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Evaluation of Low Cost Particulate Matter Sensor for Indoor Air Quality Measurement

Jayakarthigeyan Prabakar[1], Vysakh Mohan[2], Karthik Ravisankar[3]

Carbon Associates Services Pvt. Ltd., Chennai, Tamil Nadu, India

ABSTRACT: Air pollution has become a major concern in metropolitan cities, especially due to the particulate matter with diameter of 2.5 micrometers or less (PM2.5). Our research focuses on evaluation of low cost particulate matter sensor PPD42NS with commercially available Dylos DC1100 Pro indoor particulate matter monitor. We did a comparative study and the results showed good agreement with a linear correlation of 0.818.

KEYWORDS: Air Quality, PM 2.5, Particulate Matter, Particle Counter, India, PPD42NS, Dylos

I. INTRODUCTION

Rising air pollution in developing countries like India has made ailments like asthma, allergy, recurrent cough and chronic obstructive pulmonary disease a part of life in metropolitan cities of India, especially due to the particulate matter with diameter of 2.5 micrometers or less (PM2.5). While quite a few air quality monitoring stations have been built by governments in a city's public areas, the indoor PM2.5 has not yet been monitored and dealt with effectively. Our research was focused on developing a low cost solution for indoor air quality monitoring.

Why Particulate Matter?

Particulate matter (PM) consists of a mixture of extremely small particles and liquid droplets, including acids, metals, organic chemicals, and soil/dust particles. Main sources of PM include dust, fuel combustion, and mobile emissions, these are all processes that affect the air we breathe. PM is commonly divided into two categories: fine particles and coarse particles. Fine particles have diameters less than or equal to 2.5 micrometers (denoted as PM2.5), while coarse particles have diameters between 2.5 micrometers and 10 micrometers (denoted as PM10). Particulate matter is one of the six common pollutants for which the EPA has National Ambient Air Quality Standards, since it can have significant negative health impacts. These impacts vary by particle size, with smaller particles permeating into different parts of the body. PM can enter the lungs and the bloodstream (to different extents depending on size), causing effects such as aggravated asthma and irregular heartbeats. The adverse health impacts of PM and its presence make it an essential pollutant to measure.

In this paper we introduce a low cost real time system to measure particulate matter using PPD42NS particulate matter sensor whose results are compared with measurements made by Dylos DC1100 Pro laser particle counter.

II. MATERIALS AND METHODS

We used DC1100 Pro manufactured by Dylos and PPD42NS from Shinyei. The exhaust air coming out from Dylos DC1100 Pro was introduced into low cost particle counter sensor PPD42NS which measures particles greater than 1 micron in size. A microcontroller was interfaced with PPD42NS and was programmed to convert the electrical signals produced by PPD42NS into particle counts per 0.01 cubic feet. The output data was displayed in terminal window on the laptop using serial communication interface. A data logging software was used to log the data. The measured output of both these devices is shown in experimental results.

How Dylos DC1100 Pro works?

The original Dylos unit consists of a few main components: a small computer fan, a laser beam that operates at 650 nm, a photo diode, a display screen, and a power source. The current Dylos design uses the computer fan to draw in air and particles, which are then passed through the focused laser beam which results in high signal to noise ratio. The Dylos

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draws a relatively large flow rate, which is made possible by the wide air path and low - pressure fan. The photo - diode is positioned so that scattered light can be captured from various angles. The Dylos does not incorporate any optics that are used in other optical particle monitors.

The DC1100 Pro is actually sensitive enough to detect individual particles. With this ability the DC1100 cannot only count the particles, but it can also size them based on the amount of light they scatter. For convenience sake, the DC1100 displays two particle counts – small and large. The large particle count includes pollens, dust mite debris, insect feces, coarse dust, etc. The small particle count includes most bacteria, mold, fine dust, etc. The small particle count can range from many thousands down to zero so the home owner can measure his air quality with vastly greater resolution than is possible with 5 green LEDs.

The Dylos model reports particle numbers in two size bins:
• 0.5 mm and greater, which is called as small particles
• 2.5 mm and greater, which is called as large particles

The particle sizes are differentiated by an algorithm that is performed based on the amount of scattered light. These values are then displayed on the Dylos in the form of two values.

How Shinyei PPD42NS works?
The Shinyei PPD42NS sensor has a partially enclosed chamber with a single light - emitting diode, a plastic lens, and an optical receiver at a forward angle of approximately 45°. A removable cap makes it possible to swab residue off the lens. Air is drawn through the sensing volume by means of a convection current established by a small 0.25W resistor. The resulting absence of noise from fans or pumps is an attractive feature for possible applications in household settings, but the convective mechanism makes the airflow sensitive to orientation. The flow rate and maximum size of lofted particles are not specified. Signals resulting from the detection of scattered light are passed through filtering and amplification circuitry that are externally visible on the PPD42NS, resulting in 0–5 V pulses of approximately 10–100 ms in length. Documentation posted online by the manufacturer indicates that the 30 s integrated duty cycle of this PWM signal increases monotonically with “cigarette smoke”, with a zero intercept and a slightly sub-linear response at higher concentrations (Shinyei Corp, 2010). The manufacturer has also provided the relationship of 30 s integrated duty cycle is expressed as percent full scale (% FS) with total number of particles greater than 1 micron per 0.01 cu feet. We have considered the number of particles which are greater than 1 micron per 0.01 cu feet as the measuring scale for comparing the output with Dylos.

Monitoring:
Both monitoring devices were placed in a typical air conditioned office environment, where the particulate matter was measured for 3 days.

(a) (b) (c) (d)

Fig. 1. (a)PPD42NS Sensor, (b)Dylos DC1100 Pro, (c)Test Setup in office environment, (d)PPD42NS interfaced with microcontroller placed behind the Dylos particle counter

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III. EXPERIMENTAL RESULTS

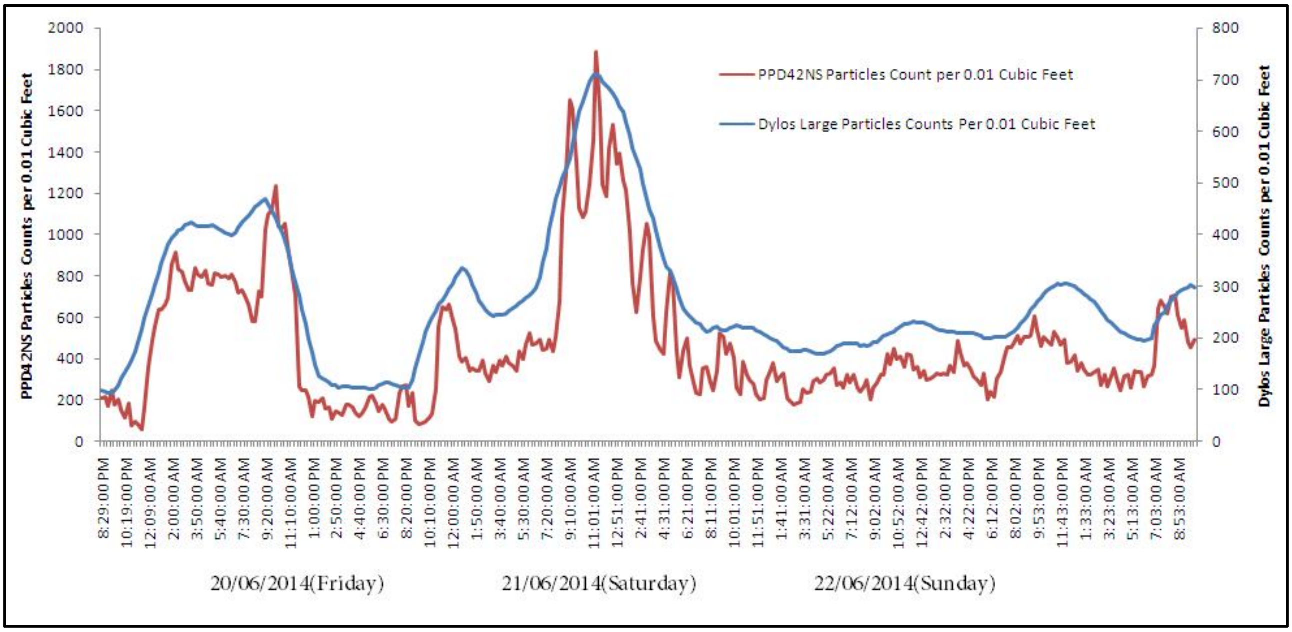

Fig. 2.(a).: Diurnal trend of Particle Counts measured using Dylos DC1100 Pro and PPD42NS Sensor

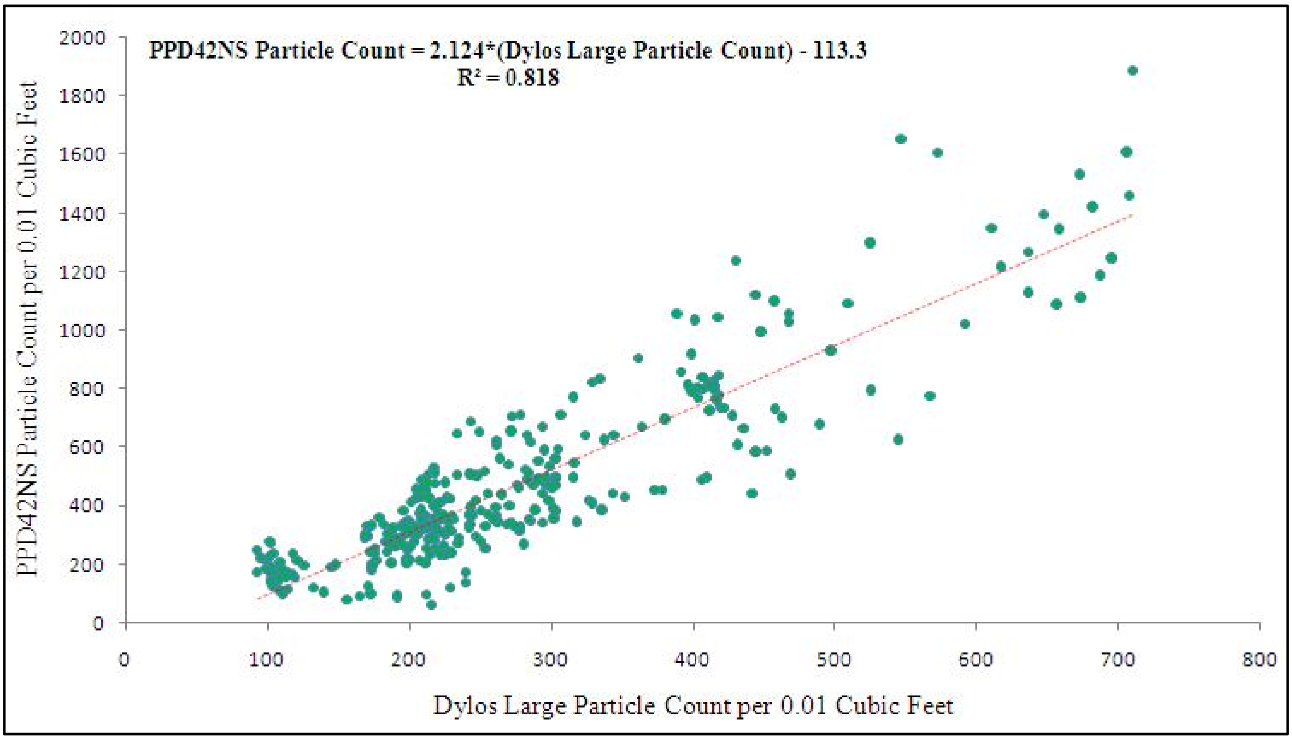

Fig. 2.(b).: Linear correlation between Particle Counts measured using Dylos DC1100 Pro and PPD42NS Sensor

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Day to day variation of particulate matter was observed (Fig. 2. (a)). Shinyei's PPD42NS data agreed well with the large particles data obtained using Dylos DC1100 Pro. A good correlation was found with $R^2 = 0.818$ (Fig. 2(b)).

Particulate Matter level was found to be minimum during working hours and maximum during non - working hours. This may be due to continuous operation of air conditioning system during working hours. The particulate matter filters present inside the air conditioning system might have reduced the circulation of particulate matter inside the office environment.

IV. CONCLUSION

We developed a low cost particulate matter monitoring system using Shinyei's PPD42NS sensor. A good correlation was found between particulate matter measurements made by Dylos DC1100 Pro and the low cost monitoring system developed by us. Air conditioning systems helped to reduce particulate matter and it played an important role in controlling the level of particulate matter circulation in indoor environment. As future work, we aim to develop a web based platform which continuously monitor particulate matter across India using our low cost system. This will help citizens to have a better understanding of the air quality around them.

REFERENCES

1. Brown, L.M., Collings, N., Harrison, R.M., Maynard, A.D. and Maynard, R.L. (2000). Ultrafine Particles in the Atmosphere, Imperial College Press, London
2. Johnson, M., Lam, N., Brant, S., Gray, C. and Pennise, D. (2011). Modeling Indoor Air Pollution from Cookstove Emissions in Developing Countries Using a Monte Carlo Single-box Model. Atmos. Environ. 45: 3237–3243
3. Smith, K.R. Indoor air pollution implicated in alarming health problems. In: Indoor Air Pollution – Energy and Health for the Poor. Newsletter published by World Bank, p.1, 2000
4. Smith, K.R. Indoor air quality and the population transition. In: Indoor Air Quality. Ed. H. Kasuga. Springer Verlag, Berlin, p.448, 1990
5. Balakrishnan K, Sankar S, Parikh J, Padmavathi R, Srividya K, Venugopal V, et al. Daily average exposures to respirable particulate matter from combustion of biomass fuels in rural households of southern India. Environ Health Perspect. 2002;110:1069–75
6. Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: A major environmental and public health challenge. Bull World Health Organ. 2000;78:1078–92