Removal of small particulate air pollutants through building surfaces

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Abstract— Usage of building envelop to catch and remove small particulate air pollutants of sizes ≤ 2.5 micrometers , chlorine etc. which are present in ionic forms along with very fine dust particles.

I. INTRODUCTION

Nine Indian cities have the dubious distinction of being in the top ten of the most polluted cities in the world in terms of atmospheric particulate matter concentration. Ambient air in most of our cities are no longer suitable for breathing in and respiratory diseases have risen sharply as a percentage of population in these cities. Identifying the source of pollution and cleaning up of the existing pollutants is a complex and multi variant problem. The situation is reaching an alarming proportion affecting the well being of the citizens and which in turn reducing the productivity of the general population and increasing the burden of caring for the sick. Numerous solutions are proposed and implemented to reduce the particulate matter in the air. Through this paper, we look at another probable solution to reduce the particulate matter around the immediate vicinity of a building.

II. SOURCES OF AIR POLLUTION

The atmospheric particulate matter (PM) consists of two types of pollutants among others 1.PM_{10} which are suspended particles having a diameter of less than 10 micrometers 2.$PM_{2.5}$ particles are having diameters of less than 2.5 micrometers. Typical sources of pollutants are [2] :

- Vehicle exhausts due to combustion of petrol and diesel fuels. The exhaust smoke quality depends on the combustion efficiency and quality of fuel
- Industrial emission from coal fired power plants and plastic industries
- Biomass smoke from cooking with wood and burning of crop wastage
- Dust from construction debris and from desert storms, pollen from flowering flora

A study conducted in Ontario, Canada concludes that there is evidence that the health damage from $PM_{2.5}$ pollution depends on the proportions of elemental or organic carbon and having elements with high oxidative potential (OP). [1]. $PM_{2.5}$ particles are considered extremely dangerous as these particles can embed inside deep tissues of the human body and act as a precursor to life threatening diseases. $PM_{2.5}$ composition : The $PM_{2.5}$ particles have a high concentration of trace metals like aluminum, carbon, ammonium , arsenic

TABLE I
COMMON AIR POLLUTANT SOURCES

Air Pollutants	Source of Emission
PM_{10}	Dust storms, coal power plants
$PM_{2.5}$	Vehicular exhausts, plastic industry
Nitrogen dioxide	Chemical industries
Carbon monoxide	Vehicular exhaust
Sulphur dioxide	Chemical industries
hydrocarbons	Biomass smoke, crop burning

III. THEORETICAL OBSERVATIONS [3]

It has been observed that computer or television screens having a very fine layer of dust grazing its surface though no dust is observed inside the room . For some reason, fine dust particles seemed to be attracted to the screen surfaces than to the other objects inside the room. Let's explore the scientific reason for this phenomena. Why does fine dust get attracted to charged screens like television or computer monitors ? Outer surfaces of screens become positively charged while displaying images . The atmospheric minute particles near to the screen tend to get polarized and align themselves towards the positive charged screen. As per the inverse square law, Intensity of force

$$F \propto \frac{1}{(\text{distance})^2}$$

which implies , more the distance is, less is the force. Since the net positive charges of the particle is at a larger distance than the net negative charges , the negative polarized area will get attracted to the positive screen surface.

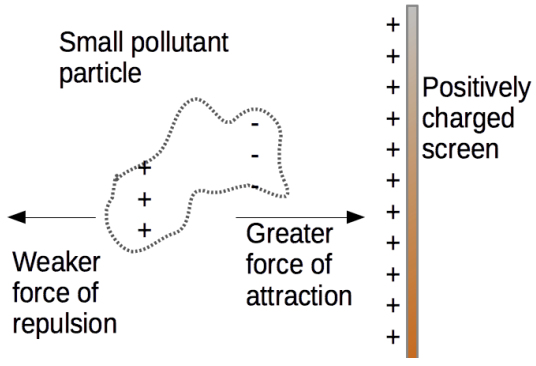

Fig. 1. Electrostatic alignment of particulate pollutant

As seen above , any charged surface can attract fine particles which can also include free floating cations (negatively charged ions) and anions (positively charged ions). Another way to charge a surface is to make the material dielectric. Dielectric materials are electrical insulators but on applying a charge , its atoms gets polarized to create a electrostatic field. We can extrapolate the same principle to any surface which can be charged.

IV. BUILDING SURFACES

Vertical building surfaces consists of opaque surfaces, transparent surfaces and openings. Each kind of surfaces has its own characteristics and can take a variety of finishing materials depending on the availability of materials, climatology's requirements, budget and aesthetic factors. Each of these surfaces excluding openings can be designed to attract atmospheric pollutants.

The different types of building surfaces are summarized below :

A. Opaque surfaces

Common finishing materials on opaque envelope of a building :

- paint on plaster : usage of electrostatic spray painting[4] can make a surface chargeable. This technique is used for industrial products and can be modified for building surfaces.
- stone cladding: Due to the nature of the material , it will not be possible to create chargeable surface on stone tiles as these are electrically neutral.
- Certain ceramics can be manufactured to exhibit dielectric properties.
- Metal cladding: Chargeable surface for these kind of materials can be created by running a small current between the two ends of the cladding module.
- curtain wall glazing : see transparent building surfaces below

B. Transparent surfaces

Adding Indium tin oxide (ITO) to glass surface is a known technique to introduce electrical conductivity while preserving the transparency properties of the glass surfaces. Indium tin oxide glasses are already available commercially for curtain wall glazing and architectural window usage. ITO thin films are available which can be applied directly to curtain wall glazing.

V. HEAT GENERATION AND POWER SOURCES

Small amount of heat is produced on electrical conductivity surfaces based on the materials electrical resistance. This could be overcome by applying the voltage at fixed intervals using any timing mechanisms instead of having a continuous supply. The overall power requirement for charging the building envelop will depend on the area but overall estimate for a medium size building will not exceed 1kw. Solar energy is an ideal source for this and can be easily added to the building structure with any commercially available solar panel kits.

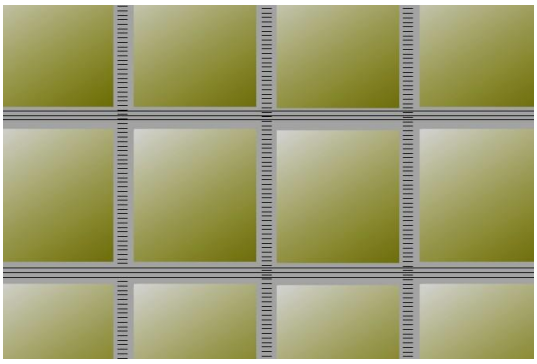

Fig. 2. Typical elevation showing glazed windows with wiring mechanisms

VI. CONCLUSIONS

The task and responsibility of controlling and eliminating pollutants lies with the respective state and central governments, the private corporations and with the individual citizens. In spite of technological solutions available for pollution control, private developers are not enthusiastic about it as it does not affect them directly and is expensive. Ideally government should bring in appropriate legislation and tax incentives for the private developer to invest in pollution control measures which in turn will help in reducing the overall pollutants.

References used are cataloged below :

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