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Assessment of Atmospheric heavy metal deposition in North Egypt aerosols using neutron activation analysis and optical emission inductively coupled plasma

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ABSTRACT

The aim of the present study is to assess the current level of atmospheric heavy metal pollution of aerosols in different cities of North Egypt using the neutron activation analysis and optical emission inductively coupled plasma techniques. The results revealed that the highest concentrations of particulate matter PM_{10} and total suspended particulate matter were close to industrial areas. From the results of the enrichment factor calculations, the most significant elements of anthropogenic origin are Ba, Sb, Ce and Zn.

1. Introduction

In recent years there has been considerable concern about the many adverse effects of elevated aerosol levels in the atmosphere, which are associated with various environments. The aerosols are divided into two principle groups— particulate matter PM_{10} and total suspended particulate matter – TSP. The PM_{10} fraction comprises fine particles of diameter equal to or less than 10 μm, which can be inhaled deeply into the lungs. The major sources of PM_{10} particles are motor vehicle emissions, windblown dust, paint sources and open waste burning (Dragana Dordevic et al., 2004; Gutierrez-Castillo et al., 2005). TSP consists of all particles in the atmosphere. High levels of TSP in air can reduce atmospheric visibility, irritate the eyes and can have long-term effects on humans (like irritation of the respiratory system causing lung damage, bronchitis and asthma), plant and animal life (Dragana Dordevic et al., 2004).

The PM_{10} and TSP contain some heavy metals, which are non-degradable, and can accumulate in the human body, causing damage to a person's nervous system and internal organs. They also act as initiating factors of cardiovascular diseases, reproductive impairment and cancer (Celine et al., 2007; Kakoli et al., 2006). Borai and Soliman (2001) evaluated the heavy metals (lead, cadmium, zinc and nickel) in airborne particles at some industrial and industrial–residential areas of Cairo, Egypt. Their results showed that, generally, PM_{10} levels have increased consistently with the growth of polluting activities in Cairo from 1991 to 1999. These reached, at Ramsis square, a PM_{10} average value that not only exceeds the reported PM_{10} values but also exceeds the TSP average reported from 1978 to 1991, which is considered an alarming indicator for adverse pollution of the Shoubra site, Ramsis and Tebbin sites that suffer from different sources of heavy metal pollution. Abdel-Halim et al. (2003) determined the minor and trace-elements in dust particulates from the cement industrial areas at Helwan, south of Cairo, to assess the air quality. High levels of particulate matter are observed, especially at the industrialized sites of Helwan and Tebbin, and these can have a serious impact on human health because of their high toxic levels. The Egyptian State of Environment report 2008 gives the annual inhaled particulate concentrations during the previous five years (2004–2008), and shows that despite the high average annual concentration during 2008 of

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about 137 μg/m^3 , which exceeds the annual average permissible limit of Environment Law (70 μg/m^3), though it is less than the annual average concentration, which was monitored during 2007 as 151 μg/m^3.

The monthly average values of PM_{10} and TSP particles were monitored by Monged (2009) in South Egypt during the summer, spring, autumn and winter. The volume-weighted average levels of mass concentrations in TSP and PM_{10} in all measured samples were 513.68 and 245 μg/m^3, respectively. Also he determined the concentrations of different heavy metals in air particulate matter using neutron activation analysis (NAA). Fifteen elements were detected (Ba, Br, Co, Sb, Cr, Fe, Ca and Zn) and some trace elements (Ce, Rb, Eu, Hf, La, Sc and Th).

Since the geographic location of Egypt is at latitude 30°N with more than 340 days of sunshine per year, it is expected that high levels of photochemical smog would occur in Egypt, with higher levels predicted for the near future, due to the increase in anthropogenic processes such as burning activities (e.g. rice straw). Therefore, the aim of the present work is mainly focused on assessment of atmospheric heavy metal deposition in North Egypt Cities (Cairo, Alexandria, El-Mansora, Tanta and Sinai) using the non destructive NAA technique. The enrichment factor (EF) ratios are estimated to specify the origin of the elements, whether it is of anthropogenic or natural origin. Also, the lead (Pb) element concentration in PM_{10} and TSP has been measured by an optical emission inductively coupled plasma spectrometer (OE-ICP) as it cannot be detected by NAA. The present work is considered as a baseline study of air quality.

2. Experimental

2.1. Sampling and sample preparation

The TSP has been sampled with high volume samplers (General Metal Works, Model GMWL-2000H) operating at a flow of about 78 m^3/h by pumping 540 m^3 of air through Whatman 41 cellulose filters of 18×25 cm. The normal frequency of filter change is every 8 h. The PM_{10} has been sampled by the filter which is placed in its proper position on the top of a suitable wire mesh. One blank filter per week is measured for background determination. Only TSP has been collected from Sinai whereas PM_{10} & TSP have been collected from the other cities. Table 1 and Fig. 1 show the sample locations and descriptions.

Table 1

City	Description of the location	Filter type
Alexandria	Refractory and Thermal block	TSP
	Industrial Areas from Refractory and Thermal block, Cement Company, the Factory of IDEAL, Iron and Stainless Steel Factory, ElDkheela Power and transformers Company	PM_{10}
Mansora	Mansora City 1 km apart from Industrial area, (Cement, Soap and oil production, Textile and Solid Waste Incineration)	TSP
	Mansora City 1 km apart from industrial area, Cement, Soap and oil production, Textile and Solid Waste Incineration and Mansora City	PM_{10}
Tanta	Tanta Station and Tanta city, 4km apart from Petroleum Manufacture area	TSP-PM_{10}
Cairo	Shoubra Industrial Area(north of Cairo)	PM_{10}
	Central of Cairo	TSP
Sinai	Industrial Area.	TSP

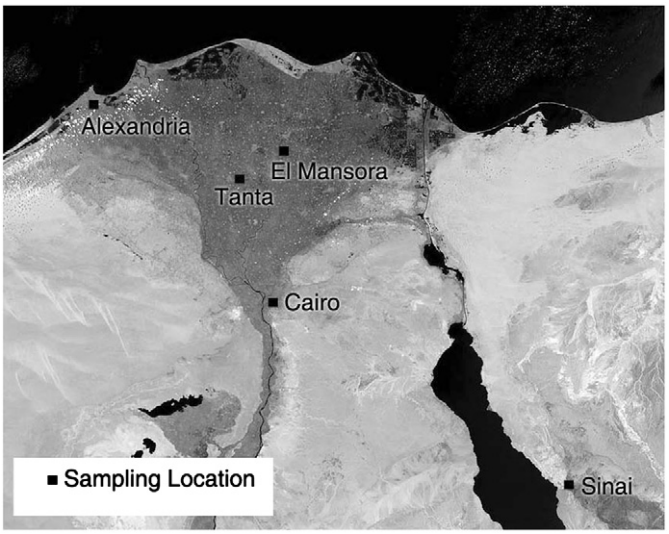

Fig. 1. Sampling locations.

2.2. Optical emission inductively coupled plasma (OE-ICP)

Lead pollution is a serious threat to human health because high lead concentrations in the blood can lead to high blood pressure, kidney problems, infertility, decreased intelligence quotient (I.Q.) levels in children, and disorders to the nervous system. The concentrations of heavy metals Pb and Cd have been determined by an OE-ICP spectrometer in the Desert Research Center in Egypt (DRC). To prepare the samples the membrane filters were cut using stainless steel scissors and placed in acid-cleaned pyrex test tubes for digesting. The procedure was as follows: 14 ml of concentrated high-purity HNO_3 was added to the filter until it was fully submerged. The mixture was heated until it was completely dry. Fifty milliliters of 5% (v/v) high-purity HNO_3 was added after initial acid digestion. Also the blank filter was digested for quality control Celine et al. (2007).

2.3. Neutron activation analysis

Thermal neutron activation analysis was used for elemental determination in air filters as well as in blank filter material (Boamponsem et al., 2010; Sitaram and Ravin, 2007). It is noted that the high flux 3.31×10^{12} n/cm^2.s of thermal neutrons of the Second Egyptian Reactor (ETRR-2) is especially favorable for the determination of the radionuclides with high precision.

Long-lived radio nuclides were determined using activation with thermal neutrons. The samples were primarily packed in aluminum cups with an irradiation time of 2 h, filters were repacked after irradiation and then were measured for the first time for 45 min after 4 days of cooling and for the second time for 90 minutes after 20 days of cooling. After irradiation the gamma spectra of radioactive filter samples are collected using hyperpure germanium (HPGe) single crystal spectrometer and the quantitative analysis is achieved for the irradiated filter samples.

2.4. Evaluation of anthropogenic inputs

The enrichment factors (EF) can be used to differentiate between the metals originating from human activities and those from natural provenance, and to assess the degree of anthropogenic influence. The EF is defined as the ratio of the concentration of an element of interest in the sample to that of a reference element in the sample divided by the same ratio in a reference