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ASSESSMENT OF THE LEVEL OF CONTAMINATION OF MARKET GARDENERS IN LEAD AND CADMIUM: CASE OF LETTUCE AND CABBAGE IN THE AUTONOMOUS DISTRICT OF ABIDJAN (CÔTE D'IVOIRE)

Gouli Bi Irié Marc[1*], Yao Brou Lazare[2], Bamba Ibrahim[1], Tano Kablan[3] and Trokourey Albert[1]

[1]Felix Houphouët Boigny University, Training and Research Unit in Structural Sciences of Matter, Laboratory of Physical Chemistry.22 BP 582 Abidjan 22, Côte d'Ivoire.
[2]National Laboratory for Agricultural Development Support (LANADA), Central Laboratory for Agrochemistry and Ecotoxicology (LCAE). 04 BP 612 Abidjan 04, Côte d'Ivoire.
[3]Nangui Abrogua University, UFR of Food Sciences and Techniques, Laboratory of Food Technology of Tropical Products. 02 BP 801 Abidjan 02, Côte d'Ivoire.

***Corresponding Author: Dr. Gouli Bi Irié Marc**
Felix Houphouët Boigny University, Training and Research Unit in Structural Sciences of Matter, Laboratory of Physical Chemistry.22 BP 582 Abidjan 22, Côte d'Ivoire.

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ABSTRACT
The main objective of this study is to assess the level of contamination in trace metal elements (Pb and Cd) in lettuces and cabbage grown on market gardening sites of the French Forces in Côte d'Ivoire (FFCI) and Agency for the Safety of Air Navigation in Africa and Madagascar (ASECNA) located in Port-Bouët in the Autonomous District of Abidjan (Côte d'Ivoire). In this work, sixty (60) cabbage and lettuce samples are analyzed using Atomic Absorption Spectrometer (AAS). The results of our analyzes show that Lead is present in all lettuce and cabbage samples in which average contents are 0.129 mg / kg and 0.305 mg / kg respectively, while Cadmium is only found in the samples of cabbage with a content of 0.062 mg / kg. The amount of Cd in cabbage and Pb in lettuces obtained in this study is lower than the permitted maximum residue limits (MRL) (0.300 mg / kg DM for Lead (Pb) and 0.200 mg / kg DM for Cadmium (Cd)). Only the Pb content which is (0.305 mg / kg) is slightly higher than the MRLs. In conclusion, this study show that the cabbages of both areas are not better for the human consumption.

KEYWORDS: Leaf vegetables, metallic trace elements, Lead (Pb), Cadmium (Cd), Lettuce, Cabbage, Contamination.

INTRODUCTION
In Côte d'Ivoire, like many other African countries and elsewhere, market gardening occupies an important place in socio-economic activities by supplying food market with their products.[1] Particularly, vegetable products contribute quantitatively and qualitatively to the improvement of the food situation of rural and urban populations by their contributions in mineral elements and especially in vitamins. In the city of Abidjan, vegetable production and more specifically that of leafy vegetables plays an important part in socio-economic activities.[2,3] It is a lucrative activity for some households and contributes significantly to the economy of the country.

However, this major agricultural activity is today confronted with enormous difficulties, among others, land insecurity, access to agricultural inputs and the lack of specialized technical supervision. Added to that, there is the thorny problem of pollution due to the proximity of the production sites of major urban and industrial traffic axes, the use of wastewater for plant irrigation and the fertility of market garden soils with poultry manure. This poultry manure often contains metallic trace elements including Lead (Pb) and Cadmium (Cd) which are dangerous for health.[4-6]

For example, in humans, Lead (Pb) can be redeposited in the soft tissues of the body and can also have effects on blood pressure, kidney function in adults, as well as reproduction and development of the body in children and on the central nervous system (decrease in intellectual quotient point, attention deficit disorder) in children, even at low doses. For Cadmium (Cd), it can affect the respiratory tract (lungs, nasopharynx) and possibly cause prostate.[7,8]

The alert resulting from this study on the potential risk of transfer of pollutants in the food chain justifies the need to assess the level of contamination of plants grown on these polluted soils irrigated with wastewater. The general objective of this study is to assess the levels of contamination by metallic trace elements (Pb and Cd) in lettuces (lactuca sativa) and cabbage (Brassica oleracea var. Capitata) cultivated in the Autonomous District of Abidjan.

MATERIALS AND METHODS

This work is focused on the lettuce and cabbage samples. These leafy vegetables were collected from two large market gardening sites, the site of the French Forces in Côte d'Ivoire (FFCI) and that of the Agency for the Safety of Air Navigation in Africa and Madagascar (ASECNA), both sites located at Port-Bouët in the Autonomous District of Abidjan (Côte d'Ivoire). The quantification of metallic trace elements (Pb and Cd) was done using SPECTRA 110 Atomic Absorption Spectrometer (SAA) (VARIAN) of the National Laboratory for Agricultural Development Support (LANADA) after digestion and mineralization of the samples.

The digestion, the mineralization of the samples and the determination of lead and cadmium were carried out according to the AOAC (Association of Official Analytical Chemists) method n ° 999.10.[9]

To digest each sample, a test sample of 0.5 g of ground material is placed in a Falcon tube. First, 3 mL of nitric acid ($HNO_,$ Purity: 37%) and 9 mL of hydrochloric acid (HCl, Purity: 37%) were successively added to the ground product under a fume hood. Another Falcon tube containing double distilled water was used as blank. To this tube (white), the same reagents which were used for the digestion of the matrix were added in the same order. The Falcon tubes were put in a water bath at 100 ° C for 60 min (1 hour), then left for cooling. After cooling down completely, 25 mL of double distilled water was added. Then, all the obtained samples were filtered on Wattman (brand) paper in a 100 mL test tube. The content of each test tube is completed with double distilled water and transferred to each tube for spectrometric analysis of trace metal elements (Pb and Cd).

Finally, the lead (Pb) and Cadmium (Cd) contents were determined from a calibration line previously carried out for each metal with concentrations of 10 µg / L, 20 µg / L, 30 µg / L and 40 µg / L. The two correlation coefficients between the absorbances and the metal concentrations of the standards are found to be between 0.997 and 0.999. The formula below is used to determine the contents of each metal in each sample.

$$C_m = \frac{(C_l - C_b).f.V}{m} \quad (1)$$

C_m (metal concentration (mg / kg or ppm)), C_l (Gross sample concentration (mg / L)), C_b (Gross blank concentration (mg / L)), f (dilution factor (f = 1 in this work)), m (mass of the sample (in g)), V (Total volume (in mL, in this work V = 100 mL)).

RESULTS

During sampling, sixty (60) samples were collected as shown in Tab. 1.

Table 1: Sampling protocol.

Matrices	FFCI	ASECNA	Total
Lettuce	15 samples	15 samples	30samples
cabbage	15 samples	15 samples	30samples
		Total quantity	60 samples

According to the method used, the DL and Q L values of Lead (Pb) and Cadmium (Cd) in lettuce and cabbage leaves were determined. The official standards of the European Union (EU) (Regulation (EC) N ° 1881/2006 and the FAO / WHO standards), on the maximum residue limits (MRLs) for lead and cadmium in edible lettuces and cabbage were recalled as indicated in Tab.2 in order to assess the level of contamination of the studied samples.

Table 2: Detection limits (DL), quantification limits (QL) and maximum residue limits (MRL) of Pb and Cd in lettuce and cabbage.

Heavy metals	Detection limits (DL) (mg/kg)	Quantification Limits (QL) (mg/kg)	Maximum residue limits (MRL) (mg/kg)
Lead	0.046	0.104	0.300
Cadmium	0.002	0.019	0.200

The average concentrations of heavy metals in leaf lettuce and cabbage vegetables collected at the FFCI and ASECNA sites are given in Tab. 3.

Table 3: Average contents and standard deviations in metallic trace elements (mg / kg DM) in lettuces and cabbage on the FFCI and ASECNA sites of Port-Bouët (Abidjan).

Matrices	Heavy metals	Average contents (FFCI)	Average contents (ASECNA)	Standard deviation (FFCI)	Standard deviation (ASECNA)
Lettuces	Pb	0.153	0.104	0.026	0.03
	Cd	ND	ND	NC	NC
Cabbage	Pb	0.307	0.303	0.165	0.144
	Cd	0.058	0.065	0.043	0.038

ND = not detected and NC = Not Calculated

DISCUSSION

The analysis of the results obtained reveals that the metal contents are very disparate and vary depending on the sampling site and also the plant species. In general, the sequence of metal contents in the vegetables studied (lettuce and cabbage) is as follows: Lead> Cadmium. In the cabbage leaves, taken from the FFCI and ASECNA sites, lead (Pb) concentrations are above the maximum residue limit (0.300 mg / kg) with the values of 0.307 mg / kg and 0.303 mg / kg for FFCI and ASECNA respectively. Cadmium (Cd) is detected in cabbage with the concentrations of 0.058 mg / kg for the first sampling site (FFCI) and 0.065 mg / kg for the second sampling site (ASECNA), but these average concentration values are below the maximum residue limit (0.200 mg / kg) (about 3-fold lower than the measure values). Lead amount found in lettuce is lower than those found in cabbage as well as for Cadmium. However, it should be noted that Cadmium occurs in the form of a trace in lettuce at the two sampling sites. This element is not detected in lettuce at both sites.

The high content of MTE, especially Lead (Pb) recorded in the cabbage leaves, is not only due to the proximity of the studied sites to main roads and wild dumps, but also by the use of wastewater, raw untreated for irrigation of vegetable crops. For comparison of our values with those of the literature, in 2013, Croatia became a Member State of the European Union (EU) and Commission Regulation (EC) 1881/2006 regarding the setting of maximum residue levels for certain contaminants in food (with modifications) became valid, while the previous regulation, which is the Ordinance on Maximum Levels of Certain Contaminants in Foods has been suspended.[10,11]

The average concentrations of Pb detected in the lettuce and cabbage leaves of GountiYena in Niamey (Niger) which vary from 0.95 mg / kg to 5.17 mg / kg, are higher than our obtained values (0.129 - 0.305 mg / kg), and much lower than those from India (21.59 - 57.63 mg / kg).[12,13] The Pb contents reported in plants (0.01 - 0.02 mg / kg) in Lagos in Nigeria are much lower than our obtained which are smaller than the values(2,7 mg/kg) obtained by Issaka in Burkina Faso.[14,15]

The Cd contents (0.58 - 0.60 mg / kg) in vegetables, obtained in the GountiYena valley in Niamey (Niger)are much higher than those we have obtained (0.062 mg / kg) only in cabbage as this heavy metal (Cd) is not detected in lettuce.[12]

By comparing the average contents obtained in this study with the values of the maximum residue limit (0.200 mg / kg DM for Cadmium and 0.300 mg / kg DM for Lead), the Pb content in lettuce is lower than the MRL. However, it is higher than the MRL in cabbage (0.305 mg / kg). As for the average Cd contents, all the obtained values are below the maximum residue limits in all the matrices (lettuce and cabbage).

CONCLUSIONS

It emerges from this study that with the method and apparatus used, Cadmium (Cd) is only detected in cabbage (*Brassica Oleracea Var. Capitata*) with an amount below the maximum residue limit allowed in foodstuffs intended for human consumption. However, Lead (Pb) is present in the two matrices (Cabbage and lettuce) with an average content in cabbage slightly above the maximum residue limit. Therefore, regular monitoring of MTEs in environmental matrices, in particular, soils, waters and vegetables should be put in place to avoid excessive accumulation of MTEs in the food chain.

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