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Heavy metals deposited in the culture of lettuce (*Lactuca sativa* L.) by the influence of vehicular traffic in Pernambuco, Brazil

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ABSTRACT

Currently one of the main sources of atmospheric pollution identified in urban centers is derived from both industrial and motor vehicle emissions. These pollutants can be adsorbed to particulate matter which is present in the air or deposited in the soil and plants, eventually reaching the human food chain. In this context, the present study aimed to determine the concentration of metals such as Cu, Pb, Cd, Ni and Zn in two subspecies of *Lactuca sativa* L. and in the soil from were lettuce samples were collected. The results for the soil samples analyzed show a possible contamination by Pb with concentration values as high as 140 mg.kg^{-1}, which are above the Brazilian standards defined by Resolution CONAMA 420/2009 (Brazilian Environmental Council). However, the values found in the lettuce itself reveal that it is still suitable for consumption.

1. Introduction

Due to their toxicity, some metals have been the subject of several studies and surveys, mainly in urban areas, and have received special attention. Those areas are subject to constant and substantial anthropogenic activities that result in the emission of a wide variety of pollutants.

Several sources release metals÷ among them, industries, vehicular traffic, industrial waste material, and sewage are the most worrying (Larcher, 2004). However, vehicular traffic, especially in large urban centers, stands out as it has been growing at alarming rates (Pandey, Shubhashish, & Pandey, 2012). Data provided by the Brazilian Traffic Department (DENATRAN) show that in the last ten years alone the fleet of vehicles in Brazil has doubled, increasing the emissions of toxic elements through the combustion of fuels and from wear parts (Baird, 2002; DENATRAN, 2010).

The anthropogenic impact on the environment, mainly in the form of air pollution, is a major concern worldwide. The inhalation of particulate matter and the consumption of contaminated water and food are the most common routes, both directly and indirectly, of contamination in humans. In addition, the physicochemical behavior of metals mostly impacts the ecosystem, influencing the diversity of species and affecting human health (Pandey et al., 2012).

Ali and Al-qahtani (2012), Pandey et al. (2012), and Sharma, Agrawal, and Marshall (2008), in studies conducted to assess the concentration of toxic metals in vegetables in urban areas, showed an increase of metals related to vehicular pollutants, with significant concentrations of some elements such as Cu, Pb, Cd, Ni and Zn. Besides, they suggest that there is a relationship between atmospheric deposition of particulate matter and metal contaminant levels in vegetable samples (Ali & Al-qahtani, 2012; Pandey et al., 2012 E Sharma et al., 2008).

In recent years, there has been a significant increase in the cultivation of vegetables with short post-harvest times in areas close to food supply centers, known as green belts. These areas are often located around large cities being, therefore, impacted by vehicular emissions. This practice brings about a serious risk in the quality of these products due to contaminants associated with motor vehicles, which are dispersed in the environment and can be deposited in soils and bodies of water (Larcher, 2004; Medeiros et al., 2008).

The contamination of vegetables by heavy metals can occur in different ways: through absorption by the use of contaminated soil and/or irrigation water in the processes of harvesting and storage, as well as in sale locations. Once present in the soil, metals can accumulate in the culture and be passed on to the end consumer. For this reason, soil becomes a major pathway of crop contamination, since it is the main source of plant nutrients (Larcher, 2004).

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Food contamination generates even greater concern, especially in vegetables that are consumed frequently and 'in nature', such as lettuce (*Lactuca sativa* L.) in Brazil. This vegetable stands out, as it is one of the most widespread crops in green belts and presents the possibility of continuous cultivation throughout a single year, along with low production costs and a low susceptibility to pests (Medeiros et al., 2008).

The consumption of lettuce grown near highways is of major concern due to the toxic pollutants emitted by motor vehicles. Thus, the purpose of this study was to determine the presence of Cu, Pb, Cd, Ni and Zn associated with vehicular traffic in samples of two types of subspecies of *Lactuca sativa* L. – *Lactuca sativa* L. var. *Crispa* and *Lactuca sativa* L. var. *Capitata* – cultivated near BR-101, km 70, Recife, in the state of Pernambuco, Brazil. Furthermore, analyses of soil samples from these vegetables cultivation areas were carried out, as they can provide the data for the calculation of transfer rates of trace metals from soil to plant. The results of this work may provide a basis for an assessment of health risks to the consumers of vegetables grown in the studied region.

2. Material and methods

2.1. Study area

The study area is located at km 70 of federal highway BR-101, at the intersection formed by the federal highways BR-101 and BR-232, in the city of Recife, Pernambuco, Brazil, at coordinates 08° 04′ 03″ S and 34° 56′ 39″ W. This area encompasses about seven hectares of land used in the cultivation of vegetables that are sold in a large distribution center for agricultural products harvested in the region. In this cultivation area there is an average productivity of 10,000 heads of lettuce per harvest, and the periods of cultivation vary according to weather conditions, usually occurring during the months of June to December. Lettuce, however, is not the only cultivated crop in the area. Other types of crops include manioc, okra, chives, and cilantro.

The soil of this area is composed of heterogeneous source materials, resulting from landfills during the construction of highways and overpasses (Freire, 2006). The preparation of the soil for planting is carried out manually.

2.2. Sample collection and preparation

Sample collection was performed in two sites of the study area, identified as sites A and B (Fig. 1). Samples of soil and of different types of lettuce were collected in 2013 and stored in plastic bags for posterior analysis.

All samples were taken to the Environmental Analysis Laboratory of the Northeastern Brazilian Regional Center for Nuclear Sciences/Brazilian Nuclear Energy Commission (CRCN-NE/CNEN) for processing and analysis. Forty centimeters long soil cores were collected randomly using a 7 cm-diameter, 50 cm-long stainless steel corer with 10 samples per site, which were subsequently sectioned into two layers of 20 cm each (0–20 cm; 20–40 cm), totaling 20 samples per site. All samples of the first layer of site A and of the first layer of site B were then mixed and macerated to a fine particle size so as to obtain two composite samples of the first layer of soil. The same procedure was performed for the samples of the second layer of both sites (EMBRAPA, 2000).

Fig. 1. Satellite location of the soil and vegetable sampling stations at the intersection formed by the federal highways BR-101 and BR-232, in the city of Recife, Pernambuco, Brazil. Source: Google maps (2015).