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A Review on Pollution Emissions and Impact from Waste Treatment and Disposal Facilities

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Abstract

Solid and liquid waste management is one of the main challenges that face sustainable environment and communities. Effluents from waste treatment and disposal facilities have direct and indirect impacts on the environment and welfare of humans. The direct impacts entail the destruction of materials, loss of aesthetic value, and damage to people's health. On the other hand, the indirect effects are principally on long term, which encompass climate change, and ecosystem imbalance. The challenge of managing waste has become greater because of high population growth rate, urbanization, economic expansion, and industrial growth. This review presents the effect of various waste management methods, wastewater treatment plants, refining and desalination plants in polluting the atmosphere. The results of this study indicate that these plants contribute to the presence of high levels of greenhouse gas emissions (GHG), volatile organic compounds, nitrogen oxides (NO_x) and sulfur oxides (SO_x). In addition, it was found that the airborne microbial count exceeded the limit in the air near the area where the waste treatment and disposal facilities are present, resulting in bad odors dominating in the air. Moreover, the cost of health care due to the effects of air pollution in these sites is on the rise. Annually, many people die due to air pollution and this number is expected to rise significantly in the future, which would further put a burden on the governments and healthcare facilities. Therefore, this issue requires robust plans and policies to address the escalating impacts if not properly managed. In response to this problem, improvement of an effective municipal waste management approaches that confer adequate economic and environmental efficacies is paramount at the national levels.

Keywords: Air pollution; Waste treatment; Mitigation; Sustainability; Greenhouse gas; Odor

Introduction

The world recognizes air pollution as an issue that significantly affects public health. There has been intensive studies and documentation of the effects of air pollution around the world [1,2]. Health effects due to air pollution are a big concern for the World Health Organization [3]. But, air pollution does not only cause toxicological effects on human health, it has also significantly degraded the environment in the last years [4,5]. In this review, the contribution of various waste management methods, wastewater treatment plants, refining and desalination plants in polluting the atmosphere are studied.

In the recent years, the population of the world has increased drastically which has led to increased industrial development and agriculture. Increased population has also led to more accumulation and generation of waste products. Waste production and its management have led to the spread of endotoxins, dust particles, dangerous microorganisms, and pungent odors into the air which further adds to the existing air pollution problems [6,7]. The rise in population has also increased demand for resources like water [8]. This had led to an increase in the number of desalination plants around the world. At present, around 5000 million m^3 of water is produced by the desalinating of sea water [9].

Desalination of sea water is one of the best alternatives to fulfill the future needs for water [10]. Nevertheless, there are many environmental impacts of the desalination process, one of which is air pollution since they depend mainly on using fossil fuels [11]. Desalination plants that are of the multi-stage flash (MSF) type cause air pollution. These plants usually require fuel to generate energy for the process of desalting. Fuels rich in sulfur are predominantly used in such plants. Various greenhouse gases are emitted because of this process such as sulfur oxides, carbon monoxide, and nitrogen oxides in the atmosphere [12].

Along with desalination plants, municipal wastewater treatment plants, refinery and petroleum wastewater treatment plants are also some of the biggest emitters of air pollutants [13]. With the growth of population, there is also a growth in demand for gas, oil, and other energy sources. This has also increased the number of refineries and petroleum wastewater treatment plants [14]. Air quality impacts are one of the common problems associated with refining and petroleum industries. This industry is one of the leading causes of the emission of greenhouse gasses and volatile organic compounds. Both aliphatic and

aromatic hydrocarbons are released into the air from the petroleum industries [15,16].

Refining of petroleum in petroleum industries involves processes like conversion, separation, and treatment. The emissions which occur during these processes are known as process emissions. Other kinds of emissions that occur are combustion emissions, which occur during the burning of fuel, and fugitive emissions that occur due to leaks. Storage and handling emissions occur while handling oil, gas, and its other derivatives. Transportation of refined products through tanks and pipelines can often lead to leaks and emissions. Auxiliary emissions are exclusively related to petroleum wastewater treatment units [15]. The petroleum wastewater is made up of a rich matrix of pollutants [17]. Therefore, auxiliary emissions arise when volatile organic compounds are stripped off from the contaminated wastewater in aeration basins, drains, and ponds which are all considered as indirect emissions [15].

Municipal solid waste treatment plants also emit similar groups of air pollutants like petroleum wastewater treatment plants directly. It is one of the major sources of landfill leaks, leachate ponds, compost, and mature compost. They emit a large amount of volatile organic compounds, hydrogen sulfide, and ammonia into the atmosphere. Landfill leaks are a significant source of hydrogen sulfide gas leaks into the air. Fresh composting sites account for releasing 3.2 ppmv to 1.7 ppmv of hydrogen sulfide gas into the atmosphere. Composting sites emit between 30 ppmv to 600 ppmv of ammonia into the atmosphere. Volatile organic compounds like cyclohexane, pinene, limonene, and p-cymene are also released into the atmosphere from landfill leaks and composting sites [18]. In one of the studies conducted in Kuwait, it was revealed that there were high concentration of volatile organic compounds near waste treatment plants and disposal facilities. Bio aerosols, ammonia, hydrogen sulfide, methane, and other gases were also detected from these areas. In addition, bad odor was an irritating problem in the surrounding area [19,20]. The production of obnoxious odors is a common problem associated with wastewater treatment plants [21].

In spite of all these issues, in developing countries, open dumpsites are still being used as a way to dispose wastes. They are contributing to air pollution, major health threats, and degradation of landscapes in the cities [22]. In developing countries like India, air pollution is a huge concern that is occurring due to the open dumping and burning of household waste [23]. Even in developed countries such as the United States of America, around fifty-four percent of the municipal waste is dumped in the landfill, and only thirty-four percent of the waste is recycled [24].

Household waste lying openly in urban cities poses health threats to people living around. Wet wastes usually undergo decomposition and produce bad odors [22]. A major by-product of the decomposition of garbage is the production of methane gas. Anaerobic respiration of bacteria leads to methane production, which can thrive in landfills. Sometimes methane concentration in landfills can reach up to fifty percent [25]. Microbial air pollution is also being caused by these landfills as they are transported around the atmosphere by the wind which leads to respiratory diseases [26].

Types of Wastewater Treatment and Disposal Facilities

Municipal wastewater treatment plant

Municipal wastewater treatment is a process in which harmful pollutants are removed from wastewater plants. Proper treatment of wastewater leads to the production of acceptable quality of water to be released into the environment. However, one of the main concerns with wastewater treatment plants is related to the amount of air emissions they cause [27].

Municipal wastewater treatment plants are a source of various greenhouse gasses and bio-aerosols. A large amount of nitrous oxide is emitted into the atmosphere due to the process of nitrification and de-nitrification [28]. There are two types of emission of greenhouse gasses from municipal wastewater treatment plants. These two types of emissions are on-site emissions and off-site emissions [29].

Off-site emission of greenhouse gasses is caused due to the process of generation of energy for bio solids transport. Aerobic and hybrid treatments cause higher generation of greenhouse gasses. On-site emission of greenhouse gasses is caused due to energy generation for fossil fuel consumption and the treatment of bio solid [29].

Figure 1 represent on and off-site air pollutant emissions from waste treatment and disposal facilities.

Refinery and petroleum wastewater treatment plant

Refinery and petroleum industries are known to be the major source of volatile organic compounds. Some of the most common volatile organic compounds found in the effluents include o-xylene, toluene, and benzene [19]. Bio-aerosols and other air pollutants like ammonia, methane, and hydrogen sulfide are also emitted from refinery and petroleum wastewater treatment plant. A bad odor can be also detected from the surroundings of these plants. The presence of volatile organic compounds is responsible for it [15].

Landfill sites

Landfills are very important for waste management. As we progress towards the future, the amount of waste we create is increasing along with the complexity of landfills, which affects the air quality near the landfills. Various gaseous compounds are produced in the landfill due to the degradation of organic matter in the waste. The gasses produced by landfills include methane, carbon dioxide, hydrogen, hydrocarbons, dust, odor, and microorganisms. These compounds also affect the surrounding area [31].

Carbon dioxide is one of the main gases obtained from waste degradation. It accounts for twenty to forty percent of the total landfill gas produced. Methane is the second major landfill gas produced by an average municipal landfill. It is a greenhouse gas associated with global warming. Hydrogen gas is another by-product of landfills along with non-methane organic compounds. Ammonia and nitrogen compounds as well as hydrogen sulfide are also produced by landfills which are the major cause of odor. Carbon monoxide and mercury may be released by a landfill, which is highly toxic to the environment. Aromatic compounds like benzene, toluene, xylene, ethylbenzene, propylbenzene, and organosulfur compounds may also be produced [31].

Desalination plants

Desalination plants are responsible for providing enormous amounts of desalted water throughout the world. The process of desalting involves the removal of huge amounts of brine from seawater. Toxic micro-organisms and other chemicals are released with the effluents in the wastewater stream [12].

As shown in figure 2, fuel combustion is carried out to obtain energy for the separation process. The process of desalination causes very high amounts of air pollution. Toxic gasses like carbon monoxide, unburned hydrocarbons, nitrogen and sulfur oxides are released into the atmosphere. Desalination plants also require fuels rich in sulfur. This causes very high emission of sulfur oxides into the air [12].

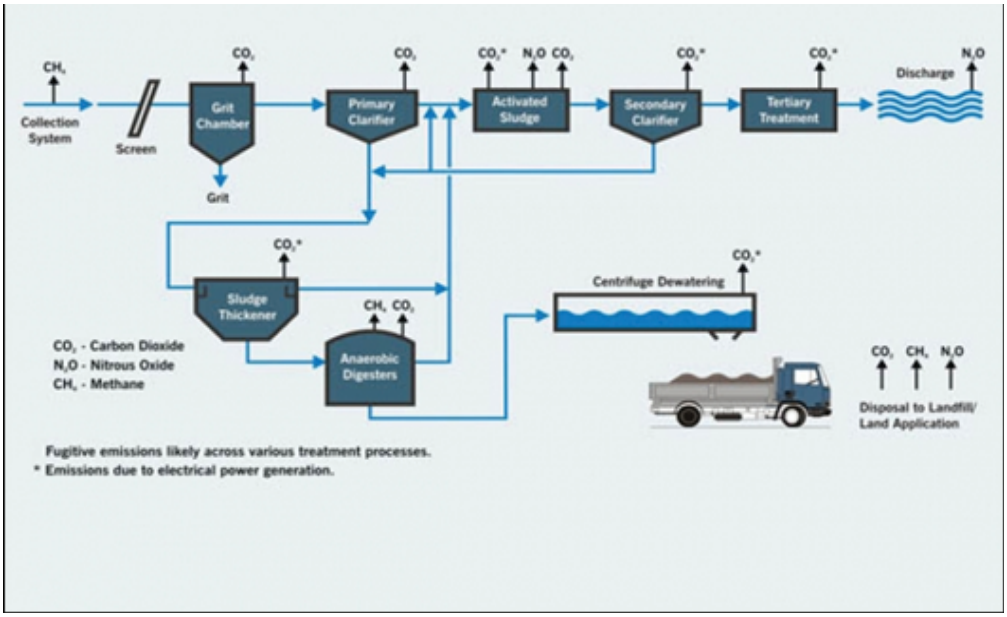

Figure 1: Fugitive emissions from different waste treatment processes [30].

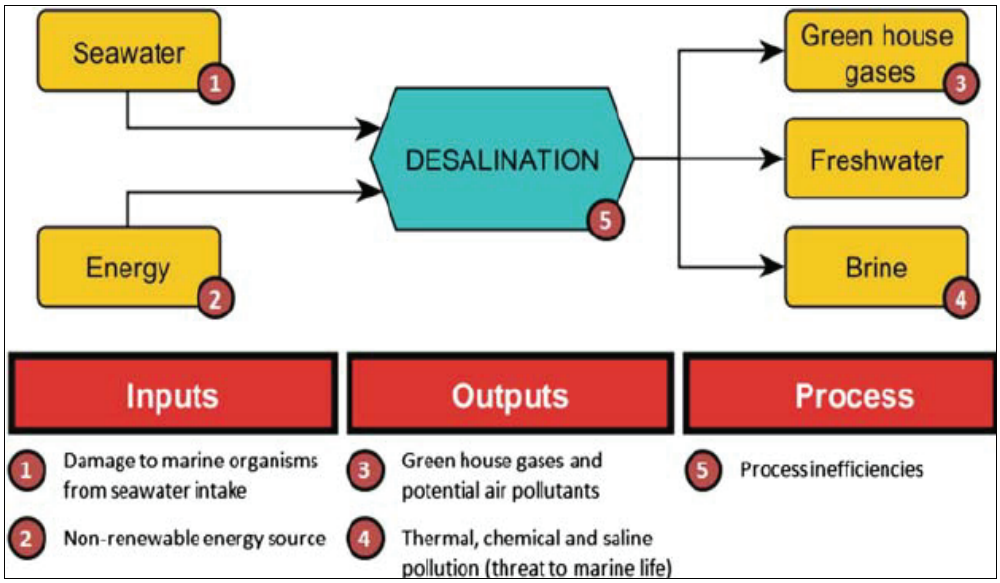

Figure 2: GHG emissions from desalination plant [32].

Types of Pollutants from Water Treatment and Disposable Facilities

Emission of volatile organic compounds (VOC's)

The release of volatile organic compounds from municipal wastewater plants is the main problem for wastewater treatment facilities. Various solvents and chemicals from municipal wastewater is a major source of volatile organic compounds. Volatile organic compounds in gaseous streams also cause issues like bad odors or and toxicity. They are a major source of air pollution [33].

Volatile organic compounds are also released during the composting of different organic wastes [33]. According to several studies, volatile organic compounds are also released during bio-drying of municipal solid waste [34]. In anaerobic digestion facilities and composting facilities, a large quantity of volatile organic compounds is released. Biodegradation of wastes causes the production of volatile organic compounds in composting sites. During the process of biological decomposition, a large number of volatile organic compounds are released from the organic matrix as well [35].

Volatile organic compound gases are also produced in landfills when household chemical products are vaporized in the landfill sites [36]. In

one study, the volatile organic compound concentration was measured in both unclosed and abandoned landfills [37]. The unclosed landfill was found to release very high concentrations of aromatic volatile organic compounds. The abandoned landfills had a lower quantity of volatile organic compounds than the unclosed landfills, but it was over the permissible limits. Benzene, toluene, ethylbenzene, and xylene were the major volatile organic compounds detected in the air [37]. But, volatile organic compounds account to only one percent of the total gasses released by landfills [36].

Refinery and petrochemical wastewater treatment plants are also a major source of releasing pollutants like volatile organic compounds into the air. Petroleum contains a large amount of volatile organic compounds in it. They have low boiling points and are immediately released into the air after contact [15].

Controlling the release of volatile organic compounds into the air is a big challenge for petroleum and the oil refining industries [15]. Both aliphatic and aromatic volatile organic compounds are released into the air from petroleum refineries. High amounts of volatile organic compounds are also detected from wastewater streams coming from petroleum plants and refineries [38].

The use of fossil fuels in desalination plants is also responsible for releasing 16,000 tons of volatile organic compounds into the air. There needs to be an alternative renewable fuel used for the desalination of seawater [39].

Emissions of VOC from different industrial sectors are presented in the figure 3.

Malodorous compounds

Malodorous compounds are formed due to the various biological and chemical processes that occur in the municipal solid wastewater and waste disposable sites. Malodorous compounds are responsible for negatively affecting people living in the surrounding areas. These compounds may include monocarboxylic acids, nitrogen, sulfur, volatile fatty acids, hydrogen sulfide, and various inorganic compounds [40].

There are many compounds that produce pungent odors. For example, Hydrogen sulfide is known to produce a strong odor of decaying eggs. Bivalent sulfur has a strong odor in low quantities. Organosulfur compounds which have crotyl mercaptans, methyl mercaptan and isopentyl mercaptans produce the odor of flatus. Many volatile fatty acids like butyric acids are also characterized by their strong, unpleasant smell [40].

It is found that young landfill has a large quantity of biodegradable organic matter which is easily degraded by micro-organisms. Therefore, rapid anaerobic fermentation is observed in such landfills. A large number of volatile fatty acids are produced because of this process. This process is also known to decrease the pH, which leads to the release of heavy metals. Acetic bacteria also grow in these landfills. When the landfill becomes mature all the carboxylic acids are consumed. Therefore, there is less production of volatile fatty acids as a landfill ages. Hence, in order to control the bad odor coming from landfills, the level of volatile fatty acids needs to be monitored [40].

Emission of greenhouse gases

Municipal wastewater treatment plants are one of the minor sources of greenhouse gases in the atmosphere. They are known to emit three major sources of greenhouse gases which are methane, carbon dioxide, and nitrous oxide [29]. Wastewater treatment plants emit methane, carbon dioxide, and nitrous oxide directly into the atmosphere. They are also found to cause indirect emissions from the generation of energy [41]. Aerobic biological treatment plants produce very large amounts of greenhouse gases as they require a large amount of energy to carry out various processes. The quantity of these gasses produced is also dependent on the influent of the wastewater, off-site treatments, and treatment processes [29].

Landfills on the other hand, are known to release various types of gasses. But, greenhouse gases are some of the largest amount of gasses released from municipal solid waste landfills. Solid waste landfills are known to release forty to sixty-five percent of methane of the total landfill gas components [36]. They also release a large amount of carbon dioxide [36].

Effective wastewater treatment coming out of refineries and petrochemical industries is necessary for the health of the people. Nevertheless, they are also known to cause large-scale emission of greenhouse gases into the atmosphere. According to one study from the EPA, in the United States of America around 0.40% of the total greenhouse, gasses are emitted by wastewater treatment plants of refineries and petroleum industries [42].

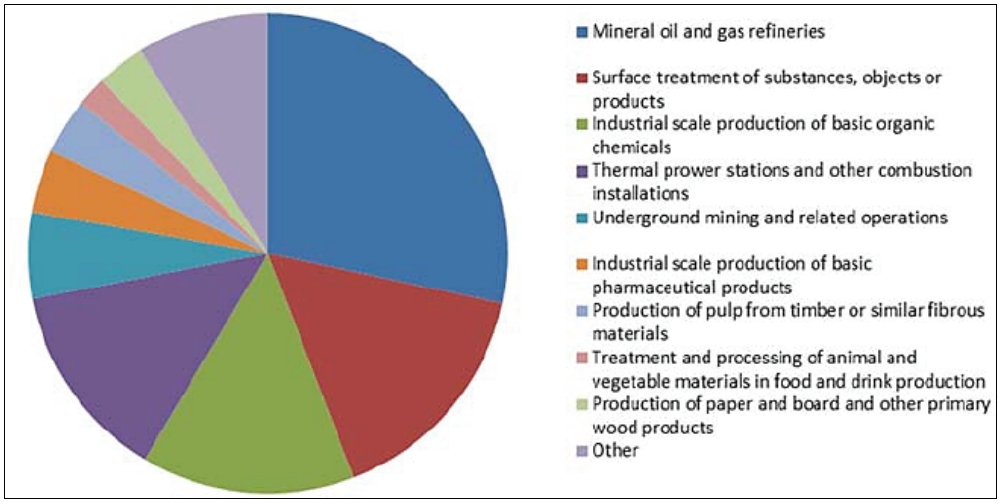

Figure 3: Non-methane volatile organic compound emission shares from European industrial facilities in 2012 [30].

Desalination plants are also a big source of hydrocarbons and carbon monoxide in the atmosphere [43]. The combustion of fuels in desalination plants leads to the production of greenhouse gasses in large amounts. Desalination plants are known to emit around 200 million tons of carbon dioxide each year worldwide [39].

Airborne microbial contaminants

Wastewater treatment plants are also known to release aerosols into the atmosphere and cause health issues to people working with the plants and living in the surrounding areas. Many kinds of bacterial and fungal communities are released into the air from these municipal wastewater treatment plants. *Mesophilic bacteria, Psychrophilic bacteria, Staphylococcus mannitol positive, Coliform bacteria, Staphylococcus mannitol negative, Pseudomonas fluorescens,* and fungi are found to be released into the atmosphere from wastewater treatment plants [44].

There have been many studies before which document that the droplets from wastewater treatment plants have ten to thousand times more bacteria than the water sources. Temperature, the velocity of the wind, the amount specific humidity, smog, and other factors are responsible for the spread of microorganism in the air along with aerosol. High humidity is responsible for the growth of micro-organisms as it provides protection to them from solar radiation and does not dehydrate the bacterial cells like the low humidity [45].

Bio-aerosols are known to contain various types of microorganisms that can cause disorders of the respiratory system, digestive system, and skin conditions. Bio-aerosols also affect the quality of air in the surrounding [6]. Studies have found that activated sludge wastewater treatment plants release a very high amount of bio-aerosols. The most common size of bacterial-aerosols in these plants was found to be higher than 8.2 μm [46].

Moreover, it was found that domestic sewage containing animal and human excreta contains the highest amounts of microorganisms. They are usually treated and released by municipal wastewater plants which, in turen, cause various micro-organisms to enter the atmosphere [6].

Landfills are also responsible for emitting the highest amount of bio-aerosols. They release bacterial and fungal species like *Pseudomonas fluorescens, mannitol-positive and negative staphylococci, Escherichia coli, Aspergillus fumigatus, Cladosporium herbarum, Gram-positive cocci, A. terreus*, and Mycological analyses into the surrounding air [47]. The fungi saprophytic fungi that decompose organic compounds are found in very high amounts near landfills [48]. Active landfills contributed to higher amounts of bio-aerosols than other kinds of landfills [49]. The configuration of these bio-aerosols in the air was affected by the climatic conditions [50]. Industrial wastewater treatment plant set up in petroleum refineries has also found to emit bio-aerosols into the air [19].

Dioxin, Nitrogen oxides (NO_x) and Sulfur oxides (SO_x)

Nitrous oxide emissions from wastewater treatment plant are an issue that needs to be addressed. It has significantly increased in the last few years in the urban areas. Nevertheless, wastewater treatment plants still contribute to only a small amount of nitrous oxide in the atmosphere when compared to the other sources [51,52]. The design of the plants and operational conditions significantly affects the release of nitrous oxide into the atmosphere. The compound is mostly released into the atmosphere during the biological nitrogen removal in the wastewater treatment plant. Domestic wastewater also has a higher amount of nitrogen. The plants which take more efforts in nitrogen removal emit a less amount of nitrous oxide into the air [51].

There are various processes that take place in the wastewater treatment plants. These processes lead to the production of oxides of sulfur and oxides of nitrogen. Combustion of fuel to run these plants also leads to the large-scale production of oxides of sulfur and nitrogen [53]. The presence of dioxins, furans, and Polychlorinated biphenyls (PCBs) has been detected in secondary effluents of wastewater plants. Although their quantity is very low, they pose a significant threat. Dioxins and furans are also generated from the combustion of fuels in these plants [54]. Sulfur gases and sulfides are produced by microorganisms in landfills, which reduce organic materials.

From previous studies, we also find out that some of the biggest sources of pollutants from desalination plants are nitrogen oxides and sulfur dioxide [43]. Desalination plants are known to contribute to about 60,000 tons of NO_x per year and 200,000 tons of SO_x per year [39].

Effects of Pollution from Waste Treatment and Disposable Facilities

Effects on human health

Air pollution from wastewater treatment and disposable facilities affects both humans and animals. Living near wastewater treatment plants, landfills, and desalination plants do cause adverse effects on human health.

Wastewater treatment plants are the biggest source of bio-aerosols and other chemicals. Due, to this factor they are a huge health risk to plant workers and people living in the surrounding area. Microorganisms from wastewaters travel through the air. They multiply and affect humans in a negative way. They may cause infections and diseases in many people. Various fungal and bacterial sources that have been isolated enter the systems of people living nearby these facilities [45].

Atmospheric emissions from waste management facilities are highly toxic to plant workers and people living around. Many people exposed to these emissions and microorganisms may show signs of respiratory problems and digestive issues [45]. Offensive odor coming from landfills and wastewater may also cause a nuisance to people in the surrounding areas [55]. Carbon monoxide released from these plants may lead to carbon monoxide poisoning, which can cause weakness, dizziness, nausea, vomiting, headache, and can even be fatal in some conditions [56]. Sulfur dioxide can cause lung diseases, damages to the eyes, and skin diseases. Nitrogen oxide may also cause respiratory diseases [57].

Volatile organic compounds like perchloroethylene, vinyl chloride, benzene, and trichloroethylene released from landfills can be very toxic and can affect humans [36]. Dioxins on the other hand, are responsible for altering the metabolism rate of the body by altering the number of metabolic enzymes. Dioxins may also alter the homeostasis of the body by hormone modulation. They may also affect the growth factors of living organisms. Dioxins may bind with the DNA and alter the expression of many different genes [58].

According to The World health organization (WHO) report, people living near landfills and waste disposal sites experience issues with a high concentration of hydrogen sulfide. Many people experience respiratory issues, cancers, and birth defects due to their contact with dangerous chemicals. Cancers of larynx, liver, pancreas, kidney, and skin have been documented.

Effects on wildlife

Over the period of hundred years, several domestic animals have died due to industrial air pollution. Little attention has been paid to the impact of air pollution on wildlife. Air pollution affects both wild animals and birds throughout the world. It has caused direct effects on wild species which include death, stress, debilitating, anaemia, and bioaccumulation. A few classes of air pollutants have changed the distribution of certain birds and animals [59].

Several studies have suggested that air pollution is responsible for the destruction of the diversity of species on earth. Contamination of the environment due to air pollution has caused the extinction of many plants and animals. Climatic changes, increase in temperature, and acid rain has altered the habitat of many species of flora and fauna. Excess amount of sulfur dioxide emission has also caused the reduction of oxygen in water which has led to wide scale death of wild marine species.

Effect on the environment

Air pollution causes huge environmental effects. However, air pollution from wastewater treatment plants, landfills, and desalination plants is very small. Nevertheless, they do contribute to the overall amount of air pollution in the world. Some of the biggest environmental consequences of air pollution are global warming, acid rain, smog formation, depletion of the ozone layer, and aerosol formation.

Global climate change or global warming is being caused by the increased anthropogenic emission of carbon dioxide and other greenhouse gasses. The increase in the release of greenhouse gasses is warming the earth. It is predicted by the end of the century that there would be 2-3°C rise in temperature if our activities continue. Global warming might help the northern countries in the winter months, but the overall effects of it would be catastrophic. It will cause the rise in sea levels as the poles melt due to the higher temperature. It will cause significant ecological changes. Many species will go extinct and the biodiversity of the earth will be badly affected [60].

Formation of acid rain is another adverse effect of air pollution. It causes damage to the aquatic life, skin disorders in humans, and changes the pH of the soil. Acid rain is formed when oxides of nitrogen and sulfur dioxide react with water in the atmosphere. It leads to the formation of sulfuric acid, weak carbonic acid, and nitric acid. These acids come down with rain and are known as acid rain. The pH of this rain is around three to six. These are also known to cause an adverse effect on monuments and buildings [61].

The formation of photochemical smog is another adverse effect of air pollution. Pollutants like nitrogen oxides and hydrocarbons that are released from various wastewater treatment plants react in the presence of sunlight to form smog. It is characterized by a haze which is brownish in color. It is only seen in the winter and it reduces visibility. Smog causes various respiratory disorders, along with allergies.

The depletion of ozone layer in the atmosphere is one of the most dangerous effects of air pollution. Ozone is known to absorb ultraviolet rays of the sun and protect the earth from its harm. Hydrocarbons like chlorofluorocarbons destroy the ozone layer and lead to the formation of ozone holes. Ozone holes have been observed in the southern hemisphere of the earth. Countries in this hemisphere have also reported higher rates of skin cancer.

The dispersion of liquid and solid particles in the atmosphere has led to the formation of a thick aerosol layer in the troposphere. This layer causes undesirable effects by blocking the radiations from the sun. Aerosols also sitting on the surface of the leaves and hinder the process of photosynthesis [61].

Economic effect of air pollution

Poor air pollution causes an adverse effect on the economic situation of the country along with its other effects. Various studies have calculated the economic burden it costs society to cure people with adverse health issues due to being exposed to air contaminants [38]. According to The Organization for Economic Co-operation and Development (OECD), three million people died prematurely due to exposure to outdoor air pollution and the Global Burden of Disease estimates that around six to nine million people will die every year due to outdoor pollution by 2060. This will drastically increase welfare costs. Healthcare costs due to outdoor air pollution are expected to rise from $21 billion in 2015 to $176 billion by 2060 [62]. The impacts of outdoor air pollution will cost one percent of a country's GDP by 2060. In countries like India, the urban population is already bearing a higher health care costs due to outdoor air pollution [63] figure 4.

Pollution during Constructional and Operational Phase

This section of the report addresses the important issues to be discussed in the environmental impact assessment during construction and operational phase of any waste treatment and disposal facilities. Table 1 and 2 show air quality and describes its anticipated impact on the environment and mitigation measures.

Conclusion

Although the incidence of air pollution from landfills, treatment plants and desalination plants is negligible when compared to emissions from other sources, they are still responsible for significant negative effects on the surrounding population. Greenhouse gas emissions are responsible for global warming and endangering the ozone layer. High quantities of nitrogen by-products released from waste-water treatment plants and desalination plants are responsible for generation of smog.

Smog is a major health-hazard and responsible for respiratory diseases and incidences of allergic reactions. Another undesirable effect of emissions is acid rains that results in harm to crops, reduction in pH of soil and a secondary effect on buildings. A serious aspect of air pollution is release of aerosols. These contain bacteria and fungi that may constitute a major health-hazard for the surrounding population. The unpleasant odour also harms the quality of life of nearby residents.

The extinction of several species of animals and loss of habitats is attributed to air pollution. Humans are not exempt from these ill-

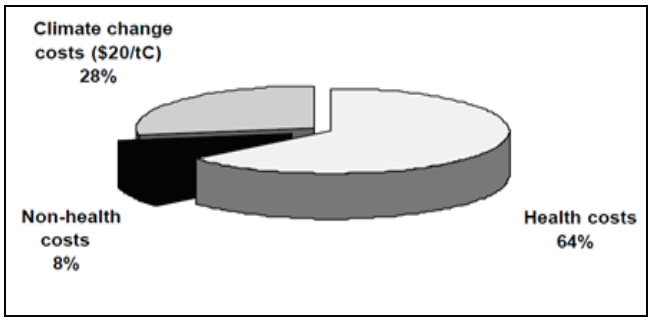

Figure 4: Health and environmental changes due to air pollution adopted from WHO [63].

Table 1: Air quality impacts-constructional phase.

Source/Unit/Activity	Impact/Aspect/Effect	Consequences	Mitigation Measure
Truck / Large vehicles	• GHG emissions • Nitrogen dioxide from exhaust emissions	• Health associated impacts (e.g. respiratory problems and eye irritation) • Ambient air pollution • Global problems (warming, acid rain, and ozone depletion)	Additional mitigation measures are not needed as AQOs are not exceeded at air sensitive receivers
High energy tool- e.g. Cut-off saws, grinders and blaster	Particulate emissions - dust	• Health associated impacts (e.g. Asthma) • Affect the ability of nearby vegetation to survive	• Use less powerful tool-e.g. Block splitter • Getting material cut off site and delivered • Water suppression • good site and housekeeping practices • Drilling through a dust 'collector' or using cordless extraction attached to the drill
Demolition of certain building	• Release of heavy metals and asbestos fibers • Release of certain fungal spores from old building • Ozone Depleting Substances	• Health associated impacts (e.g. lung cancer) • Immune system deficiency • Soil erosion • Ozone Depletion	Sample collection and analysis

Table 2: Air quality impacts-operational phase.

Source/Unit/Activity	Impact/Aspect/Effect	Consequences	Mitigation Measure
Cooling Towers	Release of Smog	Health associated impacts (e.g. respiratory problems and eye irritation)	• Additional mitigation measures are not required as natural gas emits a negligible fraction of the smog-causing gases • Locate cooling water discharge such that impacts are minimized.
Main Stack	Discharge of NO_x, SO_x, and GHG emissions	• Ambient air pollution • Associated health impacts • Global problems (warming, acid rain, and ozone depletion)	Additional mitigation measures are not needed as AQOs are not exceeded at air sensitive receivers
Desalination plant (MSF)	Offensive noise and vibration Warming the environment when high energy used	• Global warming • Ozone depletion • Ambient air pollution	• Install Desalination plant far from recreational tourist area • Optimize the system applied (desulphurization techniques).
Sludge and solid waste	Discharge of NO_x, SO_x, and GHG emissions	• Ambient air pollution • Associated health impacts • Global problems (warming, acid rain, and ozone depletion)	• Implementation of a waste management plan • Disposal of wastes at licensed disposal facilities or licensed recycling facilities
Combustion of coal	CO_2 production	Use new technologies	
Combustion of fuel or heavy oil	Suspended particles, SO_2 and CO_2	• Ambient air pollution • Associated health impacts • Global problems (warming, acid rain, and ozone depletion)	Use new technologies
Incineration	Dioxin Mercury Flue gases Ash	• Ambient air pollution • Associated health impacts • Global problems (warming, acid rain, and ozone depletion)	Use new technologies
Landfill	H_2S Aerosol	• Associated health impacts • Bad odor	• Sanitary landfill • Landfill cover

effects, and per-year human deaths due to air-pollution are on the rise. This number is set to increase in the future. This can lead to an increased burden on the existing healthcare system.

Owing to heavy economic and ecological consequences, efforts need to be directed at curbing air pollution before the tipping point is reached. Various new technologies have been sampled for the same. One such technology is nanotechnology. Carbon nanotubes (CNTs) can help in adsorption o released gases. These CNTs can be used for nitrogen adsorption, adsorption of dioxins and CO_2 capture. Purification systems based on photo catalysts, carbon adsorption and ozonolysis can purify the air at local levels. Nanotechnology may also serve as a detection system for pollution. This is especially useful in detection of heavy metals.

Author Contributions

H. A. Contributed to writing the article and R. I. helped with technical input, reviewed and edited the content for final submission.

Additional Information

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