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Full Length Research Paper

Assessment of Heavy Metal pollution due to the Lead –Zinc Mine at the Ain Azel area (northeast of Algeria)

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The aim of this present study was assess the heavy metals pollution present in sediment of soil. The study identify the heavy metals contamination in the sediment samples collected in soils of Ain Azel area using Atomic Absorption Spectrometry (AAS).The heavy metals concentration in sediments samples ranged from (mg/kg): Lead 10.45 to 94.79 , Zinc 8.13 to 89.79 , copper 8.30 to 21.73 , Chrome 5.12 to 21.46 , Cadmium 0.35 to 3.25 ,and Iron 12460 to 44190 .In our study , seven reliable indices such as Geo-accumulation, Enrichment Factor, Contamination factor, Contamination degree ,mead contamination degree, pollution Load index and Potential ecological risk index were applied to estimate metal pollution .The data generated were used to determine the quality of the sediments based on the enrichment Factor, Contamination factor, Contamination degree ,mead contamination degree, pollution Load index and Potential ecological risk index .The potential ecological risk in the order of E_R(Cd) > E_R(Pb) > E_R (Zn) >E_R (Cu) E_R > (Cr)

Key words: Heavy metal, soil, assessment, Ain Azel, Algeria.

INTRODUCTION

Pollution of the natural environment by heavy metals is a universal problem. These metals are indestructible and most of them have toxic effects on living organism. Environmental problems related to heavy metals have a long history. Heavy metals have toxic properties, leading to adverse effects on human and ecosystem health even in small doses. Usually permissible concentration levels are exceeded.(references). The sources of heavy metals contents in biosphere and hydrosphere are either anthropogenic or geogenic contamination in nature, but the anthropogenic sources are dominate in causing contamination .The anthropogenic sources are mostly observed in intense industrial area (Flaten and Steinnes 1999) Heavy metals frequently reported in the literature with regards to their potential Hazards and occurrences in contaminated soils are Fe ,Pb , Zn , Cu ,Cr and Cd (references).

Another problem encountered with heavy metal is their non-degradability: once they enter the environment they will remain there for long time. Metals tend to accumulate in soils and sediments, with immobilization due only to geological phenomenon. Accumulation in the food chain may lead to an increase stock in biota, thereby magnifying the human dose (Khan, 2008). For some heavy metals, toxic levels can be just above the background concentrations naturally found in nature.

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Therefore, it is important to take protective measures against
excessive exposure. If unrecognized or inappropriately treated, toxicity can result in significant illness and reduced quality of life (Ferner, 2001;Pendias and Pendias, 2000). The study of heavy metal deposition and accumulation is of increasing interest because of the awareness that heavy metals present in soils may have negative consequences on human health and in the environment. Heavy metals may enter into aquatic ecosystems from anthropogenic sources.

Such as industrial waste water discharge, sewage wastewater, fossil fuel combustion and atmospheric deposition (Linnik et al., 2000; Campbell et al., 2001 ; Lwanga et al.,2003).Environmental pollution by heavy metals is mainly due to the both natural processes such as weathering of minerals and anthropogenic activities related to industrialization ,urbanization and agricultural practices which are the three sources of metals in soils.

Heavy metals in the soil from anthropogenic sources tend to be more mobile, hence bio-available that pedogenic or lithogenic (Kuo. Al.; 1983 ;Basta. et al.2005). Metal-bearing soils in contaminated sites can originate from a wide variety of anthropogenic activities in the form of metal mine tailings, disposal of high metal wastes in improperly protected landfills, leaded gasoline and lead-based paints, land application of fertilizer, animal manures, bio-solids (sewage sludge), compost, pesticides, coal combustion residues, petrochemicals, vehicular emission, mining and metallurgical contamination processes ,burning of fossil fuels, and atmospheric deposition (Wuana and Okieimen 2011).

It is estimated that the contribution of metals from anthropogenic sources in soils is higher than the contribution from natural ones (Nriagu and Pacyna1988). Many authors observed significant increases in soil metal content not only in areas of high industrial activity but also in areas far from industrial centers, due to long-range atmospheric transport (Saur and Juste1994 ; Steinnes and Njastad1995). The assessment of metal contamination is most important for the human survival. The determination of the rates transfer of metals in the surface horizons of the soil cannot provide extensive indications about the state of contamination of soils. A large variety of methods has been developed to estimate heavy metal accumulation into soils and sediments. Among them, pollution risk indices are considered to be a powerful tool for ecological geochemistry assessment (Gong, et al., 2008).

The aim study attempts to understand the assessment of the heavy metals pollution in soils, identification and apportionment of sources of pollution around a lead – Zinc mines situated at Ain Azel area in Algeria. In this work the Geo-accumulation Indices ,Enrichment factor , Pollution load index (PLI) ,Contamination factor (CF) ,Degree of contamination and pollution risk indices have been applied to assess heavy metals (Pb , Zn , Cu , Cr ,Cd and Fe) distribution and contamination of the concerned soils..

Study area

The area of study is located in the North-East of Algeria. The altitude in this area varied between 900 and 1200 m where the regional climate is semi-arid mediterranean type. The high temperatures are reached in July and August with 33 °C, whereas the low temperatures are recorded in January with 1·5 °C. Precipitation is about 296 mm/year.Most of its inhabitants (more than 30.000) are concentrated in the town of Ain Azel working mainly in the production of cereals (barley ,corn (Belkhiri 2005) .

The dominant substrate soil is rich in magnesium chlorides; it only allows the development of salt-tolerant flora highly adapted and composed mainly of Chenopodiaceae (Atriplexhalimus, Atriplexpatula, Salsolafruticosa and Salicornia fruticosa) and Brassicaceae (Mauricaundiaarvensis, Matthiolafruticulosa and Diplotaxismuralis)(Nedjimi et al., 2012; Aliat and Kaabeche, 2013; Neffar et al., 2015).

The geology of the studied area mainly consists of Triassic, Jurassic Cretaceous ,Miocene and Mio-Plio-Quaternary formations (Figure.1) (Savornin, 1920 ; Galcon,1997; Guiroud,1973; Vila,1980). The Triassic formation is a little bit found everywhere. The evaporate (gypsum ,anhydrite and halite), clay and carbonate minerals (limestone and dolomite) are the predominant minerals in the Triassic formation .In the South ,Jurassic and Cretaceous formations are mainly observed in Djebels Boutaleb ,Djebel Hadjar Labiod and Foural . In the North ,these formations are observed in Djebels Kalaoun and Sekrine. The Jurassic formation is formulated by limestone,dolomite ,and marl (Guiroud ,1979).In the studied area the Cretaceous formation is subdivided into four : (1) Neocomien is formulated by clay, marl and dolomite ,(2) Barremian is constituted by limestone ,dolomite ,Sandstone and marl (500m), (3) Aptian. In the north, this formation is constituted by marl of about 60 m thick ,but in the south is constituted by limestone and dolomite (300m) ,(4) Cenomanian-Turonian is formulated by limestone and dolomite (150m).The Miocene formation is constituted by limestone, Sandstone, dolomite and conglomerate. Mio-Plio-Quaternary formation showing a a heterogeneous continental detritical sedimentation (Boutaleb, 2001; Belkhiri, 2005; Atoucheik, 2006).

MATERIALS AND METHODS

Sample collection and analysis

Surface sediments (0-5 cm) samples from three soil were collected from 15 stations (march 2015) at Ain Azel

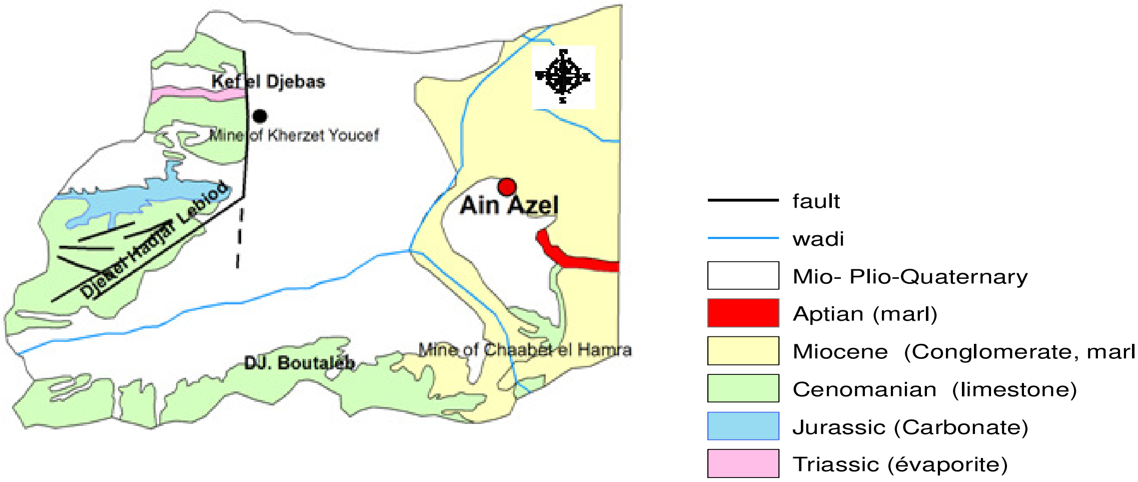

Figure 1: Geological Map of Ain Azel area

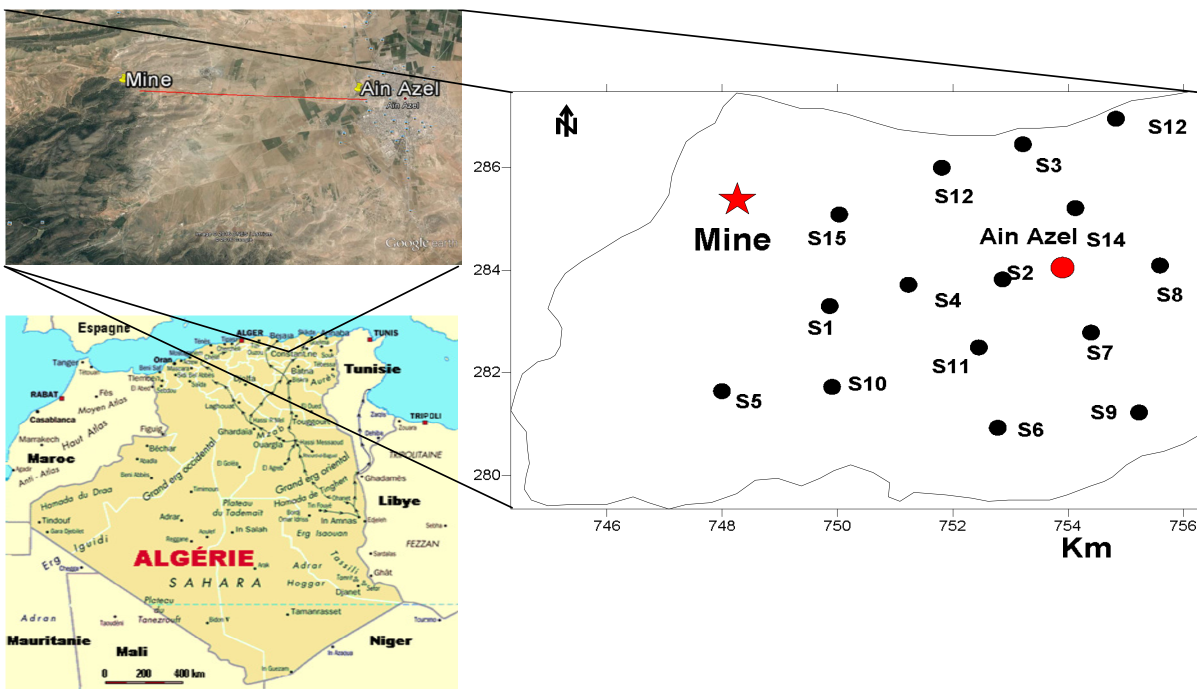

Figure 2: Map of localization of soils samples

area (Figure 2) .At each station, the surface sediment samples were collected by scraping the surface layer using a clean plastic spoon. The surface sediments of each sample were placed in polyethylene plastic bags and they were then kept in an ice box.In the laboratory , after air drying the soil samples at room temperature ,the samples were passed through a 2 mm nylon siev . The fraction less than 2mm was ground in an agate mortar and passed through a 63µm sieve to obtain silt and clay fraction. The total metals (Fe , Pb , Cu , Zn, Cd and Cr) were digested using mixture (HNO_3 +HCl)-$HClO_4$ – HF in an open system as described in (APHA (1998) and Hyacinthe and Van Cappellen (2004)

The concentrations of the constituent elements were measured using Atomic Absorption spectrometry (AAS) using Perkin Elmer AAS 3300 with (air –acetylene flam. The results obtained were subjected to analysis to determine the Geo-accumulation Index, Enrichment

Table 1: Muller ‘classification for geo- accumulation index

I_{geo} class	I_{geo} value	Designation of sediment quality
0	0	Uncontaminated
1	0-1	Uncontaminated to moderately contamination
2	1-2	Moderately contaminated
3	2-3	Moderately to heavily contaminated
4	3-4	Heavely contaminated
5	4-5	Heavely to extremely contaminated
6	> 5	Extremely contaminated

Table 2 : Classification of Contamination factor and level of contamination

CF Index	Contamination categories
CF< 1	low contamination
1≤ CF <3	moderate contamination
3≤ CF ≤6	considerable contamination
CF > 6	Very high contamination

The PLI of the place are calculated by obtaining the n-root from the n-CF_S that was obtained For all the metals

Factor, Pollution Load Index, Contamination factor, potential Ecological Risk Index of the metals in the environment.

Geo-accumulation Index (I_{geo})

Geo-accumulation Index was introduced by Muller 1969for determining the extent of metal accumulation in sediment ,and has been used by various workers for their studies . I_{geo} is defined as:

$$I_{geo}= \log_2 \frac{C_n}{1.5B_n} \quad (1)$$

Wher C_n is the concentration of element in the sediment ,B_n is the geochemical background value .The factor 1.5 is incorporated in the relationship to take into account a possible variation in background data due to lithogenic effect. The geo-accumulation index (I_{geo}) scale consists of seven grades (0-6) ranging from unpolluted to highly polluted soils . The standard Indice values are presented below (Table 1)

3.3 Pollution load index (PLI)

Pollution load index (PLI) represents the number of times by which the heavy metal concentrations in the sediment exceeds the background concentration, and gives a summative indication of the overall level of heavy metal toxicity in a particular sample (Priju and Narayana, 2006). The pollution load index (PLI) is a function of concentration factors (CF) . The CF is obtained by dividing the concentration of each metal by the background concentration .Generally pollution load index (PLI) as developed by (Tomlinson et al,1980.) which is as follows (Table 2)

$$CF = C \text{ metal} / C \text{ background value} \quad (2)$$

$$PLI = \sqrt[n]{CF1.CF2.CF3 \ldots CFn} \quad (3)$$

CF = contamination factor, n = number of metals.
C metal = metal concentration in polluted sediments.
C Background value = background value of that metal.
If The PLI value > 1 than the soil is considered as polluted, whereas PLI < 1 indicates no pollution (Harikumaret al., 2009). The world average concentration of reported shale were considered as the background value (Turekian and Wedepohl, 1961).

3.4 Enrichment factor (EF)
The enrichment factor is the relative abundance of a chemical element in a soil compared to the bedrock. Enrichment factor is a convenient measure of geochemical trends and is used for comparison between areas (Hernandez et al., 2003).
The enrichment factor is expressed as follow

$$EF = \frac{\left(\frac{C_n}{C_{ref}}\right)\text{sample}}{\left(\frac{B_n}{B_{ref}}\right)\text{Background}} \quad (3)$$

Where
Cn (sample) = the metals concentration in a sample.
Cref (sample) =the reference metals concentration.
Bn (Background) = the metals concentration in reference (background) environment
Bref (background) = the reference metals concentration in reference background environment.

Table 3 : Contamination categories based on enrichment factor (EF)

Value	Soil dust quality
EF< 1	Not enrichment
1<EF< 2	Minor enrichment
2<EF<5	Moderate enrichment
5<EF<20	Significant enrichment
20< EF<40	Very high enrichment
EF> 50	Extremely high enrichment

Table 4 Contamination categories based on contamination factor (CF)

CF Index	Contamination categories
CF< 1	low contamination
1≤ CF <3	moderate contamination
3≤ CF ≤6	considerable contamination
CF > 6	Very high contamination

Table 5: Cd degree of contamination.

C_d	degree of contamination
C_d< 8	Low degree of contamination
8≤C_d <16	Moderate degree of contamination
16≤C_d < 32	Considerable degree of contamination
C_d >32	Very high degree of contamination

The Enrichment Factors (EF) was calculated to evaluate the abundance of metals in sediments.
According to Acevedo-Figueroa et al. (2006) five contamination categories are recognized on the basis of the enrichment factor (Table 3)

Contamination factor (Cf)

CF value are suggested (Table 4) for describing the contamination factor (Hakanson ,1980).Contamination factor calculated by following equation 4

$$CF= \frac{C_{metal}}{C_{Backgroundvalue}} \quad (4)$$

C_{metal}= metal concentration in polluted sediments
$C_{Background\ value}$ = background value of the metal

Degree of Contamination (Cd)

The degree of contamination (C_d) was defined as the sum of all contamination factors .The following terminology was adopted to describe the degree of contamination for the selected metals (Table 5).

Modified degree of contamination (mC_d)

As a result of the above limitations ,Abrahim (2005) presented a modified and generalized form of the Hakanson (1980) equation for the calculation of the overall degree of contamination at a given sampling site
The modified equation for a generalized approach to calculating the degree of contamination is given below :

$$mCd= \frac{\sum_{i=1}^{n} C_f^i}{n} \quad (5)$$

Where n = number of analyzed elements and i=ith element (pollutant) and C_f contamination factor . Using this generalized formula to calculate the mC_d allows the incorporation of as many metals as the study may analyze with no upper limite .the expanded range of possible pollutants can thus include both heavy metals and organic pollutants schould the latter be available for the studied samples .for the classification and description of the modified degree of contamination (mC_d) in soils sediments the following graduations are proposed .(Table 6)

Potential Ecological Risk index

The Potential Ecological Risk Index (PERI) proposed by Hakanson (1980) to evaluate the potential ecological risk of heavy metals. This method comprehensively considers the synergy, toxic level ,concentration of the heavy metals and ecological sensivity of heavy metals (Nabholz, 1991; Singh et al.,2010 ; Douay et al.,2001).

Table 6 : Modified degree of contamination classification and description

mC_d	Classification
mC_d<1.5	Nil to very low degree of contamination
1.5<mC_d<2	Low degree of contamination
2<mC_d<4	Moderate degree of contamination
4<mC_d<8	High degree of contamination
8 <mC_d<16	Very high degree of contamination
16 <mC_d<32	Extremely high degree of contamination
mC_d≥ 32	Ultra high degree of contamination

Table 7: Criteria for degrees of ecological risk caused by heavy metals in sediments

E^i_R	class	RI	Risk level	Risk degree
E^i_R< 30	Low	RI<40	A	Low risk
30< E^i_R < 60	Moderate	40≤RI<80	B	Moderate risk
60 < E^i_R < 120	Considerable	80≤ RI<160	C	Considerable risk
120 < E^i_R 240	High	160≤RI<320	D	Very high risk
E^i_R> 240	Very high	RI≥320	-	

PERI is formed by three basic modules ; degree of contamination (Cd) ,toxic –reponse factor (T_R) and potential ecological risk factor (E_R).According to this method ,the potential ecological risk index of a single element (E^i_R) and comprehensive potential ecological index (RI) can be calculated via the following equations

$$C^i_f = C^i_f / C^i_R \quad (6)$$

$$E^i_R = T^i_R \times C^i_f \quad (7)$$

$$RI = \sum_{i=1}^{m} E^i_R \quad (8)$$

Where C^i_f is the measured concentration of heavy metal in each sampling point ; C^i_R is reference value ,here the background value of each heavy metal in soil is used ; C^i_f is the pollution of a single element ;RI is a comprehensive potential ecological risk index ; and T^i_R is the biological toxic factor of a single element ,which is determined for Zn = 1 , Pb= 5 , Cu = 5 , Cr = 2 , Cd =30 (Hakanson, 1980). The adjusted grading standards of potential risk of heavy metals in soil were summarized in (Table 7)

RESULTS AND DISCUSSION

Elemental concentration in soils

The concentration of heavy metals in soils collected and analyzed from the study area are presented in (Table 8). The mean concentration of Pb ,Zn ,Cu , Cr , Cd ,and Fe were ,36.30 mg/kg , 30.30 mg/kg ,13.43 mg/kg , 10.84 mg/kg , 0.91 mg/kg ,24721 mg/kg respectively.

High metal concentration in the soil were found for Fe ,Pb , Zn , Cu ,Cd ,while Cr had the least concentration . The mean values of the heavy metals contents can be ranked in the order of Fe, Pb , Zn ,Cu ,Cr and Cd

Geo-accumulation index

The geo-accumulation index of heavy metals for the soil of the study area is given in (Table 9) . The mean Geo-accumulation index trend for heavy metals were Fe > Cd > Pb > Cu > Cr > Zn .The elemental concentration in the studied soil sample could be categorized as : (1) Fe and Cd Moderately to heavily contaminated class , (2) Pb Uncontaminated to moderately contamination class , (3) Zn ,Cu ,Cr Uncontaminated class.

Enrichment factor

The enrichment factor (EF) is a suitable measure of geochemical trends and is used for making comparisons between areas. Because of the natural basis of metal elements, the gross concentrations of metal elements don't demonstrate the anthropogenic contribution specifically. The evaluation of heavy metals from anthropogenic contribution must be made clair. Majority of geogenic contamination and anthropogenic constituents of heavy metals in term of their distribution ,contribution ,and significant threats to living organism can be explained through enrichment factor (Atgn et al. 2000).The enrichment factor for Pb ,Zn ,Cu, Cr and Cd were 2.99, 0.51, 0.63 , 0.26,and 8.13 . Zn ,Cu , and Cr in depletion range , while Pb and Cd were enriched in the

Table 8 : Heavy metals concentration (in mg/kg) in soils of the Ain Azel area

Stations	Pb mg/Kg	Zn mg/Kg	Cu mg/Kg	Cr mg/Kg	Cd mg/Kg	Fe mg/Kg
1	16.50	11.50	09.5	10.50	1.91	18400
2	26.40	19.30	08.3	15.47	0.74	15330
3	20.16	32.40	13.4	18.12	0.52	20150
4	21.17	14.52	15.17	10.42	0.89	19630
5	32.50	15.47	11.12	13.42	1.72	12460
6	16.80	10.41	09.76	9.15	0.65	19980
7	10.45	18.32	15.42	11.76	0.54	22140
8	15.32	12.10	10.52	8.10	0.43	16470
9	58.12	52.14	10.77	6.14	0.35	43890
10	78.23	63.10	15.23	8.56	0.71	38450
11	81.45	72.19	21.73	21.46	0.47	37120
12	94.79	89.47	20.19	5.12	0.61	44190
13	19.16	15.16	11.24	10.26	0.38	19780
14	10.48	08.13	13.10	7.23	0.54	18650
15	42.90	23.85	16.26	6.89	3.25	24180
Background	20	95	45	90	0.30	46700
Min	10.45	8.13	8.30	5.12	0.35	12460
Max	94.79	89.79	21.73	21.46	3.25	44190
Mean	36.30	30.30	13.43	10.84	0.91	24721

Table 9: Index of Geo-accumulation of heavy metals in soils of Ain Azel area

Stations	I_{geo} Pb	I_{geo} Zn	I_{geo} Cu	I_{geo} Cr	I_{geo} Cd	I_{geo} Fe	I_{geo} Class					
							Pb	Zn	Cu	Cr	Cd	Fe
1	-0.86	-3.63	-2.82	-3.68	2.08	1.41	0	0	0	0	3	2
2	-0.18	-2.88	-3.02	-3.12	0.71	1.15	0	0	0	0	1	2
3	-0.57	-2.13	-2.36	-2.89	0.20	1.54	0	0	0	0	1	2
4	-0.50	-3.40	-2.15	-3.69	0.98	1.50	0	0	0	0	1	2
5	0.11	-3.20	-2.60	-3.33	1.93	0.87	1	0	0	0	2	1
6	-0.83	-3.77	-2.78	-3.88	0.53	1.53	0	0	0	0	1	2
7	-1.52	-2.95	-2.13	-3.52	0.26	1.68	0	0	0	0	1	2
8	-0.97	-3.55	-2.68	-4.05	-0.06	1.25	0	0	0	0	0	2
9	0.95	-1.44	-2.64	-3.64	-0.36	2.66	1	0	0	0	0	3
10	1.38	-1.17	-2.14	-3.97	0.65	2.47	2	0	0	0	1	3
11	1.44	-0.98	-1.63	-2.65	0.06	2.42	2	0	0	0	1	3
12	1.65	-0.67	-1.74	-2.63	0.43	2.67	2	0	0	0	1	3
13	-0.64	-3.23	-2.58	-3.72	-0.24	1.51	1	0	0	0	0	2
14	-1.51	-4.13	-2.36	-4.72	0.26	1.43	0	0	0	0	1	2
15	0.51	-2.57	-2.05	-4.70	2.85	1.80	1	0	0	0	3	2
Min	-1.52	-4,13	-3,02	-4,72	-0,36	0,87						
Max	1.65	-0,67	-1,63	-2,63	2,85	2,67						
Mean	-0,10	-2,64	-2,37	-3,61	0,68	2.68						

study area (Table 10) .The enriched trends for heavy metals in the study area were Cd > Pb>Cu> Zn >Cr .

Table 10 : Enrichment Factor (EF) of heavy metals in soils of Ain Azel area

Stations	EF Pb	EF Zn	EF Cu	EF Cr	EF Cd
1	2.09	0.33	0.53	0.29	20.31
2	4.02	0.61	0.56	0.52	7.53
3	2.33	0.49	0.67	0.46	4.03
4	2.51	0.36	0.80	0.27	7.07
5	6.09	0.61	0.92	0.55	21.56
6	1.96	0.25	0.50	0.23	16.09
7	1.10	0.40	0.72	0.27	5.07
8	2.17	0.36	0.66	0.21	4.07
9	3.09	0.58	0.25	0.07	1.24
10	4.75	0.80	0.40	0.18	2.87
11	5.07	0.95	0.60	0.29	1.96
12	2.86	0.99	0.47	0.05	2.15
13	1.31	0.37	0.58	0.26	3
14	1.39	0.21	0.72	0.20	4.15
15	4.14	0.47	0.69	0.14	20.93
Min	1.10	0.33	0.25	0.07	1.24
Max	6.0	0.99	0.92	0.52	21.56
Mean	2.99	0.51	0.63	0.26	8.13

Table 11: Contamination Factor (CF) , Contamination degree (C_d) , mead contamination degree (mC_d) , and Pollution Load Index in soils of Ain Azel area.

Stations	CFPb	CF Zn	CF Cu	CF Cr	CF Cd	CF Fe	C_d	mC_d	PLI index
1	0.82	0.12	0.21	0.11	6.36	0.39	8.02	1.27	0.63
2	1.32	0.20	0.18	0.17	2.46	0.39	7.66	1.28	0.64
3	1.00	0.34	0.29	0.20	1.73	0.43	7.94	1.32	0.73
4	1.05	0.15	0.33	0.11	2.96	0.42	8.86	1.48	0.53
5	1.62	0.16	0.24	0.14	5.73	0.26	10.72	1.81	0.73
6	0.84	0.10	0.21	0.10	2.16	0.42	7.75	1.29	0.51
7	0.52	0.19	0.34	0.13	1.80	0.47	7.79	1.30	0.59
8	0.76	0.12	0.23	0.09	1.43	0.35	12.17	4.05	0.55
9	2.90	0.54	0.24	0.06	1.16	0.93	13.25	2.20	0.78
10	3.19	0.66	0.34	0.09	2.36	0.82	14.70	2.45	1.03
11	4.07	0.75	0.48	0.23	1.56	0.78	15.15	2.52	1.25
12	4.73	0.94	0.44	0.05	2.03	0.94	18.06	3.01	1.10
13	0.95	0.15	0.24	0.11	1.26	0.42	7.01	1.16	0.53
14	0.52	0.08	0.29	0.08	1.80	0.39	6.83	1.13	0.45
15	2.14	0.25	0.36	0.07	10.83	0.51	18.89	3.14	0.95
Min	0.52	0.08	0.18	0.05	1.16	0.26	6.83	1.13	0.45
Max	4.73	0.94	0.48	0.23	10.83	0.94	18.89	4.05	1.25
Mean	1.76	0.63	0.29	0.12	3.04	0.52	10.98	1.96	0.73

Contamination factor (CF) ,Contamination degree (C_d),mead contamination degree (mC_d) and pollution Load index (PLI)

Soils samples in the station of study area were also assessed contamination factors, degree of contamination, modified degree of contamination and pollution load index are given in (table 10). The overall contamination of soils in study area ,based on the Contamination factor (CF) values indicate that the soils were contaminated with Cd and Pb ,and low contamination of other metals (Zn ,Cu ,Cr, Fe).The degree of contamination shows a low degree of contamination in stations 2, 3,6, and 7, moderate degree of contamination in stations 1,4,5,8,9,10 and 11 , considerable degree of contamination in station 15. The modified degree of contamination suggest that high degree of contamination in station 8 , moderate degree of contamination in stations 9,10,11,12,and 15, Low degree of contamination in station 5, Nil to very low degree of contamination in stations 1,2,3,4,6,7, and 13.

Pollution load index (PLI) was used to determine the pollution severity and its variation along the study area and also it can be used as a tool to compare the pollution status of different stations(Rabee et al.,2011).Results of the present study showed that pollution index (Table 11)

Table 12: Potential ecological risk index.

Stations	E^i_r					RI.	Pollution degree	Risk level
	Pb	Zn	Cu	Cr	Cd			
S1	4.1	0.24	1.05	0.11	190.8	196.3	MR	B
S2	6.6	0.4	0.9	0.17	73.8	81.87	LR	A
S3	5	0.68	1.45	0.20	51.9	59.63	LR	A
S4	7.5	0.3	1.65	0.11	87.8	97.36	LR	A
S5	8.1	4.32	1.20	0.14	171.9	185.66	MR	B
S6	4.2	0.20	1.05	0.10	64.8	70.35	LR	A
S7	2.6	0.95	1.7	0.13	54	59.38	LR	A
S8	3.8	0.24	1.15	0.09	42.9	48.18	LR	A
S9	14.5	1.08	1.2	0.06	34.8	51.64	LR	A
S10	15.95	3.3	1.7	0.09	64.8	85.84	LR	A
S11	20.35	1.5	2.4	0.23	46.8	71.28	LR	A
S12	23.65	1.88	2.2	0.05	60.9	88.68	LR	A
S13	4.7	0.3	1.2	0.11	37.8	44.11	LR	A
S14	2.6	0.16	1.45	0.08	54	58.29	LR	A
S15	10.7	0.5	1.8	0.07	324.9	337.97	HR	C
Min	2,60	0,160	0,900	0,050	34,8	44,1		
Max	23,65	4,320	2,400	0,230	324,9	338,0		
Mean	8,96	1,070	1,473	0,116	90,8	102,4		

were found to be generally low(<1) in stations 1,2,,4,5,6,7,8,9 , 13,14,15 and PLI > 1 in stations 10,11,12 these confirmed that the area is probably polluted by heavy metals (Pb and Cd)

Potential Ecological Risk Index

The results of evaluation on potential ecological risk factor (E^i_r) and the potential ecological risk index (RI) are summarized in (table 12). The distribution of minimum, maximum and mean potential ecological risk for environment in the soil samples of the study area showed that Cd posed high risk to ecological system. The order of potential ecological risk coefficient (E^i_r) of heavy metals in sediment of the study area was Cr>Pb>Cu>Zn>Cd . The Ecolological risk index (ERI) for the soil of the study area indicated that Zn ,Cu and Cr were low risk (Figure 3).

CONCLUSIONS

On the basis of multi-approach analysis, including geo-accumulation index ,enrichment factor , Contamination factor (CF) ,Contamination degree (C_d), mead contamination degree (mC_d) pollution Load index (PLI) and Potential ecological risk index ,it has been noticed that the soil of the Ain Azel area is affected by heavy metals due to mine and industry treatment of lead –Zinc .These toxic metals can cause environmental problems in ecosystems of the area due to the release of heavy metals (Pb ,Cd) from the contaminated soil to the groundwater systems and also in the plants and vegetation grown in the soil.This situation should be regularly monitored for health –related problems in the inhabitants ,because the cancer prevalence is elevated in the Ain Azel area.

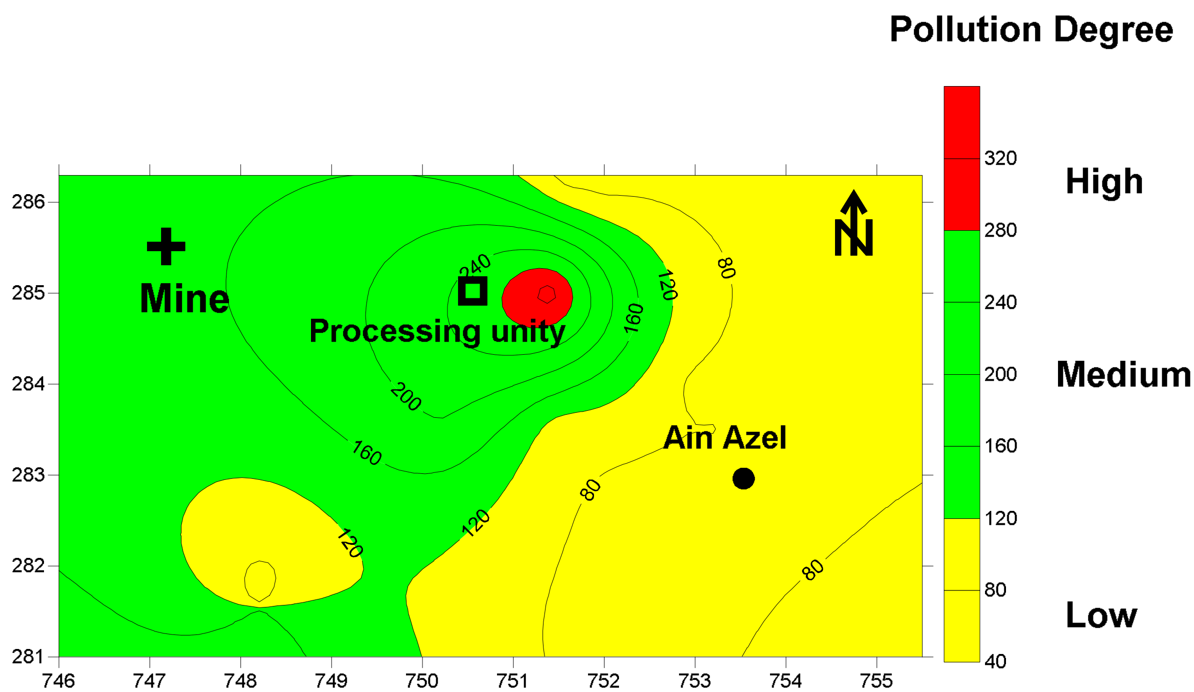

Figure 3: map of pollution degree

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