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House dusts of a volcanic island – potential impacts on human health

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Abstract.
Fogo island (Cape Verde), has an active volcano that last erupted in 2014-15, with melts mainly alkaline, of basanitic to tephritic composition. Dwellings dust composition is the result of natural and anthropogenic interactions. Nineteen house dusts were collected, in representative dwellings all over the island. Fractions < 2 mm was analyzed by ICP-MS, XRF and XRD and SEM for chemical, mineralogical, and morphological characterization. Mineral phases revealed several minerals linked to the volcanic origin. Iron mean concentration in soils, is above the 2014-105 eruption lava mean. Potentially toxic elements were below Acceptable Values (AV), e.g., As 0.6 to 3.3 mg/kg, except once sample 111 mg/kg (AV = 20 mg/kg); Cd, 0,5-3.6 mg/kg (AV = 3 mg/kg). Elements Ni and V presented concentrations above AV in all samples. But is Ti with concentrations much above AV. Risk assessment (USEPA) found As and Ni over the carcinogenic target Risk in most samples, while systemic toxicity in children is mostly due to Fe, V and Zr concentrations. Higher particles concentration is > 50 µm in diameter, suggesting that bioaccessible fraction might not be high, thus, reducing risk.

Keywords: Dust, Potentially toxic elements, Risk assessment, Fogo volcano.

1 Introduction

Fogo island dwellings dust quality is typically impacted by Sahara suspended dust transport, sea salts, anthropogenic activities (e.g., cooking) and by its geogenic volcanic nature. The last Fogo volcano eruption occurred in 2014-15, two years before this study. Indoor dust exerts an important impact in human health, by acute dust inhalation and involuntary ingestion, that might induce health outcomes. The dwellings dust monitoring is important to identify potential risk and attempt to define mitigation measures. This study aims to characterize indoor dust in different dwellings and the risk assessment to the inhabitants both by inhalation and ingestion.

2 Materials and Methods

Study area: Cape Verde archipelago (Fig. 1) origin is due to hotspot magmatism, with melts predominantly alkaline SiO_2 undersaturated of basanitic to tephritic composition, also occurring phonolites and carbonatites [1]. Fogo island, has an almost circular outline, with an area of 476 km^2 and a maximum high above sea level (asl) of 2829 m.

Fogo, an active stratovolcano, is covered by Quaternary volcanic rocks [2]. On the center of the island is a former collapsed caldera [3], with ~8 km in diameter. This collapse gave rise to a caldera scar, locally called Bordeira, with a vertical wall with maximum ~1000 m high and a flat area of ~35 km^2 (~1700 m asl).

The country air quality is also influenced by the harmattan wind, with transport of fine particles from Africa continent, between December and June. Cape Verde doesn't have local anthropogenic emissions of regional interest.

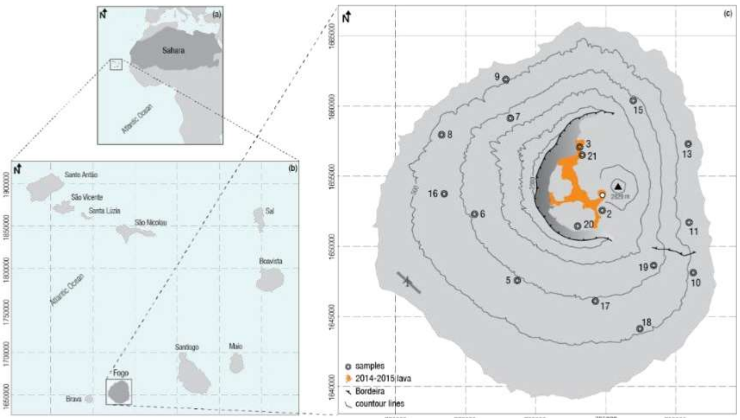

Fig. 1. (a) Cape Verde, westwards of African coast; (b) Cape Verde archipelago; and (c) Fogo Island with dwellings backyard sampling sites.

Sampling and samples preparation: In November 2017, 20 dwellings dust were collected (Fig. 1c), with new plastic broom and shovel. Each sample was identified and preserved in polyethylene bags (laboratorial grade) until laboratory, dried (< 40 ºC) and homogenized, sieved (<2 mm). Granulometry was assessed by wet sieving and Sedigraph. A portion of each sample was pulverized for ICP-MS, XRF and XRD analysis. SEM-EDS was performed for morphology and semi-quantitative chemical analysis.

Non-carcinogenic and carcinogenic risk assessment: Calculated taking into consideration that residents, both children and adults, are exposed to dust through ingestion, inhalation and dermal contact. The systemic toxicity (i.e., non-carcinogenic hazard) and carcinogenic risk for each potentially toxic element (PTE) were calculated considering each reference toxicity level, as widely described in [4]. For each PTE (As, Cd, Cr, Co, Cu, Fe, Pb, Ni, Ti, V, Zn and Zr) and exposure route, the systemic toxicity was estimated by the Hazard Quotient (HQ) and the cumulative Hazard Index (HI). If > 1, non-carcinogenic effects might occur once exposure concentration exceeds the reference dose. Carcinogenic risk was assessed by the sum of PTEs and exposure routes. The carcinogenic target risk is 1.00E−06, and risk > 1.00E−04 considered unacceptable [4].

3 Results and discussion

Mineral phases identified (XRD and SEM) in dust samples revealed several minerals linked to the geogenic characteristics of the island e.g., quartz [SiO_2], magnetite [$Fe^{2+}Fe^{3+}2O_4$], ilmenite [$Fe^{2+}TiO_3$], hematite [Fe_2O_3], fayalite [$Fe^{2+}2SiO_4$]. These minerals are in line with other studies from the Fogo Island [5]. Identified minerals reflect the influence of the volcanic products and alteration processes that lead to secondary minerals, such as clays. Morphology identified sharp particles with vesicles, typical from volcanic products but also rounded ones with a possible origin in Africa dust masses transported to the island [6]. Granulometric analysis revealed that samples collected closer to the last volcanic eruption area present higher percentage of the smaller fractions than the remaining ones. In Table 1 is presented chemical composition.

Table 1. Potentially toxic elements (PTEs) dust samples limit of detection (LOD), mean±SD (Standard Deviation), minimum (min) and maximum (max) concentration analyzed by ICP-MS, except for F and Si by XRF. The 2014-15 lava mean results is also presented. In mg/kg.

	LOD	mean±SD	min	max	2014-15 lava
As	0.01	6.8±23.8	0.56	111.0	2.47
Cd	0.001	0.11±0.07	0.046	0.360	0.176
Co	0.001	42±8.9	27.6	56.4	18.0
Cr	0.01	100±43.7	39.3	200	8.1
Cu	0.01	50±16.9	21.2	103	22.5
F	0.6	265±400	0.3	1380	-
Fe	10	81,035±12,525	63,200	107,000	46,750
Ni	0.04	104±46.5	26.2	199	8.1
Pb	0.005	8.0±8.7	2.06	41.1	10.4
Si	0.5	16,4477±9,118	150,763	179,305	-
Ti	10	12,283±2,596	8,320	17,850	7545
V	0.1	260±50.4	190	369	157.4
Zn	0.1	116±22.9	81	164	124
Zr	0.01	65±27.6	30.9	162	33.1

Iron minimum concentration of 63200 mg/kg was above the 2014-105 eruption lava mean (46750 mg/kg). PTEs revealed concentrations below Acceptable Values (AV) [7]: As from 0.56 to 3.3 mg/kg, except for 1 sample (111 mg/kg; AV = 20 mg/kg); Cd, between 0,5-3.6 mg/kg (AV = 3 mg/kg); Pb from 2.1 to 41 mg/kg (AV = 100 mg/kg); and Zn, between 81.1 and 164 mg/kg (AV = 300 mg/kg). Co presented, in almost all samples, results below AV (50 mg/kg), with a mean of 46 mg/kg. Cr with same tendency, mean = 100 mg/kg (AV = 100 mg/kg), and Cu mean = 50 mg/kg (AV = 50 mg/kg). Nickel presented concentrations above AV (50 mg/kg) in all samples (mean = 104 mg/kg) and V (AV = 50 mg/kg) ranging 190-369 mg/kg. It is Ti that presented pseudototal concentrations much above AV (500 mg/kg), ranging 8320-17850 mg/kg. Risk assessment revealed that As and Ni are over the carcinogenic target Risk for the majority of the samples, while systemic toxicity in children is mostly due to Fe, V and Zr high concentrations.

4 Conclusions

Results showed that there is a risk to human health due to the dust composition and mineralogy. Nevertheless, pseudototal concentrations might overestimate risk. To calculate effective risk, oral bioaccessible analysis is being undertaken in samples < 250 µm fraction. Yet, granulometry revealed a higher particles concentration above 50 µm diameter, what is an indicator that bioaccessible percentage might not be high, thus, reducing risk.

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