TRANSFER OF TRACE METALS BETWEEN AIR, SOILS AND CACAO BEANS IN AREAS IMPACTED BY OIL ACTIVITIES IN ECUADOR

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Introduction

Ecuador is ranked as the 4th country in oil production in South America. Most of this extractive activity is developed in the Northeast Amazonian region, since the 60's whereas the refinery activities are located along the Pacific coast, at Esmeraldas**.** Practices and technologies used during oil production generate a mixture of toxic compounds (trace metals and liquid hydrocarbons) partly released into the environment, air and water mainly. Populations are exposed to these contaminants, by water consumption, particles inhalation or plants ingestion. Even if the potential or proven impact of oil products on human health has been studied in Ecuador, health risk is not yet the subject of a political or normative recognition. The actual legislation only aims to reduce the impact of oil activities on the environment. Moreover, both regions have vast extensions of cacao crops, an exportation product recognized worldwide for its special flavor, the fine aroma. Besides, the ways of transfer of these contaminants (by foliar or root uptake) to cacao crops and their potential impacts for human health are still poorly described. This study focuses on aerosols chemical composition, soil and crops quality evaluation and human health assessment in oil-impacted areas in Ecuador.

Methods

Atmospheric particles (PM_{10}), cacao pods (separated in beans and shtells) and soil (2 or 3 depths) samples were collected in oil production areas (Dayuma and Pacayacu) and in the Pacific Coast region (Esmeraldas) close to the main refinery of the country. Trace element concentrations were determined by ICP-MS in all samples after acid digestion. PM_{10} speciation was addressed by analyzing elementary and organic carbon (EC, OC), ionic soluble species and organic compounds (sugars, polyols). Soil physic-chemical properties (pH, CEC and organic carbon) were determined. Human bioaccesibility after cacao ingestion was investigated by the BARGE *ex vivo* test performed in cacao beans and topsoils.

Results

For the air compartment, preliminary results show that, in all sites, PM_{10} contain mainly Ti and Mo, followed by Ba and Zn at Amazon region and Cr at Esmeraldas. Mo and Ba are considered as oil tracers, used as catalyzers during drilling or to liquefy subsoil rocks. No seasonal variation was observed in these metal contents. The concentrations of Ni, As, Cd and Pb did not exceed European or Ecuadorian legislation. The origin of these metals could be natural (dust) or anthropogenic (gas burning, use of catalyzers during oil drilling, oil refinery process, thermoelectric emissions or traffic.). The EC/OC ratios indicate that OC is probably originated from biomass combustion in Amazonia.

In cacao crops, among the trace metals analyzed, Cd is bioaccumulated in most of the beans reaching values higher than the critical level of 0.6 mg kg^{-1} established for Cd by the European Union (for 2019), as shown in Figure 1. Finally, between 40 and 60% of the total Cd content in cacao beans is

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bioaccessible by human ingestion, suggesting potential risks for human health raising concerns of safety in the consumption of cacao-based chocolate (mainly dark chocolate). However, the origin of Cd in soils (natural, fertilizers or oil products burning) remains unclear.

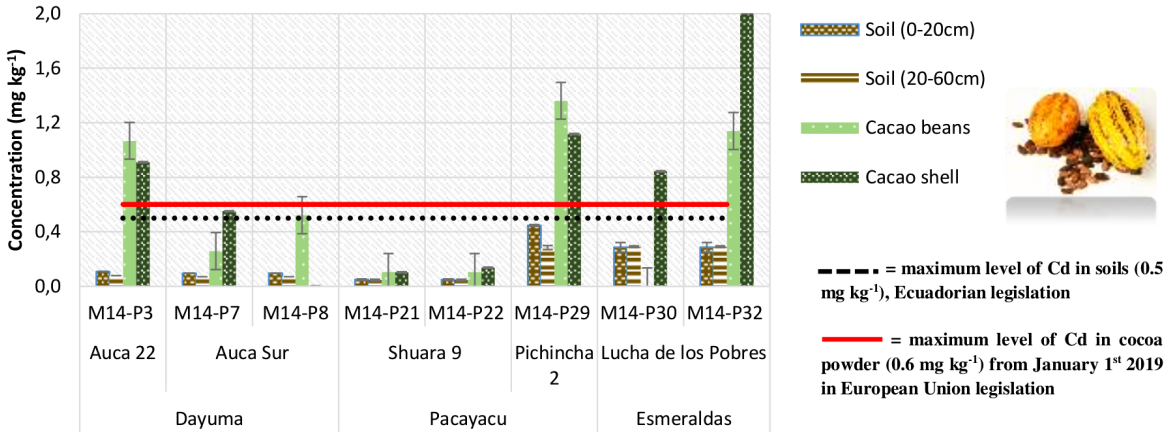

Figure 1. Concentration of Cd (mg kg-1) in soils (0-60 cm depth), cacao beans and shells in 5 sampling points in the Northern Amazon (Auca 22, Auca Sur, Shuara 9 and Pichincha 2 oil camps) and Esmeraldas.

Conclusion

This global study of socio-environmental impacts of oil activities in Ecuador takes place in the frame of the French ANR-MONOIL Project (http://www.monoil.ird.fr). It puts in evidence some high metal contents in the different compartments of the terrestrial ecosystems in Ecuador, and especially the bioaccumulation of Cd in cacao beans. This study proposes also an assessment of the risks involved for human health due to metal exposure. Nevertheless, further investigations are in progress to better determine local population's exposure to the Metals-PAHs cocktails.

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