Study introduces a "toxicity standard" of ultrafine aerosol (PM2.5) pollution over Kolkata megacity

A new study conducted in Kolkata shows that the toxicity value of PM2.5 experiences a sudden jump when the pollution reaches around 70 μg m^{-3}.

PM2.5, or particulate matter with a diameter of 2.5 micrometers or smaller, is a significant air pollutant posing serious health risks, including respiratory and cardiovascular problems, and is a key indicator of air quality.

The Government of India has taken several initiatives and policy measures to combat air pollution and the latest is the National Clean Air Program (NCAP) launched in 2019 by the MoEFCC. The programme is focused on the reduction of particulate matter by 40 % by 2026 with respect to 2017 through strategies and action plans for 131 non-attainment cities (not attaining the National Ambient Air Quality Standard of India) in India for different states. Kolkata has been identified as one of such cities in India.

Bose Institute, an autonomous research institute under Department of Science and Technology, Govt. of India which has been given the responsibility to act as the Nodal Institute to work towards the mitigation of air pollution over this city and also to act as a national knowledge partner under the NCAP, studied the toxicity of atmospheric aerosols over the atmosphere of Kolkata.

Prof. Abhijit Chatterjee and his former Ph.D students Dr. Abhinandan Ghosh and Dr. Monami Dutta also explored how the degree of the toxicity changes with the increase in total aerosol pollution load and have studied the oxidative potential (OP) of ultrafine aerosols (PM2.5) or the potential of forming the reactive oxygen species (ROS) that are introduced to the human lung cells via inhalation of particles. The enhanced presence of the reactive oxidative species makes the natural antioxidants of human cells incapable of counteracting, leading to oxidative stress in cells.

The team led by Prof Chatterjee has shown that there is a non-linear relationship between the PM2.5 pollution load and its toxicity (OP). Up to the PM2.5 pollution load of around 70 μg m^{-3}, the toxicity remains unchanged. With the increase in PM2.5, the OP values show a jump and sudden rise till the PM2.5 pollution reaches at around 130 μg m^{-3}. With the further increase in PM2.5 load exceeding 130 μg m^{-3}, OP values do not change much.

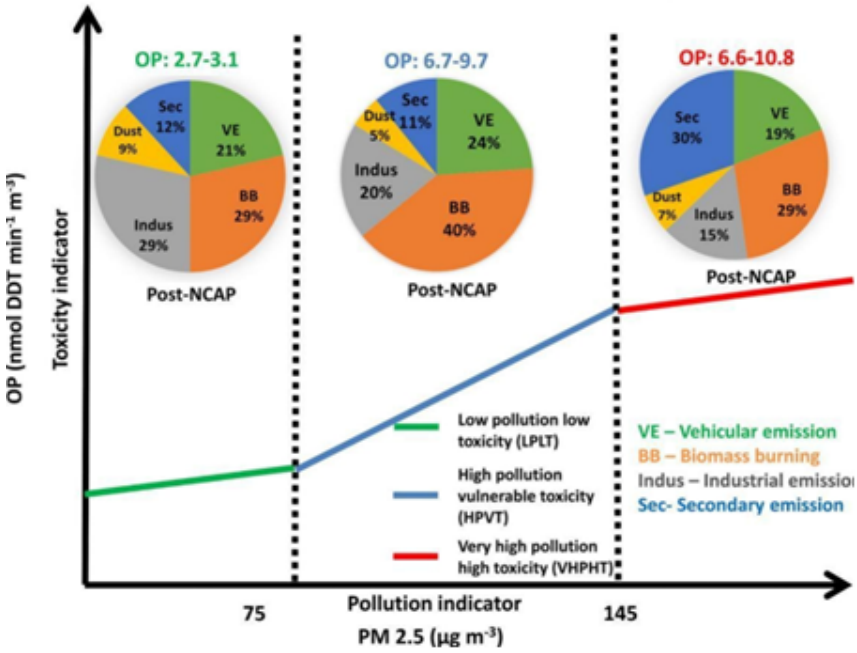

Fig: The relationship between PM2.5 and its oxidative potential over Kolkata and various sources involved for high pollution load and toxicity.

They have conducted source apportionment of PM2.5 with the help of a source-receptor statistical model (Positive Matrix Factorization) and revealed that biomass/solid waste burning is the key source of PM2.5 that is enhancing the toxicity of ultrafine aerosols over Kolkata.

They have also observed that while the National Clean Air Programme (NCAP) has been effective in reducing and curbing various air pollution sources like road-dust, constructional/demolition dust, vehicular exhaust, industrial emissions etc. However, biomass/solid waste burning could not be kept under good control. The particles emitted from this particular source are accelerating the toxicity.

The study has introduced a “toxicity standard” of PM 2.5 for this city and the value is around 70 µg m^{-3}. This implies that policies, strategies and control measures should be taken to keep PM2.5 pollution within this limit of around 70 µg m^{-3}, because once the PM2.5 load exceeds this value, the toxicity (OP) starts to increase rapidly and goes beyond control.

The study published in the journal *Science of The Total Environment* has helped urban local bodies in Kolkata to take action, carry out strict surveillance over biomass/waste burning as well as take stringent action. This has been reflected in the air quality of Kolkata in last winter (November 2024-February 2025).

Link to study: https://doi.org/10.1016/j.scitotenv.2024.176640

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