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NARRATIVE REVIEW

Public Health Risks Associated with Emissions from Open Burning of Municipal Solid Waste: A Narrative Review

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ABSTRACT

Globally, people are discarding large quantities of waste, and its management is one of the major challenges faced by cities across the globe. Open burning is a waste management practice performed by many people worldwide, which has resulted in great public health and environmental concerns.

In this narrative review, focus was on the potential environmental and human health risks of open burning of various components of municipal solid waste (MSW). Secondary data on open waste burning of organic waste, plastic and rubber waste, electronic waste and fossil fuel from 2000 to 2024, searched from reputable databases, were used.

The findings showed that the open burning of organic waste results in the emission of greenhouse gases and highly hazardous organic air pollutants, including benzene, toluene, ethylbenzene, and polycyclic aromatic hydrocarbons. Open burning of plastics releases toxic compounds, including dioxins, furans, mercury and polychlorinated biphenyls, into the atmosphere. Electronic waste burning contributes to severe air pollution due to heavy metals and is associated with increased prevalence of cardiovascular morbidity, specifically hypertension. Open burning of fossil fuels results in the release of various toxic substances, including polycyclic aromatic hydrocarbons (PAHs), black carbon, mercury, SO_2, NO_x, and volatile organic compounds. Exposure to these air pollutants is associated with low or reduced birth weight, small size for gestational age, and preterm birth and reduced lung function.

Therefore, the open burning of MSW poses severe risks to human health and the environment and hence the need for proper waste management practices.

BACKGROUND

Globally, people are discarding large quantities of waste, and its composition is more complex than ever before, as plastic and electronic consumer products diffuse.[1] Municipal Solid Waste (MSW) are generated from various sources, including residential areas that produce food waste, rubbish, ashes, and diapers.[2] The MSW is one of the big challenges faced by cities globally.[1] Countries in East Africa are faced by MSW management challenges, including indiscriminate dumping and open burning, among others.[3,4]

Open burning is a waste management practice performed by many people worldwide, especially in developing countries.[5] The open burning of waste, whether at individual residences, businesses or dump sites, is a large source of air pollutants.[6] Global emissions of Carbon dioxide (CO_2) from open waste burning are relatively small compared to total anthropogenic CO_2; however, regional CO_2 emissions, particularly in many developing countries in Asia and Africa, are substantial. Further, emissions of reactive trace gases and particulate matter from open waste burning are more significant on regional scales.[6]

Polychlorinated dibenzodioxins and dibenzofurans are highly toxic, persistent pollutants that cause cancer, immune suppression, hormonal disruption, reproductive harm and accumulate in the food chain, posing serious long-term health risks. Further, compounds including dioxin, furans, particulate matter, carbon monoxide, sulphur oxides, nitrogen oxides, benzene, toluene, ethyl benzene and 1-hexene are also produced during the open municipal Solid waste burning.[7]

The practice of open waste burning is a source of particulate matter (PM) and black carbon, which possess a greater greenhouse effect and chronic health impacts.[8] It is estimated that exposure to $PM_{2.5}$ from open burning of solid waste causes at least 270,000 premature deaths globally and 10,000–20,000 premature deaths in Africa each year.[9] In addition, open MSW burning emits toxic pollutants such as dioxins, furans, carbon monoxide, styrene gas, hydrogen cyanide, acrolein, and phosgene into the environment.[10] Despite these glaring potential risks, open burning of MSW continuously takes place in residential areas, which greatly puts the lives of many people in danger, including that of children.[11]

To enhance public awareness, this review article examined the potential environmental and human health risks associated with open burning of MSW.

METHODS

In this narrative review, the focus was on the potential environmental and human health risks brought by the open burning of various components of MSW. We modified the data search process used by[5,12] to obtain information from original peer-reviewed articles published in scientific journals, with a focus on the potential risks associated with open waste burning to the environment and human health. We carefully searched electronic literature databases, including but not limited to PubMed, Scopus, and Google Scholar, for relevant articles from 2016 to 2026. The Boolean operator "OR" was used to combine synonymous or related search terms, while "AND" was employed to connect the main concepts of waste burning, environmental pollution, human health risks, and geographical focus. Quotation marks were used to retrieve exact phrases and parentheses to improve retrieval accuracy. The following key search terms were used (("open burning" OR "waste burning" OR "municipal solid waste burning" OR "domestic waste burning" OR "open waste burning" OR "organic waste" OR "plastic waste" OR "fossil fuel" OR "rubber waste" OR "electronic waste") AND ("air pollution" OR "emissions" OR "particulate matter" OR "toxicants" OR "heavy metals") AND ("human health" OR "health effects" OR "environment") AND ("East Africa")). The data obtained were independently verified for accuracy, and any inconsistencies were resolved through discussions among the authors. The final synthesised data were subsequently summarised and conclusions drawn accordingly.

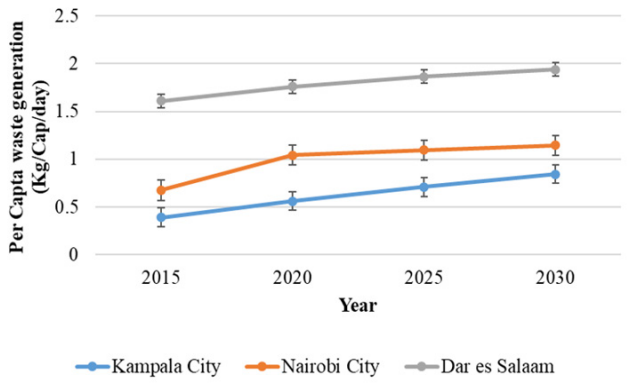
Trends of Domestic Solid Waste Generation in East Africa

Domestic solid waste generation in East Africa has increased rapidly over the past two decades due to accelerated urbanisation, population growth, industrialisation, changing consumption patterns, and economic development.[13] Major urban centres such as Kampala, Nairobi, and Dar es Salaam are experiencing substantial increases in both per capita and total waste generation (Figure 1). Studies indicate that municipal solid waste generation in East African cities currently ranges between 0.709 and 1.863 kg per capita per day, with projections of between 0.843 and 1.938 kg per capita per day by 2030 if current trends continue.[13] However, waste collection and management systems in many East African cities have not expanded at the same pace, resulting in increased illegal dumping, open burning, and environmental pollution.

Effects of unsustainable solid waste management are found all around the world, but they are worse in developing and underdeveloped countries like East African Community countries.[14] Approximately 180 million tons of waste, which is about 9% of the global waste, was generated by Sub-Saharan African countries in 2016.[15] In East Africa, a big proportion of their solid waste is not properly managed, with more than 62.5% of generated solid waste in EAC being organic, 19.6% papers and plastics, and 3% glass, while other kinds of waste occupies 14.9%.[14]

Open burning of waste produces 11% of global black carbon emissions, with 26% of global waste burnt at a residential level and 15% spontaneously burnt at dump sites.[15] Uncontrolled open burning of waste poses serious threats to both environmental quality and public health due to the release of hazardous pollutants into the atmosphere.[16] In East Africa, rapid urbanisation and population growth have significantly increased municipal solid waste generation, placing considerable pressure on already weak waste management systems.[17] At the household level, waste burning is especially common in low-income communities and informal settlements where regular waste collection services are unavailable or unaffordable. Open dumpsites across East Africa also experience frequent fires, either intentionally ignited or occurring spontaneously due to the decomposition of organic materials and accumulation of combustible waste.[18] Waste pickers may intentionally burn waste to recover metals such as copper and aluminium, thereby exposing themselves and nearby communities to toxic smoke emissions. Populations living near dumpsites face increased risks of respiratory and other pollution-related illnesses due to prolonged exposure to emissions from waste burning.[19] Weak enforcement of environmental regulations contributes significantly to the persistence of open burning practices. Although many East African countries have environmental laws and waste management policies prohibiting indiscriminate waste disposal and burning, implementation and enforcement remain inadequate.[17]

FIGURE 1: Projected Waste Generation Rates of the Three East African Community (EAC) Cities



Source: Aryampa et al., 2019

Health Risks of Open Burning of Municipal Solid Waste

Municipal solid waste (MSW) comprises a wide range of materials generated from households, businesses, institutions, and industries.[3] Its composition depends on the socio-economic and cultural practices of a given region. Open burning of MSW is a common practice at dumping sites. This practice releases a complex mixture of harmful pollutants, including particulate matter, toxic gases, heavy metals, dioxins, and furans, into the environment.[10] (Figure 2) Residues from open waste burning contaminate soil, groundwater and air,

ultimately entering the human food chain through crops and livestock.[10] Human exposure occurs through multiple pathways such as inhalation of contaminated air, contact with polluted soil and ash, and consumption of contaminated water and food.

The subsequent sub-sections discuss potential environmental and public health risks from the various major types of MSW.

Risks of Open Burning of Organic Waste

Organic waste, which includes sewage sludge, paper, cardboard, food and agricultural waste, is constantly increasing due to economic growth, increasing world population and human activities.[20] The open burning of organic waste results in the emission of greenhouse gases and some hazardous organic air pollutants, including benzene, toluene, ethylbenzene, polycyclic aromatic hydrocarbons and persistent organic pollutants.[6] The inhalation of volatile organic compounds is associated with high levels of reaction with the airway epithelium and mucosa membrane and is linked with pulmonary diseases.[21] Open burning of agricultural waste leads to increased ash content in the atmosphere, carbon dioxide and nitrogen oxide (NOx) emissions.[22]

Open burning of paper and cardboard releases pollutants, including carbon monoxide (CO), sulphur dioxide (SO_2), NOx, volatile organic compounds (VOCs), CO_2 and toxic heavy metals into the atmosphere, which are detrimental to health and the environment.[23] CO intoxication is one of the most common types of poisoning in the modern world and is one of the leading causes of death by poisoning.[24] Open burning of papers and cardboards results in the production of S-rich particles, including SO_2, which have significant effects on human health, including causing breathing difficulty, pulmonary oedema, eye irritation, and asthma attacks.[24] These results therefore call for alternative ways of managing paper and cardboard waste to prevent the adverse health effects that come with its open burning.

Risks of Open Burning of Plastic and Rubber Waste

Plastic waste forms a substantial component of municipal solid waste, and its disposal through open burning poses serious environmental and public health risks.[10] The open burning of plastics and rubber waste is a widespread practice across the globe, resulting in the release of gas emissions and ash residues that have toxic effects on human health and environment.[10,25] (Figure 3) Burning of plastics results in the release of toxic compounds, including dioxins, furans, mercury and polychlorinated biphenyls, into the atmosphere.[26] Dioxins and furans are notorious classes of organochlorine toxicants in the environmental system whose adverse effects are detrimental to public health with extreme negative economic impacts.[27] Different types of plastics release harmful toxicants when burnt.[10] The burning of drainpipes, blister packs, children's toys, bottles, and jugs made of polyvinyl chloride (PVC) releases carbon monoxide, dioxins, and chlorinated furans. These substances are carcinogenic and cause birth defects and respiratory disorders. Furthermore, burning of PVC releases hazardous halogens that pollute air and contribute to climate change.[26]

FIGURE 2: Exposure Pathways and Health Effects of Open Domestic Solid Waste Burning

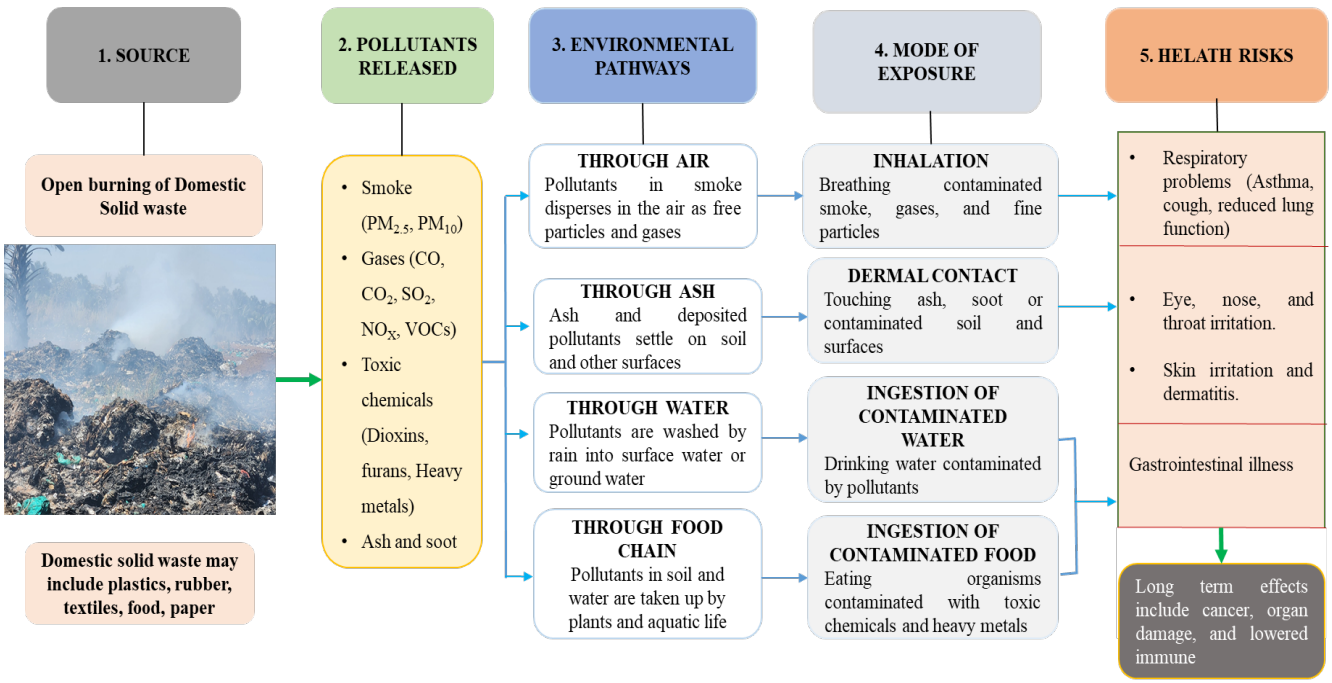
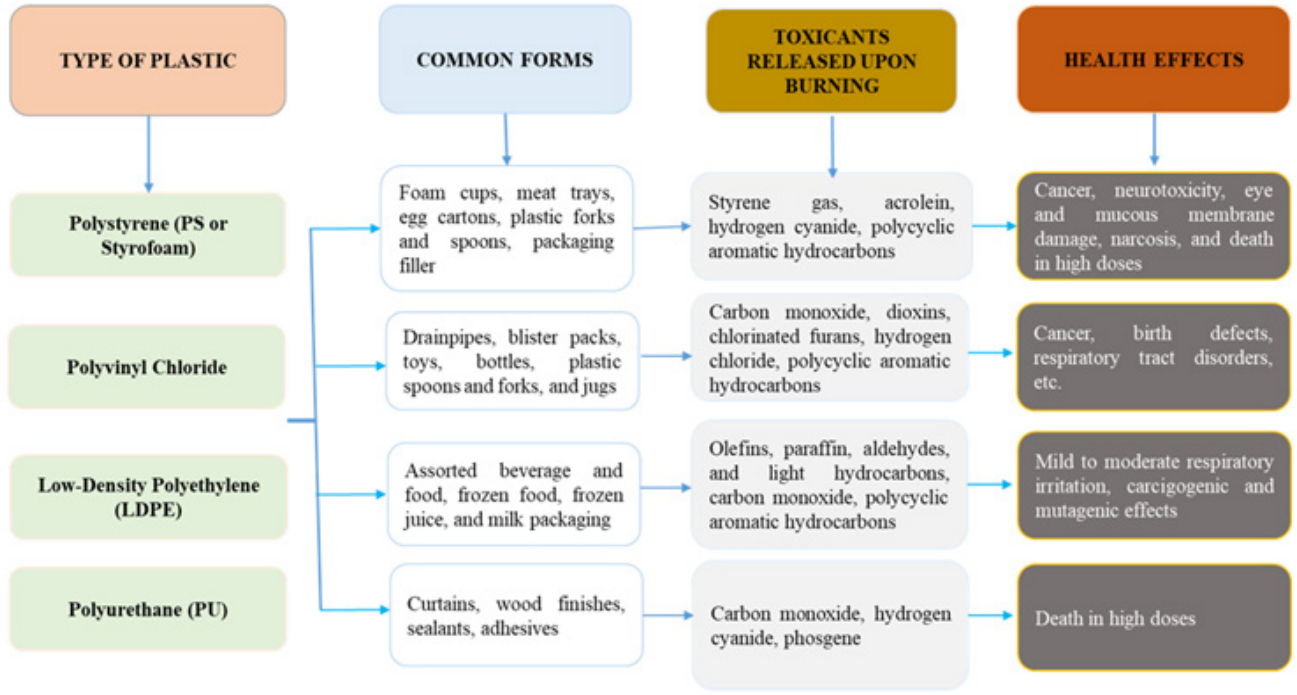


FIGURE 3: Toxic Emissions and Human Health Risks Associated with Open Burning of Plastic Waste



Source: Pathak et al., 2023

Polystyrene and styrene, found in foam cups, meat trays, egg cartons, and plastic cutlery, emit styrene gas, acrolein, and hydrogen cyanide when burnt. Exposure to these toxicants is carcinogenic and results in eye and mucous membrane damage, narcosis, or death from high doses.[10] Similarly, polyurethane, used in wood finishes, sealants, adhesives, and curtains, produces toxic gases, including carbon monoxide, hydrogen cyanide, and phosgene, upon burning.[28] These emissions can be fatal when inhaled in large quantities. Open burning of rubbers, such as car tyres, produces smoke that is an irritant to eyes, nose, and the respiratory tract.[29]

Risks of Open Burning of Electronic Waste (E-waste)

The rapid increase in the number of electrical and electronic equipment, along with their brief lifespans, has led to a significant accumulation of electronic waste. For instance, Uganda is estimated to have collected approximately 17,000 tonnes of e-waste between 2013 and 2018.[30] Electronic waste consists of old electronic devices, batteries, cables, and appliances, among others.

Open burning of e-waste is on the rise, which has led to an increase in air pollution.[30] It is observed that e-waste burning contributed to severe heavy metal air pollution, potentially explaining the increased prevalence of cardiovascular morbidity, specifically hypertension, in humans.[31,32] The burning of electronic waste also releases human-unfriendly gases, including polycyclic aromatic hydrocarbons (PAHs), dioxins, and hydrogen chloride. For the PAHs, the presence of ultraviolet light is highly toxic to aquatic life and birds. They also have adverse effects, including tumours, low reproduction, development, and immunity.[33,34]

Risks of Open Burning of Fossil Fuel

Fossil fuels are energy resources derived from altered remains of living organisms buried by sediments and exposed to elevated pressures and temperatures for millions of years.[35] Despite its importance globally, fossil fuel air pollution is responsible for around one in five deaths.[36] The open burning of fossil fuels results in the release of various toxic substances, including polycyclic aromatic hydrocarbons (PAHs), black carbon, mercury, SO_2, NO_x, and volatile organic compounds (VOCs).[37] Exposure to these air pollutants is associated with low or reduced birth weight, small size for gestational age (SGA), preterm birth, and reduced lung function.[37,38] The burning of fossil fuels is a major source of airborne fine particulate matter (PM2.5) and a key contributor to the global burden of mortality due to lower respiratory infections among children under the age of five.[39,40]

Policy and Regulatory Interventions on Open Waste Burning in East Africa

In an attempt to address the challenges of open waste burning, several East African countries have established policies, legal frameworks, and interventions aimed at

reducing or eliminating open waste burning (Table 1). These include national environmental laws and waste management regulations. Regional initiatives led by the East African Community further support harmonisation of waste management policies and strengthen regional cooperation in addressing environmental pollution. However, implementation challenges persist due to limited institutional capacity, inadequate financing, poor public awareness, and insufficient waste treatment infrastructure across many countries in the region.

TABLE 1: Regulatory Interventions on Waste Management in Some of the East African Countries

Country	Legal framework/Intervention on open waste burning	Provision on waste management
Uganda	National Environment Act Cap 181.	Provides for management of any waste generated in such a manner that does not cause ill health to the person or damage to the environment.
	National Environment(Waste Management) Regulations (2020).	Provides for control of open burning of waste.
	NEMA ban on open burning, 2026.	Calls for immediate stop on open waste burning.
Kenya	Environmental Management and Coordination Act Cap 387	Prohibits dangerous handling and disposal of wastes.
	Sustainable Waste Management Act (2022)	Restricts open burning of waste
Tanzania	Environmental Management Act (2004)	Regulates waste disposal practices, discourages open dumping and burning, and encourages sanitary landfills and waste recovery.
Rwanda	Rwanda Law on Environment (Law 48 of 2018)	Any person who unlawfully burns domestic waste, crop residues, tyres and plastic materials is liable to an administrative fine of twenty five thousand Rwandan francs.

Limitations of the study

This review has several limitations. Unpublished studies were excluded, which may introduce publication bias. Relevant evidence outside selected databases may also have been missed. There remains a scarcity of East African data linking open MSW burning to measurable pollution and health outcomes, limiting evidence-based policymaking. Although literature reports respiratory, cardiovascular, and cancer risks, it rarely quantifies associations between pollutants such as $PM_{2.5}$, dioxins, and heavy metals and hospital admissions. Monitoring around urban waste sites is inadequate despite it being emission hotspots.

CONCLUSION

The open burning of MSW poses severe risks to human health and hence the need for proper waste management systems. Practising the 3Rs – reduce, reuse, and recycle – along with composting is vital in minimising waste, conserving resources, and protecting the environment.

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