Study of Air Quality of National Science Museum at Agargaon, Dhaka

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Abstract

Ambient particulate matter, PM_{10} and $PM_{2.5}$ together with SO_2, NOx and O_3 were collected at the Library of National Science Museum in Dhaka on weekdays using Air Metrics Samplers from 4 to 29 April, 2015. The total average concentration of $47.4\pm13.9\mu g/m^3$ and $30.0\pm13.6\mu g/m^3$ were found for PM_{10} and $PM_{2.5}$, respectively, at the Library of Museum. The total average concentrations of $96.8\pm27.5\mu g/m^3$ and $27.7\pm 6.75\mu g/m^3$ were found for PM_{10} and $PM_{2.5}$, respectively in outdoor. The average ratio between outdoor/indoor $PM_{2.5}$ was 1.07 ± 0.52 and outdoor/indoor PM_{10} was 2.13 ± 0.60. The total average concentrations of black carbon (BC) in $PM_{2.5}$ were $10.2\pm5.14\mu g/m^3$ and $18.1\pm3.50\mu g/m^3$ for indoor and outdoor, respectively. The average ratio of outdoor/indoor BC in $PM_{2.5}$ was 2.09 ± 0.99. The total average $PM_{2.5}$ mass concentration was about 2.16 times lower than the standard value of Bangladesh National Ambient Air Quality Standards (BNAAQS) and about 1.2 times higher than the standard value of WHO. The total average PM_{10} mass concentration was about 3.16 times lower than the standard value of BNAAQS and about 1.05 times lower than the standard value of WHO. The 24h average concentrations of NOx, O_3 and SO_2 were $16.6\pm1.02\mu g/m^3$, $0.85\pm0.15\mu g/m^3$ and $0.49\pm0.35\mu g/m^3$ at National Museum of Science & Technology (NMST), Dhaka. The 24h average concentration of SO_2 is lower than the standard value of BNAAQS and WHO standard. NO_x and O_3 concentrations could not be compared with BNAAQS due to lack of 24h average data.

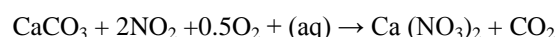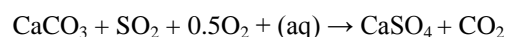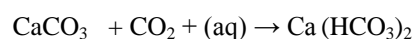*Keywords:* PM_{10}, $PM_{2.5,}$ SO_2, NO_x, O_3

1. Introduction

The problems due to air pollution in Bangladesh have been enhanced alarmingly due to the increasing population explosion, industrialization, urbanization, automobiles and other human activities [1]. A variety of air pollutants has been known for harmful effects on human health and the environment. Air pollution is a major environmental factor related to health problem affecting the developing and the developed countries alike. It not only deteriorates the ambient air in the cities but also the indoor air in the rural and urban areas and has been a great concern. In fact, in the developing world the highest air pollution exposures occur in the indoor environment [2].
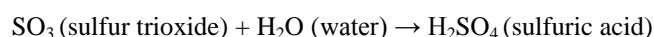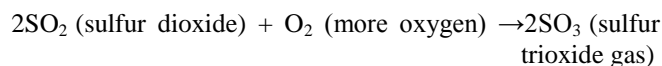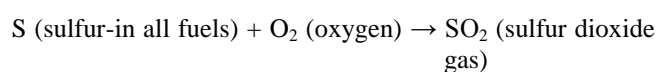
Most museums, galleries, libraries and archives, as well as many historical palaces and houses, are located in urban centers, surrounded by a complex and changeable urban atmosphere. While the last twenty years have seen a great reduction in the emissions of the pollutants that have been typically considered more harmful for vulnerable heritage materials, scientific interest is shifting towards other pollutants and particulate matter (PM) that has been a subject of great interest [3-8]. The art in museums is strictly affected by physical and chemical conditions, i.e. relative humidity, temperature, illumination, noise, vibration and atmospheric pollutants concentrations. Relative humidity fluctuation can cause the deterioration of various kinds of materials, for example sculptures, paintings, bronze-made objects, books etc. The absorption or release of moisture can determine material deformation with the appearance of cracks and breaks [9]. It is now well known that chemical composition of indoor and outdoor air can damage the state of exhibits stored in museum [10, 11] and also books of library, particularly, atmospheric pollutants can play an important role in the deterioration of art and books. Many

substances induce chemical reactions on exhibits and, for this reason; these are considered pollutants for museums. Substances typically considered pollutants for cultural heritage are: sulphur dioxide (SO_2), nitrogen oxides (NO_2), ozone (O_3) and particulate matter (mainly $PM_{2.5}$ and PM_{10}).

Stone cultural properties, particularly buildings and statues made of marble, limestone, tuff and sandstone, are greatly affected by acid rain and atmospheric pollution which dissolves the surface of the stone object, whereby decimating its value and in many cases can even cause the destruction of the object itself. The effects of some air pollutants, carbon dioxide (CO_2), sulfur dioxide (SO_2) and nitrous oxide (NO_2) on marble stone ($CaCO_3$) can be shown by the following chemical reactions:

$$CaCO_3 + CO_2 + (aq) \rightarrow Ca(HCO_3)_2$$
$$CaCO_3 + SO_2 + 0.5O_2 + (aq) \rightarrow CaSO_4 + CO_2$$
$$CaCO_3 + 2NO_2 + 0.5O_2 + (aq) \rightarrow Ca(NO_3)_2 + CO_2$$

Besides, sulfur dioxide and ozone have adverse effects on cellulose materials of libraries. The most familiar effect in libraries is brown color and brittle edges of books caused by sulfur dioxide. The reactions of SO_2 are shown below.

$$S \text{ (sulfur-in all fuels)} + O_2 \text{ (oxygen)} \rightarrow SO_2 \text{ (sulfur dioxide gas)}$$

$$2SO_2 \text{ (sulfur dioxide)} + O_2 \text{ (more oxygen)} \rightarrow 2SO_3 \text{ (sulfur trioxide gas)}$$

$$SO_3 \text{ (sulfur trioxide)} + H_2O \text{ (water)} \rightarrow H_2SO_4 \text{ (sulfuric acid)}$$

Ozone acts on unsaturated organic compounds by breaking every carbon double bond with which it comes into contact. By being a powerful oxidant, ozone can destroy paintings, textiles, archival materials, furniture, biological specimens, leather, fur, feathers, made wholly or predominantly of organic materials and therefore, ozone is extremely dangerous in the museum. The ozone formation in the

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