Influence of Recovery Efforts on Solid Waste Management Practices in Nigeria: A Review

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Received: 01/02/2022 **Revised: 15/02/2022** **Accepted: 20/02/2023**

The predominance of unwanted materials lying fallow in the environment, and the availability of information on waste management, offer the opportunity to explore the use of these resources as sources of recovered material. Regulatory drivers aim to harmonise the recovery potentials of wastes, thereby reducing the volumes sent to landfill. In this vein, this paper investigates the emissions from municipal solid wastes, which can lead to major environmental impacts. This study assessed the influence of recovery efforts on solid waste management practices in Nigeria. This was done by examining available literature chronicling pollution from unregulated dumpsites which can bioaccumulate in the environment, causing climatic impacts. It was discovered that emissions from waste can impact soil, water, and air, thus contributing to greenhouse gas emissions. Many developed countries have recorded significant improvement in adopting treatment facilities that can enable them to meet up sustainable development goals. However, developing countries still need assistance in developing a sustainable waste management programme that can help change their lifestyle, thus improving the management of the waste they produce. It becomes imperative that making the right choices can change the consumption pattern, thus, reducing the influx of pollutants whilst fostering a clean environment. Thus, a high-level recovery of resources can secure a sustainable future and a healthy environment.

Keywords: Solid waste management, developing countries, resource recovery, greenhouse emissions, integrated waste management

INTRODUCTION

Waste can be defined as potentially resourceful ingredients that can be inflowed into another process depending on the level and combination of control subjected to the materials to meet the needs of individuals, communities, and corporate bodies and keep the environment safe from harm. Around the world today, a common waste management practice is the use of unregulated disposal of waste is a deplorable practice that has caused an incessant increase in heavy metals in arable soils and thus bioaccumulation along the food chain in ecosystems, with the water resource not left out (Nnaji, 2015). There are diverse management options which determine the process steps to convert these unwanted materials to economic benefits. These include materials separation and processing technologies (recycling), thermal conversion technologies (energy recovery systems), and biological and chemical conversion technologies (anaerobic and aerobic digestion) (Tchobanoglous *et al*., 1993). In Nigeria, efforts by various waste management agencies have been set up by the state government to improve sanitation standards and better health conditions. This has led to a reduction in the number of recoverable materials in residential and commercial waste streams, thereby minimizing the problem of MSW disposal (Kofoworola, 2007). The Nigerian government established the National Environmental Standards and Regulations Enforcement Agency (NESREA) and several state agencies through their various local authorities to ensure efficient and effective modes of managing waste in the country. The National Environmental Standards and Regulations Enforcement Agency Act 2007 (NESREA Act) makes provision for solid waste management and its administration and prescribes sanctions for offences or acts which run contrary to proper and adequate waste disposal procedures and practices (Budnukaeku & Hyginus, 2021).

Effective waste management requires that these materials are characterised in a way that recovery is feasible, sustainable, and practicable. In developing countries, a common practice is to burn these wastes, to reduce their volume while in other cases, indiscriminate dumping is done especially during the rainy season when flood waters are in motion to move these household wastes away from their location. It's appalling to note that in this twenty-first century, the burning of waste and increased use of undeveloped sites are still in practice. This leads to a huge amount of material lost and the emission of pollutants. The implication of this is that this practice becomes a primary source of ambient pollutants which trickles down to other environmental aspects such as soil and water, at extra cost to mitigate (Manisalidis *et al*., 2020). It is envisaged that the management process of solid wastes is optimised to reduce greenhouse gas (GHS) emissions (Calabro, 2009) and implement processes that will help in the identified changes in the environment, to adopt the right regulations, strategy, planning and policy options. Internationally, there is a high level of environmental concern about the build-up of carbon

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dioxide (CO_2), and other GHGs in the atmosphere. This is because of their potential in causing a rise in sea levels that may result in the flooding of coastal and river delta communities. Of more critical concern are the spread of infectious diseases and increased heating which is related to mortality. Thus, it is required that potential changes in waste management over time be examined to respond appropriately (Christian, 2010).

LITERATURE REVIEW

Pollution from Solid Waste

Toxic materials in wastes may be composed of several constituents and the risks related to their treatment and disposal are quite problematic to measure due to insufficient evidence about the component composition of the likely threats. Nevertheless, the level of risk must be investigated by adopting different exposure limits, susceptible groups and guidelines established by reputable health and regulatory organisations such as the World Health Organisation (WHO, 2004). It has been projected that by 2025, the numeral of urban dwellers who produce waste may likely rise to 4.3 billion municipal inhabitants producing approximately 1.42 kg/capita/day of municipal solid waste, that is 2.2 billion tonnes per year (Hoornweg and Bhada-Tata, 2012).

Poor disposal of solid wastes generates ecological threats such as health menaces from flies and rats, pollution of water bodies through runoff and rainfall, significant levels of pollutants to the groundwater from leachate, and atmospheric emission from burning of wastes, thus reducing the aesthetic value of the environment (Mazhar *et al*., 2021). Poor administration of solid waste especially the common practice of indiscriminate dumping of wastes in water bodies and unregulated dump sites exacerbates the complications of inadequate sanitation levels across the African continent (UNECA, 2009). Some studies have revealed that 125 million tonnes per annum of municipal solid waste (MSW) were produced in Africa in 2012, of which 81 million tonnes (65%) emanated from sub-Saharan Africa (Scarlat et. al., 2015). Huge quantities of waste disposal plants and programs, which have sustainable management options rely on government supports to keep methods relevant and running to the benefit of the people. (Chen *et al.,* 2021). Pollution from these sites has reached a state of emergency across the African continent (AUDA-NEPAD, 2021).

Climatic Impacts of Waste

The consequence of emissions from MSW on climate change in diverse cities has been examined in many studies where the past and present management options were critiqued (Hupponen et. al., 2023). Most publications seldom take into cognisance the contrary-to-fact end-of-life scenarios which may interrupt the smooth functioning of naturally occurring gases, thus interfering with the carbon cycle (Lan *et al*., 2022). The increasing levels of organic and inorganic wastes in the environment are major sources of global greenhouse gas emissions (Huun, 2020). On a positive note, biogas is formed during the anaerobic decay of organic wastes, where methane and carbon dioxide are produced. This resource can be utilised in lighting, cooking, and conversion to electricity (Rasimphi & Tinarwo, 2020). Negligence of hazardous waste has raised worldwide environmental concerns and unfavourable climatic conditions. This problem The problem is severe in situations where the envisaged environmental policies and laws are in existence but are not implemented and enforced, putting at risk, humans, and ecosystems' healthiness (Alam *et al*., 2003).

Waste Management Framework

Environmental policies can influence waste management and sustainability positively. Most regulations enable the increase in flexibility of management processes. As legislation set specific targets, this fosters more environmentally and socially responsible solid waste management systems. Stricter regulations have aided the heightening of waste management standards. Though this can be a disadvantage in some cases, as there are diverse ways of managing waste and choices are based on their costs, benefits, and practicability. In Europe, there has been a continuous evolution and system optimisation to integrated waste management, to address economic, social, and environmental concerns. Moreso, some of these system drivers are affected by institutional structures – directly and indirectly. While in Africa, changes in government and political climate have affected municipal solid waste (MSW) management policy as each government comes up with their programmes while discontinuing previously established waste management schemes, not minding their effectiveness. It is expected that developing nations adopt several of the programs in Europe to improve their material recovery processes (Alo, 2014).

Adopting a robust waste management system, whose framework block leakages to potential secondary raw materials commonly found in waste streams, can improve the recycling and reuse of items that go into landfill. This improvement can eliminate health and environmental problems, leading to a decline in GHG emissions, and minimise local impacts on air, land, and water resources. this cannot be achieved without referring to the waste hierarchy, which sets the stages and outlines preferred options for recovery and disposal (EC, 2020). Building a recycling society, that avoids the significant loss of materials that are difficult to deal with safely, requires a new approach and policies aimed at improving resource efficiency, whilst reducing environmental and health impacts to achieve long-term

https://dx.doi.org/10.4314/etsj.v13i2.11

goals (EU, 2010). Though low-income countries may see this as a challenge as operating such systems requires a herculean commitment, inexpensive processes and support that spans from the grassroots level to the waste managers. The World Bank has committed to helping such developing countries operate multiple developments including social protection, urban development, environmental sustainability, and energy. These developments are backed up by technical assistance, infrastructural support, funding, and knowledge sharing (World Bank, 2019). Thus, the United Nations Development Programme is making available technical support globally, regionally, and nationally to resolve solid waste management issues and is progressing development assistance framework which requires that critical resource recovery should be approached holistically and sustainably (UNDP, 2019).
Emissions from solid wastes especially from sources like dumpsites which comprise different items such as glass, metals, and plastics are gradually interacting with other aspects of the environment, thus posing a global threat to biodiversity (Jagiello *et al*., 2022). Environmental policies have helped to sharpen the structure, responsibilities of waste producers and disposal requirements to implement control measures for solid waste management functions, especially in local communities. Diverse commitment is required at the management level so that a robust system which enables effective and transparent decision-making processes can be implemented in such a way that solid waste management systems are generic, and incorporates opportunities for integrating recovery technologies for their effective management (Tchobanoglous *et al*., 1993). This is because municipal solid waste contains a wide variety of materials, which requires communities to consider all possible options to develop a comprehensive waste management plan (Nathanson, 1997). Greenhouse gas emission is a global concern that has attracted regulators at the international and local levels. A landfill is an aspect of waste management that is of concern due to the possibility of altering the natural atmospheric gases through different disposal activities like burning which can increase carbon dioxide levels in the carbon cycle. It has been estimated that the disposal of waste in landfills contributes to global GHG emissions of about 4% (Bogner *et al*., 2007). Many countries especially in the developed world are consistently reviewing their treatment technologies and matching them against performance to meet their envisaged waste management targets. This is one of the reasons the World Bank is exploring initiatives to raise the awareness and participation of all stakeholders to reach net-zero emissions by 2050 (World Bank, 2021).
On a global level, the European Commission has identified areas of concern and is presently (2023) working on the amendment of the Waste Framework Directive. In this regard, a pilot study has been steered in the framework of evaluating effects (EC, 2023). Current developments of waste management policies established by the EU directives and the act of a waste management system can be restrained by monitoring the change in waste management legislations and strategies influencing the EU directives and associating the past and recent status to the targets (Zaccariello *et al*., 2015).

Benefits of Solid Waste Management

There has been a scaleup in the advancement of operative waste management systems adopting innovative technologies, which is vital to tackle the issues faced by unconventional methods (Ihsanullah *et al*., 2022). Waste management is beneficial from an environmental, social, and economic perspective (Sahar, 2019). Solid waste management maintains and improves environmental quality and protects public health and welfare (Baker, 2012). Considering the growing demand for discounted energy sources coupled with population pressure, Waste-to-Energy (WtE) policies are ahead, with the admittance of eccentric machinery across the world (Karmakar *et al*., 2023). The utmost histrionic of solid waste control interventions is the application of elevated recovering goals for specific fractions of the waste stream and distinct procedures to convert packaging wastes to useful resources (Goddard, 2022).

Waste Management Solution

The resource application of solid waste components has become a serious issue in material recovery processes (Xu et. al., 2022). Many new circular economy technologies are transitioning and gaining momentum (Farahbakhsh *et al*., 2023). The key component in these waste management structures is to segregate the MSW streams into categories to handle them according to their precise characteristics and performance criteria such as chemical, physical, and biological parameters (Montejo *et al*., 2011). Usually, the solid waste program comprises budgets which take into account the three priority service areas in waste management operations. This includes the solid waste collection point, disposal operations and recycling. The total cost of each solid waste management option is the planning cost, construction cost, and operation and maintenance costs (Idris *et al*., 2004). Integrated solid waste management strategies using generic procedures for material recovery (composting, anaerobic digestions, refuse-derived fuel, incineration, material recovery facility, and sanitary landfilling) are very significant and much required to meet diverse waste diversion and recovery targets. (Pujara *et al*., 2019). Composting solid wastes not only enables the stabilisation of the solid digestate to obtain a by-product with plausible quality (Ge *et al*., 2016) but also produces a conditioner for soils which

https://dx.doi.org/10.4314/etsj.v13i2.11

nourishes and nurtures the growth and development of crops. The implementation of Anaerobic digestion technologies in the field of waste management is also necessary for diverting biodegradable fractions from landfills, thus enhancing the sustainable management and treatment of organic residues (Rosa et. al, 2017). Refuse-derived fuel (RDF) is a viable generation and is a societal and economic option to prevent environmental degradation soon (Galko *et al*., 2023). Recycling comprises of reuse of waste materials with or without modifying their form and has been extensively practised by people from different countries. Recyclables include materials of high quality which has have been remodelled to other resources and sociotechnical optimum systems in integrated business processes, peculiar to individual and business needs. The resources are extracted from common household waste materials such as paper/cardboard, plastic, metal, glass, rubber, leather, and textiles (Pervez *et al*., 2021). End users of products that were initially cleaned and sorted have become profitable merchants in factories, which use these recyclables as raw materials for manufacturing an alternative invention (Khan *et al* ., 2022). A materials recovery facility receives resources, whether source-separated, pre-sorted, screed, co-mingled, or shredded and preserves them for subsequent usage as key ingredients that will enable the development of a new product in screening and planning other product developments (Zafar, 2022).

Are Waste Management Solutions Sustainable?

Environmental sustainability establishes development processes that make provision for the improvement of human well-being as far as environmental limits are concerned (UNEP, 2013). Though many developed countries are achieving their waste management goals, there are opportunities for practicable solutions to be learned and adopted by developing countries. The previous focus has been on wastes dumped illegally. However, there is a shift in concern to address wastes generated from the cradle through recycling and recovery processes to maximise economic value for recovery mechanisms. Waste disposal is now replaced by resource opportunities for the enhancement of the circular economy (UNEP, 2012).

The inadequacies in the waste management process can pose an extreme threat to human health and the environment, thus weakening socioeconomic development. It is worth of note that vulnerable communities remain at the greatest risk despite novel waste management solutions. Whilst uncontrolled burning remains the common practice in developing countries, the corresponding toxic releases, in addition to unsustainable waste management practices are still prevalent. Thus, some chemicals, by-products and toxic components from hazardous wastes are capable of accumulating in high concentrations that can be detrimental to the human reproductive, immunological, and hormonal system with cancerous risks. Such exposures can impact groups such as women, who can easily pass these toxic chemicals on to their children whilst breastfeeding. The effective management of solid wastes can contain harmful constituents, thus safeguarding the material health and well-being of future generations. On this note, the United Nations Development Programme (UNDP) supports third-world countries with waste minimisation programmes, to incorporate a practicable waste ideology using a combination of mechanical, biological, and thermal technologies. It will take longer measures and investment periods for low-income countries to divert 90% of their solid wastes from unregulated dumpsites, to become potential sources of raw materials and highly specialised revenue-generating centres expecting exclusive yields (UNDP, 2011).

THE FUTURE OF WASTE AND THE NEED FOR WASTE INITIATIVES

The suitability and efficiency of waste pre-treatment technologies, capability, and practicability can pose a challenge (Son *et al*., 2023). Thus, a precise and comprehensive emission inventory to facilitate environmental guidelines and regulatory limits, which entails developing a framework that combines a dynamic material flow model, global change assessment model and scenario analysis is required especially in developing nations if they must succeed (Lin *et al*., 2022). The future of solid waste management is transitioning from open dumps to engineered landfills in the long run. They are considered safe and reliable waste management facilities that can reduce fugitive emissions into the environment, localized pollution and eliminate illegal waste management practices that can contaminate the environment, especially noncumulative pollutants. Engineered landfills though expensive, help to separate wastes from the environment with impermeable clay and geotextile liners to prevent groundwater contamination and by collecting leachate and gas (Coffin *et al*., 2023).

Programmes that target the reduction of emissions from solid wastes are very much in high demand now. The emergence of schemes, market-based solutions and financial rewards to companies have driven environmental entrepreneurs to come up with plans to create awareness through seminars, conferences, technology shows and net zero programs for recyclable products, preferred consumer disposal programmes (categorization of waste bins), permit allocation, incentives that reward the reuse of items, a collaboration between communities and industries to help join hands with them to conserve natural resources, thus effectively

https://dx.doi.org/10.4314/etsj.v13i2.11

protect the environment from improper possible hazardous waste.

It is expected that solid waste management guidelines will continually undergo review and become stricter as awareness for pollution control increases with a drive towards sustainability globally (Wang *et al*., 2023). Hence, waste initiatives can offer novel methods of segregation and proffer state-of-the-art segregation and regulated disposal opportunities, though there is uncertainty if this will be at a decreased cost. It may also increase the knowledge of the consequence of unregulated disposal (Frifeld *et al*., 2021) Local initiatives comprise environmental assessment of greenhouse gases, energy criteria, and consumption patterns which will inevitably result in reduced environmental impact (Alviani *et al*., 2021). Thus, it is necessary to consider community perspectives on solid waste management services, recovery programs, and regulatory requirements, as well as the hindrances to sustainable practices, which is vital for exploring effective waste administration and drivers (Sewak *et al*., 2021). Public perception is also an environmental driver that has caused a recent surge, in driving recycling activities. Direct emission is an aspect captured in the life cycle impacts of waste management strategies. Decision-support tools now combine mitigation strategies that are beneficial at a reduced cost (IPCC, 2001) to assess and provide considerations for both direct and indirect impacts. (WRAP, 2006; Thorneloe *et al*., 2005, 2002). This explains why mitigation of GHG emissions from waste relies on multiple technologies whose application depends on local, regional, and national drivers (Bogner et. al., 2007).

CONCLUSION

Findings from this study reveal that recovery efforts are sustainable in reducing emissions in the environment, which has other benefits like reducing the biodegradable fraction sent to landfills as well as infectious diseases. The waste management framework has been adopted over the years with generic modifications to resolve waste management issues. It has been discovered in this study that though emissions from solid wastes can pose a threat to biodiversity, advancements in waste management provide a lasting solution to integrate different solid waste management strategies that meet the various component requirements to produce reusable materials or new products. Waste management comes at a price as regulatory requirements keep improving globally and locally. Every nation has its targets and expectations to manage solid waste in an economically beneficial way. Hence, it may take low-income countries longer periods of investment to meet their waste diversion targets. It becomes imperative for local governments and communities to adopt an attainable waste initiative.

References

Alo, B. I. (2014). Key Drivers to Sustainable Waste Management: A Compendium of Academia and Waste Managers Perspective. High-level Interactive Forum on Multi-Stakeholder Cooperation for Knowledge and Capacity Development in Waste Management pp. 15,18. Available at https://www.uncrd.or.jp/

Alam, M., Snow, E. & Tanaka, A. (2003). Arsenic and heavy metal contamination of vegetables grown in Santa village, Bangladesh. *Sci. Total Environ*., 308:83-96

Alviani, V.N., Hirano, N., Watanabe, N., Oba, M., Uno, M., & Tsuchiya, N. (2021). Local initiative hydrogen production by utilization of aluminium waste materials and natural acidic hot-spring water, *Applied Energy*, 293, 116909, https://doi.org/10.1016/j.apenergy.2021.116909.

African Union Development Agency (AUDA-NEPAD) (2021). What A Waste: Innovations in Africa's Waste Material Management. https://www.nepad.org

Bogner, J., Abdelrafie, A. M., Diaz, C., Faaij, A., Gao, Q., Hashimoto, S., Mareckova, K., Pipatti

R. & Zhang, T. (2007). Waste Management, In Climate Change: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, New York, NY, USA.

Baker, D. (2012). *Handbook of Solid Waste Technology and Management*. Auris Reference Ltd. London, U.K.

Budnukaeku, A. C. & Hyginus O. (2021). Environmental laws and management agencies in Nigeria– what hope for desecrated landscape. *Biodiversity Int J*. 5(1), 1–6. DOI: 10.15406/bij.2021.05.00190

Christian E. I. (2010). Potential Impacts of Climate Change on Solid Waste Management In Nigeria. *Earthzine*.

Calabro, P. S. (2009). Greenhouse gases emission from municipal waste management: The role of separate collection. *J Waste Management*, 29(7), 2178

Coffin, E.S., Reeves, D.M. & Cassidy, D.P. (2023). PFAS in municipal solid waste landfills: Sources, leachate composition, chemical transformations, and future challenges, *Current Opinion in Environmental Science & Health*31:100418, https://doi.org/10.1016/j.coesh.2022.100418

Chen, T., Zhao, Y., Qiu, X., Zhu, X., Liu, X., Yin, J., Shen, D. & Feng, H. (2021). Economics analysis of food waste treatment in China and its

https://dx.doi.org/10.4314/etsj.v13i2.11

influencing factors. *Front. Environ. Sci. Eng.* **15**, 33. https://doi.org/10.1007/s11783-020-1325-y

European Commission (2020). Waste. Article. Available at https://ec.europa.eu/environment/waste/index.htm

European Union (2010). Being wise with waste: the EU's approach to waste management. Available at https://ec.europa.eu

European Commission (2023). 2023 Waste Framework Directive Revision. https://environment.ec.europa.eu

Farahbakhsh, S., Snellinx, S., Mertens, A., Belderbos, E., Bourgeois, L. & Meensel, J.V. (2023). What's stopping the waste-treatment industry from adopting emerging circular technologies? An agent-based model revealing drivers and barriers. *Resources, Conservation and Recycling*, 190, 106792

Fraifeld, A., Rice, A.N., Stampe, M.J. & Muckler, V.C. (2021). Intraoperative waste segregation initiative among anaesthesia personnel to contain disposal costs. *Waste Management*, 122, 124-131, https://doi.org/10.1016/j.wasman.2021.01.006

Ge, X., Fuqing, X. & Li, Y. (2016). Solid-state anaerobic digestion of lignocellulosic biomass: recent progress and perspectives. Bioresour. Technol., 205:239-249, 10.1016/j.biortech.2016.01.050

Gałko, G., Mazur, I., Rejdak, M., Jagustyn, B., Hrabak, J., Ouadi, M., Jahangiri, H. &Sajdak, M. (2023). Evaluation of alternative refuse-derived fuel use as a valuable resource in various valorised applications, 263(Part D)125920, https://doi.org/10.1016/j.energy.2022.125920.

Goddard, H.C. 1995. The benefits and costs of alternative solid waste management policies. *Resources, Conservation and Recycling,* 13(3-4), 183-213, https://doi.org/10.1016/0921-3449(94)00021-V

Hupponen, M., Havukainen, J., Horttanainen, M. (2023). Long-term evolution of the climate change impacts of solid household waste management in Lappeenranta, Finland. *Waste Management*, 157, 69-81, https://doi.org/10.1016/j.wasman.2022.11.038

Hoornweg, D. & Bhada-Tata, P.. (2012). What a Waste: A Global Review of Solid Waste Management. Urban development series; knowledge papers no. 15. World Bank, Washington, DC. World Bank. https://openknowledge.worldbank.org/

Huun, K. (2020). Waste and its Contribution to Climate Change. Regents of the University of Colorado, https://www.colorado.edu

Ihsanullah, I., Alam, G., Jamal A. & Shaik, F. (2022). Recent advances in applications of artificial intelligence in solid waste management: A review, *Chemosphere*, 309(Part 1), 136631 https://doi.org/10.1016/j.chemosphere.2022.136631

Intergovernmental Panel on Climate Change (2001). *Climate Change: Mitigation*. Working Group III third assessment report of the IPCC. Cambridge University Press, Cambridge.

Idris, A., Inane, B. & Hassan, M.N. (2004). Overview of Waste Disposal and Landfills/Dumps in Asian Countries. *Journal of Material Cycles and Waste Management*, 6, 104-110, 10.1007/s10163-004-0117-y

Jagiello, Z., Corsini, M., Dylewski, L., Ibáñez-Álamo, J. D., Szulkin, M. (2022). The extended avian urban phenotype: anthropogenic solid waste pollution, nest design, and fitness, *Science of The Total Environment*, 838(2), 156034, https://doi.org/10.1016/j.scitotenv.2022.156034.

Karmakar, A., Daftari, T., Sivagami K., Chandan M.R., Shaik A.H., Kiran B., Chakraborty S.

(2023). A comprehensive insight into Waste to Energy conversion strategies in India and its associated air pollution hazard. *Environmental Technology & Innovation*, 29:103017, https://doi.org/10.1016/j.eti.2023.103017.

Khan, A.H., Sharholy, M., Alam, P., Al-Mansour, A.I, Ahmad, K., Kamal, M.A., Alam, S., Pervez

M.N. & Naddeo, V. (2022). Evaluation of cost-benefit analysis of municipal solid waste management systems, *Journal of King Saud University - Science*, 34(4), 101997, https://doi.org/10.1016/j.jksus.2022.101997.

Kofoworola, O. F. (2007). Recovery and recycling practices in municipal solid waste management in Lagos, Nigeria. *Waste Manag.* 27(9):1139-43. doi: 10.1016/j.wasman.2006.05.006.

Lin, L., Feng, K., Wang, P., Wan, Z., Kong, X., Li, J. (2022). Hazardous waste from the global shipbreaking industry: Historical inventory and future pathways. *Global Environmental Change,* 76, 102581, https://doi.org/10.1016/j.gloenvcha.2022.102581

Lan, K., Zhang, B. &Yao, Y. (2022). Circular utilization of urban tree waste contributes to the mitigation of climate change and eutrophication. *One Earth*, 5(8), 944-957, https://doi.org/10.1016/j.oneear.2022.07.001

Manisalidis, I., Stavropoulou E., Stavropoulos A. & Bezirtzoglou, E. (2020). Environmental and

Health Impacts of Air Pollution: A Review. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2020.00014

https://dx.doi.org/10.4314/etsj.v13i2.11

Mazhar, M.A., Khan, N.A., Khan, A.H., Ahmed, S., Siddiqui, A.A., Husain, A., Rahisuddin, V. Tirth, S. Islam, S., Shukla, N.K., Changani, F., Yousefi, M., Hassaballa, A.E. & Radwan, N. (2021). Upgrading combined anaerobic-aerobic UASB-FPU to UASB-DHS system: Cost comparison and performance perspective for developing countries. *Journal of Cleaner Production*, 284, 124723, 10.1016/j.jclepro.2020.124723

Montejo, C., Costa, C., Ramos, P., Márquez, M.C. (2011). Analysis and comparison of municipal solid waste and reject fraction as fuels for incineration plants. *Applied Thermal Engineering*, doi: 10.1016/j.applthermaleng.2011.03.041

Nathanson, J.A. (1997). *Basic Environmental Technology. Water Supply, Waste Management, and Pollution Control* (2nd Ed.). Prentice Hall, United States of America.

Nnaji, C.C. (2015). Status of municipal solid waste generation and disposal in Nigeria. *Management of Environmental Quality*. https://www.emerald.com

Pujara, Y., Pathak, P., Sharm, A., Govani, J. (2019). Review of Indian municipal solid waste management practices for the reduction of environmental impacts to achieve sustainable development goals. *Journal of Environmental Management* doi: 10.1016/j.jenvman.2019.07.009

Pervez, M.N., Mondal, M.I.H., Cai, Y., Zhao, Y., Naddeo, V. (2021). Textile waste management and environmental concerns, in Mondal, M.I.H.B.T.-F. of N.F. and T. (Ed.), *The Textile Institute Book Series*. Woodhead Publishing, pp. 719–739. https://doi.org/https://doi.org/10.1016/B978-0-12-821483-1.00002-4.

Rosa, B.P., Cesar, B., Paula, L., Coleone, E.S.A. & Campos, F. (2017). Impactos Causados Em

Cursos d'água Por Aterros Controlados Desativados No Município de São Paulo, Sudeste Do Brasil. *Revista Brasileira de Gestão Ambiental e Sustentabilidade*, 4(7)63-76, 10.21438/rbgas.040707

Rasimphi, T, & Tinarwo, D. (2020). Relevance of biogas technology to the Vhembe district of the Limpopo Province in South Africa. *Biotechnol. Rep.*, 25:e00412, 10.1016/j.btre.2019.e00412

Scarlat, N, Motola, V, Dallemand, J. F, Monforti-Ferrario, F. & Mofor, L. (2015). Evaluation of energy potential of municipal solid waste from African urban areas. *Renewable and Sustainable Energy Reviews*, 50, 1269-1286, DOI: 10.1016/j.rser.2015.05.067

Sahar, I. A. (2019). Waste Management Analysis From Economic Environment Sustainability

Perspective. *International Journal of Scientific & Technology Research*, 8(12), 1540, www.ijstr.org

Son, J., Lim, S.H., Kim, Y.J., Lim, H.J., Lee, J.Y., Jeong, S., Park, C., Park, S.J. (2023). Customized valorization of waste streams by Pseudomonas putida: State-of-the-art, challenges, and future trends, *Bioresource Technology*, 371, 128607, https://doi.org/10.1016/j.biortech.2023.128607.

Sewak, A., Deshpande, S., Rundle-Thiele, S., Zhao, F., Anibaldi, R. (2021). Community perspectives and engagement in sustainable solid waste management (SWM) in Fiji: A socioecological thematic analysis. *Journal of Environmental Management,* 298, 113455 https://doi.org/10.1016/j.jenvman.2021.113455

Tchobanoglous, G., Theisen, H. & Vigil, S.A. (1993). *Integrated Solid Waste Management*:

Engineering Principles and Management Issues. McGraw-Hill International Editions. Civil Engineering Series. McGrawHill, Inc. Singapore.

Thorneloe, S., Weitz, K., Nishtala, S., Yarkosky, S. & Zannes, M. (2002). The impact of municipal solid waste management on greenhouse gas emissions in the United States. *Journal of the Air & Waste Management Association,* 52, 1000-1011.

Thorneloe, S., Weitz, K. & Jambeck, J. (2005). Moving from solid waste disposal to materials management in the United States. Proceedings of the Sardinia '05, International Solid and Hazardous Waste Symposium, published by CISA, University of Cagliari, Sardinia.

UNECA (2009). Africa Review Report on Waste Management - Main Report. https://sustainabledevelopment.un.org

United Nations Environmental Protection (2013). Guidelines for National Waste Management

Strategies. Moving from Challenges to Opportunities. United Nations Institute for Training and Research. Available at https://www.unitar.org

United Nations Development Programme (2019). Waste Management Consultant. Available at https://jobs.undp.org

United Nations Development Programme (2011). Fast Facts. Available at www.undp.org/chemicals.

United Nations Environmental Protection (2012). Annex A, Chapter 1. In United Nations

Environmental Programme. 2015. Global Waste Management Outlook. Available at https://www.uncclearn.org

Wang, Z., Chen, Z. & An, C. (2003). A review on solid waste management in Canadian First Nations communities: Policy, practices and challenges,

https://dx.doi.org/10.4314/etsj.v13i2.11

Cleaner Waste Systems, 4, 100074, https://doi.org/10.1016/j.clwas.2022.100074.

WRAP (2006). Environmental benefits of recycling, an international review of life cycle comparisons for key materials in the UK recycling sector. Waste and Resources Action Programme.

World Bank (2019). Brief: Solid Waste Management. Article. 2019. Available at https://www.worldbank.org

World Bank (2021). World Bank Knowledge Sharing Series on Low Carbon and Climate-Smart Cities. https://www.worldbank.org

World Health Organization (2004). International Programme on Chemical Safety. Guidelines on Prevention of Toxic Exposure, Education and Public Awareness Activities. Available at http://www.searo.who.int

Xu, F., Liu, W., Bu, S., Zhang, L., Fang, J., Yu, Z., Xu, W., Hong, D, Guangtian, H. (2022). Manufacturing non-sintered ceramsite from incinerated municipal solid waste ash (IMSWA): Production and performance. *Process Safety and Environmental Protection*, 163, 116-130, https://doi.org/10.1016/j.psep.2022.05.007

Zafar, S. (2022). Introduction to Material Recovery Facility. *Recycling, Waste Management*. https://www.ecomena.org/materials-recovery-facility/

https://dx.doi.org/10.4314/etsj.v13i2.11