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Human Health Risks of Exposure To Airborne Toxic Chemicals: A Case Study of Northern Rajasthan

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ABSTRACT: In northern Rajasthan, toxic air pollutants pose different risks to health depending on the specific pollutant, including; Cancer, including lung, kidney, bone, stomach; Harm to the nervous system and brain; Birth defects; Irritation to the eyes, nose and throat; Coughing and wheezing; Impaired lung function; Harm to the cardiovascular system; Reduced fertility. The desert environment creates more air blowing in the state, and hence this carries pollutants. The air pollutants create diseases in human body.

KEYWORDS: Northern, Rajasthan, Airborne, Toxic, Chemicals, Diseases

I. INTRODUCTION

In northern Rajasthan, People inhale many of these pollutants in the air where they live. But, because these pollutants also settle into waterways, streams, rivers and lakes, people can drink them in the water or eat them in the fish from these waters. Some hazardous pollutants settle into the dirt that children play in and may put in their mouths. Major sources of toxic air pollutants outdoors include emissions from coal-fired power plants, industries, and refineries, as well as from cars, trucks and buses.

Indoor air also can contain hazardous air pollutants from sources that include tobacco smoke, building materials like asbestos, and chemicals like solvents.

Stationary sources include:

- fossil-fuel power plants and biomass power plants both have smoke stacks (see for example environmental impact of the coal industry)^[38]
- Oil and gas sites that have methane leaks^{[39][40][41][42]}
- burning of traditional biomass such as wood, crop waste and dung. (In developing and poor countries,^[43] traditional biomass burning is the major source of air pollutants
 - waste incineration (incinerators as well as open and uncontrolled fires of mismanaged waste, making up about a fourth of municipal solid terrestrial waste)^{[54][55]}
 - furnaces and other types of fuel-burning heating devices^[56]
- Mobile sources include motor vehicles, Trains (particularly diesel locomotives and DMUs), marine vessels and aircraft^[57] as well as rockets and re-entry of components and debris.^[58] The air pollution externality of cars enters the air from the exhaust gas and car tires (including microplastics)

Agriculture and forest management strategies using controlled burns. Practices like slash-and-burn in forests cause large air pollution with the deforestation.^[63] Controlled or prescribed burning is a practice used in forest management, agriculture, prairie restoration, and greenhouse gas reduction

There are also sources from processes other than combustion:

- Fumes from paint, hair spray, varnish, aerosol sprays and other solvents. These can be substantial; emissions from these sources was estimated to account for almost half of pollution from volatile organic compounds
- Waste deposition in landfills produces methane.^[69]



- Nuclear weapons, toxic gases, germ warfare, and rocketry are examples of military resources.^[70]
- Agricultural emissions and emissions from meat production or livestock contribute substantially to air pollution^{[71][72]}

- Fertilized farmland may be a major source of nitrogen oxides

Natural sources

- Dust from natural sources, usually large areas of land with little vegetation or no vegetation
- Methane, emitted by the digestion of food by animals, for example cattle
- Radon gas from radioactive decay within the Earth's crust. Radon is a colorless, odorless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.
- Smoke and carbon monoxide from wildfires. During periods of active wildfires, smoke from uncontrolled biomass combustion can make up almost 75% of all air pollution by concentration.^[75]
- Vegetation, in some regions, emits environmentally significant amounts of volatile organic compounds (VOCs) on warmer days. These VOCs react with primary anthropogenic pollutants – specifically, NO_x, SO₂, and anthropogenic organic carbon compounds – to produce a seasonal haze of secondary pollutants.^[76] Black gum, poplar, oak and willow are some examples of vegetation that can produce abundant VOCs. The VOC production from these species result in ozone levels up to eight times higher than the low-impact tree species.^[77]
- Volcanic activity, which produces sulfur, chlorine, and ash particulates

II. DISCUSSION

There are 12 compounds in the list of persistent organic pollutants. Dioxins and furans are two of them and intentionally created by combustion of organics, like open burning of plastics. These compounds are also endocrine disruptors and can mutate the human genes.

Pollutants emitted into the atmosphere by human activity include:

- Ammonia: Emitted mainly by agricultural waste. Ammonia is a compound with the formula NH₃. It is normally encountered as a gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous.^[89] In the atmosphere, ammonia reacts with oxides of nitrogen and sulfur to form secondary particles.^[90]
- Carbon dioxide (CO₂): Carbon dioxide is a natural component of the atmosphere, essential for plant life and given off by the human respiratory system.^[91] It is potentially lethal at very high concentrations (typically 100 times "normal" atmospheric levels).^{[92][93]} Although the World Health Organization recognizes CO₂ as a climate pollutant, it does not include the gas in its Air Quality Guidelines or set recommended targets for it.^[94] Because of its role as a greenhouse gas, CO₂ has been described as "the worst climate pollutant".^[95] Statements such as this refer to its long-term atmospheric effects rather than shorter-term effects on such things as human health, food crops, and buildings. This question of terminology has practical consequences. CO₂ currently forms about 410 parts per million (ppm) of earth's atmosphere, compared to about 280 ppm in pre-industrial times,^[98] and billions of metric tons of CO₂ are emitted annually by burning of fossil fuels.^[99] CO₂ increase in earth's atmosphere has been accelerating.^[100] CO₂ is an asphyxiant gas and not classified as toxic or harmful in general.^[101] Carbon monoxide (CO): CO is a colorless, odorless, toxic gas.^[103] It is a product of combustion of fuel such as natural gas, coal or wood. Vehicular exhaust contributes to the majority of carbon monoxide let into the atmosphere. It creates a smog type formation in the air that has been linked to many lung diseases and disruptions to the natural environment and animals.
- Chlorofluorocarbons (CFCs): Emitted from goods that are now prohibited from use; harmful to the ozone layer. These are gases emitted by air conditioners, freezers, aerosol sprays, and other similar devices. CFCs reach the stratosphere after being released into the atmosphere.^[104] They interact with other gases here, causing harm to



the ozone layer. UV rays are able to reach the earth's surface as a result of this. This can result in skin cancer, eye problems, and even plant damage.^[105]

- Nitrogen oxides (NO_x): Nitrogen oxides, particularly nitrogen dioxide, are expelled from high temperature combustion, and are also produced during thunderstorms by electric discharge. They can be seen as a brown haze dome above or a plume downwind of cities. Nitrogen dioxide is a chemical compound with the formula NO₂. It is one of several nitrogen oxides. One of the most prominent air pollutants, this reddish-brown toxic gas has a characteristic sharp, biting odor.
- Odors: Such as from garbage, sewage, and industrial processes.
- Particulate matter/particles (PM), also known as particulates, atmospheric particulate matter (APM), or fine particles, are microscopic solid or liquid particles suspended in a gas.^[106] Aerosol is a mixture of particles and gas. Volcanoes, dust storms, forest and grassland fires, living plants, and sea spray are all sources of particles. Aerosols are produced by human activities such as the combustion of fossil fuels in automobiles, power plants, and numerous industrial processes.^[107] Averaged anthropogenic aerosols – those made by human activities – currently account for approximately 10% of the atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease,^[108] altered lung function and lung cancer. Particulates are related to respiratory infections and can be particularly harmful to those with conditions like asthma.^[109]
- Persistent organic pollutants, which can attach to particulates. Persistent organic pollutants are organic compounds that are resistant to environmental degradation due to chemical, biological, or photolytic processes (POPs). As a result, they've been discovered to survive in the environment, be capable of long-range transmission, bioaccumulate in human and animal tissue, biomagnify in food chains, and pose a major threat to human health and the ecosystem.^[110]
- Persistent free radicals connected to airborne fine particles are linked to cardiopulmonary disease.^{[111][112]}
- Polycyclic Aromatic Hydrocarbons (PAHs): a group of aromatic compounds formed from the incomplete combustion of organic compounds including coal and oil and tobacco.^[113]
- Radioactive pollutants: Produced by nuclear explosions, nuclear events, war explosives, and natural processes such as the radioactive decay of radon.
- Sulfur oxides (SO_x): particularly sulfur dioxide, a chemical compound with the formula SO₂. SO₂ is produced by volcanoes and in various industrial processes. Coal and petroleum often contain sulfur compounds, and their combustion generates sulfur dioxide. Further oxidation of SO₂, usually in the presence of a catalyst such as NO₂, forms H₂SO₄, and thus acid rain is formed. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.
- Toxic metals, such as lead and mercury, especially their compounds.
- Volatile organic compounds (VOC): VOCs are both indoor and outdoor air pollutants.^[114] They are categorized as either methane (CH₄) or non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming. Other hydrocarbon VOCs are also significant greenhouse gases because of their role in creating ozone and prolonging the life of methane in the atmosphere. This effect varies depending on local air quality. The aromatic NMVOCs benzene, toluene and xylene are suspected carcinogens and may lead to leukemia with prolonged exposure. 1,3-butadiene is another dangerous compound often associated with industrial use.

III. RESULTS

Indoor air quality in northern Rajasthan

A lack of ventilation indoors concentrates air pollution where people often spend the majority of their time. Radon (Rn) gas, a carcinogen, is exuded from the Earth in certain locations and trapped inside houses. Building materials including carpeting and plywood emit formaldehyde (H-CHO) gas. Paint and solvents give off volatile organic compounds (VOCs) as they dry. Lead paint can degenerate into dust and be inhaled.^{[126][127]}

Intentional air pollution is introduced with the use of air fresheners, incense, and other scented items. Controlled wood fires in cook stoves and fireplaces can add significant amounts of harmful smoke particulates into the air, inside and out. Indoor pollution fatalities may be caused by using pesticides and other chemical sprays indoors without proper ventilation. Also the kitchen in a modern produce harmful particles and gases, with equipment like toasters being one of the worst sources.^[128]

Carbon monoxide poisoning and fatalities are often caused by faulty vents and chimneys, or by the burning of charcoal indoors or in a confined space, such as a tent.^[129] Chronic carbon monoxide poisoning can result even from poorly-adjusted pilot lights. Traps are built into all domestic plumbing to keep sewer gas and hydrogen sulfide, out of interiors. Clothing emits tetrachloroethylene, or other dry cleaning fluids, for days after dry cleaning.



Though its use has now been banned in many countries, the extensive use of asbestos in industrial and domestic environments in the past has left a potentially very dangerous material in many localities. Asbestosis is a chronic inflammatory medical condition affecting the tissue of the lungs. It occurs after long-term, heavy exposure to asbestos from asbestos-containing materials in structures. Those with asbestosis have severe dyspnea (shortness of breath) and are at an increased risk regarding several different types of lung cancer. As clear explanations are not always stressed in non-technical literature, care should be taken to distinguish between several forms of relevant diseases. like asbestosis, lung cancer, and peritoneal mesothelioma (generally a very rare form of cancer, when more widespread it is almost always associated with prolonged exposure to asbestos).

Biological sources of air pollution are also found indoors, as gases and airborne particulates. Pets produce dander, people produce dust from minute skin flakes and decomposed hair, dust mites in bedding, carpeting and furniture produce enzymes and micrometre-sized fecal droppings, inhabitants emit methane, mold forms on walls and generates mycotoxins and spores, air conditioning systems can incubate Legionnaires' disease and mold, and houseplants, soil and surrounding gardens can produce pollen, dust, and mold. Indoors, the lack of air circulation allows these airborne pollutants to accumulate more than they would otherwise occur in nature.

Health effects in northern Rajasthan

Even at levels lower than those considered safe, exposure to three components of air pollution, fine particulate matter, nitrogen dioxide and ozone, correlates with cardiac and respiratory illness.^[131] In 2020, pollution (including air pollution) was a contributing factor to death there, and was a significant risk factor for pollution-related diseases including heart disease, stroke and lung cancer.^[132] The health effects caused by air pollution may include difficulty in breathing, wheezing, coughing, asthma^[133] and worsening of existing respiratory and cardiac conditions. These effects can result in increased medication use, increased doctor or emergency department visits, more hospital admissions and premature death.^[11]

The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, and the individual's health status and genetics.^[11] The most common sources of air pollution include particulates, ozone, nitrogen dioxide, and sulfur dioxide. Children aged less than five years who live in developing countries are the most vulnerable population in terms of total deaths attributable to indoor and outdoor air pollution.^[134] Air pollution has both acute and chronic effects on human health, affecting a number of different systems and organs. It ranges from minor upper respiratory irritation to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks. Short and long term exposures have been linked with premature mortality and reduced life expectancy.^[137]

Mortality in northern Rajasthan

The largest cause is air pollution generated by fossil fuel combustion^[163] – mostly the production and use of cars, electricity production, and heating.^[164] A study estimates there are premature deaths because of pollutants released by high-emission power stations and vehicle exhausts.^[165]

Diesel exhaust (DE) is a major contributor to combustion-derived particulate matter air pollution. In several human experimental studies, using a well-validated exposure chamber setup, DE has been linked to acute vascular dysfunction and increased thrombus formation.

Polycyclic aromatic hydrocarbons (PAHs) have been associated with reduced fertility. Benzo(a)pyrene (BaP) is a well-known PAH and carcinogen which is often found in exhaust fumes and cigarette smoke.^[198] PAHs have been reported to administer their toxic effects through oxidative stress by increasing the production of Reactive Oxygen Species (ROS) which can result in inflammation and cell death. More long-term exposure to PAHs can result in DNA damage and reduced repair.^[199]

Exposure to BaP has been reported to reduce sperm motility and increasing the exposure worsens this effect.

Ground-level ozone (O₃), when in high concentrations, is regarded as an air pollutant and is often found in smog in industrial areas. O₃ is largely produced by chemical reactions involving NO_x gases (nitrous oxides, especially from combustion) and volatile organic compounds in the presence of sunlight.

There is limited research about the effect that ozone pollution has on fertility.^[197] At present, there is no evidence to suggest that ozone exposure poses a deleterious effect on spontaneous fertility in either females or males. However, there have been studies which suggest that high levels of ozone pollution, often a problem in the summer months, exert



an effect on in vitro fertilisation (IVF) outcomes. Within an IVF population, NO_x and ozone pollutants were linked with reduced rates of live birth

Prenatal exposure to polluted air has been linked to a variety of neurodevelopmental disorders in children. For example, exposure to polycyclic aromatic hydrocarbons (PAH) was associated with reduced IQ scores and symptoms of anxiety and depression.^[211] They can also lead to detrimental perinatal health outcomes. Exposure to fine particulate matter can increase levels of cytokines - neurotransmitters produced in response to infection and inflammation that are also associated with depression and suicide. Pollution has been associated with inflammation of the brain, which may disrupt mood regulation.

IV. CONCLUSIONS

Control

- Mechanical collectors (dust cyclones, multicyclones)
- Electrostatic precipitators: An electrostatic precipitator (ESP), or electrostatic air cleaner, is a particulate collection device that removes particles from a flowing gas (such as air), using the force of an induced electrostatic charge. Electrostatic precipitators are highly efficient filtration devices that minimally impede the flow of gases through the device, and can easily remove fine particulates such as dust and smoke from the air stream.
- Baghouses: Designed to handle heavy dust loads, a dust collector consists of a blower, dust filter, a filter-cleaning system, and a dust receptacle or dust removal system (distinguished from air cleaners which utilize disposable filters to remove the dust).
- Particulate scrubbers: A wet scrubber is a form of pollution control technology. The term describes a variety of devices that use pollutants from a furnace flue gas or from other gas streams. In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, or by some other contact method, so as to remove the pollutants

Spatiotemporal monitoring of air quality may be necessary for improving air quality, and thereby the health and safety of the public, and assessing impacts of interventions

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