



# Potentially toxic elements dynamics in the soil rhizospheric-plant system in the active volcano of Fogo (Cape Verde) and interactions with human health

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## ABSTRACT

Volcanic eruptions disturb directly and indirectly the ecosystems. Direct impact occurs on the soil–plant system with an input of new elements and indirect hazard occurs by consumption of these plants. Fogo island (Cape Verde Republic) has an active volcano and the last eruption occurred in 2014–15, expelling large amounts of materials that spread all over the island. Soils and edible plants were collected all over the island. Pollution indexes reveal contamination in all samples, mostly due to Hg and Ni and with moderate contribution of Co, Cr, Cu and Pb. Mercury is the PTE with higher contribution to the non-carcinogenic hazard quotient, both by soil ingestion and inhalation. Carcinogenic risk exceeds the target risk in all samples with the higher contribution of Ni. Transfer factor from soils to plants decreasing order is Mn > As > Zn > Cr > Cu > Cd > Pb > Ni > Co > Hg, being < 1 except for As and Mn (TF > 1 point to a significant accumulation of elements in edible plants). The hazard risk index and targeted hazard quotient shows that potential negative health outcomes can be induced by As, Cr, Cu, and Zn by consumption of edible plants.

## 1. Introduction

Volcanic eruptions represent an important input of inorganic elements directly into agricultural soils and indirectly to plants (Aji et al., 2021). Plants growing close to active volcanoes are influenced by high atmospheric contaminations above ground, and by potentially toxic elements in the rhizosphere. Continuous emission of sulphur-containing gases may affect soil parameters such as pH, nutrition composition and/or the soil microbial community (Baillie et al., 2018). According to Kochergina et al. (2017) high atmospheric SO<sub>2</sub> concentrations results in acid rain formation causing soil degradation and acidification and the same occurs by local and continuous emissions of fumarolic gases. As volcanic gases contain potentially toxic elements (PTEs), such as As, Cu, Cr, Hg, Mn, Ni, Pb, the bioavailability of nutrients and toxic elements change in environments exposed to fumarolic gases (Kochergina et al., 2017). These toxic elements have a long biological half-life and are non-biodegradable, they can be toxic, even at very low concentrations (Kharazi et al., 2021; Djahed et al., 2018), can enter the human body through various pathways, such as ingestion of soil, inhalation of dust, dermal contact with soil, and consumption of food crops grown in contaminated soil. Studies developed in the volcanic Fogo and Brava

islands (Cape Verde) suggested that in weathering processes, oxidation represents a major role, and that soils used for agriculture revealed high content of PTEs, such as Cr (Marques et al., 2018). High mean Cr concentrations were found topsoil of Santiago island (535 mg/kg; Cape Verde), and Lanzarote island (348 mg/kg; Spain), belonging to an archipelado with similar climate and geological characteristics and, like Cape Verde islands, part of the Macaronesia (Marques et al., 2012; Muhs et al., 2010). The concentrations of heavy metals and metalloids in soils have increased in local farmlands due to the volcanic activity and the transfer from soils to plants of potentially toxic elements may outcome a significant risk to human health.

Food safety is a major concern, with increasing awareness of the importance of edible plants in the human diet both positively, as a source of essential nutrients, and negatively, by elemental excess and/or presence of pollutants (Marini et al., 2021). The monitoring of soils and food crops is necessary and mandatory, to evaluate the composition, assess risk, and develop mitigation measures. Several studies evaluated the potentially toxic elements levels by food consumption in different regions of the world (e.g. Gulan et al., 2021; Shojaei et al., 2021; Isley et al., 2021), suggesting significant results concerning food safety for humans. The Food and Agriculture Organization (FAO) of the United

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