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SPATIAL AND TEMPORAL QUANTIFICATION OF PARTICULATE MATTER (PM_{10}) AND ASSOCIATED HEAVY METALS IN URBAN ENVIRONMENT OF DELHI

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ABSTRACT

Atmospheric concentrations of PM_{10} and associated heavy metals were quantified to study the air pollution load of two distinct location of Delhi viz. (1) Agricultural farms of Indian Agricultural Research Institute (IARI) and (2) Yamuna flood plains (YFP). The air sampling has been done for two consecutive years in winter season, comprising the months from November to April in 2020-21 and 2021-22 respectively. The glass fiber filter paper was used for the particulate matter deposition in high volume sampler. The monthly average concentration of PM_{10} varies from 112µg/m³ to 187µg/m³ at IARI and 205 µg/m³ to 364 µg/m³ at YFP. The highest concentration of PM_{10} was recorded in the month of January. The concentration of PM_{10} and associated heavy metals were significantly higher at the YFP area. The heavy metal concentration load was 18% and 27% more in the YFP in comparison to the IARI farms in the year 2020-21 and 2021-22 respectively. The higher concentration of heavy metals recorded at YFP because of its location which is cross section of roads having very heavy traffic throughout 24 hrs. and a thermal power plant nearby. The heavy metals concentration trend at each location was in the order of Zn > Fe>Pb>Ni>Cd. The concentration of Pb, Ni, and Cd was significantly less at IARI in comparison to YFP.

KEY WORDS : Air pollution, PM_{10}, Heavy metals, IARI, Yamuna flood plains, Delhi

INTRODUCTION

The issue of air pollution is widely recognized as one of the most critical environmental health risks of our era. Extensive research has shed light on the alarming fact that a staggering 90% of the global population is exposed to unhealthy air quality conditions (Wambebe and Duan, 2020). Particulate matter, known as PM_{10} and $PM_{2.5}$, stands as a prominent risk element contributing to early mortality and morbidity on a global scale. The impact of outdoor air pollution, encompassing ambient particulate matter, was quantified in a Global Burden of Disease Study, which revealed an alarming estimate of 6·67 million premature deaths attributable to this issue (Murray *et al.,* 2019). Combustion of fossil fuels have been identified as major contributors to the problem of air pollution (Malav and Kumar, 2022). Particulate matter (PM) comprises a combination of liquid droplets and solid particles, characterized by diameters smaller than 2.5 µm (referred to as $PM_{2.5}$, or fine particles) and between 2.5 and 10 µm (known as PM_{10}, or coarse particles). Motor vehicles, residential wood burning, bush burning, grinding operations, and certain industrial processes are the other sources of particulate matter pollution (Malav and Khan, 2017). Particulate matter associated heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr) and lead (Pb) contributed at the average 1.37 % concentrations of total particulate matter concentrations Zhang *et al.,* (2023) reported Pb and As, were the most abundant HMs found in atmospheric PM. Heavy metals are chemical elements naturally found on earth. However, human activities have altered their biogeochemical cycles, allowing their accumulation at locations where they exert a deleterious effect on organisms. As per report the dust contributes about 30 to 40 percent of Delhi's PM mass (Tripathi *et al.,* 2019). The dust particles that build up on foliar surfaces have an impact on plants growth and development. According to Chaudhary *et al.*, (2022) the deposition rate, particulate size, and chemical makeup of dust particles have adverse effect on plants. In the various composition factor of particulate matter, HMs are predominant one getting more attention due to their toxic effect on plant and humane (Chaudhary *et al.*, 2021). As per the World air quality report (2022). Delhi is in among the most polluted city of the world, therefore to assess the spatial and temporal variability of PM_{10} and associated HMs pollution has taken place.

MATERIALS AND METHODS

Sampling site

The research was carried out in Delhi, the capital of India. The study focused on two distinct agricultural regions within the city. Delhi experiences a semi-arid climate with distinct seasons: summer (March to May), monsoon (June to August), post-monsoon (September to November), and winter (December to February). On an average, Delhi receives around 700 mm of rainfall annually. Throughout the course of two years winter season, from November to April 2020-21 and 2021-22, ambient sampling was done at two distinct agricultural site of Delhi (1) IARI, New Delhi (28.63°N,77.16°E) and (2) YFP, Delhi (28.61°N,77.27° E). The air sampling was done four times in a month at each location throughout the season.

Ambient air sampling

PM_{10} were collected at both the sites IARI and YFP near Akshardham temple using Respirable Dust Samplers (RDS) (Model: APM460 BL Envirotech). The RDS sampling was done as per standard procedure to keep RDS at a height of 2 m above the ground level. As per the standard protocol samplers were sterilized with Isopropanol before each sampling and were operated 4 times in a month for 8 hour. PM_{10} samplers were operated at flow rate of 1.13 m^3 min^{-1}. PM_{10} were collected on pre-weighted glass fiber filters of size 20.3×25.4 cm^2. Quantification of the PM was done using gravimetric method (Watson *et al.*, 2017) and was stored in deep freezer at –20 °C. The concentration of PM was then determined by dividing the weight difference of the filters (before and after sampling), with volume of the air passes through the sampled filters. The mass concentrations of PM_{10} were calculated and expressed as microgram per cubic meter of air (μg m^{-3}).

Estimation of Metal concentration in PM_{10}

For estimation of HMs, Particulate matter deposited

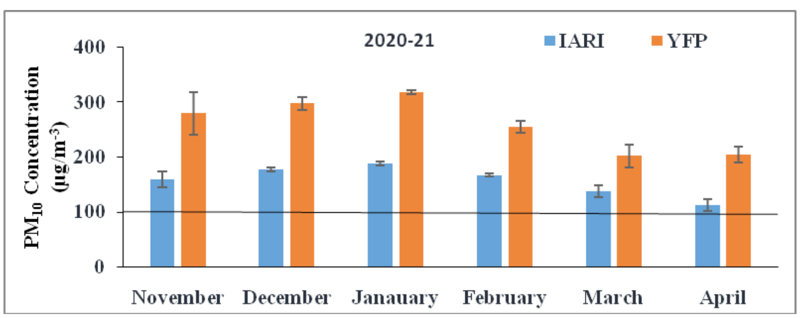

Fig. 1. Ambient air PM_{10} concentration at the both sit in 2020-21

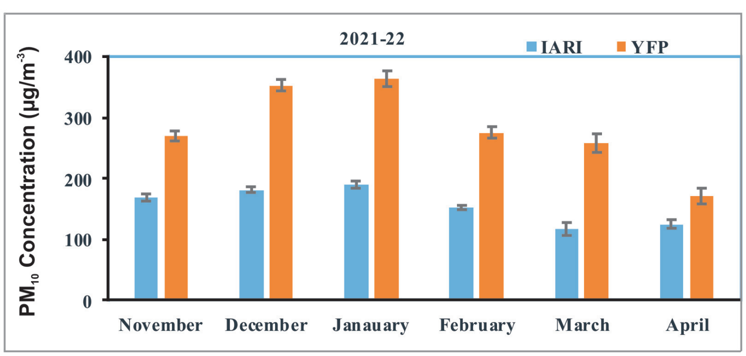

Fig. 2. Ambient air PM_{10} concentration at both site in 2021-22

glass fiber filter paper was cut in a 2 cm^2 pieces using stainless steel scissors. One piece that glass fiber filter weighed by using a microbalance. Next, the samples were extracted in a solution of 2% HNO_3 (25 ml concentration) using an ultrasonic device for 30 minutes. The resulting extract was filtered three times using Whatman filter paper (42 mm) and stored in glass bottles in a refrigerator until analysis. Heavy metal quantification was performed using AAS (Model – AA 7000, SHIMADZU) following the method described by Lindsay and Norvell (1978).

RESULTS AND DISCUSSION

Monthly Average concentration of particulate matter (PM_{10})

It is observed in the result that the PM_{10} concentration were fluctuating over the study period. Fig. 1 shows the monthly average concentration of 2020-21. The concentration of PM_{10} shows the significant changes during monitoring period. PM_{10} concentration was higher at the YFP area in comparision to IARI field in both the years. April had the lowest concentration of PM, i.e. 112 μg/m^3 and 205 μg/m^3 at IARI and YFP respectively. Month of January had highest concentration of PM which is 187 μg/m^3 and 317 μg/m^3 at IARI and YFP respectively. Fig. 2 shows the average monthly concentration of PM_{10} in 2021-22. Throughout the study period particulate matter concentration was higher than the national ambient air quality standard for 24 hour which is 100 μg/m^3. The January month had the highest concentration 190 μg/m^3 in IARI and 364 μg/m^3 at YFP. In the month of April PM_{10} concentration was 125 μg/m^3 in IARI and 190 μg/m^3 at YFP due to high wind speed which leads to higher dispersion of particulate matter as reported by Trivedi *et al.*, (2014); and Tian *et al.*, (2021).

Monthly Variation of Particulate matter (PM_{10}) associated heavy metals concentration

PM_{10} associated HMs have significant correlation with the PM_{10} concentration of atmosphere. Figure 3 shows the monthly variation of associated HMs. Concentration of HMs was higher in the January. The average monthly concentration varies from 0.002μg/m^3 to 5.40 μg/m^3. Zn was the most predominant HMs throughout the study period. Cd has been found in lowest amount. At the YFP Site

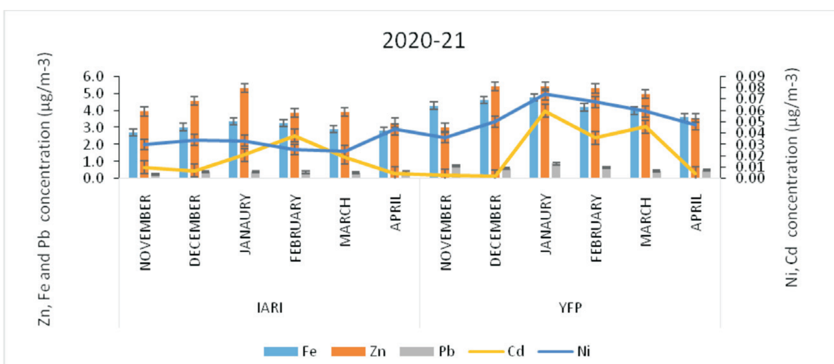

Fig. 3. PM_{10} associated heavy metals concentration at both site in the year of 2020-21

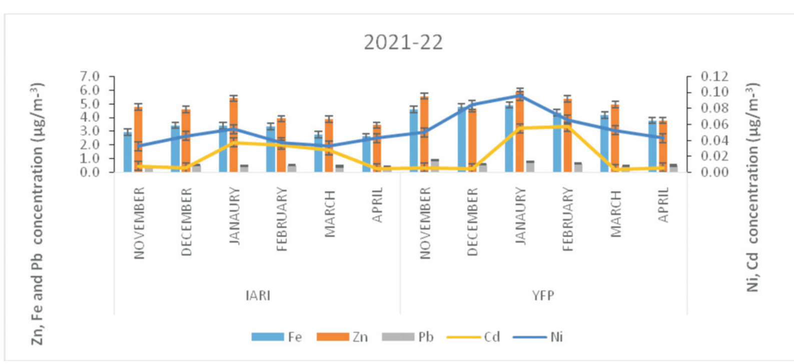

Fig. 4. PM_{10} associated heavy metals concentration at both site in the year of 2021-22

concentration of HMs were higher than the IARI field due to intersection of road and proximity with the thermal power plant. Cd and Ni concentration was much higher at YFP site compared to IARI throughout the monitoring period.

Figure 4 shows the HMs variation in the year of 2021-22. Concentration of HMs were varies from 0.006 $\mu g/m^3$ to 5.89 $\mu g/m^3$. The Highest concentration of heavy metals were found in the month of January, But at the YFP site the heavy metals concentration was significantly higher than the IARI. The predominant metals were Zn at both the sites. The average concentration of heavy metals was 18% and 27% higher at YFP then the IARI in the year of 2020-21 and 2021-22 respectively (Fig. 4 & 5). HMs concentration at YFP site were higher due to heavy traffic pollution and thermal power plant located near the site. The significant levels of zinc (Zn) in the environment can likely be attributed to automotive sources, such as the presence of Zn in lubricating oils, the gradual degradation of vulcanized rubber tires, and the corrosion of galvanized vehicle components as discussed by Garg *et al*., (2000).

CONCLUSION

In comparison to the national ambient air quality standard of India (NAAQS), PM_{10} concentration were consistently higher at both sites of Delhi throughout the winter season. PM_{10} concentration were higher at the YFP location as compared to the IARI due to higher traffic volume and thermal power pollution load. The concentration of heavy metals associated with particulate matter was comparably higher at the YFP than IARI. The heavy metals were found at both locations in the following order: Zn > Fe > Pb > Ni > Cd. The concentration of Cd, Ni, Pb was significantly higher at YFP compared to IARI. The concentration of PM_{10} in the year 2020-21 was significantly less compared to year 2021-22 due to covid-19 restriction were employed in 2020-21.

REFERENCES

Chaudhary, P., Shakeel, A. Khan, A. Sardar Khan, and Nagar, R.D. 2022. Effect of air pollutants on physiological parameters and yield attributes of paddy and wheat crops in Faridabad region, India. *Journal of Applied and Natural Science.* 14 (1): 36-44.

Chaturvedi, R. K., Prasad, S., Rana, S., Obaidullah, S. M., Pandey, V. and Singh, H. 2013. Effect of dust load on the leaf attributes of the tree species growing along the roadside. *Environmental Monitoring and Assessment*. 185: 383-391.

Chaudhary, P., Shakeel A. Khan, A. Sardar Khan, Sandeep Kumar and Lal Chand Malav. 2021. Air pollution tolerance index of wheat and rice in the proximity of gas based power plant. *Journal of Experimental Biology and Agricultural Sciences.* 9 (6): 791-804.

Garg, B.D., Cadle, S.H., Mulawa, P.A., Groblicki, P.J., Laroo, C. and Parr, G.A. 2000. Brake-Wear Particulate Matter Emissions. *Environmental Science and Technology*. 34: 4463-4469

Lindsay, W.L. and Norvell, W. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal.* 42(3): 421-428.

Malav, L.C., Khan, S.A., Kumar, S., Gupta, N. and Chaudhary, P. 2017. Effect of air pollutants on growth and yield of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) crops around the coal based thermal power plant. *Int J Curr. Microbiol App Sci*. *6*(10): 3151-3165.

Malav, L.C., Kumar, S. and Islam, S. 2022. Assessing the environmental impact of air pollution on crops by monitoring air pollution tolerance index (APTI) and anticipated performance index (API). *Environ Sci Pollut Res.* 29 : 50427-50442.

Murray, C.J., Aravkin, A.Y. and Zheng P. 2019. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study. *Lancet*. 20 (3).

Rahman, M.R. 2023. River dynamics- a geospatial analysis of Jamuna (Brahmaputra) River in Bangladesh during 1973-2019 using Landsat satellite remote sensing data and GIS. *Environmental Monitoring and Assessment.* 195(1): 96.

Tian, Y., Zhang, L., Wang, Y., Song, J. and Sun, H. 2021. Temporal and Spatial Trends in Particulate Matter and the Responses to Meteorological Conditions and Environmental Management in Xi'an, China. *Atmosphere.* 12: 1112.

Tripathi, N., Hills, C.D., Singh, R.S. and Atkinson, C.J. 2019. Biomass waste utilisation in low-carbon products: harnessing a major potential resource. *NPJ Climate and Atmospheric Sci.* DOI 10.1038/S41612-019-0039-5.

Trivedi, D.K., Ali, K., Beig, G. 2014. Impact of meteorological parameters on the development of fine and coarse particles over Delhi. *Sci. Total Environ.* 478 (1): 175.

Van Zelm, R., Huijbregts, M. A., den Hollander, H. A., Van Jaarsveld, H. A., Sauter, F. J., Struijs, J. and Van de Meent, D. 2008. European characterization factors for human health damage of PM_{10} and ozone in life cycle impact assessment. *Atmospheric Environment.* 42(3): 441-453.

Wambebe, N.M. and Duan, X. 2020 Air quality levels and health risk assessment of particulate matters in Abuja municipal area, Nigeria. *Atmosphere.* 11: 817.

Watson, J.G., Tropp, R.J. and Kohl, S.D. 2017. Filter Processig and Gravimetric Analysis for Suspended Particulate Matter Samples. *Aerosol Sci Eng.* 1: 93-105.

WHO, World Health Organization, Factsheet on ambient air quality and health, WHO: Geneva, Switzerland, http://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health, 2022.

Zhang, K., Brook, R.D., Li, Y., Rajagopalan, S. and Kim, J.B. 2023. Air pollution, built environment, and early cardiovascular disease. *Circulation Research.* 132(12): 1707-1724.