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Feasibility study on Low Cost Method for analysis of Sulphur Dioxide in Ambient Air

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ABSTRACT

Many advance colorimetric analytical techniques or methods are available to estimate/determine environmental pollutants like selenium, vanadium, thallium, iodine, sulphur dioxide, pentachlorophenol, carbon tetrachloride, mercury. Many researchers opined to make use of automatic or continuous air monitoring station. Central Pollution Control Board established many CAAQMS in all over India, but for operation of these stations is generally required skilled persons as well as a huge amount is required to install CAAQMS. According to CPCB the installation of CAAQMS approximately 1.1 crore rupees and 8 lakh rupees for operation and maintenance annually was met. Low cost method for estimation of sulphur dioxide (SO_2) is being used right now in manual monitoring stations in India. The study applies the feasibility of the alternative low cost method; Rhodamine-B has been used as a simple and sensitive colorimetric reagent for the estimation of sulphur dioxide. The results have significantly indicated that the use of NCS method for the alternative to TCM method could able to save around 3.54 crores rupees per year from proposed 1352 manual Air monitoring stations in India.

Introduction

Air quality surrounding human has a direct impact on health and property. The health effects of air pollutants are classified as short term effects and long term effects. Elderly people and children are often suffering more from the air pollution. The harmful effect of air pollution depends on the concentration of pollutants and duration of exposure (Georgii, 1969). The atmosphere has several self-cleaning mechanisms of dispersion, flocculation, absorption, agglomeration, gravity settling, rain wash etc. Today air pollutants are emitting at higher rate than the self-cleansing and they started to accumulate. So control of air pollutants at source is a more desirable and effective method through preventive or control technologies (Air quality report, 1975). The effective pollution control management is achieved through a control of Pollution and having very minimum cost for a long run investment, when compared to the costs arising from irreparable damage to the environment and to human and animal lives in the long run (Vyasulu, 1989). The careful planned institutional response must emanate from the government and the weakness of environmental management in India lies both with the institutional set up and the people (Jain and Sharma, 1989).

As such, many ways to measure air pollution, both simple chemical and physical methods and with more sophisticated electronic techniques. There are four main methods of measuring air pollution.

Passive sampling methods

Provide reliable, cost-effective air quality analysis, which gives a good indication of average pollution concentrations over a period of weeks or months. Passive samplers are so-called because the device does not involve any pumping. Instead the flow of air is controlled by a physical process, such as diffusion.

Active sampling methods

Use physical or chemical methods to collect polluted air, and analysis is carried out later in the laboratory. Typically, a known volume of air is pumped through a collector (such as a filter, or a chemical solution) for a known period of time. The collector is later removed for analysis. Samples can be collected daily, providing measurements for short time periods, but at a lower cost than automatic monitoring methods.

Automatic methods

Produce high-resolution measurements of hourly pollutant concentrations or better, at a single point. Pollutants analysed include ozone, nitrogen oxides, sulphur dioxide, carbon monoxide and particulates. The samples are analysed using a variety of methods including spectroscopy and gas. The sample, once analysed is downloaded in real-time, providing very accurate information.

Remote optical / long path-analysers

Use spectroscopic techniques make real-time measurements of the concentrations of a range of pollutants including nitrogen dioxide and sulphur dioxide.

During the past few decades the development of science and technology has brought sensitive and accurate method for the monitoring and analysis of air pollutants. Various sophisticated instrumental techniques like AAS, Anodic stripping Voltammetry, Chemiluminescence, Emission Spectrophotometry, GC, HPLC-MS, IR, NMR, UV-VIS Spectrophotometry, Neutron activation analysis and X-rays fluorescence are available in major laboratories for the analysis of various air pollutants even at the ppb levels.

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These instrumental techniques require high maintenance and well trained staff to operate in addition to initial cost. These techniques may not suit common research and chemical laboratories in a developing country like India having limited resources. The technique such as spectrophotometry and colorimetry has their significance in India due to their simplicity, low cost, selectivity, sensitivity and easy adaptability. In this technique colour reaction of the component in question with a chromogenic reagent and the intensities of the colour system which obeys Beer's and Lambert law is measured at the wavelength of maximum absorption.

In present work Rhodamine-B has been used as a simple and sensitive colorimetric reagent for the estimation of sulphur dioxide present in an air sample. Sulphur dioxide is passed through the absorbing solution of aqueous potassium iodate and N-Chlorosuccinimide (Manahan, 1983).

Material and Methods

The two sampling stations were selected randomly for the analysis of sulphur dioxide in ambient air and details of sampling stations are as follows

Sampling Point 1

Udupi garden Bus Stop, BTM Layout, 2nd stage, Bangalore, lies between latitudinal $12^0$54'29.66"N and longitudinal $77^0$36'26.6724"E.The 1st Stage of BTM Layout is separated from the 2nd Stage by the Outer ring road. BTM Layout is noted for its cafés, boutiques, and music venues. Its proximity to student residences and the young working people and the variety of restaurants make it a popular venue as an alternative to the city centre.

(Source –Google Map)

Sampling Point 2

Department of Environmental Science, Bangalore University, Jnana Bharathi campus, Bangalore, lies between latitudinal $12^0$56'47.1696"N and longitudinal $77^0$30"3.6936"E. Bangalore University located in South West of Bangalore.

(Source –Google Map)

Air sampling technique

Sampling Point 1 at BTM layout is the area which is come under residential area, samples was taken in period of 30 April to 2 May 2016.

The air samples were collected from standard handy air sampler (APM 820). The air samples were collected with a rate of 1 litre/minute for 30 minutes using rotameter handy sampler to control flow. The absorption reagent was shielded to prevent the entry of direct sunlight during and after sampling to prevent deterioration (CPCB 2011).

Analytical method

Both NCS and TCM methods were used to estimate the SO_2 for the comparison of accuracy of the results.

Method1. The Sulphur Dioxide present in ambient air was estimated by NCS method by absorbing solution of Rhodamine –B, 6M Hydrochloric acid, Standard Sodium sulphite solution by as per standard method prescribed.

Method 2. The Sulphur Dioxide present in air was also measured by TCM method spectrophotometrically with absorbing solution of Pararosaniline Hydrochloride, Acid bleached, Formaldehyde (0.2%), Sulphamic acid. The quantum of sulphur dioxide was estimated as per following formula.

$$C\ (SO_2\ \mu g/m^3) = \frac{(A - Ao) \times 10^3 \times B}{V_2 \times V}$$

Where:

A - Sample absorbance

A_0 - Reagent blank absorbance

10^3 - Conversion litres to cubic meters

B - Calibration factor, µg/absorbance

V - Volume of air sampled in liters

V_2. Volume of absorbing solution

The study is on the bases on the secondary data for present Indian manual Air monitoring stations used Tetrachloro mercurate (TCM) Method (modified West and Gaeke) to estimate Sulphur dioxide (SO_2) in ambient air.

The cost analysis was applied for chemicals requirement during monitoring and analysis of Sulphur dioxide by TCM and NCS methods. The cost analysis was done by taking chemical price of Merck Millipore price list 2015-16 and price list of S.D.Fine Chem Limited 2015-16.

Results and Discussion

In sampling station at BTM layout, the concentrations of sulphur dioxide were observed in range between 1.71 and 1.99 µg /m^3. The SO_2 values vary as varying the population movement. The maximum value of SO_2 was noticed during 1300 Hours to 1500 Hours and evening 1700 Hours to 1900 Hours (Fig 1).

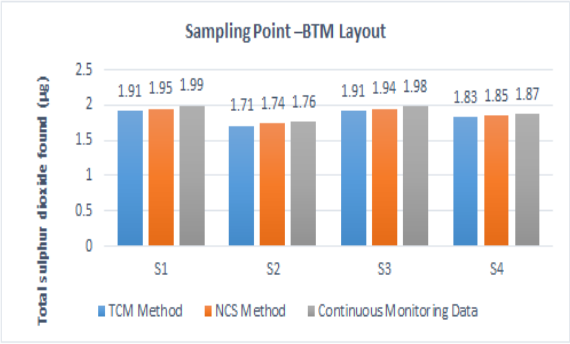

Fig 1. The analytical results of SO_2 at BTM Layout

Correlation applied for the values of SO_2 obtained from NCS and TCM method sample collected at BTM Layout sampling station and the strong correlation of 0.9938 was noticed which indicated that the accuracy of NCS low cost method is highly significant (Fig 2).

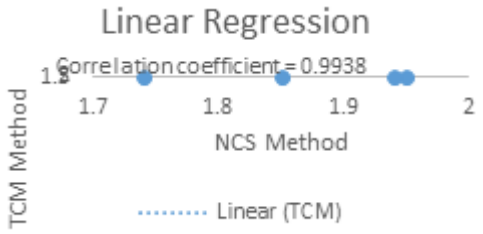

Fig 2. Correlation between NCS and TCM method at BTM Layout Sampling station

The values of SO_2 obtained NCS and Continuous Monitoring methods were also applied for correlation analysis which also confirmed that a significant in the accuracy of the NCS low cost method (Fig 3).

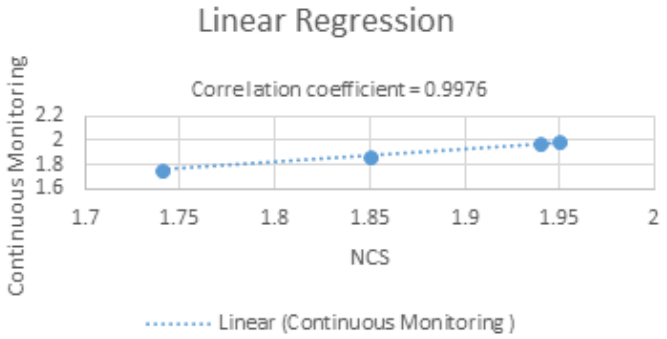

Fig 3. Correlation between NCS and Continuous Monitoring Method at BTM Layout sampling station.

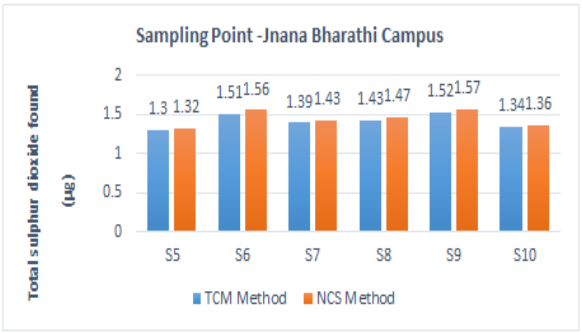

Fig 4. The analytical results of SO_2 at Jnana Bharathi Campus.

In the sampling station at Department of Environmental Science, Bangalore University, Jnana Bharathi Campus, a total six samples were taken and as per TCM method values of sulphur dioxide found in the range between 1.30 to 1.52µg /m^3. Whereas values of sulphur dioxide found in the range between 1.32 to 1.57µg/m^3 were observed as per NCS method (Fig 3). The strong correlation of 0.9951 was noticed for SO_2 values obtained from NCS and TCM method which indicates a significant in accuracy of NCS low cost method results (Fig 4).

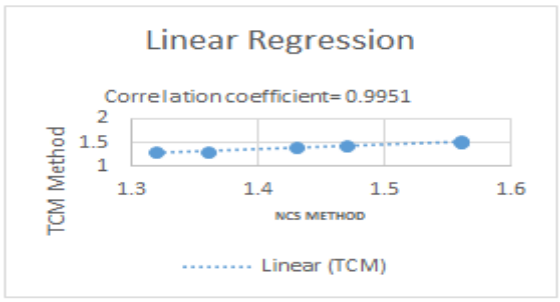

Fig 5. Correlation between NCS and TCM Method at Jnana Bharathi Campus sampling station.

Cost analysis

The cost analysis between low cost method and existing methods is also important as the accuracy of the results. The cost analysis was applied for the chemicals requirement during analysis of Sulphur dioxide by two low cost methods. The chemical price of Merck Millipore price list 2015-16 and price list of S.D.Fine Chem Limited 2015-16 were used for the cost analysis.

Cost analysis depicts that if NCS method adopt for the ambient Air Monitoring and analysis it saves around Rs. 1.38 Crore from 530 manual monitoring stations and approximately Rs. 3.54 Crore from the proposed 1352 manual monitoring stations in India (Fig 6,7,8).

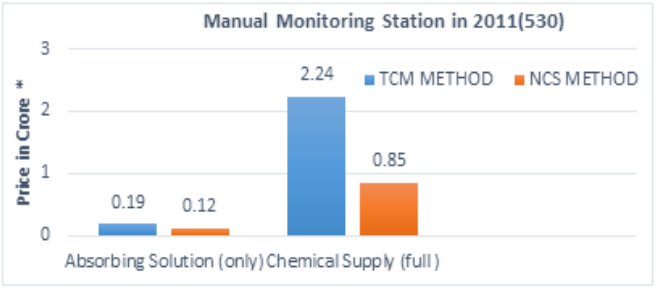

Fig 6. Cost analysis between NCS and TCM Methods.

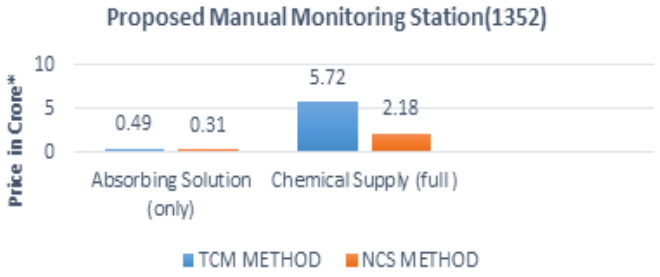

Fig 7. Cost analysis between NCS and TCM Methods.

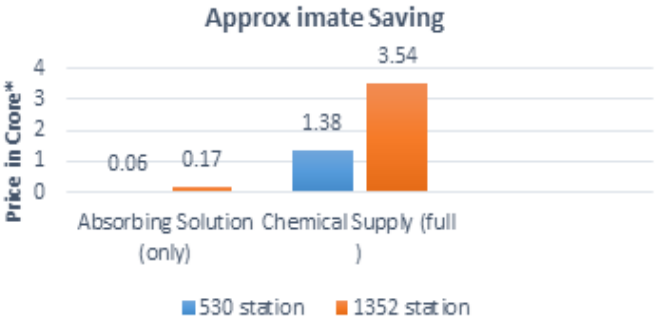

Fig 8. Comparison of Cost analysis between NCS and TCM Methods.

Conclusion

The compilation study with feasibility of accuracy of results and saving of cost by low cost NCS method compared to existing analytical technique of analysis of sulphur dioxide in ambient air. According to Chatterjee (2002) Rhodamine-B has been proposed as a simple and sensitive colorimetric reagent for the estimation of sulphur dioxide in air.

The study is on the basis of secondary data, currently in India manual monitoring station used Tetrachloro mercurate (TCM) Method (modified West and Gaeke) to estimate Sulphur dioxide (SO_2) in ambient air. The accuracy of results of SO_2 of NCS method was confirmed significantly with the method used by the Central Pollution Control. Cost analysis depicts that if NCS method is adopted for the ambient Air

Monitoring and analysis it could saves around Rs. 1.38 Crore from 530 manual Air monitoring stations and approximately Rs.3.54 Crore from the proposed 1352 manual Air monitoring stations in India.

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