A Study and Analysis on Waste Fires in India and Their Corresponding Impacts on Environment and Human Health

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A Study and Analysis on Waste Fires in India and Their Corresponding Impacts on Environment and Human Health

Rakshit Jakhar, Preeti Sachar

Abstract*: Waste fires are one of the biggest problems in India that cause various problems to the environment and human health. This article thoroughly investigates the negative impacts of waste fires on the environment, public health, and the economy and emphasizes the need for sustainable waste management practices, investment in waste management infrastructure, and stricter fire safety regulations by taking India as a study base. Education and waste management awareness programs are also important tools for promoting behavior change and achieving cost savings. The implications of waste management policies and practices in India and other developing countries are also discussed, including the need to promote sustainable waste management practices, enhance fire safety measures, encourage public participation, and strengthen regulatory frameworks. Overall, this research highlights the importance of addressing waste fires and promoting sustainable waste management practices for achieving a safer, healthier, and more sustainable society. The possible solution for the issue of waste management and waste fires in India has been discussed widely in this article to provide an overview for appropriate management of waste materials.

Keywords*: Air pollution, Health impact, Landfills, Waste fires, Waste Management.

I. INTRODUCTION

India faces significant challenges in managing its waste, particularly in urban areas. According to the Central Pollution Control Board (CPCB), India generates around 62 million tons of solid waste annually, of which only 43 million tons are collected, and 11.9 million tons are treated [1]. The remaining waste is dumped in landfills, leading to environmental pollution and health hazards. The waste management system in India is governed by the Municipal Solid Waste (Management and Handling) Rules, 2000 [2], which provides guidelines for the collection, transportation, and disposal of waste. However, implementation of these rules has been a challenge, particularly in smaller towns and rural areas. The waste management practices in India vary widely, with many cities and towns lacking basic infrastructure for the collection and disposal of waste [3]. Open dumping of waste is common, which not only creates a health hazard but also leads to the emission of greenhouse gases, contributing to climate change. There is also a lack of awareness among the public about the importance of waste segregation and disposal, leading to mixed waste being dumped in landfills. However, in recent years, there has been a push towards modernizing waste management practices in India, with a focus on sustainable solutions such as waste segregation at source, composting, and recycling [4]. Several cities, such as Bengaluru, Pune, and Surat, have implemented successful waste management models, including public-private partnerships and citizen-led initiatives. The Swachh Bharat Abhiyan (Clean India Mission), launched in 2014 [5], is a major government initiative aimed at improving sanitation and waste management in the country. The mission has led to increased investment in waste management infrastructure, including the construction of waste-to-energy plants, composting facilities, and decentralized waste management systems. Overall, waste management remains a major challenge in India, but there are signs of progress towards more sustainable and environmentally friendly practices. Waste fires in India are a significant environmental and public health issue. These fires occur when waste materials such as garbage, plastics, rubber, and other hazardous substances are burned in open dumps, landfills, or even on the streets. The smoke and toxic fumes produced from these fires can cause respiratory problems, eye irritation, and other health issues for nearby residents. India generates a massive amount of waste every day, and most of it is not properly disposed of. According to the Central Pollution Control Board (CPCB), India generates over 1.5 lakh metric tons of waste every day, and only 70-80% of this waste is collected, with only about 20-30% being processed or treated [1], [2], [5], [6]. The unprocessed waste that is left in open dumps or landfills becomes a breeding ground for waste fires. Waste fires in India are a common occurrence, especially during the summer months when the temperature rises, and the waste becomes more combustible. Artificial intelligence (AI) can be used to combat these issues in more precise and appropriate ways. AI is used for surveillance and monitoring of waste fire incidents and for waste management purposes [7]. Fig. 1. represents the average tons of waste dumped per day at the six major landfill locations in India. This dumped waste is a major cause of waste fires in these cities.

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*Correspondence Author(s)
Rakshit Jakhar*, Department of Geography, University of Mumbai, Mumbai, India. Email: therakshit27@gmail.com, ORCID ID: https://orcid.org/0000-0002-7929-5184
Dr. Preeti Sachar, Department of Geography, Swami Shraddhanand College, University of Delhi, Delhi, India. Email: preetisachar18@gmail.com.

These fires release toxic pollutants such as carbon monoxide, nitrogen oxides, and dioxins into the air, which can cause serious health problems for those exposed to them.

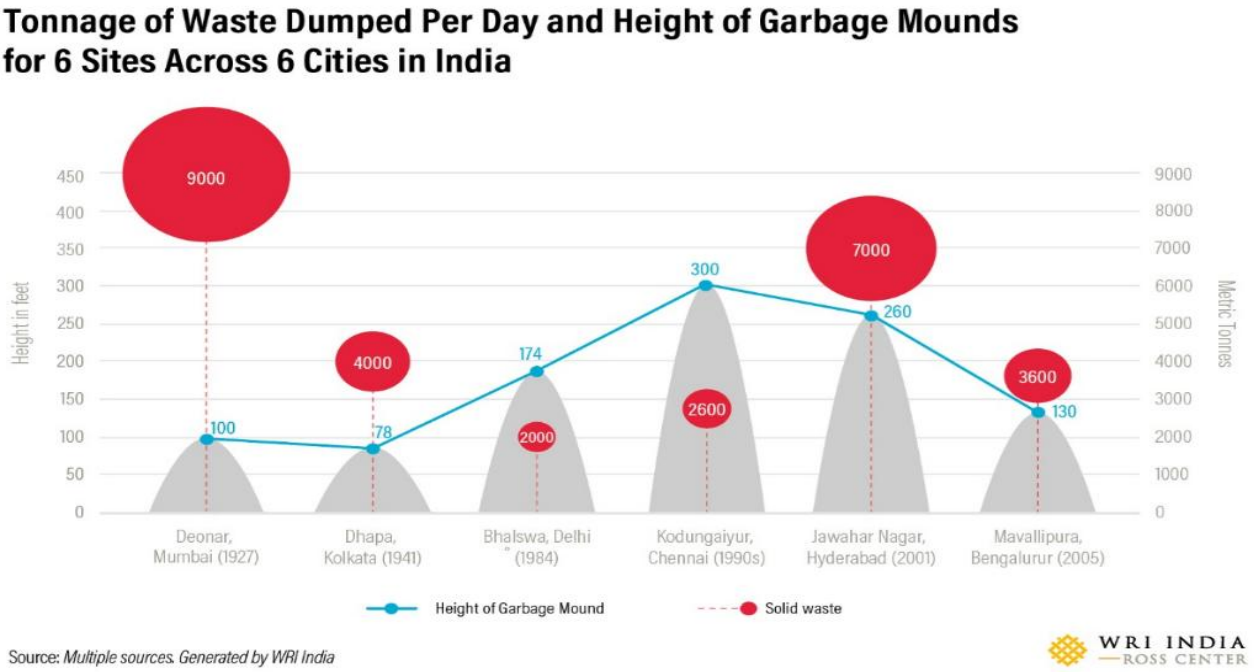

Fig. 1. Representation of six major landfill sites across India by average ton of waste materials dumped per days at these locations [8]

Waste fires also contribute to air pollution, which is a significant problem in many Indian cities. Fig. 2. Shows top six major landfill sites and these landfill locations are the major sources of waste fires among the corresponding cities.

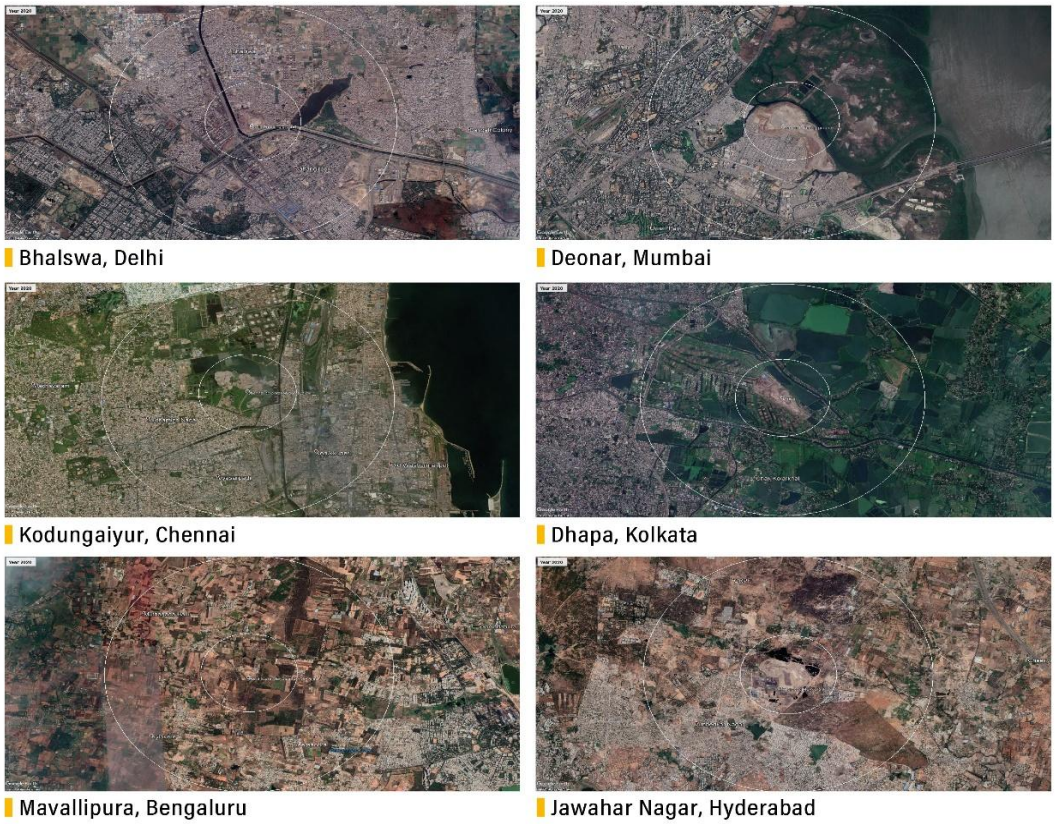

Fig. 2. List of six major landfill sites across India [8]

The world's 20 most polluted cities are in India, with air pollution causing over a million premature deaths each year. To address this issue, the Indian government has launched various initiatives to manage waste more efficiently and reduce the number of waste fires [9], [10], [11]. These include the Swachh Bharat Abhiyan (Clean India Mission) and the Solid Waste Management Rules, which aim to improve waste collection, segregation, and disposal practices across the country. However, much more needs to be done to address this issue and ensure the health and well-being of India's citizens [12]. The issue of waste management and waste fires in India is a complex problem that requires a multi-pronged approach. The Indian government and various NGOs have been working towards creating awareness among the public about the importance of waste segregation, proper disposal, and recycling [13], [14].

The government has also been investing in waste management infrastructure and implementing policies and regulations to improve waste management practices nationwide. However, the problem persists due to the lack of adequate infrastructure, funding, and proper implementation of regulations. Additionally, the issue of waste fires is often overlooked and needs urgent attention as it poses a severe threat to the environment and public health. Therefore, it is essential to focus on sustainable waste management practices, including waste segregation, recycling, and composting, to reduce the amount of waste that ends up in landfills and open dumps [15], [16]. Moreover, there is a need for strict enforcement of regulations, increased public awareness, and more funding for waste management infrastructure to tackle the issue effectively. Table 1. Shows some major waste fires incident in India over a few years.

The aim of the paper is to discuss the challenges and issues related to waste management in India, mainly focusing on waste fires, their causes, impacts on the environment and public health, and the initiatives taken by the government and NGOs to address these issues. Waste fires are also responsible sometimes for the islanding situation in the power system. Islanding is one of the bad situations in power system which creates power fluctuation in the power system [17]. The paper seeks to emphasize the need for sustainable waste management practices, increased public awareness, strict enforcement of regulations, and adequate funding for waste management infrastructure to effectively tackle the problem of waste fires in India.

Table 1. Waste fires in India, along with their location, impact, and causes.

S. No.	Waste Fire Incident	Location	Year	Impact	Cause of Fire	References
1	Deonar Dumping Ground Fire	Mumbai, Maharashtra	2016	Thick smog, respiratory problems, flight delays, school closures, thousands of tons of CO2 emitted	Unclear, possibly deliberate	[18]
2	Bhalswa Landfill Fire	Delhi	2016	Air pollution, respiratory problems, visibility issues, increased PM2.5 & PM10 levels	Unclear, possibly deliberate	[19]
3	Bandhwari Landfill Fire	Gurugram, Haryana	2018	Air pollution, respiratory problems, visibility issues, increased PM2.5 & PM10 levels	Unclear, possibly spontaneous combustion	[20]
4	Pirana Landfill Fire	Ahmedabad, Gujarat	2018	Thick smog, air pollution, respiratory problems, visibility issues	Unclear, possibly spontaneous combustion	[21]
5	Dadumajra Landfill Fire	Chandigarh	2021	Air pollution, respiratory problems, visibility issues, increased PM2.5 & PM10 levels.	Unclear, possibly spontaneous combustion	[22]
6	Pallikaranai Dump Yard Fire	Chennai, Tamil Nadu	2015	Air pollution, respiratory problems, visibility issues	Unclear, possibly deliberate.	[23]
7	Vellalore Dump Yard Fire	Coimbatore, Tamil Nadu	2017	Air pollution, respiratory problems, visibility issues, increased PM2.5 & PM10 levels, adverse effects on flora and fauna	Unclear, possibly deliberate	[24]
8	Sonsoddo, Garbage Dump Fire	Goa	2019	Air pollution, respiratory problems, visibility issues, increased PM2.5 & PM10 levels, adverse effects on flora and fauna	Electric Spark	[25]

II. METHODOLOGY

To comprehensively study the issue of waste management and waste fires in India, A thorough review of existing literature on waste management in India, waste fires, their causes, and consequences was conducted. This involved analyzing research articles, government reports, news articles, and case studies to gain an in-depth understanding of the current waste management practices and the extent of the waste fire problem in India. A selection of successful waste management models and initiatives implemented in various Indian cities, such as Bengaluru, Pune, and Surat, were studied to understand the best practices and strategies that can be adopted to tackle the waste fire issue. By applying the technology of human activity recognition at the landfill sites, we can easily monitor human behavior to protect landfill sites from possible intentional waste fires. We can consider the human activity recognition techniques discussed in Raj et al. [26], [54]. An analysis of government initiatives, such as the Swachh Bharat Abhiyan (Clean India Mission) and the Solid Waste Management Rules, was conducted to evaluate their effectiveness in addressing the waste management and waste fire problems in India. The roles and responsibilities of different stakeholders, including the government, private sector, NGOs, and the public, were analyzed to understand their contributions and potential in improving waste management practices and reducing waste fires.

Based on the findings from the literature review, data analysis, case studies, and stakeholder analysis, a set of recommendations was formulated to address the challenges related to waste management and waste fires in India effectively. Most of the data is collected and analyzed on the basic if news articles covering waste wires in India and their impact. The collected data can be saved for a long period for the future analysis of waste fires incidents with the help of optical character recognition techniques [27]. By following this methodology, the paper aims to provide a comprehensive understanding of the waste management and waste fire issues in India and offer potential solutions to tackle these problems. The major problem in India related to waste fires is not monitored or tracked specifically as it is very difficult to find the exact data related number of waste fires took place during the past years. We can implement the deployment of mobile robots at the landfill sites for tracking, monitoring, and surveillance in a better way [28].

III. CAUSES OF WASTE FIRES IN INDIA

Waste fires in India are caused by a variety of factors, including open burning of waste, improper waste disposal, electrical short circuits, natural causes, and human negligence. The practice of burning waste in the open, dumping waste in open areas, and mixing electronic waste with other types of waste can all contribute to the creation of a combustible environment that is prone to fires. Additionally, natural causes such as lightning strikes and human negligence, such as throwing cigarettes or leaving fires unattended, can also lead to waste fires [29]. Addressing these causes requires a comprehensive approach that includes education, regulation, and improved waste management practices.

A. Improper waste disposal methods

Improper waste disposal methods pose a significant problem in India, leading to health and environmental risks. Many people and organizations dispose of their waste improperly, which can include open dumping, burning, landfill use, uncontrolled dumping, and littering [30]. These methods can lead to waste fires, pollution, and health risks for nearby residents, release toxic pollutants into the air, cause respiratory problems and other health issues, and contribute to water pollution and environmental degradation.

B. Lack of waste management infrastructure

The lack of waste management infrastructure is a significant problem in India, particularly in urban areas. The country generates a massive amount of waste every day, and without proper infrastructure, this waste can accumulate and lead to pollution, health risks, and other environmental problems [31]. Some of the factors that contribute to the lack of waste management infrastructure in India include:

- ***Limited funding:*** Waste management requires significant funding to develop and maintain infrastructure such as landfills, waste processing facilities, and waste collection systems.
- ***Lack of political will:*** Waste management is often a low priority for political leaders in India, and as a result, there is often a lack of political will to invest in infrastructure and improve waste management practices.
- ***Limited technical expertise:*** Developing and managing waste management infrastructure requires technical expertise in areas such as engineering, urban planning, and environmental management. However, there is a shortage of such expertise in many municipalities in India.
- ***Poor waste collection systems:*** Many municipalities in India lack proper waste collection systems, which can lead to waste being left on the streets or dumped in open areas.
- ***Inefficient waste processing:*** Even when waste management infrastructure exists, it may not be efficient or effective at processing waste, leading to waste accumulation and pollution.

C. Inadequate fire safety measures in waste processing facilities

Inadequate fire safety measures in waste processing facilities, including landfills, incinerators, and waste-to-energy plants, are at risk of catching fire due to the large amounts of combustible materials they handle. Without proper fire safety measures, these fires can spread quickly, leading to significant damage, pollution, and health risks [32], [33]. Some of the factors contributing to the inadequate fire safety measures in waste processing facilities include:

- ***Lack of regulations:*** There are often inadequate regulations in place to ensure that waste processing facilities have proper fire safety measures in place. This can lead to facilities cutting corners to save costs, putting workers and nearby communities at risk.
- ***Poor training and awareness:*** Workers at waste processing facilities may not receive adequate training on fire safety measures or the risks associated with fires. Additionally, nearby communities may not be aware of the potential hazards of waste processing facilities, making it difficult to evacuate or respond appropriately in the event of a fire.
- ***Ageing infrastructure:*** Many waste processing facilities in India are ageing and may not have been designed with modern fire safety measures in mind. These facilities may have outdated equipment or inadequate ventilation systems, making them more prone to fires.
- ***Improper waste segregation:*** Improperly segregated waste, such as batteries or electronic waste, can pose a higher risk of fires. If these materials are not handled and stored properly, they can lead to fires in waste processing facilities.

IV. ENVIRONMENTAL AND HEALTH IMPACTS OF WASTE FIRES IN INDIA

The possible impacts of waste fires on human health and environmental factors in India has been discussed below in details:

A. Air pollution and its effects on human health

Air pollution from waste fires in India significantly impact human health, exacerbating the country's existing air quality crisis. Inadequate waste management infrastructure and lack of public awareness resulting in the prevalence of waste fires, which release toxic fumes and particulate matter harmful to health, especially in densely populated urban areas.

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Exposure to these pollutants can lead to various health issues, including respiratory problems, cardiovascular complications, cancer, cognitive impairment, and adverse pregnancy outcomes. Vulnerable populations like children, the elderly, and those with pre-existing conditions are at greater risk. Addressing this issue requires investment in better waste management infrastructure, promotion of recycling and waste reduction, public education on the dangers of waste burning, and stricter regulations and enforcement. Tackling air pollution from waste fires and other sources is crucial for protecting public health and enhancing the overall quality of life in India [34], [51].

B. Soil and water contamination

Waste fires in India can also have serious impacts on soil and water quality, leading to contamination and potential health risks for people and wildlife. It results in soil and water contamination due to the release of toxic substances from burning solid waste, including plastics, electronic waste, and other hazardous materials. This contamination poses significant risks to both the environment and public health, leading to reduced soil quality and fertility, negative impacts on agriculture, loss of biodiversity, and health issues for humans and wildlife [35]. To mitigate these problems, India needs to focus on improved waste management through proper waste segregation, recycling, composting, and the establishment of sanitary landfills. Furthermore, waste reduction initiatives should be promoted, encouraging the public to adopt sustainable practices, such as using reusable items and minimizing single-use plastics. Raising public awareness and education on the environmental and health risks associated with waste fires is crucial for discouraging this harmful practice. Lastly, enforcement of waste management and waste burning regulations, including imposing penalties for illegal waste burning and monitoring waste disposal sites, is essential for curbing soil and water contamination, ultimately safeguarding public health, preserving ecosystems, and ensuring sustainable development in India [31].

C. Loss of biodiversity and ecosystem damage

Waste fires in India can have severe environmental and health impacts, including loss of biodiversity and ecosystem damage. When waste materials are burned, they release harmful pollutants into the air, water, and soil, which can have negative effects on the environment and human health. Air pollution is a major concern associated with waste fires. The smoke and ash from burning waste can contain a range of harmful pollutants, including particulate matter, carbon monoxide, and dioxins [36], [37]. These pollutants can cause respiratory problems, cardiovascular disease, and other health issues for people living in the surrounding areas. In addition, air pollution can have broader environmental impacts, such as acid rain, which can damage crops, forests, and aquatic ecosystems. Waste fires can also cause damage to local ecosystems and biodiversity. Burning waste can release toxic chemicals and heavy metals into the soil and water, which can harm plants and animals. In addition, the removal of waste from natural ecosystems can disrupt nutrient cycles and alter soil structure, leading to long-term ecological damage [38]. Finally, waste fires can contribute to climate change by releasing greenhouse gases into the atmosphere. Methane, a potent greenhouse gas, is released when organic waste materials are burned. This contributes to global warming and can have long-term impacts on the environment.

V. ECONOMIC IMPACTS OF WASTE FIRES IN INDIA

There are several impacts of waste fires creates in the economy of India, which are discussed below in details:

A. The financial cost of firefighting and waste management

Waste fires in India have not only significant environmental and health impacts but also cause economic damage. Waste fires can cause significant financial costs associated with firefighting. Firefighting operations require a significant number of resources, including personnel, equipment, and materials. These costs can be substantial, especially if the fire spreads to adjacent properties or forests. Waste fires can also cause property damage to nearby homes, businesses, and infrastructure, resulting in additional costs for repair and reconstruction. Waste fires are often caused by improper waste management practices, such as open dumping or burning of waste. Improper waste management can result in additional costs for waste collection, transportation, and disposal. Waste fires can also have significant health impacts on people living in nearby areas, resulting in increased healthcare costs and lost productivity due to illness.

B. Damage to infrastructure and property

Waste fires in India can have severe environmental and health impacts, including loss of biodiversity and ecosystem damage. These fires release a range of pollutants into the air, soil, and water, which can harm both human health and the natural environment. One of the main environmental impacts of waste fires is air pollution.[39] These fires release large amounts of particulate matter, carbon monoxide, and other hazardous gases into the atmosphere, which can cause respiratory problems, heart disease, and other health issues in humans and animals. In addition, the release of greenhouse gases contributes to climate change, which can have wide-ranging impacts on the natural environment. Waste fires can also have a significant impact on local ecosystems. The release of pollutants can harm plants and animals in the surrounding areas, disrupting the natural balance of the ecosystem. This can lead to a loss of biodiversity, as well as other ecological problems, such as soil degradation and water pollution. Moreover, waste fires can contaminate soil and groundwater resources, posing severe risks to agriculture and human health. The leaching of toxic chemicals from burned waste materials can cause long-term soil contamination, which may hinder plant growth, reduce agricultural productivity, and result in the accumulation of harmful substances in the food chain.

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This, in turn, can have detrimental effects on the health of humans and animals that consume contaminated food or water sources. The harmful by-products of waste fires, such as dioxins and furans, are particularly concerning due to their persistence in the environment and their potential to bioaccumulate. These chemicals are known to be toxic, carcinogenic, and endocrine disruptors, posing significant risks to humans, wildlife, and aquatic life. Moreover, the burning of plastics, rubber, and electronic waste can release heavy metals, such as lead, mercury, and cadmium, which can have severe neurological and developmental effects on humans and animals. Waste fires can also lead to the displacement of local communities and wildlife, as the fires can spread rapidly and create hazardous living conditions. This may force people and animals to abandon their homes and habitats, exacerbating problems like urban migration, deforestation, and habitat loss.

C. Impacts on local businesses and industries.

Waste fires in India can have significant economic impacts on local businesses and industries. These fires can cause disruptions to supply chains, production processes, and transportation networks, leading to decreased productivity and higher costs for businesses. Additionally, the costs associated with firefighting and waste management can be substantial, further adding to the economic burden [40]. One of the major economic impacts of waste fires is on the tourism industry. Areas affected by waste fires can become highly polluted, which can deter tourists and negatively impact the hospitality sector. This can result in lost revenue for local businesses that rely on tourism, including hotels, restaurants, and tour operators. Waste fires can also affect the health of workers and residents in the affected areas. This can lead to increased absenteeism and decreased productivity, as workers may need to take time off to recover from illness or care for sick family members. In addition, the long-term health impacts of exposure to air pollution can lead to chronic illnesses, which can result in high healthcare costs for individuals and the government. waste fires can have significant economic impacts on local businesses and industries, including decreased productivity, lost revenue, and increased costs associated with firefighting and waste management [41]. These impacts can be especially severe in communities where waste fires are common and can lead to long-term economic and social dislocation.

VI. GOVERNMENT INITIATIVES TO ADDRESS WASTE FIRES

There are several initiatives has been taken out by the Government of India to tackle the issue of waste fires in future, which are given below:

A. The Laws and regulations on waste management and fire safety

The Indian government has taken several initiatives to address waste fires and improve waste management in the country. Table 2. Shows some major and important initiatives taken by the government of India (GOI) to mitigate the issue of waste fires.

Table 2. Some major rules and initiatives are taken by GOI to mitigate waste fire issues [1], [2], [5], [7].

S. No	Rule	Description
1	The Solid Waste Management Rules, 2016	The Ministry of Environment, Forest and Climate Change (MoEFCC) introduced the Solid Waste Management Rules in 2016, which lay down guidelines for the segregation, transportation, and disposal of solid waste. The rules also emphasize the need for setting up of waste processing facilities, including waste-to-energy plants, to reduce the amount of waste that is sent to landfills.
2	Swachh Bharat Abhiyan	Launched in 2014, the Swachh Bharat Abhiyan is a national cleanliness campaign aimed at achieving a clean and open defecation-free India by 2022. The campaign has a strong focus on solid waste management and has helped in creating awareness about waste segregation and disposal among the public.
3	National Clean Energy Fund	The National Clean Energy Fund was set up in 2010 to promote the development of renewable energy technologies and to fund projects related to clean energy. The fund has been utilized to set up waste-to-energy plants across the country, which help in converting waste into energy and reducing the amount of waste sent to landfills.
4	National Action Plan on Climate Change	The National Action Plan on Climate Change (NAPCC) was launched in 2008 to address the challenges posed by climate change in India. The plan has identified waste management as an important area for action and has emphasized the need to promote the use of clean technologies, including waste-to-energy technologies.
5	Fire Services Act, 1944	The Fire Services Act of 1944 provides for the establishment of fire services in every state in India and lays down guidelines for fire safety in buildings and public places. The act also provides for the training of fire personnel and the enforcement of fire safety regulations.
6	The National Building Code of India	The National Building Code of India (NBC) provides guidelines for the design, construction, and maintenance of buildings in the country. The code includes provisions for fire safety, such as the installation of fire alarms, fire extinguishers, and other fire-fighting equipment in buildings.

The state governments have also taken steps to improve waste management and prevent waste fires. For example, the Delhi government has banned the dumping of all kinds of waste in open landfills and has set up several waste-to-energy plants to process the city's waste. Similarly, the Maharashtra government has set up a committee to study the causes of waste fires and recommend measures to prevent them.

B. Government programs and initiatives to promote proper waste management.

The Indian government has taken significant steps towards promoting proper waste management in the country, with several programs and initiatives targeting different aspects of waste management.

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These initiatives have played a crucial role in raising awareness about proper waste management practices, leading to the development of innovative technologies and business models in the sector. Swachh Bharat Abhiyan, launched in 2014, is a national cleanliness campaign aimed at achieving a clean and open defecation-free India by 2022.

This campaign places a strong emphasis on solid waste management and has raised awareness about waste segregation and disposal among the public. The Clean India Mission, also launched in 2014, focuses on cleanliness and sanitation in rural areas. It emphasizes waste management and has promoted awareness about proper waste segregation and disposal among rural communities [42].

The National Green Corps engages school children in environmental conservation and sustainable development. This program includes waste management activities, such as waste segregation and composting, which help raise awareness about proper waste management among children. The Waste to Wealth Mission, launched in 2018, promotes the conversion of waste into wealth using innovative technologies and business models. This program focuses on waste segregation, recycling, and composting, creating new opportunities for waste management entrepreneurs. The Sustainable Alternative Towards Affordable Transportation (SATAT) program, launched in 2018, aims to promote the use of compressed biogas (CBG) as a sustainable and affordable fuel. This program encourages the production of CBG from organic waste and has created new opportunities for waste management and renewable energy businesses. Finally, the Swachh Survekshan is an annual cleanliness survey conducted by the Ministry of Housing and Urban Affairs to assess the cleanliness and sanitation of urban areas in the country. This survey includes parameters related to waste management, such as waste segregation, processing, and disposal, and has helped in raising awareness about proper waste management among urban communities.

C. Challenges and limitations of government interventions.

The Indian government has taken several initiatives to address waste fires and improve waste management in the country. However, there are also several challenges and limitations associated with these interventions. Some major challenges and limitations are discussed below [43], [44]:

- ***Challenges:*** The lack of adequate waste management infrastructure, including waste collection and processing facilities, is a major challenge in India. This has resulted in the dumping of waste in open spaces, which can lead to waste fires. Despite the government's efforts to create awareness about waste segregation and disposal, many people are still not aware of the proper methods of waste disposal. This has resulted in the continued dumping of waste in open spaces, which can increase the risk of waste fires. The government's initiatives to improve waste management and prevent waste fires require significant investment. However, the lack of sufficient funding has resulted in the slow progress of these initiatives. Although there are regulations in place to prevent waste fires and promote proper waste management, the enforcement of these regulations is often weak. This has resulted in the continued dumping of waste in open spaces and the lack of accountability for those who violate waste management regulations.
- ***Limitations:*** The government's initiatives to address waste fires and improve waste management may not reach all parts of the country, particularly in rural areas, where waste management infrastructure is often inadequate. The private sector has a crucial role to play in waste management and can bring in new technologies and business models to improve waste management. However, the involvement of the private sector in waste management is limited, and there is a need for greater public-private partnerships in this area. There are several government agencies involved in waste management, including the MoEFCC, the Ministry of Housing and Urban Affairs, and state-level agencies. However, there is often a lack of coordination among these agencies, which can lead to inefficiencies in waste management. The use of technology can significantly improve waste management and prevent waste fires. However, the adoption of technology in waste management is limited, and there is a need for greater investment in this area.

Overall, while the government's initiatives to address waste fires and improve waste management in India are laudable, there is a need for greater investment, coordination, and involvement of the private sector to address the challenges.

VII. SOLUTION AND RECOMMENDATION

Waste management is a critical issue in India due to the significant amount of waste generated daily. However, there are several solutions and recommendations that can help improve waste management practices in the country. One of the essential practices is waste segregation at the source, which involves separating organic waste from non-biodegradable waste like plastic, glass, and metal. By doing so, waste can be recycled and disposed of efficiently, reducing the amount of waste that ends up in landfills. Another important measure to improve waste management practices in India is conducting awareness campaigns to educate the public about the importance of waste management, waste segregation, and the harm caused by littering [45]. Such campaigns can help change public behavior and promote responsible waste management practices. Recycling initiatives can also be promoted to reduce the amount of waste generated in India. This can be achieved by setting up recycling centers, encouraging the use of recycled products, and incentivizing companies that use recycled materials in their products. Fig. 3 shows a complete structure of waste management and waste fires solution by taking Indian environmental changes as a case study.

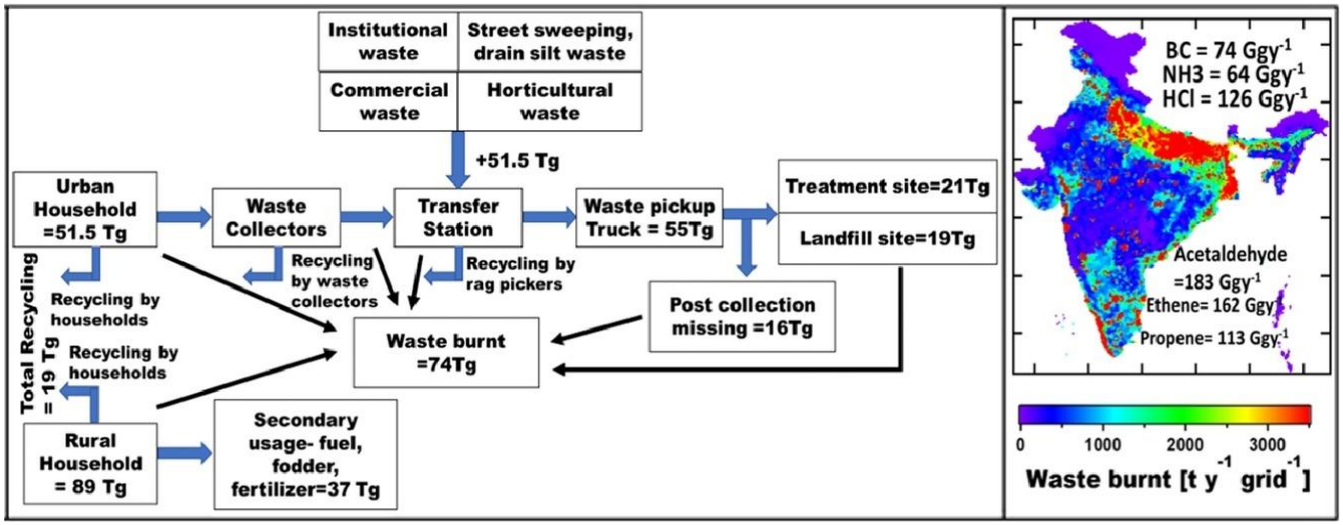

Fig. 3. A comprehensive idea of waste management and waste fires impact on Indian environment [46]

Composting is another effective solution that can significantly reduce the amount of waste sent to landfills, especially organic waste. Households and businesses can be encouraged to compost by providing training and resources for composting. Effective waste collection and disposal systems should be put in place to ensure that waste is disposed of safely and efficiently. This can be achieved by setting up waste collection centers, improving the transportation of waste, and developing landfill management systems. Public-private partnerships can also help improve waste management practices in India [47]. The government can work with private companies to develop and implement waste management initiatives that are sustainable and efficient. Finally, the use of technology can be a game-changer in waste management practices in India. Waste management apps can be developed to provide information about waste management practices, help citizens report littering, and track waste collection. By working together, India can reduce waste and ensure a cleaner and healthier environment. Overall, improving waste management practices in India will require a comprehensive approach involving government policies, public awareness, and private sector involvement. Increased investment in waste management infrastructure can have significant benefits for communities and the environment. One of the most significant benefits is the reduction of environmental pollution. By implementing better waste management infrastructure, the likelihood of waste ending up in landfills, waterways, or the air can be minimized, leading to a cleaner and healthier environment. Proper waste management can also improve public health by reducing the spread of diseases caused by waste. Better waste management infrastructure can also reduce the likelihood of contaminated water supplies and soil, improving overall public health [48], [52]. Investing in waste management infrastructure can also contribute to mitigating climate change by reducing greenhouse gas emissions from landfills and waste incineration. Recovering valuable resources from waste streams, such as metals, plastics, and organic matter, can help conserve natural resources and reduce the need for new materials. This can have positive economic and environmental impacts, as it reduces waste and can create new opportunities for resource recovery and recycling.

Increased investment in waste management infrastructure can also create new jobs in areas such as waste collection, sorting, recycling, composting, and waste-to-energy facilities, thereby contributing to economic development. Improved waste management infrastructure can also result in cost savings for municipalities and businesses by reducing waste disposal fees and increasing revenue from recycling and resource recovery programs. In conclusion, investing in sustainable waste management practices and infrastructure can have significant environmental, economic, and social benefits for communities. The benefits of proper waste management are numerous, and increased investment in infrastructure can help address many of the challenges associated with waste management, leading to a cleaner and healthier environment for all along with the agricultural impacts in areas like Rajasthan.[53] Education and awareness programs for waste management are essential for promoting sustainable waste management practices and reducing the negative impact of waste on the environment and public health. These programs can increase public knowledge about waste management practices and their environmental and health impacts, which can encourage individuals to take action to reduce their waste generation and adopt sustainable waste management practices. Education and awareness programs can also help to improve waste separation and recycling rates by providing information on what can and cannot be recycled, how to properly separate recyclable materials, and where to dispose of hazardous waste. This can result in significant reductions in waste generation and increased diversion of waste from landfills. Furthermore, education and awareness programs can help to reduce contamination in recycling streams by educating individuals on how to properly prepare materials for recycling and what materials should not be included [49]. This can improve the quality of recycled materials and increase the marketability of recycled products. Education and awareness programs can also promote behavior change by encouraging individuals to adopt sustainable waste management practices such as reducing, reusing, and recycling materials. This can lead to significant reductions in waste generation, which can help conserve natural resources, reduce pollution, and mitigate climate change.

Education and awareness programs can lead to cost savings for municipalities and businesses by reducing the amount of waste generated, increasing recycling rates, and minimizing contamination in recycling streams. This can result in cost savings for waste management services and increase revenue from recycling and resource recovery programs [50]. Education and awareness programs for waste management are critical for promoting sustainable waste management practices and reducing the negative impact of waste on the environment and public health. By increasing public knowledge, improving waste separation and recycling, reducing contamination, promoting behavior change, and achieving cost savings, education and awareness programs can contribute to a more sustainable and resilient society.

VIII. CONCLUSION

Improved waste management practices play a critical role in reducing the negative impact of waste on the environment, public health, and the economy. Measures such as waste reduction, reuse, recycling, and proper disposal, along with increased investment in waste management infrastructure, can bring several benefits, including reduced pollution, improved public health, reduced greenhouse gas emissions, resource recovery and recycling, job creation, and economic benefits. This article reveals the significance of the issue, as waste fires are a major source of air pollution, causing harm to individuals, animals, and ecosystems and contributing to climate change. They also have a significant impact on public health, particularly in India where air pollution is a major concern, and can cause damage to infrastructure and property, leading to loss of income for businesses and individuals. Furthermore, research on waste fires can inform waste management policies and practices, highlighting the need for proper waste disposal and management systems, as well as the importance of fire safety measures. This can ultimately contribute to achieving sustainable development goals related to environmental sustainability, public health, and economic growth. Waste management practices should be prioritized, and waste fires should be addressed as a critical issue. Policymakers, waste management professionals, and the public should work together to promote sustainable waste management practices, and education and awareness programs should be implemented to increase public knowledge, improve waste separation and recycling, reduce contamination, promote behavior change, and achieve cost savings. Moreover, this article will provide a deeper insight into causes, possible impacts, and measures taken to mitigate the waste fire issue in India.

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AUTHORS PROFILE

Rakshit Jakhar, He received his master's degree in Geography from the University of Mumbai in 2019 and the bachelor's degree in Geography from The University of Delhi in 2017. His area of research interests includes Climate Change, Environment Geography, Agriculture Geography, Oceanography, Geomorphology, Hydrology, Environmental policy and governance and Land use and land cover change.

Dr. Preeti Sachar, she is an associate Professor in the Department of Geography, Swami Shraddhanand College, University of Delhi. Received her Bachelor of Arts Degree in Geography (Honours) from Kirori Mal College, University of Delhi in 1994, (University Topper) and received the Master of Arts degree in Geography from Delhi School of Economics, University of Delhi in 1996 also received her MPhil (1999) and PhD (2003) from Delhi School of Economics, University of Delhi. Her teaching experience in the field is 21 years. Her area of research is Natural Resource Management and Environment Geography.