Arsenic in Paracatu: A conceptual model for environmental and epidemiological assessment and political contextualization

Z.C. Castilhos  
*Center for Mineral Technology, Rio de Janeiro, Brazil*  
*Environmental Geochemistry Department, Fluminense Federal University, Niteroi, RJ, Brazil*

E. Mello De Capitani  
*School of Medicine, State University of Campinas, Campinas, SP, Brazil*

I.M. de Jesus, M.O. Lima & K.C.F. Faial  
*Evandro Chagas Institute (IEC/MS), Belém, Pará, Brazil*

S. Patchineelam, W. Zamboni & E.D. Bidone  
*Environmental Geochemistry Department, Fluminense Federal University, Niteroi, RJ, Brazil*

ABSTRACT: The objective of this work was to share the methodological bases applied in this research project, starting from a conceptual model for As environmental and epidemiological assessment in Paracatu city, from which a basic framework was elaborated, herein called Plan of Action (PoA).

1 INTRODUCTION

When it comes to perform an environmental contamination assessment and epidemiological study, a multidisciplinary research team is essential. Additionally, many local technicians and supporting staff are fundamental. However, isolated human resources are not enough. More than recognized experts from many fields, this sort of research needs a priceless integration space, where creativity can emerge to solve unusual problems. The objective of this work was to share the methodological bases applied in this research project, starting from a conceptual model for As environmental and epidemiological assessment in Paracatu city, from which a basic framework was elaborated, herein called Plan of Action (PoA). The team of researchers has also considered distinct aspects, such as the socioeconomic and political contextualization in Paracatu, the local population health vulnerability by additional diseases, financial and educational concerns that may become more difficult to deeply and/or to clearly understand the hypothesis of this project and its results. The results should return to the communities and they are not, unavoidably, in complete agreement with populations’ expectations. This study is part of the 3-years environmental and health assessment research project performed by Brazilian institutions under the general coordination of CETEM.

2 METHODS

2.1 *Rationale and plan of action*

This research project was designed after it was demanded by the Municipality of Paracatu and lunched more than one year after the first contacts. The basic question of the local Government was on human health risks by Arsenic (As) environmental exposure in Paracatu city. The concern about this issue is increasing locally due to the expansion of gold mining activities (from 18 Mtpa to 61 Mtpa) on distinct mineral deposits (harder—B2- sulfide was found as the mine goes deeper) and, also, as a consequence of notes in some local newspapers and websites about the As potential exposure by the Paracatu population and its associated risks to the human health, i.e., its carcinogenic effects and connected deaths.

The PoA proposed was guided by the toxicological aspects of As environmental exposure. Most cases of human toxicity from As have been associated with exposure to inorganic As. There is good evidence that inorganic As is carcinogenic to humans by both oral and inhalation routes. Oral uptake is generally the most important route of exposure, whereas inhalation normally contributes less than 1% to the total dose. Non-cancer effects observed after inhalation of air, with high As levels at workplaces, are increased mortality from car-
diovascular diseases, neuropathy and gangrene of the extremities. Changes in skin are also indicated as the early non-carcinogenic effect and the most prominent carcinogenic effect. In addition, several organic arsenicals accumulate in fish and shellfish, but these derivatives (mainly arsenobetaine and arsenocholine, also referred to as “fish arsenic”) have been found to be essentially nontoxic. Because of this fact, the epidemiological study included a fish and shellfish ingestion question. PoA also considered the Paracatu specific environmental and its political situation. Thus, geographic data, hydrography, land uses, soil types, economic development (present and past activities, historical gold mining development since artisanal to companies; other mineral exploitation, economic crisis, employment rate, etc.) and future plans, expressed in “Plano Diretor do Município”, were evaluated.

2.2 Paracatu city and gold mining general aspects

Paracatu city is located at the northeast of the Minas Gerais State. The gold mining has been developed in Paracatu since the 1700’s with the discovery of placer gold in the creeks. Small scale gold mining peaked in the mid 1800’s until the 1980’s. The industrial open pit gold mine activities began in 1976–77 and it is estimated to continue until 2042. Major mining-related features at the Paracatu mine includes an open pit mine, two process plants, two tailings facilities and related surface infrastructure. Estimated site restoration costs are around 200 million dollars.

Paracatu has approximately 85,000 inhabitants (2010) and more than 85% of population lives in urban areas. Although the mining site area is classified as a rural area, there are neighborhoods bordering the site and, in some places, no more than few meters separates mining from homes.

2.3 Performed steps of Plan of Action

The following steps were performed to evaluate environmental aspects: (i) As levels in soils and sediments from the three watershed, sub-basins of Rio Paracatu; (ii) As levels in freshwater; (iii) As levels in drinking water (from sources as far as tap water, based on Municipality approved plan for water supply), and, (iv) As levels in groundwater for human consumption and from monitoring wells; (v) As levels in atmosphere. After that, using the (vi) human health risk assessment methodology (US EPA, 1989), all the environmental data were integrated to estimate risks of As environmental exposure. Additional studies on (vii) mineralogy and soil characterization, (viii) As ecotoxicology in soils and in freshwater and (ix) microbial activities in soil and sediments were performed in order to better understand the mobility/retention and ecological significance of As levels measured in environmental matrices. In parallel, human health aspects were evaluated: (x) carcinogenic and skin problems statistics in Paracatu and (xi) mortality data cancers type linked to As exposure from official data bank. In addition, it was performed a (xii) social network analysis aimed to create a strategy to communicate the main results to the local population. Finally, the epidemiological strategy (xiii) was established after environmental data availability and was performed after approval by the National Commission for Ethics in Research. Socioeconomic and quality of life indicators were also evaluated (xviii).

2.4 Political contextualization

One should declare that support by local government as well as by the Public Attorney Office at state level were essential. This support is time-demanding because it depends on the comprehension the scientific bases of PoA by managers. However, it was fundamental to access the environmental reports of the mining companies that have been sent to the Environment Municipal Secretary, as well as to access to municipality health data bases from the Health Municipal Secretary. This closeness with local municipalities and their administrative background, on the other hand, brings their reality, which includes personal efforts, technical gaps, overcharge of work, low income, etc. In consequence, technical reports on environmental monitoring of several mining companies may not be adequately evaluated regarding to the sufficiency. Additionally, the local health data base is complex to search information, but worst situation takes place considering information available under notification and/or quality control. This situation is general in municipalities, unfortunately, with obvious exceptions. A very close relationship with local health care workers is needed and recommended, as they have known local population for a long period, they are welcome at homes and act as the link between population and researchers, revealing unique aspects from a specific population. Overall, a chronic problem is the discontinuity that naturally occurs after changes in the public government, which may happen within each 4 years. Unfortunately, this research project passed through by this situation. Fortunately, the local social links were strong enough to overcome any concern.

3 CONCLUSIONS

The model of action discussed here tend to promote and establish a better background for cooperation
between local and external institutions, either in the technical and scientific fields, as in the local political field in the Brazilian mining city actual context.

ACKNOWLEDGEMENTS