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Metallic contamination of medicinal plants as consequences of soil pollution

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Abstract

Medicinal plants used by populations are harvested in the environment subjected to contamination by pollutants including heavy metals, toxic to humans. The objective of this research is to assess contamination of 5 medicinal plants commonly used in Benin by mercury and growing sometimes in areas at risk of mercuric contamination. Material plant studied included Croton lobatus, Hemizygia bracteosa, Desmodium velutinum leaves and Cissampelos owariensis and Calyptrochilum christyanum aerial parts. These plants, as well as soils on which they are established, were collected, respectively in Abomey-Calavi, Savalou, Abomey for the 3 first plants and Avrankou for the 2 last. Direct Mercury Analyser (DMA 80 TRICELL) was used to quantify mercury in dry plant powders and dried soil grains. The results obtained reveal mercury's presence in all plants and soils samples. Mercury concentration varies between 18.36 and 133.54µg/kg in soils and between 20.45 and 89.13µg/kg in leaves. Soil concentrations are below threshold value of 1mg/kg. Plants have been shown to accumulate mercury, or even very accumulative for Croton lobatus and Desmodium velutium. This study shows that harvesting medicinal plants on soils contaminated by heavy metal is a risk for human health.

Keywords: *Croton lobatus*, *Hemizygia bracteosa*, *Desmodium velutinum*, *Cissampelos owariensis*, *Calyptrochilum christyanum*, heavy metal, mercury, medicinal plant, contamination.

Introduction

Heavy metals are chemical elements with a density greater than 5-6g/cm^3 resulting from earth crust alteration[1,2]. They are naturally present in all compartments of environment. Heavy metals are not biodegradable, accumulate in environment and at all levels of food chain from plants growing on contaminated soils. Certain metals are necessary for carrying out biological processes. They are known as "essential"[3]. Those are toxic e.g. iron, copper, zinc, manganese ... etc. The essential heavy metals are in small quantities in biological tissues and become toxic when their concentrations are high. There are also some heavy metals toxic to living organisms (cadmium, lead, mercury, etc.) even with very low concentrations[4,5].

The pollution of the human living environment, including rivers, soils and plants therefore constitutes a threat to his health. Mercury poisoning lead to liver cancer, esophagus cancer, cirrhosis; neurological and behavioral disorders (encephalopathy, euphoria, depression, ataxia, dysarthria, blindness, deafness, etc.); pulmonary disorders (respiratory tract irritation, pulmonaryembolism, cough, dyspnea), skin disorders (allergy, acrodynia), kidney disorders, digestive manifestations (abdominal pain, bloody vomiting, digestive perforation)[6-9,10]. For example, mercury pollution in Minamata Bay caused a health disaster in Minamata (Japan), and this led to the adoption of Minamata Convention for Protection of Human Health and Environment from harmful effects of mercury in October 2013.

Heavy metals presence in soils is either natural or due to anthropogenic activities including the use of synthetic fertilizers, phytosanitary products in agriculture's sector as well as industrial and mining activities.

In addition, humans almost entirely depend on plants for feeding, medical treatment, dressing, building a house, as a raw material, etc... In Africa, at least 80% of population uses traditional medicine for diseases treatment[11]. Medicinal plants used by Benin people to treat diseases are collected on all types of soil, whether they are contaminated with traces of heavy metals or not. This study was undertaken to screen to what extent the use of medicinal plants collected on heavy metals-contaminated soils by populations poses a health risk. It aims to assess the degree of mercury contamination of some medicinal plants that grow on contaminated soil.

Materials and methods

Material plant: *Croton lobatus, Hemizygia bracteosa, Desmodium velutinum leaves* and *Cissampelos owariensis,*

Calyptrochilum christyanum aerial part constitute material plant used. These first three plants were harvested respectively in Abomey-Calavi (6°24'50"N, 2°20'28"E), Savalou (7°56'17"N, 1°57'36"E), and Bohicon (7°10'15"N, 2°4'2"E), and the rest in Avrankou (6°37'32"N, 2°38'25"E for *C. christyanum* and 6°32'38" N, 2°38'55" E for *C. owariensis)*. Each plant has been identified by the National Herbarium of the University of Abomey-Calavi (Benin). A specimen of each plant was deposited in the said herbarium. The identification numbers were respectively AA 6541/HNB, AA 6542/HNB, AA 6543/HNB, AA 6544/HNB, AA 6545/HNB.

Mineral material: Mineral material was made up of soils taken from places where plants are harvested (Abomey-Calavi, Savalou, Abomey, Avrankou).

Chemical material: Reagent (mercury) used in this study came from chemical company Sigma-Aldrich-Fulka (Saint Quentin, France).

Quantification of mercury content in soils: Soils were dried in laboratory at 16°C and sieved. Only grains with diameter of less than 0.63mm were used for assay by atomic absorption spectrophotometer by using a Direct Mercury Analyser (DMA-80). It is an atomic absorption spectrophotometer inside which sample undergoes "a thermal decomposition followed by the gold amalgamation and a detection of atomic absorption spectrometry"[12].

After calibrating, sampled 100mg of grains of each soil were placed in nacelles, that which are placed on analyser's autosampler. Concentration was read from computer which was connected to it. Analysis lasted 6 to 7 minutes. This operation was repeated 3 times.

Quantification of mercury content in plants: The plants content in mercury was analysed using the mercury quantification method in soils.

Material plant was collected from places where soil was collected. It is dried and then reduced to a powder. 60mg of powder from each sample were weighed, deposited on nacelles and introduced into mercury analyser for dosage in triplicate.

Statistical analyses: All measurements are made in triplicate and data obtained were presented as mean ± standard deviations with $P< 0,05$.

Results and discussion

Mercury content in soils: Mercury content results (Figure-1) showed that mercury was detected in all soils. The most contaminated soils were those from Savalou and Avrankou (where *Hemizygia bracteosa* and *Cissampelos owariensis* were collected) with respective contents of 133.54 ± 4.19µg/kg (0.13354 ± 4.19mg/kg) and 130.28 - 0.72µg/kg (0.13028 ± 0.72mg/kg). They were followed by that from Avrankou (where *Calyptrochilum christyanum* was harvested) with a content of 84.67 ± 0.53µg/kg (0.08467 ± 0.53mg/kg), Bohicon with a content of 18.43 ± 0.26µg/kg (0.01843 ± 0.26mg/kg) and finally Abomey-Calavi with a content of 18.36 ± 0.82µg/kg (18.36 - 0.82mg/kg). The presence of mercury in soils could be linked to anthropogenic activity as the collection place in Savalou is an old landfill containing waste batteries components. In Avrankou, the plants of soils were collected from an old palm plantation, where pesticides containing mercury were probably used. Since pesticides are not biodegradable, there would have been persistence. The least polluted soils were those from Abomey and Abomey-Calavi, which are by roadside. Mercury detected there could be brought by runoff from crop fields where pesticides or mercury-based fertilizers were used. However, mercury contents of these soils were lower than limit value of mercury of 1mg/kg of dry earth[13].

Mercury content in plants: Figure-1 showed that all the targeted plants were contaminated with mercury. *Croton lobatus* harvested by roadside is the most accumulating plant with a content of 89.13 ± 1.75µg/kg and *Cissampelos owariensis*, with a content of 20.45 ± 0.60µg/kg, was the least accumulator. *Croton lobatus* and *Desmodium velutinum* tolerated mercury more than the other 03 plants.

The presence of the mercury in plants could be due to its absorption by this metal from the contaminated soils. In other words, the soils were depolluted by the plants, which are known as phytoremediation. The mercury extraction from the soils by the plants could due to the chelation process. Physicochemical conditions, plant physiology and high concentration of mercury, would have allowed mercury to migrate to the leaves, which explains their presence in these plant organ[9]. Although values found in soils are below threshold value of 1mg/kg[10], this low concentration could constitute a risk of toxicity for living organisms even at very low concentrations[14].

In addition, mercury concentrations in *Croton lobatus* and *Desmodium velutinum* leaves were higher than those in soils. However, these two plants could be mercury accumulators and can even be considered as hyper accumulators and be indicated for phytoremediation which is soil depollution by plants which accumulate pollutants[16]. The ability of *Croton lobatus* to extract and accumulate mercury from soils was previously used to decontaminate former Akouédo landfill in Abidjan, Côte d'Ivoire [7].

However, these plants are used for therapeutic purposes. Mercury presence in leaves shows that harvest place of medicinal plants is very important. Regular consumption of herbal medicines contaminated with mercury could lead to mercury accumulation in human body and cause serious chronic diseases. Mercury, like other metallic trace elements, is toxic to plants, humans and animals[18].

This study is the first to be carried out on these medicinal plants (with the exception of *Croton lobatus*).

These medicinal plants that grow on old landfills, agriculture soils and polluted soils should not be used for therapeutic purposes. An awareness of populations on mercurial contamination of medicinal plants that grow on these grounds is necessary.

Conclusion

This study made aimed to assess the contamination of some medicinal plants growing on contaminated soils by mercury. The results showed that soils were contaminated by mercury resulting from anthropogenic activities. Mercury concentrations in soils were below threshold value of 1mg/kg. The plants which grown on these soils also contain mercury. Two of them were found to be very accumulative. These plants can be used for phytoremediation. Mercury presence in plants is a public health problem. People can be poisoned by mercury while seeking treatment. An awareness of populations on the choice of the places of harvesting medicinal plants is desirable.

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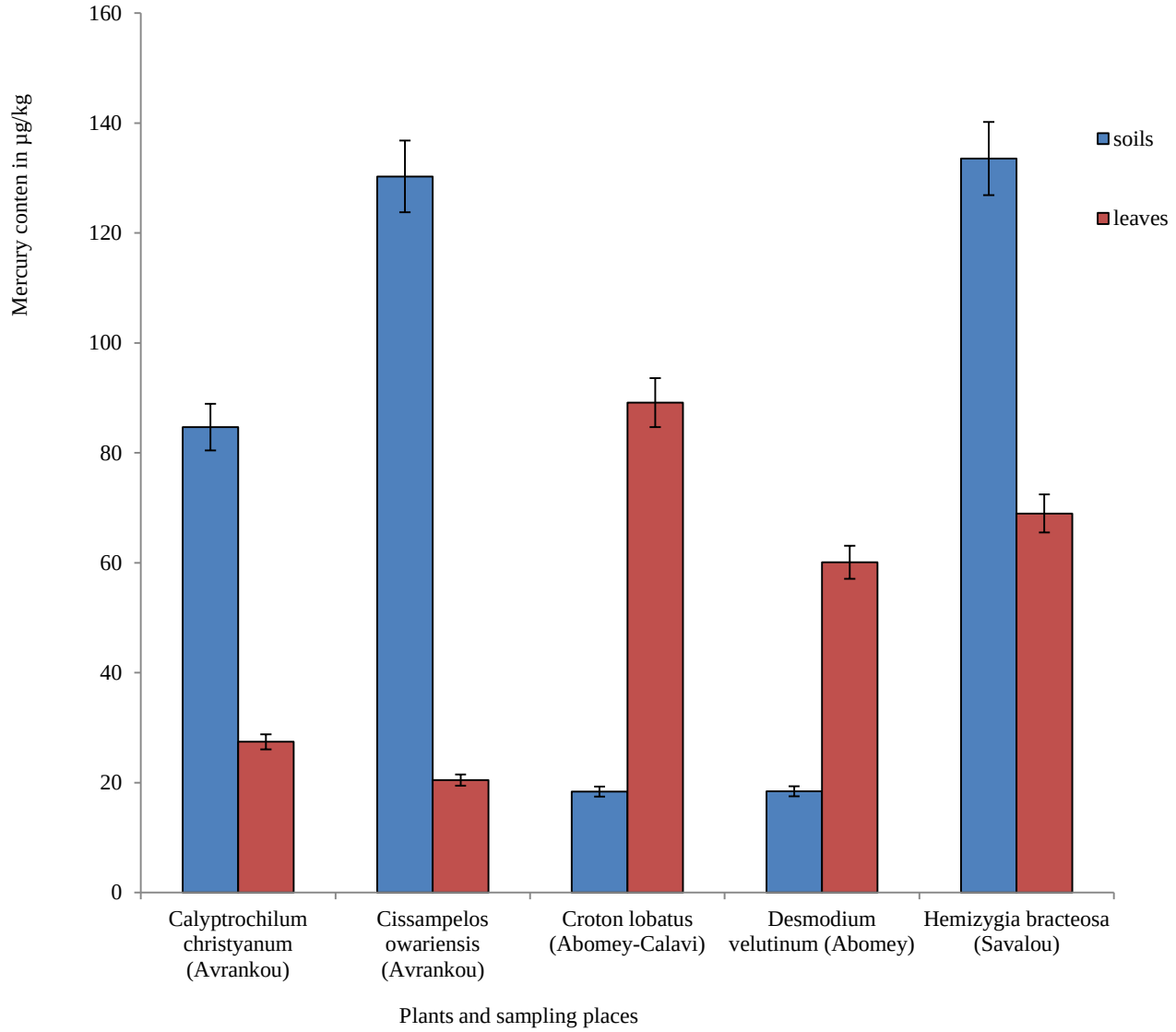

Figure-1: Mercury content (µg/kg) in soils and leaves of 5 plants (Harvest cities are in parentheses below plant names).

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