Development of Remote Operated, Low Flow Rate, Light Weight TSPM Sampler Suitable for Morphological Analysis using UAVs

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TITLE

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RESUME

Nous présentons un échantillonneur de particules TSPM (Total Suspended Particulate Matter) (TSPM) à débit très faible, compact, léger et télécommandé, qui convient tout à fait pour échantillonner les aérosols à des fins d'analyse morphologique et de mélange. L'échantillonneur développé est extrêmement utile pour les plates-formes UAV (Unmanned Aircraft Vehicle) embarquées où la limitation du poids de la charge utile est un problème majeur. L'instrument dispose de deux unités 1) Unité de contrôle 2) Unité d'échantillonnage. L'unité de commande sert à commander à distance l'échantillonneur équipé d'un échantillonneur à faible débit. Les communications n / b des unités sont effectuées en utilisant un émetteur et un récepteur à 433 MHz.
Les poids de l'unité de contrôle et de l'échantillonneur sont de 64 et 200 g, piles comprises. Le débit de l'échantillonneur a été maintenu à <1 ml / min. L'échantillonneur développé a été testé par rapport à son fonctionnement à distance et à son aptitude à des études de morphologie et d'états de mélange. L'opération à distance facilite la collecte de particules à un moment et à un endroit donnés (horizontal et vertical). Les particules recueillies à différentes échelles de temps ont été analysées à l'aide de SEM équipées d'EDS. EDS a été utilisé pour explorer la composition chimique élémentaire qui a montré que même les particules molles avaient une morphologie non perturbée. Pour une longue période de fonctionnement (~ 8 heures), les particules collectées sur le filtre en PTFE peuvent également fournir des informations sur la concentration gravimétrique en masse (µg / m3).
L'échantillonneur TSPM a été développé avec des capacités de fonctionnement à distance. Il fonctionne avec des piles légères et à faible débit (fonctionne avec des piles rechargeables à courant continu). Les micrographies de particules individuelles révèlent des morphologies non perturbées.

ABSTRACT

We present a very low flow rate, compact, lightweight and remote operated TSPM (Total Suspended Particulate Matter) particulate sampler which is quite suitable for sampling the aerosols for morphological and mixing state analysis. The developed sampler is extremely useful for on-board UAV (Unmanned Aircraft Vehicle) platforms where payload weight limitation is a big issue. The instrument has two units 1) Control unit 2) Sampler unit. Control unit is for remote controlling the sampler unit which is equipped with the low flow rate sampler. Communications b/w the units are made using transmitter and receiver at 433 MHz.
The weights of the control unit and the sampler unit are 64 and 200 gm, respectively including their batteries. The sampler flow rate has been kept to be <1 ml/min. The developed sampler has been tested against its remote operation and its suitability for morphology and mixing state studies. The remote operation helps in the collection of particles at given time and place (horizontal and vertical). The particles collected at different time scale of operations were analysed using SEM equipped with EDS. EDS was used to explore the elemental chemical composition which showed that even the soft particles have unperturbed morphologies. For long operation period (~8 hr), particles collected over the PTFE filter can also give gravimetric mass concentration (ug/m3) information.
A light weight, low flow rate, battery operated (works on small DC power rechargeable batteries) TSPM sampler has been developed with remote operation capabilities. The micrographs of individual particles reveal unperturbed morphologies.

MOTS-CLÉS :TSPM, morphologie, télécommande, UAV **KEYWORDS:** TSPM, morphology, remote control, UAV

1 INTRODUCTION

Suspended particulate matter (SPM) in air generally is a complex, multi-phase system of all airborne solid and low vapor pressure liquid particles having aerodynamic particle sizes from 0.01-100 µm and larger.[1,2,3] SPM measurement has concentrated on total suspended particulates (TSP), with no preference to size selection.[4,5]The increasing vehicular growth rate, frequent traffic jams and not much improvement in the number of roads has resulted in a significant rise in the TSPM (total suspended particulate matter) level of Delhi. However, although vehicles continue to be the biggest contributor to the Delhi's ambient TSPM level, significant contributions from other pollution sources, such as roadside dust, industries, trans-boundary

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migrations, power plants, solid waste and local sources, have also been observed.[6,7] The samplers are commonly used to collect the airborne particulate component of the atmosphere. A variety of options available for the sampler provides broad versatility and allows the user to develop information about the size and quantity of airborne particulate material and, using subsequent analytical techniques, information about the physico-chemical properties of the particulate matter can be obtained. Several methods are available for measuring SPM in ambient air.[8,9] The most commonly used devices are APM800 envirotech personal sampler, small programmable pocket pump and automated low volume samplers, which consists essentially of pump and a filter, and which is usually operated to collect an 8-hrs sample. Air is drawn into the sampler and through a PTFE filter or quartz filter by means of a pump, so that particulate material collects on the filter surface. Airborne particulate matter retained on the filter may be examined or analyzed by a variety of methods (SEM-EDX, HRTEM, XRF etc.)

Each sampler has its own attributes, specificities, advantages, and disadvantages. Some samplers with less weight and other excellent features lags in flow rate requirements, especially having high volume flow rate. Contrary to this, some samplers with low volume flow rate are too heavy as well as not suitable for remote based operation. For better understanding of physicochemical properties such as morphology of particulate matter, the sampler should have low volume flow rate. As it is mentioned earlier that these aforesaid samplers lacks in other requirements. So, a light weight compact TSPM sampler was developed to study the particle's shape and size (morphological parameters) after impaction on tin substrate. This kind of sampler which is remote operated has all the certain features to be suited for airborne observations.

2 MATERIALS AND METHODS

2.1 Sampling details:

Atmospheric observations were conducted at CSIR-NPL, New Delhi (**28.6100° N, 77.2300° E**) which is a densely populated region with very high aerosol loading and poor air quality.

2.2 Instrumentation:

Remote monitoring system is used to collect the data wirelessly. This work mainly focuses on design of a wireless monitoring retrieval communication system that effectively communicates between transmitter and receiver.

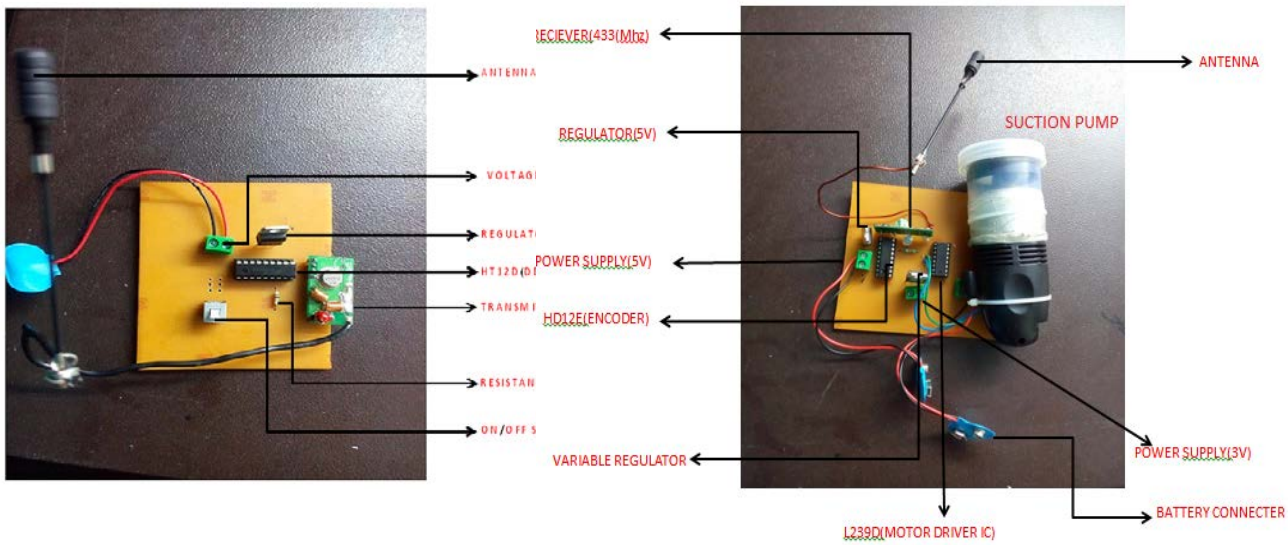

FIG 1: Circuit diagram of transmitting unit and Receiving unit

The above shown unit comprises of transmitter and receiver section. These sections contains Voltage regulator, variable regulator and L293D motor driver IC along with other components. L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. A 37 mm Teflon filter was used for the collection of TSPM during the process.

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2.3 Methods:

TSPM samples were analyzed by SEM-EDX at National Physical Laboratory, New Delhi. The SEM-EDX analysis was carried out with the help of scanning electron microscope SEM equipped with an energy dispersive X-ray system. The samples were placed in the corner of SEM-EDX chamber. The working conditions were set at an accelerating voltage of kV, a beam current of µA and a detector mm away from the samples to be analyzed. X-ray detection limit is ~0.5%. The resolution of the EDS system is capable of collecting spectrum from multiple points, lines across the interface and elemental mapping. The EDX analysis was carried out at each analysis point and the elements present were both qualitatively and quantitatively measured. The weight percentage of each element present in the spectrum was identified.

3 RESULTS AND DISCUSSION:

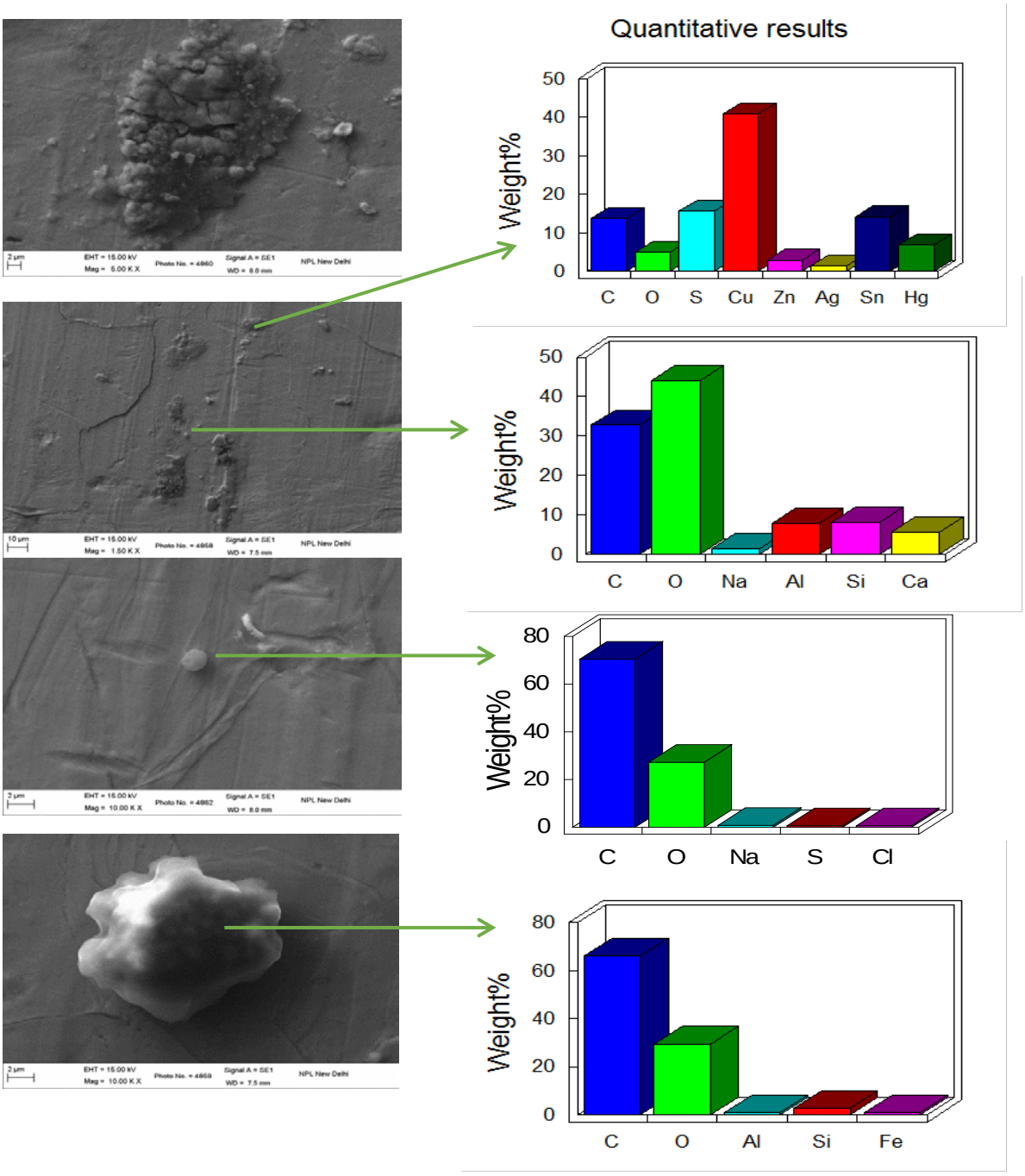

FIG 2: SEM-EDX Analysis of some of the representative samples (a) particle having size comparable to coarse mode (b) particle is flat, irregular in shape, and agglomerate showing signature of anthropogenic source (c) particle is partially spherical in shape (d) Potato shaped carbon rich particle.

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The above particles were collected by remote operated compact TSPM sampler and characterized by SEM-EDX facility at CSIR-NPL. Images shows that the sampler is collecting both coarse and fine particles as well as chemical composition of some of the particles have also been shown in figure.
Figure (a) shows particle having size comparable to coarse mode.
Figure (b) shows that the particle is flat, irregular in shape, agglomerate and having size of 10um, whereas the other particle in on the same picture shows signature of anthropogenic source with relatively high concentration of copper, carbon, sulfur, and mercury.
Figure (c) shows particle is partially spherical in shape. EDX confirms that it is alumino-silicate particle with relatively high amount of carbon.
Figure (d) shows Potato shaped carbon rich particle which shows signature of anthropogenic source.
The carbonaceous particles are the significant component of total ambient particle mass. In the present study, most of the particles analyzed are carbonaceous. The group of particles characterized by high X-ray intensity contains varying fraction of carbonaceous particulates.

4 REFERENCES

Khemanr, L.T. (1989). Physical and chemical characteristics of atmospheric aerosols in Air pollution control, Encyclopedia of Environmental Control Technologies, Co. P.N. Chermisions Gulf Publication, U.S.A.

Wilson, W.E., Suh, H.H. (1997). “Fine particles and coarse particles concentration relationship relevant to epidemiologic studies” Journal of Air and Waste Management Association, 47, 1238-1249.

APHA (1972). Intersociety Committee, Methods of Air Sampling Analysis, “A Public Health Association 11101-di-70-t, tentative, Method for analysis of SPM in the ambient air.

Method for Measurement of Air Pollution-SPM, IS-5182 (Part-IV) 1999.

NAPRAC REPORT (1962). The measurement of air pollution, National Air Pollution Research Council, Tokyo Cornastha, 360.

Srivastava, A. and Jain, V.K. (2005). A Study to Characterize the Influence of Outdoor TSPM and Associated Metals on the Indoor Environments in Delhi. J. Environ Sci Eng. 47: 222-231

Srivastava, A. and Jain, V.K. (2007b). A Study to Characterize the Suspended Particulate Matters in an Indoor Environment in Delhi, India. Build Environ. 42: 2046–2052.

Reference Method for the Determination of Suspended Particulates in the Atmospheric (High Volume Method)," *Federal Register,* Vol. 36(84), April 30, 1971.

Katz, M., (1977). Methods of Air Sampling and Analysis. 2nd Ed. APHA.

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