BIOMONITORING OF AIR POLLUTION THROUGH TRACE ELEMENT ANALYSIS

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Abstract:

Research work is currently going on to determine the suitability in the use of local lichen species for biomonitoring air pollution in Ghana. The study area being investigated are the gold-mining areas situated in the Moist Evergreen and Semi-Deciduous forests in Ghana. The nuclear analytical techniques being used in this work are instrumental neutron activation analysis and tube-excited x-ray fluorescence spectrometry. The present report covers results of quality control exercise carried out to validate the quantitative methods being used. This includes our participation in an intercomparison exercise carried out among participants of the IAEA coordinated research project. The samples analyzed were two lichen samples from two completely different areas using neutron activation analysis. Only short- and medium-lived irradiations were carried out. Satisfactory results were obtained for most of the elements identified and quantified.

1. INTRODUCTION

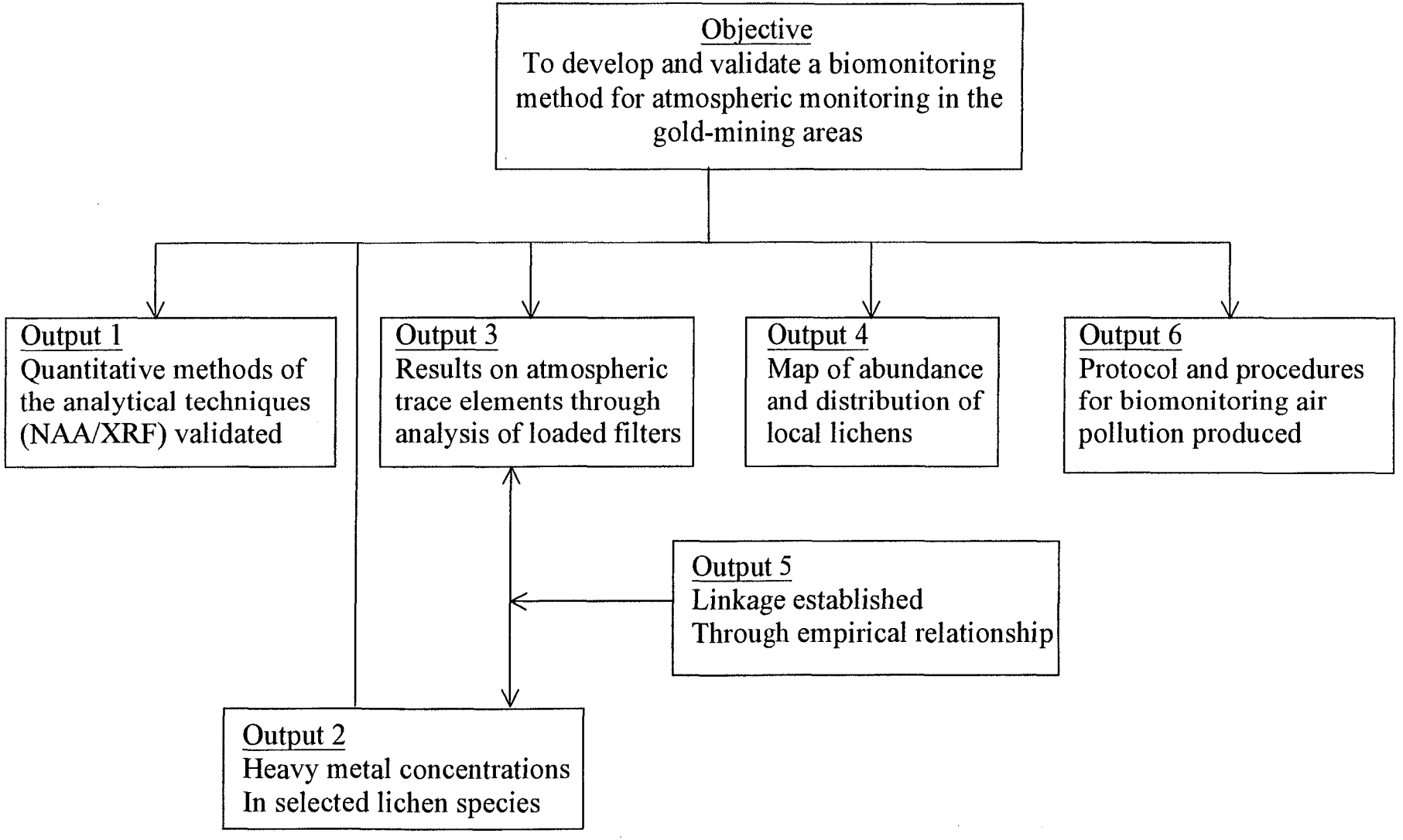
The gold-mining processing methods of the type of gold ore predominant in the country, requires high temperature roasting of the ore. This roasting therefore leads to the release of oxides and sulfides of heavy metal pollutants into the environment [1, 2]. Consequently, for those mines situated in the forest zones, biomonitoring of air pollution offers a convenient and cheaper method if properly developed and tested.

The main project objective is therefore to develop and validate an indirect, simpler, and less expensive method for studying heavy metal pollutants in ambient air of gold mining industries using biomonitors (lichens).

The expected project outputs are:

1. The quantitative methods of the applied nuclear-related analytical techniques, of Instrumental neutron activation analysis (INAA) and x-ray fluorescence spectrometry (XRF), validated for the analysis of lichen samples.
2. Map of the abundance and distribution of identified local lichen species in the project areas.
3. Report on heavy metal concentration levels in selected lichen species. (baseline and prevailing levels).
4. Report on concentrations of atmospheric trace elements through analysis of loaded air filters.
5. Empirical relationship developed linking elemental concentration in lichen samples to that in ambient air.
6. Protocol and procedures in the use of local lichens for biomonitoring air pollution produced.

Figure 1. shows at a glance the project Objective and outputs.



The above project is being done in collaboration with the Botany Department of the University of Ghana, who are providing the personnel for the species identification. It has also been possible to get the Ecological Laboratory of the University of Ghana on board in an active participation and support for the project.

The present studies is continuing on the basis of the last renewal of the contract No. 9934/RO for the period 1998/12/01 to 1999/11/30, and this report covers essentially our participation in the quality control exercise being carried out through the intercomparison analysis of two unknown lichen samples with different levels of elemental concentrations.

2. METHODS

2.1. Sample Preparation

The lichen samples were prepared by weighing 100 - 200 mg from the homogeneously ground sample. They were then wrapped in thin polythene foils, put into polythene capsules and sealed with a hot soldering iron. Replicate analyte samples were prepared, two each for short irradiation, medium irradiation It was not possible to carry out long irradiation and further replicate analysis since the MNSR reactor developed some temporal electronic problem. This problem has, however, been solved.

2.2. Sample Irradiation

Irradiation of the samples was done using the GHARR-1 reactor operating between 10 - 15 kW and at neutron flux in the range of 1 - $5x10^{11} ns^{-1}cm^{-2}$. Each of the capsules was sent into the reactor for irradiation by means of a pneumatic transfer system operating at a pressure of 25 psi. The irradiation was also categorized according to the half-lives of the elements of interest. At the end of the irradiation, the capsules were returned from the reactor, allowed to cool down until the activities have reached the acceptable level for handling. Each of the samples was then placed on the detector for counting. The irradiation schemes and corresponding (n,γ) product radionuclides was presented in the first report at the first RCM [3].

2.3. Qualitative and Quantitative Analysis

The PC-based gamma - ray spectroscopy system consists of an N-type High Purity Germanium (HPGe) detector model GR2518, an HV Power Supply Model 3103, a Spectroscopy Amplifier Model 2020, all manufactured by Canberra Industries Inc., a Silena EMCAPLUS Multi-Channel Analyzer (MCA) Emulation Software Card and a 486 micro-computer for data evaluation and analysis. The detector operates on a bias voltage of 3000(-ve)V, and has resolutions of 0.85 keV and 1.8 keV for Co-60 gamma-ray energies of 122 keV and 1332 keV respectively. The relative efficiency of the detector is 25%. By means of the MCA, the spectra intensities for the samples were accumulated for some pre-set times. The qualitative analysis which involves the determination of the various elements in the samples and the quantitative determination of their concentrations were achieved using the Gamma Spectrum Analysis Software SPAN 5.0

3. RESULTS AND DISCUSSIONS

Two lichen materials labeled L-1 and L-2 were analyzed using instrumental neutron activation analysis. The following elements were identified and quantified in the lichen sample L-1: Al, As, Ca, Cl, Co, Cr, Fe, K, La, Mn, Na, Sb, Sc, V, and Zn. For the lichen sample L-2, for the few irradiations carried out , these were the elements identified and quantified: Co, Fe, K, La, Na, Sc, and Zn. Evaluation of the results of participating countries by the IAEA has been published [4], with graphical presentation of the results for the samples L-1 and L-2 . In the L-1 sample the concentrations of the following elements fell within the 95% confidence interval (CI) of the laboratory mean: Cl, Co, K, Mn, Sc, and V. Those that fell within three times the 95% confidence interval are: Al, Cr, Na, Sb, and Sc. The elements whose determined values fell outside the three times 95% confidence interval (3x CI) include: As, Ca, Co, Fe, La, and Zn. In the case of As it has been discovered that the error was due to transposition of results from print out into the table of results. Hence for the L-1 lichen analyzed 40% of the samples had elemental concentrations within the 95% CI, 73% within 3x CI, and 33% outside the 3X CI range.

In the L-2 sample the elements falling within the confidence interval are: K, La, and Sc. Those elements lying outside the range of confidence interval include: Co, Fe, and Zn.
These results were obtained from a maximum of two replicate analysis. Increasing the number of replicate samples would have improved further the quality of the results obtained.
In both the L-1 and L-2 lichen samples, the concentration of the following elements fell outside the 3x CI range : Co, Fe, and Zn. The irradiation and counting scheme for these elements need be investigated further through the analysis of some carefully selected biological plant reference materials to help improve the accuracy of the determination of Co, Fe, and Zn

4. PLANS FOR THE FUTURE

ACTIVITY	**PERIOD**
1. Field trip to Prestea Gold Mines • Survey of lichen species • Sampling and storage of lichens • Air sampling for PM_{10} and $PM_{2.5}$ particulates	March
2. Identification of lichen species	April
3. Sample Preparation • Separation and cleaning of lichen species • Grinding (lichen powder) and pelletization • Wet digestion of lichen samples with HNO_3 and H_2O_2	April
4. Laboratory Analysis • Analysis of lichen samples by INAA and EDXRF • Analysis of digested lichen samples by TXRF • Analysis of reference materials • Gravimetric analysis and elemental analysis of Airborne particulates	April/May/June

5. Field trip to Prestea Gold Mines — July/August
    - Repeat sampling of lichens and aerosols

6. Laboratory Analysis — August
    - Repeat analysis of lichens and aerosols

7. Data Reduction and Evaluation — September
    - Lichen mapping (abundance and concentration distribution)
    - Establishing empirical relationship (aerosol
        - lichen concentration linkages)

8. Development of a protocol for biomonitoring air pollution. — October

9. Project reports — November

PROJECT OUTPUTS, ACTIVITIES, AND STATUS (BAMFORD, GHANA)

SPECIFIC OUTPUTS	ACTIVITIES	STATUS
1. Quantitative methods of analytical techniques (NAA/XRF) validated	• Analysis of CRMs an SRMs • Participation in intercomparison runs	• Validation carried out on NAA using NBS Orchard Leaves, and BCR-CRM No. 279 • Interccomparison exercise carried out with 2 lichen samples • Intercomparison exercise with moss samples is on-going
2. Heavy metal concentrations in selected lichens	• Field survey of local lichens • Sampling and sample preparation of lichens • NAA and XRF analysis • Data evaluation	• On-going
3. Atmospheric elemental concentrations from analysis of loaded filters	• Sampling atmospheric particulates for PM_{10} and $_{2.5}$ • Gravimetric analysis • Trace element analysis • Data evaluation	• Yet to be done
4. Map of abundance and distribution of local lichens	• Field survey • Sample collection • Species identification • Data evaluation • Generation of a lichen map	• On-going
5. Linkage between elemental concentrations in lichens and the atmosphere established	• Statistical evaluation of results from outputs 2 & 3 • Development of an empirical relationship	• Yet to be done
6. Protocol and procedures for biomonitoring of air pollution	• Protocol for sampling and sample preparation • Protocol for analysis	• Yet to be done

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