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Contaminations in metallic trace elements (Lead, cadmium) of urban and periurban market garden perimeters in the municipality of Lokossa in Benin

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Abstract

Faced with the challenge of global food security, the production and consumption of vegetables in urban and peri-urban areas are a nutritional asset. However, demographic pressure, poorly regulated cultivation practices and growing pollution cannot guarantee the sanitary quality of the products harvested. This study aims to evaluate the metallic contamination of the soil, irrigation water and market garden crops produced on the urban market garden perimeter in the municipality of Lokossa in Benin. The samples of irrigation water, soil and vegetables were taken for this purpose and analyzed by a lead (Pb) and cadmium (Cd) Molecular Absorption Spectrophotometer at the water and food quality control laboratory of the Ministry of Health. We observed respectively an accumulation in the soil (0.52mg /kg) followed by vegetables (0.58mg /kg) obtained against 0.2mg /kg fixed by the WHO and in water (0, 42mg / L) obtained against 0.0004mg / L set by the GESAMP standard. As for Cadmium, the levels are at the threshold of standards for soil (0.10mg /kg), vegetables (0.05mg /kg) but largely exceeds the accepted standard for water (0.07mg / L) obtained against 0.00021mg / L set by the GESAMP standard. The consequences induced by this contamination are health risks for consumers. To remedy this, it is urgent that steps be taken to identify all potential sources of contamination in order to avoid or control them.

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Introduction

Metallic Trace Elements (MTEs) such as Pb, Cd have been and are released into the environment (both natural and anthropogenic sources), posing a threat to the health of people exposed to them both through inhalation and food. Consumption of food (vegetables, fruits) grown in MTEs contaminated areas carries the risk of potential negative health effects (Järup 2003; Briki *et al.,* 2015; Gutiérrez *et al.,* 2016; Soltani *et al.,* 2017, Wu *et al.,* 2018). The source of human exposure to such metallic trace elements as Cd and Pb is food. In a number of studies levels of these metals have been investigated in various food products (Gbago *et al,* 2003; Yingliang *et al.,* 2014; Soylak *et al.,* 2015; Wu *et al.,* 2018; Ouikoun *et al.,* 2019). The major pathway of human exposure to metallic trace elements is their transfer from soil to edible plant. Plants take up metallic trace elements and accumulate them in their edible and non-edible parts. Consumed in sufficiently high amounts can cause human health problems (Jolly *et al.,* 2013). Cadmium an increased risk of cancer. This element is nephrotoxic and may cause kidney failure (Hounkpatin *et al.,* 2013; Margozato *et al.*, 2020). Exposure to lead occurs mainly through the food chain, although ingestion of soil and dust can also be an important contributor. Exposure to Pb through food intake, which can cause adverse health effects, has been intensively studied for human health risk assessment (Sun *et al.*, 2011; Boon *et al.*, 2012). Exposure to Pb can impair brain and nervous system, and can also cause chronic kidney disease (Hounkpatin *et al.,* 2017).

In developing countries south of the Sahara, urban and peri-urban market gardening in coastal areas plays an important role in the supply of vegetables to rapidly growing cities (Gnandi *et al.*, 2006). This intensive agriculture is very dynamic, but it is not safe (Agueh *et al.*, 2015). The uncontrolled use of agricultural inputs and pesticides in large quantities leads to environmental and public health problems that create other economic constraints related to the high cost of production (Akogbeto *et al.*, 2005). Thus, the use of pesticides in agriculture is certainly useful for maximizing yields in cash and vegetable crops, but use must take into account a number of considerations to minimize health and environmental impacts.

Of all of the above, it should be noted that the unsurable use of pesticides in market gardening poses a risk of heavy metal poisoning to the consuming population. Thus, it is necessary to work to improve the health of consumers.

This study aims to assess the metal contamination of soil, water and vegetable crops produced on urban market gardening perimeters in the municipality of Lokossa in Benin.

Materials and methods

Study Framework

Located in the Department of Mono, on the edge of the Atlantic coast, the Municipality of Lokossa (Fig.1) is between 6 degrees 34' 52' and 6'44' 25' north latitude and between 1-36' 46' and 1'52' 17' of east longitude and covers an area of 260 km² for a population of 109839 inhabitants in five boroughs (Ogouwale *et al.,* 2007). Like the entire coastal region, it enjoys a sub-equatorial climate, characterized by low temperature variations (annual average of 27.4 c) and bimodal rainfall: (i) a large dry season from November to April, ii) a large rainy season from April to July, iii) a small dry season from August to September, iv) a small rainy season from September to October. The annual rainfall average is 882.1mm. (Bamahossovi *et al.,* 2016).

Sample

This study is a descriptive and analytical cross-sectional study conducted in the market gardeners of Chicomè in Benin in 2019. Sampled was the most consumed and mature vegetables ready for consumption, water and soil.

Water samples are taken at six (06) sites that are the points of the streams most used by market gardeners. The samples were taken from a two-liter bottle embedded in a denominational wooden cage for the occasion. This is weighted by two rock masses that are laterally attached to it. The bottle has a polystyrene cap attached to a wire that has been pulled to unclog it (a knot is made at each meter to assess the depth of the immersion); the bottle is removed from the water when it is filled. The collected water was kept cool at about 4°C in a cooler primed for the occasion. A total of 6 water samples are collected.

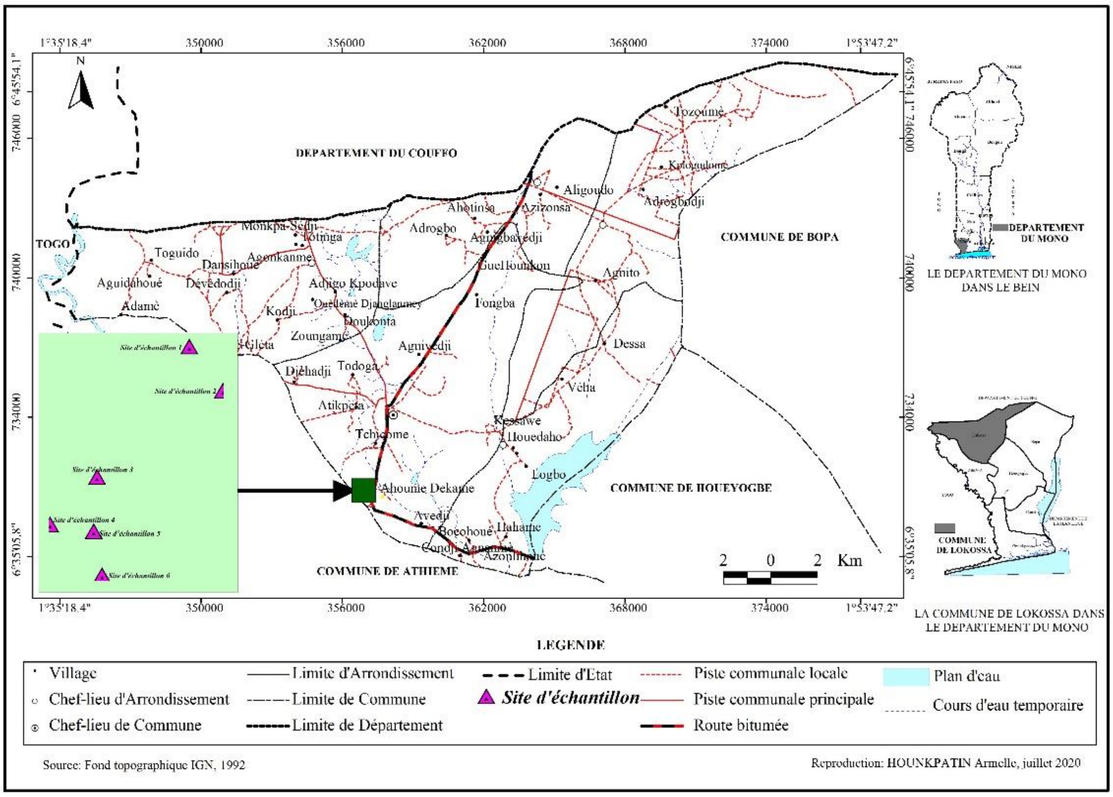

Fig. 1. Geographical location of study area.
Source: (Hounkpatin, 2020).

The most consumed vegetables such as *Lactuca sativa, Brassica oléracea* and *Daucus carota* are selected. 12 samples are taken stored in labelled sterile bags. Only mature market garden products ready for consumption are taken from the watered boards at the rate of four plants taken at random for each species. 12 samples were taken.

Soil samples are taken from 0-20cm in the root zone of crops, on boards watered with water. Each pick of market garden products corresponds to a soil sample. 12 samples are taken. Soils are collected by site using a Beckmann dumpster. Once removed, these soils are poured into sterile vials and placed in a cooler.

A total of 30 samples were collected as follows: 6 water samples, 12 soil samples, 12 vegetable samples *(Lactuca sativa, Brassica oléracea and Daucus carota*) stored in a cooler closing from the accumulator to the laboratory.

Laboratory analysis

The methods used for the analyses are based on the mineralization of the samples according to HACH and those of dosages to the Molecular Absorption Spectrophotometer (DR 3900) by Dithizone methods for the dosage of lead and cadmium. The analyses were carried out at the Water and Food Quality Control Laboratory (LCQEA) of the Ministry of Public Health in Benin.

Statistical analysis of data

International Journal of Innovation and Applied Studies ISSN 2028-9324 Vol. 10 No. 1. Jan. 2015, pp. 21-29 software Epi info, Excel 2016, the regulatory standards used are those set by GESAMP (1982) for water, the PNEC INERIS standard for soils and by WHO (2001) for market garden products. The compliance tests were done with the Student test at the 5% threshold.

Results

Evaluation of lead and cadmium content in watering vegetables.

Fig. 2. shows the levels of lead and cadmium in the watering water of vegetables.

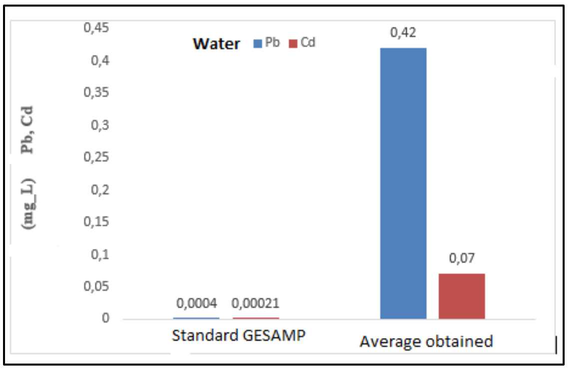

Fig. 2. Average ETM content (mg/L) (Pb, Cd) in vegetable water**.**

From the analysis of this Fig. 2, it is noted that the average levels obtained in lead water (0.42mg/L) and Cadmium (0.07mg/L) exceed all the regulatory standards set by GESAMP for these metals: Pb (0.0004mg/L); Cd (0.00021mg/L). It is inferred that the water water from the crops is contaminated with Lead and Cadmium.

Evaluation of lead and cadmium content in vegetables.

Fig.3 illustrates the levels of lead and cadmium in vegetable crops.

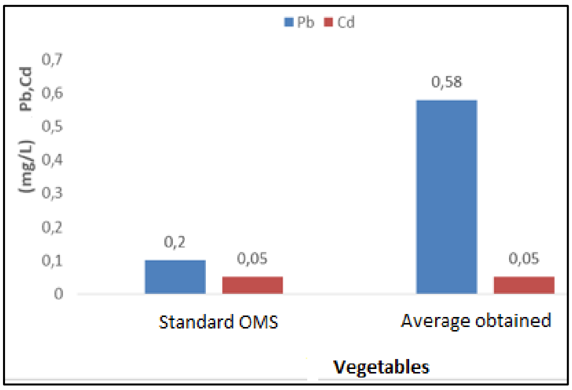

Fig. 3. Average ETM content (mg/kg) (Pb, Cd) in vegetable.

At the vegetable level, the average lead content (0.58mg/kg) is higher than the WHO/FAO standard (0.2mg/kg), but the average cadmium content (0.05mg/kg) obtained is equal to the regulatory standard set by WHO/FAO (0.05mg/kg). In fact, during the rains the ETM elements present in the environment are found in the lake by runoff, these elements once in the lake sediment.

Evaluation of lead and cadmium content in soil

Fig. 4 shows the levels of lead and cadmium in soil samples.

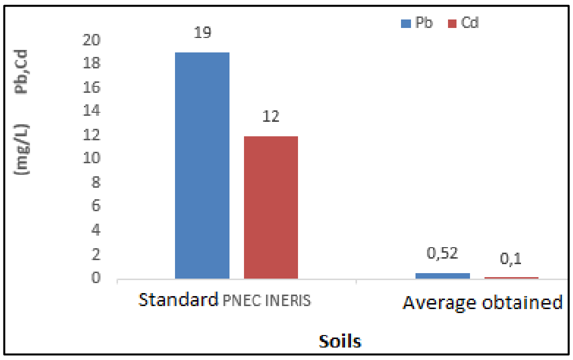

Fig. 4. Average (mg/L) ETM (Pb, Cd) in soils.

From the analysis in Fig. 4, soils are not contaminated with lead or Cadmium, as the averages obtained are all below the regulatory standard required by PNEC INERIS: Pb (19mg/kg); CD (12mg/kg) for soils.

Discussion

The different concentrations of chemical elements such as lead and cadmium indicate contamination of heavy metals in water, soil and market garden products in the market garden perimeter of the municipality of Lokossa.

In the watering waters of this market gardening perimeter we find that the lead concentration significantly exceeds that allowed by the regulations that is to say the GESAMP standard with a difference ranging from 0.0416 or 1000 times more; this could be due to an anthropogenic origin that can be explained by all the human activities carried out around the water points which are used not only by market gardeners but also by others peoples for various purposes given their location in urban and peri-urban environments where other activities are carried out. These results are in line with those of Pazou *et al.,* 2010; who indicated that, apart from market gardening crops and soil, water from the

Houéyiho (Cotonou) market garden site in the Republic of Benin is contaminated not only with heavy metals but also with nitrates. It is the same as for cadmium still in water whose average values obtained are much higher than recommended. Both cadmium and lead are metal trace elements that are easily found in surface waters and in pits in urban areas. They are drained in these reservoirs by stormwater runoff and come mainly from the various human activities carried out in urban areas: garbage dumps; the combustion of petroleum products; coal combustion partly explains this contamination.

In market garden products (vegetables) from the site, the trace metal elements (Pb and Cd) are found at varying concentrations depending on the chemical element dosed and the type of vegetable sampled. As a result, lead remains more accumulated with high value that set by regulation or standards. On the other hand, cadmium has a concentration close to that recommended. These results are similar to the results of Atidegla *et al.,* 2011; which found from a study conducted from 2009 to 2010 at the Yodo-Condji et Ayi-Guimou market garden site that, in vegetables (carrot, large morelle and tomato) the lead level exceeds 41.6 and 38 times more the Beninese standard. With a slight difference in Cadmium which according to their study is not at the threshold of the standard but exceeds it from 25.6 to 40 times. The same observation was made recently by Pazou *et al.,* 2020; who also found that vegetable crops at the Houeyiho market garden site in Benin are highly contaminated with heavy metals such as Pb, Cu and Zn. In the market garden areas of Cotonou where similar work was carried out by Agbossou, 2005 ; exceeding the standards allowed by the levels of heavy metals (lead, iron, copper, cadmium, etc.) for most cultivated vegetables were justified by the use of compost based on household waste according to the author. Further and in the same contexts on a study carried out in Côte d'Ivoire, Kouakou *et al.,* 2015; confirm a contamination of some market garden products in Cadmium, Lead, Copper, Zinc and Nickel that make them unfit for consumption. In Belgium, the results works of Kestemont's, 2008 ; are also in line with ours because, after a study carried out in several vegetable gardens in several municipalities of the Charleroi entity, he noticed that the vegetables of the gardens are loaded with heavy metals including lead.

In the soil, our results indicate the presence of lead and cadmium with average values below accepted standards. This could be explained either by a professional awareness of the adoption of new farming practices or by a large infiltration of these chemical elements much more in depth and or a heterogeneity of the compost used during the formation of the boards. Several authors have detected the presence of these heavy metals in soils in market gardening environments with varying concentrations depending on the site and type of fertilizer used. This is the case of Nguelieu, 2017; which confirms a high contamination of soils of the urban market garden perimeter of Yaounde in Cameroon. According to studies of Atidegla *et al.,* 2017; which are associated with ours, in droppings and composts only iron concentration exceeds standards and other Pb and Cd elements are in acceptable concentrations. According to Semde, 2005; if some of the heavy metals go directly into the soil and water, most of it is first emitted into the atmosphere before joining the other two elements.

At the end of this study, we note that the consumption of these contaminated vegetables could pose a threat to the health of consumers. Some of the metal elements such as lead, when highly concentrated, act negatively on various organs and can cause severe psychomotor disorders and affect the immune system according to Legault and Paquette, 2007. In front of this situation, it is then advisable from the work of Pazou *et al.,* 2020; to cook market garden products before their consumption, which greatly reduces the concentration of these metals in finished products for consumption.

Conclusion

In sum, this study assessed the quality of soil, water and vegetable products in the market garden perimeter of the municipality of Lokossa. The result is that metal trace element concentrations (Pb and Cd) are high in water and market garden products in accordance with soil-level standards and acceptable to the stated standard. This work has great interest in preserving the resources of vegetable soils in urban and periurban areas. Given the many sources of suspected contamination, there is no prediction to be made of the cause-and-effect relationship between available soil elements and MTEs in soils. Regardless of the concentration of the chemical element found, its presence alone poses a certain threat to the health of consuming populations. However, efforts remain to be made to further reduce these concentrations through awareness of the actual use of compost manufactured on the site. The risks of contamination studied with respect to existing sources and many other sources in the study perspective will be important information for taking preventive or interventional measures.

Conflicts of interest

Authors declare no conflict of interests.

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