# Pollution and Mental Health: The Hidden Psychological Impact

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## Abstract

Pollution is multifaceted global issue, with its prolonged effects on physical health while impact on mental health often ove remphasized. Exposure to environmental pollutants including air, water, noise, light and chemicals influences the mental, cognitive and psychological well-being. Air pollutants as particulate matter exposure causes neuro-degeneration, oxidative stress and neuro-developmental disorders like autism spectrum disorder (ASD) and attention-deficient/hyperactivity disorder (ADHD). While prolonged exposure to heavy metals in water exacerbates mental function and psychological distress. Similarly, noise pollution increases the anxiety, depression and cognitive disruption. Light pollution disrupt the circadian rhythm, causes sleep deprivation and emotional instability. This chapter emphasize the excessive burden of pollution on marginalized communities where impacts on mental health interact with the existing health discrepancy. It also focuses on the psychological stress of polluted environments aggravate by anxiety and ecological grief. By addressing this hidden psychological impact of pollution needs a holistic approach that incorporate the policy, int ervention of public health and services of mental health.

Keywords: Mental health, Pollution, Psychological well-being, Neurological disorders, Anxiety

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# Introduction

#### 1.1. Defining Pollution and Its Various Types

The word pollution is originated from Latin word "Pollutioneum" which means "to make contaminated or spoil". Pollution is defined as the inauspicious alteration of environment due to anthropogenic activities and directly or indirectly affects the living environment such as plants, animals and humans (Al-Dulaimi et al., 2021). Pollution is a mixture of different contaminants formed by various chemicals including dust, smoke, dyes, fumes, gases or overuse of energy resources (Mia et al., 2019). It also refer as the introduction of undesirable substances in environment that alter the biological, physical and chemical properties of soil, air and water. Pollutants are the substances that have an effect on climate, cause pollution and human diseases, leading to increase morbidity and mortality (Shetty et al., 2023).

Two major types of pollution arise due to anthropogenic activities are categorized by direct or indirect effects on human beings as shown in figure 1. Pollution that have indirect effects considered as surrounding pollution is air, water and soil pollution. While noise pollution is type of pollution that have direct effects on humans (Sharma and Kashyap, 2022). Air Pollution is referred to as the addition of harmful chemicals that alter the physical, biological or chemical characteristics of air. It is also considered as the poisoning of envelope of air. Pollutants such as carbon monoxides, oxides of sulphur, chlorofluorocarbons dust particles, oxides of nitrogen and other hydrocarbons are responsible for air pollution (Noel et al., 2022).

Water pollution occurs by the entry of toxic contaminants into the water bodies. The contaminants (particulate matter or chemicals) enter into the rivers, lakes due to natural process such as eutrophication or due to human activities as industrial wastes, oil spills or agricultural practices (Goel, 2006).

Pollution that occur due to presence of chemicals including fertilizers, pesticides, herbicides, insecticides that cause changes the soil composition is called soil pollution (Khasanova et al., 2023). Noise pollution considered the presence of unpleasant sounds in the surrounding that interrupt with natural balance (Karki et al., 2024).

#### 1.2. Overview of Mental Health and Psychological Well-being

Mental health refers to as the condition of mind described by adjustment of good behavior, emotional well-being, freedom from disabling and anxiety and allow the individual to use their capabilities in melodiousness with the social values (Gautam et al., 2024). Similarly, psychological well-being is a multi- dimensional contrive that surrounds emotional and mental health, satisfaction and happiness of an individual. According to WHO, psychological well-being is the state of mind through which an individual work productively, cope with life



Fig. 1: Types of pollution on the basis of their effects



Fig. 2: Relation between Environmental pollution and mental health

stresses normally (Sheldon & King, 2001). It consist of various key components e.g., life satisfaction, lower level of negative emotions, personal growth, more positive emotions, positive relationships and autonomy (Dhanabhakyam & Sarath, 2023).

## 1.3. Connecting Environmental Pollution with Mental Health

Environmental pollution due to polluting agents are increasing due to over population, industrialization and urbanization and technology are developed globally. There is a close association between pollutants (e.g., heavy metals, noise pollution, pesticides, light pollution, environmental catastrophes, IR) and mental health. Various mental health disorders such as stress, depression, anxiety, psychiatric syndromes are due to exposure of environmental pollution as shown in figure 2 (Ventriglio et al., 2021).

#### 2. Air Pollution and Cognitive Decline

#### 2.1. Particulate Matter and Its Effect on Brain Health

Air pollution is the most predominant issue in the whole world. According to WHO report, 3.8 and 4.2 million people pass away due to indoor and outdoor pollution every year (Kim et al., 2015). Particulate matter are condensed particles accumulate in the atmosphere including spores, combustion particles, and soot. These PM due to their small size penetrate in the lungs, promulgate through blood vessels in body and adversely effects the health. Long term exposure of PM also degenerate the immune system, which lead toward other diseases such as asthma, bronchitis, colds and cardiovascular diseases (Calderon-Garciduenas et al., 2022). Particulate matter (PM2.5) affects the central nervous system triggering neurotoxicity, oxidative stress and systemic inflammation. (Thomson, 2019).

#### 2.2. Long-term Exposure and Memory Impairment

As Air pollution is the major bestower to the global implication of disease. Long term exposure PM2.5 associated with memory impairment in both children and adults (Yuan et al., 2023). During

childhood, air pollutants exposure imperil the acquirement of neurologic potential and diminish the cognitive and emotional resources of an individual (Rivas et al., 2019). According to National Institutes of Aging Report, older adults have more memory loss and cognitive impairments than other age groups, thus accelerate other health problems e.g., Alzheimer's disease, dementia and Parkinson's disease (Ma et al., 2023).

# 2.3. Links Between Air Pollution and Neurodevelopmental Disorders (e.g., ADHD, Autism)

Air pollution is increasing globally due to overpopulation, rapid development of urbanization and industrialization. In developing countries, higher level of nitrogen dioxide and particulate matter aggravate air quality problems. Exposure to pollution increases the risk of neurological disorders such as attention-deficit/hyperactivity disorder (ADHD) and autism. ADHD is neurodevelopmental disorder depicted by recurrent patterns of hyperactivity, impulsivity and inattention, affects about 8 to 12% of children globally (Luo et al., 2019). It can jeopardize psychiatric illnesses, addiction, social disability and criminality (Ahmad et al., 2024).

Air pollutants raise the risk of ADHD by mechanism such as direct toxicity, neuroinflammation and oxidative stress. PM2.5 through bloodbrain barrier or olfactory bulb enter into the brain, triggering microglial cells, that release cytokines and inducing neuroinflammation as shown in figure 3 (*Block &* Calderon-Garciduenas, 2009). Oxidative stress due to reactive oxygen, nitrogen dioxide and PM2.5 leading to the cellular damage. It also disrupts the neurotransmitter, neurons and glial cells (*Aghaei et al., 2019*).

Autism is another neurodevelopmental disorder characterized by disablements in the communication and social interaction (McGuinn et al., 2020). According to Centers for Disease Control and Prevention, 1 out of 59 children has been affected by Autism Spectrum Disorder (ASD). Oxidative stress and inflammation induces during prenatal and postnatal exposures ofair pollutants including particulate matters (PM2.5, PM10), oxides of sulphur and nitrogen (Stoner et al., 2014).

#### 3. Water Pollution and Mental Health Risks

#### 3.1. Contaminated Water and Neurological Damage

Neurological disorders increase due to environmental pollution. Both biodegradable and non-biodegradable pollutants leading towards the neurological problems. Water polluted with toxic metals and other pollutants enhances aging and neurodegenerative disorders (Aslam et

al., 2021). Various types of pesticides such as pyrethroids, organo-phosphates, carbamates are the risk factors for neurodenegenerative disorders and also cause serious brain damage (Scorza et al., 2023).



Fig. 3: Mechanism involved in air pollution and neuroinflammation

## 3.2. Heavy Metals in Water (e.g., Lead, Mercury) and Their Impact on Mental Function

Industrialization and urbanization are the two major factors of water pollution. Pollutants containing chemicals, heavy metals, enter into water bodies through runoff from industries, villages and cities (Briffa et al., 2020). Toxicity due to heavy metals vary depending upon the concentration, nature, biological reaction of metals and duration of exposure to organisms (Masindi & Muedi, 2018). Heavy metals e.g., lead, mercury exposure occur through contaminated water, increased absorption rates in various tissues of human body as heart and brain. Mercury and lead poisoning mainly target nervous system and damage cerebrum and cerebellum (Tchounwou et al., 2012).

#### 3.3. Psychological Stress in Communities Facing Water Scarcity and Pollution

Water scarcity is a physical reality that can be observed consistently across the world. Psychological distress due to water scarcity and pollution in different communities is a major concern now a days. Prolonged consumption of contaminated water may lead toward the mental disorders (Brewis et al., 2021). The depression and anxiety caused by scarcity of clean water can be increased, leading to the stress condition (Wutich, 2020).

#### 4. Noise Pollution: The Unseen Mental Strain

## 4.1. Chronic Noise Exposure and Psychological Stress

Noise pollution refers to as the continuous exposure to enormous sound levels that can be harmful to living beings. According to WHO, sound levels of lesser than 70 dB are not dangerous to humans (Karki et al., 2024). On the other hand, exposure of 85 dB of noise for 8 hours can be harmful and noise pollution can cause different health issues includes hypertension, headache, fatigue and sleep disorders. Noise is the major risk factor of causing mental defects and psychological distress such as aggressiveness, lessen cognitive performance and irritability (Hardoy et al., 2005).

## 4.2. Sleep Disturbances and Their Cognitive Consequences

Sleep is an essential factor of glucose regulation, hormonal release and cardiovascular function. Glucose hormone is released and stress hormone is inhibited during sleep and healthy and peaceful sleep play role in memory stabilization (Halperin, 2014). However noise due to transportation means is a global issue and major cause of sleep disturbance. Poor sleep affect the metabolism of glucose and sensitivity of insulin (Basner, 2008). Sleep deprivation causes memory loss, diminish attention, affects decision making ability (Alhola and Polo-Kantola, 2007).

#### 4.3. Urban Noise and Its Link to Anxiety and Depression

Most of the people live in urban areas and urban noise adversely effects the people of all age groups (Guha, 2022). Studies reported that effects of traffic noise likely to be linked with depression and anxiety (Gupta et al., 2018). Noise can affect the human health through direct or indirect way and initiate the psychological stress and mental disorders. Noises due to traffic associated with the Parkinson's disease and Alzheimer's disease (Cantuaria et al., 2021).

#### 5. Chemical Pollution and Neurotoxicity

#### 5.1. Industrial Chemicals and Mental Health

Industrial chemicals includes toluene, lead, polychlorinated biphenyls, methyl mercury and arsenic are major causes of neurodevelopmental disorders and dysfunctioning of brain (Grandjean & Landrigan, 2006). Mental health disorders such as anxiety, depression, mood effects physical health and social skills developmental. Studies reported that various environmental chemicals impact the mental health. These chemicals change the neurotransmitter system, impair the blood-brain barrier (BBB), alter the gene expression and increased the risk of mental disorders (James & OShaughnessy 2023).

## 5.2. Pesticides, Endocrine Disruptors, and Mental Health Disorders

Pesticides are the chemicals used to control undesirable organisms which causes deleterious effects to important crops (Garud et al., 2024). Endocrine disruption chemicals (EDCs) or endocrine disruptors are natural as well as synthetic chemical compounds that disrupt the endocrine system and produce long-term changes in living organisms (Modica et al., 2023). Exposure to endocrine disruptors e.g. DDT, phthalates, plasticizers found in detergents, food cans, cosmetics leads to severe health outcomes. Long-term exposure to EDCs contributes to the different syndromes such as diabetes mellitus, Alzheimer's disease and autism (Johri et al., 2024).

## 5.3. The Impact of Household Chemicals on Cognitive Functions

World population changes have led to aging, an ultimatum faced by most countries. Aging is the major factor for mental disorders especially Alzheimer's disease. The environmental pollutants and household chemicals pose a great threat to the cognitive functions (Wang et al., 2024). People stay indoor most of the time and indoor air quality badly effect the human health. Household chemicals used for cleaning purposes, disinfectants for hygiene and control of infection (Le Moual et al., 2012). Significant correlation between these household chemicals and cognitive functions, memory impairments (Kim et al., 2015).

## 6. Light Pollution and Sleep Disorders

## 6.1. Circadian Rhythm Disruptions Due to Excessive Artificial Light

Light especially artificial light is essential, as it ameliorate the visual performance. However long term exposure of light disrupt the circadian rhythm and causes health issues (Tähkämö et al., 2019). Circadian rhythm are endogenic variation in behavioral, physical and mental activity. The replacement of incandescent light bulb by most efficient light sources includes LED emitted spectrum with blue component has been the factor of health impacts (Beam & Motsinger-Reif, 2011). These health impacts includes inhibition of melatonin secretion and disturbance of internal body clock. The circadian rhythm disruption associated with wide range of illnesses such as obesity, cancer, diabetes and heart problems as shown in figure 4 (Benke & Benke, 2013).



#### 6.2. Sleep Deprivation and Mental Health Implications

Majority of population lives in cities and spend most of the time indoor. Living in urban environment enhances the exposure of artificial light and increases the risk of several diseases (Touitou et al., 2017). Mostly workers who work at night shift, have a disturbed circadian rhythm and develop sleep deprivation. Sleep deprivation is condition characterized by insomnia, sleep time misalignment and neurological disorders (Reinberg & Ashkenazi, 2008).

## 6.3. Emotional Instability Due to Altered Sleep Patterns

Sleep disturbances affects negatively emotional regulation and well-being. Emotional instability refer as transdiagnostic process occur in association with psychiatric disorders. It can be expressed by symptoms of irritability, hyperarousal, and mood shifts (Sesso et al., 2024). Altered sleep patterns are diagnostic criterion for various psychiatric states. Patients with schizophrenia, panic disorders, anxiety and frequently related to the sleep disturbances, which links to emotional instability (Riemann et al., 2024).

#### 7. Climate Change and Mental Health

## 7.1. Environmental Stressors and Psychological Well-being

Climate change and mental health are considered as the greatest problems facing worldwide. Climate change negatively effects the mental

and physical health through various pathways (Krewski et al., 2006). Environmental stressors are the factors which play role to compel reproductive success, ecosystem development and productivity (Liu et al., 2020). All organisms, communities and populations effected by stressors. Environmental stressors are risk factors for various psychological and psychiatric disorders (Lawrance et al., 2022).

## 7.2. Ecological Grief and Anxiety Over Global Environmental and Climate Changes

Global environmental changes causes a diversity of threats to human health such as well-being and mental health. Extreme weather events and natural catastrophes e.g., stress reactions occur due to floods are major risk factors of causing mental disorders (Ellis & Albrecht, 2017). Emotional response to the losses due to global environmental changes is called ecological grief. Another loss due to environmental changes considered to the disturbance of cultural and personal identities (Cunsolo & Ellis, 2018).

## 8. The Role of Environmental Injustice

## 8.1. How Marginalized Communities Are Disproportionately Affected by Pollution

Communities and group of peoples which are discriminated or experience exclusion due to difference in the power among the cultural, political and social aspects are marginalized communities. Good health is increases in some parts of globe while no improvement seen in other parts according to WHO. These differences in health and life contemplation become apparent due to the environmental conditions in which people survive, develop and work (Santacruz-Marquez et al., 2024). Exposure to pollution is higher for marginalized communities and disproportionately affected them, due to distinction in health status (Gochfeld & Burger, 2011).

## 8.2. Psychological Burden of Living in Polluted Environments

The healthy environment allow the individuals to perform their social activities and manage the mental stress and spend time with positive way in natural environment. However due to anthropogenic activities, environmental pollution became a global issue, not only threaten human life but also causes psychological burden (Bouzid et al., 2013). Living in polluted environments affects all facets of social, physical, economic and mental alterations and be a threat to healthy green life. Psychological distress is associated with accumulation of reactive oxygen species after intracerebral hemorrhage induced oxidative stress and long-term exposure to these stressors caused many other diseases (Wang et al., 2007).

## 8.3. Socioeconomic Stressors Compounded by Environmental Harm

The interaction between socioeconomic stressors and environmental harm has damaging outcomes for the communities. Environmental pollution has detrimental impacts on the education, business, food insecurity, loss of agricultural production (Joshi et al., 2023). Due to these stressors, people face economic problems include isolation, financial shortage and loss of work efficiency (Rahman et al., 2018).

#### 9. Psychological Mechanisms Linking Pollution and Mental Health

## 9.1. Inflammation and Oxidative Stress in the Brain

Imbalance between the production of reactive oxygen species and antioxidants is known as oxidative stress. This imbalance occur from exposure of free radicals or ROS to pollution causing agents e.g., air, particulate matters and ozone. Reactive oxygen species (ROS) increase level trigger signaling pathway that stimulate inflammation, which is a pathogenic mechanism in various diseases. Brain is an organ abundant with fatty acids, use high level of oxygen and energy while poor in antioxidant. Oxidative stress will manifest due to increase of reactive oxygen species that target macromolecules and oxidize proteins, lipids or DNA (Moulton & Yang, 2012). Their oxidized products accumulated by free radicals, which are liable for the aging of brain and deteriorate cognitive functions. Alzheimer's disease is an ongoing neurodegenerative disease due to oxidative stress and causes memory loss (Block & Calderon-Garciduenas, 2009).

## 9.2. Neurotransmitter Disruptions Due to Pollutants

The information in central nervous system processes and send to the peripheral nervous system through synapses. For Transmission of information among CNS and PNS, neurotransmitters play a key role and conduct messages through synaptic pathway (Teleanu et al., 2022). Pollutants can disrupt the neurotransmitters by changing the balance of neurotransmitters such as amino acids, glutamate or GABA (Xia et al., 2022). Inflammation of nervous system can be caused due to air pollution, which in turn enhance the level of cytokines. Imbalance in the level and metabolism of neurotransmitters cause psychological disorders as epilepsy, Alzheimer's disease, Parkinson disease and autism (Hanada, 2020).

## Hormonal and Immune System Alterations and Mental Health

Exposure to pesticides, heavy metals, plasticizers or industrial chemicals through air, water etc. causes stress in living beings that trigger hormonal and immune system. Stress is the response of body against psychological and physical hazards (Mohanty & Svingen, 2024). Two essential system respond to stress in human are hypothalamic-pituitary-adrenal axis and autonomic nervous system. Stressed people have increased level of neuropeptides in CNS i.e., central corticotropin-relaesing hormone (CRH). Pollutants can block or mimic the receptors and normal function of hormones and associated with risk of various disorders such as depression, anxiety, schizophrenia (Vasile, 2020).

## 10. Coping with Pollution-Related Mental Health Challenges

#### 10.1 The Role of Policy in Reducing Pollution and Improving Mental Health

Pollution can be prevented by reducing the use of hazardous substances, contaminants, increasing the use of less toxic substances and by implementation of conservation techniques. Pollution prevention act was passed by congress in 1990 states that Environmental protection agency should provide financial help to states and implement various activities (Occhipinti et al., 2024).

- Pollution should be control by preventing their sources.
- Pollution should be treated in environmentally safe way, if prevention or recycyling of material should not be possible.

Federal government play a key role in limiting the sources of pollution such as industrial facilities, off-road engines and power plants since 1970s (Abrashkin & Vershinin, 2018).

#### 10.2.Community Support and Public Health Interventions

Individual-level strategies as well as environmental level strategies such as counseling, education and policy alterations are included in public health interventions. The main objective of community support and public health interventions is to prevent the pollution and must promote the psychological well-being of population.

## 11. Global Case Studies

## 11.1. Air Pollution in Urban Areas and Its Impact on Public Mental Health

Air pollution, a global issue in developing countries which revealed to effect mental health significantly. A research was conducted in china to study the impact of air pollution on mental health and psychological well-being of Chinese university students. Results suggested that normal air quality not linked with negative mental health but bad air quality air vigorously associated with higher level of mental disturbances (Zu et al., 2020).

# 11.2. The Flint Water Crisis: Long-term Psychological Effects

Lack of sufficient quantities of clean water poses a global challenge to the economic and health circumstances. Out of 4 billion people's, 2/3 of the population be faced water scarcity, due to lack of water hygiene and sanitation conditions (Gaber et al., 2021). Study reported that lead polluted the water in Flint, Michigan and children were mostly effected to high lead levels. Water crisis was also causes enhanced levels of depression, anxiety and neuro-inflammation (Trejo et al., 2024).

## 11.3. Noise Pollution in Major Cities and Its Mental Health Burden

Noise pollution from different sources due to industrialization and urbanization become a serious problem in highly populated areas of the world. In Beijing, health survey was conducted to investigate the distribution of noise pollution and its impact on health. Results indicated Beijing residents were exposed to noise pollution through the construction works, railway, road traffic and noise associated to mental health effects such as fatigue, anxiety, sleep disturbance and headache (Ma et al., 2018).

#### 12. Future Research Directions

#### 12.1. The Need for Holistic Approaches to Environmental and Mental Health Policies

Environmental pollution and mental health are major challenges which the world will continue to combat for years. This chapter outlines evidence on the importance of pollution on mental health, various kinds of pollution causes anxiety, depression, stress and dementia. These challenges must be overcome to raise awareness about the effects of pollution, government should integrate mental health consideration into policies. Policies should support community led initiatives that assist environmental viability and mental health.

#### Conclusion

Pollution has detrimental effects on mental health, with innumerable research studies demonstrated its harmful psychological impacts. Different types of pollution including air, water, light, noise and climate changes bestow to a range of psychological issues from stress, anxiety and depression to decline in cognitive functions. Exposure to heavy metals, oxides of sulphur, nitrogen and particulate matter ( $PM_{2.5}$  and  $PM_{10}$ ) has been associated with elevated rate of diminished brain functions and mood disorganization. In conclusion, hidden psychological impact is a critical zone for further research. Preventing and reducing pollution can improve and promote the mental health and psychological wellbeing.

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