Arsenic in atmospheric particulate matter in Paracatu, MG, Brazil

WZ. de Mello & J.A. Matos
Departamento de Geoqumica, Instituto de Quimica, Universidade Federal Fluminense (UFF), Centro, Niteroi, RJ, Brasil

Z.C. Castilhos
Departamento de Geoqumica, Instituto de Quimica, Universidade Federal Fluminense (UFF), Centro, Niterói, RJ, Brasil
Centro de Tecnologia Mineral (CETEM), Cidade Universitária, Rio de Janeiro, Brasil

L.I.D. da Silva, M.C. Carneiro & M.I.C. Monteiro
Centro de Tecnologia Mineral (CETEM), Cidade Universitária, Rio de Janeiro, Brasil

ABSTRACT: Concentrations of As were determined in atmospheric suspended particulate matter at eight air monitoring stations installed in the surroundings of an open pit gold mine in Paracatu (state of Minas Gerais, Brazil). The concentrations of As associated with total suspended particulates varied from < 0.64 to 18.8 ng m⁻³ (mean = 5.7 ± 4.0 ng m⁻³). Concentrations of As varied spatially and seasonally, controlled by origins of soil-derived dust, prevailing wind direction (northeast), wind speed and seasonal distribution of precipitation.

1 INTRODUCTION

Arsenic (As) is an element found naturally in the lithosphere, hydrosphere, biosphere and atmosphere. However, it is one of the most toxic elements to humans, whose exposure usually occurs through food, water and air. Background levels for As in air are typically 0.2-1.5 ng m⁻³ for rural and 0.5-3 ng m⁻³ for urban areas (WHO, 2001). The city of Paracatu (MG) is potentially exposed to air pollution caused by As associated with atmospheric particulate matter (PM) arising from operational activities related to a nearby open pit gold mining. The objective of this study was to investigate the concentrations of As associated with atmospheric PM and the major processes controlling their spatial and temporal variations in Paracatu. This study is part of the environmental and health assessment conducted by Brazilian research institutions under the general coordination of CETEM.

2 METHODS

2.1 Study area

The municipality of Paracatu (8,229.6 km²) is located in the northwest border of Minas Gerais (MG) state (southeast region of Brazil) and has a population of ca. 90,000 inhabitants, of which about 95% live in the Paracatu city. 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 20th century. Nowadays, it is the largest open pit gold mine in the world. Local mean annual precipitation is ca. 1,442 mm (for the period 2004-2012). The region has distinct April-September dry (290 mm) and October-March rainy (1,134 mm) seasons. Mean annual temperature is 21 °C with mean monthly values varying from 17 to 24 °C. The prevailing wind direction is northeast (NE), with monthly mean wind speed varying from 2.8 to 4.4 m s⁻¹, with maximum in the dry season.

2.2 Sampling and analysis

Atmospheric PM samples, collected from May 2011 to June 2012, by the gold mining company were requested by the Municipality of Paracatu for determination of As. Sample collection, on glass fiber filters, was carried out at eight air quality monitoring stations, installed in the surroundings of Morro do Ouro (within ca. 5 km radius), which belong to an air monitoring network of the gold mining company established in the area. Each station has a total suspended particulate (TSP) high-volume sampler and one of them has a PMIO (PM with aerodynamic diameters less than 10 µm).
TSP and PM10 samples were collected for a 24-h sampling period. For the determination of As, one polypropylene tube and ultrasonically extracted a 1" x 8" strip of each filter was inserted in a 50-mL (at 70 °C for 3 h) with 10 mL of a mixture of HCl (16.75%) and HNO₃ (5.5%). The resulting solution was allowed to cool and then completed to 20 mL with ultra-pure water. The next steps were centrifugation, filtration through a 0.45 µm pore size Nylon membrane, and analysis by ICP-OES. Recovery efficiencies were in the range of 80–120%. The limit of detection (LoD) was 7.5 µg L⁻¹ (in solution) and 0.64 ng As m⁻³ (in air). Concentrations of As in blank glass fiber filters were below the LoD.

3 RESULTS AND DISCUSSION

3.1 Concentrations

Arsenic content was determined in 112 TSP samples, corresponding to 14 samples from each of the eight air monitoring stations (one sample for each month), of which 42 samples (38%) were below the LoD. Concentrations of As in TSP measured at the 8 stations varied from 0.64 to 18.8 ng m⁻¹. With mean (± standard deviation) and median values of 5.7 ± 4.0 ng m⁻¹ and 4.6 ng m⁻¹, respectively. The highest concentration was found at the Alto da Colina station. At the Arena station, where both TSP and PM10 were sampled, of the 14 samples provided from each of these sample categories, 6 of them were collected simultaneously and exhibited As concentration values above the LoD. The average PM10/SP As concentration ratio (n = 6) was 0.61 (median=0.65), varying from 0.36 to 0.84.

3.2 Spatial variation

Figure 1 shows the mean concentrations of As associated with TSP measured at the eight air monitoring stations. The mean concentrations of As varied spatially from 0.64 to 10.2 ng m⁻³.

The lowest mean concentrations of As were found at Barragem and Santo Antonio stations located south of the gold mine of Morro d'Ouro. Concentrations of As at Barragem station were all (n = 14) < 0.64 ng m⁻³. The highest mean concentrations of As were found at the Arena and Alto da Colina stations, located south of the current active mining area of Morro do Ouro. Interestingly, Santo Antonio station exhibited the highest mean TSP concentration (500 ng m⁻³; geometric mean = 3800 ng m⁻³) and the lowest mean mass concentration of As in the TSP (2000 ng g⁻¹ TSP). The Arena station had the second highest mean TSP concentration (4800 ng m⁻³; geometric mean = 36000 ng m⁻³) and the highest mean mass concentration of As in the TSP (66000 ng g⁻¹ TSP). Therefore, the highest concentrations of As found at the sites located closest to the southwest border of the current active mining area of Morro do Ouro are attributed to emissions of dusts from operational activities. Therefore, the higher concentrations of As in the dust, and the predominant NE winds.

3.3 Seasonal variation

Concentrations of As associated with TSP varied seasonally. During the study period, the highest concentrations occurred between May and September, and the lowest between October and April (Figure 2). These periods overlap respectively the dry dary season precipitation plays an important role mitigating dust dispersion from the mining area. Besides, mean wind speed
Figure 1. Mean (± standard deviation) concentrations of As associated with total suspended particulates at eight air quality monitoring stations in Paracatu (MG). At Barragem station, all concentrations were below the LoD (<0.64 ng m⁻¹).

4 CONCLUSIONS

Mean concentration of As in atmospheric TSP was 5.7 ± 4.0 ng m⁻³, varying from < 0.64 to 18.8 ng m⁻³.
Concentrations varied spatially and seasonally by more than an order of magnitude, controlled by a combination of anthropogenic and natural processes (origin of soil dusts, prevailing wind direction (NE), wind speed and seasonal distribution of precipitation). The highest concentrations were found at Alto da Colina station and during dry season.

ACKNOWLEDGEMENTS

To Brazilian Agencies CAPES and CNPq.

REFERENCE