

Chapter 20

Environmental Management and Sanitation: Perspectives on Waste



Israel Adedayo Adeoye, Kayode Hassan Lasisi, Temitope Fausat Ajibade, Ehizonomhen S. Okonofua, Musbahu Abdullahi Bagwai, Oluwaseyi Aderemi Ajala, Adedamola Oluwafemi Ojo, Bashir Adelodun, and Fidelis Odedishemi Ajibade

Abstract The rapid upsurge of industrialization and increasing global population has led to the tremendous generation and indiscriminate disposal of waste without corresponding treatment and management plans. Moreover, the rise in global economic development and living standards of people especially in developed nations has greatly increased the quantity and complexity of generated waste and consequentially, promoting environmental pollution. This chapter outlined some fundamental and theoretical aspects of environmental management and sanitation. The earlier sections considered briefly the concept of waste, its generation, classification and types, and the available treatment and management technologies. Later in this chapter, some challenges facing these management technologies alongside some sustainable measures in ensuring adequate environmental sanitation were highlighted. Finally, possible ways of achieving sustainable development goals (SDGs) via proper environmental management and sustainable practices were put forward.

I. A. Adeoye

Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Nigeria

K. H. Lasisi · T. F. Ajibade

Department of Civil and Environmental Engineering, Federal University of Technology, Akure, Nigeria

Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, PR China

University of Chinese Academy of Sciences, Beijing, PR China

E. S. Okonofua

Department of Geomatics, University of Benin, Benin City, Nigeria

M. A. Bagwai

Department of Life Sciences, School of Technology, Kanno State Polytechnic, Kano, Nigeria

O. A. Ajala

Department of Chemistry, Faculty of Science University of Ibadan, Ibadan, Nigeria

Keywords Environmental management · Environmental sanitation · Sustainability · Waste Management · Sustainable development goals

1 Background

The continuous migration of people from rural areas to urban cities among other factors such as industrialization, abrupt climatic change, and fossil fuel overconsumption has resulted in a huge quantity of wastes which in turn had caused serious environmental pollution (Das et al., 2019; Ajibade et al., 2021b). For the well-being of man and the environment (which encapsulate proper sanitation), engagement of techniques leading to environmental management and sanitation is of paramount importance (Abdel-Shafy & Mansour, 2018). Managing waste efficiently could be a herculean task if proper guidelines are overruled, but it could also be a smooth and continuous process without a hitch if established guidelines are adequately followed (Ferronato and Torretta 2019). Furthermore, the efficiency and sustainability of this process will only be guaranteed if the concept of environmental management and sanitation is properly defined and engaged.

Environmental management is a concept which involves the allocation of both natural and artificial resources with the aim of making optimum use of the environment to satisfy human needs at the minimum and if possible, for an indefinite future (UNEP, 2004–5). Environmental management can also be regarded as the definite decisions and actions taken concerning policy and practices with regards to how environmental resources are protected, allocated, developed, used, rehabilitated, remediated, monitored, and evaluated (Mitchell, 2002; Scarlat, 2015). For efficient environmental management, environmental managers must have a good system and plan that provides a framework for managing environmental responsibilities in a way that is integrated into the overall operations. In the same manner, environmental sanitation refers to activities aimed at controlling man's environmental factors

A. O. Ojo

Department of Civil Engineering, Yaba College of Technology, Yaba, Lagos, Nigeria

B. Adelodun

Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria

Department of Agricultural Civil Engineering, Kyungpook National University, Daegu, South Korea

F. O. Ajibade (✉)

Department of Civil and Environmental Engineering, Federal University of Technology, Akure, Nigeria

University of Chinese Academy of Sciences, Beijing, PR China

Key Lab of Environmental Biotechnology, Research Centre for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, PR China

e-mail: foajibade@futa.edu.ng

that may cause disease and improving the standard of basic environmental conditions that affect the well-being of man (Alabi, 2010). Some of these environmental conditions include clean and safe water supply, adequate and safe housing, clean and safe ambient air, proper waste management and disposal, and protection of food from biological and chemical contaminants (Ekong, 2015).

Having considered the concept of environmental management and sanitation, it is of utmost importance to operate whatever waste management schemes or activities are employed in a way that reduces environmental health hazards and risks and also ensures economic growth and social progress (Chang & Pires, 2015). The purpose of this chapter is to highlight some components of waste alongside their common treatment methods and to also emphasize the need for environmental management and sanitation of waste generated. Furthermore, possible challenges facing waste treatment and management were discussed. All these thus provide a solid framework on environmental sanitation and sustainability on waste, which can be adopted for more sustainable development goals attainment.

2 The Concept of Waste

Waste has been a great matter of public concern since the existence and habitation of humans in conglomerate forms such as cities and towns. The mass of waste that had since then been produced in the world has grown considerably, and this growth has been witnessed more in high-income countries revealed by the link between national gross domestic product (GDP) and waste generation per capita for each country. The voluminous state of waste generation has caused data on waste to often be incomplete and quite unreliable. Recent estimates suggest that globally, the municipal solid waste (MSW) alone generated more than 2 billion tonnes per year at the turn of the millennium (Hoornweg & Bhada-Tata, 2012). Defining “waste” could be controversial because of its perception which differs from individual to individual and one region to the other. What tends to be termed a waste by an individual may be a useful resource by another. This ambiguity has resulted in an avalanche of definitions given by different organizations and experts. Outlined as follows are some definitions of wastes given by world-recognized agencies, which is believed to largely represent the perception of every individual irrespective of their age, race, and gender and are generally acceptable.

As formulated by the European Union, “Waste shall mean any substance or object which the holder discards or intends or is required to discard” (European Commission, 2006).

The Basel Convention on the international movement of hazardous waste gave a similar definition on waste, but it was related to national legislation as “substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law” (Bassel Convention, 1992). The use of the words *discard* and *dispose of* makes it another difference between these definitions which meaning has been disputed. Subsequently, European Commission

added definitions of *by-products* and criteria for when waste ceased to be waste *as end of waste*. (European Commission, 2008).

The US Environmental Protection Agency (EPA) defines **waste** as “any unnecessary resource use or release of substances into the water, land or air that could harm human health or the environment” (USEPA, 2021).

Vividly, the stated definitions of waste try to capture the various perspective of every individual or organization as initially iterated. However, it seems impossible to distinctly define any material properties as waste, except for states and situations where it appears or declares as such.

3 Waste Generation and Influencing Factors

An unavoidable consequence of all processes where any class of object identified as “materials” is used is the *constant generation of waste*. Processes ranging from industries such as manufacturing of goods and extraction of raw materials, domestic/municipal, commercial, and so on all generate wastes (Karak et al., 2012). There is an increase in the volume of waste generated nowadays compared to previous decades or even centuries ago when the fraction of human and activities were small (Iraia et al., 2015; Liu & Wu, 2010). In addition, waste generation varies by quantity and complexity from region to region and season to season, and it is directly proportional to economic activities. The quantity of waste generated per capita in developed countries is higher when compared to that of developing countries (Lagerkvist & Dahlén, 2012). The present world population of 7.7 billion could reach around 9.7 billion by 2050 (UN 2018). The world generates about 1.3 billion tons of waste per year (1.2 kg/capita/day), and the data is set to increase to 2.2 billion tons in 2025 (Hoornweg & Bhada-Tata, 2012). Therefore, the situation is expected to worsen as the amount of waste generation continues to rise across the globe outstripping the rate of urbanization. By 2050, the world is expected to generate 3.40 billion tons of waste annually, increasing drastically from the recent 2.01 billion tons (Kaza et al., 2018). One-third of this waste will come from Asia, with major contributions from China and India. Waste generation in urban areas of India will be 0.7 kg per person per day in 2025, approximately four to six times higher than in 1999 (Kumar & Smith, 2017). This increase in the long term might lead to serious pollution with their impact on human health and wellness of the environment highly consequential unless an effective management system is put in place. Waste generation in most parts of the world is dependent on the type of activities and processes dominant in that region (Olabode, 2018; Chu et al., 2016; Iraia et al., 2015; Liu & Wu, 2010; Rafia et al., 2011). Some of these factors include but are not limited to the following:

- (i) Population: This factor seems to have the most dominant impact on waste generation especially solid waste generation in most parts of the world.
- (ii) Lack of advanced technology and facilities for separation at the source.
- (iii) Strength of solid waste management policy and enforcement.
- (iv) Income status of the individual.
- (v) Environmental education and awareness.

4 Waste Classification and Types of Wastes

Waste classification is a vital exercise of grouping produced wastes into different categories to avoid/prevent pollution problems that can endanger public health or by complying with legislation to avoid potential fines. Waste can be characterized based on its different features such as its source (i.e., their places of origin) and their nature (whether they are dangerous or not). These wastes also exhibit different properties such as biological/biodegradable properties, mechanical and physical properties, chemical and elemental properties, and combustible properties (Chang & Pires, 2015).

4.1 *Classification of Waste Based on Source*

Wastes classified based on their sources include a municipal waste (such as commercial and services waste), industrial waste (such as manufacturing, chemical, construction, energy, refineries, mining, and agricultural), medical waste, and other waste not considered as municipal, industrial, or medical waste. When the source of waste is properly identified (particularly municipal waste streams), it aids the understanding of the classifier in the proper classification process. A schematic representation of waste classification by origin with some main activities generating different types of waste is shown in Fig. 20.1.

4.1.1 Municipal Waste

As the name suggests, these are wastes from household, commercial, and institutional outlets and this also includes collections from public and private service areas such as market, street cleaning, sewage cleaning, garden, park and so on. They belong more to the category of waste discarded by the end consumers. Common components of wastes found in municipal wastes streams are paper (soft and hard), glass, plastics, aluminum, textiles, wood, organic waste, aluminum, and ferrous materials (Chang & Pires, 2015). This waste when generated is dealt with locally and almost immediately by landfilling, incinerating, or other suitable local treatment (Baccini & Brunner, 1991). Similar to our discussion in Sect. 3, the generation of the waste components is influenced by education level (in terms of recycling knowledge), economic level (in terms of income and standard of living), climatic conditions, and festive or special seasons like carnival, Christmas, New Year, and other celebrations (G'omez et al., 2009). As a subheading consideration, municipal waste can also be further characterized by its nature which may either be hazardous or nonhazardous or even possesses inert properties (Ludwig et al., 2003; Chang & Pires, 2015).



Fig. 20.1 Waste classification by origin with different activities generating the waste

4.1.2 Agricultural Waste

Agricultural wastes are wastes generated from various agricultural practices ranging from crop planting to animal farming, and this could be at either subsistence or commercial level. According to the OECD, agricultural waste is waste produced as a result of various agricultural operations. It includes manure, slurries, crop residues, and other wastes from farms, poultry houses, and slaughterhouses; harvest waste; fertilizer run-off from fields; pesticides that enter into the water, air, or soils; and salt and silt drained from fields (OECD, 1997). The growing capacity of agriculture in most countries has led to an increase in agricultural wastes which in most cases is more than four times municipal solid waste produced in such countries.

4.1.3 Industrial Waste

Industrial wastes are waste generated from activities emanating from different industrial sectors such as manufacturing, mining, construction/building and demolition, metallurgy, non-metallurgy, and food processing industries (EIONET, 2009). Although, the waste components generated from industries may differ from one industry to another, depending on the used raw materials, the manufacturing processes, and the product outlets. However, the common end products are sludges, product residues, kiln dust, slags, and ashes (JeyaSundar et al., 2020). These waste components can be subclassified into solids, liquids, and gases in which the efficient management of the liquid waste produced posed the main treatment concerns for industrial waste. In another sense, industrial waste components can be further subclassified as hazardous (such as flammable waste, corrosive waste, and toxic materials) and nonhazardous (such as carton, glass, rock, metals, plastic, and organic waste) (Millati et al., 2019). Their classification may sometimes involve using specific methodologies such as material flow analysis and also depend on the waste destination and processing method (Chang & Pires, 2015).

4.1.4 Medical Waste

Medical wastes (also known as hospital or health-care wastes) are wastes mostly in the class of solid or liquid which are generated from human or animal health-care facilities and/or related research. The common components of waste found include cotton swabs, needles, syringes, razors, scalpels, chemical solutions, blood containers and samples, tissues parts, body parts, fecal samples, other surgical devices, and radioactive materials. Some of these wastes are produced when patients (human and animal) are immunized, examined, or treated, while others are produced through laboratories, research and development outlets, and other related centers. Similar to municipal and industrial wastes, medical wastes can also be subclassified into hazardous (such as infectious, toxic, and radioactive materials) and nonhazardous waste which is not dangerous neither do they pose serious risks of infection to anyone in case of improper handling (Mbongwe et al., 2008; Jeyasundar et al., 2020). However, the World Health Organization (WHO) made some distinct classification of these medical wastes (WHO, 2012) as given in Table 20.1.

4.2 *Classification of Waste Based on Nature*

Wastes classified based on their nature include hazardous waste and nonhazardous waste. Each of them is elaborated in subsequent sections.

Table 20.1 WHO classification of medical wastes

Medical waste type	Waste component
Infectious waste	These are wastes from patients in isolation wards (containing blood and its by-products), discarded diagnostic samples, infected animals from laboratories, contaminated materials (swabs, bandages), and equipment (such as disposable medical devices)
Pathological waste	These are body parts (either recognizable or non-recognizable) and contaminated animal carcasses
Sharps	These include syringes, needles, disposable scalpels, blades, and other sharp instruments
Chemicals and heavy metals	These include broken mercury thermometers, mercury, solvents, disinfectants, and chemical derivatives
Pharmaceuticals	These include drugs that are expired, unused, and contaminated; vaccines and sera
Genotoxic waste	These are highly hazardous, mutagenic, teratogenic, or carcinogenic materials, such as cytotoxic drugs and their metabolites resulting from their use
Radioactive waste	These contain glassware that are contaminated with radioactive diagnostic or radiotherapeutic materials

4.2.1 Hazardous Waste

Waste is classified as hazardous when it has a greater risk of posing a severe threat to human beings and the environment. The components of these wastes include corrosive products, infectious products, explosives, radioactive/nuclear substances, flammable materials, oxidizers, and so on. Almost all categories of waste type (be it municipal, industrial, or medical) contain some number of hazardous substances or materials having the capacity to adversely impact human's life whether in the short or long term. The distinction between a waste being classified as hazardous or nonhazardous can sometimes be debatable depending on whether it is viewed scientifically or in legal terms. Generally, in the environmental context, a material is deemed to be hazardous when it contains properties such as toxicity, reactivity, corrosivity, and ignitability, and this is mostly in line with a legal standpoint (Jeyasundar et al., 2020), while from a scientific perspective, the basis of research being carried out determines the actual definition of hazardous waste. For example, a waste generated during scientific research may contain hazardous substances, but the waste itself may not be classified as hazardous, depending on whether the concentrations of the hazardous compound in it are sufficiently low (Vallero, 2019). This is where the legal perspective seems different, as their definition is based on the expectations of the harm the waste may like cause, especially in the long term. Because of this, various countries (specially developed ones) have various rules and regulations with codes to identify if wastes are hazardous or nonhazardous.

4.2.2 Nonhazardous Waste

Waste is classified as nonhazardous when no characteristics of hazardous can be traced from it prior to any physical, chemical, or biological transformations (Chang & Pires, 2015). A larger portion of the wastes generated from municipal, agricultural, and even industrial or medical are nonhazardous. Some examples of nonhazardous wastes have been highlighted in the discussion on municipal, industrial, and medical wastes in Sects. 4.1.1, 4.1.2, and 4.1.3, respectively.

5 Waste Treatment and Management Technologies

When waste is processed in such a manner that it has little or no effect on the environment, it is termed waste treatment or waste management (Tchobanoglous et al., 2014). There are various forms of technologies that can be employed in treating waste of any kind. These can be broadly categorized into physical, chemical, biological, thermal, and sustainable treatment methods. Under each of these methods are different techniques used which are peculiar to the waste type. A detailed explanation of these treatment techniques is not covered in this chapter. Meanwhile, a brief description of the physical, chemical, biological, thermal, and sustainable treatment methods is discussed in the following sections.

5.1 Physical Treatment

The physical treatment method is achieved by using techniques that are void of chemicals or microbes for waste treatment. Some of the major processes include sorting/screening, flotation, sedimentation, filtration, evaporation, air stripping, and membrane-based filtration processes. The dominant use of the physical method is in treating liquid waste (especially hazardous wastewater), and before the operation commences, the solid wastes are firstly separated from the liquid waste to reduce the cost of treatment. Generally, it is relatively cheaper to treat a low volume with high concentration waste than complex unsegregated waste (Christensen, 2011). Part of the most important aspect of the physical treatment processes is to segregate or classify the waste into categories of solid, liquid, or gas. By so doing, the volume of waste will be reduced, and this will facilitate the treatment process (Jeyasundar et al., 2020). In a broader perspective and for the optimum waste treatment process, the physical method can be combined alongside other methods.

5.2 Chemical Treatment

The chemical treatment method is used for treating waste by applying chemical reactions techniques to reduce harmful waste into less harmful ones in the environment. Some of the major processes include oxidation, reduction, neutralization, precipitation, coagulation, and flocculation. They are closely related to physical treatment methods except that chemicals are adopted for its implementation. They are advantageous in volume reduction and resource recovery from wastes, which makes them a fit for off-site landfilling before disposal. Liquid waste, which is prohibited from being disposed for landfilling without any form of pretreatment, is also treated chemically to make them less toxic or nonhazardous before disposal.

5.3 Biological Treatment

The biological treatment method can be adopted for both organic solid waste and organic liquid waste. This can be achieved either by engaging (i) microbial mediated methods such as anaerobic digestion and composting via aerobic process and (ii) plant-mediated methods such as phytoremediation (El-Haggar, 2007). During implementation, either method can be used individually or both can be combined for more effective output. For anaerobic processes, anaerobic bacteria degrade waste without oxygen, and they are mostly adopted for treating concentrated organic waste or organic sludges, while for the aerobic process, oxygen is needed to degrade waste, and they are mostly used for the treatment of industrial and municipal wastewater (McDougall et al., 2001; Chang & Pires, 2015). In recent years, advanced techniques had been developed to treat petroleum-contaminated soils using aerobic bacteria (Jeyasundar et al., 2020).

5.4 Thermal Treatment

The thermal treatment method is used mostly for treating solid wastes, especially municipal solid wastes. It is the process of using heat to treat and reduce waste materials. Most commonly used techniques in this category include open burning, incineration, gasification, and pyrolysis. Amongst them, open burning is the most popular with long-standing history, but it is environmentally harmful because it is a form of incinerator with no pollution control mechanism (Oluwatuyi et al., 2020; Ajibade et al., 2021a). Meanwhile, there are controlled incinerators in which the temperature can be adjusted to control the burning of waste and liberation of gases and heat energy (Zaman, 2009; Havukainen et al. 2017). Basic incinerator types are fixed-bed or fluidized-bed plants. They are more advantageous than open burning in that they do not only reduce waste volume and transportation costs; they help in

drastically reducing harmful greenhouse gas emissions (Sharma, 2015; JeyaSundar et al., 2020). Pyrolysis and gasification are closely related techniques that decompose organic waste using either no or low quantity of oxygen and high temperature. The former requires no oxygen while the latter requires little oxygen for the treatment process. In practice, gasification allows the burning process to recapture energy without leading to air pollution which makes it more advantageous than pyrolysis.

5.5 Sustainable Treatment

The sustainable treatment method is not a popular concept when it comes to discussing the available waste treatment techniques. However, it has recently been established and defined as the type of treatment which combines various two or more types of treatment, and process can recover raw material from waste with a prospect of conserving them for full reutilization (El-Haggar, 2007). A perfect example of this treatment method is waste recycling which entails converting waste into raw material and then producing other products from it (Adama, 2012; Hotta & Chika 2014). Composting is also a form of sustainable treatment which through a biological treatment means converts organic waste into a safe by-product.

6 Challenges Facing Waste Treatment and Management Technologies

Globally, many countries face critical problems concerning waste management. The development level of a country greatly determines how their waste will be managed and the impact those treatment and management measures will reflect (Zhao & Duo, 2015). Choice of waste management depends on the decisions taken by city leaders as well as the structures related to the nature, quantity, and quality of local waste produced (Baldwin & Dripps, 2012). Some of the challenges that can be encountered in waste management include insufficient government priority and political support for action; poor finance; inadequate long-term planning, indiscriminate disposal of waste; poor handling and disposal of hazardous wastes; insufficient recycling and reuse; ineffective legislation and institutions; lack of skilled personnel; and poor monitoring and enforcement (Adewumi et al., 2020). Summarily, these challenges are discussed under five source areas.

(i) Lack of environmental awareness in society

Environmental awareness plays a major role in sustainable waste management and sanitation in society. The involvement of people in waste management has a major effect on the overall operational efficiencies of any waste management system or approach adopted. For instance, the inefficient recy-

cling activity can be directly traced to poor waste-sorting behavior among people. When materials that are recyclable are mixed with other wastes, they result in environmentally and economically inefficient recycling operations (Jagdeep et al., Singh et al., 2014). As noted by Mbeng et al. (2009), strong concern among people for a clean environment and the belief that learning, information, and awareness campaigns are important drivers to behavior change. However, this does not necessarily translate into increased participation in recycling or reuse initiatives. In developed countries, although disposal and management of waste are of great environmental concern, they are not fully aware of its consequences at the global level. There is still a need to have proper understanding about how resource issues are linked to global environmental issues such as climate change, which is an issue that is of a particular concern to people. Thereby, resulting in poor public participation in waste management. Hence, there is a need to successfully educate the public to be aware of the association between people's waste disposal behavior and global concerns in the same way as they are aware of how climate change is linked to car use and local flooding. Consequently, the public would be conscious of their actions and will improve participation in waste management.

(ii) Increasing global quantities of waste

The increase in the amounts of waste generated globally has shown the effect of economic growth on waste amounts. The waste generation rates per capita in developing countries are relatively low as compared with developed countries. However, waste generation rates in developing countries are increasing rapidly. The increase in waste generation rates even at already high waste generation rates, especially in developed countries, can be linked to the rate of consumption of resources in the world (Jagdeep et al., 2014).

Innovation in production has led to the generation of new and increased amounts of wastes that are entering into the waste streams. Consequently, the world is still faced with challenges to manage wastes sustainably due to inadequate waste sorting, products that are not suitable for recycling. Even developed countries with relatively developed waste management facilities are not left out. This understanding, therefore, underscores that despite the development and improvement in the waste management system, the overall waste management is still not sustainable (Jagdeep et al., 2014).

(iii) The increasing complexity of product composition and variety in the production and consumption systems

During extraction processes, high-quality material resources produced are used to make various products in the manufacturing industries by combining various raw materials. Therefore, the manufacturing systems combine materials to production. These products enter the consumption system and leave the system in various form of wastes, further resulting in the dilution of resources in space and time. Also, as reported by Gößling-Reisemann (2011), these transformations lead to changes in physical, chemical, and biological properties of the material resources.

Waste management processes either “concentrate” these resources through, for example, recycling, or further “dilute” them in one of their residues, such as through incineration or composting. From a resource scarcity perspective, the dilution of the many scarce material resources is not sustainable, and these resources should be reintroduced into the socio-technical systems. The manufacturing and consumption systems dilute the resources to a critically low level owing to the increasing product composition complexity. This leads to energy-intensive and hence costly recycling operations. This is the case for many materials where recycling is not economical or not possible technologically. When limited energy is available, the cost of production of pure substances will prevent the recycling of materials beyond certain limits. Therefore, as reported by Vesilind et al. (2007), using nonrenewable resources is not sustainable, and attempts to close their loops will lead to greater damage than good. Furthermore, the recycling of complex waste streams poses great technological challenges, thereby reducing their potential utility (Göbbling-Reisemann, 2011). Product diversity has considerably increased over the last few decades which consequently, there is an increase in waste materials discarded in the waste management systems with the potential to further increase. However, waste is classified and sorted in limited numbers of fractions. At the end of their use, products with complex material compositions are often difficult to treat when disposed of. This is a challenge for the current waste management system to handle the wastes more sustainably due to complicated waste treatment processes (United Nations Environment Program, 2011). Hence, to enhance efficient cycles of reuse such as remanufacturing and reassembly, it is essential to maintain resource quality throughout the production chain in the industrial sector. Consequently, it is very necessary to properly consider the possibility of a system to concentrate or dilute the resources.

- (iv) Barriers to practical implementation and performance of various approaches to waste management

Apart from the lack of facilities for proper waste management, there exist many factors which are inhibiting execution and performance of various innovations in resource management, and this is yet to be properly addressed. Consequently, policies, during implementation stages, fail owing to reasons such as an economic situation or competition existing approaches. Therefore, there is failure of the policy decisions to achieve the intended goals. For example, Walls in 2006 noted that the concept of extended producers responsibility (EPR) has been introduced to enhance product development processes, particularly design for environment, in companies and to achieve greatly needed resource recovery. However, the external costs of waste management are not well captured in EPR which results to reduction in incentives for waste prevention and green products design (Dubois, 2012). Jagdeep et al., (2014) noted that findings have revealed that the EPR lacks needed potential to drive eco-design at least in the short run where (1) prices of product are inelastic and the effects of the EPR equal for all producers (Gottberg et al., 2006) and (2) in

cases where such innovations become economically harmful to “green technology loses and profitability wins” (Vesilind et al., 2007).

(v) Private sector

Generally, there is a lack of funding that may be used to establish or equip a waste management system operated by private contractors. This is caused by little or no incentives or initiatives for the private sector in waste management and the unwillingness of authorities to give waste management services to private operators. Another factor affecting the involvement of private individuals is poor public awareness. However, if the people are willing to participate and the private sectors are motivated to contribute to waste management, there is a need for support and provision of funding from the government for effective and sustainable participation.

7 Ensuring Environmental Sanitation and Sustainability on Waste: Achieving SDG

7.1 Environmental Sanitation and Sustainability on Waste

The need to ensure proper environmental sanitation and sustainable practices especially on proper waste management and treatment is not far-fetched. Poor sanitation leads to the spread of infections and diseases which are detrimental to human health. Schistosomiasis (sometimes referred to as bilharziasis), one of the human parasitic diseases, is ranked second after malaria in terms of public health and social-economic importance in tropical and subtropical areas as the disease is prevalent in more than 70 developing countries, infecting over 200 million people in which 20 million suffer severe consequences from the disease (UNICEF & WHO 2019). Comprehensive environmental sanitation management will ensure that proper intervention is introduced and implemented to encourage behavior change.

Also, improper environmental sanitation or hygiene has great financial and economic implications, both directly and indirectly. The impact of inadequate environmental sanitation on health results to direct medical costs associated with treating and controlling sanitation-related illnesses. Certainly, this will lead to reduced or lost human productivity and increased government expenditures on the provision of health services. Furthermore, poor sanitation can discourage tourism thereby leading to reduction in revenue generated from tourism due to the high risk of disease contamination. If the economy of such a city depends largely on tourism, that will lead to a recession. According to an analysis conducted in Ghana, the health cost resulting from poor water, sanitation, and hygiene is equivalent to 2.1% of the annual gross domestic product (GDP). Poor environmental sanitation practices, especially in the context of indiscriminate littering and improper discharge of sewage and solid waste into water bodies, render the habitat unsafe for aquatic animals, thereby leading to their death and consequently can lead to loss of biodiversity.

In the light of the above discussion, improved environmental sanitation management will not only enhance the sustainability of environmental resources but also present a more secure and healthier future for people. On the one hand, as healthy people make a healthy community, a healthy community is a more lucrative place for goods, services, and investment which in the long term will ensure economic sustainability.

7.2 Achieving Sustainable Development Goals

Sustainability has a major focus of environmental studies and human development and resource use. While the idea of sustainability has many aspects, as touching environmental management, its central idea is to use resources in ways that do not diminish them. Natural resources such as wildlife, land, and water should be protected so that coming generations can enjoy healthy living. However, one of the most important questions in environmental studies is how to improve the well-being of man within the limits of the earth's natural resources. A viable way out of this condition is sustainable development. Sustainable development can be explained as the development that meets the present needs without compromising the ability to come generations to meet their own needs (Mitchell, 2002).

To achieve the sustainable development goals relating to environmental sanitation and waste management, the adoption and effective implementation of the following actions are recommended.

(i) Establishment of efficient solid waste regulations

A very vital aspect of sustainable waste management is proper planning. Although waste management services and operations are typically handled at the local level, both local and federal governments significantly contribute to defining the regulatory framework within which the development of solid waste management services can be placed. It is the responsibility of national governments to establish environmental regulations. National laws encourage local governments to adhere to common social and environmental standards. Local governments also establish rules and regulations that guide households and institutions on the proper management and disposal of waste. Typically, the section that regulates waste management is separate from the section that operates services to promote accountability.

(ii) Adopting a circular model of consumption

A major structure of resource consumption at the global level is the linear system of resource consumption. Various resources are transformed into diverse products in a predominantly global production system. These products are distributed to consumers on the global market and wastes disposed into the water management system. Despite the increase in the rate of recycling of materials, such as paper and metals, the linear production-consumption chain is still predominantly in use (Jagdeep et al., 2014).

To make resource management sustainable, it requires “decoupling” resource consumption with the economic growth and a transition towards a circular model of resource consumption, where reuse and recycling of resources are introduced through strategic planning from the production to the consumption chain (Jagdeep et al., 2014). This calls for a definite approach to a waste management system that must go beyond the mere safe disposal, or recovery, of generated waste and seeks to address the fundamental causes of the problem by attempting to change unsustainable patterns of production and consumption (UN, 2018).

(iii) Citizen engagement

The role of a strong relationship with the public in successful and sustainable waste management cannot be overemphasized. To achieve sustained waste management, public engagement is very essential. Citizens are relied on to consciously reduce the quantity of waste they generate, manage specific waste types at home, dispose of waste properly, abide by waste management rules and regulations, pay for waste management services, etc. To motivate this support, it is necessary that governments gain public trust. Cities and countries are encouraged to engage the public by providing high-quality services that earn approval and trust that will motivate citizens to pay for services, be environmentally conscious, and abide by guiding rules and regulations.

(iv) Education

Educational programs are a key aspect of raising awareness on waste and ensuring proper waste management. Contrary to popular belief, many people do not know enough that at the local level, inadequate collection of waste, uncontrolled disposal, and inappropriate siting of waste facilities can negatively affect both environmental and public health. Many are not aware that at a global level, waste contributes to climate change and is one of the major sources of pollution in oceans. A number of countries reach citizens using media. Effective programs can be organized, and interesting environmental content can be organized in diverse languages through media and advanced technology, such as television, radio, and on social network platforms. Educating young by adopting an environmental-related subject in the school curriculum can be very vital to public education. This will not only educate young citizens, but they will also become more environmentally conscious.

(v) Integration of waste pickers and strengthening of the recycling value chain

Recognizing and formalizing informal waste pickers can lead to improved waste collection and recycling. The collection and sale of recyclable materials to middlemen who then clean and aggregate materials to distribute to the industry are vital roles played by waste pickers in the recycling value chain. Through proper integration and formalization, governments and associated corporations can improve the prospects of waste pickers by ensuring an innovative partnership model between the private sector and waste pickers. Also, governments should oversee the transaction and ensure that fair prices and bargaining material from the middlemen. Formal recognition of waste pickers

will also allow them to boost of job security and acknowledgement of their work and therefore improve their productivity and commitment.

8 Conclusion

Undoubtedly, the economic performance coupled with the habitual living standards of people living in a country or region will continuously affect their waste generation rate, which in the long run may become either a blessing or menace, depending on the management and sustainability strategies put in place. Ensuring effective environmental sanitation and sustainability, especially in the area of waste, is one of the main objectives that SDGs seeks to address. Therefore, this chapter has provided information on how this can be effectively achieved by considering the concept of environmental management and sanitation and how they relate to waste generation, waste classification and waste treatment, and management technologies. Moreover, possible ways to ensure proper environmental management and sustainable practices with adequate perspective on waste to meet the SDGs were put forward. These actions and measures, if painstakingly given due diligence, will result in a truly sustainable environment that continually promotes the well-being of the individuals living in them.

References

- Abdel-Shafy, H. I., & Mansour, M. S. M. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, 27(4), 1275–1290. <https://doi.org/10.1016/j.ejpe.2018.07.003>
- Adama, O. (2012). Emerging relations in informal sector recycling in Kaduna. *Urban Forum*, 23(4), 449–466.
- Adewumi, J. R., Ajibade, T. F., & Ajibade, F. O. (2020). Appraisal of on-site sanitation facilities and solid waste management in public places within Akure municipality, Nigeria. *Journal of Civil Engineering, Science and Technology*, 11(1), 8–21. <https://doi.org/10.33736/jcest.1872.2020>
- Ajibade, F. O., Adelodun, B., Ajibade, T. F., Lasisi, K. H., Abiola, C., Adewumi, J. R., & Akinbile, C. O. (2021a). The threatening effects of open dumping on soil at waste disposal sites of Akure City, Nigeria. *International Journal of Environment and Waste Management.*, 27(2), 127–146. <https://doi.org/10.1504/IJEWm.2021.10030610>
- Ajibade, F. O., Adelodun, B., Lasisi, K. H., Fadare, O. O., Ajibade, T. F., Nwogwu, N. A., Sulaymon, I. D., Ugya, A. Y., Wang, H. C., & Wang, A. (2021b). Environmental pollution and their socio-economic impacts. In A. Kumar, V. K. Singh, P. K. Singh, & V. Mishra (Eds.), *Microbe mediated remediation of environmental contaminants*. Woodhead Publishing, Elsevier. <https://doi.org/10.1016/B978-0-12-821199-1.00025-0>
- Alabi, J. (2010). *Nigeria & and environmental sanitation*. Retrieved from http://Nigerianmasterweb.com/.../index.php/2010/10/05/title_10
- Baccini P, Brunner P (1991) Metabolism of the Anthroposphere. Springer, .
- Baldwin, E., & Dripps, W. (2012). Spatial characterization and analysis of the campus residential waste stream at a small private Liberal Arts Institution. *Resources, Conservation and Recycling*, 65, 107–115. <https://doi.org/10.1016/j.resconrec.2012.06.002>

- Basel Convention. (1992). *Basel convention on the control of transboundary movements of hazardous wastes and their disposal ASEL*. <http://www.basel.int/text/con-e.pdf>
- Chang, B., & Pires, A. (2015). In N.-B. Chang & A. Pires (Eds.), *Sustainable solid waste management: A systems engineering approach* (1st ed.). The Institute of Electrical and Electronics Engineers, Inc. Published 2015 by John Wiley & Sons, Inc.
- Christensen, T. H. (2011). Introduction to waste management. In T. H. Christensen (Ed.), *Solid waste technology and management* (pp. 3–16). Wiley.
- Chu, Z. J., Wu, Y., Zhou, A., & Huang, W. C. (2016). Analysis of influence factors on municipal solid waste generation based on the multivariable adjustment. *Environmental Progress & Sustainable Energy*, 35(6), 1629–1633.
- Das, S., Lee, S. H., Kumar, P., Kim, K. H., Lee, S. S., & Bhattacharya, S. S. (2019). Solid waste management: Scope and the challenge of sustainability. *Journal of Cleaner Production*, 228, 658–678. <https://doi.org/10.1016/j.jclepro.2019.04.323>
- Dubois, M. (2012). Extended producer responsibility for consumer waste: The gap between economic theory and implementation. *Waste Management & Research*, 30, 36–42.
- EIONET. (2009). *What is waste? EIONET*. Available at: <http://scp.eionet.europa.eu/themes/waste/#treatment>. Accessed on December 2021.
- Ekong, I. E. (2015). An assessment of environmental sanitation in an urban. *African Journal of Environmental Science and Technology*, 9(7), 592–599.
- El-Haggag, S. M. (2007). Current practice and future sustainability. In S. M. El-Haggag (Ed.), *Sustainable industrial design and waste management* (pp. 1–19). Academic Press. <https://doi.org/10.1016/B978-012373623-9/50003-4>
- European Commission. (2006). Directive 2006/12/EC. *Official Journal of the European Union*, L50(9), 114.
- European Commission. (2008). Directive 2008/98/EC of the European Parliament and of the council of 19 November 2008 on waste and repealing certain directives. *Official Journal of the European Union*, L312, 3–30.
- Ferronato N, Torretta V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *International Journal of Environmental Research and Public Health*. 2019; 16(6):1060. <https://doi.org/10.3390/ijerph16061060>.
- Gómez, G., Meneses, M., Ballinas, L., & Castells, F. (2009). Seasonal characterization of municipal solid waste (MSW) in the city of Chihuahua, Mexico. *Waste Management*, 29(7), 2018–2024.
- Göbbling-Reisemann, S. (2011). Entropy production and resource consumption in life-cycle assessments. In B. R. Bakshi, T. G. Gutowski, & D. P. Sekulic (Eds.), *Thermodynamics and the destruction of resources*. Cambridge University Press.
- Gottberg, A., Morris, J., Pollard, S., Mark-Herbert, C., & Cook, M. (2006). Producer responsibility, waste minimization and the WEEE directive: Case studies in eco-design from the European lighting sector. *Science of the Total Environment*, 359, 38–56.
- Havukainen, J., Zhan, M., Dong, J., Liikanen, M., Deviatkin, I., Li, X., & Hörttnanainen, M. (2017). Environmental impact assessment of municipal solid waste management incorporating mechanical treatment of waste and incineration in Hangzhou, China. *J. Clean. Prod.*, 141, 453–461. <https://doi.org/10.1016/j.jclepro.2016.09.146>
- 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. <https://openknowledge.worldbank.org/handle/10986/17388> license: CC BY 3.0 IGO
- Hotta, Y., & Chika, A.-S. (2014). Waste reduction and recycling initiatives in Japanese cities: Lessons from Yokohama. *Waste Management & Research*, 32(9), 857–866.
- Iraia, O. G., Oihane, K. E., Cristina, M., Ana, M. M. A., & Ainhua, A. V. (2015). Identification of municipal characteristics regarding household waste generation and their forecasting ability in Biscay. *Waste Management*, 39, 26–34.
- JeyaSundar, P. G. S. A., Ali, A., Guo, D., & Zhang, Z. (2020). Waste treatment approaches for environmental sustainability. In P. Chowdhary, A. Raj, D. Verma, & Y. Akhter (Eds.),

- Microorganisms for sustainable environment and health* (pp. 119–135). Elsevier. <https://doi.org/10.1016/B978-0-12-819001-2.00006-1>
- Karak, T., Bhagat, R. M., & Bhattacharyya, P. (2012). Municipal solid waste generation, composition, and management: The world scenario. *Critical Reviews in Environmental Science and Technology*, 42(15), 1509–1630.
- Kaza, S., Yao, L. C., Bhada-Tata, P., Van Woerden, F. (2018). *A global snapshot of solid waste management to 2050*. Retrieved from open knowledge repository. <http://hdl.handle.net/10986/30317>
- Kumar S, Smith, S. R. (2017). Challenges and opportunities associated with waste management in India. *Royal Society Open Science*, 4 (3), 160764.
- Lagerkvist, A., & Dahllén, L. (2012). Solid waste generation and characterization. In R. A. Meyers (Ed.), *Encyclopedia of sustainability science and technology*. Springer. https://doi.org/10.1007/978-1-4419-0851-3_110
- Liu, C., & Wu, X. W. (2010). Factors municipal solid waste generation in China: A multiple statistical analysis study. *Waste Management and Research*, 29(4), 371–378.
- Ludwig, C., Hellweg, S., & Stucki, S. (Eds.). (2003). *Municipal solid waste management*. Springer. <https://doi.org/10.1007/978-3-642-55636-4>
- Mbeng, L., Probert, J., Phillips, P., & Fairweather, R. (2009). Assessing public attitudes and behaviour to household waste management in Cameroon to drive strategy development: A Q methodological approach. *Sustainability*, 1, 556–572.
- Mbongwe, B., Mmereki, B. T., & Magashula, A. (2008). Healthcare waste management: Current practices in selected healthcare facilities, Botswana. *Waste Management*, 28(1), 226–233. <https://doi.org/10.1016/j.wasman.2006.12.019>
- McDougall, F. R., White, P. R., Franke, M., Hindle, P. (2001). *Integrated solid waste management: a life cycle inventory*. 2nd ed. Blackwell Science; 2001, ISBN 0-632-05889-7.
- Millati, R., Cahyono, R. B., Ariyanto, T., Azzahrani, I. N., Putri, R. U., & Taherzadeh, M. J. (2019). Agricultural, industrial, municipal, and Forest wastes: An overview. In M. J. Taherzadeh, K. Bolton, J. Wong, & A. Pandey (Eds.), *Sustainable resource recovery and zero waste approaches* (pp. 1–22). Elsevier. <https://doi.org/10.1016/B978-0-444-64200-4.00001-3>
- Mitchell, B. (2002). *Resource and environment management*. Singapore (2nd ed.). Pearson Education Publishers.
- OECD. (1997). *Glossary of environment statistics* (Studies in methods, series F, no. 67). United Nations.
- Olabode, A. (2018). Assessment of waste generation and sanitation strategies for sustainable environmental Management in Akungba-Akoko, Nigeria. *Journal of Waste Management and Disposal*, 1(1), 102.
- Oluwatuyi, O. E., Ajibade, F. O., Ajibade, T. F., Adelodun, B., Olowoselu, A. S., Adewumi, J. R., & Akinbile, C. O. (2020). Total concentration, contamination status and distribution of elements in a Nigerian state dumpsites soil. *Environmental and Sustainability Indicators*, 5, 100021. <https://doi.org/10.1016/j.indic.2020.100021>
- Rafia, A., Keisuke, H., & Rabaah, T. (2011). Factors affecting waste generation: a study in a waste management program in Dhaka City, Bangladesh. *Environmental Monitoring and Assessment*, 179, 509–519.
- Scarlat, N. M.-F. (2015). Evaluation of energy potential of municipal solid waste from African urban areas. *Renewable and Sustainable Energy Reviews*, 50, 1269–1286.
- Sharma, R. S. (2015). The impact of incinerators on human health and the. *Reviews on Environmental Health*, 28(1), 67–72.
- Singh, J., Laurenti, R., Sinha, R., & Frostell, B. (2014). Progress and challenges to the global waste management system. *Waste Management & Research*, 32(9), 800–812. <https://doi.org/10.1177/0734242X14537868>
- Tchobanoglous, G., Burton, F. L., Stensel, H. D., Tsuchihashi, R., & Metcalf & Eddy/AECOM. (2014). *Wastewater engineering: Treatment and resource recovery* (Vol. 1, 5th ed.). McGraw-Hill. ISBN 978-0-07-340118-8.

- UNEP. (2004–5). *Environmental management and community participation – Enhancing local programmes*. Nairobi, Kenya.
- UN (2018). The Sustainable Development Goals Report; UN: New York, NY, USA, 2018.
- UNEP. (2011). *Towards a green economy: Pathways to sustainable development and poverty eradication, Part II: Investing in Energy and Resource Efficiency*.
- UNICEF and WHO. (2019). Affordability Country Case Study Methodology Guide. WHO/UNICEF Joint Monitoring Programme (JMP) and WHO Global Assessment and Analysis of Sanitation and Drinking Water (GLAAS)..
- USEPA. (2021). *Sustainability – Lean & environment toolkit: Chapter 2*. Available at <https://www.epa.gov/sustainability/lean-environment-toolkit-chapter-2>. Accessed on 22 December 2021.
- Vallero, D. A. (2019). Hazardous wastes. In T. M. Letcher & D. A. Vallero (Eds.), *Waste* (2nd ed., pp. 585–630). Academic Press. <https://doi.org/10.1016/B978-0-12-815060-3.00031-1>
- Vesilind, P., Heine, L., & Hamill, S. (2007). Kermit's lament: it's not easy being green. *Journal of Professional Issues in Engineering Education and Practice*, 133, 285–290.
- World Health Organization (WHO). (2012). *Waste from health-care activities*. WHO. Available at: <http://www.who.int/mediacentre/factsheets/fs253/en/>. Accessed on December 2021.
- Zaman, A. U. (2009). Life cycle environmental assessment of municipal solid waste to energy technologies. *Global Journal of Environmental Research*, 3(3), 155–163.
- Zhao, S., & Duo, L. (2015). Bioaccumulation of cadmium, copper, zinc, and nickel by weed species from municipal solid waste compost. *Polish Journal of Environmental Studies*, 24(1), 413–417. <https://doi.org/10.15244/pjoes/28960>