



Environmental pollution with waste and the possibility of recycling- Review

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Abstract

Environmental pollution caused by waste accumulation is one of the most pressing global issues today. As urbanization and industrialization accelerate, waste generation has increased exponentially, leading to the contamination of land, water, and air, which severely impacts ecosystems and human health. Waste, particularly plastic and organic waste, contributes significantly to environmental degradation. Improper waste disposal methods, exacerbate pollution and result in the depletion of natural resources. However, recycling presents a viable solution to mitigate the effects of pollution. The process of recycling reduces the volume of waste sent to landfills, conserves raw materials, and minimizes energy consumption. However, the effectiveness of recycling efforts is hindered by factors such as insufficient infrastructure, limited technological advancements, and a lack of public awareness. Despite these challenges, innovations in recycling technologies, such as advanced sorting systems, chemical recycling, and waste-to-energy processes, show promise in improving efficiency and expanding the types of waste that can be recycled.

Keywords: Environmental degradation, Wastes, Human Health, Recycling technologies.

Introduction

A major source of anxiety for humans throughout history has been waste management. Ever since the dawn of civilization, people have wondered how to properly dispose of garbage, particularly when it starts to build up around their homes. In response, they have developed creative and

practical solutions to this problem, which threatens their very survival [1;2].

In light of this, other innovations have evolved, such as waste recycling and the principles behind the recycling economy, which seek to mitigate environmental degradation by reusing and recycling materials

and to protect natural resources from degradation [3].

Environmental pollution

The atmosphere of Earth makes it unique among planets in that it supports life. We owe it everything to it. First and foremost, there is air, which must be free of hazardous contaminants and compounds and be breathable for humans and other creatures. However, the atmosphere is continually being contaminated by a wide variety of objects [4].

Unwanted changes to our environment may have negative impacts on all living things, including humans. This phenomenon is known as pollution. This happens when people prioritize short-term profits above the long-term advantages to the environment. The ecological alterations caused by humans are unparalleled by any natural phenomena [5].

A pollutant is a material that contributes to environmental contamination. A material becomes a pollutant when its concentration beyond its natural abundance, which may be generated by either human actions or natural events. Substances can exist as liquids, solids, or gasses [6].

Since the degree to which air pollution affects human health is proportional to the concentration of the pollutant, even a little amount of air pollution is more harmful than the same amount of food pollution [7]. When pollutants end up in water, they may travel long distances, particularly in the marine environment. There are a few ways to categorize contaminants from an ecological standpoint: Chemical contaminants that break down in the environment: These may be decomposed quickly by the elements. For instance, sewage from homes and unwanted produce [4].

Contaminants that stay in the environment for a long time unaltered and take a long time to break down are called slowly degradable pollutants. An example would be the vast majority of plastics and other non-biodegradable contaminants: These will not break down in the environment. They accumulate and are difficult to remove from the environment once discharged. For instance, harmful substances such as lead or mercury. Pollution may also be categorized according to the kind of human activity that causes it. An essential difference about pollution sources must be addressed before we examine the different industries. There are two main types of pollution sources: point and non-point. One way to think of point sources is as plainly recognizable locations [8;9].

Wastes

To put it simply, waste is everything that people do not desire or need and is hence not put to any good use. The term "garbage" may also describe the waste that is visible to the naked eye. The majority of human activities inevitably result in waste. however there has been an increase in biomedical and industrial hazardous waste due to healthcare facility expansions and diversification in the industrial sector, which poses serious risks to both human and environmental health [10]. The many forms of waste include:

A. Plastic waste

Discarded or discarded plastic items that have a negative impact on ecosystems, animals, and people are known as plastic pollution or garbage. The large quantity of plastic that does not be recycled and is instead dumped in landfills is also included [11]. The seas and ecosystems are negatively impacted by the three quarters that do not make it into recycling programs. Marine life is particularly vulnerable since most plastic waste from developing nations makes its way to the ocean. The chemical composition of plastic makes it

very slow to decompose, taking 400 years or more, which poses a significant problem since it is present in so much of what we eat [12].

B. Municipal waste

Collected and processed garbage that is either owned or managed by a municipality is called municipal waste. It includes garbage from homes, workplaces, schools, and local companies. Municipal sewage networks and treatment, together with building and demolition waste, are not included in the definition[13].

C. Industrial waste

Many different types of materials, each with its own level of environmental toxicity, make up the Industrial Solid Waste Region. Paper, packing, oils, solvents, paints, sludge, ceramics, stones, metals, and waste from food processing, glazing, paints, and resins would normally fall into this category [14].

D. Agricultural waste

Everyone needs food, but it's also clear that farming has an effect on the planet. One example is that agriculture is known to contribute about 21% of global greenhouse gas emissions. The detrimental effects of farming on ecosystems, marine life, and human well-being [15].

Numerous sources contribute to the generation of agricultural solid wastes. Chemicals used to kill insects are one example. Agricultural solid wastes are carelessly dumped or burned in public places, leading to the generation of air pollution, soil contamination, a harmful gas, smoke, and dust. If pesticide use were to end entirely, global food production would likely decrease by around 42% [16].

E. Hazardous waste

It results in a great deal of hazardous waste and the consumption of harmful chemical

amounts. About 110,000 different kinds of harmful compounds are now on the market. New chemicals with various industrial and other applications enter the market at a rate of 1,000 every year. Petrochemical, petroleum, wood treatment, metal, and energy production plant sources include industrial hazardous waste [17]. The most common forms of hazardous trash are those containing solvents, chlorine, or urea-fungicide [18].

F. Radioactive waste

Materials having radionuclides present or polluted to an extent that exceeds prescribed clearance standards are considered radioactive waste. The waste poses a bigger threat when its radioactive content is higher than the set standards. Immobilization, shielding, and, in some instances, remote management are necessary for radioactive waste because of the high radiation levels that may be present [19].

Because radiation affects every living thing on Earth, radioactive waste poses a significant threat to both people and ecosystems. On the other hand, low-level radiation isn't always dangerous, but high-level radiation certainly is[20]. Nuclear power plants produce radioactive waste with a half-life of thousands of years. High radiation exposure may harm the central nervous system, kill, and induce gastrointestinal side effects such as nausea, vomiting, hair loss, diarrhea, bleeding, and intestinal lining deterioration[21].

G. Medical waste

Used needles and syringes, dirty bandages, bodily parts, blood, chemicals, medications, medical equipment, radioactive materials, diagnostic samples, and other waste products are all considered medical waste according to the World Health Organization (WHO). Waste . The community, trash handlers, and health care professionals are all put at risk of diseases, harmful effects, injuries,

and environmental pollution due to poorly managed health care waste. Fifteen percent of all medical waste contains potentially pathogenic, toxic, or radioactive substances[22].

Environmental impacts of wastes

Environmental pollution is known to cause a variety of health problems, including the spread of communicable diseases like cholera and typhoid as well as non-communicable diseases like cancer and asthma. The worst impact of pollution on health outcomes is most noticeable in low-income countries, where it is responsible for around 90% of all deaths. Air and water pollution are the two most pervasive problems in nations with low per capita GDP [23].

The use of technology to alter ecosystems is just one of many human actions that have the potential to harm the environment. Energy sources, such as light, heat, sound, or several other potentially harmful chemical compounds, may also contribute to pollution. The rapid increase in both urbanization and industry throughout the globe has led to the release of several pollutants into the air, which may be either artificially generated energy or naturally occurring toxins [24].

Integrated wastes management

One of the most pressing problems that the government is trying to solve is waste management. Due to its interconnection with international trade, it also has a worldwide scope. Waste is created and discarded as worthless material due to human activity. The origins of trash have a timeline that mirrors that of the universe itself. Solid waste management was not an issue in the past in prehistoric communities, cities, and villages where urbanization was not widespread [25].

The vast majority of the world's population now resides in cities, which has led to a dramatic shift in consumer behavior and the

kinds of goods sold in stores. As a result, the quantity and composition of municipal solid waste have grown and changed dramatically. Cutting down on the usage of virgin raw materials and ramping up recovery and reuse rates are two of the most effective ways to lessen the burden on landfills [26].

Prevention and reduction

The waste hierarchy states that in order to have effective and long-lasting waste management, garbage avoidance must take precedence. The goal of waste prevention is to keep a material from ending up in the trash, rather than managing it after it occurs [27]. The term "waste prevention" refers to the practice of taking steps to reduce or eliminate waste. This include efforts to lessen waste production as a whole via means such as product design, public education and awareness campaigns, and incentive programs. Another aspect of waste avoidance is the lessening of potentially dangerous compounds in materials and consumer goods [28].

The responsibility for reducing waste lies with both producers and consumers, who must modify their consumption and production habits. To put waste avoidance into practice at the community level, policies and laws are necessary. Reducing and preventing waste has several advantages. For instance, reducing waste has a direct effect on lowering climatic and environmental impacts. Economic advantages accrue from waste avoidance since it lowers the cost of trash management [29].

Recycling of wastes

recycling involves collecting and reusing these containers. Table.1 show the most important methods used for recycling. The things' components may be used to create new goods [30]. A process known as carbide collection allows for the separation of recyclable materials from non-recyclable trash utilizing specific containers and pickup trucks. It is the responsibility of the garbage collector

in certain areas to sort the trash by kind (e.g., paper, plastic, metal) before collection. Both energy and natural resources may be better conserved by recycling. By lowering pollution levels in the air, water, and soil, recycling contributes to environmental protection [31].

Recycling helps cut down on pollution, energy consumption, and the loss of potentially valuable resources by transforming them into new products. Reduced demand for raw materials, less greenhouse gas emissions [32].

Table.1 showing the most important methods used for recycling

N o	Name	Use	Process	Referenc es
1	Mechanical Recycling	Plastics, metals, and paper	Mechanical recycling involves the physical processing of waste materials. The material is shredded, cleaned, and sometimes melted down to form new products. This method is most commonly used for plastic and metal recycling.	[33]
2	Chemical Recycling	Plastics (especially complex plastics), textiles, and organic waste.	This method involves breaking down materials into their chemical components through various processes such as pyrolysis, depolymerization, or gasification. These materials are then used to produce new chemicals, fuels, or raw materials for manufacturing.	[34]
3	Biological Recycling	Organic waste such as food scraps, yard waste, and agricultural residues.	Biological recycling (also called composting) uses microorganisms to break down organic material into compost. This process happens in aerobic conditions (with oxygen).	[35]
4	Electrochemical Recycling	Electronics and batteries.	Electrochemical recycling uses electrical currents or chemical reactions to extract valuable materials from electronic waste or spent batteries. It is particularly useful for recovering metals like gold, silver, and copper.	[36]
5	Thermal Recycling	Some plastics and non-recyclable materials.	Thermal recycling involves using heat to break down materials into simpler components or convert waste into energy (through processes like incineration or waste-to-energy system).	[37]
6	Upcycling (Creative Reuse)	Textiles, furniture,	Upcycling is the process of taking waste materials and transforming them into new products of higher value or utility. It is a more creative form of	[38]

		plastics, and general waste.	recycling that focuses on repurposing items rather than breaking them down into raw materials.	
7	Circular Economy	All types of materials and products.	A circular economy aims to design products with their entire lifecycle in mind, encouraging the reuse, repair, refurbishment, and recycling of products to extend their life and reduce waste.	[39]
8	Landfill Mining (Resource Recovery)	Old landfills and waste that was once considered unrecyclable.	This method involves excavating waste from old landfills, extracting recyclable materials, and sorting them for reuse. It is an emerging technique used to recover valuable materials from waste that has already been buried.	[40]
9	Source Separation	All recyclable materials	Source separation involves sorting waste materials at the point of disposal (household, industrial, or commercial level) to make recycling more efficient. This can be done manually or with the help of machines.	[41]

Conclusion

Waste buildup and inadequate management are major contributors to environmental contamination, which in turn endangers ecosystems, human health, and the delicate natural balance. The increasing amount of trash, which includes chemicals, plastics, and industrial waste, has far-reaching effects, such as soil contamination, air pollution, and water contamination. It has societal and environmental impacts since it interferes with natural processes, reduces biodiversity, and speeds up the rate of climate change. Still,

recycling seems like a good bet for reducing pollution's negative effects. Recycling helps preserve natural resources, save energy, and decrease greenhouse gas emissions by converting garbage into useful resources. It also minimizes the amount of waste that ends up in landfills. As part of the circular economy, which aims to reduce waste and protect the environment via the constant repair, reuse, and recycling of materials, it is an essential component.

References

- 1- Soper, K. (2003). Waste Matters. *Capitalism Nature Socialism*, 14(2), 129-134.
- 2- Babu, B. R., Parande, A. K., & Basha, C. A. (2007). Electrical and electronic waste: a global environmental problem. *Waste Management & Research*, 25(4), 307-318.
- 3- Robinson, W. S. (2009). Ecological correlations and the behavior of individuals. *International journal of epidemiology*, 38(2), 337-341.
- 4- Amato, F., Rivas, I., Viana, M., Moreno, T., Bouso, L., Reche, C., ... & Querol, X. (2014). Sources of indoor and outdoor PM_{2.5} concentrations in primary schools. *Science of the Total Environment*, 490, 757-765.

- 5- Vesilind, P. A., Peirce, J. J., & Weiner, R. F. (2013). Environmental pollution and control. Elsevier.
- 6- Xu, X., Nie, S., Ding, H., & Hou, F. F. (2018). Environmental pollution and kidney diseases. *Nature Reviews Nephrology*, 14(5), 313-324.
- 7- Shetty, S. S., Deepthi, D., Harshitha, S., Sonkusare, S., Naik, P. B., & Madhyastha, H. (2023). Environmental pollutants and their effects on human health. *Heliyon*, 9(9).
- 8- Wang, G. X., Huang, D., Ji, J. H., Völker, C., & Wurm, F. R. (2021). Seawater-degradable polymers—fighting the marine plastic pollution. *Advanced science*, 8(1), 2001121.
- 9- Cao, J. J., Huang, H., Lee, S. C., Chow, J. C., Zou, C. W., Ho, K. F., & Watson, J. G. (2012). Indoor/outdoor relationships for organic and elemental carbon in PM_{2.5} at residential homes in Guangzhou, China. *Aerosol and Air Quality Research*, 12(5), 902-910.
- 10- Mishra, R. K., Mohammad, N., & Roychoudhury, N. (2016). Soil pollution: Causes, effects and control. *Van Sangyan*, 3(1), 1-14.
- 11- Demirbas, A. (2011). Waste management, waste resource facilities and waste conversion processes. *Energy Conversion and Management*, 52(2), 1280-1287.
- 12- Batterman, S., Godwin, C., Chernyak, S., Jia, C., & Charles, S. (2010). Brominated flame retardants in offices in Michigan, USA. *Environmentinternational*, 36(6), 548-556.
- 13- Alabi, O. A., Ologbonjaye, K. I., Awosolu, O., & Alalade, O. E. (2019). Public and environmental health effects of plastic wastes disposal: a review. *J Toxicol Risk Assess*, 5(021), 1-13.
- 14- Zhang, J., Qin, Q., Li, G., & Tseng, C. H. (2021). Sustainable municipal waste management strategies through life cycle assessment method: A review. *Journal of Environmental Management*, 287, 112238.
- 15- Slezakova, K., Castro, D., Pereira, M.d.C., Morais, S., Delerue- Matos, C., Alvim- Ferraz, M., 2019. Influence of tobacco smoke on carcinogenic PAH composition in indoor PM₁₀ and PM₂₅. *Atmospheric Environment*.
- 16- Koul, B., Yakoob, M., & Shah, M. P. (2022). Agricultural waste management strategies for environmental sustainability. *Environmental Research*, 206, 112285.
- 17- Adejumo, I. O., & Adebisi, O. A. (2020). Agricultural solid wastes: causes, effects, and effective management. *Strategies of sustainable solid waste management*, 8(10.5772).
- 18- LaGrega, M. D., Buckingham, P. L., & Evans, J. C. (2010). Hazardous waste management. Waveland Press.
- 19- Misra, V., & Pandey, S. D. (2005). Hazardous waste, impact on health and environment for development of better waste management strategies in future in India. *Environment international*, 31(3), 417-431.
- 20- Deng, D., Zhang, L., Dong, M., Samuel, R. E., Ofori-Boadu, A., & Lamssali, M. (2020). Radioactive waste: A review. *Water Environment Research*, 92(10), 1818-1825.
- 21- Chapman, N., & Hooper, A. (2012). The disposal of radioactive wastes underground. *Proceedings of the Geologists' Association*, 123(1), 46-63.
- 22- Windfeld, E. S., & Brooks, M. S. L. (2015). Medical waste management—A review. *Journal of environmental management*, 163, 98-108.
- 23- Robinson, B. H. (2009). E-waste: an assessment of global production and environmental impacts. *Science of the total environment*, 408(2), 183-191.
- 24- Zhang, Z., Malik, M. Z., Khan, A., Ali, N., Malik, S., & Bilal, M. (2022). Environmental impacts of hazardous waste, and management strategies to reconcile circular economy and eco-sustainability. *Science of The Total Environment*, 807, 150856.
- 25- Seadon, J. K. (2006). Integrated waste management—Looking beyond the solid waste horizon. *Waste management*, 26(12), 1327-1336.
- 26- Cobo, S., Dominguez-Ramos, A., & Irabien, A. (2018). From linear to circular integrated waste management systems: A review of methodological approaches. *Resources, Conservation and Recycling*, 135, 279-295.
- 27- Sakai, S. I., Yano, J., Hirai, Y., Asari, M., Yanagawa, R., Matsuda, T., ... & Moore, S. (2017). Waste prevention for

- sustainable resource and waste management. *Journal of material cycles and waste management*, 19, 1295-1313.
- 28- Fercoq, A., Lamouri, S., & Carbone, V. (2016). Lean/Green integration focused on waste reduction techniques. *Journal of Cleaner production*, 137, 567-578.
 - 29- Zhang, M., Feng, G., Yin, W., Xie, B., Ren, M., Xu, Z., ... & Cai, Z. (2017). Airborne PCDD/Fs in two e-waste recycling regions after stricter environmental regulations. *Journal of Environmental Sciences*, 62, 3-10.
 - 30- Meng, Y., Ling, T. C., & Mo, K. H. (2018). Recycling of wastes for value-added applications in concrete blocks: An overview. *Resources, Conservation and Recycling*, 138, 298-312.
 - 31- Narisetty, V., Cox, R., Willoughby, N., Aktas, E., Tiwari, B., Matharu, A. S., ... & Kumar, V. (2021). Recycling bread waste into chemical building blocks using a circular biorefining approach. *Sustainable energy & fuels*, 5(19), 4842-4849.
 - 32- Cheng, L., Chen, X., Gu, J., Kobayashi, N., Yuan, H., & Chen, Y. (2024). Chemical recycling of waste plastics: Current challenges and perspectives. *Fundamental Research*.
 - 33- Virtanen, Y., & Nilsson, S. (2013). *Environmental impacts of waste paper recycling*. Routledge.
 - 34- Liu, Y., Shi, J., Jin, H., & Guo, L. (2024). Chemical recycling methods for managing waste plastics: a review. *Environmental Chemistry Letters*, 22(1), 149-169.
 - 35- Zuberer, D. A., & Zibilske, L. M. (2021). Composting: the microbiological processing of organic wastes. In *Principles and applications of soil microbiology* (pp. 655-679). Elsevier.
 - 36- Rai, V., Liu, D., Xia, D., Jayaraman, Y., & Gabriel, J. C. P. (2021). Electrochemical approaches for the recovery of metals from electronic waste: A critical review. *Recycling*, 6(3), 53.
 - 37- Kijo-Kleczkowska, A., & Gnatowski, A. (2022). Recycling of plastic waste, with particular emphasis on thermal methods. *Energies*, 15(6), 2114.
 - 38- Zhao, X., Boruah, B., Chin, K. F., Đokić, M., Modak, J. M., & Soo, H. S. (2022). Upcycling to sustainably reuse plastics. *Advanced Materials*, 34(25), 2100843.
 - 39- Morseletto, P. (2020). Targets for a circular economy. *Resources, conservation and recycling*, 153, 104553.
 - 40- Parrodi, J. C., Lucas, H., Gigantino, M., Sauve, G., Esguerra, J. L., Einhäupl, P., ... & Van Passel, S. (2019). Integration of resource recovery into current waste management through (enhanced) landfill mining. *Detritus*, 8, 141-156.
 41. Cimpan, C., Maul, A., Jansen, M., Pretz, T., & Wenzel, H. (2015). Central sorting and recovery of MSW recyclable materials: A review of technological state-of-the-art, cases, practice and implications for materials recycling. *Journal of Environmental Management*, 156, 181-199.