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RESEARCH PAPER

Soil Pollution Assessment in Mass Steel Company and the Surrounding Environment

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A B S T R A C T

Present study investigated the effects of Mass Steel Company (MSC) on local soil pollution and held on February 2022. For this purpose, 32 locations near Mass Steel Company at four distances as (25, 50, 75, and 100 meters) were selected. Samples were examined for heavy metals chromium (Cr), lead (Pb), zinc (Zn), copper (Cu) and nickel (Ni) using XRF Philips PW1730. Numerous indices were used to measure soil pollution, including contamination factor (CF), degree of contamination (C_{deg}), pollution load index (PLI) and metal contamination index (MCI). The main results were: heavy metals were ranged as: 183-164.5 ppm for Cr, 7-35.5 ppm for Cu, 141-194.5 ppm for Ni, 26-54 ppm for Zn and 137.5-281.5 ppm for Pb. Sampling direction showed significant effects on the concentrations of Cr, Cu, Ni, Zn and Pb. However, sampling distances from the company center were showed significant effect on the concentrations of Cu, Ni and Pb. Negative correlations were observed between Cu and Ni, and Pb and Zn by correlation coefficient values of -0.800** and -0.719** respectively at $p \leq 0.001$. Moderate contamination with Cr, Cu, and Ni was commonly seen in the sampling sites when compared to the local soil background from Sulaymaniyah City. According to average soil background, however, a high level of contamination (16 C_{deg} 32) in all sampling sites was observed. PLI in all of the investigated locations have shown a decline in site quality (PLI > 1). Except east and south directions at distances of 25 m and 100 m away from the company, and the north direction at the distance 25 m, the PLI < 1 has shown perfection of the site. Accordingly, results showed that agriculture, industry, transportation, and nature were the primary contributing sources of heavy metals in soils from the study area.

KEY WORDS: Heavy Metal, Soil Pollution, Indices, Mass Steel Company.
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1. INTRODUCTION

The buildup of dangerous elements in the environment is known as environmental pollution. Humans may be exposed to health concerns, and natural ecosystems may be harmed (Radojevic *et al*., 2006). The ecosystem of soil is thought to be a complex, dynamic, living system that might get contaminated by human activity (e.g. industrial areas).

Pollutants are deposited on the soil surface when poisonous metals, trace elements, and other organic compounds build up on the soil (Sharma and Raju, 2013). From a pollution source, these contaminants may sometimes travel a great distance via wind and rain (Stanley *et al*., 2014).

Steel factory is one of the industrial enterprises that release pollutant in the form of dust and gases that end up in the soil. A significant fraction of soils in industrialized nations have background values that are greater than those in similar undisturbed regions for several hazardous contaminants, including harmful and poisonous elements and compounds (Hu *et al*., 2013).

Heavy metals and other harmful compounds are filtered and deposited in soils because of their special characteristics and structure. Heavy metals were highly accumulated in calcareous soil, mainly controlled by secondary enrichment in the processing of carbonate rock weathering. Accumulation of heavy metals in soil may result in deteriorating soil quality, reduce soil fertility and crop production, and even threaten human and

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animal health as well as causes changes in the composition and activity of the soil microbial community (Fei *et al*., 2020). The following heavy metals are often introduced by human activities: (Cd, As, Cr) only Cr (+6) is harmful, (Hg, Cu, Ni, Pb, and Zn). Regrettably, the damage caused by heavy metal contamination is almost irreparable (Liang *et al*., 2011). The geology, geographic features, and local climate are thought to be the primary natural elements affecting the environment where heavy metals are dispersed. the components and mechanisms that make up the whole ecosystem and environment are often negatively impacted by rising human density, heavy industrialization, and overuse of natural resources (Karim *et al*., 2014).

Given their prolonged biological half-lives of elimination and inability to degrade, heavy metals accumulate in organisms in large amounts. The presence of hazardous heavy metals in soils is well documented to have negative impacts on human health, particularly in youngsters (Vickers, 2017). The goal of this research is to investigate any potential issues with pollution caused by heavy metals dumped at various locations by the Mass Iron and Steel Company. Different contamination index approaches, including enrichment factor (EF), index of geoaccumulation (I_{geo}), contamination factor (CF), contamination degree (C_{deg}), pollutant load index (PLI), element contamination index (ECI), and overall metal contamination index (MCI).

2. MATERIALS AND METHODS

2.1 The area of study

Sulaymaniyah is one of the Iraqi cities in Kurdistan Region. It has an area of more than 1200 km^2. The majority of the territory is a high plateau that rises over 850 meters above sea level. As going toward north, the land becomes hillier and the larger perennial river, the lower Zab, drops before finally emptying into the river Tigris. There are also several ephemeral watercourses that dry up in the summer; the region is bordered by springs and subterranean water sources, the majority of which are utilized for agriculture and water supply (Maulood and Hinton, 1979).

2.1.1 Steel Mass Company

Other names of the company are Mass Iron and Steel Industry Co. and Mass Global Investment Group Bazyan steel plant. It locates in Qadhaa Bazyan in Sulaymaniyah, P.O. Box 21, Kurdistan, Iraq. The GPS coordinates of the company exactly is: 35°39'36.5"N 45°02'20.6"E. The company is operating since 2013 under parent organization of Mass Group Holding Ltd. with PermID of the parent company: 5037412487 [100%] and Mass Iraq Iron and Steel Industry Co., the proprietor with PermID of the owner company: 5050905115. The production capacity is 1250 thousands of tons of crude steel annually. In this company the number of employees is 70. The electric arc furnace (EAF) is the primary manufacturing machinery (massgroupholding, 2022).

2.1.2 Sampling site selection

In February 2022, soil samples were gathered from 32 locations in the surface layer using an auger. Four directions were selected including north, east, south and west, each with four distinct circumferential belts with distances of 25, 50, 75, and 100 meters from the center of the company (Figure 1).

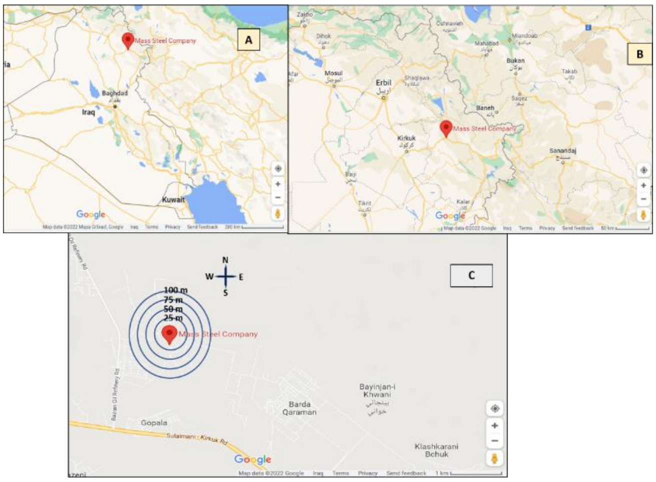


Figure 1: A. Map of Iraq. B. Kurdistan Region. C. Mass Steel Company showing the sampling directions.

2.2 Soil heavy metal determination

Five metals, including chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn) were examined in the soil samples utilizing the XRF Philips PW1730.

2.3 Methods for assessing soil contamination

For the purpose of this research, several indices have been used to evaluate the distribution and pollution of heavy metals in the surrounding environment of Steel Company. The utilized indices are CF (contamination factor), C_{deg} (contamination degree), PLI (pollutant load index), ECI (element contamination index), and overall MCI (metal contamination index). Typical soil backgrounds (Kabata-Pendias and Mukherjee, 2007) and local soil backgrounds (Alnaqshabandi, 2014) are used in this study, which are global uncontaminated background soils (Table 1). Additionally, aluminum was used as a metal of normalization for the sake of this investigation.

Table 1: Crust's background concentration of the studied heavy metals (local and average soil).

Elements	***Background (ppm)***	
	Local	**Average soil**
Cr	105.9	59.5
Cu	33.1	38.9
Ni	161.5	29
Zn	70.15	70
Pb	9.93	27

2.3.1 Contamination factor (CF)

The contamination factor (CF) is calculated by dividing each metal's soil concentration by its background concentration (concentration in unpolluted soil).

$$CF = C\ Heavy\ metal\ /\ C\ Background \text{ ……….. (1)}$$

C is the heavy metal content in the soils of the study region served as the basis for calculating the *C* background concentrations (Khudhur *et al*., 2018).

2.3.2 Contamination degree (C_{deg})

It is a generalised version of the degree of contamination (C_{deg}) formula that has been changed (Aikpokpodion *et al*., 2010), this formula were also projected by (Hakanson, 1980). It is calculated by the following equation:

$$Cdeg = \sum (Cm\ /\ Bm) i \text{ …………….. (2)}$$

(Cr, Cu, Ni, Pb and Zn) are the various metals that are represented by the letters *i* while *Cm* is the measured concentration in the soil and *Bm* is the background concentration value of the metal *m* in the research region.

2.3.3 Pollution load index (PLI)

The Pollution load index (PLI) is an empirical index that evaluates the degree of heavy metal pollution on a comparative basis. The geometric mean of all evaluated CF at a sample site served as the basis for calculating the PLI for the individual sampling regions (Afrifa *et al*., 2013).

$$PLI = (CF1 \times CF2 \times CF3 \times CFn \ldots\ldots..)\ 1/n \text{ ………. (3)}$$

The number of metal index, or n, offers a quick, comparable way to gauge the amount of heavy metal pollution (Bambara *et al*., 2015).

2.3.4 Metal contamination index (MCI)

The overall metal contamination index (MCI) is an expression of a specific metal contamination within a sample or the total metal contamination for a sample in proportion to the background values of the corresponding metal (Singh et al., 2015). It is stated as:

$$MCI = \sum (Cm - Bm\ /\ Bm) \text{ ……….. (4)}$$

where *I*, *C* and *B* are as previously specified. MCI, according to Aikpokpodion *et al*. (2010), was created to characterize contamination with generic trace elements.

2.4 Statistical Analysis

SPSS Statistical Analysis Package for Windows® (version 26) and Microsoft Excel (2019) were used to analyze and evaluate the results. Data reported as mean, maximum and minimum values. Factorial experiment with CRD design was performed for determining the significant difference among the sampling directions and distances along the company center using Duncan’s test. A p-value of <0.05 was considered significant. Pearson’s correlation was analyzed to determine the significant correlations between the paired metals in the studied sites.

3. RESULTS AND DISCUSSION

3.1 Soil heavy metal contents

Due to health concerns to human, heavy metal accumulation in surface soils is of great concern (Salah *et al*., 2013). During the present study Cr, Ni and Pb concentrations were exceeded the local background and average range of soils according to Alnaqshabandi (2014) and Kabata-Pendias and Mukherjee (2007) respectively. Regarding to (Table 2), different values of heavy metals were observed depending on the sampling directions and distances along the company.

Table 2: Determined heavy metals in the soil samples around Mass Steel Company.

Maximum chromium value (183 ppm) was observed in north-75 meters away from the company, however the lower value (164.5 ppm) was observed in east-50 meters away from the company. Such content of soil chromium may refer to its abundance in the parent material, since, the median content of soil Cr has been established as 54 ppm in the world (Khudhur *et al*., 2018). The increased Cr content of surface soils is due to pollution from various sources. Furthermore, directions showed to have significant effects on chromium concentration (Table 3).

Sampling sites		*Metal concentration (ppm)*				
Directions	**Distances**	***Cr***	***Cu***	***Ni***	***Zn***	***Pb***
North	**25 m**	169.5	7.5^{d}	193.5	47.5	142.5
	50 m	181.5	30.0^{ab}	151.0	51.5	203.5
	75 m	**183.0**	**35.5^{a}**	**141.0**	53.0	193.5
	100 m	181.5	29.0^{ab}	151.0	**54.0**	205.0
South	**25 m**	169.5	8.0^{d}	193.0	51.0	**137.5**
	50 m	181.0	22.0^{bc}	175.0	49.0	220.5
	75 m	173.0	8.0^{d}	190.5	49.5	140.0
	100 m	168.0	**7.0^{d}**	**194.5**	50.5	139.0
East	**25 m**	174.5	16.5^{cd}	184.0	41.5	243.0
	50 m	**164.5**	11.5^{d}	152.5	**26.0**	**281.5**
	75 m	165.5	10.0^{d}	173.5	39.5	214.0
	100 m	171.0	14.5^{cd}	167.5	33.0	266.0
West	**25 m**	178.0	15.0^{cd}	189.0	52.0	175.0
	50 m	181.5	22.5^{bc}	167.5	50.0	215.5
	75 m	182.0	26.5^{ab}	164.5	49.0	212.0
	100 m	175.0	16.0^{cd}	183.5	41.0	246.0
Maximum		**183.0**	**35.5**	**194.5**	**54.0**	**281.5**
Minimum		**164.5**	**7.0**	**141.0**	**26.0**	**137.5**

Different letters mean significant differences.

Table 3: Pearson's correlation values between the heavy metal pairs during the study.

	Cr	***Cu***	***Ni***	***Pb***	***Zn***
Cr	1	0.872**	-0.450	0.039	0.633**
Cu		1	-0.800**	0.290	0.381
Ni			1	-0.533*	0.096
Pb				1	-0.719**
Zn					1

***Correlation is significant at the 0.01 level (2-tailed).*
**Correlation is significant at the 0.05 level (2-tailed).*

The highest value was recorded in west, while the lowest was observed in east which may refer to the direction of wind in the area.

Significant differences among the sites were observed regarded to cupper concentrations. It was ranged between (7-35.5 ppm) in both north-75 m and south-100 meters away from the company. Maximum nickel was 194.5 ppm observed in south-100 meters away from the company while minimum value was 141 ppm observed in north-75 meters away from the company. Moreover, with referring to Table 2, a negative correlation was observed between Cu and Ni contents 75 m and 100 m away from the company by correlation coefficient value of -0.800** at $p \leq 0.001$ (Table 3). Maximum zinc was 54 ppm detected in north-100 meters away from the company and the minimum zinc value was 26 ppm detected in east-50 meters away from the company. Lead was ranged between 137.5-281.5 ppm observed in both south-25 m and east-50 meters away from Mass Steel Company. Lead correlated negatively with zinc by correlation coefficient value of -0.719** at $p \leq 0.001$ (Table 3). The increasing heavy metals in soil in such area may be due to fallout of iron and steel factory dusts over the years, as well as climate, soil origin, type of the parent rocks, composition or human activities (Mlitan, 2013).

Sampling direction showed significant effects on the concentrations of Cr, Cu, Ni, Zn and Pb (Table 4).

Table 4: Effect of directions and distances on soil heavy metal contents around Mass Steel Company.

	Sites	Metal concentration (ppm)				
		Cr	*Cu*	*Ni*	*Zn*	*Pb*
Directions	**North**	178.88^{a}	25.50^{a}	159.13^{c}	51.5^{a}	186.13^{bc}
	South	172.88^{b}	11.25^{c}	188.25^{a}	50.0^{a}	159.25^{c}
	East	168.88^{b}	13.13^{c}	169.38^{bc}	35.0^{b}	251.13^{a}
	West	179.13^{a}	20.00^{b}	176.13^{ab}	48.0^{a}	212.13^{b}
Distances	**25 m**	172.88	11.75^{c}	189.88^{a}	48.0	174.50^{c}
	50 m	177.13	21.50^{a}	161.50^{b}	44.1	230.25^{a}
	75 m	175.88	20.00^{ab}	167.38^{b}	47.8	189.88^{bc}
	100 m	173.88	16.63^{b}	174.13^{b}	44.6	214.00^{ab}

Different letters mean significant differences.

Highest Cr (179.13 ppm) was detected in west and the lowest level (168.88 ppm) was observed in east. Greatest Cu (25.50 ppm) and Zn (51.5 ppm) were observed in north, whereas, lowest copper (11.25 ppm) was detected in south and the lowest Zn (35 ppm) was in east. Highest Ni (188.25 ppm) was detected in south and lowest level (159.13 ppm) was observed in north. Greatest Pb (251.13) was observed in east and minimum value (159.25 ppm) was detected in south. Moreover, sampling distances from the company center were showed significant effect on the concentrations of Cu, Ni and Pb. The maximum values of Cu (21.50 ppm), Ni (189.88 ppm) and Pb (230.25 ppm) were detected 50 m, 25 m and 50 meters away from the company respectively, while the minimum values of Cu (11.75 ppm), Ni (161.50 ppm) and Pb (174.50 ppm) were observed 25 m, 50 m and 25 meters away from the company.

3.2 Contamination factor (CF)

According to the local soil background, the CF of the trace elements (Cr, Cu, Ni and Zn) in soil samples from the analysed locations generally indicated low to moderate contamination (Table 5), whereas, Cr showed considerable pollution in different locations including north 50 m, 75 m, 100 m, south 50 m, and west 50 m and 75 m along the company. CF readings for Cu are low to a moderate pollution. Cu contamination was determined to be moderate in the north at a distance of 75 metres (CF = 1.07).

Moreover, nickel and lead have caused considerable to very high pollution based on average soil background. However, lead generally showed very high pollution in all sites based on local soil background. Moreover, Pb showed the highest CF of 28.35 which indicate very high pollution 50 meters east of the company (Table 5) and this may be attributable to the impact of industry, agricultural runoff, and other human inputs. Moreover, the characteristics of the substrate in addition to the physicochemical parameters governing dissolution and precipitation substantially influence the accumulation of metals in these regions (Khudhur *et al*., 2018).

Table 5: Soil contamination factor based on local and average soil backgrounds.

Sampling sites		***Contamination factor***									
Directions	***Distances***	***Cr***		***Cu***		***Ni***		***Zn***		***Pb***	
		L.B.	***A.S.***	***L.B.***	***A.S.***	***L.B.***	***A.S.***	***L.B.***	***A.S.***	***L.B.***	***A.S.***
North	**25 m**	1.60	2.85	0.23	0.19	1.20	6.67	0.68	0.68	14.35	5.28
	50 m	1.71	3.05	0.91	0.77	0.93	5.21	0.73	0.74	20.49	7.54
	75 m	1.73	3.08	1.07	0.91	0.87	4.86	0.76	0.76	19.49	7.17
	100 m	1.71	3.05	0.88	0.75	0.93	5.21	0.77	0.77	20.64	7.59
South	**25 m**	1.60	2.85	0.24	0.21	1.20	6.66	0.73	0.73	13.85	5.09
	50 m	1.71	3.04	0.66	0.57	1.08	6.03	0.70	0.70	22.21	8.17
	75 m	1.63	2.91	0.24	0.21	1.18	6.57	0.71	0.71	14.10	5.19
	100 m	1.59	2.82	0.21	0.18	1.20	6.71	0.72	0.72	14.00	5.15
East	**25 m**	1.65	2.93	0.50	0.42	1.14	6.34	0.59	0.59	24.47	9.00
	50 m	1.55	2.76	0.35	0.30	0.94	5.26	0.37	0.37	28.35	10.43
	75 m	1.56	2.78	0.30	0.26	1.07	5.98	0.56	0.56	21.55	7.93
	100 m	1.61	2.87	0.44	0.37	1.04	5.78	0.47	0.47	26.79	9.85
West	**25 m**	1.68	2.99	0.45	0.39	1.17	6.52	0.74	0.74	17.62	6.48
	50 m	1.71	3.05	0.68	0.58	1.04	5.78	0.71	0.71	21.70	7.98
	75 m	1.72	3.06	0.80	0.68	1.02	5.67	0.70	0.70	21.35	7.85
	100 m	1.65	2.94	0.48	0.41	1.14	6.33	0.58	0.59	24.77	9.11

L.B.: Local Background
A.S.: Average Soil Background

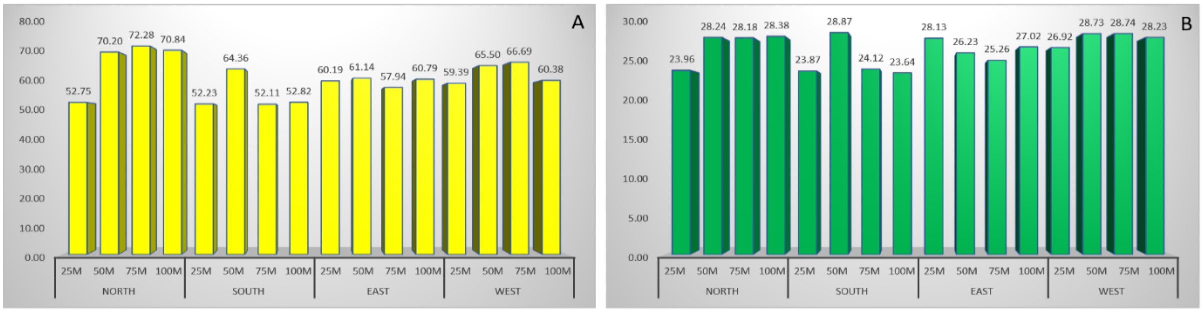
Soil contamination (CF) classes	
CF Value	***Contamination Level***
Less than 1	Low pollution
1<CF<3	Moderate pollution
3<CF<6	Considerable pollution
CF>6	Very high pollution

3.3 Contamination degree (C_{deg})

The findings of the soil samples' tests for degree of contamination (C_{deg}) in the area under study are shown in (Figure 2). The degree of contamination in every direction is very high as compared to the local soil background as given by Aikpokpodion *et al.* (2010). Whereas, all directions are different from the average soil background by showing a considerable degree of contamination (C_{deg} = 16 - 32).

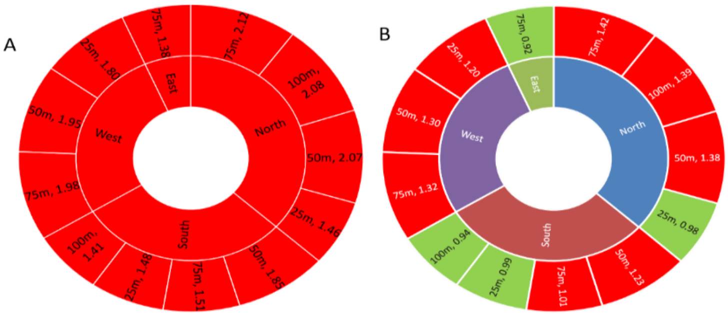
3.4 Pollution load index (PLI)

According to Tomlinson *et al*., (1980), if PLI = 1 it means perfection and there is no heavy metal contamination. When PLI values are greater than 1 they indicate the presence of heavy metal contamination in the studied locations (Deterioration of the site quality). Based on the local soil backgrounds at each of the study sites, (PLI) values were greater than 1 (Figure 3).



C_{deg} Value	Degree of Contamination
< 8	Low Contamination Degree
8-16	Moderate Contamination Degree
16-32	Considerable Contamination Degree
≥32	Very high Contamination Degree

Figure 2: Degree of contamination (C_{deg}) in the studied sites: A/ on the base of local soil background and B/ on the base of average soil background.



PLI values	Pollution Load
< 1	Perfection
= 1	Only baseline levels of pollutants are present
> 1	Deterioration of the site quality

Figure 3: Pollution Load Index (PLI): A/ based on the local soil background, B/ based on average soil background.

The findings revealed a decline in the quality of the site that may be related to the absence of dust collectors and a wall encircling the facility. Additionally, the environment is exposed to all of the factory's gases and pollutants.

Table 6: Metal contamination index (MCI) based on local and average soil backgrounds.

Sampling sites		***Detected metals (ppm)***									
Directions	***Distances***	***Cr***		***Cu***		***Ni***		***Zn***		***Pb***	
		L.B.	***A.S.***	***L.B.***	***A.S.***	***L.B.***	***A.S.***	***L.B.***	***A.S.***	***L.B.***	***A.S.***
North	**25 m**	0.60	1.85	-0.77	-0.81	0.20	5.67	-0.32	-0.32	13.35	3.59
	50 m	0.71	2.05	-0.09	-0.23	-0.07	4.21	-0.27	-0.26	19.49	5.11
	75 m	0.73	2.08	0.07	-0.09	-0.13	3.86	-0.24	-0.24	18.49	5.56
	100 m	0.71	2.05	-0.12	-0.25	-0.07	4.21	-0.23	-0.23	19.64	5.19
South	**25 m**	0.60	1.85	-0.76	-0.79	0.20	5.66	-0.27	-0.27	12.85	3.56
	50 m	0.71	2.04	-0.34	-0.43	0.08	5.03	-0.30	-0.30	21.21	4.00
	75 m	0.63	1.91	-0.76	-0.79	0.18	5.57	-0.29	-0.29	13.10	3.46
	100 m	0.59	1.82	-0.79	-0.82	0.20	5.71	-0.28	-0.28	13.00	3.69
East	**25 m**	0.65	1.93	-0.50	-0.58	0.14	5.34	-0.41	-0.41	23.47	3.24
	50 m	0.55	1.76	-0.65	-0.70	-0.06	4.26	-0.63	-0.63	27.35	3.13
	75 m	0.56	1.78	-0.70	-0.74	0.07	4.98	-0.44	-0.44	20.55	3.48
	100 m	0.61	1.87	-0.56	-0.63	0.04	4.78	-0.53	-0.53	25.79	3.19
West	**25 m**	0.68	1.99	-0.55	-0.61	0.17	5.52	-0.26	-0.26	16.62	3.94
	50 m	0.71	2.05	-0.32	-0.42	0.04	4.78	-0.29	-0.29	20.70	4.19
	75 m	0.72	2.06	-0.20	-0.32	0.02	4.67	-0.30	-0.30	20.35	4.43
	100 m	0.65	1.94	-0.52	-0.59	0.14	5.33	-0.42	-0.41	23.77	3.22

L.B.: Local Background
A.S.: Average Soil Background

Metal contamination index (MCI) values	
MCI values	***Contamination level***
< 5	Very low contamination
5-10	Low contamination
10-25	Medium contamination
25-50	High contamination
50-100	Very high contamination
> 100	Extremely high contamination

According to average soil backgrounds, the studied locations have been designated as perfect (PLI 1), (north 25 m PLI = 0.98) and (south 100 m PLI = 0.94 and south 25 m PLI = 0.99) and (east 75 m PLI = 0.92) and the direction north distance (50 m, 75 m, 100 m) showed deterioration in the site quality (PLI = 1.38, 1.42, 1.39) respectively and direction west all showed deterioration in the site quality and direction south distance (50 m and 75 m) showed deterioration in the site quality (PLI = 1.23, 1.01) respectively. The results of this investigation are congruent with those of studies carried out by (Namuhani and Cyrus, 2015) around a facility in (Uganda) that processes steel.

3.5 Metal contamination index (MCI)

According to the arrangement of MCI given by (Aikpokpodion *et al*., 2010) and based on local soil backgrounds all direction indicated very low contamination except for Pb that indicated medium contamination (10-25) in the directions of north, south and west (Table 6), but the direction east and the distances 50 m and 100 m (MCL = 27.35 and 25.79) respectively have shown high contamination. Based on average soil background the metal (Cr, Cu and Zn) have shown very low contamination, but the metal (Ni) in all directions has shown low contamination and the metal (Pb) in the direction of north and the distances 50 m, 75 m and 100 m (MCL = 5.11, 5.56 and 5.19) respectively indicated low contamination.

4. CONCLUSIONS

According to the findings of this study, exceeded concentrations of Cr, Ni and Pb above local background and average range of soils were observed due to the emissions from Mass Steel Company. Different values of heavy metals were observed depending on the sampling directions and distances along the company. Wind may consider as an important factor of heavy metal distribution along different directions. The increasing heavy metals in soil in such area may be due to fallout of iron and steel factory dusts over the years, as well as climate, soil origin, type of the parent rocks, composition or human activities. and this may be attributable to the impact of industry, agricultural runoff, and other human inputs.

Statements and Declarations

The authors did not receive support from any organization for the submitted work.

Conflict of interest:

The authors declare that they have no conflict of interest.

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