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Research Article

Using Life Cycle Assessment and Damage Cost for Modelling of Concrete Waste: Environment study

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ABSTRACT

Most developing countries have faced a challenge while managing waste for over a decade. The main factors that influence waste management in developed countries' cities include the strain on national resources caused by the high costs of waste management, the lack of knowledge and skills necessary for efficient waste management, and the rising amount of waste produced. Despite implementing systems designed to stop the waste threat, these countries need help with waste management. Due to this issue, numerous issues relating to the harmful consequences of waste products have emerged due to factors like the city's growth, the industry's rapid development, and population growth. However, scientists are working to identify the problem's current state and the best remedy. In this context, the issue of solid waste control and management uses a specific significance as the trend toward urbanization conditions the continued growth of the waste quantity. The effective resolution of this issue guarantees the continued advancement of society and business. The government, which is in charge of a state's continued evolution, works to develop new tools and strategies to make things better. In the United States and Europe, many methods and initiatives have been established at the local, regional, and governmental levels to give an effective solution to the problem of solid waste management. These countries implement garbage collection, transportation, and recycling at the local and regional levels, with a focus on industrial competitiveness, involvement of other countries' landfills, or inter-municipal collaboration. The modernization of the industry must be planned in an economically advantageous way such that expenses are reduced and output is increased. An economical method is therefore needed all over the world to curb this issue.

Keywords: Life Cycle Assessment, Concrete Waste

1. Introduction

One of the best methods to use to control waste management is through an approach referred to as "life cycle assessment," "life cycle analysis," or "eco-balance". This strategy bridges the gap between the type of solid waste and the social or ecological impact it causes. Industrial effects like pollution and greenhouse warming do not directly hurt the environment; the product's action affects the ecosystem (Viau et al., 2020). LCA is a technique that has applications in the social, physical, and normative sciences and can be used to address various environmental problems. It is a research tool that concludes an examination of an environmental issue, its social causes, and the best solutions. International organizations, such as the ''World Business Council for Sustainable Development'', have developed environmental standards and guidelines to advance ecological concerns and behaviors about different environmental processes (Shwedeh, F., Hami, N., & Baker, S. Z. A, 2020). There have been initiatives in this area, such as demonstration projects for cleaner production, educational programs and initiatives, and the development of environmental guidelines, which show the impact that both the government and businesses have placed on efficient ecological management (Reddy, P. J. 2019).

Businesses in both the private and public sector businesses have given their views about environmental opportunities and problems by incorporating environmental issues into their business processes through cleaner production, environmental impact assessment, life cycle analysis, and public reporting. The EIOLCA program is the most popular LCA technique currently used as a model for environmental planning and decision-making (Yas, H., Mardani, A., Albayati, Y. K., Lootah, S. E., & Streimikiene, D., 2020). It is a paradigm for generalized planning and decision-making that addresses all facets of environmental preservation and has three key components (Rives et al., 2019). The first is planning's multidisciplinary aspect, including land use, social, economic, ecological, and technical factors. The second and third parts, which also demand public involvement in the planning process, all include requirements for the execution of corrective programs, evaluation of results, and a continual feedback loop. Wassily Leontief assumed that proportionality relationships might be used to simulate the intricate interconnections inside an economy while developing this approach of LCA (Reddy, 2019). The economic input-output model (EIOM) is the first-order Taylor series approximation of the fundamental, more complex interactions (Khadragy, S., Elshaeer, M., Mouzaek, T., Shammass, D., Shwedeh, F., Aburayya, A., and Aljasmi, S., 2022). This model is an effective practical tool for analyzing small motions surrounding observed data. This paper will discuss the financial study of the solid waste life cycle and management and its overall impact on the environment.

2. Literature Review

The housing and construction industries use a third of the energy in OEC&D member countries. The energy used in manufacturing machinery, assembly, and construction materials, as well as the transportation of those goods, is added up in this. Contrarily, the non-building industries charge 30–50% of all consumed goods and 40% of solid waste (Guo et el., 2021). Resources are becoming more scarce due to the effects of global warming and the worsening of the environment. According to Global Footprint Network, the ability of finite resources to support human consumption shortly is dubious ("Municipal solid waste management planning," 2016). Humans must devise treatments that improve building efficacy regarding operational and material logic to lessen the built environment's environmental footprint (Reddy, 2019). Practices like Life Cycle Assessment (LCA) help find design options that reduce environmental degradation and provide practical information necessary to achieve these advancements (Salameh, M., Taamneh, A., Kitana, A., Aburayya, A., Shwedeh, F., Salloum, S., and Varshney, D., 2022). Sustainability is becoming more of a focus in Australia among policymakers and construction professionals. LCA practitioners and pertinent authorities are responsible for providing relevant BMCC-LCA information and ensuring that the data may be appropriately collected at the B/C level (Ravikumar, R., Kitana, A., Taamneh, A., Aburayya, A., Shwedeh, F., Salloum, S., & Shaalan, K., 2022). An objective gauge to assess construction plans that avoid problems is life cycle assessment, which is being examined as actions are sought to decrease the effects of construction. Strategies like the AusLCI initiatives have been developed to increase and preserve the information necessary in the LCA's endeavor to improve the Life Cycle Assessment application in construction-related decision-making (Shwedeh, F., Hami, N., & Bakar, S. Z. A., 2021). These topics serve as the foundation for this analysis, which compares conventional and nonconventional Australian dwellings to examine the application of life cycle assessment (Khudhair, H. Y., Jusoh, A., Nor, K. M., & Mardani, A., 2021)..

Industry and businesses are assessing how their operations impact the environment as environmental awareness grows (Xia et al., 2022). Companies have responded to this awareness by offering eco-friendly products and employing eco-friendly production techniques and environmental management systems. Raw material acquisition, processing, and even consumption result in waste production. Waste, trash, and junk all refer to the same thing (Tisserant et al., 2017). When a material no longer provides value to a person, that material is regarded as waste. These items are then thrown away or collected (trash collection) for disposal. This falls under waste management, which also covers waste identification, collection, sorting, storage, processing at the source, transportation, recycling, and disposal (Viau, S., Majeau-Bettez, G., Spreutels, L., Legros, R., Margni, M., & Samson, R. 2020).

Solid wastes are any waste that is not fluid, including solid, semi-solid, and even gaseous and liquid materials in containers (Stegmann, 2018). In urban and rural environments, the sources and concentrations of solid waste vary. Agriculture, mining, industry, and municipal trash are these regions' leading producers of solid waste. As a result, industrial, commercial, institutional, building and demolition, municipal, process, and agricultural wastes are some of the origins and forms of solid waste (Aburayya, A., Salloum, S., Alderbashi, K., Shwedeh, F., Shaalan, Y., Alfaisal, R., Malaka, S. and Shaalan, K., 2023). Municipal and non-municipal solid wastes are two general categories for these wastes. Municipal solid wastes are trash from homes, businesses, and city construction debris. In contrast, non-municipal solid wastes are primarily agricultural, industrial, and mining. Wastes from all of the aforementioned above contain toxic materials that can be dangerous. Solid waste collection involves gathering waste, sorting it (sometimes), and transferring it to the designated site. This spot could be a recycling facility, a landfill, or another place to dispose of trash (Salloum, S., Al Marzouqi, A., Alderbashi, K. Y., Shwedeh, F., Aburayya, A., Al Saidat, M. R., & Al-Maroof, R. S., 2023).

The collection of waste products is the responsibility of municipal and city councils in numerous towns and cities worldwide (Misganaw, 2022). However, collecting garbage from its source and delivering it to the appropriate location are also activities of private organizations (Shwedeh, F., Hami, N., Bakar, S. Z. A., Yamin, F. M., & Anuar, A., 2022). The collection of municipal and household garbage is a global endeavor that involves a large number of participants and partners. They serve as mediators, regulators, or users of garbage collection services. According to scientists, these actors include families, neighborhoods, non-governmental organizations (NGOs), local and federal governments, for-profit businesses, unincorporated private businesses, and external support agencies (ESAs). Living in a clean environment is the top priority for residential households and communities (Mulya et al., 2022). They typically want high-quality service providers at the lowest cost since they must purchase waste collection services. In low-income residential neighborhoods, solid trash collection should be given priority (Yas, H., Alnazawi, A. A., Alanazi, M. A., Alharbi, S. S., & Alghamdi, A., 2022). Therefore, residents instead dump their solid waste in open spaces close to their homes, alongside highways and railway tracks, as well as in rivers and other bodies of water. As a result, the locals in these places risk becoming ill. When citizens are dissatisfied with the garbage collection services provided, they frequently organize community-based organizations (CBOs) to assist them in enhancing their local environment or contact their government for service enhancement (Yas, H., Jusoh, A., Streimikiene, D., Mardani, A., Nor, K. M., Alatawi, A., & Umarlebbe, J. H., 2021).

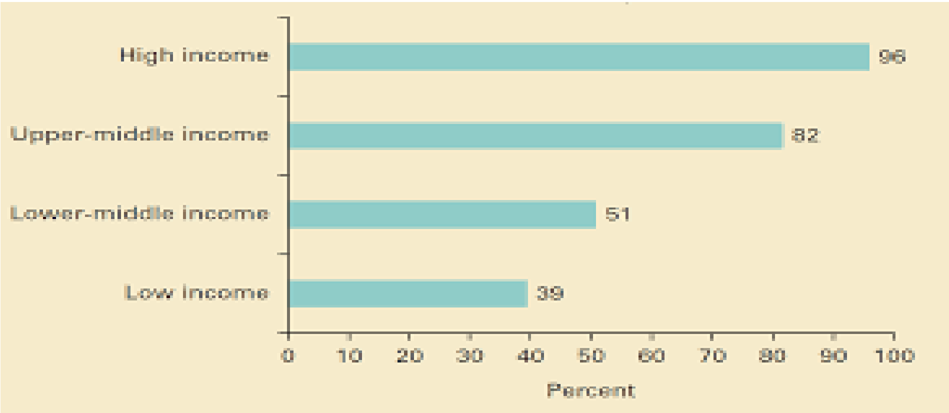


Figure 1: Residents' waste production

Even though many NGOs come from outside their work. communities, some may come from within. NGOs serve as a conduit between the local population and the government to improve service delivery (Khudhair, H. Y., Mardani, A., Albayati, Y., Lootah, S. E., & Streimikiene, D., 2020). They assist the populace in comprehending the significance of environmental management, the peril of irresponsible trash disposal, how to voice their concerns to the appropriate government agencies and waste collection authorities, and how to access local financing options (Khudhair, H. Y., & Hamid, A. B. A., 2015). The folks can also find work through the NGOs. Local administrations are entirely responsible for collecting and disposing of solid waste. Their political and personal interests sometimes drive them to act by their bylaws (Yas, H., Mardani, A., & Alfarttoosi, A., 2020). For example, the national government provides the authority to issue local governments with the bylaw enforcement authority required for effective garbage collection. The local governments must raise public knowledge of the value of garbage collection and proper disposal to attain efficiency in solid waste (Khudhair, H. Y., Jusoh, A., Nor, K. M., & Mardani, A., 2021). Additionally, this aids in collecting solid garbage by the neighborhood and municipal government. Collecting solid trash and preserving environmental soundness are crucial national government functions in any nation (Saeed, M. D., & Khudhair, H. Y., 2024). It is the responsibility of the national government to establish the institutional and legal framework for all actions required to improve solid waste collection and give local governments the authority to carry out these actions. Additionally, it provides the local government with guidelines and capacity-building materials pertinent to this service delivery (Alsaud, A. B., Yas, H., & Alatawi, A., 2021).

Regarding the collection and treatment of solid waste, the private sector—both formal and informal—also plays a crucial role. The traditional private sector mainly operates businesses that collect garbage to make money. The private legal industry collaborates with the governmental sector to offer the community's waste collection services (Yas, H., Alkaabi, A., Al Mansoori, H. M., Masoud, M., & Alessa, A., 2021). Because they want to attract more clients, this industry is more likely to provide efficient waste collection services at a lower cost than the public sector.

Individuals, families, or unregistered organizations engaged in unregulated operations make up the informal private sector on the other side. These individuals are typically looking for a source of money and come from impoverished locations. The rate of trash creation, as well as the availability of resources and equipment to support this collection, all affect how effectively solid wastes are collected. Poor or absent rubbish collection in specific low-income neighborhoods worldwide results in waste dumping in neighboring open spaces and vacant lots (Yas, H., Mardani, A., & Alfarttoosi, A., 2020).

Due to disparities in resource endowments and the level of technology accessible for use, the extent and technique of garbage collection vary from country to country and between developed and developing countries. In most developing countries, the issue of solid waste collection and handling is made worse by the growing urban population (Khudhair, H. Y., Jusoh, A., Mardani, A., & Nor, K. M., 2019). Even though these countries spend much money collecting solid garbage, they need help with the waste generation rate. Solid waste produced in underdeveloped nations has a very different composition from that of developed countries (Aboelazm, K. S., 2024). The wastes generated in underdeveloped nations are more minor in particle size, have a higher density, and have a higher moisture content. Most of these nations rely on the municipal fees they get to deal with the issue of solid waste collection. Further delays and a slower rate of rubbish collection result in waste building up in or close to residential areas (Ibrahim, E., Sharif, H., & Aboelazm, K. S., 2025).

Customers occasionally refuse garbage collection fees due to the delayed service delivery, which furthers the problem's escalation (Azevedo et al., 2021). People favor the solid trash collection services provided by the private sector over those offered by the government because the private sector is doing a better job providing them. Most governments in developing nations have chosen to turn to the private sector for waste collection. However, this does not absolve the local government of its responsibility to supervise waste collection in its purview (Khandelwal et al., 2019). The collection and transportation of solid waste receive minimal attention from national governments in most developing nations (Aboelazm, K. S., Ibrahim, E., Sharif, H., & Tawakol, F., 2025). These governments give rapid urbanization much attention and make plans to speed up industrialization and urban expansion. However, they must take adequate precautions to prevent waste accumulation or improve solid waste collection methods (Yas, H., Mardani, A., Albayati, Y. K., Lootah, S. E., & Streimikiene, D., 2020).

The easy transportation of solid wastes is also hampered by the fast urbanization and expanding population in municipalities (Aboelazm, K. S., Tawakol, F., Ibrahim, E., & Ramadan, S. A., 2025). Waste transportation through towns is slowed down by traffic congestion, bad road conditions, and weather. Residents often resort to throwing their solid wastes in vacant spaces with no or poorly designed garbage collecting facilities and patterns in the neighborhood (Antelava et al., 2019). Usually, this occurs in low-income areas where the locals cannot pay for waste collection services. As previously said, these folks frequently resort to dumping in public areas, rivers, and by the sides of roads, which is a problem that jeopardizes their health (ZF, 2016). Some sites, particularly those in slums, are also overcrowded and difficult for waste collectors to access.

The advantage of obtaining waste collection services from private service providers is that it allows residents in locations where they can afford them (Kaza & Yao, 2018). Although this is the case, regular containers are typically only available to keep the garbage onset collected. Solid garbage is held in drums, plastic containers, or even paper bags in specific locations until it is collected (Aboelazm, K. S., & Afandy, A., 2019). Garbage is taken out of these containers by the collectors who arrive. A problem that affects the effectiveness of solid waste collection is caused by humans and animals scavenging for valuables among the trash, which disturbs the environment, and causes garbage to be distributed (Khudhair, H. Y., Alsaud, A. B., Alsharm, A., Alkaabi, A., & AlAdeedi, A., 2020).

Christensen (2010) states that most developing nations still collect solid waste using outdated techniques like road sweeping and garbage trucks. Trash collectors frequently use trucks to move waste from producing sites to disposal locations (Aboelazm, K., 2022). In communities with a medium level of affluence, it occasionally happens that the homeowners help the garbage collectors load the trash onto the trucks (Ludwig et al., 2018). When residents in low-income communities dispose of their rubbish in public places, the competent authorities are accountable for collecting the waste and transporting it to the proper dumping sites (Aboelazm, K. S., 2021).

Most of the solid wastes gathered in developing nations are thrown in open dumpsites, which poses risks to the environment's health, mainly if dumping is done for a long time. Landfill usage in these nations is relatively minimal. Usually, recyclable materials like scrap metal and plastic containers are used. Compared to underdeveloped countries, affluent countries produce more solid garbage on average (Aboelazm, K. S., Dganni, K. M., Tawakol, F., & Sharif, H., 2024). These nations consume more than developing nations, which explains why. Their solid waste is produced in vast quantities and lacking in organic substances (Al-Fadhli, 2016). These nations ' government regulations and environmental concerns allow waste collection companies to provide efficient services, particularly in urban areas.

In these nations, substantial regional variations exist in how solid waste is collected. According to Al-Fadhli (2016), in some locations, those responsible for producing the trash gather the waste and put it in temporary storage bins or any other materials placed strategically for commercial garbage collectors to pick them up. Due to environmental difficulties connected to garbage dumping, some wealthy nations have chosen to ship their solid wastes and dump them in other countries. In this situation, rich nations attack underdeveloped nations with lax environmental regulations or allow more dumping. Electronic garbage, textiles, and plastic containers are only a few examples of solid waste these nations frequently export across borders (Vyas et al., 2022). Industrialized nations ship these materials to underdeveloped countries for reusing, recycling, or disposal. Several countries, including Australia, the United Kingdom, Canada, New Zealand, and others, use curbside collection of domestic solid waste. This technique uses trucks with specialized construction to gather trash (Aboelazm, K. S., Tawakol, F., Dganni, K. M., & AlFil, N. Z., 2024).

Urban residents frequently receive specific municipal or city council containers to dump solid garbage. These containers are placed by the roadside and picked up by passing trucks. Recyclables can be collected using this technique and then transported to designated locations for sorting and recycling. This approach's primary goals are to raise the rate of recycling and lower the volume of solid trash that is disposed of. Some nations additionally transport their garbage to specified locations via underground conduits. This illustrates modern technology being applied to the collection of solid trash. The vacuum system's impact causes the waste to travel through the channels. The Envac method, and Metro Taifun single-line and ring-line systems, among others, are standard systems that garbage collectors utilize to collect waste in this manner. Various solid waste collecting methods and strategies are necessary to improve effective service delivery. The maximum amount of rubbish a household can produce during a given period is regulated in some developed nations (Yas, H., Alsaud, A., Almaghrabi, H., Almaghrabi, A., & Othman, B., 2021).

These tools are simple and suitable for individuals and small groups to deliver rubbish-collecting services (Balasubramanian, 2021). The use of the techniques for small-scale waste collection requires minimal financial outlay. The anotime-honourednored process used by most municipal governments to collect solid wastes, particularly dust in towns, is road sweep. The application action of the most influential and financially sound methods is necessary for commercial garbage collection. Developed nations gather and transport solid waste using specialized vehicles and other modern means. Several developing countries also get help from wealthy nations to collect their garbage.

3. Methodology

According to ISO, life cycle assessment is the process of compiling and evaluating the efforts, outputs, and potential ecological effects of a product system over its lifecycle. Right now, life cycle assessment is a crucial tool for making decisions about sustainability. According to its level of service and assistance, its significance has yet to be determined. When environmental policy became essential in countries participating in the Economic Cooperation and Development organization, LCA was developed. The study gives examples of the main components of the Life Cycle Assessment. In general, life cycle assessment assesses potential effects on the environment that manufactured goods, processes, or services may have over their lifetimes. The idea of organizing natural resources according to their life cycles can be shown using figures. With the help of the numbers, it is possible to show how energy enters the system while goods and waste leave.

4. Analysis and Discussion

4.1 Data Sources

The data sources include input-output matrices, economic impacts generated from those matrices, power consumption about average electricity prices, fuel and mineral use, other energy and fertilizer usages, other pollutants, and greenhouse and hazardous emissions.

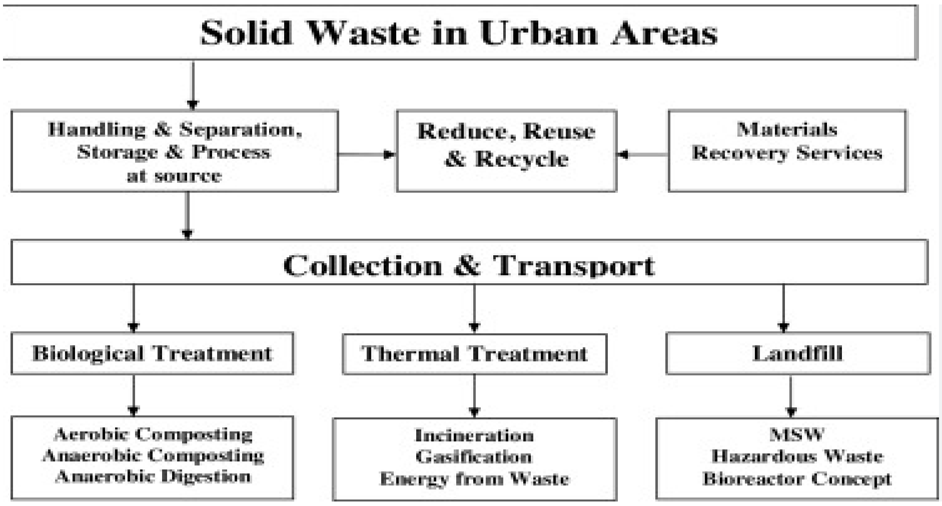
4.2 The Environmental Planning Process

The following are the considerations during the planning process. The environmental EIOLCA should concentrate on minimizing ecological hazards of the input of the combination of pollutants emitted. The model must pay attention to technological challenges to ensure that all nations have access to the finest technology. Before making judgments regarding EIOLCA, potential financial repercussions should be considered. Financial aid programs and methods of transmitting relevant technology should also be chosen. It should also emphasize user-oriented concerns as part of information campaigns to inform everyone whom the environmental choice can impact (Das, S., Lee, S. H., Kumar, P., Kim, K. H., Lee, S. S., & Bhattacharya, S. S. 2019).

4.3 Solid waste in urban Areas

This table shows the stages that the waste goes through from collection to recycling

Table 1: solid waste cycle in Urban areas



Public health and environmental sustainability depend on urban solid waste management. The process starts with classifying garbage from households and businesses into organic, recyclable, and non-recyclable categories. To minimize waste, we should use resources wisely and reduce excessive packaging and disposables. Encouraging people to repurpose items before disposal and repairing or repurposing goods can extend their lifespan. Recycling facilities are crucial for transforming materials like paper, glass, plastics, and metals into new products (Aboelazm, K. S., Tawakol, F., Ibrahim, E., & Sharif, H., 2025). Material Recovery Facilities (MRFs) play a crucial role in material recovery. They use mechanical and manual processes to sort and prepare recyclable materials for manufacturers. Anaerobic digestion, which occurs without oxygen, decomposes organic waste, producing biogas and a nutrient-rich byproduct called digestate. Utilizing energy from waste materials is a topic of interest, with processes like incineration, gasification, and anaerobic digestion offering energy and heat generation possibilities (Aboelazm, K. S., 2023).

4.4 Environmental Plans and Policies

Effective environmental planning also requires the development of institutions and organizations (Abdallah et al., 2020). Regarding the economic side, institutional development addresses organizational and legal constraints and human resource shortages. In contrast, legal institutions form the foundation of development and environmental control. For instance, property systems and land-use planning regulations are a substantial element in EIOLCA. They are crucial in any rural or agricultural development or conservation endeavor, yet programs are frequently started without understanding these core systems. The relevant laws, rules, and environmental standards are included in legal systems and the regulatory framework required by the government to implement them. Some nations have multiple agencies working together to create environmental plans. Such "multi-planning agencies" are groups of connected planning organizations that provide a more significant input of specialization and job coordination (Balasubramanian, 2021). The goal of inter-organizational growth must take into account the new formal and informal connections that have been made between government agencies as well as those that have been made with private industry, nonprofit organizations, and the community (Xia et al., 2022). EIOLCA is currently a pressing necessity in most developing nations to enhance institutional capacity for sustainable development (Yousefi et al., 2021). However, selecting environmental policy tools is considered crucial to promoting sustainable development and improving institutional and legislative systems. Technological, regulatory, and economic tools are the primary tools for implementing environmental policies (Mandpe et al., 2022).

Some methods use conversion factors to express solid waste quantities in terms of volume. However, the fundamental complaint is that it is scientifically unjustified to aggregate diverse waste types without considering their environmental properties. Nearly every environmental issue that LCAs address results from landfill emissions (landfill gas). The impacts of waste disposal's theoretical components, which still need to be adequately developed, are understated. When efforts are made to aggregate emissions, significant issues also generate. Another method that has drawn criticism is the so-called "critical volume method," which determines a hypothetical "critical volume" by dividing the quantity of each pollutant by the limit of its maximum allowable concentration. These permissible levels of human toxicity are reflected by these regulatory limits: maximum exposure concentrations at work or maximum emission levels ("Municipal solid waste management planning," 2016). The critical volumes for air and water, respectively, are then added to aggregate the emissions.

Types of waste in Gulf countries

This graph presentation shows different gulf countries and their municipal solid wate generation rates in a day. From the analysis, united states have the most munical solid waste produced while Oman has the least.

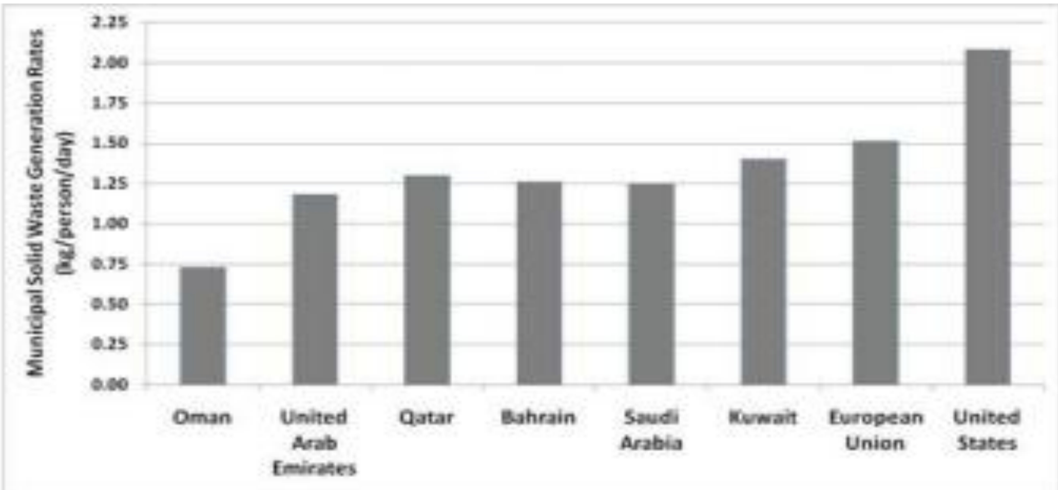


Figure 2: representation of types of waste in gulf countries

Study Objective: To assess municipal solid waste management in Al-Ahsa, Saudi Arabia. Garbage Generation: Al-Ahsa generates 3,800 cubic meters of municipal solid garbage per day, or 1,140 metric tons. The average daily generation rate per capita is 0.95 kilos. This is below Saudi Arabia's average. Regional Comparisons: The average MSW generation rate for the US, EU, and developing countries is 2.08, 1.51, and 0.50. This shows that developed areas generate more garbage. Waste generation differences may be due that Saudi Arabia's high level of life and affluence, including a significant share of foreign workers, may explain its low trash creation rate per capita. It may be because Saudis utilize more packaged meals and bottled beverages.

4.5 Cost Analysis

Solid waste management is an essential component of modern life. However, it may be an expensive effort for both businesses and governments. The actual cost of waste includes more than just the direct collection and disposal costs (Paes et al., 2020. It also considers indirect costs such as lost resources, health hazards, and environmental damage. Understanding the cost of garbage is essential for effective waste management. By analyzing the financial impact of waste, businesses can identify areas for improvement and implement waste reduction and cost-cutting solutions (Christensen, 2010). In addition to the bottom line, this has the potential to improve the environment and create a more sustainable future. It should be underlined how crucial financial analysis for solid waste management is to businesses and society (Balasubramanian, 2021). Companies can identify areas for improvement and potential savings by understanding the whole cost of waste, including direct and indirect costs. A brand's reputation is enhanced by proper waste management, which reduces costs and delivers better environmental effects (Wang et al., 2020). We presented a case study of a company that successfully used waste management practices and enjoyed substantial financial gains. When money is invested in waste management, the environment and society gain, and there is a good return on investment (Das et al., 2019).

Global Trends in solid waste management

This table shows how money was distributed in 2016 to cover different solid waste impact category. This year's total cost goes higher for several impact categories, but terrestrial acidification damage costs are the highest.

Table 2: LCA Results 2016

LCA Results of 2016

No.	Impact category	Unit	Total	Transportation	Landfilling	Recycling	Price per unit	Damage Cost of Transportation	Damage Cost of Landfilling	Damage Cost of Recycling	Total
1	Global warming	kg CO2 eq	1.16E+08	33017322	62914685	19706009	0.057	1881987.354	3586137.045	1123242.513	€ 6,591,366.91
2	Stratospheric ozone depletion	kg CFC11 eq	41.970631	8.1872608	25.906161	7.8772099	30.4	248.8927283	787.5472944	239.467181	€ 1,275.91
3	Ozone formation, Human health	kg NOx eq	967287.37	215949.3	523235.21	228102.85	18.7	4038251.91	9784498.427	4265523.295	€ 18,088,273.63
4	Fine particulate matter formation	kg PM2.5 eq	243943.87	15180.096	129206.81	99556.961	79.5	1206817.632	10271941.4	7914778.4	€ 19,393,537.43
5	Ozone formation, Terrestrial ecosystems	kg NOx eq	983848.08	219293.5	532776.54	231778.03	18.7	4100788.45	9962921.298	4334249.161	€ 18,397,958.91
6	Terrestrial acidification	kg SO2 eq	531669.96	121466.48	303253.51	106949.97	5.4	655918.992	1637568.954	577529.838	€ 2,871,017.78
7	Freshwater eutrophication	kg P eq	8781.6372	2415.9714	5540.6525	825.01324	1.9	4590.34566	10527.23975	1567.525156	€ 16,685.11
8	Marine eutrophication	kg N eq	692.84035	195.51567	433.50576	63.81892	3.11	608.0537337	1348.202914	198.4768412	€ 2,154.73
9	Terrestrial ecotoxicity	kg 1,4-DCB	2.99E+08	1.79E+08	1.12E+08	7577330.2	8.89	1595510970	998437233.5	67362465.48	€ 2,661,310,668.48
10	Freshwater ecotoxicity	kg 1,4-DCB	1073742.3	452076.28	548593.99	73072.031	0.0369	16681.61473	20243.11823	2696.357944	€ 39,621.09
11	Marine ecotoxicity	kg 1,4-DCB	429471.42	189334.36	212201.14	27935.919	0.00756	1431.367762	1604.240618	211.1955476	€ 3,246.80
12	Human carcinogenic toxicity	kg 1,4-DCB	59558.157	39296.352	18788.757	1473.0481	0.214	8409.419328	4020.793998	315.2322934	€ 12,745.45
13	Land use	m2a crop eq	6668341	1335554.2	5286555.7	46231.096	0.0261	34857.96462	137979.1038	1206.631606	€ 174,043.70
14	Mineral resource scarcity (atmospheric emissions)	kg Cu eq	136737.89	40489.77	77030.705	19217.416	4.2	170057.034	323528.961	80713.1472	€ 574,299.14
15	Mineral resource scarcity (emissions to water - soil)	kg Cu eq	136737.89	40489.77	77030.705	19217.416	0.239	9677.05503	18410.3385	4592.962424	€ 32,680.36

The 2016 LCA results show that transportation contributes significantly to global warming, ozone depletion, human health, fine particulate matter formation (PM2.5), terrestrial acidification, freshwater and marine eutrophication, and ecotoxicity. It also influences land use planning and infrastructure development, emphasizing the need for sustainable practices. The role of transportation in mineral resource scarcity underscores the importance of resource-efficient practices and recycling. These findings highlight the need for stringent measures to combat climate change and protect terrestrial ecosystems. This table shows how money was distributed in 2015 to cover different solid waste impact category. The damage cost for global warming depreciates from 2018, 2017 to 2016. however, the cost to deal with the issues is still high and affecting the economy.

Table 3: LCA Results 2015

LCA Results of 2015											
No.	**Impact category**	**Unit**	**Total**	**Transportation**	**Landfilling**	**Recycling**	**Price per unit**	**Damage Cost of Transportation**	**Damage Cost of Landfilling**	**Damage Cost of Recycling**	**Total**
1	Global warming	kg CO_2 eq	1.08E+08	30909834	58898854	18448178	0.057	1761860.538	3357234.678	1051546.146	€ 6,170,641.36
2	Stratospheric ozone depletion	kg CFC11 eq	39.291655	7.6646697	24.252576	7.3744092	30.4	233.0059589	737.2783104	224.1820397	€ 1,194.47
3	Ozone formation, Human health	kg NO_x eq	905545.62	202165.3	489837.22	213543.1	18.7	3780491.11	9159956.014	3993255.97	€ 16,933,703.09
4	Fine particulate matter formation	kg PM2.5 eq	228372.99	14211.153	120959.57	93202.261	79.5	1129786.664	9616285.815	7409579.75	€ 18,155,652.23
5	Ozone formation, Terrestrial ecosystems	kg NO_x eq	921049.26	205296.04	498769.53	216983.69	18.7	3839035.948	9326990.211	4057595.003	€ 17,223,621.16
6	Terrestrial acidification	kg SO_2 eq	497733.58	113713.31	283896.9	100123.38	5.4	614051.874	1533043.26	540666.252	€ 2,687,761.39
7	Freshwater eutrophication	kg P eq	8221.1071	2261.7605	5186.9939	772.35282	1.9	4297.34495	9855.28841	1467.470358	€ 15,620.10
8	Marine eutrophication	kg N eq	648.6165	183.03595	405.83518	59.745372	3.11	569.2418045	1262.14741	185.8081069	€ 2,017.20
9	Terrestrial ecotoxicity	kg 1,4-DCB	2.80E+08	1.68E+08	1.05E+08	7093670.8	8.89	1493669885	934707134.9	63062733.41	€ 2,491,439,753.71
10	Freshwater ecotoxicity	kg 1,4-DCB	1005205.6	423220.35	513577.35	68407.858	0.0369	15616.83092	18951.00422	2524.24996	€ 37,092.09
11	Marine ecotoxicity	kg 1,4-DCB	402058.35	177249.19	198656.39	26152.775	0.00756	1340.003876	1501.842308	197.714979	€ 3,039.56
12	Human carcinogenic toxicity	kg 1,4-DCB	55756.572	36788.074	17589.475	1379.0237	0.214	7872.647836	3764.14765	295.1110718	€ 11,931.91
13	Land use	m2a crop eq	6242702.2	1250306.1	4949116	43280.175	0.0261	32632.98921	129171.9276	1129.612568	€ 162,934.53
14	Mineral resource scarcity (atmospheric emissions)	kg Cu eq	128009.94	37905.317	72113.852	17990.772	4.2	159202.3314	302878.1784	75561.2424	€ 537,641.75
15	Mineral resource scarcity (emissions to water - soil)	kg Cu eq	128009.94	37905.317	72113.852	17990.772	0.239	9059.370763	17235.21063	4299.794508	€ 30,594.38

The 2015 LCA results highlight the environmental impacts of transportation and waste management, including high greenhouse gas emissions, ozone depletion, fine particulate matter formation, and challenges to terrestrial and marine ecosystems. Transportation contributes to acidification, eutrophication, and ecotoxicity, while responsible waste management practices are crucial. Sustainable planning and efficient resource management are also essential to address land use impacts and mineral resource scarcity.

Table 4: impact Category

No.	Impact category	Unit	Total	Transport, freight, lorry 16-32 metric ton, EURO3 {GLO}| market for | APOS, S	Waste concrete, not reinforced {RoW}| treatment of waste concrete, not reinforced, collection for final disposal | APOS, S	Waste concrete, not reinforced {RoW}| treatment of waste concrete, not reinforced, recycling | APOS, S
1	Global warming	%	100	28.552308	54.406576	17.041116
2	Stratospheric ozone depletion	%	100	19.507118	61.724496	18.768385
3	Ionising radiation	%	100	27.52683	62.503311	9.9698591
4	Ozone formation, Human health	%	100	22.325248	54.093047	23.581705
5	Fine particulate matter formation	%	100	6.2227821	52.965797	40.811421
6	Ozone formation, Terrestrial ecosystems	%	100	22.289366	54.152318	23.558316
7	Terrestrial acidification	%	100	22.846219	57.037924	20.115857
8	Freshwater eutrophication	%	100	27.511629	63.093617	9.3947543
9	Marine eutrophication	%	100	28.219441	62.569358	9.2112014
10	Terrestrial ecotoxicity	%	100	6.00E+01	3.75E+01	2.5311763
11	Freshwater ecotoxicity	%	100	42.102866	51.091774	6.8053601
12	Marine ecotoxicity	%	100	44.085439	49.40984	6.5047214
13	Human carcinogenic toxicity	%	100	65.979798	31.546908	2.4732936
14	Human non-carcinogenic toxicity	%	100	68.659339	28.577095	2.7635656
15	Land use	%	100	20.028283	79.278425	0.69329232
16	Mineral resource scarcity	%	100	29.611229	56.334572	14.054199

The environmental impact analysis of transportation and waste concrete processes reveals significant impacts on global warming, stratospheric ozone depletion, air quality concerns, aquatic ecosystems, land use alterations, and mineral resource scarcity. These activities contribute to 54.41% of global warming, 28.55% of stratospheric ozone depletion, and 40.81% of fine particulate matter formation. These processes also contribute to ozone formation and marine ecosystems (Mehta, K. P. 2001).

Table 5: Natural logarithmic calculation in 2018

2018			
No.	**Impact category**	**LCA Results of Transportation**	**Damage Cost of Transportation**
1	Global warming	17.45137935	14.58667534
2	Stratospheric ozone depletion	2.241415834	5.655858442
3	Ozone formation, Human health	12.42163537	15.3501589
4	Fine particulate matter formation	9.766576799	14.14233382
5	Ozone formation, Terrestrial ecosystems	12.43700276	15.36552629
6	Terrestrial acidification	11.84623012	13.53262907
7	Freshwater eutrophication	7.928693156	8.570547042
8	Marine eutrophication	5.414476996	6.549099722
9	Terrestrial ecotoxicity	19.1443693	21.32929635
10	Freshwater ecotoxicity	13.16044265	9.860898923
11	Marine ecotoxicity	12.29010626	7.405222167
12	Human carcinogenic toxicity	10.71772341	9.175944146
13	Land use	14.24369332	10.59787336
14	Mineral resource scarcity (atmospheric emissions)	10.74764107	12.18272559
15	Mineral resource scarcity (emissions to water - soil)	10.74764107	9.31634934

The data reveals the significant environmental impacts of transportation activities, including exacerbated global warming, moderate impact on stratospheric ozone depletion, severe impacts on human health through ozone formation, and significant contribution to fine particulate matter formation. It also highlights the need for cleaner and more sustainable transportation practices, and highlights the need for comprehensive sustainability measures and policies within the transportation sector.

Table 6: Landfilling impacts 2018

2018			
No.	**Impact category**	**LCA Results of Landfilling**	**Damage Cost of Landfilling**
1	Global warming	18.0961266	15.23142259
2	Stratospheric ozone depletion	3.393317248	6.807759857
3	Ozone formation, Human health	13.30662282	16.23514635
4	Fine particulate matter formation	11.90800604	16.28376306
5	Ozone formation, Terrestrial ecosystems	13.32469381	16.25321734
6	Terrestrial acidification	12.76116083	14.44755978
7	Freshwater eutrophication	8.758704003	9.400557889
8	Marine eutrophication	6.210741533	7.345364259
9	Terrestrial ecotoxicity	18.67561122	20.86053826
10	Freshwater ecotoxicity	13.35395035	10.05440662
11	Marine ecotoxicity	12.40412634	7.519242254
12	Human carcinogenic toxicity	9.979850406	8.438071142
13	Land use	15.61951393	11.97369397
14	Mineral resource scarcity (atmospheric emissions)	11.39079584	12.82588037
15	Mineral resource scarcity (emissions to water - soil)	11.39079584	9.959504115

Landfilling practices have significant environmental consequences, including contributing to global warming, ozone depletion, human health, terrestrial acidification, freshwater eutrophication, marine eutrophication, and human carcinogenic toxicity. The Life Cycle Assessment (LCA) score of 18.10 and damage cost of 15.23 show that landfilling significantly impacts climate change, human health, and land use. It also contributes to ozone formation, fine particulate matter formation, terrestrial acidification, freshwater eutrophication, marine eutrophication, and human carcinogenic toxicity.

Table 7: Natural logarithmic calculation for 2017

2017			
No.	**Impact category**	**LCA Results of Transportation**	**Damage Cost of Transportation**
1	Global warming	17.3744183	14.50971429
2	Stratospheric ozone depletion	2.164454787	5.578897396
3	Ozone formation, Human health	12.34467435	15.27319787
4	Fine particulate matter formation	9.68961576	14.06537278
5	Ozone formation, Terrestrial ecosystems	12.36004171	15.28856523
6	Terrestrial acidification	11.76926903	13.45566798
7	Freshwater eutrophication	7.851732109	8.493585995
8	Marine eutrophication	5.337515964	6.47213869
9	Terrestrial ecotoxicity	19.06740826	21.25233531
10	Freshwater ecotoxicity	13.0834816	9.783937876
11	Marine ecotoxicity	12.21314523	7.328261137
12	Human carcinogenic toxicity	10.64076238	9.098983114
13	Land use	14.16673234	10.52091238
14	Mineral resource scarcity (atmospheric emissions)	10.67068005	12.10576457
15	Mineral resource scarcity (emissions to water - soil)	10.67068005	9.239388319

A 2017 analysis of transportation's environmental and economic impacts revealed significant concerns, including global warming, ozone depletion, fine particulate matter formation, terrestrial acidification, freshwater eutrophication, marine eutrophication, and terrestrial ecotoxicity. These impacts have significant economic consequences, with damage costs associated with several categories. The data also highlights the need for sustainable transportation practices and policies to mitigate environmental harm and economic risks, promoting a more sustainable future.This graph shows the relationship between impact and cost for transportation method in 2017. Figure 5 presents the results of the damage cost for three methods from the year 2017, in which R 2 = 0.614. In addition, the damage cost forecast for the three methods shows that it will keep increasing in the future.

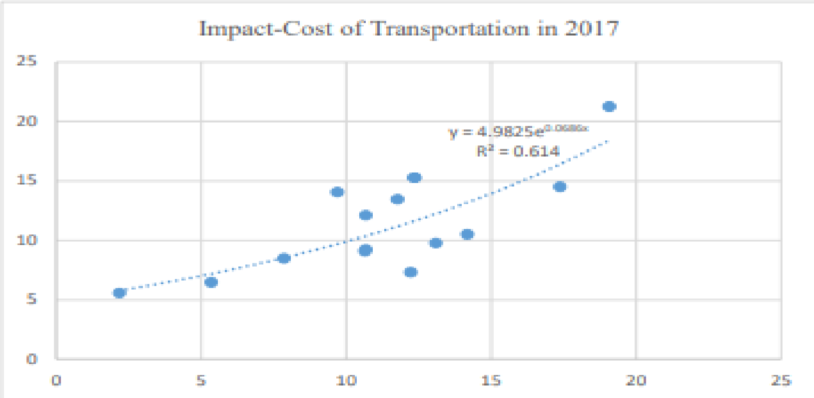


Figure 3: relationship between impact and cost for transportation method in 2017

Figure 3 displays the 2017 relationship between environmental impact and transportation costs, focusing on three distinct transportation methods. The graph reports a reasonably strong correlation between impact and cost, as indicated by an R-squared value of 0.614. On the graph, the x-axis represents transportation impact, while the y-axis represents cost. The upward trend of data points implies that as transportation methods exert a more substantial environmental impact, their associated costs also increase. This table shows the Natural logarithmic calculation for the filling method in 2017.This data shows how different categories benefited in 2017 and their damage cost in land filing.we can compare the LCA results with damage cost to determine the profits.

Table 7: Natural logarithmic calculation for the filling method in 2017

2017			
No.	**Impact category**	**LCA Results of Landfilling**	**Damage Cost of Landfilling**
1	Global warming	18.01916556	15.15446155
2	Stratospheric ozone depletion	3.316356194	6.730798802
3	Ozone formation, Human health	13.22966177	16.1581853
4	Fine particulate matter formation	11.83104503	16.20680205
5	Ozone formation, Terrestrial ecosystems	13.24773276	16.17625629
6	Terrestrial acidification	12.68419978	14.37059874
7	Freshwater eutrophication	8.681742961	9.323596848
8	Marine eutrophication	6.133780486	7.268403212
9	Terrestrial ecotoxicity	18.59865018	20.78357723
10	Freshwater ecotoxicity	13.27698931	9.977445582
11	Marine ecotoxicity	12.32716527	7.442281176
12	Human carcinogenic toxicity	9.902889324	8.36111006
13	Land use	15.54255289	11.89673293
14	Mineral resource scarcity (atmospheric emissions)	11.3138348	12.74891932
15	Mineral resource scarcity (emissions to water - soil)	11.3138348	9.88254307

The on landfilling activities in 2017 demonstrates significant environmental effects and related damage costs in a number of areas. With a significant impact score of 18.02 and a damage cost of 15.15, global warming stands out as a major issue, underlining its role in greenhouse gas emissions and associated costs. Additionally, landfilling has a noticeable impact on concerns relating to human health, with ozone generation receiving a 13.23 impact score and a 16.16 damage cost in this category. Similarly, fine particulate matter formation highlights concerns about air quality and public health, with an impact score of 11.83 and a damage cost of 16.21. Furthermore, landfilling's impact extends to terrestrial ecosystems, acidification, and ecotoxicity, all of which display substantial environmental consequences, as reflected by their impact scores and damage costs. These findings underscore the need for improved waste management practices and policies to mitigate the adverse environmental and economic impacts of landfilling. While certain categories like marine eutrophication and mineral resource scarcity exhibit relatively lower impacts and damage costs, they still demand attention to ensure sustainable resource use and minimize ecological disruption (El-Fadel, M., Findikakis, A. N., & Leckie, J. O. 1997). In Figure 4, the relationship between the environmental impact and the cost associated with landfilling in the year 2017 is examined. The graph provides coefficients of the determinants and reports an R-squared (R^2) value of 0.5902. When comparing this R-squared value to the one derived for 2018, it becomes evident that it is slightly lower. As the environmental impact of landfilling increases, there is a corresponding escalation in the costs involved.

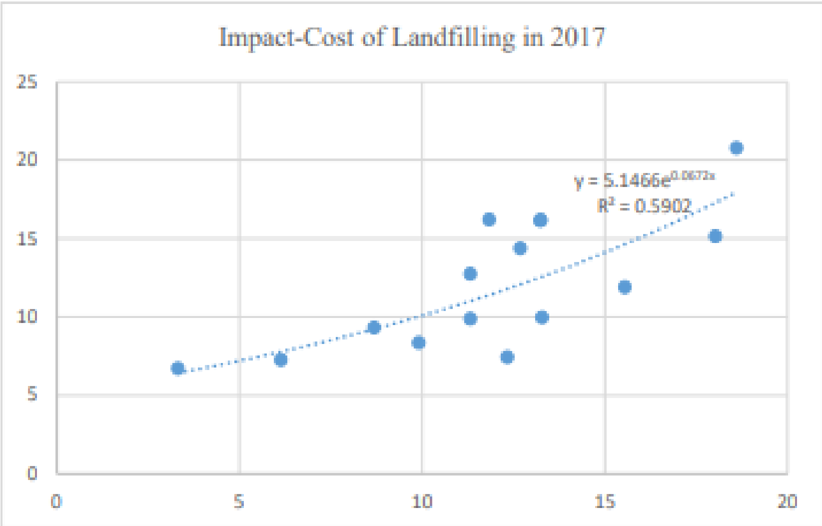


Figure 4: Environmental impact and the cost associated with landfilling in the year 2017 is examined

5. Conclusion

Despite numerous criticisms, LCA has allowed for identifying and evaluating environmental impacts. Industrial activities are a significant factor in adopting different LCA methodologies, and organizations must look beyond their traditional spheres of influence to evaluate the upstream and downstream effects of their operations. Rather than focusing solely on site-specific effects, they are increasingly expected to consider the environmental risks associated with producing their raw materials and consumer use of their products (Khandelwal et al., 2019). More efforts must be made to improve product recycling and reusability, provide safe disposal options for used chemicals and residues, and support organizations in reducing losses through improved management and maintenance procedures. These efforts go beyond simply relying on every LCA decision.

6. Recommendations

The current constraints must be managed to encourage the adoption of zero waste management. First, developing nations need assistance with education and implementing waste collection, sorting, and recycling programs (Kandakatla et al., 2017). The importance of intelligent consumerism should therefore be conveyed to wealthy countries. Additionally, it is essential to encourage community engagement in waste removal initiatives. Utilizing the opportunities found is vital, as is lowering the risks and weaknesses of zero waste management. The zero-waste policy has a very high potential for reducing waste. Therefore, making everyone aware of their responsibility for the earth's survival is crucial.

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