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Exposure of agricultural products to metallic trace elements in the limestone mining area of Scan Mine in the Canton of Tokpli (Togo): Case of grains of *zea mays* (corn), leaves and stems of *corchorus olitorius* (Ademe) and tubers of *manihot esculenta* (Cassava)

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ABSTRACT: The pollution of environmental components by metallic trace elements around many mining sites is known around the world. This metallic pollution constitutes a serious public health problem and the bioaccumulation of these metallic trace elements by food plants is a major concern. This study highlighted the level of pollution by metallic elements in edible products of three plant species (*zea mays, corchorus olitorius and manihot esculenta*) regularly grown in the Tokpli limestone mining area. The analysis of metallic trace elements in soil and plant samples is respectively carried out by inductively coupled plasma microwave atomic emission spectrometer (ICP-AES 4200) and inductively coupled plasma atomic emission spectroscope (the Optima 80,000 ICP). The contents of various metallic trace elements were analyzed in the grains of *zea mays*, the leaves and stems of *corchorus olitorius* and tubers *of manihot esculenta*. The results show a high accumulation of most of these elements in edible products and in soils. These metallic elements in the soil would come from mining activity, the degradation of soils and other ecosystems, and the misuse of chemical fertilizers and pesticides. Their presence in edible products would be linked to the process of bioaccumulation by root and/or aerial ways.
The pollution factors are of metallic trace elements (Hg, Fe, Pb, Al, Se…) in edible products such as *zea mays (Hg: 2806.29; Fe: 1667.62; Pb: 1622.99), corchorus olitorius (Hg: 3463.24; Al: 2715.78; Fe: 1882.98)* and *manihot esculenta (Fe: 964.51; Hg: 670.13; Se: 539.26)* plants grown around the Tokpli mining area are much higher than the thresholds recommended by the World Health Organization (WHO). Consumption of these products could expose consumers to chronic poisoning.

KEYWORDS: Limestone mining; Metallic trace elements, Contamination, Bioaccumulation, Edible agricultural products.

1 INTRODUCTION

Africa has diverse mineral resources in relatively large quantities. For centuries has been a place of exploitation of natural resources in general and mining resources in particular. The mining sector has experienced an impressive boom over the past ten years, around foreign companies and African countries intend to derive maximum benefit from this activity. Unfortunately, mining activities are sources of pollution by metallic trace elements. These metallic trace elements behave differently in their environments. In the soil, they are linked to different constituents and come in different chemical forms. They can change into soluble forms or migrate towards other constituents of the soil or into the liquid phase depending on the physicochemical conditions. The behavior of heavy metals in soils strongly depends on the nature and the proportion of the content of different components of the soil such as clays, carbonates, silica, and organic matter [1]. The mechanisms of heavy metal transfer between natural reservoirs are: adsorption, desorption, precipitation and dissolution [2]. These mechanisms influence the bioavailability of metallic trace elements. This bioavailability at mining sites is a function of the phenomenon of mine acid drainage (AMD) and soil activities in rhizospheric zones. Bioavailability is the ability of a quantity of an element present in the soil to be absorbed by a living organism [3].

Mine Acid Drainage makes the environment acidic and metallic elements can quickly change into solution and be available to the biosphere.

The root zone of plants is influenced by biological activity in the soil. This biological activity determines the eco-dynamics of metallic elements locally by precipitation, complexation and absorption. Activity in the rhizospheric zones can modify pH, the redox potential and the dissolution of minerals. The processes involved are active or passive, biological or physicochemical and lead to the solubilization of heavy metals or, on the contrary, to their in solubilization by either directly modifying their status (soluble / insoluble, oxidized / reduced, complexed / uncomplexed and adsorbed / not adsorbed) or by acting on their carrying phases (alteration, dissolution and precipitation) [4], [5], [6].

Food plants are exposed to heavy metals through air or root ways. Heavy metals are present or deposited by air on the surface of organs (leaves, stems) and they enter through the stomata in the form of particles, gaseous compounds (Hg, As) or dissolved in rain or irrigation water [7]. They are also absorbed by the roots in the water soil [7].

Some plants are very accumulating others not at all. Lead, cadmium and mercury present risks of variable toxicity on the different types of vegetable.

Vegetables take up lead, cadmium and mercury in relative amounts from the soil. Root crops (carrots) and leaf crops (lettuce) present a higher risk of lead poisoning than fruit vegetables (beans and tomatoes). Mercury and cadmium negatively affect the growth and photosynthetic activity in tomato plants. Chlorophyll concentrations decrease and stems wither at ground level after tomato plants are exposed to these two heavy metals.

Trace metallic elements that accumulate in plant and animal species can become toxic [7]. This toxicity can result from an accumulation of the element in the food chain and causes dysfunctions in the animals and humans who consume these products [8], [9].

Metals such as mercury, lead, cadmium, arsenic, copper, nickel etc. have toxicological effects on living organisms even at low concentrations. Human beings are exposed to these metals through the consumption of contaminated water, vegetable products and animals.

The bioaccumulation of heavy metals by grown plants constitutes a major problem in eco-toxicology as revealed by numerous studies [10], [11], [12], [13].

This study aims at researching some metallic trace elements in the grains of *zea mays* (maize), the tubers of *manihot esculenta* (cassava) and the leaves of *corchorus olitorius* (Adémè, local name in West Africa) which are the agricultural products most consumed in the limestone mining area of Scan Togo.

2 MATERIALS AND METHODS

2.1 THE STUDY AREA

Tabligbo is the main town in the Yoto prefecture of located in the South -East of the Maritime Region in Togo. The limestone mining site is located about 8 km to the northeast of the town of Tabligbo. In this area the limestone is mined by two companies, Scan Togo and Wacem separated by a distance of about 8 km (Figure 1). The limestone exploited by Scan Togo is found in the Tokpli Township in the municipality of Sika Kondji. The area of the mine covers of 14 km^2 with a large marshy part towards the North. Tokpli township has, according to the (2010), census 12,800 inhabitants and 3,200 to 3,500 households. The township is divided into 10 villages and each village has 03 to 15 districts, hamlets or farms. The population is predominantly rural and lives mainly on the products of its harvest. *Zea mays* (corn), *corchorus olitorius* (Ademe) and *manihot esculenta* (cassava) are the plants commonly grown, consumed and marketed in the area. The area is entirely located in the coastal sedimentary basin formed by a set of plateaus of variable geometry with surfaces slightly inclined towards the south [14]. The area is characterized by extensive wasteland, plantations, palm trees and teaks. The soils here are predominantly hydro-morphic are black in color. The soils encountered consist of sandy, Paleocene carbonate and green Eocene clay. The area is crisscrossed by small streams leading to marshes or ponds. The average annual precipitation is around 1060.43 mm with 92 rainy days. The annual temperatures are on average 28.5 °C and the average wind speed varies between 01 and 04 m/s.

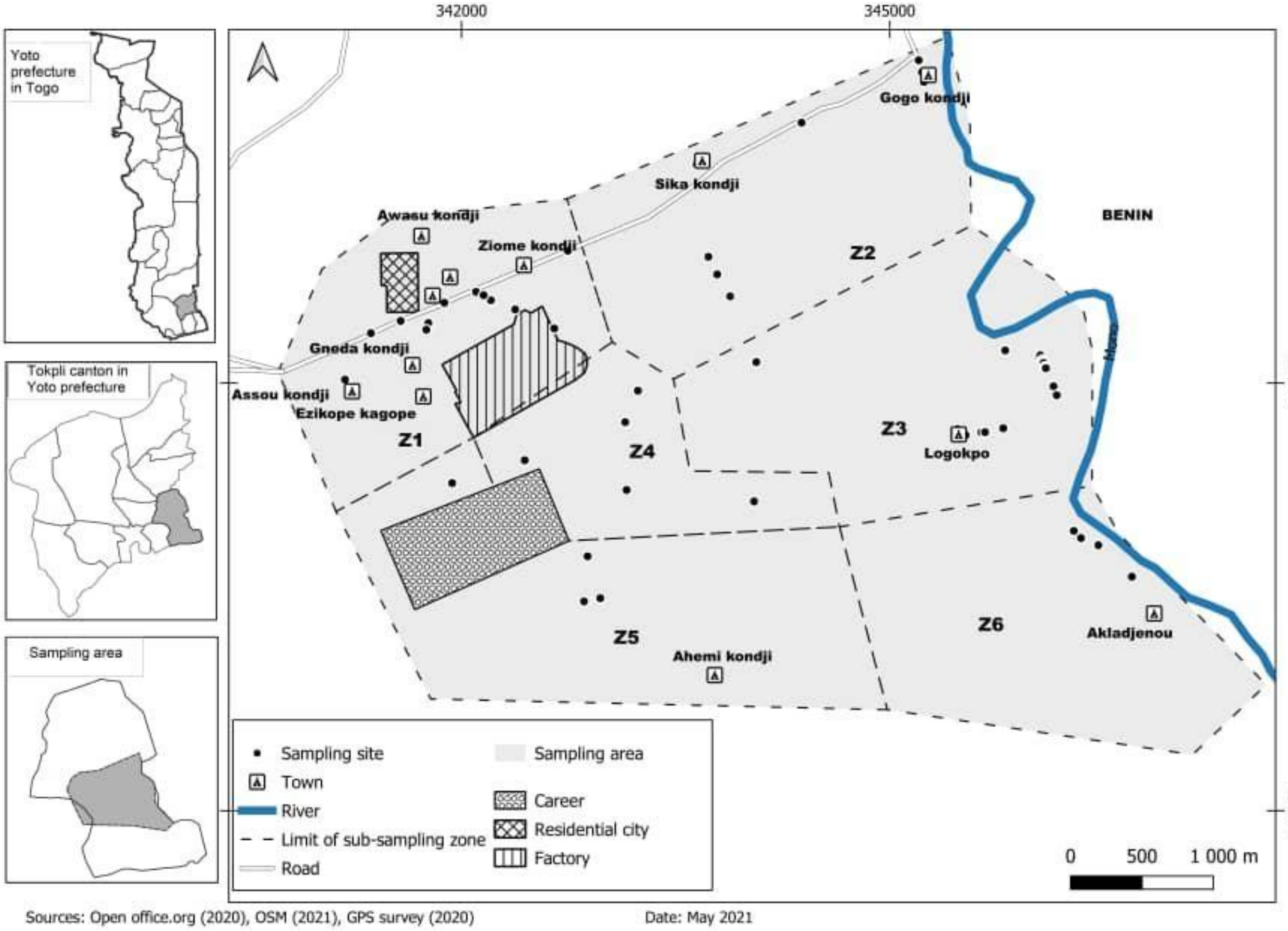

Fig. 1. Map of study area

2.2 Sampling And Data Analysis

For study purposes, samples were taken at 6 points around the factory and quarry (Z1, Z2, Z3, Z4, Z5 and Z6). At each point, samples of soil, corn, leaves, stems and cassava tubers were taken. To account for the influences of all types of mining pollutants the samples were organized into composites. A composite sample is the set of samples of points likely to receive a majority of one or more pollutants of the same type.

Z1 receives mostly wastewater and dust from the plant

Z2 receives mostly dust from factory and quarry

Z3 receives mostly dust from the quarry

Z4 receives mostly leached water from new waste rock piles of and dust from the quarry

Z5 receives mostly leached water from old piles of waste rock and dust from the quarry

Z6 receives mostly dust from the quarry

Then a composite sample of the soil, corn grain, cassava tubers and the leaves and stems of *corchorus olitorius* was made. These samples weighing 2, 5 kg were put in plastic bowls and then transported to the laboratory for analysis. Samples of cassava tubers and *corchorus olitorius* leaves and stems were first washed with tap water and then rinsed with distilled water to remove any heavy metal deposits on the surface. All samples were dried in ambient air at about 40 °C to a constant weight in the Laboratory of Applied Hydrology and Environment of the University of Lomé. After drying, the samples were ground and reduced to a fine powder (approximately 180 µm) before proceeding to the mineralization process with regal water (mixture of pure nitric acid (15.8 M) and pure hydrochloric acid (12M)).

The phyisico-chemical analysis of the composite samples was carried out at the Bureau of Mines and Geology of Burkina Faso (BUMIGEB). The mineralization of the samples and heavy metal analyses (Fe, Mn, Al, Cd, Pb, Cu, Zn, Co, Ni, Cr, As, Hg, Ag, Se and Sb) were carried out at the "Laboratory of Faso". For reasons of availability of devices, two apparatus were used for the analyses. The analysis of edible products is done with an atomic emission spectroscope with an inductively coupled plasma (ICP Optima 80000) and that of soils is done using MP-AES 4200 (plasma atomic emission spectrometer microwave).

The protocol of analysis has taken into account plant analysis standards (USF EPA 3051 standards) and heavy metal analysis standards (US EPA CLP ILM 053 D and SW-84 66020/6020 A standards) [15], [16], [17].

The pollution factor was determined. The pollution factor is the ratio of the average concentration of a metal in an analyzed edible agricultural product to the value of the standard for the same metal. This factor makes it possible to specify the degree of pollution.

3 Results And Discussion

3.1 The Content Of Metallic Trace Elements In The Soils Where Plants Are Collected

Table 1. Metallic trace elements (mg/kg) researched in the soil samples of soils

Soil sample at the plant collection sites	Pb	Cd	As	Ni	Co	Mn	Cr
Composite soil of Noutouvi Kondji and Seka-Kondji (Z1)	36	< 1	< 10	< 1	< 1	615	44
Composite soil of Gogo Kondi, Logokpo (Z2)	32	< 1	< 10	< 1	3	1332	59
Akladjenou soil (Z3)	33	< 1	< 10	< 1	5	1342	53
Assou Kondji Ezikopé Kagopé soil (Z4)	47	< 1	< 10	< 1	< 1	531	39
Composite soil around the quarry (Z5)	60	< 1	< 1	< 1	5	1899	97
Composite soil of the fields around the factory (Z6)	22	< 1	< 10	< 1	5	392	32
Mean value	**38,33**	**< 1**	**< 10**	**< 1**	**3,8**	**1018,5**	**54**

Table 2. Metallic trace elements (mg/kg) researched in the soils samples

Soil sample at the plant collection sites	Cu	Ag	Fe	Al	Se	Ti	Zn	Sb
Composite soil of Noutouvi Kondji and Seka-Kondji (Z1)	16	< 1	17083	14223	< 1	169	42	< 1
Composite soil of Gogo Kondi, Logokpo (Z2)	30	< 1	29151	19976	< 1	338	49	< 1
Akladjenou soil (Z3)	37	< 1	29161	19956	< 1	348	45	< 1
Assou Kondji Ezikopé Kagopé soil (Z4)	11	< 1	13152	9756	< 1	99	51	< 1
Composite soil around the quarry (Z5)	20	< 1	30877	32669	< 1	123	60	55
Composite soil of the fields around the factory (Z6)	6	< 1	8643	5730	< 1	166	46	< 1
Mean value	**20**	**< 1**	**21344,5**	**17051,7**	**< 1**	**207,2**	**48,8**	**55**

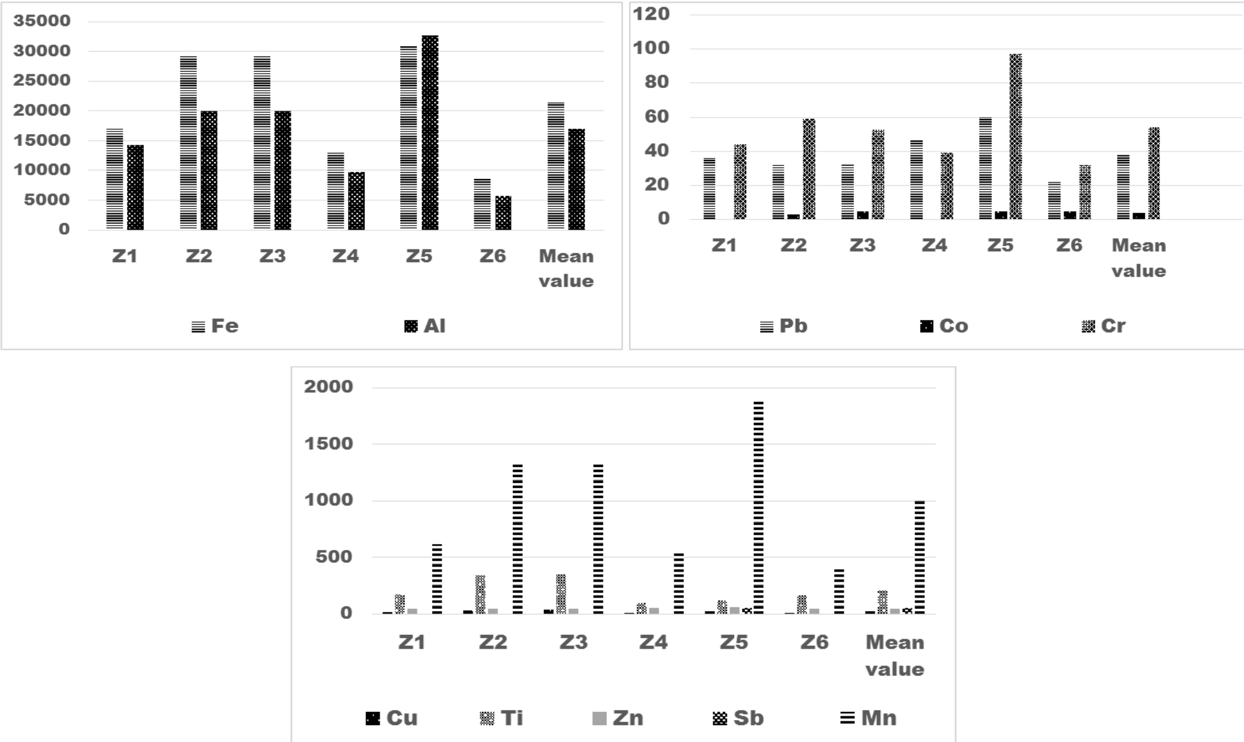

Fig. 2. Mean content of metallic trace elements in the soils samples

Tables 1 and 2 show the average metal contents in the six soil samples. High concentrations of Fe, Al, Mn and Ti can be noticed. The contents of Sb, Cr, Zn, Pb, Cu and Co are low. The concentrations of Fe, Al, Co, Cr, Cu, Zn and Ti are lower than those of the geochemical backgrounds [18], [19] respectively fixed at 35000 mg/kg, 80400 mg/kg, 17 mg/kg, 83 mg/kg, 25 mg/kg, 71 mg/kg and 3000 mg/kg. However, these soils are polluted by Mn, Sb and Pb since their contents are higher than those of the geochemical backgrounds which are respectively 600 mg/kg, 0.2 mg/kg and 17 mg/kg. The soils are therefore an important reservoir for these metallic trace elements and for the plants that grow there.

These significant stocks of heavy metals in the soil are well demonstrated by Table 4 where overall the contents in the soil are distinctly higher than those found in analyzed vegetable samples. Plants grown on these contaminated soils absorb these elements and concentrate them in the root. The sap distributes them to the plant organs. Mining areas are sites of soil and ecosystem degradation linked to heavy metal deposition [15], [20], [21]. Since the study area is an agricultural area, heavy metals in the soil can also come from the misuse of fertilizers and pesticides.

3.2 Influence Of Ph And Organic Matter In Soils Where The Plant Samples Are Taken

Composite samples of the three plants were taken from six different zones (Z1, Z2, Z3, Z4, Z5, and Z6) around the Scan factory and the quarry. The values for organic matter and pH of the soils are presented in Table 3.

Table 3. pH and organic matter (OM) of soils

Soil sample at the plant collection sites	OM en %	pH
Composite soil of Noutouvi Kondji and Seka-Kondji (Z1)	6,10	6.80
Composite soil of Gogo Kondi, Logokpo (Z2)	6,48	6.98
Akladjenou soil (Z3)	6,46	6.96
Assou Kondji Ezikopé Kagopé soil (Z4)	6,812	6.95
Composite soil around the quarry (Z5)	7,32	6,85
Composite soil from the fields around the factory (Z6)	3,22	8.00
Average	**7,32**	**6,85**

The results in Table 3 show that the soil is on average poor in organic matter (7, 32%) and slightly acidic pH (pH 6, 85).

The low organic matter content and the weakly acidic pH are compatible with the availability of metallic elements which will therefore accumulate in plants [22], [15], [23].

3.3 Size Distribution Of Mine Waste

Mining activities generate waste and their size distribution is presented in figure 3.

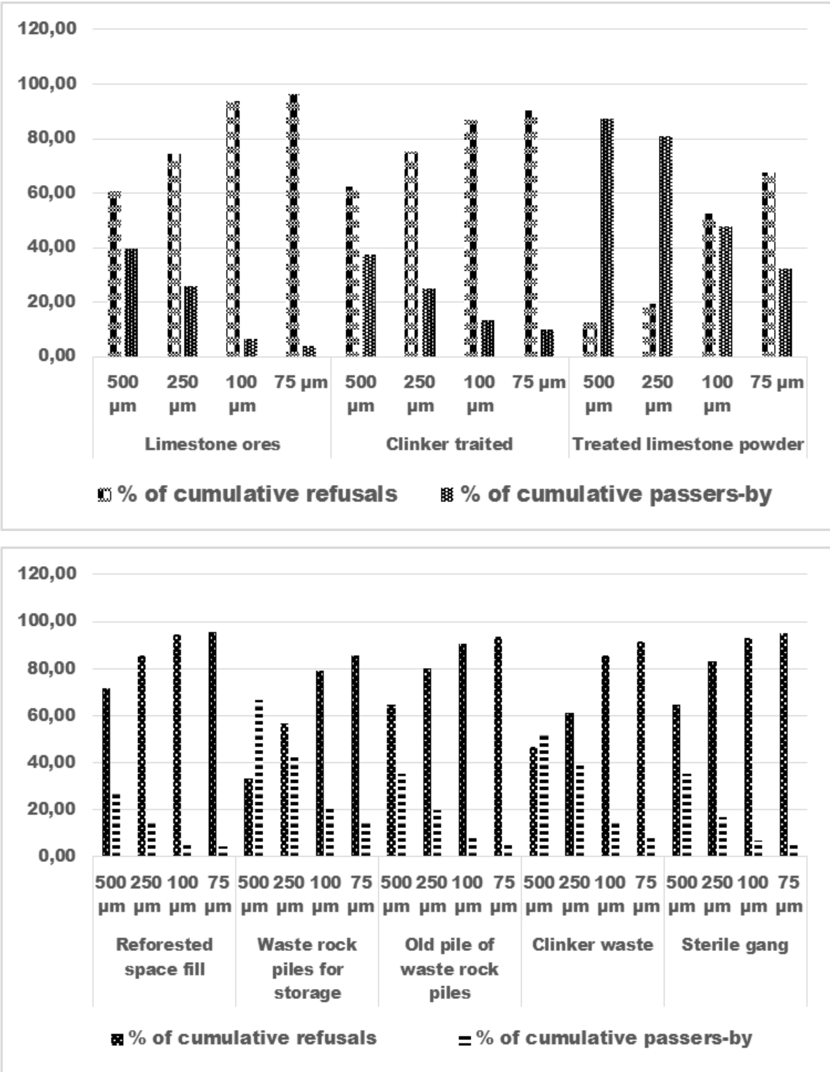

Fig. 3. Particle size of mine waste from the limestone mining and clinker production site at Topkli

Particle size analysis of samples from the Topkli limestone mining area shows that limestone contains about 87% of particles smaller than 500 µm and 32% have a diameter less than 75 µm. The clinker contains 37.57% particle size below 500 µm and only 9.83% particle size below 75 µm. Overall, tailings consist of approximately 66.88% particulate matter less than 500 µm in diameter and 48% of particulate matter less than 75 µm in diameter.

Clinker waste contains 53.24% less than 500 µm in diameter, 38.85% less than 250 µm in diameter and only 8.63% less than 75 µm. The embankments and the sterile gangue consist respectively of 28.30 and 35.40% of particles less than 500 µm. Old mine waste from the Tokpli site is a source of dust. The metallic trace elements contained in waste are remobilized and sent by wind and water to the other environmental components that accumulate them over time. Cultivated soils transfer these trace metal elements to the crops that accumulate them.

3.4 THE CONTENT OF THE METALLIC TRACE ELEMENT IN THE EDIBLE PARTS OF THE THREE GROWN PLANTS

The results of the analyses of the metallic trace elements are presented in Tables 4 and 5 below.

Table 4. The contents (mg/kg) of metallic trace elements in samples and their thresholds of toxicity according to World Health Organization (WHO)

Sample.	As	Se	Zn	Sb	Pb	Cd	Ni	Fe
Zea mays (corn)	1,49	< 1	35,64	0,98	16,23	0,46	1,14	333,52
Manihot esculenta (cassava tubers)	0,40	5,39	9,17	0,14	2,27	0,11	1,06	192,90
Corchorus olitorius (leaves and stems)	2,12	2,77	38,66	0,49	14,21	0,33	3,41	376,60
Mean value	**1,34**	**4,08**	**27,82**	**0,54**	**10,90**	**0,30**	**1,87**	**301,01**
WHO toxicity threshold	**0,01**	**0,01**	**5,00**	**0,02**	**0,10**	**0,05**	**0,05**	**0,20**

Table 5. The contents (mg/kg) of metallic trace elements in samples and their thresholds of toxicity according to World Health Organization (WHO)

Sample	Co	Ag	Mn	Cr	Hg	Cu	Ti	Al
Zea mays (corn)	< 1	< 1	33,40	0,99	2,81	3,72	16,61	245,45
Manihot esculenta (cassava tubers)	< 1	< 1	8,06	1,21	0,67	1,99	2,92	60,85
Corchorus olitorius (leaves and stems)	< 1	< 1	47,61	6,66	3,46	10,21	15,61	543,16
Mean value	< 1	< 1	**29,69**	**2,95**	**2,31**	**5,31**	**11,71**	**283,15**
WHO toxicity threshold	**2,00**	**0,01**	**0,05**	**0,05**	**0,001**	**3,00**		**0,20**

Tables 4 and 5 show that the concentrations of cobalt and silver in all samples are below the detection limit (<1) as well as the content of selenium in corn with the exception of these two metals, the edible parts taken from the three species contain the residues of the target metallic trace elements at concentrations above World Health Organization standards. The results show that the Fe, Al, Mn and Zn contents are highest in the studied samples. Similar results for silver bioaccumulation and the contents of Fe, Al, Mn and Zn in market garden products grown on urban soils along the Lomé-Aného highway in southern Togo were also reported by Gnandi et al. in 2008.

Only corn contains a high content of Pb. Cassava is the species with the lowest concentration of metallic trace elements. Corn contains the greatest concentration of trace metallic element. The presence of metallic trace elements (Al, Cr, Fe, Co, Ni, Cu, Zn, Cd and Pb) in commonly consumed food products including *manihot esculenta* in mining areas was already demonstrated by a study in the Democratic Republic of Congo in mining areas in Katanga province in 2015 [7].

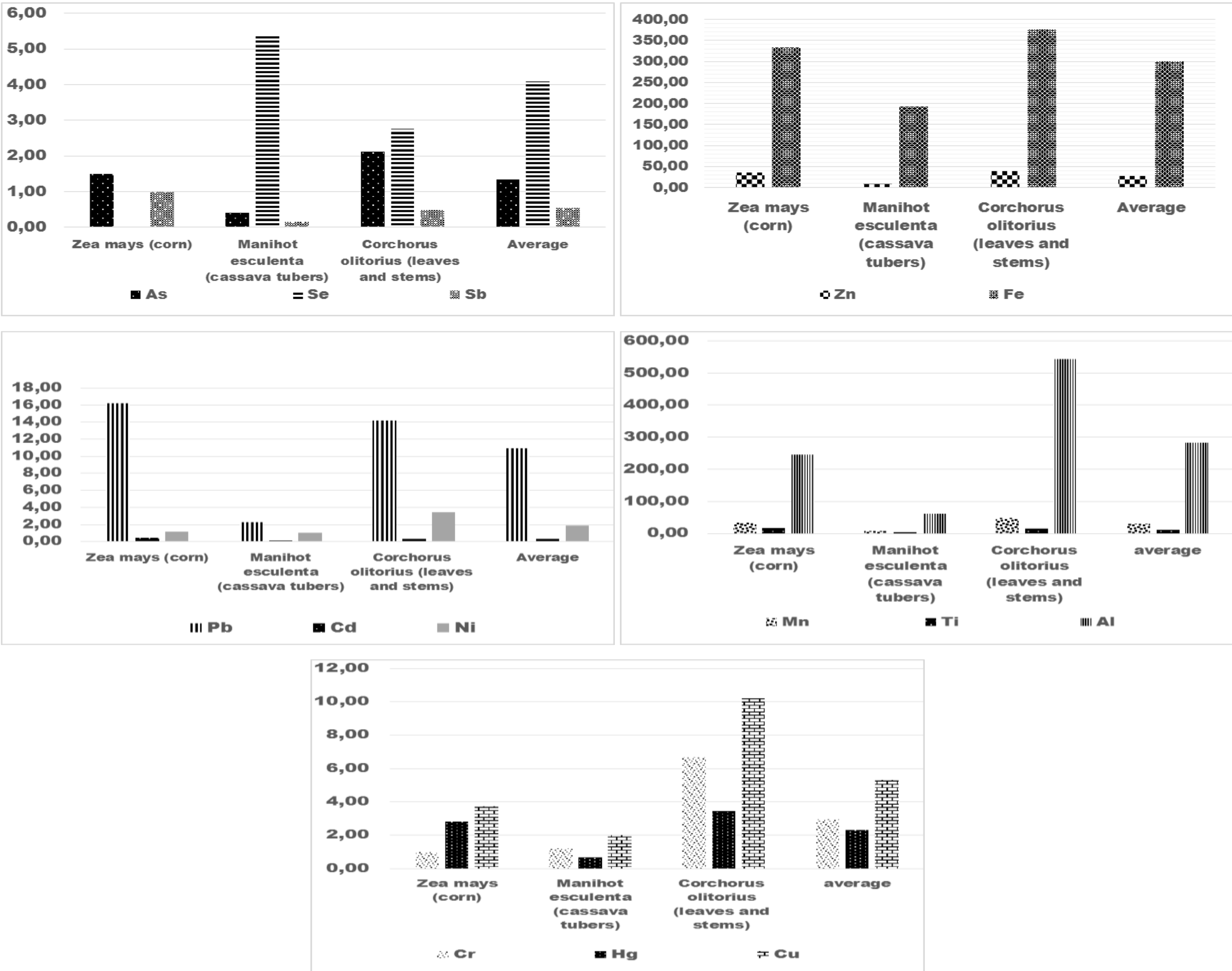

Fig. 4. The content of metallic trace elements in the analyzed samples

The results of the MTE analyses of the organs of the three plants are shown in Table 1 and Figure 4. Figure 5 shows the pollution factors calculated from WHO standards [24] for the various metallic elements at the level of each species. The pollution factor makes it possible to evaluate the pollution of edible agricultural products of the area by metals. A product is more polluted by a metal when it has a higher pollution factor for that metal. A metal is more polluting when it has a higher pollution factor. If the pollution factor exceeds 1, this indicates that the average concentration of the metal in the product being analyzed exceeds the value of the standard. This implies pollution of the sample.

The pollution factors of the trace metal elements studied are very high for the three agricultural products except copper which is less than 1 in the cassava tubers. All the agricultural products are polluted by the metallic trace elements. This pollution poses a serious threat to the environment in general and to humans in particular through the food chain [25], [26].

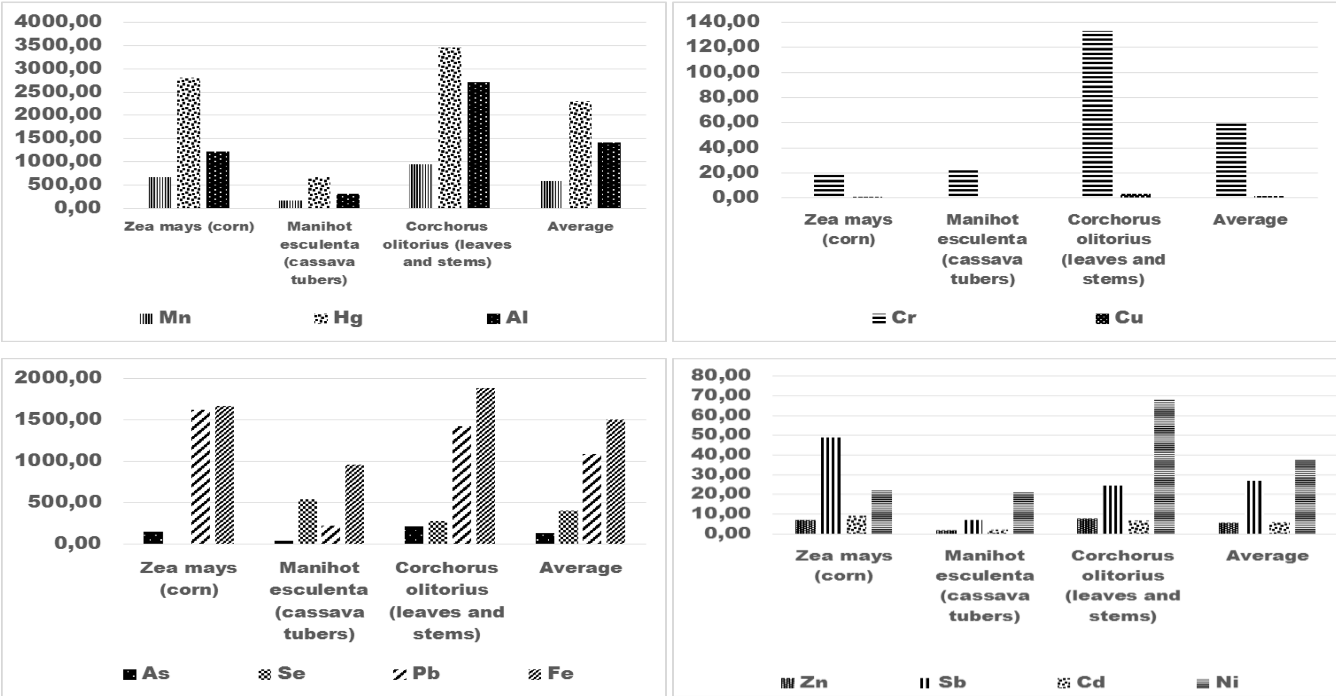

Fig. 5. Pollution factors of the metallic elements in the samples (WHO standards, 2004)

Table 6. Average content of MTE in soil samples versus edible parts of plants

ETM	Pb	Mn	Cr	Cu	Fe	Al	Ti	Zn	Sb
Average content of MTE in the soil samples	38,3	1018,5	54,0	20,0	21344,5	17051,7	207,2	48,8	55,0
Zea mays (corn)	16,23	33,40	0,99	3,72	333,52	245,45	16,61	35,64	0,98
Manihot esculenta (cassava tubers)	2,27	8,06	1,21	1,99	192,90	60,85	2,92	9,17	0,14
Corchorus olitorius (leaves and stems)	14,21	47,61	6,66	10,21	376,60	543,16	15,61	38,66	0,49

Tables 4, 5 and 6, show the metallic element contents in the soils from which the edible parts of the plants are taken. The contents of Cd, As, Ni and Se are below the detection limit in soil samples unlike the edible parts of plants where these levels are above the detection limit. The content of Ag is below the detection limit in both soil and plant samples. Co is not detected in plant samples but is detected in soil samples. This absence in edible products could be explained by the fact that Co accumulates more in soil than in the leaves of plants [27], [13]. It is recognized that Co binds to oxides of Mn and Fe and is more soluble at acidic pH. The pH of 6.85 (Table 2) of the soil is almost neutral. As a result, Co availability in these areas is reduced for plants

Mining and agricultural activities permanently supply the soil with MTE, and the processes of bioaccumulation are the basis for the concentration of these elements in the various organs of plants. The metallic trace elements can be bio accumulated in the organs of plants by air from the dust which is deposited on the leaves of the plants. Factory and quarry activities are sources of significant dust which spreads over the area.

These dusts loaded with metallic trace elements are deposited on the surface of the leaves and stems of plants and they enter the stomata in the form of particles, gaseous compounds or are dissolved in rainwater to be assimilated and bio accumulate [25]. This can be the case of metallic elements which are found in plant organs but not detected (Cd, As, Ni and Se) or have a low (Pb) content in soils.

3.4.1 Bioaccumulation Of Metal Trace Elements By Zea Mays (Corn)

Table 7. Pollution factors for the metallic elements in samples of zea mays (corn)

Type of Sample: Zea mays (corn)	*Hg*	*Fe*	*Pb*	*Al*	*Mn*	*As*	*Sb*
	2806,29	1667,62	162,30	1227,26	668,03	149,35	49,08
	Ni	*Cr*	*Cd*	*Zn*	*Cu*	*Se*	
	22,89	19,75	9,20	7,13	1,24		

The analysis of the results of table 7 shows that the factor of pollution is much higher than 1 in corn grains. The metallic trace elements the most bio-accumulated are Hg, Fe, Al, Mn, Pb, As, of which the values are respectively 2806.29, 1667.62, 162.30, 1227.26, 668.03 and 149.35. The pollution factors for of other elements vary between 49.08 and 1.24. This pollution factor is 10 to 1000 times higher to the threshold recommended by WHO. The results show that the content in Se is however less than the limit of detection. The values being greater than 1, indicate that the corn grains analyzed are polluted by the twelve (12) metallic trace elements. The consumption of the corn by human being is a source of dysfunctionning of vital organs caused by the metallic trace elements.

3.4.2 Bioaccumulation Of Metal Trace Elements By Manihot Esculenta (Cassava)

Table 8. Pollution factors for of the metallic elements in the samples Manihot esculenta (Cassava)

Type of sample: Manihot esculenta (cassava tubers)	*Fe*	*Hg*	*Se*	*Al*	*Pb*	*Mn*	*As*
	964,51	670,13	539,26	304,24	22,72	161,21	40,19
	Cr	*Ni*	*Sb*	*Cd*	*Zn*	*Cu*	
	24,27	21,11	7,24	2,29	1,83	0,66	

The pollution factors in table 8 show that *Manihot esculenta* presents higher factors for in Fe, Hg, Se, Al and Mn, these values are respectively 964. 51, 670.13, 539.26, 304.24 and 161.21. The other metallic trace elements (As, Cr, Pb, Ni, Sb, Cd and Zn) have pollution factors that vary between 40.19 and 1.83. All these values are higher than the threshold recommended by WHO. The pollution factors are between 0.98 times and 1317, 43 times greater than to the thresholds recommended by the World Health Organization for food. However, the pollution factor for Cu is lower than 1. Therefore, the samples of ***Manihot esculenta*** are not polluted by Cu. The consumption of these tubers exposed consumers to the detrimental effects of the metallic trace elements whose factors of pollution are higher than 1.

3.4.3 Bioaccumulation Of Metallic Trace Elements By Corchorus Olitorius (And Stems)

Table 9. Pollution factors for the metallic elements in the samples corchorus olitorius (leaves and stems)

Type of sample: Corchorus olitorius (leaves and stems)	*Hg*	*Al*	*Fe*	*Pb*	*Mn*	*Se*	*As*
	3463,24	2715,78	1882,98	142,06	952,27	276,96	212,06
	Cr	*Ni*	*Sb*	*Zn*	*Cd*	*Cu*	
	133,20	68,29	24,53	7,73	6,64	3,40	

The results of the analysis of *corchorus olitorius* leaves and stems shows that the pollution factor for all metallic trace elements researched is greater than 1. The metallic trace elements most present are Hg, Al, Fe, Mn, Se, As, Pb and Cr whose values are respectively 3463.24, 20715.78, 1882.98, 1420.62, 952.27, 276.96, 212.06, 142.06 and 133.20. The pollution factors for other elements (Ni, Sb, Zn, Cd, Cu vary between 68.29 and 3.40. The pollution of *corchorus olitorius* leaves and stems by these metallic trace elements are 10 to 1000 times greater than the threshold recommended by WHO. The consumption of these leaves and stems expose the consumers to health problems related to these metallic trace elements.

Overall, the results show that the soils of the Tokpli limestone mining area are contaminated by heavy metals and indicate that there is a strong contamination of the organs of the vegetable species studied for these metallic elements. The area is a serious source of health risk caused by the continuous emissions of metal pollutants from mining and agricultural activities. These emissions are alarming and constitute an imminent danger to the populations that consume these agricultural products [17] and other animal species that live in the environment [28]. The metallic trace elements once in the human body provoke negative effects on vital organs [29], [30], [31].

4 CONCLUSION

It emerges from the results of this study that the soils in the Tokpli/Tabligbo limestone mining area contain metallic element, some of which contain more than the geochemical background value. The presence of heavy metals in soils is most likely a result of mining activity, degradation of soils, and other ecosystems and the misuse of fertilizers and pesticides. Corn seeds, cassava tubers, the leaves and stems of *corchorus olitorius* leaves and stems**)** taken from these soils and which are agricultural products for human consumption are polluted by these trace metal elements. The concentrations of heavy metal in the samples are in many cases significantly above the WHO standard for food products. The slightly acidic pH and the low content of organic matter favors the bioavailability of these metallic elements and make them available to plants.

The high levels of metallic elements in agricultural products are linked to their bioaccumulation through the root way and/or the air way. This contamination exposes human and animal consumers to many diseases and damages agricultural and animal production. Considering this imminent danger, farmers and herders must carry out their activities far from the mining area and use fertilizers and pesticides according to the recommendations of officials from the ministry in charge of agriculture and the environment.

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DISCLOSURE STATEMENT

Conflict of Interest: The authors declare that there are no conflicts of interest.

Compliance with Ethical Standards: This article does not contain any studies involving human or animal subjects.

REFERENCES

[1] Deschamps, T., Benzaazoua, M., Bussière, B., Beleme, T., Mbonimpa, M., (2006). « Mécanismes de rétention des métaux lourds en phase solide: cas de la stabilisation des sols contaminés et des déchets industriels", Vertigo la revue électronique en sciences de l'environnement [Online], Volume 7 Numéro 2 septembre 2006, posto online no dia 08 setembro 2006, consultado o 22 abril 2021. URL: DOI: https://doi.org/10.4000/vertigo.2171.

[2] Salomons, W., Forstner, U., (1980). Trace metal analysis on polluted sediments II. Evaluation of environmental impact, Environ Technol. Lett., 1, 506-510.

[3] Newman, M.C., et Jagoe, C.H., (1994). Ligands and the bioavailability of metals in aquatic environments. Bioavailability: physical, chemical and biological interactions. J. M. Heamelink, P. F.

[4] Hinsinger, P., (1998a). How do plant roots acquire mineral nutrients? Chemical processes involved in the rhizosphère. Advances in Agronomy. Faculty of agriculture université of Western Australia. 64, 225–265. 42p.

[5] Zhang, G., Lombi, E., Zhao, F.-J., Sun, B., Filtz, W., Zhang, H., McGrath, S.P., (2002). In situ fixation of metals in soils using bauxite residue: chemical assessment. Environmental pollution, 118, 435-443.

[6] Deneux-Mustin, S., Roussel-Debet, S., Mustin, C., Henner, P., Munier-Lamy, C., Colle, C., Berthelin, J., Garnier-Laplace, J., Leyval, C., (2003). Mobilité et transfert racinaire des éléments en traces: influence des micro-organismes du sol. Tec et Doc. - Lavoisier, Paris.

[7] Kalonda D. M., Tshikongo A. K., koto F. K. K., Busambwa C. K., Bwalya Y. K., Cansa H. M., Tambwe K. J-L., Kalala Z. L., Otshudi A. L., (2015). Profil des métaux lourds contenus dans les plantes vivrières consommées couramment dans quelques zones minières de la province du Katanga, 96: 9049 – 9054, 6p. DOI: http://dx.doi.org/10.4314/jab.v96i1.2.

[8] Baise D., et Paquereau H. (1997). Teneurs totales en éléments traces dans les sols agricoles de Seine-et-Marne. Etude et Gestion des sols. 4 (2): 77-94.

[9] Li Q.S., Chen Y., Fu H.B., Cui Z.H., Shi L., Wang L., Liu Z.F. (2012). Health risk of heavy metals in food crops growm on reclaimed tidal flat soil in the pearl River Estuary, China. J Hazard Mater. 227-228 (7): 148-54.
[10] Moustier P., E.Bridier et N.T.T.Loc, (2000). Laqualité sanitaire des produits maraîchers à Hanoi: les apports d'une enquête auprès des consommateurs. In: Gestion de la sécurité des aliments dans les pays en développement.E.Hanak, E.Boutrif, P.Fabre et M.Pineiro (eds), actes de l'atelier international, CIRAD-FAO, 11-13 décembre2000, Montpellier, France, 3p.
[11] Verloo M., (2003). Métaux lourds dans les denrées alimentaires: origine et évolution des teneurs, symposium. In: Les oligo-éléments dans l'alimentation en Belgique, 3p.
[12] Saad Z., V. Kazpard, K. Slim et P. Nabhan, 2006. Relation entre métaux traces dans le tabac et la nature du sol au Liban. Cah. Agric., 15 (2), 203-211.
[13] Gnandi K., Tozo K., Edorh A. P., Abi H., Agbeko K., Amouzouvi K., Baba G., Tchangbedji G., Killi K., Bouchet P. et Akpagana K., (2008). Bioaccumulation de certains éléments métalliques dans les produits maraîchers cultivés sur les sols urbains le long de l'autoroute Lomé- Aného, Sud Togo, Acta Botanica Gallica, 155: 3, 415-426, 13p.
[14] Lamouroux M. (1966). Carte pédologique du Togo au 1/1 000 000. Notice explicative N° 34. ORSTOM, Paris. 99p.
[15] Grobelak A., Napora A. (2015). The Chemophytostabilisation Process of Heavy Metal Polluted Soil. PLoS One. 10 (6): 0129538. doi: 10.1371/journal.pone.0129538.
[16] Leguedois, S., Sere, G., Auclerc, A., Cortet, J., Huot, H., Ouvrard, S., et al. (2016). Modelling pedogenesis of Technosols. Geoderma, 262,199-212.
[17] Koumolou L., Edorh A.P., Agbandji L., Hounkpatin S.A., Elegbede B. (2012). Threat of the health quality of garden produces linked to pollution by toxic metals on some gardening sites of Benin. Am. J. Environ. Sci. 8 (3): 248–52.
[18] Mc Lennan, S. M., 2001. Relationships between the trace element composition of sedimentary rocks and upper continental crust. Geochemistry, Geophysics, Geosystems. (G3) 2 (4).
[19] Bowen H.J.M. (1979). Environmental chemistry of the elements. Academic Press, NewYork, 49-62.
[20] Ali, Z., Malik, R. N., Shinwari, Z. K., Qadir, A. (2015). Enrichment, risk assessment, and statistical apportionment of heavy metals in tannery-affected areas. Inter-national journal of Environmental Science and Technology, 12 (2), 537-550. DOI: https://doi.org/10.1007/s13762-013-0428-4.
[21] Jiang, Y., Shi, L., Guang, A.-L., Mu, Z., Zhan, H., &Wu, Y. (2017). Contamination levels and human health risk assessment of toxic heavy metals in street dust in an industrial city in Northwest China. Environmental Geochemistry and Health, 1-14. https://doi.org/10.1007/s10653-017-0028-1.
[22] Planquart P., Bonin G., Prone A.et Massiani C., 1999.-Distribution, movement and plant availability of trace metals in soils amended sewages ludge composts: Application tolowmetalloadings. Sci. Total Environ. 241, 161-179.
[23] Hakkou R. (2011), Environnement minier: Le Drainage Minier Acide: Prédiction et Restauration des sites générateurs de DMA, Cours MSP/GDM, 2ie Ouagadougou, 108 p.
[24] WHO, 2004. Guidelines for foodand drink water quality, Chemical factsheets, 3rd edition. Geneva, Swiss, 460p.
[25] Aduayi-akue A. A. Gnandi K. (2014).Evaluation de la pollution par les métaux lourds des sols et de la variété locale du maïs Zea mays dans la zone de traitement des phosphates de Kpémé (Sud du Togo). International Journal of Biological and Chemical Science 8 (5): 2347-2355. 09 pages. DOI: http://dx.doi.org/10.4314/ijbcs.v8i5.37.
[26] Smida, O., Souissi, R., Salem, M., Souissi, F., (2021). Geochemical Assessment and Mobility of Undesired Elements in the Sludge of the Phosphate Industry of Gafsa-Metlaoui Basin, (Southern Tunisia). Applied Sciences, 11p. DOI: 10.3390/app11031075.
[27] Brooks R.R., (1998). Plants that hyper accumulate heavy metal, their role in phytoremediation, microbiology, archaeology, mineral exploration and phytomining.Wallingford (Royaume Uni), CAB international, 384p.
[28] Miquel G., Landrum, H. L. Bergman and W. H. Benson. Boca Raton, USA, Lewis Publishers (2001).Effet des métaux lourds sur l'environnement et la santé.Rapport Office parlementaire d'évaluation des choix scientifiques et technologiques, 162p.
[29] Morel, J. L., Chenu, C., &Lorenz, K. (2015). Ecosystem services provided by soils of urban, industrial, traffic, mining, and military areas (SUITMAs). Journal of Soils and Sediments, 15 (8), 1659-1666.
[30] Aguilar, M., Mondaca, P., Ginocchio, R., Vidal, K., Sauve, S., Neaman, A. (2018). Comparison of exposure to trace elements through vegetable consumption between a mining area and an agricultural area in central Chile. Environmental Science & Pollution Research, 25 (19), 19114 - 19121. https://doi.org/10.1007/s11356-018-2116-x.
[31] Kumar, M., Gogoi, A., Kumari, D., & Borah, R. (2016). Review of perspective, problems, challenges, and future scenario of metal contamination in the urban environment. Journal of Hazardous, Toxic, and Radioactive Waste, 21 (4), 04017007. https://doi.org/10.1061/ (ASCE) HZ.2153-5515.0000351.