

Human health risk assessment by As environmental exposure in Paracatu: An integrated approach

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ABSTRACT: The objective of this study was to estimate the potential risk on the health of residents of Paracatu (adults and children) due exposure to arsenic present in soil, water, air and food. For the assessed receptors, the risk due to the present contamination scenario was higher than the limit considered acceptable. The main pathways were ingestion of water while swimming and inhalation of particulates. It is important to highlight that human health risk assessment is a very conservative modeling, trying to protect the human health including critical subpopulations. Epidemiological study carried out at Paracatu city will bring new elements to the uncertainties in the human health risk assessment.

1 INTRODUCTION

Arsenic (As) is a naturally occurring element widely distributed in the Earth's crust. However, it is one of the most toxic elements to humans, whose exposure usually occurs through food, soil, water and air. The relationship between the intensity of the environmental contamination and the potential risks to human health can be assessed by the human health risk assessment methodology proposed by USEPA (1989). This methodology allows expressing risk as a comparable numeric estimates, which permits to establish priority of impacted areas, as well as the evaluation of remediation techniques. Therefore, the objective of this study was to estimate the potential risk on the health of residents of Paracatu (adults and children) due exposure to arsenic present in soil, water, air and food. This study is part of the environmental and health assessment conducted by Brazilian research institutions under the general coordination of Center for Mineral Technology (CETEM).

2 METHODS

2.1 Study area

Paracatu (8,229.6 km²) has a population of ca. 90,000 inhabitants, of which about 95% live in the urban area. The economy is centered on cattle raising, agriculture (mainly soybean, corn, rice and beans) and gold mining. The gold-mine operations in Morro do Ouro, a low-grade gold deposit located close to the northern border of Paracatu

city, began in the late 80 s. Nowadays, it is the largest open pit gold mine in the world.

2.2 Sampling and analysis

Surface water, sediment and soil from the sub-basins of Córrego Rico and Ribeirão-Entre-Ribeiros, which may be impacted by gold mining, were collected. Samples were also collected in the sub-basin of the Escuro river (reference area). Arsenic levels were analyzed in all samples (Bidone *et al.*, 2014). In addition, arsenic levels were accessed in atmospheric PM (Zamboni *et al.*, 2014). Moreover, tap water samples provided by the water supply company were collected. Arsenic concentration resulted not only below the drinking-water quality criteria (10 µg/L) but also, below the limit of detection (<0.5 µg/L), except one sample (1.6 µg/L) (Bidone *et al.*, 2014). Thus, ingestion of tap water was not considered an exposure pathway in this risk assessment and the "water ingestion" in this work is related only to the ingestion of water while swimming.

2.3 Human Health Risk Assessment

The human health risk assessment was accomplished according to the methodology proposed by USEPA (1989) and the guidelines suggested by CONAMA 420 (2009). This methodology is composed of four stages: 1) elaboration of a qualitative conceptual model concerning to arsenic contamination and transference among environmental multimedia, exposure pathways and potential receptors: adults and children; 2) chronic exposure assess-

ment (magnitude, frequency and duration of the exposure) for the receptors and exposure pathways previously selected (by using estimated or measured As levels in soils, freshwater, tap water and atmospheric PM); 3) Toxicity assessment: the weight of evidence for As carcinogenicity (Group A) exists and a carcinogenic unit risk (which depends on the exposure pathway and is related to the likelihood of developing cancer as a result of that specific exposure) is provided and the reference of dose (RfD) for As non-carcinogenic effects and; 4) risk characterization, which summarizes and combines outputs of the exposure and toxicity assessments to characterize baseline risks, both in quantitative expressions and qualitative statements.

3 RESULTS AND DISCUSSION

Figure 1 shows the conceptual model developed for the study area after a qualitative risk assessment.

For adults, the hazard quotient regarding the exposure to non-carcinogenic contaminants for all assessed exposure pathways was less than 1, resulting in an acceptable risk (Figure 2).

For children, the hazard quotient to non-carcinogenic contaminants for all assessed exposure pathways was less than 1. However, the hazard index (sum of all exposure pathways HQs) was higher than 1, resulting in potential hazard (Figure 4). For carcinogenic effects, the Incremental Lifetime Cancer Risk (ILCR) was higher than 10^{-5} (for the ingestion of water and inhalation of

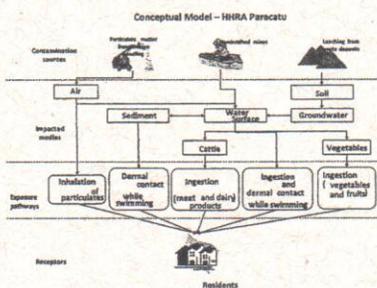


Figure 1. Conceptual model for human health risk assessment.

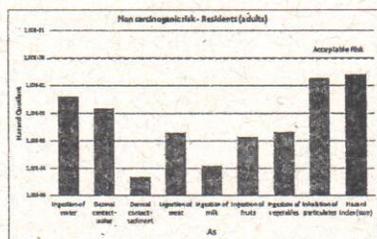


Figure 2. Noncarcinogenic hazard for adult residents.

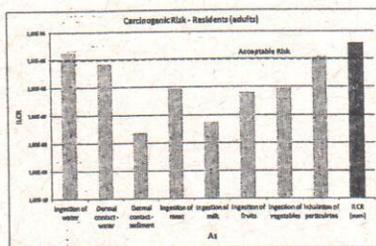


Figure 3. Carcinogenic risk for adult residents.

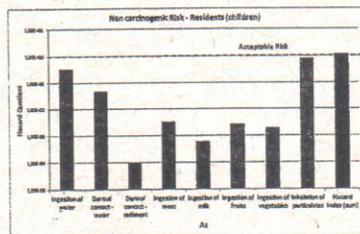


Figure 4. Non carcinogenic risk—Residents (children).

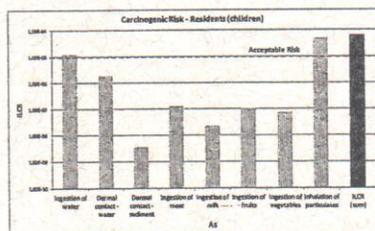


Figure 5. Carcinogenic risk—Residents (children).

particulates exposure pathway), resulting in an unacceptable risk (Figure 5).

4 CONCLUSIONS

The results showed that the environmental exposure to As does not represent potential hazard of non-carcinogenic effects for adults, but children are at risk. For carcinogenic effects, children and adults are at risk. The pathways that contributed most to this result were ingestion of water (while swimming) and inhalation of particulates.

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