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Evaluation of the factor of enrichment of atmospheric particulate matter in the Campus of UFMG, Belo Horizonte

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ABSTRACT

The particulate matter present in the atmospheric air of large cities is one of the pollutants that causes great environmental risks. Due to their composition of solids and liquids varying in size, shape, composition and origin, they have an impact on the health of the exposed population, agriculture, forests and acidification of lakes. In this scenario, the present work had as objective to evaluate the concentration of the 10-micrometer particulate matter, commonly called PM_{10}, and the elementary concentrations in air filters whose sampling was carried out at the Campus of the Federal University of Minas Gerais. For this, a high-volume sampler was used to collect the particulate matter. The elementary concentration of the particulate matter was determined via neutron activation analysis, method k_0. Applying the enrichment factor technique, the influence of anthropogenic sources at the sampled site was investigated. The results showed anthropogenic interferences of zinc, sodium, chromium and iron and a geogenic impoverishment of cobalt.

Keywords: Particulate Matter, Neutron Activation Analysis, k_0-method.

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1. INTRODUCTION

The development of Brazilian cities has caused the increase of particulate matter (PM) in the atmosphere, caused mainly by anthropogenic activities. The population that lives mainly in the cities contributes to the emissions of the PM pollutant through the circulation of automobiles, industrial processes, resuspension of soil dust, etc. [1].

The PM is a pollutant that damages human and animal health and endangers the environment if the concentration levels are in disagreement with the current legislation, which currently limits the PM_{10} to 50 $\mu g.m^{-3}$ as defined by the National Council of the Environment (CONAMA) [2].

Currently, the environmental monitoring system performed in Brazil is based on the sampling of PM with a diameter of 10 μm, known as PM_{10}. The size of this particle contributes negatively to the environment as for example the formation of acid rains and in the health with the increase of hospitalizations due to respiratory problems [3].

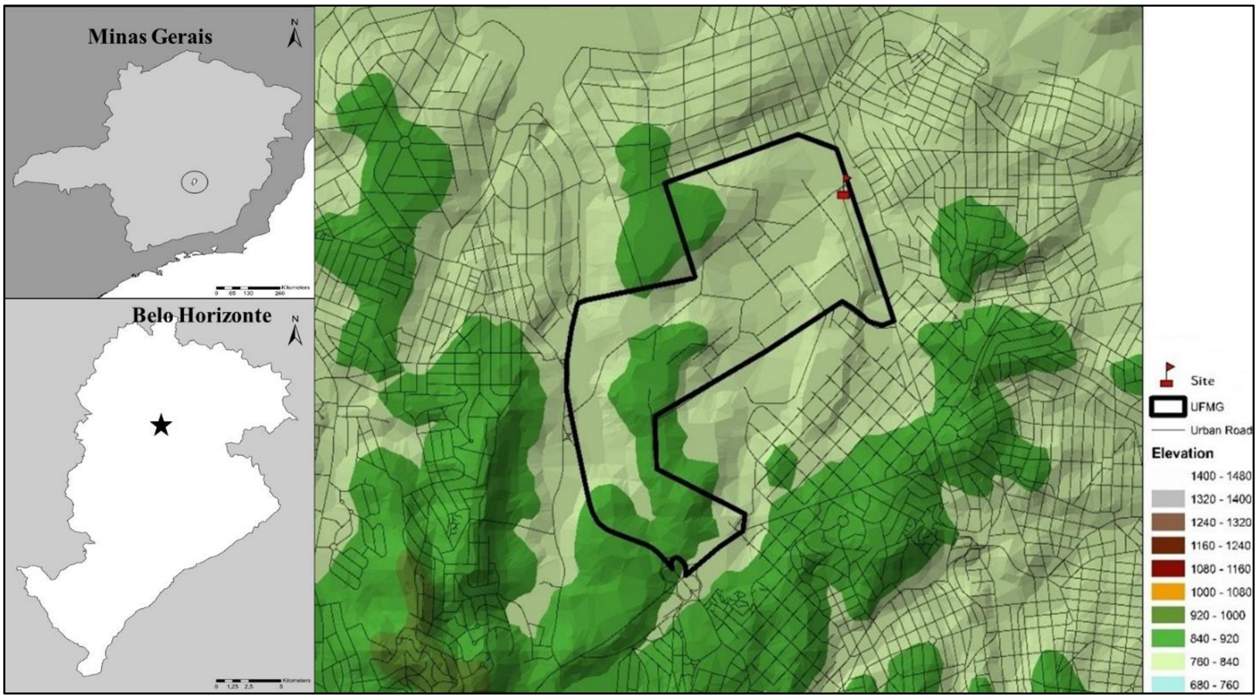
Specific studies on air quality that address PM_{10} describe the penetration of this particle in the respiratory system, bringing complications caused by the inhalation of PM in the urban environment [4] [5] [6].

2. METHODS

Belo Horizonte is the main city and capital of the state of Minas Gerais. It has an estimated population of 2,523,794 million inhabitants in 2017, with a population density of 7,167 inhab/km^2, behind only São Paulo, with approximately 12 million inhabitants, and Rio de Janeiro, with approximately 6,3 million inhabitants. The territorial area is of 331,401 km^2 and presented a fleet, in the year of 2016, of 1,783,961 automobiles [7].

The location chosen for the PM sampling in Belo Horizonte was the Campus of the Federal University of Minas Gerais, which is located in the Universal Mercator Transverse Coordinate System (UTM) 23K (X = 609055, Y = 7803326) as shown in Figure 1. In order to choose the location, the presence of car emissions, the flow of people in the surroundings and the physical safety of the sampling equipment were considered.

Figure 1: *Sampling location of PM_{10} at the UFMG Campus.*



Source: Author.

2.1. Sampling

Seven samplings were performed in the winter period in 2014, using glass fiber filters and a properly calibrated large volume sampler that has a flow capacity of 1,13 m^3min^{-1} and an uncertainty of less than 1 % in a period of 24 hours, according to the determinations of CONAMA's number 3/1990 [2] [8].

2.2. Particulate Matter Analysis

The technique used was the neutron activation analysis method k_0 [9] using the TRIGA MARK I IPR-RI reactor located at the Center for the Development of Nuclear Technology (CDTN). This reactor operates at a power of 100 kW and thermal neutron flux of 6.35 x 10^{11}.cm^{-2}.s^{-1}.

To perform the analysis, an area of 30 cm^2 of the filter was used without being sampled, called "white" in triplicate to verify the influence of the concentration of the elements present in the filter material. The samples were also analyzed in the same dimensions and packed in polyethylene tubes, along with neutron flux monitors [10].

After irradiation, gamma spectrometry was performed in a spectrometer consisting of HPGe detector with 25% relative efficiency and resolution of 1.85 keV for ^{60}Co energy and with associated electronics. The acquisition of the spectra was through the Genie 2000 program.

For the spectrum analysis, the HyperLab program [11] was used and the elemental concentration calculation was performed with Kayzero software for Windows [12].

2.3. Enrichment Factor

The enrichment factor (EF) is an indicator of anthropogenic contamination that depends on three factors: the amount of natural element present at the sampling site, the anthropogenic interference and the sedimentation capacity of the elements in the system [13]. Eq. 1 was used, adopting Sc as normalizer, since it is an element that is not anthropogenically influenced and whose mean concentration was 0.05 $mg.kg^{-1}$. Values of elements present in the Earth's crust were used as reference.

According to Mecray and Brink [13]:

$$EF = (Me_{sample}/El_{sample})/(Me_{crust}/El_{crust}) \tag{1}$$

at where:

Me sample: concentration of the element in the sample;

El sample: concentration of the sampled normalizing element;

Me crust: concentration of the reference element in the earth's crust;

El crust: concentration of the reference normalizing element in the earth's crust.

The EF reference value 1 indicates that the analyzed element is of natural origin, unlike the values above, which indicate anthropogenic origin. The scale used is: values <1 no enrichment, 1 to 3 little enriched, 3 to 5 moderately enriched, 5 to 10 moderately severe enrichment, 10 to 25 severe enrichment, 25 to 50 very severe enrichment and above of 50 extremely severe enrichment [13]. The elements used were Co, Cr, Fe, Na and Zn.

3. RESULTS AND DISCUSSION

After sampling, the elementary concentrations in PM_{10} were calculated using the parameters covered in the equipment instruction manual and the EFs were calculated in an Excel worksheet. The elementary anthropogenic interferences obtained are presented in Table 1.

Table 1: Enrichment factor data of the elements.

Element	**Values Earth Crust mg.kg^{-1}** [14]	**Average Sampling mg.kg^{-1}**	**Enrichment Factor**
Co	17,3	0,05 ± 0,005	0,79
Cr	92	3,02 ± 0,22	9,69
Fe	39175	249 ± 13,13	1,89
Na	24260	4837 ± 253	58,9
Sc	14	0,05 ± 0,002	1
Zn	67	2207 ± 104	9737

Observing the results, it is verified that the cobalt presented impoverishment in relation to its natural concentration in the terrestrial crust, meaning that there was geogenic alteration at the study site. As for iron, low enrichment. The other elements obtained great enrichment, standing out the zinc, in which there was an anthropogenic interference of more than 9700 times in relation to the natural concentration of the earth's crust.

4. CONCLUSION

Samples of PM collected in air filters at the UFMG Campus had their elemental concentrations determined and submitted to the enrichment factor calculation. The results confirm the anthropogenic influence in the sampled site, which is a place of great circulation both of automobiles and of people who attend the Campus.

Finally, the elements that obtained the greatest anthropogenic interference were Zn, Na, Cr, Fe. Co was the only element that obtained an impoverishment in the earth's crust due to a geogenic alteration at the study site.

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