IX LATIN AMERICAN SYMPOSIUM ON ENVIRONMENTAL AND SANITARY ANALYTICAL CHEMISTRY

APRIL 17-20, 2011 ▪ SALVADOR, BRAZIL

BOOK of ABSTRACTS

PROMOTION

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Human risk assessment for air pollution by passive biomonitoring: a case study in São Mateus do Sul, Paraná, Brazil.

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Keywords: air quality, tree bark, $PM_{2.5}$

In developing countries significant sources of air pollution may go undetected in areas that do not have qualified structure to measure air contaminants. In this context, simplified methods of measuring ambient particles, such as portable impactors and trace elements accumulate in tree barks, may provide information to identify areas influenced by source emissions. Extraction of oil from shale may impact air quality. From burning oil shale, the main atmospheric pollutants are particles, sulfur oxides and nitrogen oxides (Ots, Reisner, 2007). Particles emitted by shale oil plants have a bimodal distribution with average 100 modal count median diameters (CMDs) of 24 (SD 4) and 52 (SD 9) nm, which are within the size range that may impact human health (Saldiva et al., 2002). Studies using plant indicators have shown that emissions from shale oil plants affect vegetation, but the possible health effects of ambient concentrations of emissions derived from shale oil plants have not yet been determined.

In this study, simplified methods to measure trace elements in tree barks and in fine particles in filters to evaluate the possible health effects of the emissions of a shale oil plant operating in São Mateus do Sul (Paraná, Brazil) were used. These analyses were carried out by energy dispersive X-ray fluorescence spectrometry (EDXRF) to determine concentrations of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, S, Si, V and Zn in tree bark and Fe, S and Si in particulate matter $PM_{2.5}$. Health data of respiratory diseases of the studied population was obtained from the patient files from the local public health center. The resulting data were evaluated obtaining element concentration distribution maps. These maps were also used to identify hot spots, to estimate element mobility of Fe, S and Si present in the air, as well as, to correlate element concentrations found with health data of the local population. The SURFER geo-statistical software (Golden software Surfer) and the attenuation model of concentration were used to treat these results. For statistical tests, STATISTIC® 8.0 software and SPSS 13.0 was used.

Results obtained indicated significant associations between respiratory morbidity and industrial emissions. Thus the emissions from the shale oil industry affect the health of inhabitants of the city of São Mateus do Sul. This was also demonstrated by measurements of element concentrations in $PM_{2.5}$ and the accumulation of trace elements in tree barks. Factor analysis and the descriptive analysis (ANOVA) of element concentrations in tree barks downwind of the shale plant suggest that Fe, S and Si may be used as tracers of shale industry pollution. The combination of spatial characterization of pollution and clinical data revealed that adverse effects were significant ($p = 0.042$, ANOVA) for the population older than 38 years.

From the results obtained it was also concluded that the use of tree bark as a bioindicator is an adequate strategy in environmental impact studies in those areas with no conventional network of air pollution monitoring.

Acknowledgments

The authors thank CAPES for the fellowship of doctorate.

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