International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 18 No. 1 Oct. 2016, pp. 297-306

http://www.ijias.issr-journals.org/

Metal Traces Elements contents in cultivated and uncultivated soils of Constantine region (Algeria) dosed by x-ray fluorescence

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ABSTRACT: Metal Traces Elements are present in agricultural soils, because they are naturally the Earth's crust components. But also because of human intake. They are more or less with drawed by the cultivated plants and can potentially cause safety problems of agricultural products destined to the human being food and animals feed. These metal or metalloids are called "traces" because they are present in very low concentrations in the earth's crust or in the living organisms' .they designate oligo-essential elements in the biological processes, but toxic at high levels (zinc. Copper .selenium chrome) .a soil rich in these elements cause a real environmental problem. The main aim of this study is determining the rates of these elements, for us, we used the technique of x-ray fluorescence. The analysis results showed the existence of undesirable elements such as lead, zinc, arsenic and selenium Se as element in question with minor rates in some studied sites. Among these sites: the pilot farm of Bouaoune, the pilot farm of Baaraouiya.

KEYWORDS: trace element, heavy metals, soil pollution, x fluorescence, Metallic Elements Traces dosage.

1 INTRODUCTION

Modern man must pay a particular attention to the ground. Furniture coverage of the earth's crust has its elementary components inert or living, and has its ecological functions .in fact, this natural source is now subject to increasingly strong pressures uses. In the ecosystem, soil is not a holder compartment, an inert compartment. The soil is an organized material that transforms, absorbs, adsorbs and in which circulate energy flow and material flow.

Metal Traces Elements rates (MTE) in soils vary according to the geochemical background and atmospheric deposition of natural (volcanism, erosion, dust) or anthropogenic (industry, transport) and contributions by man (fertilizers, pesticides, animal waste, sewage sludge, etc.). Metal Traces Elements enter the food chain in particular because of their absorption by plants of different cultures. Indeed, the evolution of cultures is mainly due to a significant size and textural heterogeneity of soil and to a considerable fertility, generally controlled by the presence of the organic matter. The latter plays an important role of maintaining the structural stability which in turn influences the physical, chemical and biological properties in the conservation or increase the ability of soil to retain water (Gregorich, 1997), regulates biological activities and contributes to the diversity and complexity of soils (Genot et al., 2007).

The mineral elements in the soil are important for the development and growth of crops. The amounts of minerals transferred throughout the food chain from the plant to the animal and to the human being, depend on the levels present in the soil. In soils, the mineral elements are grouped into major elements and into a trace elements, the latter being the 80 chemical elements whose concentration in the earth's crust, is for each of them less than 0.1%. They together account for

0.6% of total mineral elements, while the major elements 12 intervene to 99.4% (Scardigli, 2006). In addition to proteins, carbohydrates and fat, our body absolutely needs minerals as well as vitamins. They accelerate metabolic reactions (enzyme catalysts) and involved in the production and regulation of hormones in the expression of immune defenses and protection against certain oxidizing compounds (Scardigli, 2006). The major elements are generally required in fairly large quantities and micronutrients in small quantities. The first objective of fertilization is to provide the major components plants. Lack or excess of these minerals is often responsible for low crop yields.

Thus the objective of this work consists of a physicochemical characterization of agricultural soils of pilot farms (cultivated and uncultivated) in the region of Constantine and in the determination of levels of trace metals and trace elements.

2 MATERIALS AND METHODS

GEOGRAPHICAL AND GEOLOGICAL SITUATION OF THE STUDY AREA

Constantine is a town in the center of eastern Algeria that lies between latitude 36 ° 17 'and longitude 6 ° 37' precisely 245 km of Algerian Tunisian border,and of 431 km from the capital Algiers westward and of 89 km from Skikda to the north and of 235km from Beskra south.

Constantine is limited:

- in the north by Skikda;
- to the east by Guelma;
- to the west by Mila;
- in the South by of Oum el Bouaghi.

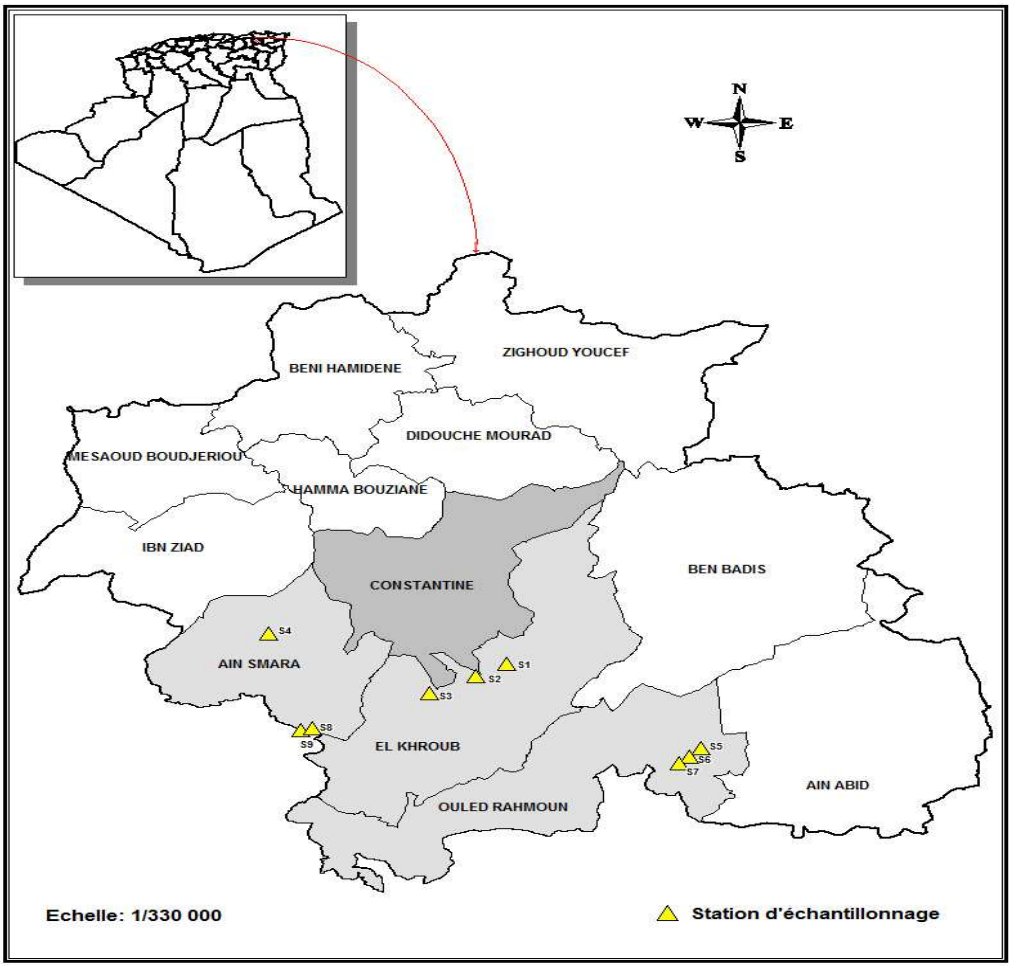

Fig. 1. Constantine Geographical map

It is built on a majestic rock on both sides of Wadi Rhumel, it is well surrounded by genuine natural obstacles; geographical landmarks show that the region is not homogeneous with respect to its position relative to sea level. It is between the two KENTOUR lines 400 and 800 m and 1200 m to the south. Constantine is among the most important provinces of the country, it covers an area of about 2297.20 square kilometres.

SOIL CHARACTERIZATION OF EXPERIMENTAL SITES

The study is reported in four pilot farms of Constantine region, coordinated sites are reported in Table N°1.

Site N° 1: The pilot farm of Baaraouiya (a plot of 500 m2 remained fallow for about six years uncultivated land
Site N°2: Experimental Farm ITGC belonging to Ain El Bey Tray, within the municipality of El Khroub; cultivated plot intended for cropping farm trials.
Site N° 3: Khadri Ibrahim pilot farm comprising (cultivated plot) located in Ain El Bey.
Site N° 4: The pilot farm Khadri Ibrahim (cultivated plot) located at the exit of Ain Smara town.
Site N° 5: The pilot farm Bouaoune Bounouara (cultivated land).
Site N° 6: The pilot farm Bouaoune Bounouara (cultivated land).
Site N° 7: The pilot farm Bouaoune Bounouara (uncultivated land).
Site N° 8: The pilot farm Bouchebaa, located in the new city of Constantine (cultivated land).
Site N° 9: The pilot farm Bouchebaa uncultivated land.

We conducted our study on cultivated and uncultivated plots; in the Table N°1 are grouped coordinates of the new sites.

Table N° 1: Coordinates of sampling sites in Constantine region.

Coordinates	**Latitude** (N)	**Longitude** (E)
S1	36° 16' 30,22''	6° 40' 18,10''
S2	36° 15' 53,36''	6° 38' 52,19''
S3	36° 15' 1,58''	6° 36' 43,98''
S4	36° 18' 1,32''	6° 29' 24,87''
S5	36° 12' 20,97''	6° 49' 6,99''
S6	36° 12' 15,91''	6° 49' 3,40''
S7	36° 11' 59,43''	6° 48' 51,65''
S8	36° 13' 16,84''	6° 31' 24,19''
S9	36° 13' 17,82''	6° 31' 28,24''

The land of these farms are occupied by calcimagnesic soils, characterized by low depth which is due to the presence of calcium crust and crust at a stony load moderately important.

These areas cover a larger area, generally located on the lower grounds and very low slope (land of Baaraouiya pilot farm and ITGC: alluvial terraces of Oued Boumerzoug) are characterized by a deep profile and fine surface texture and very thin in depth. The soil is very beating; dry period is very compact and difficult to work in wet period it is full of water, so the plot is impractical.

CLIMATIC CHARACTERISTICS OF THE REGION

Belonging to the Mediterranean region, climate study area is characterized by an average rainfall distributed with a great irregularity in time. The humidity is higher in winter (from 75 to 76%) than in summer (38-53%), it is accentuated by rainfall (500-600 mm) and wind North-South direction. The climate ranges from the sub - humid and semi - arid.

Sampling: In this study, sampling was performed from 15 to 20 samples per parcel by the vertical lines and the method zigzag method using an auger or a stainless steel scoop in the plow layer (from 0-30 cm of depth).

Generally selected parcels are parcels for large crops (Durum wheat, soft Wheat, Barley, and Oats) and for non-cultivated plots. The samples were collected in four pilot farms in the plow layer (from 0-30 cm of depth). They have been preserved, from the sampling to the laboratory in sealed plastic. In the laboratory we performed the removal of stones and plant debris with a sieve size of 2mm diameter. Samples designated for physicochemical analysis are sieved on a sieve diameter of 0,140mm and dried in air then in an oven at a temperature of 105 ° C to the constant weight. The fine fraction was selected on two criteria:

- The metals are most associate with the fine fraction
- determination of X-ray metals fluorescence requires the use of very fine particle size and the choice of a uniform fraction.

The samples were subjected to routine analysis, parameters and methods used are summarized in Table 2 (particle size analysis, pH, electrical conductivity, available phosphorus, organic carbon, total nitrogen, and cation exchange capacity) in soils analysis laboratory and agricultural fertility FERTIAL of Annaba. Other samples (sieved 0,140mm) were used for assay by X-ray Fluorescence major elements and trace elements in Chemistry Research Unit of Environmental and Molecular Structural laboratory (CHEMS). University of Mentouri brothers of Constantine.

Table N° 2: element and analytical techniques

Parameters	Technical analysis
Granulometry	NF X 31-107
organic carbon	NF ISO 10694
total nitrogen	NF ISO 13878
pH	NF ISO 10390
total limestone ($CaCO_3$)	NF ISO 10693
Phosphorus	NF X 31-161
cationic exchange capacity (CEC)	NF X 31-130
electric Conductivity (EC)	NF X10970
exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+})	NF X 31-108
Manganese (Mn^{2+})	NF X 31-120
Metal traces elements MTE	Fluorescence XRF

DETERMINATION OF MAJOR AND MINOR ELEMENTS IN AGRICULTURAL SOILS USING XRF FLUORESCENCE:

XRF is a non-destructive method, accurate, fast and without any negative impact to the environment. The elements of the periodic table from Beryllium to Uranium can be measured simultaneously on the same sample qualitatively and quantitatively. Concentrations close to 100% can be obtained without dilution, contrary to ASA: atomic absorption, with a very good reproducibility. The detection limits for trace elements is of the order of PPM. Tables' N° 6 and N° 7 respectively show the contents of major elements and trace elements in the two soil types (cultivated and not grown). From Given results, we note that the contents of the major elements of the majority of samples of uncultivated soil are slightly above the levels of the cultivated soil and this is probably due to the long period of fallow.

Statistical analyzes: in order to determine the existence or absence of a correlation between the physic-chemical parameters studied and metal trace elements, a statistical analysis of variance by Spearman correlation test was performed. For this, Excel and SPSS software statistics, Version 20 were used**.**

3 RESULTS

Characteristics of soil study. MTE behaviour in soil is influenced by the physical and chemical soil characteristics (texture, pH, organic matter, total limestone, CE and CCC.) [INRA, 2002]. Knowledge of the particle size is particularly important because the fine fractions and in particular clays provide soil cohesion because of their electrical properties and their lamellar structure. The clay rate is higher (69.66%) in the cultivated soil in uncultivated soil is (64.33%). Soil texture of the sites is argillaceous-sandy. The values of the sand fraction are (26.46%) and silt is (18.77%) and of uncultivated soil is higher than those of the cultivated soil.

Table 3: The Granulometry of both types of soil

		CLAY %	SAND %	SILT %
Granulometry of cultivated soil	**S2**	**48**	**23,4**	**28,6**
	S3	**50**	**26,20**	**23,80**
	S4	**69,66**	**17**	**13,33**
	S5	**61,14**	**28,28**	**10,57**
	S6	**64,57**	**25,14**	**10,28**
	S8	**53,33**	**30**	**16,66**
Granulometry of uncultivated soil	**S1**	**46,4**	**23,4**	**30**
	S7	**64,33**	**26, 00**	**9,66**
	S9	**53,33**	**30**	**16,66**

Physico - chemical characteristics: For all sites, the water pH of samples analyzed is alkali (means pH greater than 7) look at (Table N° 4). This pH can block the absorption or availability of phosphorus; Boron, Copper, Iron, Manganese and Zinc in the plant (works of BENSAADI A...). The pH values are lower in uncultivated soils (minimum of 7.92 and minimum of 8.62) compared with cereals grown in soil have a minimum of 7.99 and a maximum of 8.38.

Measurements of the electrical conductivity of a site reveal variable values to another. These values are lower in cultivated soils (0,244mmhos / cm) than in non-cultivated soils (0,357mmhos / cm). Of same, for the assessment of soil salinity risk (EC), it is highly dependent on the organic matter content and affects the growth of crops as well as vegetative part of the roots look at (Table N° 4) and an electrical conductivity less than 0.7 so there is little risk of soil salinity.

Active lime rates were analyzed and we look for the limestone rate that can block the absorption of fertilizers. Indeed, the analyzed samples have a high lime content (> 16%) and for non-cultivated soil is less lime content (<12%) for the cultivated soil, except for the sample Ain Smara S4 (1.859%) and the sample of Bouchebaa S8 is (1.421%). For these latter samples, it is necessary to follow its evolution in time to avoid later blocking problems caused by this element.

The CEC is the index of soil fertility. The values of this parameter are more important to the uncultivated soil (22.22 mEq / 100g) than the cultivated soil and this because of the fallow years carried out on these sites. So they can be classified in ascending order of MO:

Cultivated ground: **S5> S6> S2> S4> S8> S3.**

Uncultivated ground: **S7> S9> S1.**

Organic Statute. Regarding the organic matter content, almost all of the samples have a low organic matter content (<1.5%) (Table 4). These results all rates are outside the range proposed by Eliard [2-5%] only a single sample site S1 has a higher rate of approximately 2.392% probably because of the long period fallow (5 years or more). These levels show that these soils are fairly loaded MO much of which consists of TOC (Table 4) and the ratio varies between 4.6% and 3.7%. They can be classified in ascending order of MO:

Cultivated ground: S4> S8> S5> S6> S2> S3

Sol Not Grown: S1> S9> S7

The C / N ratio is considered as the index of the good or the bad evolution of the Organic Material. The value of this ratio recorded in the two types of soil is optimal and estimated at 10 which represent the maximum decomposition of the nitrogen.

Table 4: Physical and chemical characteristics of the two types of soil

physicochemical parameters	*Cultivated soil*	*uncultivated soil*
Average pH water *Variation*	**8,38** **7,99 - 8,790**	**8,398** **7,92 - 8,62**
CE Average conductivity *(Mmhos / cm) Variation*	**0,244** **0,119 - 1,734**	**0,357** **0,106 - 3,02**
Active lime % average *$CaCO_3$ Variation*	**11,66** **7,262 - 21,915**	**16,917** **14,545 - 19,278**
CEC average *meq/100g Variation*	**21,32** **17,160 - 24,855**	**22,22** **19,858 - 27,63**
Organic material average *MO% Variation*	**1,152** **0,462 - 1,914**	**1.439** **1,00 - 2,392**
Total nitrogen Moyenne *NT % Variation*	**0,1125** **0,064 - 0,166**	**0,1345** **0,038 - 0,170**
C/N average *Variation*	**10,24** **7,218 - 11,530**	**10,698** **14,070 – 26,315**

METAL TRACES ELEMENTS CONCENTRATIONS ON THE DIFFERENT STUDIED SITES

Average rates of the most abundant elements such as iron and manganese in soils are statistically comparable to the threshold α = 0.01. The recorded values at S6 (cultivated soil of Bouaoune at a depth of 60cm: 66070ppm at S5 (cultivated soil of Bouaoune at a depth of 30cm: 62285ppm) and at S7 (uncultivated soil of Bouaoune at 30cm of depth: 49800ppm) for Iron are relatively high in comparison to other studied sites regarding the manganese, we observe a disparity of concentrations: 49357ppm S5; 500ppm for S2 : 350ppm;for s3: 90and 50ppm for S8 and S9 respectively.

Significant differences are also observed for contents of Chrome, Nickel and Copper. For Chrome, the values of the S7 sites (240,83ppm); S5 (240ppm); S6 (239,28ppm); S8 (230ppm) which are higher than those found in S2 (160ppm); S3 (130ppm); S1 (120ppm); S4 (100ppm) and S9 (50ppm). The nickel content, it decreases in S5 (75ppm), S6 (74,28ppm) to S4 (20ppm), S9 (20ppm) through S2 (70ppm), S1 (60ppm), S3 (60ppm) and S7 (61, 66ppm).

For copper, the highest value is recorded in the site S8 (110ppm) and S9 (100ppm), while the other sites it is closer to one another, ranging from 50ppm at S2, S7 and S6: 40ppm for S3 and S5 and the lowest is recorded in the site S4:10ppm.

The other elements, namely; Zinc, Lead, cobalt, selenium and arsenic present some significant differences at α = 0.01 and α = 0.05 Table 7. The concentrations of these elements are more or less homogeneous and for the element Co there is only one value for the S4 site, three values for Se (S6 = 40ppm, 50ppm = S7, S1 = 60ppm), only two values for Pb at two sites namely S1 (110ppm) and 90ppm for S2. The values of Arsenic are 230ppm for S3 and 200ppm for S1.

Concerning zinc, four sites are devoid of this element, namely, S2, S4, S6 and S9. For other sites, the highest value is marked at S5 (600ppm), S3 (350ppm), S7 (300ppm) and S1 (22ppm).

TOTAL POPULATION OF MTE

Total concentrations were measured on the ten studied MTE (**Table 5**), soil samples collected for the study purposes. The order of abundance of elements is as follows:

Co> Fe> Mn> Cr> Zn> Cu> As> Pb> Ni> Se. The most variable elements are Cr, Ni, Zn, Cu, Mn and Fe (CV> 50%); the least variable elements are Co, Se, Pb and As (CV <25%).

Table 5: ETM coefficient variation dispersing of different studied sites

CV %	**Cu**	**Zn**	**Ni**	**Cr**	**Co**	**Se**	**Fe**	**Mn**	**Pb**	**As**
Cultivated soil	60	66	100	166	0	0	57,53	60	0	8,69
uncultivated soil	25	16,13	33,33	53,33	0	0	52,08	48,14	0	25

4 DISCUSSIONS

Only Cr, Co and Ni, in the studied sites, presented high values than those usually observed in most agricultural soils in the world. The contents of Zn, Mn and Fe are all in the area of critical contents in soils, which can cause toxicity phenomena, as reported by some authors, G. Colinet, N.K. Fageria and RB Clark who situate the critical contents in soils, for manganese, between 1000 and 3000 mg.kg $^{-1}$ for copper, 60 to 125 mg.kg $^{-1}$, for zinc, 100et between 250 mg. kg -1., 100 and between 250 mg. kg $^{-1}$.

Some MTE, namely Co, Se, Pb and As in the two types of studied soils present a relatively low coefficient variation, even zero. MTE with a low coefficient variation relatively have a slow potential mobility [N.U. Benson]. At the opposite, elements such as Cr, Ni, Cu, Zn, Mn and Fe are highly variable, thus weakly retained in the ground, which could make them most labile and more bio available and by the plant of [B.J. Alloway].

The statistical analysis showed that most of the MTE are cross-correlated linearly, significantly, which may suggest that these MTE coexist as components of minerals in soils. The differences of concentrations observed between sites and accumulation compartments of MTE in soil could be attributed to influence soil processes, combined between them, on the distribution of these MTE. Indeed, soil formation involves redistribution of soil components (carbonates, clays, oxides, organic materials), often governed by water infiltration in the soil profile [J.Legros].

Leached particles will tend to redeposit downstream of the profile, and give birth to soil layers with modified properties. These soil layers are qualified, respectively, of eluvial horizons (or leached) and of accumulation horizons [D. Baize]. The MTE associated with compounds having left the soil profile, or migrated within the profile and thus undergo enrichment and impoverishment.

Table 6: Total average contents of metals traces elements (values in mg / kg or ppm)

	Cultivated soil						Uncultivated soil			AFNOR NF U44-041	Agricultural soils
ElemeCu	**S2**	**S3**	**S4**	**S5**	**S6**	**S8**	**S1**	**S7**	**S9**		
Zn	50	40	10	40	51,42	110	40	50	100	100	60 – 150
Ni	0	350	0	600	0	130	22	300	0	300	1 – 300
Cr	70	60	20	75	74,28	60	60	61,66	20	50	20 – 60
Co	160	130	100	240	239,28	230	120	240,83	50	150	50 – 200
Se	-	-	642390	-	-	-	-	-	-	30	20 – 50
Fe	-	-	-	-	40	-	60	50	-	10	-
Mn	48700	34120	17110	62285	66074	9220	31300	49800	5450	-	-
Pb	500	350	100	49357	490	90	270	380	50	-	-
As	90	-	-	-	-	-	110	-	-	100	20 – 300
	-	230	-	-	-	-	200	-	-		-

The MTE no associated with leached materials, and living in the upper horizon are indirectly enriched, following the departure of material from this horizon, and, conversely, we can observe an impoverishment of immobile elements in the accumulation horizons, with a significant addition of material.

Leaching can also lead to the impoverishment of MTE of surface horizons, because, the water layer passing through the soil profile has the ability to dissolve the most labile elements and drive them in depth [D.Sparks]. The departure of the metals into the surface may be offset by their partial accumulation, further downstream, in the profile.

Concentrations in MTE of a ground undergoing metal leaching and leaching should grow with the Depth, at least until the horizon accumulation [D. Baize]. This is much more marked in Bouaoune pilot farm (S6), where the majority of MTE accumulate in the deep horizon.

By intervening the concept of parent rock, Baize indicated that the concentrations observed in the deeper horizons reflect the natural occurrences of MTE in soils. Thus, the contents of MTE decreasing to surface horizons indicate a predominantly natural source, from the alteration of parent material (parent rock).

The accumulation of MTE in surface was noted in most studied areas, without speaking of contamination. It is about Fe, Mn, Co and Cr at Bouaoune pilot farm, Khadri pilot farm and experimental farm of ITGC. However, the highest concentrations of MTE in horizon's surface reflect the affinity of MTE for carbon in the surface horizons.

Therefore, the observed MTE are originally pedogenetic, however, some contaminations were observed for Pb, at S1 and S2 and for As, at S3 and S1. Mr .Kloke had proposed an arsenic content of 20 mg.kg $^{-1}$ and it turns out that agricultural contamination by this element is in the fork: 16 to 13 mg.kg $^{-1}$. However, these infections attributed to agricultural activities or the situation of the sites in question near the road traffic, stay much less negligible for lead.

The pH of the various studied sites is of alkaline which makes the absorption of some MTTE in soils less difficult for plants. This PH can be responsible for the dissolution of MTE and increase their mobility. Thus, These MTE could enter in the food chain especially that the studied areas have a high agricultural productivity.

The correlation matrix between studied metals and physicochemical parameters (**Table 7**) showed that these correlations are above the threshold of "significance".

- The correlation between the fine fraction (<63at microns) and most metals is quite good (r> 0.50). This result confirms previous studies by showing that metals preferentially associate with the finer fraction of the ground (Clayey).

Table 6: Spearman's correlations between the various fractions (clay, sand and silt) and studied metals

	clay %	sand %	silt %
pH	-0,001	0,317	-0,225
N	-0,414	-0,288*	0,659
P	0,343	0,205	-0,501
K	-0,005	-0,163	0,142*
Ca	-0,508	-0,217*	0,708**
Mg	-0,473**	0,226	-0,690**
S	0,095*	0,036**	0,084**
Cu	0,050	0,079	-0,083
Fe	0,602**	-0,197**	-0,502
Cr	0,620**	-0,097**	-0,572
Ni	0,224	0,096*	-0,186
Mn	0,274**	0,187**	-0,387

Table 7: Correlation between MTE soils studied as a whole: uncultivated soils

	N	P	K	Ca	Mg	Cu	Fe	Cr	Ni	Mn	Zn	As	Se	pH
N	1													
P	-,215	1												
K	,424*	,285	1											
Ca	,919**	-,14	,381*	1										
Mg	-,66**	,24**	,83	-,62	1									
Cu	-,044	-,021	,431	-,26	,239	1								
Fe	,031	,59**	,528**	-,106	,415**	,526	1							
Cr	-,024	,758**	,486**	-,101	,516**	,457	,877**	1						
Ni	,019	,075	,437*	-,126	,047	,545	,580	,543*	1					
Mn	,054	,605*	,491**	-,071	,235**	,567	,774**	,776**	0,717	1				
Zn	,400	-,400	-,80**	,40**	-,040**	-,50	,400	,000	-,50	-,80	1			
As	,160*	,198	,258	,614*	-,638	-,056	-,626**	,198**	,314*	,217*	-	1		
Se	,866	,00	,866*	,866**	-,866**	-1,0	-,866	-,866	,866	,00	-	-	1	
pH	-,186	,042	-,469	-,138	-,014**	,418	-,183**	-,05**	-,135	-,12**	-,80	,135	,866	1

5 Conclusion and Outlook

This study showed the presence of heavy metals in soils of cereal crops at various concentrations and even very high. Nevertheless, these various concentrations are typically nontoxic and uncontaminated according to the international standards (AFNOR standards, according to INRA 1998 and agricultural soils standards). The soils of this study are alkaline, very poor in organic matter, rich in matter of cation exchange capacity and weak at standpoint fertility.

The MTE contents observed in limestone soils in Constantine region are relatively large (for some). The order of abundance of these elements is: Co> Fe> Mn> Cr> Zn> Cu> As> Pb> Ni> Se. Among the MTE contents obtained in these soils, only those copper and lead are usual according to AFNOR standards and contents of agricultural soils. The contents of Zn, Mn and Fe are in the range of critical contents in soils, which can cause toxicity phenomena. These MTE coexist as components of soil processes. The accumulation of selenium in the depths (to 60cm at Bouaoune farm and to 30cm at Baaraouiya farm) turns contaminant for soil and toxic to the plant that converts human health without they are not alarming. But the soil of the pilot farm of ain el Bey (S3) is contaminated with arsenic. The contents of other MTE (Cu, Pb and Co) are more or less homogeneous in the different studied areas. It would be so interesting to conduct a study on the speciation of metal trace elements in these soils in order to better prevent possible contamination.

Efforts are still needed to further reduce these concentrations through sensitization, the effective use of compost made on the site or provided by mineral fertilizers. The use of copper salts, zinc, manganese, boron or molybdenum as minerals amendments intended to fight against soil deficiencies, constitute a clear path for soil enrichment of MTE. Similarly, the use of traditional organic fertilizers such as farmyard manure or manure, will participate in the increase of the content of MTE in the ground.

In order to limit the bioavailability of trace elements, two major parameters must be controlled: soil pH and the organic matter content.

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