Air Pollution Studies of the Highest point of the Dar es Salaam City by X-Ray Fluorescence Analysis

Yusuf Koleleni

Physics Department, Faculty of Science, University of Dar es Salaam, P.O. Box 35063 Dar es Salaam, Tanzania

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Abstract
A survey of the environmental pollutants in the city of Dar es Salaam was conducted. Aerosol sampling was conducted using a Sierra Anderson two way impactor for particles less and greater than 10 microns. Analysis was possible with X-ray fluorescence (XRF) tube excitation. We explore the analytical parameters of the spectrometer and present aerosol results for the months of January and February 1993/94 for cites at the highest points of the Dar es Salaam. The results have local significance but are also compared to international values. Lead values is of the order of 0.004 mg/L for Dar es Salaam (DSM) while World health Organisation (WHO), United States of America (USA), Canada and European Economic Community (EEC) values stands at 0.005 mg/L.

Keywords: Air pollution, X-ray, fluorescence, analysis, aerosol sampling, pollutants, Dar es Salaam, analytical parameters

Résumé
Une étude sur les polluants environementaux dans la ville de Dar-es-Salaam a été menée. L'échantillonnage de l'aérosol a été conduite en utilisant le "Sierra Anderson Impactor" à deux voies pour les particules de plus ou moins 10 microns. L'analyse a été menée au tube excité de rayon X fluorescent (RXF). Nous déplorons les paramètres analytiques du spéctromètre et présentons les résultats de l'aérosol pour les mois de Janvier, Février et Mars 1993/94 pour citer les plus hauts points de Dar es Salaam. Les résultats ont une signification locale, mais sont aussi comparables aux valeurs internationales. La valeur la plus élevée se trouve à l'ordre de 0,004 mg/L pour Dar es Salaam (DSM) alors que les valeurs établies par l'Organisation mondiale de la Santé (OMS), les Etats Unis d'Amérique (EUA), le Canada et la Communauté Economique Européenne (CEE) s'éleve à 0,005 mg/L.

Mots clés: Pollution de l'air, rayon X, analyse de la fluorescence, échantillonnage de l'aérosol, polluants, Dar es Salaam, paramètres analytiques

Introduction

A number of analytical nuclear techniques have so far been developed for use in high sensitivity analysis. Methods like Atomic Absorption Spectroscopy (AAS) which make use of high temperature flames and graphite furnaces or mercury at ordinary temperatures, have limited detection limits for low Z elements. Neutron Activation Analysis (NAA) involves nuclear reactor and has good sensitivity over many elements with a disadvantage of expensive equipment and the need of well trained technical staff. The Electron Probe Micro Mass Analysis (EPMA) is very good for individual particle analysis and their distribution but the equipment is however relatively expensive (Tolgyessy and Klehr 1987). The Proton Induced X-ray Emission (PIXE) and Proton Gamma ray Emission (PIGE) from an extensive accelerator can provide accuracy of better than 6% when corrections for x-ray self absorption and proton stopping power for intermediate thickness of 1.5 to 11 mg/cm^2 XRF seems to be suited for elemental analysis of different types of samples and particularly air pollutants when collected on thin filters. The main advantages include the possibility of multi-element, short time analysis and is normally non-destructive. Some disadvantages involve matrix effects and lack of sensitivity which are mostly solved in TXRF (Koleleni 1990).

Energy Dispersive X-ray fluorescence (EDXRF) analysis has achieved significant development over the last few years in terms of good detection limits of the technique for various elements and rooms for

variety of applications. Improvement have been on the side of collimations, source-sample-detector distances, count rates which has emomous effects on, reduced background, improved detection limits and increased precision (Kinyua, 1983; Koleleni, 1989; Koleleni, 1990; Koleleni and Van Grieken, 1990). Environmental applications such as aerosols demand high precision and low detection limits, these are quoted in the literature review section. Radioisotope sources and x-ray tubes for various characteristics and intensities can be used to achieve order of 60 parts per billion (ppb) for most of the elements (Jaklevic *et. al.* 1990). Yoneda and Horiuchi (1971) were the first to come up with the idea of total reflection conditions when using x-rays under optically flat surfaces. It was then followed by a systematic progress on the side of instrumentations which resulted into detection limits of nanogram (ng) levels for most of the elements (Aiginger and Waubraschek, 1974).

Detection limits for TXRF at the ng/ml of picogram (pg)-level, in absolute mass is attainable and is currently ranging from 10 to 0.01 ng levels from results of Muia *et. al.* 1990, Wabrauschek and Kregsamer 1989, Koleleni and Van Grieken 1990 while Ninomiya *et. al.* 1989 has reported Detection limit (DL) of 20 ng level. The actual detection limits for various elements are given in Table 1 and 2 for XRF and Table 3 for TXRF.

During the last few years there has been a growing interest in the pollution investigation in view of increased levels of both technical and scientific activities in some parts of Africa. In the city of Dar es Salaam alone there are for example cement factories and an oil refinery, which may have a local and international long range influence (NEMC, 1993). In this work, we are interested in the analysis of aerosol for studies of pollution using X-ray fluorescence XRF spectrometry.

Aerosol Exercises and Significance

Demand on the part of analytical techniques in both spatial resolution and sensitivities are highly needed. Apparently, there has been some work done in water pollution (Mwilike 1984) and in medical applications (Mwiruki 1991) using EDXRF (Energy Dispersive X-ray Fluorescence) but little has been on aerosols. There is a pilot study conducted by National Environmental Management Council (NEMC) of Tanzania in the city of Dar es Salaam, to quantify carbon monoxide, sulphur dioxide, suspended particulate matter, nitrogen dioxide, Hydrocarbons and lead at Gerezani, Kariakoo, Askari Monument, Muhimbili Medical centre and Bahari Beach. These are working and living areas.

Industrialization and accelerated development of new processes and new materials have introduced new potential hazards. By making measurements on aerosols in these places it is possible to evaluate the hazard potential in the cases where the relations between exposure and effects are known. However, these relations are often not known and the aerosol characterization can be used, in conjunction with epidemiological and toxicological studies to find such relations. By studying aerosol, opportunities to develop safer environments may be accelerated and monitoring routines may be developed. For quite some time, trace analysis of aerosols has been ignored in many parts of Africa. Such studies have been mainly conducted in developed countries, and thus, information regarding the elemental composition is still limited in this region. Many people have lost their lives or incurred severe damage as its consequence (Koleleni, 1989). The artificially generated particles are dominated by small size (<2.5 µm). The small size fraction which is inhailable is found in the accumulation made and not only affect the localized area but also subjected to a long range transportation and, is of particular implications with regard to health hazards.

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Recent studies about air borne particulate matter composition in arid regions were reported by Penkett *et. al.* (1979) for Gezira (Sudan), while Annergarn *et. al.* (1983) showed that soil has been the major source of most of the elements in Gobaded, Namibia. Crozart *et. al.* (1978) and Crozart (1979) reported vegetation as a source of suspended particulate matter in the Savannah and forest regions of Ivory coast after activities are conducted. Trace analysis results for Kinshasa, Zaire and Butare, Rwanda reported by Maenhaut *et. al.* (1985) Maenhautt and Akilimali (1987) pinpointed contributions from crystal dusts and burning biomass. In many of these, none performed the analysis locally, either due to lack of knowledge in the appropriate sample collection, analytical techniques, data interpretation, lack of equipments or otherwise.

We have chosen cites which have not been evaluated before and for many elements which have limitations in other equipments. The results obtained are within WHO guidelines (Nriagu and Pacyna 1988).

Problems Caused by Aerosols

Human exposure to trace elements via inhalation will be in the form of an aerosol containing very small particles (fume-form) but not necessarily gas or large particles (dust-form). The inhaled particles may be deposited in the respiratory tract or may go up to