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# A Comprehensive Study of the Impact of Waste Fires on the Environment and Health

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**Abstract:** The escalating crisis of environmental degradation, with waste fires acting as a potent accelerant, has reached a critical juncture that demands immediate attention. This crisis disproportionately affects developing and low-income nations, where unregulated disposal and incineration in open areas have become rampant. These open waste fires serve as hotbeds for many environmental hazards ranging from air and water pollution to soil degradation. In addition, they contribute to the growing threat of marine litter and are a significant source of greenhouse gas emissions, exacerbating global climate change. Beyond their environmental toll, waste fires present an immediate and long-term threat to human health, causing respiratory problems and skin conditions and potentially leading to more serious health outcomes, such as cancer. Their impacts are multidimensional, affecting not only the environment but also pose severe health risks to communities, especially those near waste-burning sites. In this technologically advanced era, the application of artificial intelligence (AI), Machine Learning (ML), and deep learning technologies has the potential to revolutionize waste fire management. These technologies can significantly improve the accuracy of identifying, monitoring, and ultimately mitigating waste fires, making them indispensable tools in the fight against this complex issue. This article offers a comprehensive and in-depth examination of the historical evolution of waste fires, with the aim of shedding light on the critical factors that contribute to their occurrence. We explore the scientific mechanisms by which waste fires lead to environmental pollution and public health crises, providing a holistic understanding of their far-reaching impacts. We present an overview of significant research initiatives, policy interventions, and technological solutions that have been proposed or implemented by authoritative bodies around the world. By synthesizing existing research and offering new insights, this paper aims to facilitate a deeper understanding of the intricacies of waste fires and spur innovative solutions for their sustainable management and eventual eradication. Therefore, this article focuses on environmental and human health problems while outlining the comprehensive approach and potential contributions to solving this critical issue.

**Keywords:** air pollution; climate change; greenhouse gas (GHG); particulate matter (PM); soil pollution; waste fires



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## 1. Introduction

Waste fires occur because of the intentional and unintentional burning of waste substances, such as plastics, food items, garbage, or other waste materials. These fires might produce harmful pollutants and chemicals in the environment, causing a threat to the atmosphere and public health. Waste fires are also waste resources and can spread fast, posing a threat to surrounding spaces. The incidents of waste fires are becoming a major and growing problem in several countries, leading to critical health and atmospheric problems [1]. Waste fires generally arise when waste, such as household garbage, is burnt without taking appropriate measures, often generating gases and chemicals into the environment. This is most dangerous in areas with a dense population, where the impacts

of waste fires can spread quickly, causing damage or harm to the atmosphere and public health, raising significant awareness among people affected by the unfortunate health and socioeconomic impacts of waste fires [2]. Waste fires have been considered to harm public health basically by increasing ambient exposure to dangerous chemicals [3]. The impacts of waste fires might be described into two main parts: deliberate and accidental. Waste fires of the deliberate type are generally set by humans looking to throw off their wastage rapidly and cheaply. In addition, accidental waste fires generally occur due to carelessness, such as the butt of a cigarette thrown into a trash bin or the storage of waste materials near a heat source [4].

The effects on the environment and people's health of waste fires are far-reaching and could have long-term consequences. Waste fires produce toxic gases and chemicals into the climate, including particulate matter (PM), nitrogen oxides, and carbon monoxide. Burning biomass waste materials releases heavy toxic air, soil, and water, such as volatile organic compounds and polycyclic aromatic chemicals. These pollutants might have a critical effect on the health of the elderly, pregnant women, and children, who are more sensitive to the dangerous impacts of air pollution. Additionally, exposure to the smoke generated by this incident would cause headaches, eye irritation, and even nausea. There are a total of 339,000 premature deaths per year that could be ascribed to vulnerability to waste fire smoke through the increased risk of diseases related to the respiratory system, such as hypertension, asthma, respiratory infections, and cardiac arrest [1,4–7]. It is also responsible for global warming, which is expected to improve as heavy heat strokes are faster. Understanding the underlying mechanisms of the health and environmental issues of waste fires is critical to obstructing the related burden of these diseases. Figure 1 shows the Venn diagram representing the local, regional, and global impacts of waste fires.

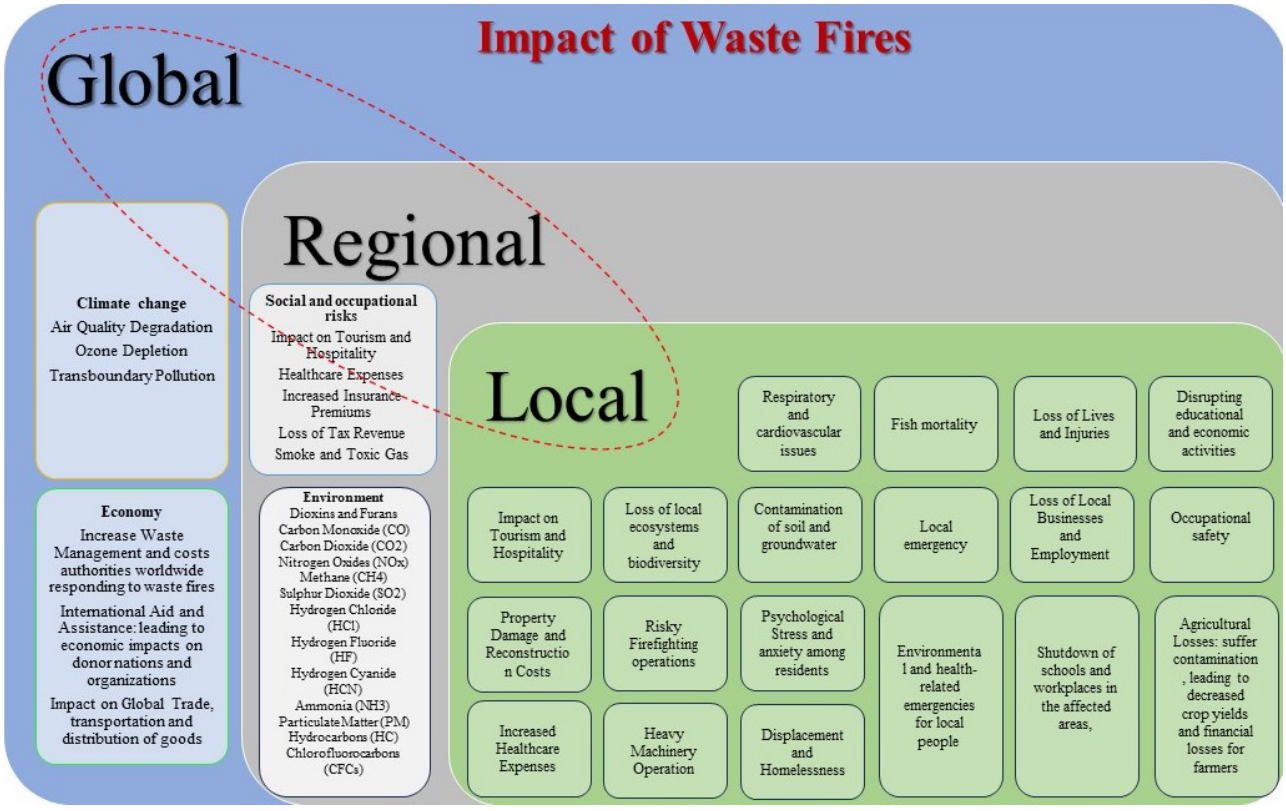


**Figure 1.** The local, regional, and global impacts of waste fires.

The incident of fire in waste is common in all parts of waste recycling and affects every business that is responsible for the collection, sorting, reassessment, recycling, transportation, and recovery of energy from waste materials. Management of fire risk in waste

facilities is necessary. This is because waste disposal facilities represent a necessary social function, and fire incidents in the facilities of waste management facilities could impact the entire society. By circumventing the risk of fires, obstructions in generation could be avoided in nearby businesses and waste facilities. Obstructing fire risk in waste facilities and controlling it in a real way can also provide assistance for the sustainability of the environment with fewer discharges into the air and minimize the consequences for the residents in the community [8,9]. One of the biggest challenges in waste management is a random fire that causes numerous problems for the companies of waste management companies. Various causes are responsible for the ignition of fire in waste management, such as human error, improper waste storage, friction, and technical or electrical failure. Incidents of waste fires are gradually becoming major forerunners of wildfires, although previously, accounting for environmental and socioeconomic cripples of both is executed in separation from each other, without caring about the effect of their compound [10]. It is necessary to take measures to prevent waste fires from occurring due to the increasing serious health and environmental impacts of waste fires. The best way to reduce waste fires is through appropriate waste management, involving the waste separation into multiple categories, such as non-organic and organic waste, and assuring that it is accurately disposed of through compost, recycling, or other types of waste management. Thus, the risk of fire from waste could be reduced with proper waste management, and it is also helpful to decrease the amount of garbage that is filled up on the landfill site.

The burning of crop residue is also considered waste fires and is the biggest problem in developing countries such as India, Pakistan, Bangladesh, etc. Determined global projections and scenarios are used to estimate long-term food security at the global level in an area of socio-economic and environmental change scenarios (see Table 1). One of the major problems today the world deals with is the scarcity of food items for the rapidly growing population of humans [11]. To meet the current and prospective demand for food, the agricultural field needs to produce more food grains. As the area, quantity, and number of food grains grown have increased rapidly in recent years, crop residual management is a serious challenge.

**Table 1.** List of reported dumpsite waste fire incidents in developing countries.

| Year/Month | Area, Country | Name of Dumpsite | Causalities |
|---|---|---|---|
| 2000, July | Metropolitan Manila, Philippines | Payatas dumpsite | 200 [12] |
| 2005, February | Bandung City, Indonesia | Leuwigajah dumpsite | 143 [13] |
| 2015, December | Shenzhen, China | Hongao dumpsite | 77 [14] |
| 2016, April | Guatemala City, Guatemala | Guatemala dumpsite | 24 [15] |
| 2018, March | Maputo City, Mozambique | Hulene dumpsite | 16 [16] |
| 2017, September | Metropolitan Delhi, India | Okhla landfill | 2 [17] |
| 2017, April | Metropolitan Colombo, Sri Lanka | Meethotamulla dumpsite | 34 [18] |
| 2017, March | Addis Ababa, Ethiopia | Qoshe dumpsite | 113 [19] |

The residual burning produces various environmental problems. Recently, air quality in the northern part of India was severely affected due to the burning of agricultural waste generated after harvesting rice crops, which happens every year [20]. Due to the lack of efficient and affordable agricultural waste removal techniques, farmers are burning crop residues in open environments to clean the area and prepare for the next crop [21]. Figure 2 shows the haze and fog that occurred in the northern part of India due to the open burning of agricultural waste. One of the biggest environmental problems facing humanity is waste management [22]. Fire in garbage facilities is a serious problem that occurs regularly and has several negative effects on the environment. Previous research has demonstrated that high levels of pollution are created as a result of fires in municipal trash. Additionally, combating fires that start in garbage storage facilities is typically difficult. Some of the causes are the abundance of fire hazards and the large volume of fuel accessible in sanitary landfills [23]. Therefore, fires in garbage facilities can cause considerable environmental

damage. Due to the high emissions over an extended period of time, it can have an impact on nearby residential areas and other social functions. Ecology can be negatively impacted by smoke emissions along with the surge of damping water.

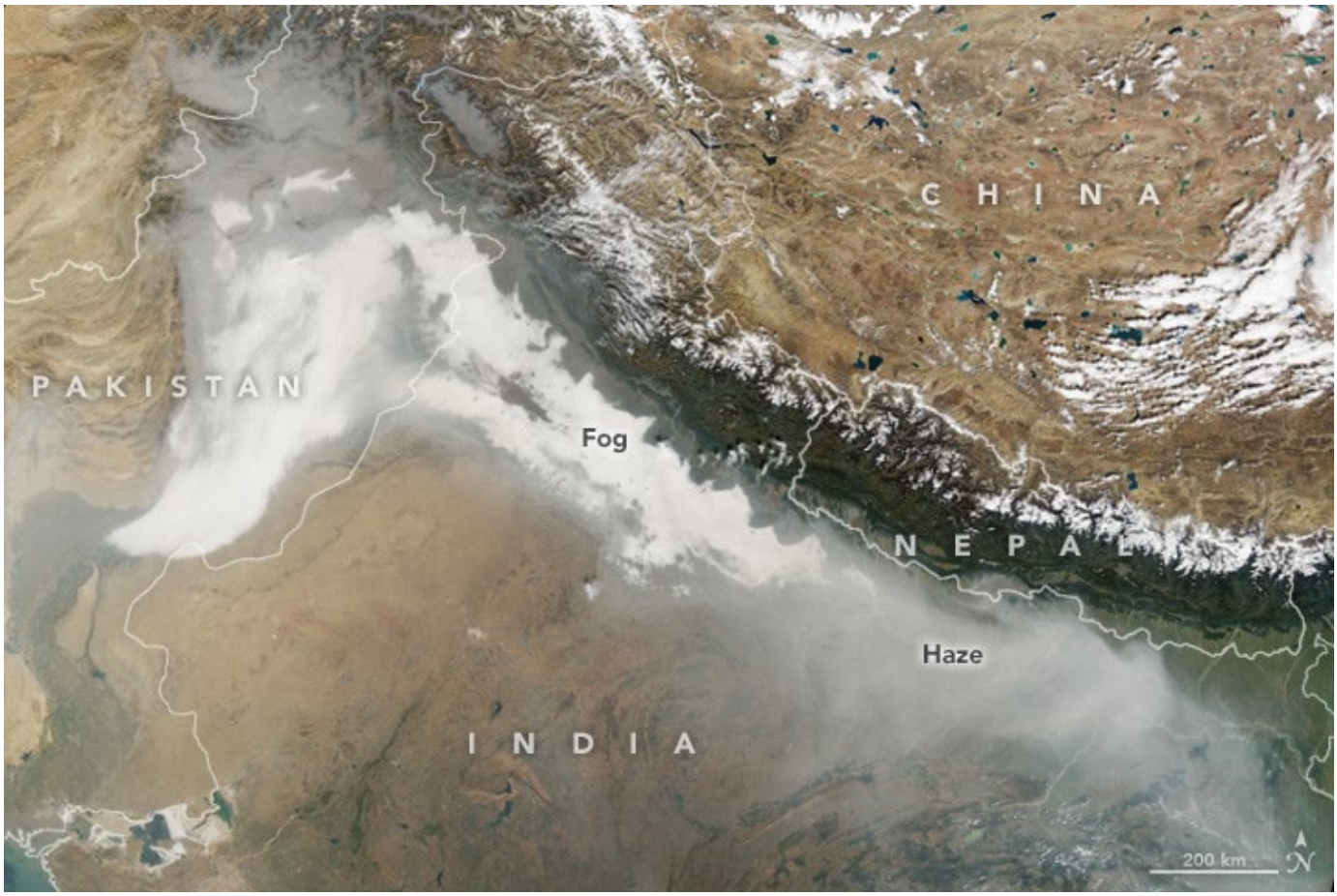


**Figure 2.** The haze and fog distribution over the northern part of India due to the burning of crop residue on 8 November 2017, taken by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite Earth Observatory [24].

*The Previous Review Works*

The problem of waste is a global one that is unlikely to be solved. According to the World Bank report, the levels of solid waste generation have recently increased and are expected to increase sharply in the forthcoming years to 2.2 billion tons per year in 2025 [25]. Unwanted materials, by-products, and hazardous products are burnt in an open place, usually at low flame, without any kind of management, and are considered waste fires in waste management sites [26]. It is used to reduce the volume of waste items. In recent decades, many researchers and technologists have been working to develop an optimal waste management system to combat the issue of waste fires. Battiston et al. [27] present an investigation of accidents related to a case study of a real fire incident in a waste disposal using numerical simulation. This study used an actual case of a waste fire incident in an industry in the northern part of Italy. The fire started in a pile of unsorted municipal trash and quickly spread to additional piles of leaves, wood, and storage spaces for plastic and paper products. Fire brigades were used during the experiment, which took a few hours to control and put out the flames, which helped reduce damage. This type of study allows for a comparison between model predictions and actual development. Savoshinsky et al. [28] present a technique for fire management during municipal waste transport using a geographical information system (GIS). The scenario of using geoinformation systems to

address the issue of fire safety in municipal trash transportation demonstrates the system's application. Zybina et al. [29] describe the safety of fire incidents at the municipal landfill for solid waste. The most common threat is open dumping fires because the production of biogas makes them easier to start, and thus, the resulting combustion products can be harmful to people. The use of computer modeling allows for the evaluation of the success of the actions carried out to overcome the problem of waste fires. This paper illustrates the construction of a fire protection system for the hazardous material dumping site using computer modeling.

Rykaa et al. [30] present the effects of a fire incident in an illegal landfill site located in the southern part of Poland by considering the generation of toxic chemicals and their corresponding influence on the climate. The objective is to provide research findings on the toxicity of garbage from a fire at a Trzebinia landfill site in Poland. Both the waste and soil samples are estimated in this document. Burnt garbage might contain contaminants that are dangerous to the health and safety of land and water. As a result, it is crucial to carry out studies and combat the harmful impacts of trash fires. Aderemi et al. [31], using a filthy dump in Lagos, Nigeria, as a case study, offer an attempt to provide some information on landfill fires and their possible health implications. This study indicates that the Nigerian government must have a strict and potential law and management policy to stop waste fires at waste landfills to overcome the issue of various health and environmental consequences. Ichinose et al. [32] present a study on the relationship between illegal dumping and waste management. This study indicates that the lack of facilities for intermediate waste processing has significantly increased the incidence of illegal dumping. Øygard et al. [33] describe the impact of a mismanaged fire incident and the corresponding requirement of a firefight for the chemical generation of landfill leachate. By digging and using water to cool, the fire at the dump location was extinguished in this research article. This paper estimates various chemical compounds generated from the landfill site.

## 2. Some Major Impacts of Waste Fire on Environment and Human Health

A current hot topic is environmental contamination. There is pollution of air, soil, and water. All types of open burning are harmful to the environment and the people. The air we inhale is polluted by smoke. Our land, freshwater, reservoirs, river systems, and streams are contaminated with ash. Anything that you burn outside can start a wildfire. The probability of these negative consequences can be reduced by burning only substances that have been allowed and by adhering to state rules and regulations. About 41% of the garbage produced worldwide is burnt openly. However, in the developing world or low-income countries, these data are higher. In less-rich countries, it might be challenging to build a successful garbage collection or disposal system. At every recognized municipal solid waste disposal site, eight pollution tracking parameters are ammonia ($NH_3$), carbon dioxide ($CO_2$), carbon monoxide (CO), hydrogen sulphide ($H_2S$), methane ($CH_4$), nitrogen dioxide ($NO_2$), sulphur dioxide ($SO_2$), and suspended particulate matter [34]. Waste open fire is popular because it is inexpensive, effective, and fast, but this process is very harmful to the environment. The open burning of garbage might increase soil, water, and natural toxins, as well as emit several harmful chemicals into the air. Waste fires are responsible for many environmental problems, such as air pollution, soil pollution, water pollution, GHG emissions, loss of biodiversity, and climate change. Burning waste makes our environment more fragile. Due to their small size and capacity to remain suspended in the air, discharged contaminants can be deeply breathed, causing persistent bronchitis, asthma, and other respiratory disorders. Over time, these factors increase mortality, especially in vulnerable populations like children and the elderly. The loss of biodiversity is a quiet disaster. Every lost species reduces ecological resilience, harming agricultural pollination and forest health. Global ecology irreversibly alters when pollution makes areas uninhabitable, causing species extinction in light of global climate change. Figure 3 shows the major impacts of landfill fire incidents on climate and human health.

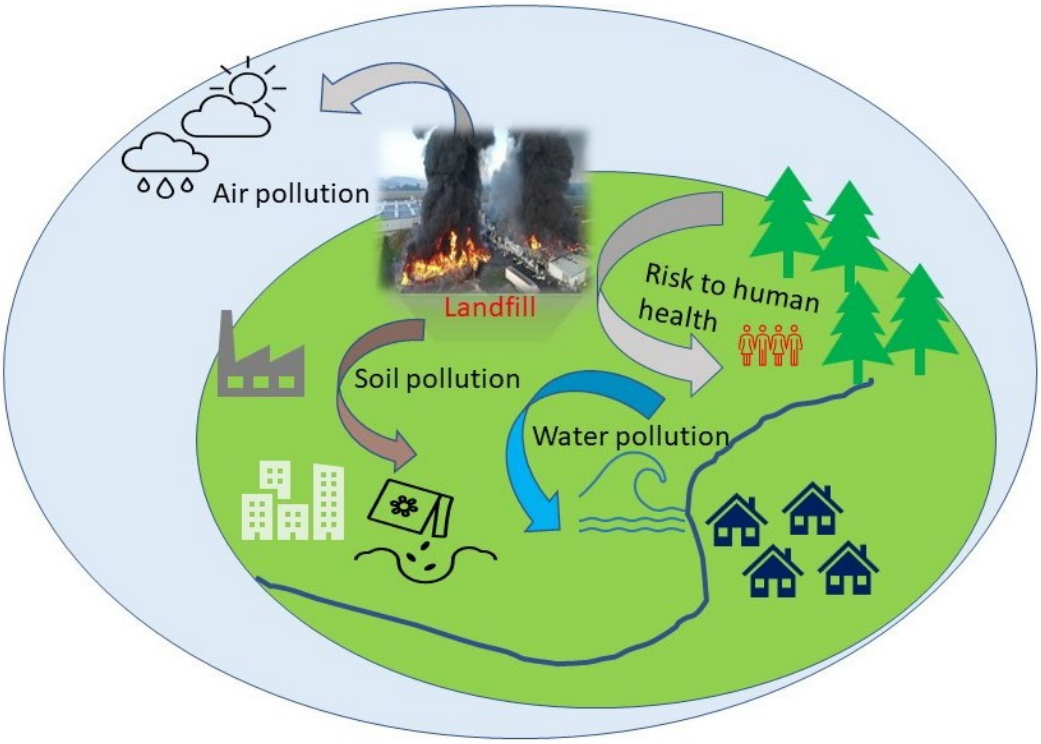


**Figure 3.** The major impacts of fires from waste landfills are on the environment and human health.

### *2.1. Air Pollution*

Waste fires contribute to air pollution by releasing a variety of dangerous chemicals into the environment, including dioxins, particulate matter, toxic materials, and furans [35]. There has not been much discussion of the importance of numerous garbage burnings as a local or global cause of air pollution [36]. Due to the intense heat present during a fire, the smoke that is released is usually immediately elevated and spreads much above ground level [37]. Sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) from waste burning cause acid rain. These emissions produce acids with water vapor in the atmosphere. Acid rain harms ecosystems, soil, and buildings [38]. This issue addresses acid rain's environmental effects and air pollution from uncontrolled trash burning. Burning forbidden substances, such as trash, plastic, and painted or varnished wood, damages the atmosphere because these substances produce carcinogens that contaminate our air. Smoke and dust can cover large areas. People may find odors irritating. Smoke traces and smells both have the potential to infiltrate homes or influence things outside of them, such as automobiles or hung clothes. Significant volumes of GHG are released into the atmosphere during open garbage burning; these substances include methane ($CH_4$), carbon dioxide ($CO_2$), and different sizes of particulate matter, such as $PM_{2.5}$ and $PM_{10}$, which are frequently associated with poor air quality and can cause serious cases of respiratory illness [39–42]. Some other hazardous chemicals are responsible for causing cancer, such as polyaromatic hydrocarbons (PAHs), including benzo(a)pyrene (BAP), released into the air as a result of uncontrolled combustion of organic materials or agricultural containers or bags contaminated with pesticides or other dangerous harmful substances, which are also released into the air [42,43]. Furthermore, pollutants emitted by open landfills can corrode metal fencing and damage the paint of the house. Figure 4 presents the list of harmful chemicals released after waste fire incidents.

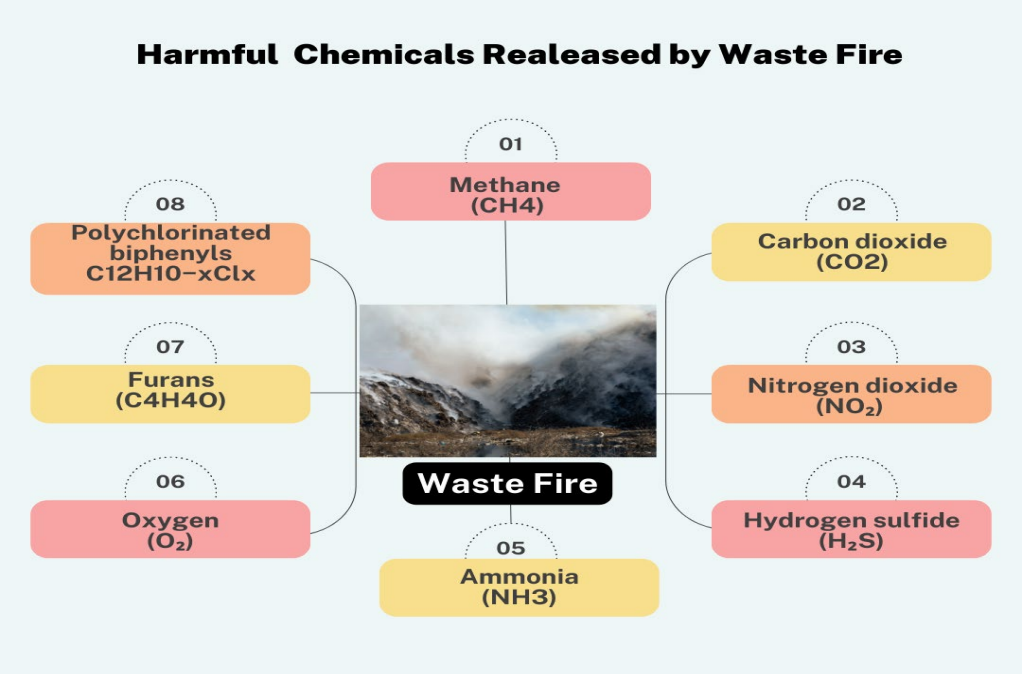


**Figure 4.** List of harmful chemicals released after waste fire outbreaks.

### *2.2. Soil Pollution*

The accumulation of persistent poisonous substances, chemicals, acids, toxic isotopes, or disease-causing factors in soils that have a negative impact on plant and animal health is called soil pollution. The largest portion of environmental contamination is carried out by soil since it is a "universal sink" [44]. It is contaminated in many ways. To maintain soil fertility and increase productivity, it is vital to prevent soil contamination. Soil contamination is also caused or is being exacerbated by the large amounts of man-made solid waste, sewage, waste fires, landfills, and other products of modern treatment plants for waste, even contaminated water [45,46]. The temperature and landfill gases produced during the decomposition of organic waste products are likely to cause unintentional combustion, and sometimes, the garbage is purposely burnt. Polycyclic aromatic hydrocarbons (PAH), mainly those without alkylated hydrocarbons, are often formed through incomplete combustion activities, while methylated PAHs are more indicative of biogenic origins [47]. The creation of hazardous substances, mainly PAHs, can result from high-temperature combustion of organic and biomass matter. Ashes, smoke, and charcoal are examples of pyrogenic materials in which PAHs can be found. The presence of ash and charcoal can significantly increase the toxicity of soils and water sources [48,49]. The primary issues with PAHs are their ability to cause human cancer, genotoxicity, persistence, and biosorption. These all-hazardous chemicals generated by incomplete combustion of waste are responsible for soil contamination. Furthermore, fires have been observed to promote the formation or remobilization of polychlorinated biphenyls (PCB), polychlorinated dibenzofurans (PCDF), and polychlorinated dibenzo-p-dioxins (PCDD), which will be important due to their possible impacts on people and wildlife [50,51]. Both inorganic and organic chemicals have the ability to function as environmental pollutants in the soil and pose risks. Trace elements that include cadmium (Cd), arsenic (As), chromium (Cr), copper (Cu), manganese (Mn), nickel (Ni), mercury (Hg), lead (Pb), nickel (Ni), manganese (Mn), zinc (Zn) and radionuclides are the most frequently found inorganic soil pollutants [52,53]. However, mercury (Hg) is sensitive to the heat emitted during a waste fire in high amounts, in addition to environmentally damaging toxins that brutally affect respiratory organs and the brain.

Organic substances are carbon-based compounds, and many of them are anthropogenic in nature and, to a lesser extent, substances originating from environmental events such as volcanic activity or wildfires. Figure 5 describes the list of chemicals that can easily contaminate soil. Synthetic organic pollutants created for certain purposes, such as insecticides like endosulfan, hexa-chlorobenzene (HCB), dieldrin, dichlorodiphenyltrichloroethane (DDT), and hexachlorocyclohexane (HCH, lindane), or as intermediate or industrial chemicals, such as polychlorinated biphenyls (PCBs) and volatile organics (VOC), can be the source of soil contamination. Pyridinium fluorochromate (PFC) and polybrominated diphenyl ethers (PBDE). (PBDE) are also responsible for soil pollution [54,55]. Therefore, as a result, any of these chemicals that have been kept and discovered during the prolonged existence of garbage at the landfill site have the potential to be discharged into the soil in the event that waste fire occurrences occur at the landfill location.

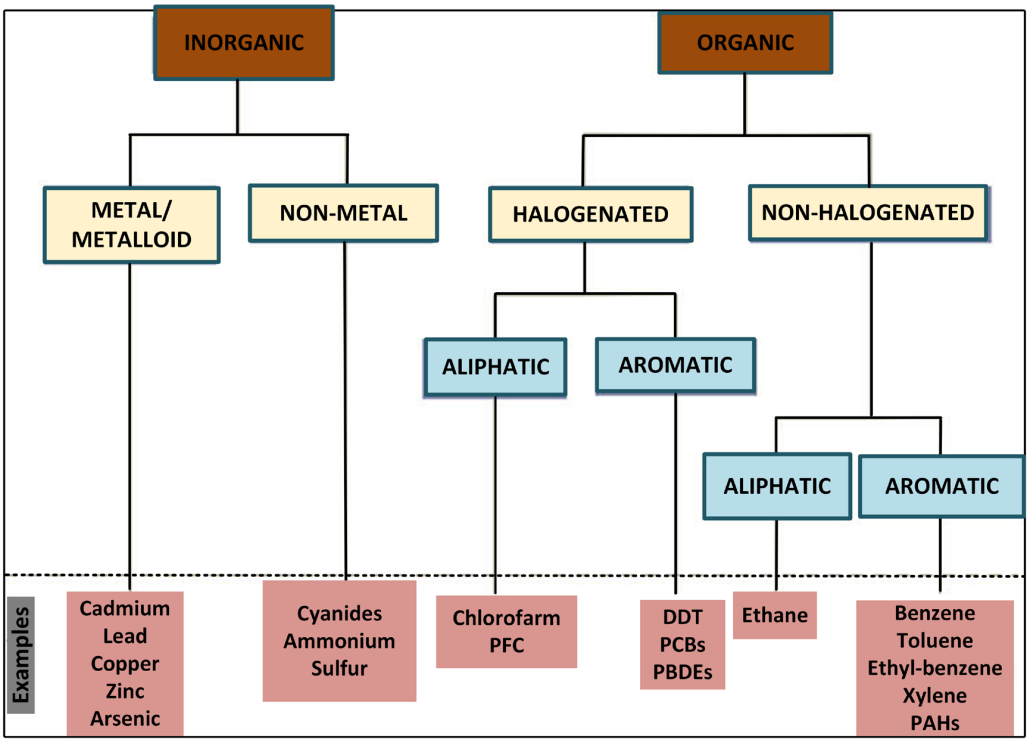


**Figure 5.** Categorization of the most important soil pollutants [54,56].

### *2.3. Water Pollution*

Human activities can also lead to water pollution that puts waterways at risk or reduces their quality. For example, wildfires and waste fires can destroy lakes and make them acidic. Both increased population and industrialization create risks to freshwater resources, including lakes. Lakes and other freshwater sources provide freshwater for houses and community groups, as well as support a variety of biomes; therefore, maintaining these resources is crucial. Tragically, garbage is occasionally dumped near lakes without considering the effects. In certain places, the disposal of industrial waste is still not tightly regulated. Although we are aware of how essential lakes and other waterways are, man-made contamination sources persist [57,58]. While there are set-up rules for the dumping of harmful industrial waste, these contaminants are thrown into ponds or waterbodies that link lakes. The US Environmental Protection Agency (EPA) has identified two forms of water pollution: point-source and nonpoint-source. The EPA defines point-source pollution as pollution from a single source, such as smokestacks, drainage tubes, industrial waste, wastewater treatment plants, factories, and power plants. Nonpoint source pollution is a mixture of pollutants discharged from a vast area. Pollution occurs from multiple sources, making it harder to identify and handle (e.g., thunderstorms, runoff, oils, grease, animal

waste, pesticides, and fertilizer) [59]. Together with industrial pollution, some people also contaminate lakes by dropping trash or waste in them [60].

Agriculturally based pollutants that impact groundwater include pathogens, nutrients, metals, pesticides, and salts. Furthermore, dangerous compounds released into river water by urban operations are present in partially treated and untreated sewage, solid/liquid waste, and construction waste components, which are also the main source of water contamination [61]. Acid rain is the result of the emissions of sulphur dioxide ($SO_2$) and nitrogen oxide ($NO_2$) from chimneys and exhaust pipes, which are produced by manufacturing companies and can have a negative influence on the environment and human health [62]. A solid landfill liner is not always required, although landfill drainage from garbage disposal is a known reservoir for groundwater contaminants. Therefore, waste disposal and waste fires have a wide impact on the quality of water in several ways.

### *2.4. Impacts on Human Health*

The burning residue can contaminate land and groundwater and infect vegetables and cattle, which can then infiltrate the human food supply. Furthermore, some specific chemicals released during waste fires might accumulate in animal fats and later in people because we consume dairy products, meat, and fish. Those who live close to a landfill fire have adverse health effects from toxins released during the burn. The width between communities and the location of the waste fire is one of the most crucial variables in determining the influence on health. In general, the presence of PM10 in the air due to fires at landfill sites greatly affects the health of humans [63]. There is a specific relationship between PM10 concentration in the air and the relative increase in the death risk. The particles of waste combustion also contain varying amounts of sulphur, and the acidic nature of sulphur compounds (e.g., ammonium sulphate, ammonium bisulphate, or sulfuric acid) makes the transition metals in particles more bioavailable, greatly increasing the potential of waste combustion PM2.5 to cause oxidative stress and systemic health effects [43,64,65]. People who are exposed to these pollutants in the air usually experience headaches, coughing, eye and nose irritation, and breathing problems. Individuals who suffer from respiratory diseases, including emphysema, asthma, and heart disease, are particularly vulnerable to environmental pollution. Environmental pollution can also exacerbate allergies, lung infections, bronchiolitis, and pneumonia [66,67]. Chronic diseases of the respiratory and cardiovascular systems, kidney problems, cancers, tumors or malignancies, and diseases of the lymphatic and hematological systems are only a few of the long-term impacts of trash burning. According to certain research, landfill fires can affect the reproductive system, fetuses, newborns and the onset of congenital abnormalities [68–70]. Figure 6 shows some of the major health problems associated with waste fires and landfills.

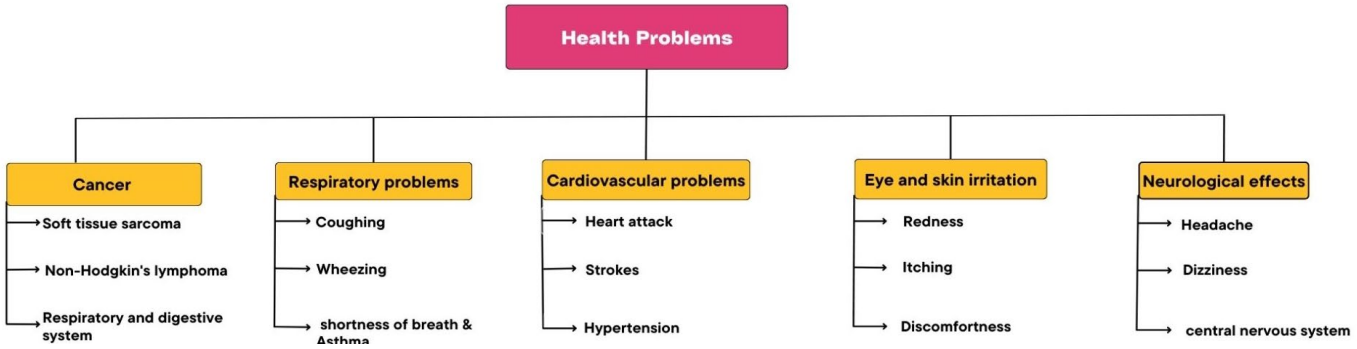


**Figure 6.** Major health problems associated with waste fires.

The harmful health effects brought on by prolonged exposure to heavy metals, their quantities, and how they enter a person's body might cause their persistent buildup in the liver and kidneys, which may disrupt a number of metabolic processes, which aggravate

conditions and illnesses of the neurological, skeletal, kidney, and cardiovascular systems. Exposure to heavy metals has been shown to have harmful effects on health: respiratory tract, nose, sinuses, and lungs; while drinking contaminated water may increase your risk of colorectal, stomach, and oral cancer; hearing loss; kidney and liver dysfunction; problems in the central nervous; neurological conditions that include excretion and hypersensitivity diseases as well as numbness or tingling, postural hypotension, and neurodegenerative disorders [71,72].

### *2.5. Impacts on Social Economy*

Waste fires pose a multidimensional threat to the social economy. Uncontrolled garbage combustion releases several dangerous compounds and contaminants into the environment. Air pollution can cause several health problems in local communities [73,74]. This increases healthcare costs and reduces productivity due to lost labor hours. In addition, such fires destroy recyclable materials. It eliminates recycling revenue and increases waste, which harms the environment. Waste fires can damage infrastructure such as recycling plants and landfills, requiring costly repairs or replacement. Fires cause more than just immediate costs. Given the health risks and stigma of these incidents, the prices in adjacent neighborhoods drop. This can also affect tourism, as environmental views can strongly influence traffic. Waste-fire-ravaged regions may lose tourism, hurting their economies. Another financial burden is fire cleanup, which typically requires specialized processes to mitigate environmental damage. Recurrent fires in waste management facilities can cause temporary or permanent shutdowns, causing job losses. Waste management companies may face rising insurance prices if they are considered high-risk due to frequent occurrences [75,76].

## 3. Safety Measures to Mitigate Waste Fires

Most waste fires occur in waste landfills that have been continuously filled even though the landfill site is beyond its optimal capacity. Waste fires that occur in landfills are either started as a result of chemical reactions and increased temperature or intentionally to reduce the volume of waste. A substantial amount of dangerous toxic chemicals is produced in high concentrations by landfill fires, and these pollutants can spread over great areas by dense clouds of toxic smoke [77]. Fires in the garbage can have significant negative impacts on the environment or seriously harm human health. There are several methods to limit or avoid these impacts, such as blocking waste fires, limiting the extent and expansion of fire, and reducing the consequences of waste fire consequences. However, all of these measures need proper planning and organization. While the mitigation of waste fires can be done in various ways, one of the best approaches based on our studies is to focus on the following strategies.

- Design and layout of the waste management facility
- Appropriate organization and planning
- Reception of garbage products
- Storage and handling of waste products
- Proper action during fire incidents
- Adequate action plan after a fire outbreak

These particular courses of action are suggested to reduce the risk of waste fire in several facilities depending on the process of handling waste and the strategies determined for a possible future fire outbreak. In other words, the storage strategy affects the emergency action plan, and the estimation of the input for the extinguished water depends on the strategies specified in the action plan and the order considered with respect to the extinguished media utilized. Thus, entire plans must be admitted, developed, conveyed, and trained before the occurrence of waste fire. Table 2 shows the recommended course of action to mitigate waste fires.

**Table 2.** Recommended measures for the mitigation of waste fires [78–81].

| Course of Action | Recommended Measures |
| --- | --- |
| Design of waste management | 1. Make sure that there is space for material transport.<br>2. Make sure that extinguishing equipment is available.<br>3. Verify that there is enough lighting at the facility.<br>4. Design for a fire detection system and perhaps automatic process stopping |
| Organization and plans | 1. Develop a storage strategy that addresses how to classify and preserve various waste fractions.<br>2. Create an emergency action plan.<br>3. Investigate extinguishing water sources.<br>4. Create schedules and procedures for operation and maintenance.<br>5. Prepare sampling techniques and tools.<br>6. Create a fire detection strategy that includes manual monitoring.<br>7. Share the safety work.<br>8. Identify the roles and the alarm alert chain. |
| Waste reception | 1. Set up a waste control reception.<br>2. Direct risk percentages to certain locations<br>3. Set requirements and communicate them upstream within the delivery cycle. |
| Storage and handling of waste | 1. Setup procedures for storage design<br>2. Restrict the size of garbage piles and the duration of storage.<br>3. To prevent the spread of a fire and make it easier to put it out, provide adequate distance between stacks. |
| During fire outbreaks | 1. Develop a plan and make sure that you have access to drivers and packers.<br>2. Contact the rescue organization.<br>3. Gather runoff water and sample it.<br>4. Provide a safe working environment and enough safety equipment.<br>5. Think about rerouting incoming garbage and stopping some processes. |
| After fire incident | 1. Handle waste that has been harmed by fire and contaminated runoff water.<br>2. Analyze if buildings need to be sanitized.<br>3. After a fire, evaluate the situation.<br>4. Record your experiences and results.<br>5. Create a strategy for training and growth.<br>6. Regularly practice fire drills. |

It is crucial to realize that even if several actions are suggested, this does not imply that these policies must be implemented uniformly throughout all facilities. What measures are adopted depends on the activities taking place in the facility, the item that is being held, as well as local laws and other circumstances. There are several regulations that define maximum altitudes and transitions between trash piles. They may be helpful in certain circumstances, but it is important to understand that risks vary based on the sorts of fractions and combinations [82]. To effectively handle garbage, the essential heights and space between stacks could change. Moreover, crucial stack sizes and separations depend not only on the threat of fire expansion but also on the likelihood of effective and safe firefighting operations by the rescue and fire departments. This must be considered when stacking the debris in long rows or blocks. It is important to consider how different forms of barriers are used [83].

In recent decades, several models have been invented for the simulation of waste fire mitigation. For the modeling of material dispersion throughout the atmosphere, a variety of models are known regarding the space and time data collected by using meteorological conditions, such as AERMOD presented by the US EPA (United States Environmental Protection Agency) and generally considered for short-range impact up to 50 km, the California Puff (CALPUFF) created by the US EPA and considered for the long range of more than 50 km, the Community Multiscale Air Quality (CAMQ) system for modeling was developed by the US EPA in 2019 which is responsible for the evaluation of chemical

reactions in the environment, and many more [84,85]. These models are developed and used to address the issue of waste fires and their relative impacts on the environment.

The importance of policies and regulations in prevention and control cannot be understated, as effective risk assessment and zoning can ensure waste management facilities are located away from vulnerable areas while stringent waste storage and disposal regulations mitigate the chances of accidental fires. Modernizing waste management infrastructure, supported by government policies, can incorporate advanced fire prevention systems. Equally vital is regular training of personnel in these facilities and instigating public awareness campaigns about the dangers and preventatives of waste fires. Regular inspections by authorities will ensure compliance with safety standards, and penalties for violations can act as effective deterrents. Collaborative research and stakeholder engagement, underpinned by a dedicated regulatory body and incentives for green technologies, can further strengthen the overall framework. A combination of preventive strategies and responsive measures, driven by well-designed policies, is pivotal in mitigating the risks and repercussions of waste fires [86,87].

In general, several studies have been created for the evaluation of durability, breakdown, or vulnerability in landfills, including slope instability and problems of specific design elements such as failure of the gas/leachate collection system, for example, or of the lining. The Delphi method and conventional hydrological risk assessments can be used to analyze the failure of the landfill liner [88]. Remote sensing can be used to monitor risk factors and areas of fire occurrence at the landfill site for waste management. After the integration of artificial techniques into remote sensing technology, remote sensing might be useful to mitigate various environmental issues created by open fires [89,90]. Artificial intelligence can play a vital role in protecting the environment. The Monte Carlo simulation technique and the first-order reliability technique with an artificial neural network are used to examine the stability of the reliability of the landfill on the gradient in several parameters of rainfall [91] by developing a unique probabilistic risk assessment approach that uses Taylor series and Monte Carlo techniques to analyze the risk of slope failure in landfills from both the vulnerability and the hazardous perspectives [92]. These initiatives have gone far in taking safety measures into account to control the incidence of failure in various engineering elements of landfill engineering during the design and operating stages.

## 4. Conclusions

Solid waste from municipal landfills could be dangerous to the environment and people's health because of poor management, as well as a lack of adequate prevention schemes. This research attempted to assess the health risks and environmental damage related to waste combustion and landfilling. The information was acquired using a desk evaluation design and from publicly existing sources. The three main topics of the reviewed literature were waste disposal sites, environmental contamination due to waste burning, human health problems due to waste fires, and appropriate measures to overcome this problem. Many dangerous gases such as carbon dioxide ($CO_2$), hydrogen sulphide ($H_2S$), methane (CH4), and many more can be released from landfills and waste fires. This research paper also provides some details on model simulation to combat waste fires and their corresponding impacts on the environment and human health. These toxins have been associated with problems with the lungs and some cancers, such as lung cancer. Soil pollution and water pollution from open fires and waste fires have been discussed in detail. In addition, this article provides an extensive study of waste fires and landfills on the environment and human health, as well as possible techniques for the elimination of this problem.

We provide a comprehensive background on how we can overcome this problem, as waste combustion and landfilling represent serious threats to human and environmental health and must be addressed comprehensively. Enhanced waste management strategies should be prioritized first. Recycling, composting, and garbage minimization should be prioritized to reduce the load on landfills. Furthermore, improvements in landfill layout and

consistent maintenance are crucial. The negative effects on the surrounding environment can be mitigated by the installation of cutting-edge gas collection systems and efficient leachate treatment facilities. Public education initiatives also play a crucial role. Waste fires can be greatly mitigated if the public is made aware of the many ways in which they can cause harm to the environment and people's health. These steps, taken together, provide a detailed plan for improving the sustainability and safety of waste management. The findings of this study indicate that the lack of facilities for intermediate waste processing has significantly increased the incidence of illegal dumping and will contribute to the research community, where early-stage researchers can obtain the state of the background of waste fires. The findings of this study indicate that the lack of facilities for intermediate waste processing has significantly increased the incidence of illegal disposal.

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