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Contamination of anti malarial plants by Lead and cadmium in cotonou, Republic of Benin

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Abstract

In order to investigate the level of contamination with toxic heavy metals in anti-malarial plants sold in the markets of Cotonou, some anti-malarial plants were selected through an ethno-botanic survey by using the ATRM (Triple Purchase of Healing Plants) a method elaborated in Togo. Out of 35 species of plants listed as anti-malarial, 5 were selected for the assessment of the contamination with toxic heavy metals. Our study showed that the maximal values for almost all samples contaminated with lead and Cadmium was above the standards accepted by the World Health Organization (WHO). Besides, it was revealed that the contamination with toxic heavy metals depends on each species as well as on the site of purchase. *Senna rotundifolia* was more contaminated with lead (2.733mg / kg ± 0.356mg / kg) and with cadmium (0.583mg / kg ± 0.044mg / kg) on the site of Vossa than on the site of Dantokpa (1.825mg/kg ± 0.133mg/ kg and 0.062mg/kg ± 0.015mg/kg) respectively. It comes out of our investigations that the administration of herbal preparations containing these plants could have an impact on the health of the populations and on the environment.

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Introduction

Plants have always been used for health purposes since prehistoric times and this tradition has been passed on from one generation to the other (Soh *et al.*, 2007, Kansole, 2009). According to the World Health Organization (WHO), 80% of the population of developing countries relies almost exclusively on traditional medicine for their health care needs (Farnsworth *et al.*, 1985). In some countries, the government encourages the use of medicinal plants which are cheaper than imported drugs. The therapeutic properties of plants were empirically known in Africa (Nacoulma, 1996). For instance, in Nigeria, the majority of the population depends on the use of herbal medicines because conventional medicines became increasingly expensive. (Fasola and Egunyomi, 2005; Obi *et al.*, 2006). In Togo, many plants are used in the treatment of several diseases including malaria and various infectious diseases (de Souza, 2005). Since the medical use of plants in Africa can negatively impact the health of the population due to their toxicological characteristics, to improve the use of this African medicine, several phytochemical investigations were conducted in order to provide scientifical justification for the use of traditional medicinal plants (Dougnon *et al.* 2012a). For this reason, Neuwinger (1996) devoted part of its works to the chemical and toxicological studies of 305 plants species from various African countries. Also, Kamanzi, (2002) has done important work about the pharmacological and phytochemical properties of medicinal plants in Ivory Coast.

In Cotonou, the main city of the Republic of Benin, medicinal plants are mostly sold in markets and the population puts their confidence in these traditional "pharmacies"; It is therefore justified to consider the toxicological quality of these plants because of the environmental pollution due to the use of chemical fertilizers. Since the 1950s when cotton cultivation was introduced in Benin, the environment has continuously been pressured because of the new farming practices. These practices cause important pollution that affects all environmental compartments with various pollutants including toxic heavy metals. The concentration of toxic heavy metals increases with the years (File Sat, 1997) and may thus constitute a real threat. Recent studies have shown that the food chain in Bénin is contaminated by the toxic heavy metals (Koumolou *et al.*, 2012). Plants, including medicinal plants are the first contaminated. In addition to the dose of toxic heavy metals (lead, cadmium and mercury). Independently from the dose, only the presence of theses metals in the food chain is a threat for human health. Despite this, toxicological properties of medicinal plants consumed in Benin are poorly studied . The objective of this work is to determine the presence of toxic heavy metals (lead and cadmium) in some anti-malarial plants sold in some of the most popular markets in Cotonou.

Setting, materials, and methods

The ethno-botanical survey

Cotonou, (Figure 1) where the ethno-botanical survey was carried from November 2011 to February 2012 is located in the department of Littoral, Republic of Benin (West Africa) This survey was conducted in 17 markets where the anti-malarial medicinal plants were purchased. These markets are: Wologuèdè, Ste. Rita, Fifadji, Zogbo, Mènontin, Kindonou, Godomey, Adjatokpa, Vèdoko, Brain Self, Vossa, Vodjè-Rail, Aidjèdo, Saint-Michel, Dantokpa, Gbégamey and Fidjrossè. In each market, these plants were selected based on the frequency of their use as anti malarial medicine Five plants were selected: *Senna rotundifolia Linn.* of the family of Fabaceae , *Pavetta corymbosa (DC)* of the family of Rubiaceae family, *Senna siamea (Lam.)*, Fabaceae, *Dichapetalum madagascariense (DC)*, Dichapetalaceae and *Morinda lucida Benth* , Rubiaceae.

After the selection, the five most frequent used anti-malarial plants listed above was purchased using the so called " Buying on Triplet of Medicinal Plants" in three different markets: Godomey, located in the town of Abomey-calavi; Dantokpa market the largest one in Cotonou and Vossa market located in the 8th arrondissent of Cotonou.

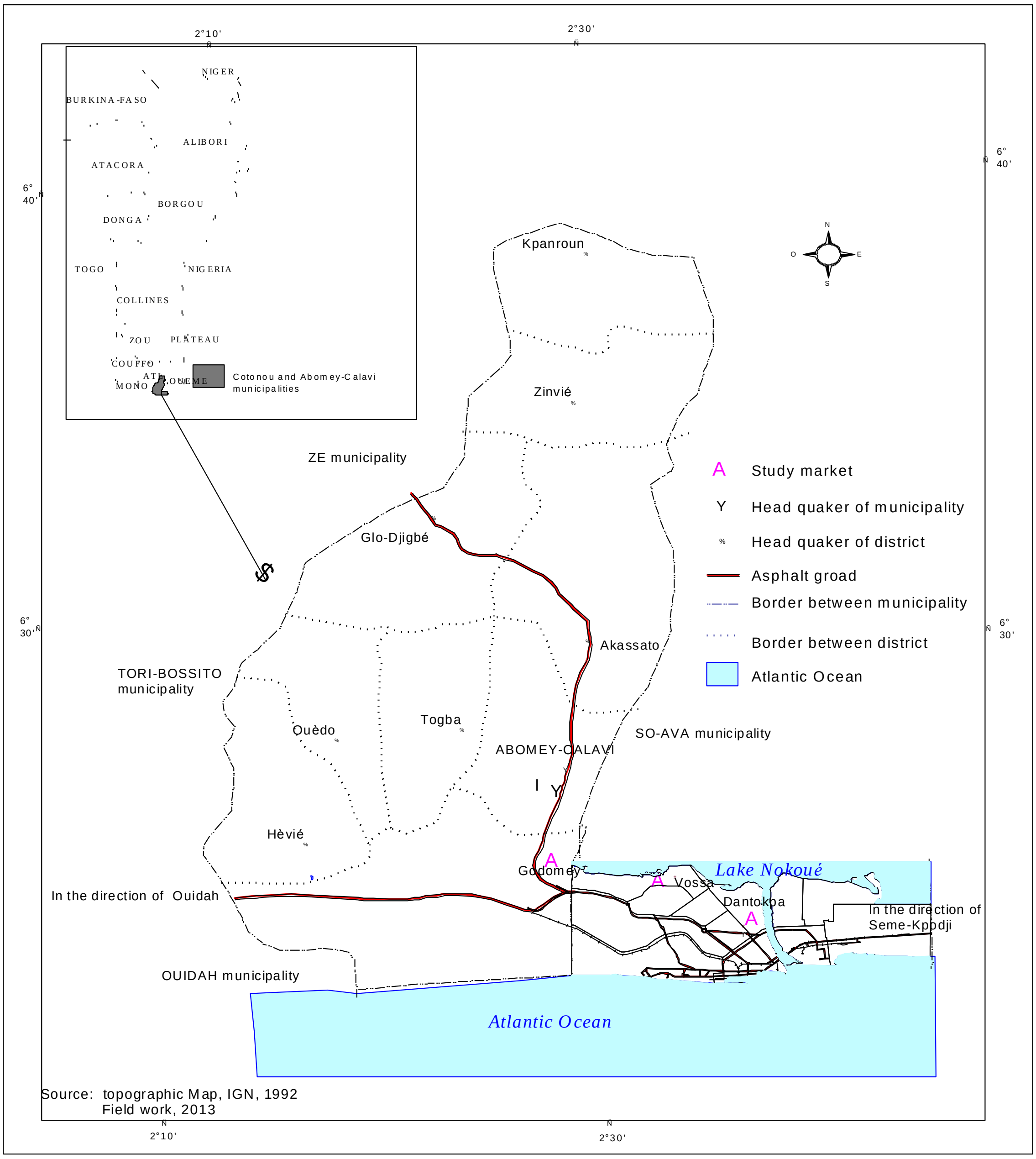

Fig. 1. Study area location.

Fig. 2. Atomic Absorption Spectrophotometer (Dougnon, 2012)

Fig 3. Materials used(Dougnon, 2012)

Fig. 4. *Senna rotundifolia*

Fig. 5. *Pavetta corymbosa*

Fig. 6. *Senna siamea*

Toxicological analysis

The toxicological analysis was made by using the following equipments:

- Herbarium consists of antimalarial medicinal plants identified in markets;
- Crusher;
- Accurate scale;
- Atomic Absorption Spectrophotometer (AAS) with a correction of background noise, a burner air - acetylene and an appropriate gas supply;
- Hollow cathode lamp specific to the element (in this case: lamps of Pb, and Cd);
- Thermo-Griddle statee;
- Programmable oven
- Quartz crucibles and glassware (flasks, Erlenmeyer),
- 6N hydrochloric acid,
- Nitric acid 0.1M.

The Toxicological analyses were conducted in the Laboratory of Soil Science, Water and Environment (LSSEE) of the National Institute of Agricultural Research of Benin (INRAB) in the Republic of Benin. Lead and cadmium were investigated in samples of medicinal plants using the technique of Atomic Absorption Spectrophotometer (AAS) 110 Flame following reference standards NF ISO 1146 1995 and NF X 31-147 1996.

Sampling

Anti-malarial medicinal plants are purchased. For each species, the following parts were taken for analysis: the entire plant (leaves, leafy stems and roots). These different parts were washed and crushed. The powders were collected and placed in transparent plastic bags with numbers corresponding to each particular species.

Procedure

Vegetable powders (medicinal plants) were incinerated in a muffle furnace at 550 ° C for 24 hours. The ash thus obtained was dissolved in 2 cc of HCl 6N is evaporated on a hot plate at 125 ° C. The remaining somehow viscous obtained was again dissolved and recovered using HNO_3, 0.1M in a flask of 100 cc. The solution thus obtained is used to determine the lead and cadmium by atomic absorption spectrophotometry (AAS).

For the flame system used, the detection limits of the instrument are as follows:

- To Lead, 0.0100ppm (0.0100mg / L)
- For Cadmium, 0.0020ppm (0.0020mg / L).

Results and discussion

Toxicology results

The heavy metals analysis (lead and cadmium) focused on five plants that have a high utilization rate. These are: *Senna rotundifolia L.* of the family Fabaceae, *Pavetta corymbosa (DC).* National Federation Rubiaceae *Williams*, *Senna siamea (Lam.) HS Irwin* and *Barneby* Fabaceae, *Dichapetalum madagascariense (DC). Keay* and Dichapetalaceae of *Morinda lucida Benth* Rubiaceae.

Plant contamination with heavy metals Pb and Cd

Since herbs are considered as food products that can be cooked and drunk or take the form of a toothpick, WHO standards for food products were chosen (0.3 mg / kg for lead and 0. 2 mg / kg for cadmium). (Be able to see Table I).

Table I. shows that all plants are contaminated with lead and cadmium in all three selected markets. These markets are: Dantokpa, Godomey and Vossa.

Comparison of toxic metals at the three sites (See figure 7, 8, 9, 10, 11).

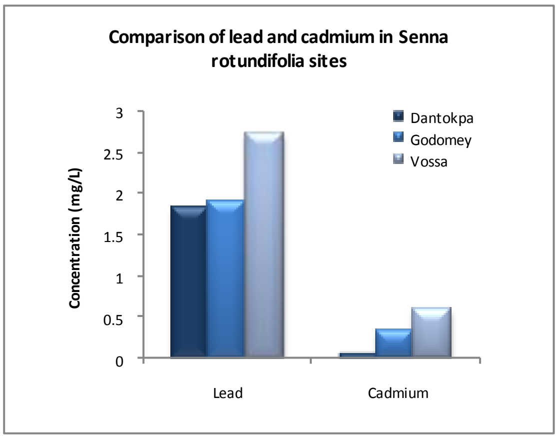

Fig 7. Comparison of lead and cadmium in *Senna rotundifolia*

Contamination of *Senna rotundifolia* on three sites is significantly different. So the origin of this species may be different from one site to another.

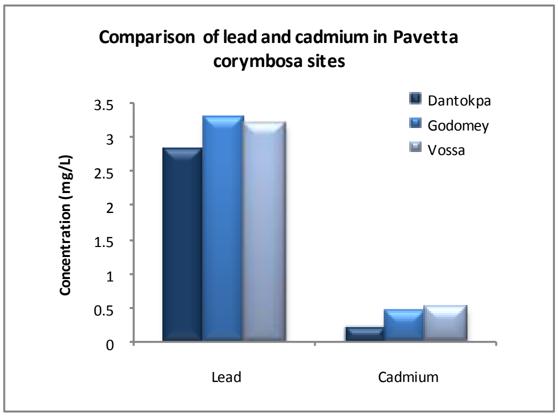

Fig. 8. Comparison of lead and cadmium in *Pavetta corymbosa*

Fig. 8. Comparison of lead and cadmium in *Pavetta corymbosa* at the three sites

The average lead content of *Pavetta corymbosa* at the three sites was significantly different ($p < 0.05$).

The site of Vossa has a high concentrations of cadmium compared to the other two sites. We could then conclude that the origin of this species on this site has an influence on the results obtained.

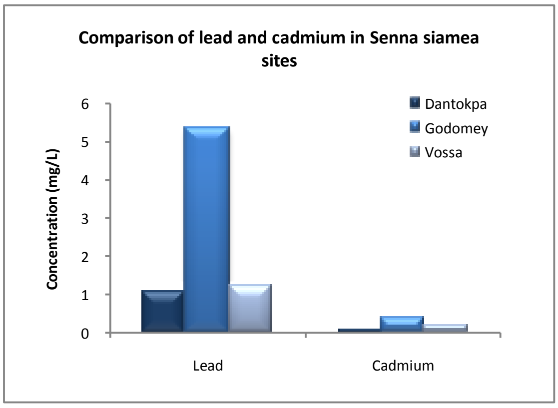

Fig. 9. Comparison of lead and cadmium in *Senna siamea*

Fig. 9. Comparison of lead and cadmium in *Senna siamea* on the three sites

The mean levels of lead and cadmium for *Senna siamea* were significantly different at the three sites ($p < 0.05$). We therefore noted that contamination of

Senna siamea for lead at the site of Godomey exceeded highly that of Dantokpa and Vossa.

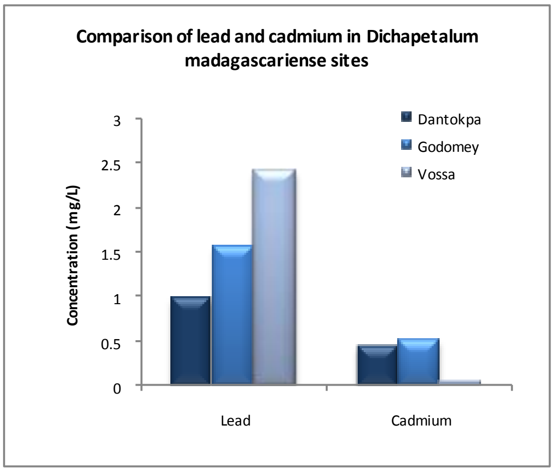

Fig. 10. Comparison of lead and cadmium in *Dichapetalum madagascariense*

Fig. 10. Comparison of lead and cadmium in *Dichapetalum madagascariense* on three sites. The mean levels of lead and cadmium for *Dichapetalum madagascariense* were significantly different at the three sites ($p < 0.05$). The site of Vossa recorded a lower cadmium concentration than the other two sites.

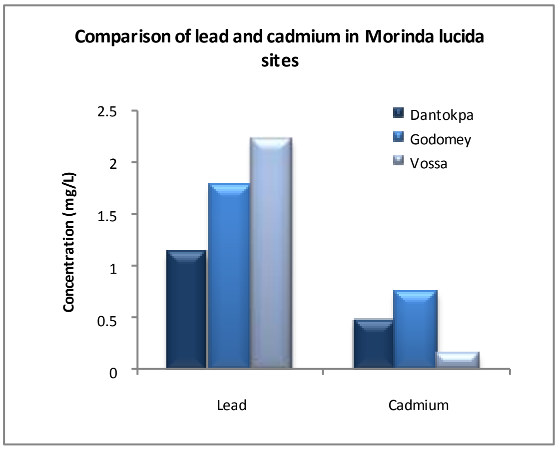

Fig 11. Comparison of lead and cadmium in *Morinda lucida*

Fig. 11. Comparison of lead and cadmium levels in *Morinda lucida* on three sites

All the mean levels of lead and cadmium were significantly different ($p < 0.05$) at all three sites.

Discussion

In Africa, where more than 80% of the population uses traditional medicine for primary health care, a variety of plants is used daily. Treatment of diseases by plants became a cultural phenomenon (Koudouvo *et al.* 2006).

The so called «Buying on Triplet of Medicinal Plants " (BTMP), is an ethno botanical survey method developed by Koudouvo *et al* (2006) in Togo. It consists to visit the same herbalist in the same market three times and purchase medicinal recipes to treat the same disease. According to this procedure, the purchased recipes are in large numbers at the initial purchase, a reduced number at the second step and very small number at the third one. The BTMP) method is the contribution to promote the Pharmacopeia and the African Traditional Medicine. (Adjanohoun 1986, 1989; Koudouvo *et al*, 2006). It serves as a base to preserve plants for future generations, reduces the number of recipes to consume and allows to select the most used plants for a given disease.

Thanks to this method, we have selected on a rational basis the five most used plants. The five plants were identified in the Faculty of Science University of Abomey-Calavi according to the international nomenclature. Reference samples of identified plants are deposited and preserved in the herbarium of the University of Abomey with reference numbers.

Toxicological analysis were conducted by using the method recommended by the WHO (WHO, 1998). Toxicology results showed that all plants are contaminated with lead and cadmium in all markets (See table I).

Table I. Contamination of all plants by lead and cadmium on three sites.

			Plomb (ppm)			Cadmium (ppm)		
Standards (OMS,1998)				**0.3**			**0.2**	
Sites			**Dantokpa**	**Godomey**	**Vossa**	**Dantokpa**	**Godomey**	**Vossa**
	Senna rotundifolia		1.711	2.302	2.833	0.055	0.345	0.589
			1.823	2.033	3.199	0.079	0.359	0.581
			1.677	1.644	2.226	0.078	0.298	0.592
			1.986	1.763	2.6	0.051	0.315	0.639
			1.928	1.768	2.807	0.047	0.323	0.514
		Means. ± SD	1.825 ± 0.133	1.902 ±0.265	2.733 ±0.356	0.062 ±0.015	0.328 ±0.024	0.583 ±0.044
	Pavetta corymbosa		2.835	2.902	3.738	0.162	0.35	0.581
			2.867	3.272	3.798	0.189	0.437	0.523
			2.697	3.363	2.637	0.198	0.468	0.475
			3.287	3.453	2.615	0.169	0.53	0.446
			2.429	3.425	3.207	0.277	0.455	0.48
		Means. ± SD	2.823 ± 0.311	3.283 ± 0.224	3.199 ±0.571	0.199 ± 0.045	0.448 ±0.064	0.501 ± 0.052
	Senna siamea		1.126	5.802	1.79	0.068	0.348	0.201
			1.223	4.972	1.197	0.097	0.388	0.199
			1.056	5.494	1.034	0.088	0.376	0.168
			0.987	4.695	1.124	0.087	0.473	0.157
			1.043	5.857	1.035	0.15	0.355	0.165
		Means. ± SD	1.087 ±0.090	5.364 ±0.513	1.236 ±0.317	0.098 ±0.030	0.388 ±0.050	0.178 ±0.020
	Dichapetalum madagascariense		1.011	1.809	2.521	0.422	0.498	0.033
			1.041	1.54	2.558	0.389	0.448	0.041
			0.986	1.444	2.213	0.483	0.486	0.028
			0.885	1.432	2.322	0.475	0.569	0.047
			1.012	1.59	2.511	0.476	0.554	0.046
		Means. ± SD	0.987 ±0.060	1.563 ±0.152	2.425 ±0.149	0.449 ±0.041	0.511 ±0.049	0.039 ±0.008
	Morinda lucida		1.174	1.902	2.328	0.474	0.803	0.159
			1.173	1.943	2.195	0.454	0.766	0.168
			1.084	1.864	2.235	0.456	0.705	0.157
			1.115	1.563	2.024	0.469	0.706	0.164
			1.099	1.568	2.253	0.497	0.785	0.152
		Means. ± SD	1.129 ±0.042	1.768 ±0.186	2.207 ±0.113	0.47 ±0.017	0.753 ±0.045	0.16 ±0.006

Table I shows that all the analyzed plants were contaminated with lead and cadmium in all three selected markets.

All the concentrations recorded in analyzed plants were above the detectable limits. In all samples the concentrations of Cd and Pb exceeded WHO permissible values (0.3 mg / kg for lead and 0.2 mg / kg for cadmium) for food (WHO, 1998). This contamination of medicinal plants with lead and cadmium can also be explained by pollution of the air and soil, the use of polluted irrigation water, exhaust fumes, pesticides and fertilizers (Caldas and Machado 2004; Jarup 2003; Zaccaroni *et al.* 2003).

In Benin, a study related to the contamination with heavy metals conducted at the University of Abomey-Calavi has shown that the marine environment and its compartment such as water, sediments that contributed to fishery products are highly polluted by heavy metals (Montcho, 2005). Agonkpahoun (2007) analyzed the water, sediment and fish products from Lake Nokoué and the Okpara River. Guédénon *et al.*, (2012); Hounkpatin *et al.*, (2012) have conducted similar studies respectively on Oueme River at Bonou and Nokoue lake at Ganvié. The results showed that heavy metals are toxic in the inland waters of Benin. Gnandi *et al.*, (2008) have been working on the bioaccumulation of some trace elements in the Products grown on urban soils along the highway-Aného Lome, (South Togo). They found heavy metals are accumulated in these products. Toxic heavy metals are found in snails (Edorh *et al.*, 2009), in soils and vegetables (Koumolou, 2011; Dougnon, 2012b).

The present results are similar to those of Barthwal *et al* (2008) on the accumulation of heavy metals in medicinal plants (*Abutilon indicum*, *Calotropis procera*, *Euphorbia hirta*, *Peristrophe bycaliculata* and *Tinospora cordifolia*) collected from three different environmental sites of a city in Congo. The result showed that all species were contaminated and that contamination by heavy metals varies from one species to another. The same observation was noted by comparing the contamination of lead and cadmium in each plant species. This study also showed that lead was highest in *Calotropis procera* (> 0.3 mg / kg) in the area polluted than in the residential area in the Congo. In Brazil, analyzes of 10 types of medicinal plants, some samples of brown of India, gotu kola and ginko biloba recorded concentrations of cadmium and lead higher than the permissible level (Caldas and Machado, 2004).

Excessive intake of toxic heavy metals by consumption of contaminated herbal remedies has been reported in Asia, Europe and the United States (Dunbabin *et al.* 1992; Kakosy *et al.* 1996). Dey *et al.* (2010) recorded lead in all medicinal plants in his study. Higher concentrations of lead were found in aerial parts of the plant. This contamination could be due to air and water pollution. As consequences, the consumption the contaminated herbal plants could pose health problems. In fact, high levels of Pb and Cd can cause acute health problems and chronic conditions including cancer, kidney damage, heart problems, liver failure, damage to the reproductive system, disorders of memory, even death and can cross the placenta, with toxic effects on the fetus (Agoramoorthy *et al.*, 2008, Kadir *et al.*, 2008, Kwon *et al.* 2003).

Conclusion

The results of the present study showed that all herbal medicinal plants purchased in the three study sites are highly contaminated with toxic heavy metals. The causes of this contamination could be at two key levels: exposure to air pollution and agriculture. Through the risk assessment of pathology, we advise against consuming them keeping in mind that the body has natural systems of detoxification. Moreover, ecosystems, of which man is an essential component, are not immune to this contamination by heavy metals. And the risk of biomagnification, due to their persistence in the environment and cumulative transfers in food chains, do not help the situation already very alarming.

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