Int. J. Pure Appl. Sci. Technol., 27(2) (2015), pp. 59-64

International Journal of Pure and Applied Sciences and Technology

ISSN 2229 - 6107

Available online at[**www.ijopaasat.in**](www.ijopaasat.in)

Research Paper

Heavy Metals Contamination in *Lactuca Sativa L.* (Lettuce) from Two Agricultural Sites of Abidjan

Seka Yapoga Jean[1,*], Yapo Ossey Bernard[1] and Yapi Dopé Armel Cyrille[1]

[1] Department: UFR of Management and Environmental Sciences, Nangui Abrogoua University, 02 Bp 801 Abidjan, Cote d'Ivoire

* Corresponding author, e-mail: (sekayapoga@yahoo.fr)

(Received: 26-1-15; Accepted: 7-4-15)

Abstract: *Heavy metals such as Zn, Cd, Cu, Pb and Cr proportion in soil and Lactuca sativa L. were determined by Atomic Absorption Spectrophotometry. Then, the average concentrations of Pb, Cd, Cr, Cu and Zn in soil from Attécoubé agricultural site were respectively 496.54, 1.56, 1.72, 70.96, 1749mg.kg^{-1} and those from Cocody agricultural site were respectively 37.13, 1.84, 1.62, 72.94, 1002.4.Indeed, the proportion of Zn found was highest in the both sites with the mean concentration 1749mg.kg^{-1} and 1002.45mg.kg^{-1}. The pollution index (PI) in soils from Attécoubé and Cocody were >1. In addition, the concentrations of Zn, Cu and Pb were the greatest in vegetables from the both agricultural sites. Hence, the proportion of heavy metals in lettuce crops was higher than those of WHO/FAO recommendations.*

Keywords: Heavy Metals, Contamination, Agricultural Site, Vegetables.

---

1. Introduction

Environmental pollution is a major problem in the world. Human activities, industry, erosion and urbanization can induce soil pollution in various ways. The prolonged presence of heavy metals in urban soils can amplify the conta mination process (Poggio *et al.*, 2008). However, anthropogenic sources of heavy metals in agricultural soils also include residues from mines, waste disposal, urban effluents, pesticides, sludge and fertilizers (De Kimpe and Morel, 2000). Large amounts of heavy metals such as cadmium (Cd), chromium (Cr), lead (Pb), copper (Cu), and zinc(Zn)persist in the soil and can either be adsorbed to soil particles or leached into ground water (Khan, 2006).Several of these elements such as Zn are necessary for human health and are beneficial when taken into the body in foods. Conversely, (Cd), (Pb) and (Cr) have no known biological function and are toxic to humans.

However, heavy metals are present in the lettuce produced in urban areas. Khan *et al*. (2006) have shown that lettuce grown in heavy metal rich soils are also contaminated. The lettuce can absorb heavy metals from contaminated soils. This contamination can be dangerous for human health because the lettuce is the most consumed vegetables (Kouakou *et al.*, 2008). The aim of the study was to determine the concentrations of heavy metals (Pb, Cd, Cr, Cu and Zn) in soil and lettuce collected from two agriculture sites.

2. Materials and Methods

2.1. Site Description

Soils and vegetables were collected from 2 agricultural sites in Abidjan. The 2 agricultural sites ((Cocody (C) and Attécoubé (A)) were located respectively at Cocody (N 0519.388’; W 00336.737') and Attécoubé(N 0521.528’; W 0402.679'). The selection of these two agricultural sites is justified by the fact that they have several vegetable species in common and are contaminated by heavy metals (Kouakou *et al.,* 2008).The control soil(T) was taken far from source of contamination and was located at Cocody (N 0524.704'; W 00357.189')in Abidjan.

2.2. Soils and Vegetables (Lettuce) Sampling

A study was conducted from November 2013 to July 2014 with three campaigns. Soils were collected at 20cm deep by using a plastic scooper. Sampling of soils was done on delimited sites having a surface of 70 m x40 m. The soil samples were taken on 5 surfaces of 6m^2 per site. For each surface of 6m^2, 6 samples were taken from an area from 1x1m (fig 2). The samples of each surface of 6m^2 were mixed to obtain an average sample. They were stored in the polythene sampling bags.
Vegetables samples were collected in triplicate from the same field (fig 2).

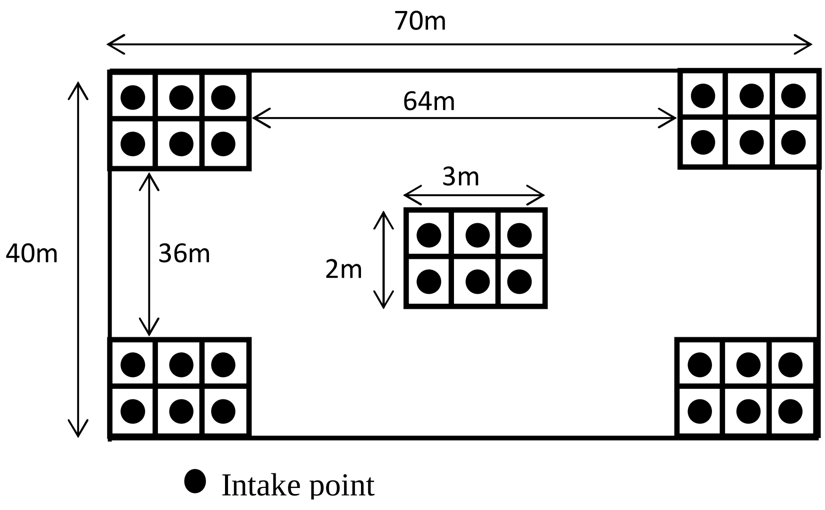

Fig 2: Soils and vegetables sampling plan

2.3. Soils Samples Analysis

The soil samples were air dried. They were ground and passed through < 2 mm sieve. Soils physicochemical properties have been assessed according to the ISO standard (AFNOR, 1994). They include: pH_{H2O}, pH_{KCl}, $CaCO_3$, cation exchange capacity (CEC), organic carbon (C_{org}).

For heavy metals analysis, two grams (2 g) dry soil samples were digested in about 15 mL of aqua-regia ($HCl:HNO_3$ = 3:1) for 4 hours using a hotplate maintaining a heating temperature of 110 °C.

The samples were next placed in a 100 mL Pyrex glass beaker and diluted with distilled water up to 50 mL. The solution was cooled and filtered through Whatman No.42 filter paper. The filtrates were analyzed for five metals (Zn, Cu, Pb, Cd and Cr) by Atomic Absorption Spectrophotometer (Varian AA20).

2.4. Pollution Index (PI)

The pollution index (PI) has been used to evaluate the degree of multi-element contamination. This is considered a better method of evaluation because heavy metals contamination in the surface environment is associated with a cocktail of contaminants rather than one element (Chon *et al*., 1998). Although a variety of PI is used by researchers, the basic concept is the same. In this study, the PI of soils was computed using average levels in soils tolerable to plants growth given byKloke, 1979. The equation is as follows: PI = [Cd/3 + Cu/100 + Pb/100 + Zn/300)/4].

When PI values are > 1, the soils are considered to be contaminated by anthropogenic inputs.

2.5. Lettuce Samples Analysis

The collected plants were washed with distilled water and separated into root and leaves. They were air dried. The dried samples were ground and passed through < 2 mm sieve.

Five hundred milligrams (500mg) of dried weight of each fraction were digested with 10 mL of $HClO_4$ and HNO_3 mixture (1:3) at about 80 °C for 4 h. The resulting cleared colored solutions were made up to a mark in a volumetric flask (25 mL) with distilled water. Sample blanks were analyzed to correct the possible external contributions while replicate samples were also evaluated. All the analyses were done in triplicate to ensure reproducibility of the results. The digested samples were analyzed by Atomic Absorption Spectrophotometer (Varian AA20).

3. Results and Discussion

3.1. Levels of Heavy Metals in the Sites

Table 1 presents the physicochemical characteristics of the soils. In both agricultural sites, Pb and Zn are above the safe limits given by Kabata-Pendias and Pendias (2001)whereas Cu, Cd, and Cr contents are below the safe limits. The highest concentration for lead was recorded from Attécoubé site with a mean value of 496.54±58.5 mg.kg^{-1}.

Table 1: Physicochemical parameters and heavy metals concentrations **(**mg.kg^{-1}) of the soils

	Attécoubé (n=15)	Cocody (n=15)	Control (n=15)	MAC
pH_{eau}	7.6± 0.12	7.41±0.17	5.47±0.14	-
pH_{KCl}	7.03± 0.12	6.89±0.21	4.82±0.24	-
CEC(méq/100g)	8.35± 0.98	12.25±3.05	10.77±1.57	-
C_{org}(mg.kg^{-1})	335.57±50.92	468.56±157.04	211±55.88	-
$CaCO_3$(g.kg^{-1})	14.64±0.83	12.8±1.09	14±0.26	-
Pb	496.54±58.5	37.13±8.42	6.77±1.98	20-300

Cd	1.56±0.22	1.84±0.37	0.75±0.16	1-5
Cr	1.72±0.17	1.62±0.35	1.57±0.19	50-200
Cu	70.96±14.25	72.94±8.83	15.14±1.21	50-140
Zn	1749±177.5	1002.45±95.31	39.46±7.8	150-300

MAC: Maximum Allowable Concentration in soil (mg.kg^{-1}) Kabata-pendias (2001).
n = number of analyzed soils samples.

These sites could be impacted by various anthropic activities. A PI >1 (table 2) was found in Attécoubé and Cocody sites. Heavy metal proportions observed were due to the nature of soil, the waste water and municipal sludge, the use of agrochemicals and the rain water. These results are checked by work of Kouakou *et al.* (2008) which stressed that the agricultural sites of Abidjan were contaminated by heavy metals. That could be explained by the geographical situation of the sites. Indeed, the sites are subjected to significant road traffic. These heavy metals, once in the atmosphere, join the particles and could remain inside several weeks before bringing back to the ground by rain water. Other particles can also be carried by the wind and to settle on the ground (Ramade, 1991).Also, factors like pH of soil and amount of organic matter of the soil affect heavy metal adsorption and retention in soil (Khan *et al*., 1992). Similar results were reported by kouakou *et al*. (2008) in Abidjan (Côte d'Ivoire) and Kapungwe *et al. (*2013) in urban area in Lusaka (Zambia). Kissao *et al* (2014) reported the same trend in Lomé area (Togo).

Table 2: Pollution index of the soils

Sites	Pollution index (PI)
Attécoubé	3.03
Cocody	1.20
Control	0.17

3.2. Levels of Heavy Metals in Lettuce

Heavy metal concentrations in leaves and roots of lettuce are presented in table 3. Results revealed variable metal levels in different parts of the vegetable samples. Cd, Pb and Zn concentration in vegetable samples are higher than the permissible limits set by the FAO/WHO (2001).In both sites, Zinc has the highest mean concentration in the roots and leaves respectively.

Table 3: Levels of heavy metals in the lettuce (mg.kg^{-1})

Sites	lettuce	Pb	Cd	Cr	Cu	Zn
	Roots (n=45)	13.55±1.1	0.47± 0.04	0.43±0.05	12.5±1.2	310.93±39.1
Attécoubé	Leaves (n=45)	24.81±2.6	0.18±0.03	0.25±0.06	14.03±2.9	291.05±39.4
Cocody	Roots (n=45)	19.08±1.1	0.8±0.1	0.28±0.1	23.9±3.6	219.18±11.3
	Leaves (n=45)	27.36±2.6	0.39±0.1	0.2±0.04	13.22±2.9	360.38±26
RMLV(mg/kg)		**0.30**	**0.20**	**2.30**	**73.30**	**99.40**

FAO/WHO (2001)

RMLV: Recommended maximum limits for vegetables ($mg.kg^{-1}$);
FAO: Food and Agriculture Organization; WHO: World Health Organization

The results can be explained by the fact that fertilizers and waste water used are sources of heavy metal pollution in agricultural areas (Kabata-Pendias, and Pendias, 2001). The droppings used for the amendment of the various sites of study are all contaminated by heavy metals. These results are confirmed by Kouakou *et al*. (2008) who found that the droppings used on the agricultural sites of Abidjan are rich in heavy metals. The presence of heavy metals in the vegetable is related to that of metals in the soil. The amendment of the soils by droppings in an inappropriate way tends to increase metals in the ground (Mustin, 1987).

4. Conclusion

The sites of Attécoubé and Cocody had PI >1 including that these soils are polluted. This pollution probably is originated by the application of biocides, fertilizers, domestic activities and industrial activities. The results showed the potential accumulation of heavy metals in vegetables grown in these agricultural sites. Particularly Zn, Cd and Pb concentrations were higher in lettuce leaves than the permissible limits set by the FAO/WHO. The presence of these metals in vegetables of the various sites could be at the origin of food poisonings. They expose serious health risks. Nevertheless, it would be hazardous to grow vegetables on the various soils studied. Also, the sewage and industrial sludge, effluents and chemicals from the laboratories shouldn't be disposed near urban agricultural area.

References

[1] AFNOR, Qualité des sols, Recueil de Normes Françaises, AFNOR, Paris France, (1994), 533.
[2] H.T. Chon, J.S. Ahn and M.C. Jung, Heavy metal contamination in the vicinity of some base metal mines in Korea-A review, *Geosystem Engineering*, 1(2) (1998), 74-83.
[3] C.R. De Kimpe and J.L. Morel, Urban soil management: A growing concern, *Soil Science*, 165(1) (2000), 31-40.
[4] FAO/WHO, *Report on the 32ndSession of the Codex Committee on Food Additives and Contaminants*, ALINORM 01/12, Beijing, People's Republic of China, 20–24 March (2000), Joint FAO/ WHO Food Standard Programme, *Codex Alimentarius Commission, 24th Session*, 2–7 July (2001), Geneva, Switzerland.
[5] A. Kabata-Pendias and H. Pendias, Trace Elements in Soils and Plants (Third Edition), CRC Press, (2001), 413.
[6] A. Kabata-Pendias, Trace Elements in Soils and Plant (4th ed.), CRC Press, Boca Raton, 24(2011), 105-115.
[7] E.M. Kapungwe, Heavy metal contaminated food crops irrigated with wastewater in Peri Urban Areas, Zambia, *Open Journal of Metal*, 3(2013), 77-88.
[8] A. Khan, M. Ibrahim, N. Ahmad and S.A. Anwer, Studies on accumulation and distribution of heavy metals in agricultural soils receiving sewage effluents irrigation, *In: Proceedings of 4th National Congress of Soil Science*, 24-26 May (1992), Islamabad.
[9] A.G. Khan, Rhizoremediation- An enhanced form of phytoremediation, *Journal of Zhejiang University*, Science B 7(2006), 503-514.
[10] G. Kissao, T. Koffi, P. Aléodjrodo, A. Hazou, A. Koffi, A. Komi, B. Gnon, T. Gado, K. Koffi, B. Philippe and A. Koffi, 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: Botany Letters*, 155(3) (2014), 415-426.
[11] A. Kloke, Content of arsenic, cadmium, chromium, fluorite, lead, mercury and nickel in plants grown on contaminated soil, *United Nations ECE Symposium*, Warsaw, Poland, August 20-24 (1979).

[12] J.K. Kouakou, B. Yves-Alain, E.S. Ahoua, B. Denis and O.D. Denezon, Diagnostic d'une contamination par les éléments traces métalliques de l'épinard (*Spinacia Oleracea*) cultivé sur des sols maraîchers de la ville d'Abidjan (Côte d'Ivoire) amendés avec de la fiente de Volaille, *European Journal of Scientific Research*, 21(3) (2008), 47-487.

[13] M. Mustin, Le Compost: Gestion de la Matière Organique (Edit), François Dubusc, (1987), 954.

[14] L. Poggio, B. Vrščaj, E. Hepperle, R. Schulin and F.A. Marsan, Introducing a method of human health risk evaluation for planning and soil quality management of heavy metal-polluted soils, *Landscape and Urban Planning*, 88(2-4) (2008), 64-72.

[15] F. Ramade, Eléments D'écologie, Écologie Appliquée, Action De l'homme sur la Biosphère (4ème édition), McGraw-Hill, Paris, (1991), 558.