table 1).The minimum value of Co was found (0.111 ppm) at Giddu chowk while maximum concentration (0.55 ppm) was found at Naseem Nagar (Fig. 5, Table 1).At different locations in Qasimabad area, Cr ranges from 2.612 to 9.506 ppm (Fig. 6, Table 1).From 2.649 to 13.92 ppm values of Zn have been found at different locations in the study area (Fig. 7, Table 1).In the soil samples of studied area, the concentration of Fe varies from 205 to 299 ppm (Fig. 8,Table 1). The values of pH found greater than 8 in all locations, but in Serish Nagar and Poonam area the 8.77 pH and 8.62 values were recorded respectively (Table 2).The highest reading for turbidity was noted at Shehbaz building and Naseem nagar areas with 3.8 and 3 NTU respectively (Table 3). These high values show the presence of large number of sediments in the water.Higher values of TDS were found in Poonam area with 429 and 419 mg/L ranging within the 600 mg/L prescribed by WHO.The maximum limit for electrical conductivity is 1000 us/cm. In studied areas, the maximum limit found in Poonam area which is 670 us/cm (Table 3). WHO guidelines for other parameters such as chloride, nitrate, calcium, magnesium and sulphate are 250 mg/L, 50 mg/L, 150 mg/L, 75 mg/L and 250 mg/L respectively. In studied areas, the values of chloride, nitrate, calcium, magnesium and sulphate were found within the permissible limit.The high concentration of Fe was found in all tap water samples of studied areas. The highest reading was noted at Naseem Nagar with 3.5 ppm, 3 ppm at Alamdar, 2.5 ppm at poonam and Serishnagar (Table 4). Zinc was recorded highest at Giddu with 0.431 ppm and 0.35 ppm from samples taken in March to November respectively. While at Poonam, the concentration of Zn was found 0.371 ppm (Table 4). At Alamdar, the concentration of Ni was found higher with 1.687 ppm (Table 4), while 0.16and 0.159 ppm of Ni was found at Alamdar and Shehbaz building areas respectively (Table 5). The concentration of Cadmium showed the highest values at all studied areas ranging from 0.02 ppm to 0.16 ppmat Naseem nagar and Serishnagar areas respectively (Table 5). Chromium was found within the standard limit only at Giddu chowk area while all areas exceeded the WHO guidelines. The highest values were found at Shehbaz building area with 0.132 ppm and 0.11 ppm (Table 4). The highest reading for cobalt in tap water samples was found with the reading of 0.08 ppm in the Poonam area (Table 4). The highest lead concentration was reported from AlamdarandGiddu areas with 0.376, 0.304 ppm (Table 4) respectively while from Sehrish Nagar area led values are 0.33 ppm (Table 5) . Other locations such as All other areas showed higher concentration of Pb with values of 0.274, 0.239 and 0.181 ppm at Poonam, Shehbaz and Naseem Nagar, Alamdar Chok and Gidduchok showed reltively low values of lead (Table 5).

Table.1 Concentration of heavy metals (ppm) in soil samples at various locations of study area.

Locations	Ni	Pb	Zn	Cr	Co	Fe
Serish Nagar	1.176	1.73	2.649	9.019	0.428	283
Shehbaz Building	0.816	1.6	8.048	4.339	0.454	205
Giddu Chowk	1.229	1.69	11.14	8.382	0.111	299
Poonam Area	0.575	2.18	10.96	6.792	0.420	223
Naseem Nagar	0.939	1.5	12.72	9.506	0.55	277
Alamdar Chowk	1.180	3.5	13.92	2.612	0.511	287

Table 2: Concentration of Physical and Chemical parameters in water samples during March at various locations of study area.

Physio-Chemical Parameters	**Samples of March**											
	Locations											
	NN		**AC**		**SB**		**PP**		**GC**		**SN**	
	1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
pH	8.14	8.23	8.24	8.25	7.79	7.9	8.62	8.7	8.25	8.35	8.77	8.54
E.C(us/cm)	407	420	401	407	426	428	636	640	395	392	430	432
TDS(Mg/L)	260	269	257	260	273	274	407	410	253	251	275	276
Turbidity(NTU)	1.2	1.5	1	1.1	1.6	1.4	2.2	2.1	1.4	1.8	2.5	2.6
Chloride(Mg/L)	35	38	80	82	40	44	35	31	25	22	30	32
Ca(Mg/L)	32	34	44	40	38	34	32	35	34	30	32	30
Mg(Mg/L)	11.52	11.4	11.52	11.42	12.96	12.25	16.56	16.48	11.52	11.5	12.96	12.9
Sulphate(Mg/L)	62.5	64	26	24	80	80.2	64	62	61	60	62	66
Nitrate(Mg/L)	1.786	2.052	1.786	1.282	2.081	2.152	2.376	2.891	1.638	1.624	1.786	1.823

Table 3: Concentration of Physical and Chemical parameters in water samples during November at various locations of study area.

Physio-Chemical Parameters	**Samples of November** **Locations**											
	NN		AC		SB		PP		GC		SN	
	1	2	1	2	1	2	1	2	1	2	1	2
pH	8.22	8.04	7.52	7.61	8.25	8.16	8.12	8.25	8.2	7.87	8.3	8.24
E.C(us/cm)	426	421	408	411	422	430	670	655	371	375	440	446
TDS(Mg/L)	273	269	261	263	270	275	429	419	237	240	282	285
Turbidity(NTU)	3.2	3	1.8	1.9	3.5	3.8	1.6	1.2	1.4	1	1.7	1.8
Chloride(Mg/L)	54	45	30	35	35	40	70	85	36	35	38	40
Ca(Mg/L)	30	32	34	32	34	36	44	46	30	32	32	36
Mg(Mg/L)	11.52	10.34	15.84	15.3	13.68	13.5	11.52	11.5	12.24	12.22	11.52	11.5
Sulphate(Mg/L)	62.6	66.4	63.4	63.3	70	68.2	116	111.6	76	77.1	66	68
Nitrate(Mg/L)	17.119	17.138	1.62	1.786	5.112	5.033	2.384	2.229	1.824	1.786	2.426	2.081

Table 4: Concentration of heavy metals (ppm) in water samples at various locations of study area.

Physio-Chemical Parameters	**Samples of March**											
	Locations											
	NN		AC		SB		PP		GC		SN	
	1	2	1	2	1	2	1	2	1	2	1	2
Fe (0.3)	3.52	3.42	1	1.6	1.76	1.52	2.54	2.5	1	1.4	1.33	1.25
Zn (3)	0.09	0.07	0.231	0.2	0.25	0.24	0.37	0.3	0.35	0.22	0.08	0.07
Cu (2)	BDL	BDL	0.328	0.32	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mn (0.05)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Ni (0.02)	1.68	1.53	BDL	BDL	0.04	0.03	0.01	BDL	BDL	BDL	BDL	BDL
Cd (0.003)	0.166	0.16	0.049	0.051	0.03	0.04	0.07	0.07	0.08	0.08	0.05	0.05
Cr (0.05)	0.081	0.083	0.056	0.058	0.13	0.13	0.1	0.1	0.03	0.02	0.07	0.07
Co (00)	0.05	0.054	0.07	0.065	0.07	0.07	0.08	0.08	0.06	0.06	0.06	0.06
Pb (0.01)	0.086	0.08	0.376	0.371	0.24	0.24	0.27	0.27	0.3	0.3	0.29	0.27

Table 5: Concentration of heavy metals (ppm) in water samples at various locations of study area.

Physio-Chemical Parameters	**Samples of November**											
	Locations											
	NN		AC		SB		PP		GC		SN	
	1	2	1	2	1	2	1	2	1	2	1	2
Fe (0.3)	0.8	0.9	3.3	3	0.47	0.67	0.3	0.44	0.6	0.8	2.51	2.54
Zn (3)	0.2	0.05	0.05	0.04	0.13	0.13	0.15	0.12	0.43	0.43	0.08	0.08
Cu (2)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mn (0.05)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Ni (0.02)	0.05	0.05	0.12	0.16	0.11	0.15	BDL	BDL	BDL	BDL	BDL	BDL
Cd (0.003)	0.16	0.16	0.05	0.05	0.06	0.06	0.06	0.06	0.03	0.03	0.02	0.025
Cr (0.05)	0.08	0.08	0.05	0.06	0.1	0.11	0.06	0.06	0.04	0.05	0.08	0.089
Co (00)	0.03	0.04	0.06	0.06	0.04	0.04	0.05	0.06	0.12	0.15	0.02	0.014
Pb (0.01)	0.18	0.18	0.07	0.07	0.12	0.12	0.27	0.27	0.04	0.03	0.32	0.33

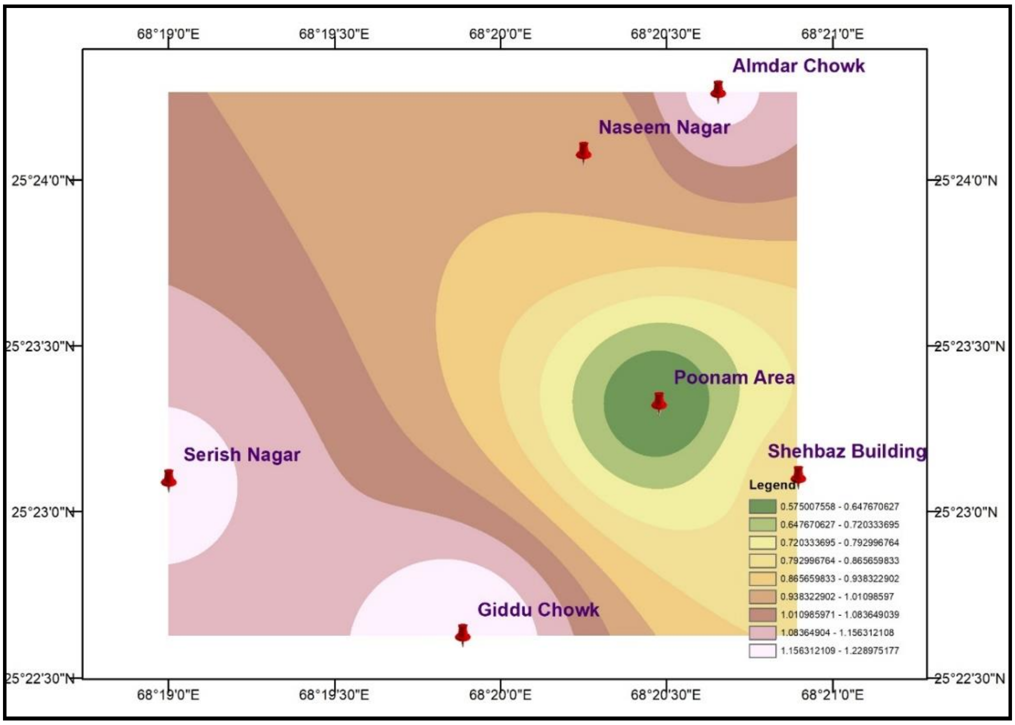


Figure. 3. Showing the concentration of Ni in soil samples

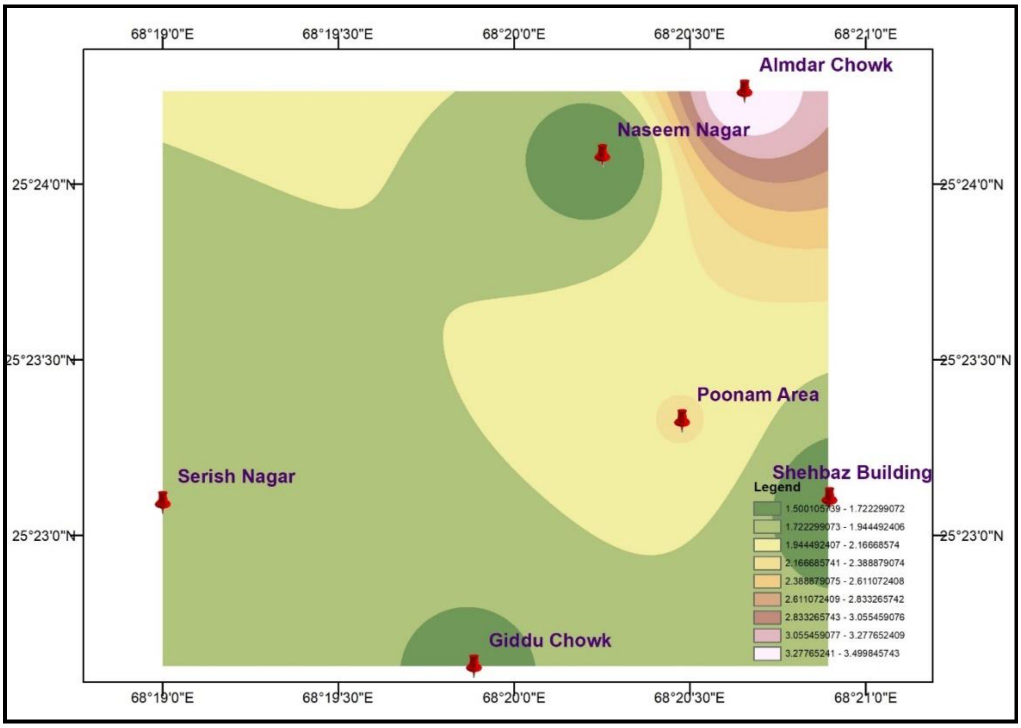


Figure. 4. Showing the concentration of Pb in soil samples)

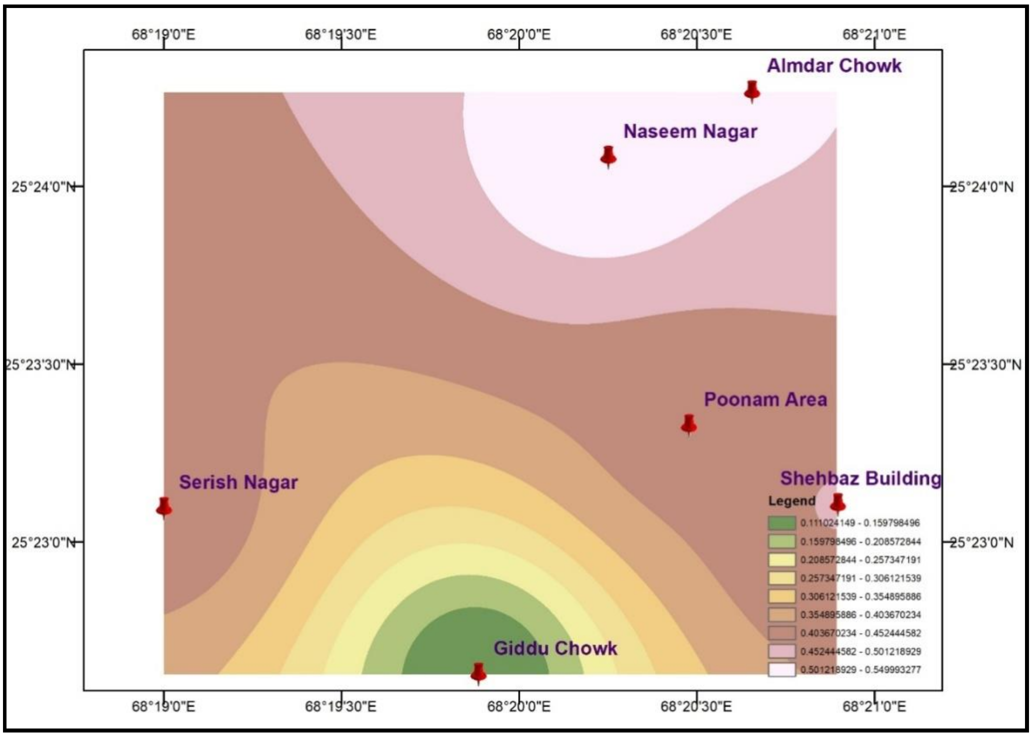


Figure. 5 Showing the concentration of Co in soil samples

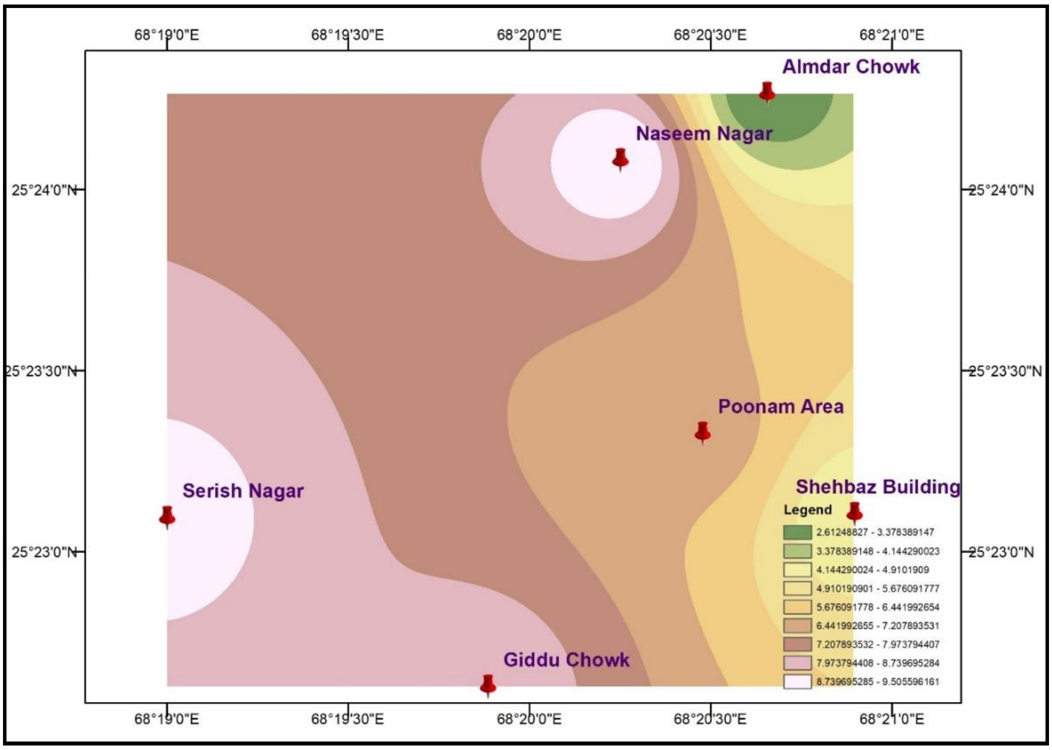


Figure. 6. Showing the concentration of Cr in soil samples

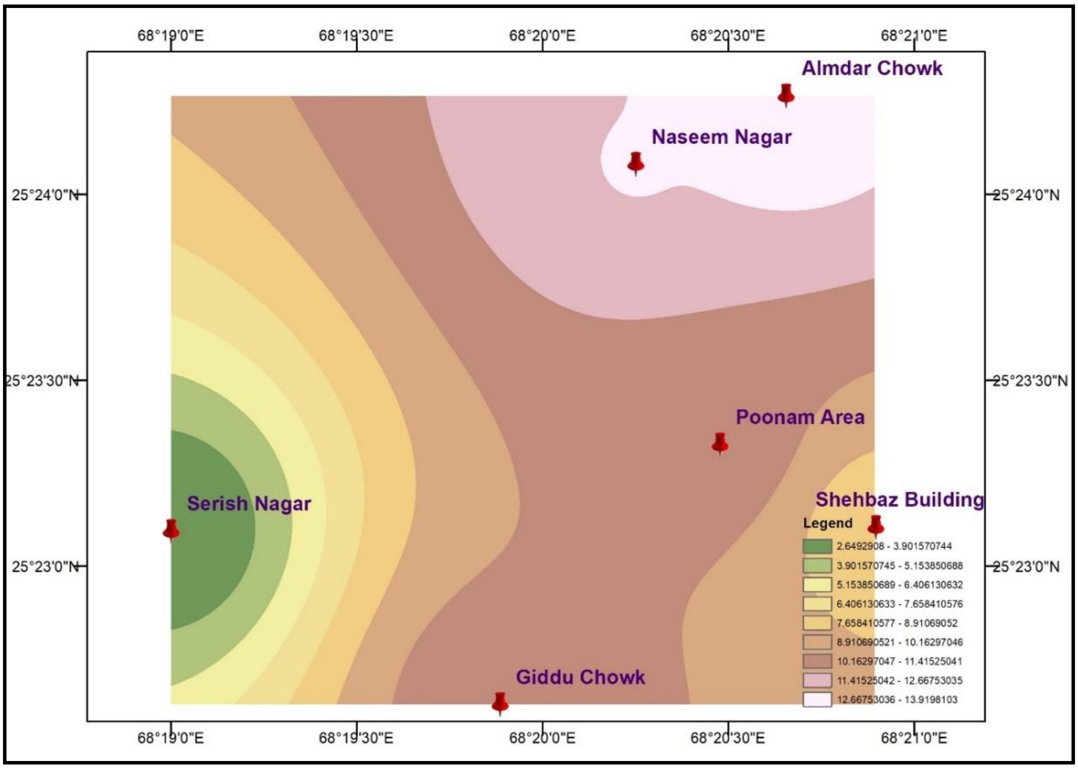


Figure. 7. Showing the concentration of Zn in soil samples)

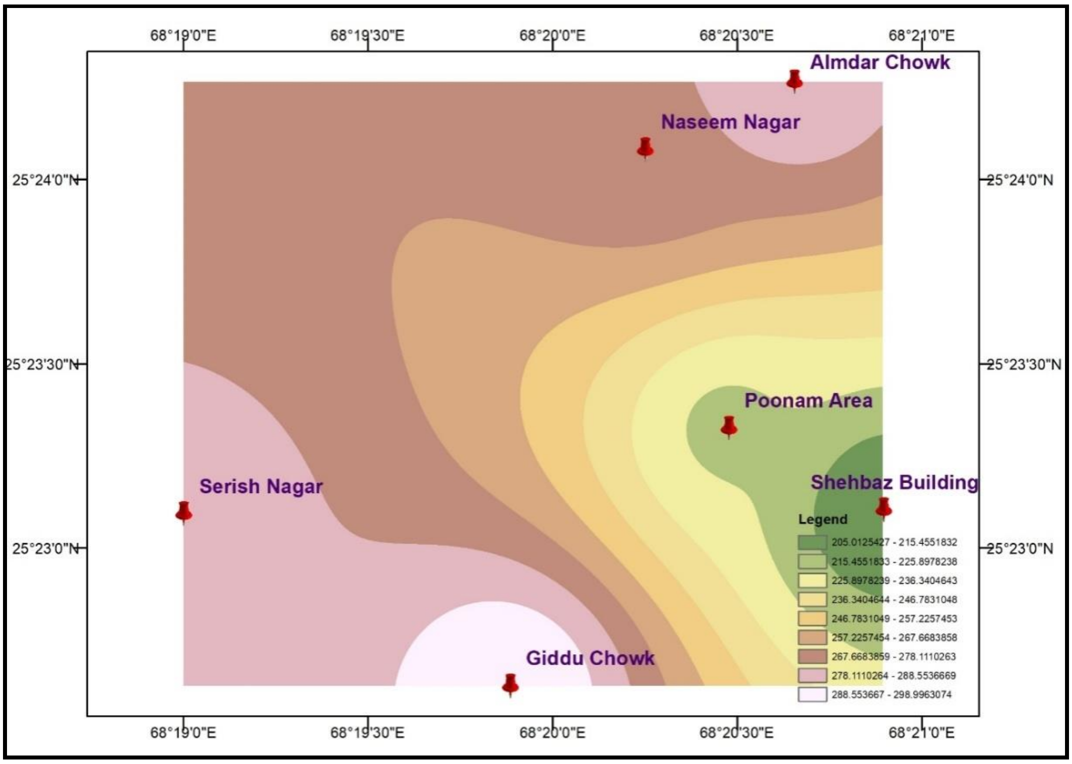


Figure. 8. Showing the concentration of Fe in soil samples

DISCUSSION

The concentration of Ni in soil depends upon several factors including soil's parent materials. Usually alluvial horizons are rich in Ni concentrations. Normal range of Ni in natural soils is 3 to 1000 ppm (Cempel and Nikel, 2006). Pb normally ranges from 2 to 300 ppm in normal soils (Hindarwati and Soeprobowati, 2018). The values of cobalt vary with respect of type of soil. For example, the soil formed from acidic rocks, sandstone, and limestone is devoid of Co whereas the soil derived from ultrabasic rock is rich of Co (Nascimento et al., 2022). Mineralized zones yield high values of Co up to 1000 ppm. Soils formed from different types of rocks show different values of Cr. Along with Co, the values of Cr become higher in soils which are formed by igneous rocks particularyultrabmafic (Nascimento et al., 2022). However, chromite is the principal mineral source of Cr (Garnier et al., 2009; Hseu and Iizuka, 2013). The average content of Cr in soils worldwide is around 84 ppm (McGrath, 1995).

Zn is the second most commonly found metal, after Fe. Natural Zn concentrations in soil range from 10 to 300 ppm, with an average of 50 ppm (Kaur et al., 2023a). It is an important plant micronutrient that is required for numerous physiological activities (Kaur et al., 2023a). Zn is an important micronutrient that is eventually liberated during mineral weathering (Opfergelt et al., 2017). Zinc is an essential micronutrient engaged in key activities such as photosynthesis (Frassinetti et al., 2006).

Iron is the most frequent metal in the lithosphere and a scarce resource for most plant species. However, it is the fourth most abundant element in soil (Porkodi et al., 2023). Hematite, or ferric oxide is the most common type of iron in soil. It gives soil a reddish hue and is insoluble. Soils having Fe contents below 3.5 ppm are considered Fe-deficient (Porkodi et al., 2023).

The analyzed physical and chemical parameters for water samples were pH, Electrical conductivity, Total dissolved soilds, turbidity, chloride, nitrate, calcium, magnesium, sulphate. The guidelines of these parameters are determined by World Health Organization. Some parameters were not found satisfactory when compared with WHO limits. WHO guidelines for pH of water are from 6.5 to 8.5.Water with high pH may be responsible for the corrosion of metallic pipes and can carry heavy metals along with it. Exceeding values of pH may cause stomach disorder, swelling of hair fibers, and skin problems (Dewangan et al., 2023).Turbidity is generally caused by the suspended and colloidal particles which are responsible for the obstruction of transmission of light through water. It is a measure of relative clarity and cloudiness of water. The WHO guidelines for turbidity are less than 1 NTU. However, Environmental Protection Agency of Pakistan suggests the value for turbidity may not exceed 5 NTU. The results of collected samples show much higher values even upto 3 NTU. Out of twelve samples, almost all samples were found above the WHO limits.Water with high turbidity may lead to the rejection of drinking water by the consumers. High total dissolved solids (TDS) can change the taste of water and may cause excessive scaling in pipes, heating units and boilers. Cadmium occurs in coal, petroleum and in combination with Zinc in low concentration in most rocks. From industrial point of view, it is present in nickel cadmium batteries, photography, paint, fertilizers, pigment, corrosion of galvanized pipe and sewage sludge disposal. Cadmium may cause cancer and is related with cardiovascular diseases. Also it is responsible for bone, lung and renal diseases. In low dose, it can cause vomiting, coughing, headaches. Cadmium may enter human body by inhalation and ingestion. In inhalation form, it is more toxic and its major source is tobaccosmoke (Ganguly et al., 2018). In the studied areas, the concentration of cadmium in tap water samples was found above the WHO standard guidelines. It is a matter of serious concern to the population of that area.The tap water of the area poses a potential threat because the concentration of chromium is found higher almost in all areas (Table 3 and 4). Some metals are essential for human to sustain life while other metals like cobalt, iron, copper, zinc, manganese, etc are needed at low levels by human body to function properly. Some metals are dangerous for the health of people like chromium, lead, cadmium (Balali-Mood et al.,2021). Metals in water supply may be the result of anthropogenic activities or may occur naturally. Naturally occurring metals are dissolved in water when it comes into contact with rock or soil material. Metals may enter into water from industrial wastes, poor sewage system, agriculture activities, corrosion of pipes and leakage from waste disposal sites. It is very alarming that high concentration of Pb was found in tap water samples almost in all areas of Qasimabad. As most of the lead which enters in human body in many ways like in the form of inhalation of dust from lead paints, waste gases from gasoline, various foods, and old homes containing lead water pipes. Contaminated drinking water is removed in urine but in children there is a risk of Pb buildup. The after effects of lead consumption may damage to the central nervous system, brain and liver, cardiovascular dysfunction (Wang et al.,2013). Other damages may be memory and concentration problems, Lungs dysfunction, Anemia and reduced pulmonary function and digestive problems. New study reveals the link of lead with crime and anti-social behavior in children (Unnisa and Rao, 2011). At Naseem Nagar, the concentration of Ni was found higher with 1.687 ppm. The occurrence of Ni in drinking water may be due to the industrial source and agriculture activities. It is considered as an essential trace metal but its high dose may damage human health. Its detrimental effect is hair loss and it is also carcinogenic. Its study on rats and dogs showed their weight reduction (Saeed and Attaullah, 2014). It is also a serious concern that high concentration of iron, chromium and cadmium were found at many locations.

The findings of alarming presence of heavy metals in tap water from the studied area can be taken as a reference to the concerned policy makers and the administrative institutions to take inititatives for the safe and clean water supply system to the inhabitants which is their basic right.

CONCLUSION

The soil in the Qasimabad area was found non-contaminated with respect to heavy metals. The area is mostly commercial and residential and there is less agricultural activity in the area. This may be the main reason for non-contamination of soil. The area contains very poor drainage system and during rains this system seems totally ineffective. The condition of the said drainage system may infiltrate the tap water system lines wherever they may be broken and contaminate the tap water. Majority of people in the area rely on tap pipe water system to satisfy their water thirst. Tap water was found highly contaminated in the area.

AUTHORS CONTRIBUTION

Kashif Ahmed Memon proposed the main concept and was involved in field activity and write-up. Muhammad Hassan Agheem assisted in establishing and supervising the research methodology. Ghulam Mustafa Thebo handled the writing and editing of the manuscript. Muhammad Ali Solangi assisted in constructing diagrams. Javed Ali Kalhoro, provision of relevant literature Shahid Ali Shaikh helped in the discussion. Zainab Ursani helped in field data collection.

CONFLICT OF AUTHORS

The authors declare no any conflict of intrest regarding the publication of this manuscript.

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