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Waste disposal and landfill: Potential hazards and their impact on groundwater

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Abstract

The waste management should be aware of the complexity of the potential of CO₂ and methane gas present in the soil and further works must be processed on the assumed landfill gas presence. Moreover, there are other landfill gas properties to be noted. Methane is colorless, odorless landfill gas, typically related to various largely odoriferous compounds that provides a certain warning showing its presence. Yet, lack of odor does not mean that it is deprived of methane, because, the level of Methane can be reliably assessed only by properly calibrating using the methane detector.

Methane and Carbon dioxide are flammable gases and they can burn when mixed with about 12.5% of v/v air. If the Methane or Carbon dioxide is mixed with air in this composition in a confined space, the ensuing combustion can create an explosion, while Methane is supposed to be an Asphyxiating gas. There are other asphyxiating gases in the landfill that can cause adverse health hazards at somewhat low concentration levels. The long-lasting OEL- Occupational Exposure Limit remains at 0.65% (v/v). Their presence can be confirmed only by appropriately measuring with calibrated detectors.

Also, it is understood that carbon dioxide gas is heavier than air and Methane gas is lighter, but in all the practical applications, the density of methane and CO₂ is taken as equal to air. However, in landfill site situations, the ratio mixture methane and CO₂ make them heavier or lighter than air. Hence, the landfill gas can accumulate on top or in the base of voids and in the confined spaces, to create problems later.

Due to this, the survey highlights the need for immediate relocation of the dumpsites to a safe and sufficient distance from every human town, village, and community settlements, and also provide environmental and resettlement education programs for all those people living in the surrounding areas almost fifty meters from the dumpsite as intervening measures. Rendering the precise scientific and substantiating evidence in an effective and realistic manner can undisputedly provide a clear potential to decrease air pollution, which no longer develops an expensive and damaging levy on public security and health.

Keywords: health, pollution, environment, landfill, resettlement, solid waste disposal, management, dumpsite, social-economic, waste landfill gas, leachate, methane, CO₂.

Introduction

Background: Landfill impact, waste management, is demanding process in every country. It creates an adverse implications for human health, circular economy, environmental preservation, and sustainability.

The approach made by residents for open dumpsites as a disposal of the solid waste materials is a primitive application of the management of solid waste in various places in the world. This is because, it becomes the most scantily provided service facilities by the local municipal authorities, and this system has proved to be the most inefficient, outdated and unscientific. The dumping of solid waste is observed within the city limits and also on the outside of the urban city limits. Due to the global population increase, and the growing demand for all the commodities like food, water and all the essential goods, the amount of waste has also increased generated regularly by every household. This waste is thrown and discarded eventually into the sites provided by municipal disposal segments. Further, because of inadequate and ineffective waste disposal management, these dumpsites convert into the major sources of health and environmental hazards to all the residents staying in the dumpsite vicinity. The effective pollution produced in the earth, like water, air and land, is the major problem of concern. As stated by Nguyen, *et al.*, (2011) [22], several cities in the global developing countries encounter a dire health and environmental degradation risks, because of the regular solid waste development and inadequate municipal system of management.

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They have underestimated to what extent the toxicity of landfill contaminants can suppress and restrain the human immune system (Gazasia, 2021)^[6].

After examining with studies regarding the effects of health and environmental developed from waste dumps, it indicated that there is a definite link between them. It specifies that this leads to an increase in interest to study environmental pollution related subjects as they have a sure effect on animals and plants. Because of the solid waste disposal, there is a definite environmental and health implications for people living in wastes dumpsite close proximity (Wagner, 2007)^[26]. The ever-increasing resource consumption have resulted in enormous solid waste amounts from industrial and domestic actions, and they pose considerable threats to human safety and health. However, the problems of municipal solid waste in an inappropriate disposed manner are abundant to be mentioned. Flood occurrences, health deteriorates, environmental pressures, accidents, are a few negative effects. In various developing countries, disposal sites of solid waste are observed in the urban area outskirts. They have become the major contamination ground and source for children, due to the proliferation of flies, rodents, incubation, and mosquitoes. They generate diseases, which get transmitted to affect the

health of population, which has developed proper organic defenses in a creative and formative manner. Such drastic situation generates respiratory, gastrointestinal, genetic, dermatological, and similar infectious diseases (Tudor, *et al.*, 2011)^[16].

Landfills can generate devastating effects upon the environment

Emission of Methane gas

- Biodegradable waste of one tonne quantity generates landfill gas of around 250 and 450 cubic meters, which includes around 55% methane, 45% carbon dioxide;
- Methane gas has actually 230% more toxicity than CO₂ and any other greenhouse gases. Its emission generates a significant climate pollution and change;
- Methane gas can act as a flammable source and it can explode if exposed to heat;
- As per the US EPA- Environmental Agency of Protection, a sizeable emission amounts contribute to global climate change and warming. This is mainly due to landfill gas traces, and the disposed food wastes (Gazasia, 2021)^[6].

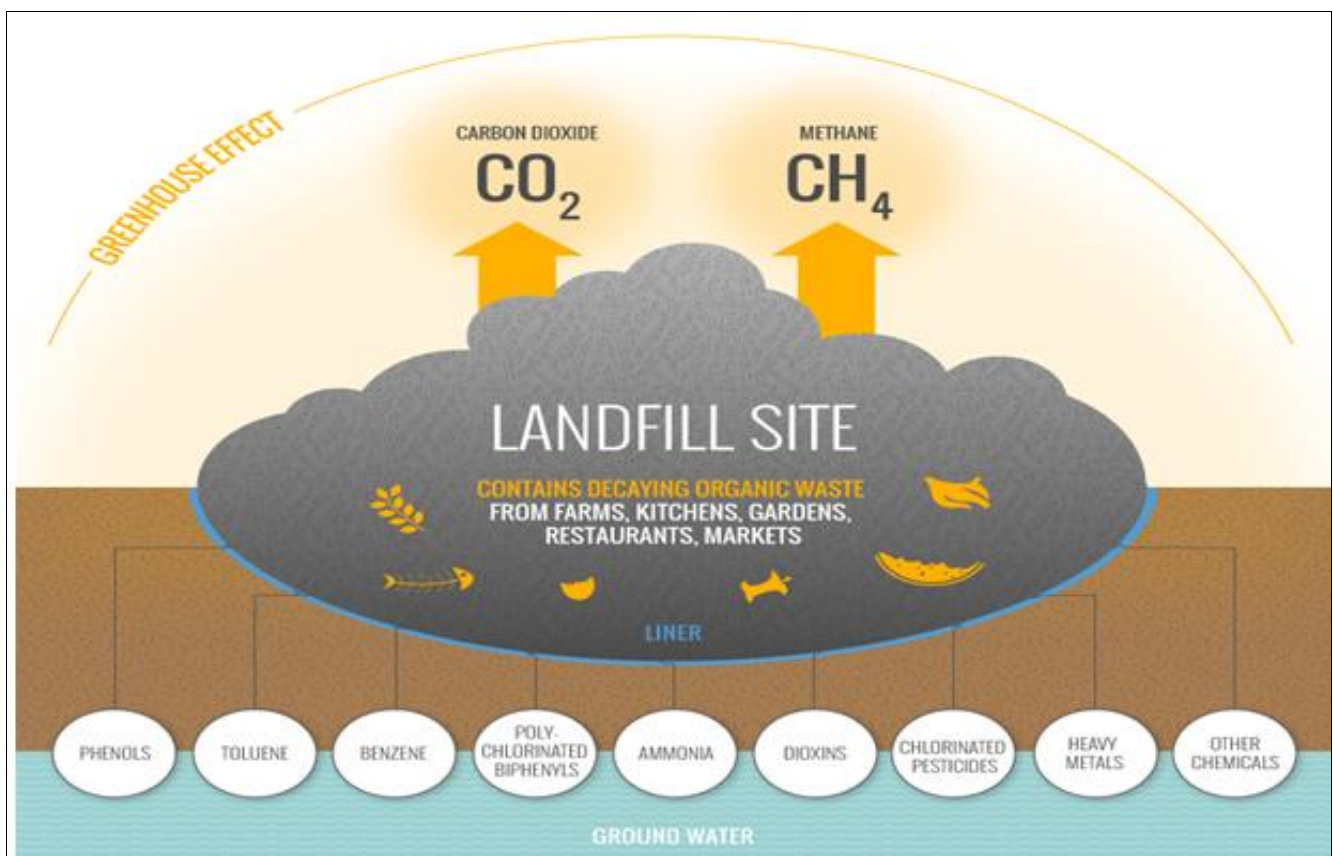


Fig 1: Landfill sites and gas generation (Gazasia, 2021)^[6].

Contamination of the Leachate

- The organic and inorganic concoction generates pollutants like Leachate, and they are generated during the site operation of the landfill. The Leachate can start leaking from the contaminants of the landfill to adjoining soil and also enter the groundwater.
- The kind of Leachate involves endocrine-disrupting

chemicals, toluene, benzene, phenols, heavy metals, ammonia, chlorinated pesticides, and dioxins;

- Even though several landfills have pipes and liner, fittings designed to root out the Leachate, as per the EPA specifications, there is not any, single system to provide complete and definite protection (Gazasia, 2021)^[6].

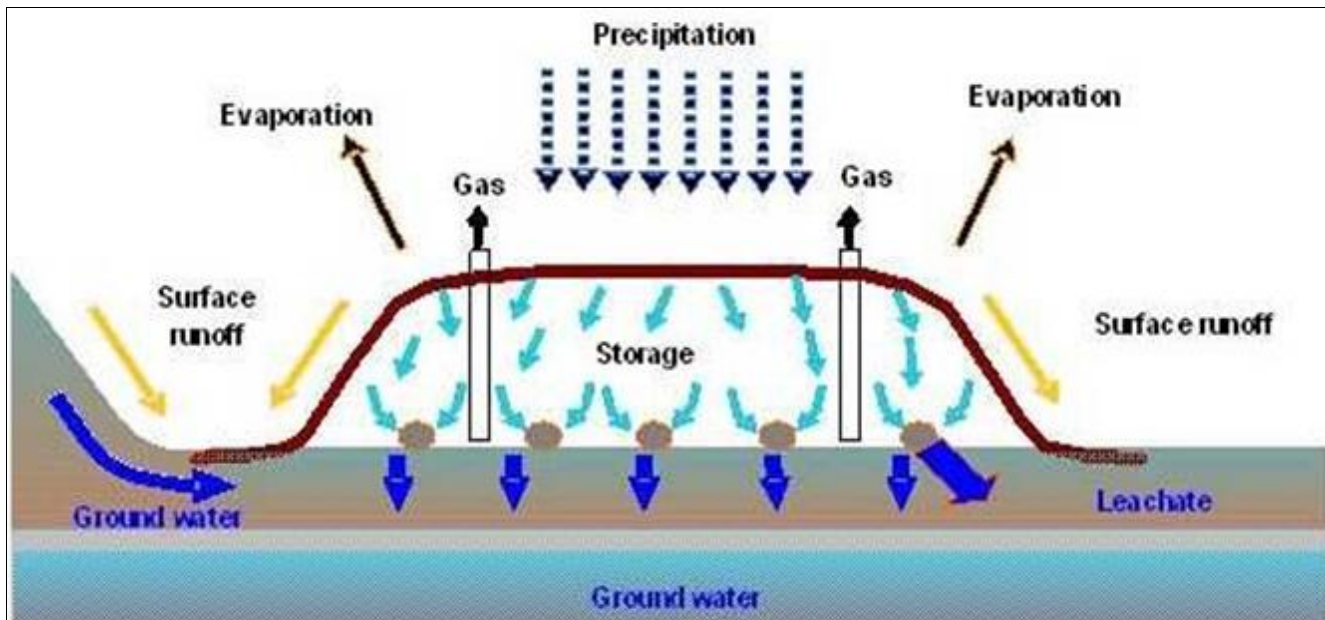


Fig 2: Water Pollution sources and landfill Leachate (Timlett, & Williams, 2008) ^[20].

Consequences due to leaks

- A leak from the landfill can permit toxins to spread by escaping completely into the atmosphere, and this always leads to contamination of soil, air, and water. There are numerous health risks associated with residing in the landfill proximity, including:
- Specific kinds of cancer, particularly linked to the brain, bladder;
- The Hygiene and Tropical Medicine School of Research in London have discovered that newly born baby living nearby landfill areas had more risk of defects at birth;
- Residing near the landfill site means exposing to toxic chemicals that reduce the effective performance of the body immune system, and that can lead to larger infection risks;
- It is evident that children residing near the landfill and waste sites, or near the contaminated water bodies, are more frequently hospitalized due to intense respiratory problems and infections (Jitendra Giri, *et al.*, 2014) ^[18].

Scientific ways to dispose waste

The scientific method used for the landfills can alter the entire waste disposal and management scenario.

The urban dwellers are normally woken up by the collectors of garbage as they whistle and deposit the daily garbage in the waste collection automobile. Many people are unaware of the consequences of the garbage thrown haphazardly and the advantages of its disposal through the municipal vehicle. The urban civic authorities have tried for several years to dispose of waste material in landfills, where large land spaces are demarcated particularly for the disposal of garbage. The landfill concept in the urban region was basically created because of a large land area located far away from the residential buildings. The garbage got disposed of incessantly recycled and hence, the landfill did

not exhaust itself. However, due to population expansion of the urban areas over several years have transformed the landfills to become a dump yard, with no regard for its lifespan or capacity (Said, 2009) ^[17].

Presently, the Indian landfills pose tremendous and abundant threats because of their indiscriminate disposal and unscientific ways of operation, design, and waste disposal. The most important landfill threat is because of the methane gas emission produced due to the accumulation of waste. This Methane gas can cause landfill fires, results in the burning of garbage, causing extreme air pollution. Landfills further pose numerous health hazards as they have become a storehouse of bacteria and viruses, causing lung and cardiovascular diseases (Said, 2009) ^[17].

Scientific Landfill Functioning

This mentions the scientific designs at the time of construction. The largest problem of the normal landfill is the solid waste seeping process into nearby soil and water underlying, contaminating them all. Scientific landfill functioning can eliminate these risks of seeping waste into underground sources because the bottom basic layer built from 90 meters of clay. Hence, it arrests any leakage or seepage within the landfill. Above the bottom layer, the drainage layer is built of soil, of 15-meter length, a vegetative 45-centimeter layer to reduce soil erosion. These layers ensure that the Leachate is gathered prior to seeping underground.

The scientifically designed landfills can perform like Degas's system as they reduce methane production. These layers soak a large number of impurities of the disposed waste, while methane develops gradually in normal landfills. The installed scientific vertical wells in landfills also help extract methane frequently, when the gas can be further used for heat and electricity generation purposes.

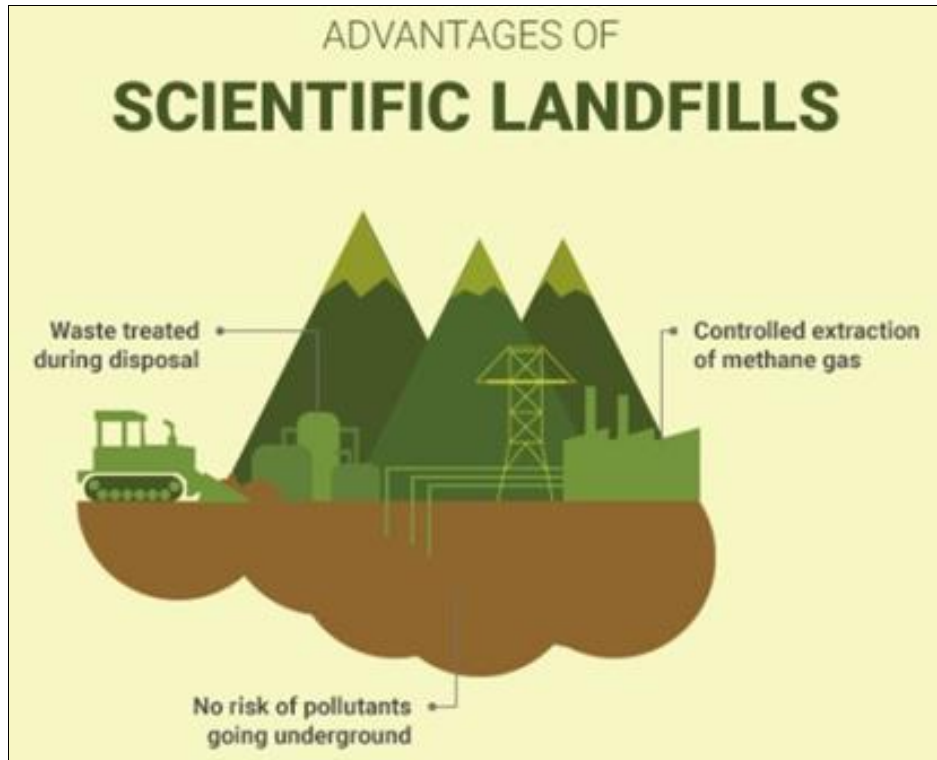


Fig 3: Scientific landfill advantages (Agnihotri, 2020) [1].

A scientifically designed landfill creates no pollutant risk of seepage into underground or it does not generate methane to ignite the garbage (Agnihotri, 2020) [1].

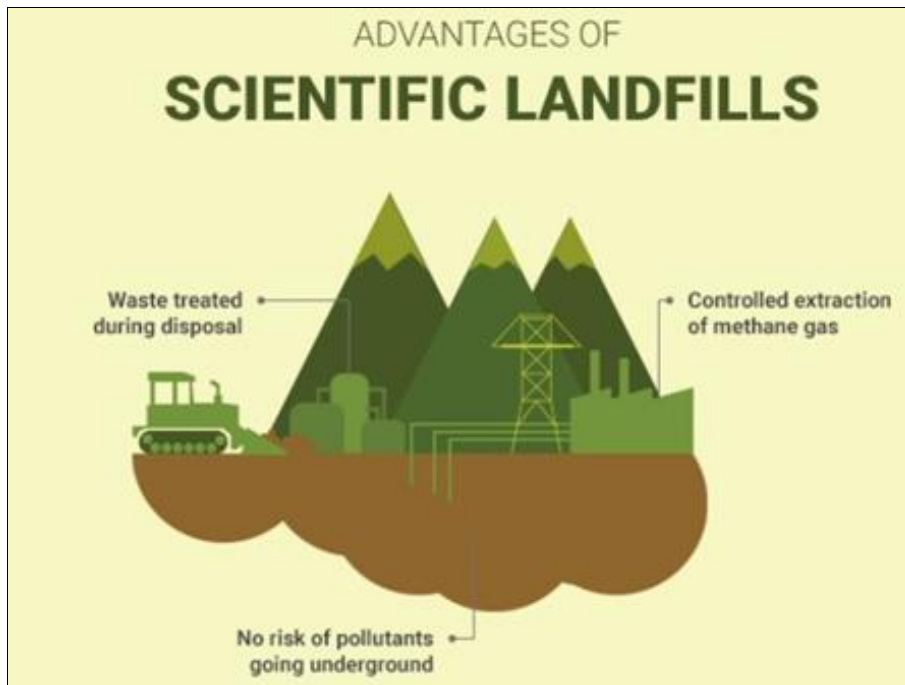
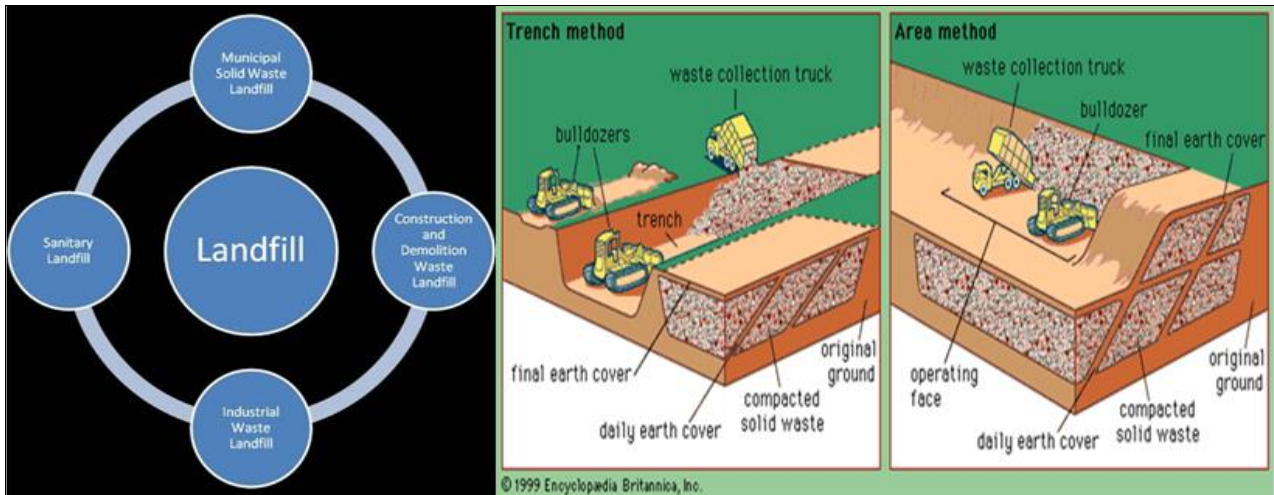


Fig 4: Modern features of a sanitary landfill (Milik, 2010) [13]

The waste accumulation impact can be very dangerous for several residents and communities in II developing countries. Egypt gets highly challenging issues with no efficient management or properly defined strategies to

manage solid waste. This inflicts acute environmental risks on their communities, while toxic material drains a large amount in the local economic and residential zones (Said, 2009) [17].



Waste Accumulation

There are Sanitary landfills; MSW- Municipal solid waste landfills; Demolition and Construction waste landfills;

Industrial Waste generated Landfills and so on (Said, 2009) [17].

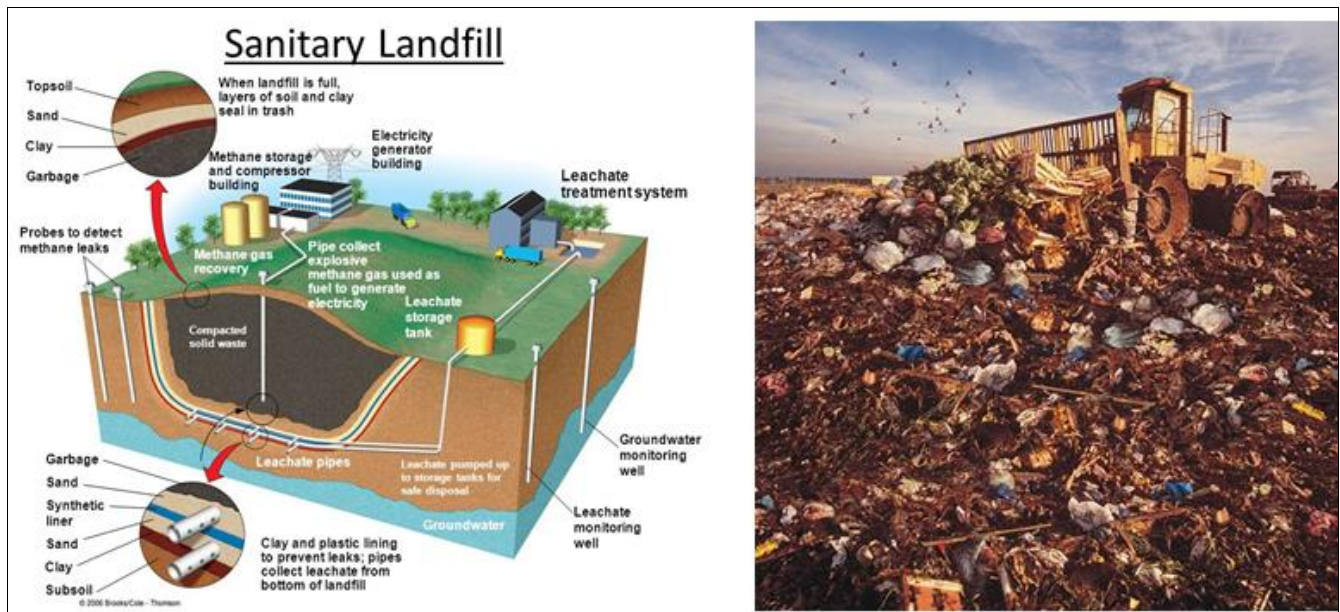


Fig 5: Sanitary and municipal solid waste landfills (Roido & Agisilaos, 2009).

Aim and Objective

The major aim of this paper is to explore the potential hazards due to landfill and waste disposal and to assess the impact on human health, and the environment, and further, gather the scientific contemporary data on innovative and scientific ways to find the waste disposal prospect.

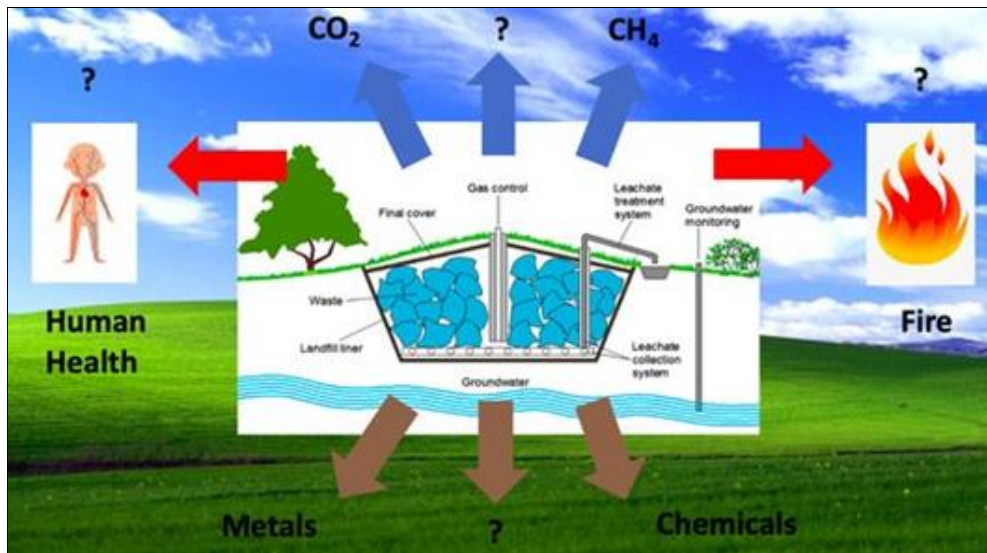
Objectives

1. To investigate what kind of waste materials reaching the landfill and what effects landfill pollution can generate on human health and the environment?

2. To identify the link between the incompetent waste management systems, and the related environmental and health impact;
3. To identify the ways to reverse the pollution effects;

Review of literature

The environmental impact due to landfill explains how the waste management program commenced, and proceeded in the past several decades and what is going to be the future of waste management, landfill programs and how to avoid the environmental impact.



Environmental Impact

MSW- Municipal solid wastes are always explained as the residential and industrial produced waste that comes from the institutional and commercial non-processed type of wastes sources, considering exceptions like universal, hazardous wastes, liquid wastes, construction, demolition wastes, industrially processed wastewaters (Tchobanoglous & Kreith, 2002) ^[19].

The landfill impact explains the effects on the environment and the commencement process of waste management program started in the previous many decades and what is likely to be the waste management future related to landfill programs, and the innovative process to avoid the impact on the environment. The waste disposal management must follow the stipulated norms and prescribed standards, to manage all types of waste coming from residential and industrial zones, failing which, all the various stages will be considered as the inadequate solid waste management process and their primary focus should be mostly on integrated waste management strategies and plans (Smyth, Fredeen & Booth, 2010) ^[23].

Operational logistics plays a vital role in waste management planning and designing. The human resources, requisite equipment, and budget required to plan and design the system must be considered at the designing stage, mentioning the ways these plans should be implemented, processed at every stage, monitored, and finally reviewed. Many organizations and service providers are required to manage the commercial waste collection, recycling process, composting, and so on (Matsumoto, 2011) ^[12]. The related waste service providers and their contractual relationship can be negotiated to obtain the contract provisions that will permit the successful waste management implementation strategy. Before developing a comprehensive plan, the general idea of the volume and waste composition is needed. This data can be gathered by conducting the survey on waste characterization, or waste audits, which information is elemental to logistical designing and planning. After waste audit implementation, they should measure the progress and achievement of the plan, for further review (Timlett & Williams, 2008) ^[20].

In that sense, the solid waste clarifies regarding the solid materials discarded and recovered from agricultural, households, institutional, commercial, healthcare, constructional, and industrial, sources, together with the

solid municipal waste generation in the cities and towns, apart from sewage, industrial waste, water dispersed solids (Chertow, 2007) ^[3]. The only problems generated in all the developing countries are due to their unorganized solid waste management system, which is implemented at the collection source point, disposal section, and the stages of transportation (Eltayeb, Zailani & Ramayah, 2010) ^[4]. Hence, in the municipal waste context, in developing countries, the waste materials involved are normally not known to be a municipal waste. The municipal solid waste management is referred to as the program of designing, planning, financing, and implementation to collect the solid waste, transport them to the appropriate destination, effective treatment, and finally disposed of in the environmental and socially preferred manner (Environment Canada, 2007) ^[5].

Guiding framework

There is an intense discussion regarding the product production and impacts associated with waste materials. Due to increasing pressure and support to improve the social and economic environment impacts proper actions are needed to use materials efficiently, while waste management is involved in further research to implement new procedures. Considering the USA, 6% raw materials are used out of waste materials, and that end up as product. Merely 1% of products, turn up as sturdy and durable, while the remaining goes as waste (Seadon, 2006) ^[18]. Every country has a significantly different waste management system. The only difference is in their waste management explanation and implementing strategies. However, eventually, the prominent issue remains, and it is to achieve specific goals and objectives (Purcell & Magette, 2010) ^[14].

Limitations and Concerns

Basically, waste and garbage are dirty materials and it is the ideal place to generate bacteria and related viruses to breed and stay in. The growth of rubbish in cities is a big problem everywhere in the world for many hundred years. Landfills are known to be the main illness source generating unpleasant smells. The garbage spreads through the harmful wastes sent from several toxic material sources discarded and thrown away as garbage. These toxic materials and chemicals get clogged in the water pipelines and start

spreading through the drinking water. Such problems are created by people and turned out to be disasters, and they are completely related to environmental pollution. Even though more modern and advanced technologies are generated and applied, the additional unbelievable consequences of waste generation will result. Basically, man is entirely responsible to create waste and he has to face the consequences (Wagner & Arnold, 2008) [27].

In real practice, the entire O₂ free environment is difficult to achieve. A certain percentage of oxygen will always remain in any process, while a small amount of oxygen is used in the process. In the waste materials, semi-volatile and

volatile substances exist. Hence, the further reaction of thermal desorption can occur by ions, atoms, and molecule separation of the solid, liquid, and gas from the waste surface (University of Victoria, 2004) [25].

Methods: For waste diversion and minimization, three R's are normally utilized and they indicate "recycle, reuse and reduce". Due to the increase in the rates of waste generation, the cost of processing also increased accordingly, while the landfill available space reduced. The three R's turned out to be the prime tenet, when sustainable management attempts are made (Tudor *et al.*, 2011) [21].

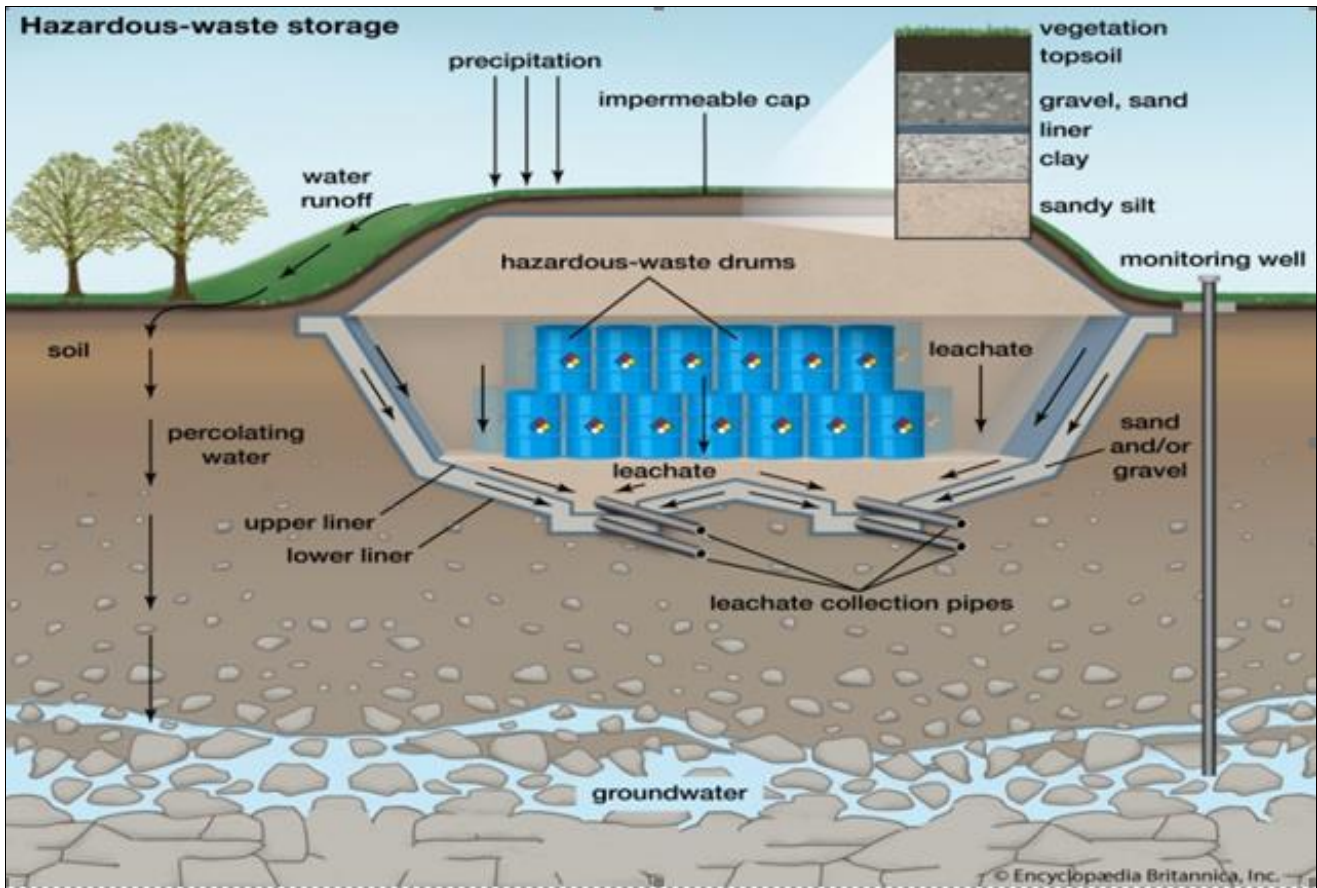


Fig 6: Waste landfill having a Leachate collection system (Hazardous-waste landfill, 2021).

Also, waste management, eight prime segment methods were identified, and each of them can be divided into different categories. They are source reduction, reuse, recycling, composting, incineration, land applications, animal feeding, fermentation, and finally landfills.

The framework configuration of development links to various waste management work policies, practices, and the impact they create on human health and the environment in various countries. Diverse iterations of the framework were recommended by the field experts and every outcome linkage was elaborated.

Hypothesis: Waste disposal, land, and landfills are the most potential environmental pollution risk, hazard zones, and sources.

The future of waste disposal, land and landfill

Even though several governments have directed with proper legislation to make an utmost effort to decrease dependence on the landfill for the disposal of waste, they have found

three highly cost-effective strategy, and hence, their method will possibly remain the most appropriate and established process of waste disposal (Gazasia, 2021) [6].

The right opportunity

It is well known that all landfill sites generate a tremendous amount of gas and chemicals. Hence, there remains a good opportunity to regulate and stabilize these landfill and waste disposal sites to improve biofuel production and reduce the harmful environmental impact.

The use of landfill gas involves local governments, industries, and surrounding people to cooperate and integrate community planning with commitments. It is to get clean air, greenhouse gas reduction, while renewable energy, improves public welfare, health, safety, and economic development (Gazasia, 2021) [6].

The hierarchy of waste disposal, land, and landfill consistently direct towards reducing, recycle, and reuse of landfilling materials as specified in 2009 directives. As per that, any country is not allowed to use landfills for above

35% of biodegradable waste. Its major purpose is to get rid of waste generation and the remaining waste to be reused and recycled. If not, generating energy using the waste material, thermo-vaporization process. Ultimately, the waste has to arrive at the landfills, without any other possibilities of its exit ways (Gazasia, 2021) ^[6].

Result

The results proved that waste disposal, land, and landfill are the prime source of environmental risks. Hence, adequate research should be done to understand the drastic environmental impact mainly because of haphazard waste disposal, land and landfill management.

Hence, it is obvious when the waste avoidance, recycling, and reuse status is achieved, a large number of waste materials will obviously reach the landfill eventually (Ansari, *et al.*, 2019) ^[2]

Conclusion

The prime assessment conclusion is that waste disposal and landfills develop tremendous risk factors. However, the rich living style related to the prevailing situation adopted in industrialized countries, the functioning of the waste management system without landfilling appears somewhat unreal, at least in the near future. A consequential structure developed in this review paper provides a clear linkage picture between deprived waste management methods and that will provide guidance for further action, research, and policy (University of Toronto, 2008).

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