IMPACT ASSESSMENT OF SEWERAGE DRAINS ON GROUNDWATER QUALITY OF FAISALABAD, PAKISTAN. A PHYSIO-CHEMICAL ANALYSIS

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ABSTRACT: Waste water of the second biggest industrial and the third largest populated city Faisalabad was mostly discharged directly in small drains located within the city. This waste water was always not properly treated and directly approached the main drain flowing away from main city. So the impact of disorganized drainage system on groundwater was understandable. Water samples (n=40) were collected from five drains of city randomly and analyzed to check contamination level ofMg, Pb, Cr, Cd, Ni, Fe, Zn, Ca, and Cu. Physical parameters including temperature and Electrical Conductivity (Ec) and pH were recorded. The spatial patterns of study area were computed using inverse distance weighted(IDW) technique of visual interpretation. The results were compared with PEPA and WHO drinking water quality standards. Consequences indicated higher trends of pollution for some physiochemical parameters including Electrical Conductivity, Nickle, Magnesium, Lead, Iron, and Cadmium in groundwater of city area under study while Calcium level at some locations reached near alarming point. Values of remaining parameters were found within acceptable limits of given standards. The raising values of metals in drain and groundwater samples empowered the infiltration phenomena in selected area.

Keywords: Groundwater, Drains, Metal contamination, Faisalabad

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INTRODUCTION

The word groundwater is specially signified for the water found under the upper layer of earth, present underneath the water table in porous soils by infiltration of surface water. It provides water for drinking purpose, to run industries and maintains water supply for irrigation purposes (Mahananda *et al.*, 2010). The population expansion with industrial growth upsurges several pollution problems in urban groundwater. Industrial effluent in drainage channels induced high pressure on urban natural water resources. The water management processes need continuous assessment of sewerage channels to control pollution level of city water (Onder *et al.*, 2007 and Jien *et al.*, 2011).

Environmental anxieties related to the groundwater usually pay attention on the impact of human induced pollution especially from drains containing domestic and industrial waste. Peculiar industrialization and population growth has increased the production of wastewater in cities which falls in drainage channels and further pollutes the shallow groundwater reserves of cities. Water pollution by these drainage channels has converted to a serious problem because polluted water can affect millions of lives by causing water-borne diseases including jaundice, diarrhea, cholera, typhoid and dysentery etc. (Rahman, 2008).Ground water quality of big cities of Pakistan such as Lahore, Karachi, Peshawar, Sialkot, Gujarat, Rawalpindi, Sheikhupura and Faisalabad depreciate by the unrestrained disposal of urban effluent water, untreated industrial liquid waste in to city waste drainage channels and excessive use of pesticides and fertilizers. Faisalabad is thickly populated and one of the leading industrial center of Pakistan. The demand of fresh water has been increasing on daily basis due to its rapid population and industrial growth. The purpose of this research is to invent the contamination level of city ground water resources resulted by the interaction of city drains and associated ground water reserves.

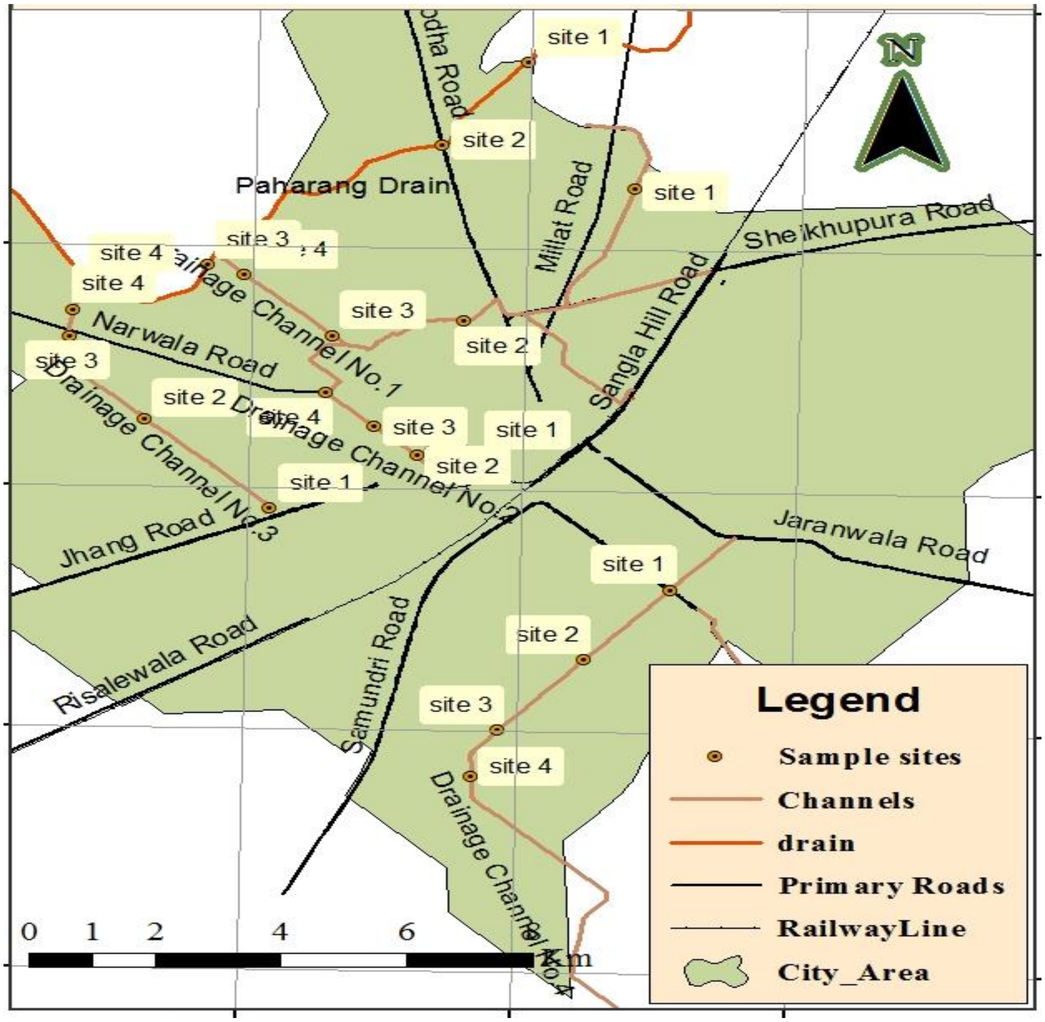

Fig. 1:Map showing sample sites in Faisalabad city.

MATERIALS AND METHODS

Sampling was done during the month of August, 2013 between 9am to 5pm. Polystyrene bottles having one litter (1L) capacity were used to collect water samples. Bottles were capped properly to avoid any contamination and shifted instantaneously to laboratory for analysis without any addition of preservatives. Forty samples out of which, twenty were collected from drains (four from open drain and sixteen from covered drains) and remaining twenty from groundwater sources available in the proximity of these drains. The sampling points were selected using Global Position system (GPS) device and verified from Google earth. Shape file of these points was prepared for mapping and Geo-statistical analysis. These coordinates were helpful in showing the exact location of sampling sites on maps and to do the required inverse distance weighted (IDW) analysis. Physical parameters including pH and temperature were recorded at the spot in filed. Electrical conductivity and some chemical parameters including Calcium, Magnesium, Nickel, Zinc, Chromium, Lead and Cadmium were tested in laboratory by Atomic Absorption Spectrophotometer.

Sample digestion for heavy metal detection: All water samples were digested for heavy metal detection in Atomic Absorption Spectroscopy (AAS). Water sample (100ml) was transferred in beaker along with concentrated HNO_3 (5ml) placed on the hot plate to evaporate down the material to 20ml. The beaker was allowed to cool down and HNO_3 (5ml) was again added into it. The beaker was covered with glass plate and placed on hot plate second time. Constant heating was provided for few minutes until the solution appeared more clear and light colored by adding little amount of HNO_3. Sample was filtered and distilled water was added to make final volume 100ml. At the end, the digested samples were shifted to Atomic Absorption spectrometer for heavy metal determination.

Spatial Analysis: Spatial maps of obtained values for assessment of pollution level in groundwater and sewerage drain water intended through interpolation method. Inverse distance weight technique in Arc Map 10 software of Geographical Information System (GIS) was used. Inverse distance weighted(IDW) of heavy metals and selected physical parameters were performed on individual basis.

RESULTS AND DISCUSSION

Results obtained from spatial analysis showed higher contamination of Iron, Lead, Nickel, Magnesium and Electric conductivity. All remaining parameters were within acceptable limits of WHO and PEPA. Values of Calcium concentration in waste water collected from drains of Faisalabad and in ground water were 44-136 (ppm) and 30.5-211.5ppm, (table1). IDW maps showed that there was not major difference between the values of Calcium in drain water and ground water of Faisalabad city area. Although acceptable limits had not been decided by WHO and PEPA for Calcium in water however concentration determined (200 mg/l) was in accordance with Udeh (2004).

Table 1: Showing descriptive statistics of Calcium, Magnesium, Nickel, Zinc, Chromium, Lead, Eclectic conductivity and Iron concentration in drains and ground water

S. No.	Element	Ground Water			Drain Water		
		Range (ppm)	Mean	St. Dev.	Range (ppm)	Mean	St. Dev.
1.	Calcium	30 - 211	91.05	45.21	44 - 136	80.25	25.96
2.	Magnesium	14.5 - 72	44.45	17.56	25.5 - 69	47.00	11.99
3.	Nickel	-.04 - .09	.0245	.039	-.01 - .07	.036	.024
4.	Chromium	-.03 - .01	-.004	.011	-.03 - .14	.0220	.039
5.	Zinc	.24 - .88	.445	.180	.20 - .89	.393	.165
6.	Lead	-.01 - .17	.066	.037	.05 - .12	.0710	.025
7.	Iron	.30 - 1.33	.487	.219	.40 - 1.42	.735	.287
8.	Electric Cond.	4 - 6	4.48	.719	4 - 7	5.22	.786

Spatial concentration of Chromium ranged from -0.03 to 0.14ppm in drains and -0.03 to 0.01ppm in groundwater well within the WHO limits of less than 0.05ppm. Zinc ranged from 0.20 to 0.89ppm in sewage water and 0.24 to 0.88ppm in Ground water. The bearable limit for Zinc contamination in water was 5mg/l given by Pakistan environmental protection agency and World health organization. Copper contamination ranged between 0.02 to 0.09ppm in waste water and 0.02 to 0.1ppmin groundwater. WHO has provided the maximum allowable limit (0.003ppm) for cadmium in water and PEPA standards were quiet different with maximum level of 0.01ppm. In Faisalabad, drain and ground water cadmium contamination remained well below the international standards with higher values of 0.01ppm at some locations of drain sewerage water and ground water. Water was acidic with pH level less than 6 and more alkaline with pH above 9, its best and balanced quality was attained with pH level of 7. pH in drain water of Faisalabad city ranged between 6.5 to 8.5 and in ground water between 6.06 to 7.9 indicating that pH remained within limits of WHO and PEPA set standards. Maps indicated that pH values in areas Millat Town, Nanakpura, Sargodha road, Muradabad, Gobind Pura, Karim Town and Sahib Nager ranged between 7.85 to 8.50. Lowest pH among other areas observed in Chokera, Rail Bazaar Circular road, Sheikh Colony, Rafique Colony, and Marzipura, which ranged between 6.5 to 7.1.

In all the drain waters of Faisalabad, Iron contamination crossed the national and international standards. Observed values ranged between 0.40 to 1.42 ppm in drain water and 0.30 to 1.33 ppm in surrounding ground water. Iron was observed well above the given standard levels of PEPA and WHO (less than 0.03 ppm) in ground water of city area showing that waste water from drainage channels was affecting the ground water resources of study area in terms of higher iron contamination through infiltration. All the ground water resources of study area were thickly polluted with iron adulteration which was a dangerous element and could become a reason for multiple human and animal diseases (Popa*et al.,* 2012).

IDW map depicted that in drain water, Lead ranged between 0.05-0.12 ppm and in Ground water resources (-0.01 to 0.17 ppm). Collectively contamination of Lead in drain water of Faisalabad was well above the observed standards. On the other hand values of Lead in ground water were not much different from drain water. Map indicated that areas of Karim Town and Waris Pura were having highest Lead contamination level of 0.11 and 0.17 ppm. Higher lead contaminants depicted the infiltration drains in soil to ground water reserves of city making water useless for human consumption.

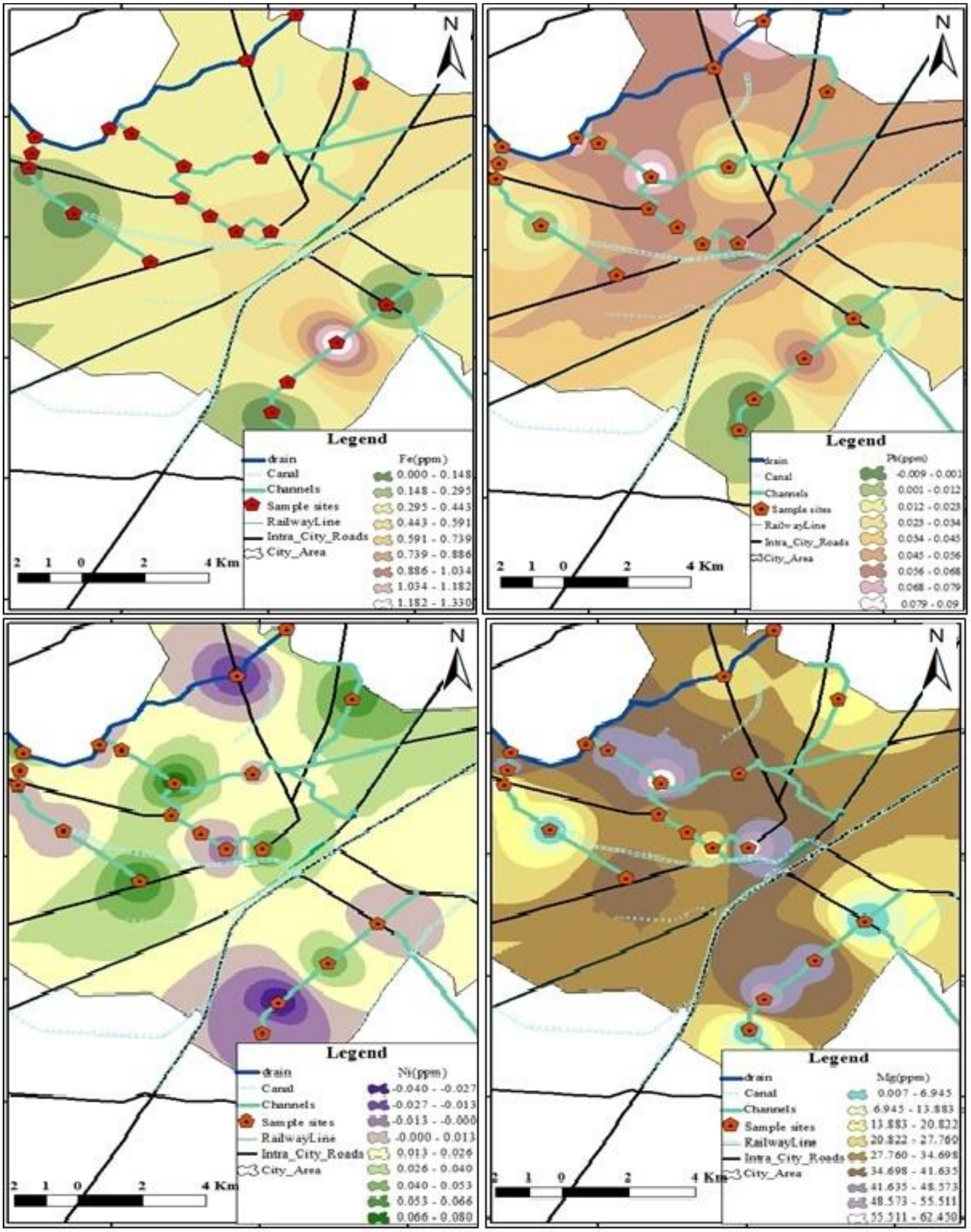

Figure 2: Map of Iron, Lead, Nickel and Magnesium Concentration in ground water of Faisalabad City

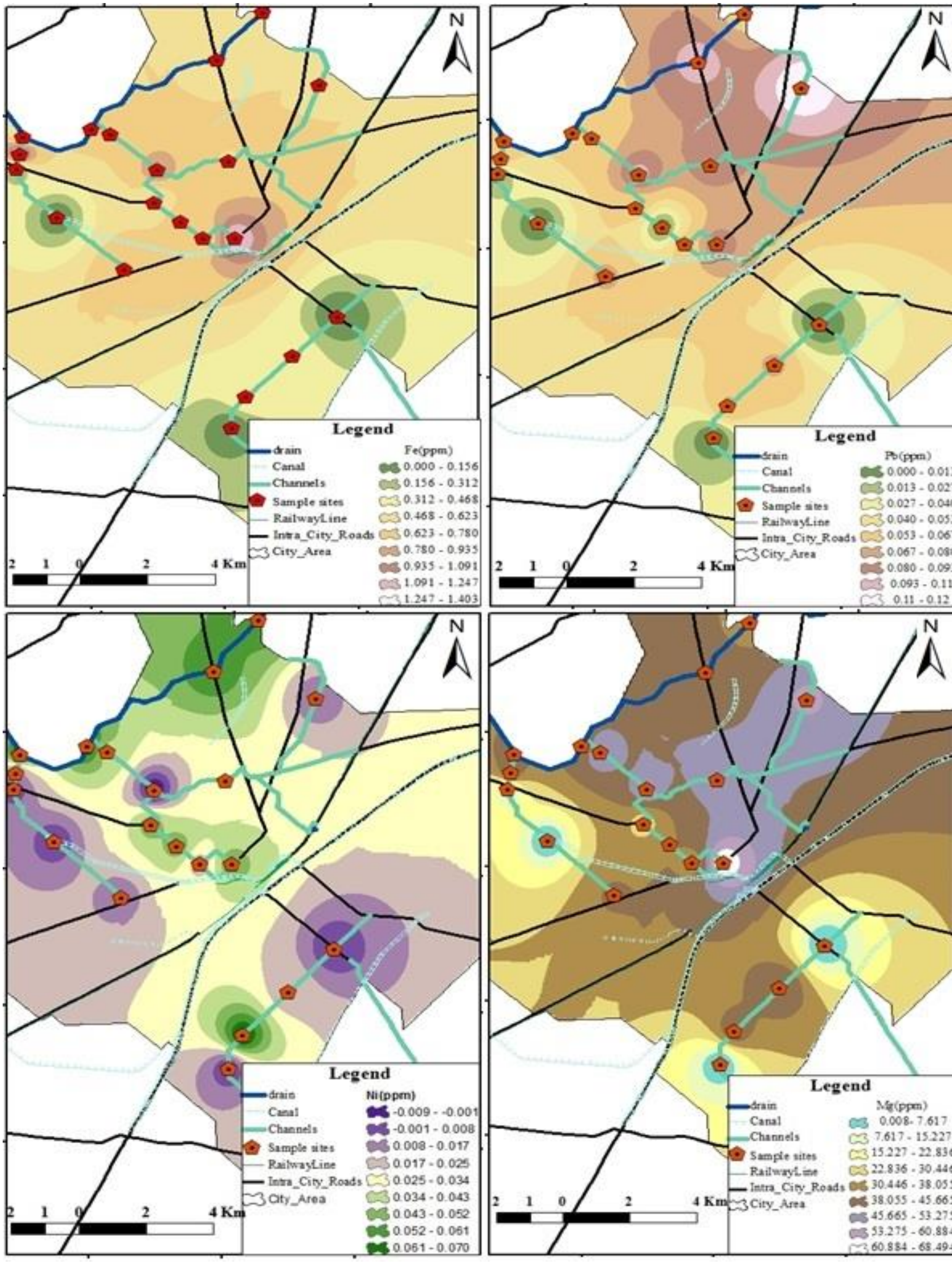

Figure 3: Map of Iron, Lead, Nickel and Magnesium Concentration in drain water of Faisalabad City

Rapid industrial growth has become one of necessities in developing countries like Pakistan. It happened to be a major contamination source for ground water. Various natural, anthropogenic and industrial activities have been identified as the main cause of Nickel contamination in ground water (Srikanth *et al.,* 1993). In Faisalabad city, water contamination due to heavy metals was increasing day by day because of infiltration of drains which were getting untreated waste material from nearby industries. It was agreed upon by both Pakistan Environmental Protection Agency and World Health Organization that good drinkable water should have contained proportion of Nickel below 0.02 ppm. It was therefore, revealed that the water quality of Faisalabad city was affected with high Nickel contamination, as most of the study areas had higher level than national and international standards. The values of Nickel in drain waters were found between -0.01 to 0.07 ppm while in ground water resources it range between -0.04 to 0.09 ppm.

Unrestrained industrial activities, unplanned sewage system caused rapid increase of Magnesium (Mg)in ground waters of some major industrial cities of developing world (Reddy *et al.,* 2009; Jeevanandam *et al.,* 2012). Inverse distance weighted (IDW)maps of study area indicated that Magnesium (Mg) level was gradually raising in ground water and in some areas it crossed the limits i.e. 50mg/l set by PEPA and WHO.

In drain water of Faisalabad, Magnesium (Mg) level ranged from 25.5 to 69ppm and in groundwater it was from 14.5-72ppm. This high disparity level of Magnesium contents in groundwater showed variable groundwater quality of city area. Maps indicated that water seepage abridged the groundwater quality by raising the value of Magnesium in groundwater of Faisalabad city. As a result, ground water had become less convenient for domestic use and agricultural activities because it contained an uneven amount of nitrates in it. Imbalance of Magnesium not only reduced the quality of water but also affected the growth level of plants and animals. Higher level of Mg along with other nitrates could cause water hardness and its low level had multiple health risks including acute myocardial infarction (Kousa *et al.,* 2008).

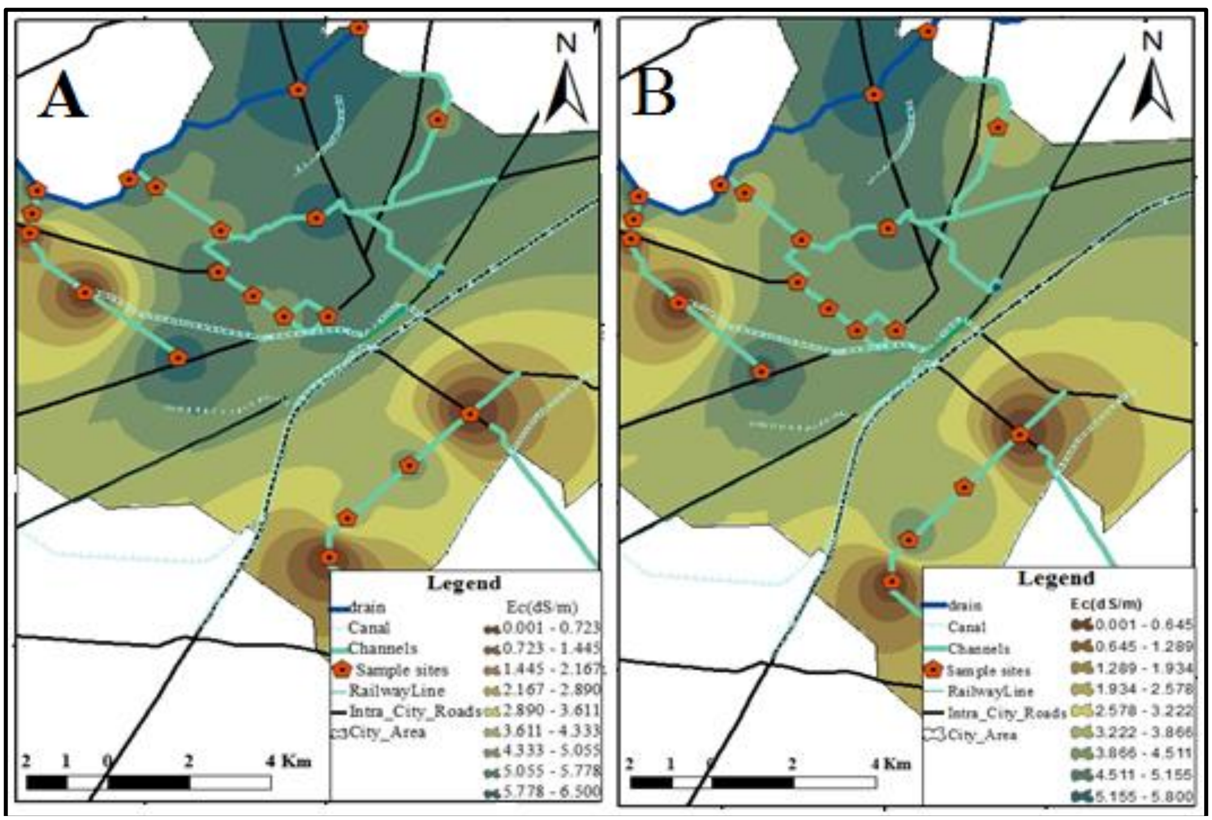

Fig. 4:Map (A)Showing Electric conductivity (dS/m) in ground and Map (B) Showing Electric conductivity in drain water of Faisalabad City

Since Electric conductivity was vital to measure which was closely related to salts or salinity level in soil and water as dissolved salts regarded as good electronic conductors. The higher Electric conductivity values could be harmful for the growth of some plants. If more dissolved salts in irrigated water were present then it would harm some plants roots (Ayars *et al.,* 1993 and Beltran, 1999). The results indicated that the range of electric conductivity in drain water remained between 3.9-6.5 dS/m while in ground water its ranged from 3.5 to 5.8 dS/m. These values were well above the permissible limits of 250 (µS/cm) for drinking water as suggested by WHO and PEPA (WHO, 2006).

Conclusion: Values of five parameters among selected thirteen Physio-chemicals, were higher than the given standards of WHO and PEPA standards. Although values of Zinc, Iron, Lead, Magnesium and Nickel were found high in study area showing few hot spots for their excessive contamination. This situation existed because of multiple industrial units scattered all over the city and throwing their waste in city drainage channels without treatment. So chemicals of industrial waste percolated downward along with other impurities made groundwater polluted and harmful for domestic use of citizens. If same level of contamination proceeds, water would become more polluted and useless for human as well as for industrial activities day by day. It was therefore necessary to find out some permanent precautionary measures to control the excessive amount of industrial wastes reaching drainage channels without any proper treatment.

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