

# AIR POLLUTANTS INDUCED HAIR FALL

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## ABSTRACT

Hair fall is a common concern among human beings. The bodily factors are proven to be responsible for it. However, in addition to it, external environmental factors are also responsible for the same. This paper sheds light on the various air pollutants viz. particulate matter including dust, suspended, respirable, and fine particulate matter and gaseous pollutants viz. sulphur dioxide, oxides of nitrogen, polycyclic aromatic hydrocarbons, volatile organic compounds, carbon monoxide, carbon dioxide, ultra-violet radiation and humidity responsible for human hair fall and the mechanism involved in it.

## INTRODUCTION

Scalp hair is often regarded as a symbol of beauty and vitality across many cultures. Hair is treasured by everyone as it is a sign of beauty, confidence and young look (Luqmanet *al.*, 2017). The loss of hair can significantly impact the emotional and psychological well-being of affected individuals. Different aspects can cause female and male pattern baldness (Singh, 2019). Hair fall affects around two-thirds of men under the age of 35 in the United States, according to the American Hair Loss Association (AHLA, 2024). Women make up 40 percent of American hair loss sufferers (Sandoiu, 2019). A quantity of hair fall is ordinary in males and females, on average, someone loses between 50 and 100 hairs per day (Johnsons, 2019).

According to the American Academy of Dermatology, about 80 million men and women in the United States alone will suffer from alopecia traction, telogen effluvium, universalis, and more. A large proportion of this hair fall is due to uncountable factors, such as genetic auto-immune conditions, hormone disruption, and ageing. However, scientists have recently discovered that certain factors in our environment may be partially responsible for hair fall (Megan, 2019). Air pollutants can cause hair fall. The effect of dust and fuel particles on the scalp of humans found that exposure to common pollutants reduced the levels of four proteins (Kant, 2019). Pollution can cause hair fall and especially in countries such as India it has emerged as one of the primary causes for hair fall problems. The literature review revealed the paucity of studies on air pollutants as an environmental factor for hair fall. Thus, this is the identified knowledge gap in the subject domain. To fill the knowledge gap with new knowledge this study was carried out with the objective to identify the air pollutants responsible for hair fall and the mechanism involved in it.

Air pollution means the presence in the outdoor atmosphere of one or more contaminants such as dust, fumes, gas, mist, odour or vapour, in quantities with characteristics, and of durations such as to be injurious to human, plant or animal life or property or which unreasonable interfere with the comfortable

adjustment of life and property. Air pollutants can be either natural or maybe the result of various activities of man like industrial operations. Industrial contaminants can be either by-products of external combustion like smoke, dust, and sulphur dioxide by-products of internal combustion like the reactions in petrol and diesel engines. Further, the emissions can be either primary pollutants or secondary pollutants. Air pollutants can be classified into two types viz. particulate matter and gaseous pollutants (Rao and Rao, 2007). The mechanism of air pollutants induced hair fall is as follows:

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### Particulate Matter

A mixture of airborne particles made up of metals, organic compounds, ions with biological origins, and a core of carbon particles that vary in size makes up air-born particulate matter. Particulate matter can be deposited on the hair surface for those living in highly polluted environments this leads to hair surface changes such as loss of shine and structural alteration due to the frictional force of particulate matter on the follicle (Samraet *al.*, 2024).

**Dust:** Dust is made of solid particles predominantly larger than the colloids and capable of temporary suspension in air or other gases. They do not tend to flocculate except under electrostatic forces, they also do not diffuse but settle under the influence of gravity (Rao and Rao, 2007). Dust triggers allergies which are referred to as scalp infection. It leads to an itchy scalp which can be mild at first but when the right measures are not taken more hair can fall out (Singh, 2019).

**Suspended particulate matter:** Suspended particulate matters are fine solids or liquids that are distributed in the air as a result of activities such as combustion processes, industrial operations or natural sources with a diameter of 100-10 microns. Suspended particulate matter can interfere with the chemical processes in dermal papilla cells (present at the base of hair follicles). These cells control the formation of the hair shaft and promote hair growth. They are responsible for hair growth, retention and the

hair life cycle. Suspended particulate matter triggers various concerns leading to hair fall (Deshpande, 2019).

**Respirable suspended particulate matter:** The respirable suspended particulate matter (PM<sub>10</sub>) is particulate matter suspended in ambient air with an aerodynamic diameter of less than 10 microns (Warsito *et al.*, 2019). Exposure to PM<sub>10</sub> and diesel particulate matter lowered the levels of beta-catenin protein key for hair growth and other proteins (cyclin D1, cyclin E, and Cyclin-dependent Kinase2) responsible for hair growth and hair retention (Kwon, 2019).

**Fine particulate matter:** Fine inhalable particles, with diameters that are generally 2.5 micrometres and smaller can easily settle on the scalp and hair strands. These particles have the potential to clog the hair follicles over time, preventing the natural growth cycle and ultimately causing hair thinning and fall. Exposure to fine particulate matter causes the scalp to become sensitive, uncomfortable, dry and oily. Hair follicles can be weakened and there are some signs of this, it can even cause hair fall (Son and Kwon, 2024).

#### **Gaseous Pollutants**

In addition to the particulate matter, gaseous pollutants are also responsible for hair fall. Gaseous pollutants are carbon dioxide, hydrocarbons, methane, nitrous oxide, sulphur dioxide, and water vapor. Prolonged exposure to these gases can lead to hair fall.

**Sulphur dioxide and oxides of nitrogen:** Sulphur dioxide is a colourless gas with a pungent odour. It is produced from the combustion of any sulphur-bearing materials especially coal. This is one of the principal constituents of air pollutants. Oxides of nitrogen (NO<sub>x</sub>) are the second most abundant atmospheric contaminants. NO<sub>x</sub> represents composite atmospheric gases, nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>), which are primarily involved in air pollution. These gaseous pollutants can disrupt the delicate balance of scalp's natural oils, leading to dryness, itchiness, and inflammation. When the scalp is compromised, it becomes more difficult for hair follicles to produce healthy strands, resulting in increased hair shedding and reduced hair growth. Exposure to harmful gaseous leads to hair moisture loss at a faster rate. This leads to the dehydration of hair, eventually causing the hair strands frizzy and brittle (Zade and Dhabekar, 2018).

**Polycyclic Aromatic Hydrocarbons:** Polycyclic aromatic hydrocarbons (PAHs) are released from vehicle exhaust, asphalt roads, burning wood, industrial smoke, and trash from industry waste. Groundwater, soil, and air can all contain persistent PAHs. In urban air, PAHs are adsorbed on the surface of suspended particulate matter. According to Zade and Dhabekar (2018), pollution levels cause oxidative stress on the cells of the hair follicles, which increases hair fall and causes androgenic alopecia. The metabolism of xenobiotics can be activated by PAHs, converting them into quinones. Quinones are redox-cycling molecules that are important in particulate matter toxicity because they generate reactive oxygen species (Rajput, 2015). Polycyclic hydrocarbons are the reason for "sensitive scalp disorder" which is one of the major reasons for hair fall (Godse and Zawar, 2012).

**Volatile Organic Compounds:** Volatile Organic Compounds (VOCs) are chemicals that are commonly found in indoor environments such as homes, offices and schools. These compounds can be emitted from various sources, including cleaning products, paints, adhesives and even furniture. Exposure to VOCs can have a direct impact on the health of hair and scalp. VOCs can also be causing inflammation and irritation of the scalp, which can exacerbate hair fall. The chemicals can strip the scalp of its natural oil and moisture, leading to dryness. This can create an unhealthy environment for hair growth and contribute to hair fall (The impact of pollution on hair loss, 2023). The VOCs are carried and recirculated in closed environments finally getting

deposited over the scalp and hair causing irritation and hair fall (Zade and Dhabekar, 2018).

**Carbon monoxide and carbon dioxide:** Carbon monoxide (CO) is an odourless and colourless gas that has its major origin in the incomplete combustion of carbonaceous materials. Carbon monoxide present in cigarette smoke can restrict blood flow to the hair follicles, depriving them of essential nutrients and oxygen. This can weaken the hair follicles and eventually lead to hair thinning and hair fall (The impact of pollution on hair loss, 2023). Carbon dioxide is a colourless gas having a faint sharp odour and a sour taste. It is one of the most important greenhouse gases linked to global warming. Carbon dioxide has the potential to accumulate on the hair and scalp or infiltrate deeper skin layers through hair follicles or percutaneous absorption (Son and Kwon, 2024).

**Ultra-Violet radiation:** The sun is the source of Ultra-Violet (UV) radiation. UV radiation can be divided into three types according to the wavelength: UVA (315-400 nm), UVB (280-315 nm) and UVC (100-280 nm) (Dario *et al.*, 2015). UV radiation from the sun is not only harmful to the skin but also has a damaging effect on hair follicles leading to hair fall. Excessive exposure to UV radiation can weaken the structure of the hair, causing it to become brittle and prone to breakage. The UVA radiation penetrates the hair shaft, depleting its moisture and natural oils, resulting in dry and dull hair. Over time, this can lead to hair thinning and hair fall. UVA radiation penetrates deep into the hair cortex, breaking down the protein bonds that give hair its strength and elasticity. This can result in weakened hair follicles and increased hair shedding. UVB radiation on the other hand, primarily affects the outer layer of the hair, known as the cuticle. Prolonged exposure to UVB radiation can cause the cuticle to become damaged and lift, leading to frizz, split ends, and hair breakage. This can ultimately contribute to hair fall (The impact of pollution on hair loss, 2023).

**Humidity:** Humidity is the concentration of water vapor present in the air. Moisture compels the hair cuticle to swell and lift. This allows environmental debris easy access to penetrate the cortex, creating brittleness and breakage. Simultaneously, humidity also sparks extreme sebum buildup along the scalp and strands, and high humidity to increased dandruff, infections, and hair fall (Cole, 2023).

**Mechanism of hair fall caused by air pollutants:** Airborne pollutants due to their size (<10µm) can enter the pores of hair. Fine particulate matter (< 2.5 µm) is lipophilic and can easily pass through the fat-filled spaces between skin cells. The scalp develops sensitivity, discomfort, dryness and oiliness when exposed to particulate matter. Hair follicles can be weakened and there are some indications that this can cause hair fall. Hair fibres and scalp offer enough surface for binding of particulate matter that can penetrate the superficial cuticle or skin layers. One of the primary mechanisms behind the adverse effects of particulate matter is the generation of reactive oxygen species (Gyengeet *et al.*, 2022). Particulate matter from air pollution has the ability to absorb polycyclic aromatic hydrocarbons on its surface including reactive oxygen species dependent inflammatory reactions in the skin. This process has the potential to exacerbate hair fall (Junet *et al.*, 2020). Prolonged exposure to gaseous can lead to hair fall. These pollutants can disrupt the delicate balance of scalp natural oils, leading to dryness, itchiness, and inflammation. Exposure to harmful gaseous pollutants leads to hair moisture loss at a faster rate (Zade and Dhabekar, 2018). Polycyclic aromatic hydrocarbons increase oxidative stress on the hair follicle cells, leading to increased hair shedding the mechanism seen in people suffering from androgenic alopecia (Vierkotter, 2010).

## **CONCLUSION**

In addition to the internal factors to the hair fall external environmental factors are also responsible for the same. Of these external environmental factors, air pollutants play a major

role. The particulate matter including dust, suspended, respirable and fine particulate matter are responsible for hair fall. The gaseous pollutants PAHs, VOCs, UV radiations and humidity also contribute to it. Exposure to these air pollutants may trigger hair fall. Those individuals who are exposed to these air pollutants should take preventive and precautionary measures to avoid hair fall.

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