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PHYSICOCHEMICAL ASSESSMENT OF SOIL AND DRINKING WATER QUALITY; A CASE STUDY OF URBAN AREA OF GREEN TOWN, LAHORE

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ABSTRACT: Environmental quality is greatly focused on water and soil. The purpose of this research was to assess and compare the ground water and soil quality of Green Town, Lahore with World Health Organization (WHO) standards. A total of 27 samples were obtained from seven locations namely IC-I, 3C-II, 5C-II, ID-II, 2D-I, 2D-II and 3D-I. Physicochemical parameters were examined and correlation analysis was applied to check association among parameters. Inverse Distance Weight (IDW) technique was used to create maps. Results showed that sodium (287.35 ppm) and bicarbonate (518.67 ppm) in soil collected from location 3D-I and 5C-II, respectively exceeded WHO standards that showed these two locations are unsuitable for agriculture purpose. In water samples total dissolved solids (1423.3 ppm), hardness (723 ppm), chloride (323 ppm), and sulfate (255.6 ppm) for location 3C-II and magnesium (70ppm) for 3D-I exceeded WHO standards. It showed that water in majority of the test area was safe for consumption except of location 3C-II.

Keywords: Physicochemical, Groundwater, Correlation, Inverse distance weight, Lahore and soil quality.

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INTRODUCTION

Soil and water are the two fundamentals of life. Although water is collectively described as a renewable resource, the sustainability of useable water is still under debate. The overall quantity of water on this planet is almost 1.4 trillion cubic meters (Farid *et al.*, 2012). Drinking water quality is crucial factor with respect to public health in fact access to clean drinking water is primary human right. The most suitable and extensively used source of drinking water is groundwater; unfortunately, the increase in intrusive anthropogenic activities is contaminating this water on a gradual basis (Ashraf *et al*., 2015).

Like other under developed countries, Pakistan is also facing poor drinking water quality and mismanagement of groundwater resources (Khan *et al*., 2013). Increase in consumption of filthy drinking water resulted in many health issues (Aher, 2012). In Pakistan, about 50% of all the identified illness cases are due to the use of contaminated drinking water and 40 % deaths occur due to water borne diseases (Ullah *et al.,* 2014). In near future Pakistan may face the issue of water scarcity (Khan *et al*., 2013). The only solution to deal with this problem is to use groundwater as it is a natural resource that is dependable in terms of hygiene because usually it has a persistent composition.

Soil is vital part of our environment; it is present as a thin layer on the earth crust. One can define soil as isolated mineral material resulted by geological and environmental process (Manimegalai and Sukanya, 2014). Rock fragments under some have biochemical process results in the transformation of soil (Shaikh and Bhosle, 2013). All the basic needs of animals and human beings are fulfilled by soil (Sumithra *et al.,* 2013). Increased human activities caused disturbances in natural balance of soil ecology on a large scale increasing complexity resulting in changes that are beyond any repair (Machender *et al*., 2011). The only technique to assess health of soil is to perform physicochemical analysis then according to its quality one can suggest fertilizer (Ganorkar *et al.*, 2013). In Pakistan soil is facing challenges of infertility, salinity and erosion. Moreover, heavy metal pollution is also becoming a serious concern, Unfortunately this issue has not been addressed by legislation bodies and policy makers (Ali *et al.,* 2015). The purpose of this study was to have an overview of current groundwater and soil quality, to relate findings with WHO permissible values and to find correlation between physicochemical parameters.

Sample collection: The samples for both water and soil were collected from seven locations namely IC-I, 3C-II, 5C-II, ID-II, 2D-I, 2D-II and 3D-I sectors of Green town, Lahore).Water samples were collected in triplets. Polystyrene bottles of 1.5 liter capacity were used for this purpose. For obtaining soil samples, a stainless steel spade was used and the soil was stored in plastic bags.

Sample storage: Water samples for chemical analysis were preserved with 5% HNO_3. The Soil samples were spread out on polyethylene sheets for initial sorting. The samples were air dried at room temperature (20–28°C). Samples were sieved through 4.76mm mesh size after grinding. Finally, they were placed in polythene containers, closed, labeled and placed at room temperature for analytical processing.

MATERIALS AND METHODS

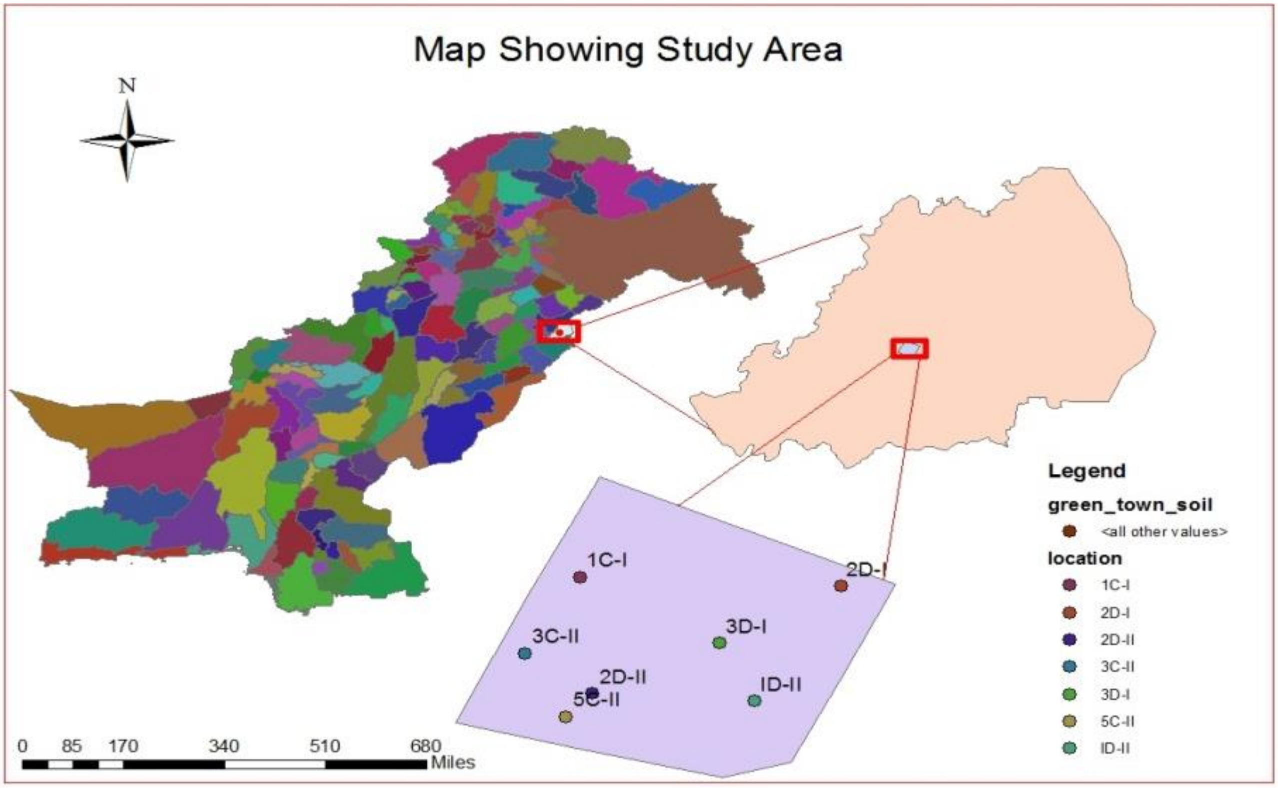

Figure 1 Map Showing Study Area

The basic parameters for both soil and water such as pH, electrical conductivity (EC) and dissolved oxygen (DO) were measured using pH meter, conductivity meter and DO meter respectively. Soluble cations (Ca^{2+}, Mg^{2+} and Na) and soluble anions (Cl^-, HCO_3^- and SO_4^{2-}) were measured by titration method as described in United States Department of Agriculture USDA handbook no.60. (Ibrahim, 2016 and Goswamee *et al*., 2015).

For water physical parameters like color were determined by using Hellige aqua tester, turbidity was determined by using a calibrated turbidimeter unit, total suspended solids (TSS) and total dissolved solids (TDS) according to standard method as given by Eaton *et al.*, (2005). Heavy metals (Cu^{2+}, F^-, Zn^{2+}, Mn^{2+}, Fe, Ni^{3+} and Pb^{2+}) as well as total hardness were determined by Spectroquant spectrophotometer Pharo-100 Merck (Germany). Flame photometer was used for sodium and potassium.

Statistical analysis and spatial analysis: MS Excel 2010 was used for descriptive statistics. Correlation analysis was done to find the link among studied parameters. Arc GIS 10.2.2 was used to perform spatial analysis. Spatial Interpolation is achieved by applying Inverse distance weight (IDW) technique. At the end spatial maps were generated for both soil and water samples.

RESULTS AND DISCUSSION

Soil: The average value of soil pH of study area was 8.01. According to WHO standards, the permissible limit for pH is 6.5- 8.5 which showed that all locations had pH within this safe range. A strong positive correlation ($r>0.7$, $p=0.001$) was observed for pH with chloride (Cl^-), electrical conductivity (EC), sulfate (SO_4^{2-}), Sodium is one of the constituents that form earth's crust. Some of the salts are required by plants (Kronzuckerm *et al.*, 2013). The permissible Na limit for soil is 200 ppm as per WHO and Pakistan standards (WHO, 2008). All the locations had Na according to standards except 3D-1. This is may be the result of rise in water table as some of the salts from water may be deposited in upper soil layers. The Na exhibited strong positive correlation ($r > 0.7$, $p=0.001$) with Cl^-, SAR, SO_4^{2-} and RSC (table 2).
**, Correlation is significant at the 0.01 level (2-tailed) *, Correlation is significant at the 0.05 level (2-tailed), Mg^{2+}

(magnesium), CO_3^{2-} (carbonate), Na^+ (sodium), Cl^- (chloride), K^+ (potassium), SO_4^{2-} (Sulfate), Ni^{3+}(nickel), NO_3^-(nitrate), Pb^{2+}(lead).

The Cl^- values varied from 24.8 to 141.8 ppm. The existence of chloride is not natural so, the amount found in soil is usually contributed by precipitation or anthropogenic activities. Excess of chloride can be harmful for plant health as well as for food chain (Huang and Pang, 2011). All the locations have chloride according to standards i.e., 250 ppm (WHO, 2008). From Table 1, a strong positive correlation (r>0.7, p=0.001) is observed for Chloride with SO_4^{2-} and RSC. SO_4^{2-} values in the selected sample locations ranged from 33.621 to 384.24 ppm. According to standards, the safe sulfate level of soil is 400 ppm (WHO, 2008). Once again, this parameter is found to fall within the required limits in all cases. From Table 1, a strong positive correlation (r >0.7, p=0.001) can be seen for sulfate with RSC and SAR. Plant take sulfur in the form of sulfates which is essential part of protein so , sulfate testing is important (Hinckley *et al*., 2016).

Table-1: Correlation among physicochemical parameters of soil.

	Saturation (%) SP	PH	EC	Mg^{2+}	Na	Cl	SO_4	SAR	RSC
Saturation (%) SP	1								
PH	-0.40	1.00							
EC	-0.51	0.91**	1.00						
Mg^{2+}	-0.08	-0.28	-0.01	1.00					
Na^+	-0.64	0.92	0.87*	-0.38	1.00				
Cl^-	-0.11	0.90**	0.89**	-0.17	0.75*	1.00			
SO_4^{2-}	-0.51	0.86*	0.90**	-0.18	0.91**	0.84*	1.00		
SAR	-0.64	0.89**	0.83*	-0.43	0.99**	0.72	0.91**	1.00	
RSC	-0.51	0.91**	0.99**	-0.01	0.87*	0.89**	0.90**	0.83*	1.00

Figure-2 Spatial distribution of soil sodium

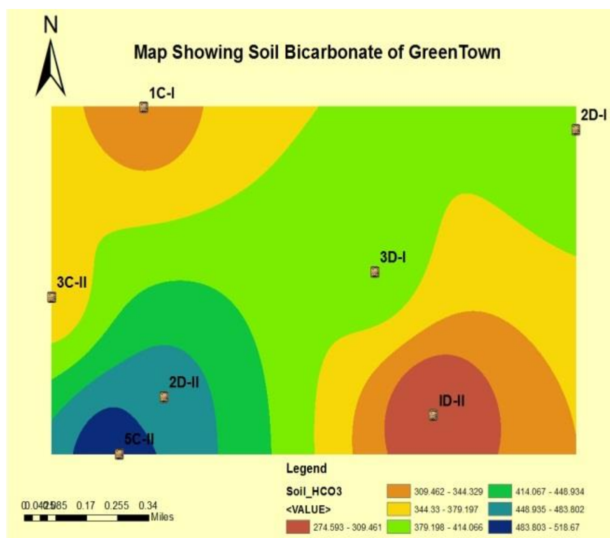

Figure-3 Spatial distribution of soil bicarbonates

Parameters like Ca^{2+},Mg^{2+},SAR at all the locations were within the acceptable limit according to WHO standards and no standard value for RSC is defined by WHO it was determined only to check whether there is increase or decrease in carbonates or bicarbonates (Goswamee *et al*., 2015) .

Water: Total dissolved solids (TDS) reflect the quantity of dissolved particles present in water. High concentration of TDS makes the water corrosive, salty and brackish (Fontenot *et al*., 2013).

Groundwater TDS values ranged from 282 to 1423 ppm (figure 4) for the tested locations, whereas the relevant standard places a cap at 1000 ppm. It can be seen that location 3C-II demonstrated non-compliance. From Table 2, TDS can be observed to had a strong positive correlation (r>0.7, p=0.001) with conductivity , hardness , HCO_3^-, Na^+ , Cl^-, K^+, SO_4^{2-} and Ni^{3+}.Total hardness does not cause serious health effects. The value ranged from 110 to 723 ppm.

The permissible limit for hardness is less than 500 ppm as per WHO and Pakistan standards. It can be seen that

Apart from 3C-II all the locations had hardness value according to defined permissible limits (figure 5). This was may be due to presence of carbonates and chlorides or may be due to uneven sewage disposal (Bhattacharya and Chakraborty, 2012). Table 2 shows that hardness had a strong positive correlation(r>0.7, p=0.001) with Ca^{+}, Na^{+}, Cl^{-}, K^{+}, SO_4^{2-} and Ni^{3+}. Chloride value ranged from 17.5 to 323 ppm (figure 6). The permissible limit as per WHO and Pakistan is less than 250 ppm. It can be seen that Apart from 3C-II all the locations had chloride according to defined permissible limit. It was may be as a result of using some disinfectant or may be as the site was located in the neighborhood of industrial area (Majolagbe *et al.*, 2011).

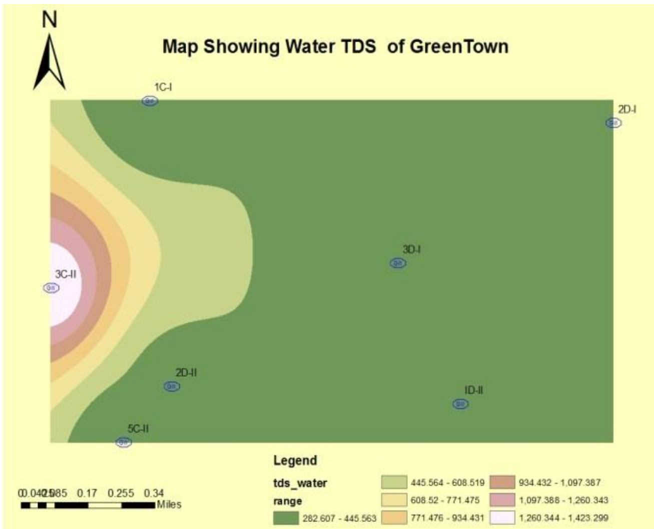

Figure-4 Spatial distribution of water TDS

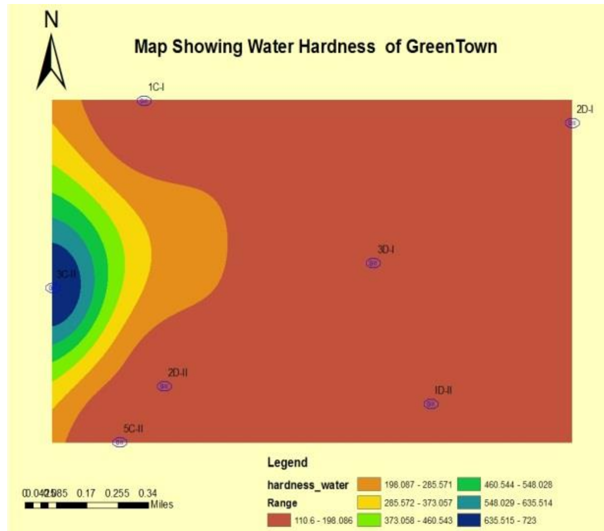

Figure-5 Spatial distribution of water hardness

Table-2: Correlation Among Physicochemical parameters of water

	HCO_3^-	Mg^{2+}	CO_3^{2-}	Na	Cl^-	K	SO_4^{2-}	Ni
HCO_3^-	1							
Mg^{2+}	0.176	1						
CO_3^{2-}	0.940**	0.324	1					
Na^+	0.961**	0.299	0.997**	1				
Cl^-	0.942**	0.325	0.999**	0.998**	1			
K^+	0.994**	0.256	0.953**	0.971**	0.956**	1		
SO_4^{2-}	0.956**	0.318	0.998**	0.999**	0.998**	0.967**	1	
Ni^{3+}	0.906**	0.350	0.974**	0.969**	0.974	0.925**	0.966**	1

**, Correlation is significant at the 0.01 level (2-tailed) *, Correlation is significant at the 0.05 level (2tailed) HCO_3^- (Bicarbonates), Mg^{2+} (magnesium), CO_3^{2-} (carbonate), Na^+ (sodium), Cl^- (chloride), K^+ (potassium), SO_4^{2-} (Sulfate), Ni^{3+}(nickel)

Table 2 showed strong positive correlation(r>0.7, p=0.001) Cl^- with K^+, SO_4^{2-} and Ni^{3+}. Sulfate is usually non-toxic in groundwater. Its main source in water is geological nature of soil and when water flows over rocks (Taiwo *et al.*, 2011). The value ranged from 42 to 255.6.ppm (figure 7). The permissible limit for sulfate is less than 200 ppm as per WHO and Pakistan standards. It can be seen that Apart from 3C-II all the locations had sulfate according to defined permissible limits. From Table 2, it is clear sulfate had a strong positive correlation (r>0.7, p=0.001) with Ni^{3+}.

The permissible limit for magnesium is 50 ppm as per WHO and Pakistan standards (WHO, 2008). Apart from 3D-I all the locations had magnesium according to standards (figure 8). Sewage and industrial waste could be the cause of this high value of magnesium at one location (Tank *et al.*, 2010).

Parameters like color, pH, turbidity, DO, Ca^{2+},Mg^{2+}, Na^+, K^+ and nitrate at all the locations were within the acceptable range according to WHO standards (WHO, 2008). The metals in the current study were found on trace levels. So, they had not played any serious role in the contamination of groundwater.

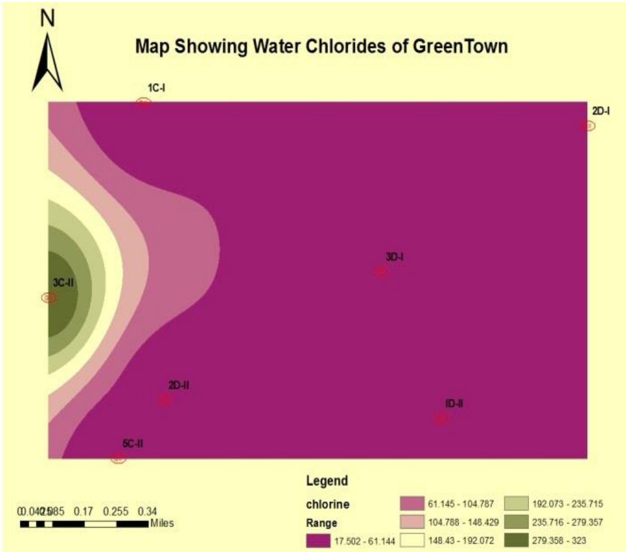

Figure-6 Spatial distribution of water chloride

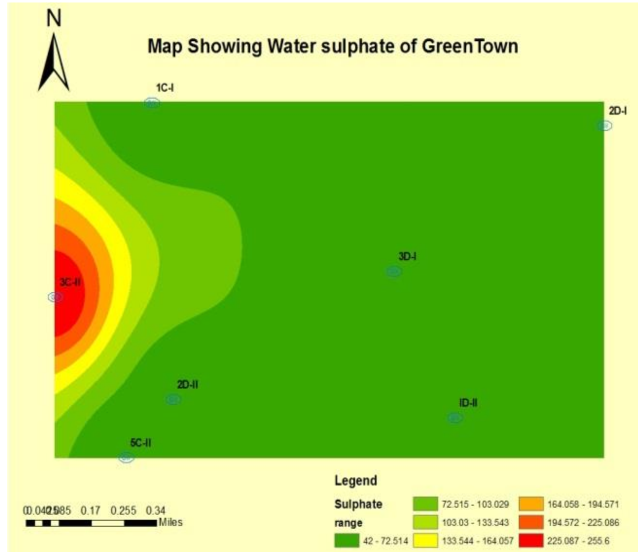

Figure-7 Spatial distribution of water sulphate

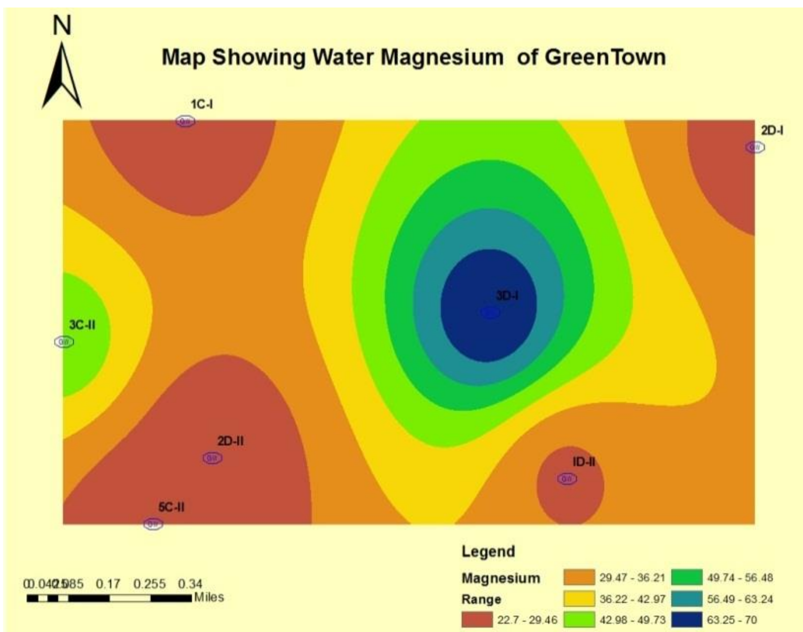

Figure-8 Spatial distribution of water magnesium

Table 2: Correlation Among Physicochemical parameters of water.

	color	PH value at 25^{0}C	Turbidity	TSS	TDS at 103 ^{0}C	conductivity	DO at 20 ^{0}C	Total hardness as CaCO3	Ca^{2+}
Color	1								
PH value at 25^{0}C	0.9035**	1							
Turbidity	0.993**	0.934**	1						
TSS	0	0	0	1					
TDS at 103 ^{0}C	0.996**	0.87*	0.98**	0	1				
Conductivity	0.995**	0.873*	0.98**	0	0.99**	1			
DO at 20 ^{0}C	-0.903**	-0.71227	-0.889*	0	-0.92**	-0.93**	1		
Total hardness as CaCO3	0.99**	0.88*	0.99**	0	0.998**	0.99**	-0.91**	1	
Ca^{2+}	-0.1861	-0.37	-0.226	0	-0.155	-0.15	0.1093	-0.165	1
HCO_3^-	0.9401	0.748*	0.930**	0	0.965**	0.967**	-0.97**	0.952**	-0.070
Mg^{2+}	0.324	0.229	0.287	0	0.302	0.297	-0.007	0.317	0.1497
CO_3^{2-}	1**	0.903**	0.99**	0	0.99**	0.995**	-0.903**	0.99**	-0.186
Na^+	0.9974**	0.88*	0.99**	0	0.99**	0.99**	-0.926**	0.999**	-0.165
Cl^-	0.99**	0.90**	0.99**	0	0.99**	0.99**	-0.905**	0.99**	-0.179
K^+	0.953**	0.768*	0.943**	0	0.97**	0.976**	-0.95**	0.965**	-0.022
SO_4^{2-}	0.99**	0.885*	0.99**	0	0.99**	0.99**	-0.917**	0.99*	-0.184
Total iron	0.612128	0.499	0.562	0	0.588	0.58	-0.37	0.610	0.3235
Ni^{3+}	0.9747**	0.841*	0.94**	0	0.967**	0.966**	-0.88*	0.973*	-0.048
$NO3^-$	0.342193	0.113	0.255	0	0.333	0.326	-0.225	0.345	0.627
Pb^{2+}	0.238909	0.399	0.312	0	0.243	0.244	-0.211	0.240	0.339

**, Correlation is significant at the 0.01 level (2-tailed)*, Correlation is significant at the 0.05 level (2-tailed)TSS (total suspended solids), TDS (Total dissolved solids), DO (Dissolved Oxygen), Ca^{2+} (Calcium), HCO_3^- (Bicarbonates), Mg (Magnesium), CO_3^{2-} (carbonates), Na^+ (sodium), Cl^- (Chlorides), K^+ (potassium), SO_4^{2-} (Sulphates), Ni^{3+}((Nickel), NO_3^- (nitrate), Pb^{2+}(lead)

Conclusion: The analysis performed for soil samples collected from all the seven locations showed location 3D-I and 5C-II were not suitable for agricultural perspective. Moreover, water from the location 3C-II was harmful for consumption. The possible reasons for this contamination can be anthropogenic activities and excessive use of fertilizers and disinfectants.

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