Sub-Sahara African Academic Research Publications
December, 2022, Editions

JBER
Journal of Biodiversity and Environmental Research
Vol.26, No.4, ISSN 2211-8735

THE PLACE OF SOLID WASTE MANAGEMENT IN THE MAINTENANCE OF CLEAN & HEALTHY URBAN FEDERAL CAPITAL TERRITORY, ABUJA - FCT

***PROF. YAYOK P. K (PHD; **GODWIN A. AGI; ***ALIYU MOHAMMAD; ****KUZAYET SHAIBU SANI**
*Nile University of Nigeria, Abuja; **Central Bank of Nigeria (CBN), Abuja - FCT ***Federal Road Maintenance Agency (FERMA) Abuja ****Rivers State Polytechnic, Bori, Rivers State.

Abstract
This research paper theoretically underpins the solid waste management practices in Urban Federal Capital City, Abuja as basis for a blueprint towards attaining a clean and healthy urban centre through enhanced and intensified initiative of the local government councils to address waste problems in cooperation with other concerned stakeholders (private sectors and non-government organizations) of the society. In Municipal Solid Waste Management (MSWM) in developing countries five typical problem areas can be identified: - inadequate service coverage; operational inefficiencies of services; limited utilization of recycling activities; inadequate management of non-industrial hazardous waste; and inadequate landfill disposal. This article discusses some of these problem areas in Abuja Urban capital and suggests possible approaches for improving the situation. Emphasis is on the problem of inadequate landfill disposal. Open uncontrolled dumping is still the most common method of solid waste disposal in developing in the Federal Capital - Abuja. Although the environmental consequences are often quite evident because of the health hazards, the problem is seldom dealt with. Reasons for not dealing with the problem are low political priority, inadequate resources allocated, and/or missing know-how regarding alternative solutions for operating and managing a landfill/dump. To improve the current situation, alternative institutional and financial models for disposal activities must be developed and applied. Knowing the costs of waste disposal activities are a prerequisite that enables municipalities to make decisions about their programs with regard to cost minimizing and better planning for the future. The guidelines for management of Urban cities should not be based primarily on the existing requirements of sanitary landfills in Abuja, but should mainly take into account the basically different physical and economic situations prevailing in developing countries. In that respect efforts should also be undertaken to upgrade existing dumpsites and so "aiming" in the long run in the direction of a sanitary landfill

Keywords: Solid Waste Generation, Solid Waste Management, Landfill, Waste Disposal, Waste Collection.

Introduction

The amount of solid waste, both of general and dangerous waste, has been rapidly increased. This situation has placed an impact on the environment as generally seen in many areas. The main causes are from the continuing economic growth and the increasing number of population, in urban areas rather than rural areas, followed by the increasing number of factories. The technological development has been done to facilitate the human from the daily consumption of both individuals and households becomes waste.

Since the consumption of population has been increased within the crowded living, the amount of solid waste has also been increased in every minute. (Winai Wirawatthananon, 1995 retrieved, June 2022,. The total amount of solid waste in Thailand is approximately 15.16 million tons per year or 41,532 tons per day. The capacity to collect the waste is about 12.73 million tons per year or 84.00%. With this figure, the amount of recycling waste is around 12.43 million tons or 82.00% (organic and recycled wastes). Semi-urban communities always seriously face a problem of solid waste management. This is because the limited managing potential of local administrative organizations. The problem is generally related to insufficient service provision, delayed collection, accumulative solid waste amount in community, and incorrect management of solid waste according to the sanitation principles. The involvement of community in waste separation is mostly little to none. This is because the lack of behavior and significant mechanism to clearly promote cooperative process.

The problem of solid waste in community has occurred because people lack knowledge, understanding and involvement in reducing and separating waste from the households. The waste from everyday use is in different forms. It is left into the waste lands and the containers provided by the local agencies. It is also burnt in one's own land.

Regarding the local waste collection, it was found that the amount of waste which could be collected per day was about 7 cubic meters. This amount comprised 40% of degradable wet waste and another 60% of dry waste. They all were brought to put together into the waste land of municipality by piling and landfilling. Furthermore, it was found that an important obstacle for local community was that insufficient budget for dealing with the increasing amount of solid waste.

It is, therefore, the solid waste management based on an involvement of the community members with variety of occupations and using environmental education process will be a significant tool in providing them knowledge in order to promote awareness and behavioral changes toward the management of household waste. In recent years of fast population growth, increase in urbanization and industrialization in Abuja has created severe problems for solid waste management in the whole Local Government Councils. The increased level of consumption is the characteristics of the population of cities leading to generation of enormous quantities of solid waste material. The impacts of such pollution are felt both at local, as well as, at distances from sources.

Domestic and industrial discharges lead to contamination of air, eutrophication with nutrient and toxic materials which in turn lead to degradation of air, land and affect flora and fauna badly. Since olden times municipal bodies remained responsible for keeping the roads clean, collect city garbage and to carry out its safe disposal. Solid waste management has become one of a major concern in environmental issues(Mazzanti & Zoboli, 2018). This is particularly true to urban areas where population is rapidly growing and the amount of waste generated is increasing like never before(Kathiravale & Mohd Yunus, 2018). Current earth's population is about +/- 8.5 billion and it is most of the enlightened bodies of the cities that employ largest number of employees for the purpose of cleaning the city, but only less than 30% of the waste generated is collected by the staff keeping aside the tendency of nonworking of the employees. Many estimates of solid waste generation are available but, on the average, it is projected that under municipal conditions, the amount of waste generated per capita will rise at a rate of 10%–16.33% annually (Shekdar 2019). Because of the increasing factor on solid waste at present, if we follow this presumption the calculated per capita waste generation on daily basis is 983.36 g in 2016. At such a stage solid waste generation will rise up to 1,200g in the year 2030. The table 1 below present the solid waste management based on waste generation in one of the largest cities in the world.

Table 1 The present scenario of solid waste management

0	Functional element	Detail
1	Detail Segregation of storage at source	Generally absent, waste is thrown on streets
2	Functional element Primary collection	Does not exist, waste is deposited on the streets and picked up through sweeping
3	Waste storage deposits	Very unscientific, waste is stored on open sites/ masonry enclosures. A few containers are however, is use
4	Transportation	Manual loading is open trucks/ Partly dumper placers
5	Frequency of removal	Irregular/Alternate day/ Once in three days/ Once in a week
6	Processing	No processing is carried out except A to Z municipal power plant
7	Disposal	Unauthorized dumping in open space

(Source solid waste management, NEERI, 2014 adapted retrieved in 2022).

The solid waste generation will have significant impact in terms of land required for disposal of waste as well as methane emission. Such a large quantity of solid waste requires well managed system of col-lection, transportation and disposal. It is required that we have proper knowledge about the nature of waste material, its collection and disposal along with recycling and energy generation potential. The traditional routine approach to solid waste management is normally municipal bodies handle all aspects of collection, transport and disposal and this has emerged as a reality of mixed success all over the world in advanced or developing cities. The search for more efficient and economical solid waste collection agenda in most of the urban areas has taken shape adopting several directions towards better partnership with communities along with private sector combining adequate economic policies, e.g., recycling credits by paying the recycler, land-fill disposal levies at land-fill sites designed to minimize the quantity of waste being land-filled and product charges like packing tax to disallow over-packaging. Legal approach and restrictions on the quantity of pollutants a factory can discharge of minimum air and water quality standards are being particularly proved effective in monitoring pollution in many parts of the globe. The efficiency depends mainly on good enforcement capacities and proper monitoring procedures where urban growth pressures and pollution issues are far greater.

Statement of Problem

The management of waste is becoming complex and the facilities provided cannot cope with the increasing demand and needs. Therefore, the best approach needs to be implemented immediately while considering environmental, social and economic aspects (Aye &

Widjaya,2017). The drivers of sustainable waste management were clarified by Agamuthu et al, (2019), which include human, economic, institutional and environment aspect. The research observes that each driving group, when considered in local context as managing solid waste for a particular society may differ from the others. For example, waste managers in Africa need to tackle some issues including, lack of data, insignificant financial resources, vast different of amount and waste types between urban and rural area, lack of technical and human resources, low level of awareness and cultural aversion towards waste (Couth & Trois, 2017). This is far different from what is seen in the developed world economies, their approach to waste management is the issue of cities vis-à-vis cities and urban areas per urban. Therefore, the problems faced among cities differ with two distinct groups; urban and non-urban. While some of the cities are having specific national policy on solid waste management, some others experience problems such as increasing urban population, scarcity of land, services coverage area, inadequate resources and technology, and so on (Yayok, 2019).

Objectives:

The main objective of this study is to investigate the place of solid wastes and its management in maintaining clean and health urban federal capital -Abuja. To achieve this, the supporting objectives are to examine: -

i. The role of solid waste generation in achieving a clean and an environmental healthy City Capital, Abuja;
ii. The place of solid waste disposal for achieving cleanliness and environmentally healthy City Capital, Abuja;
iii. The place solid waste management in achieving a clean and an environmental healthy City Capital, Abuja;
iv. The place of integrated solid waste management for sustaining and achieving an environmentally clean and healthy City Capital, Abuja;
v. The role of solid waste collection and transportation in sustaining a clean and healthy City Capital, Abuja;
vi. The place of the Urban Capital Abuja in the maintenance of a clean and healthy City Capital, Abuja.

Research Questions:

The researcher will employ the following questions to establish the objectives. They are as follows: -

i. What is the role of solid waste generation in achieving a clean and an environmental healthy City Capital, Abuja?
ii. What is the place of solid waste disposal for achieving cleanliness and environmentally healthy City Capital, Abuja?
iii. What is the role solid waste management in achieving a clean and an environmental healthy City Capital, Abuja?
iv. What role does integrated solid waste management plays in sustaining and achieving an environmentally clean and healthy City Capital, Abuja?
v. What functions can solid waste collection and transportation input in to sustain a clean and healthy City Capital, Abuja?

vi. What role does the Urban Capital Abuja play in the maintenance of a clean and healthy City Capital, Abuja?

Research Hypothesis

$H0_1$ There is no significant role that solid waste generation in achieving clean and healthy City Capital, Abuja;

$H0_2$ The place of solid waste disposal has no significant impact in achieving cleanliness and healthy City Capital, Abuja;

$H0_3$ There is no significant place that solid waste management plays in achieving a clean and an healthy City Capital, Abuja;

$H0_4$ The place of integrated solid waste management is not significant in sustaining and achieving an environmentally clean and healthy City Capital, Abuja;

$H0_5$ The role of solid waste collection and transportation is not significant in sustaining a clean and healthy City Capital, Abuja t;

$H0_6$ The place of the Urban Capital Abuja is not significant in the maintenance of a clean and healthy City Capital, Abuja.

Operational Terms

Operational waste means all cargo-associated waste and maintenance waste; and for this purpose, "cargo associated waste" means all materials which have become wastes as a result of use on board a ship for cargo stowage and handling and include dunnage, shoring, pallets, lining and packing materials, plywood, paper, cardboard, wire and steel strapping;

Copy Operational waste.' means all cargo associated waste, maintenance waste, cargo residues, and ashes.

Operational waste and domestic waste are overlapping categories and it is often not clear to the crew how certain wastes should be classified. Operational waste will be managed as part of existing waste facilities at the site. A few incinerated oily rags and cardboard and one indicated plastics and paper are compacted.

Wasteful clinical care includes the unnecessary duplication of services. Operational waste occurs when care could be produced using fewer resources within the system while maintaining the benefits.

Operational waste water drainage systems at the compressor stations will be developed to manage the following types of waste water: • storm water (rain water and surface water run-off from buildings, roads, green and gravel areas) • potentially polluted surface water - originating from locations where any of the following are located: o generators or fuel storage tanks o oil coolers o condensate tank.

Processes produce waste. The operation of nuclear power plants for electricity generation produces different kinds of nuclear waste in different kinds of physical states, of which the lion's share is low- and intermediate-level waste

More Definitions of Operational waste means all cargo-associated wastes and maintenance waste including ash and clinkers, and cargo residues.

Save Email Related to animal waste means any waste consisting of animal matter that has not been processed into food for human consumption.

Medical Waste means isolation wastes, infectious agents, human blood and blood products, pathological wastes, sharps, body parts, contaminated bedding, surgical wastes, potentially contaminated laboratory wastes, and dialysis wastes.

Biomedical Waste means any Solid Waste or wastes which may present a threat of infection to humans. The term includes, but is not limited to, non-liquid human tissue and body parts; laboratory and veterinary waste which contains human-disease-causing agents; used disposable sharps, human blood, and human blood products and body fluids; and other materials which, in the opinion of the Department of Health and Rehabilitative Services, represent a significant risk of infection to persons outside the generating facility.

Nuclear waste means a quantity of source, byproduct or special nuclear material. **Pathological waste** means waste material consisting of only human or animal remains, anatomical parts, and/or tissue, the bags/containers used to collect and transport the waste material, and animal bedding (if applicable).

Hazardous Waste Management Facility means, a facility for the collection, storage, processing, treatment, recycling, recovery, or disposal of hazardous waste. Universal waste means any of the following hazardous wastes that are managed under the universal waste requirements.

E-waste means waste electrical and electronic equipment whole or in part or rejects from their manufacturing, refurbishment and repair process which are intended to be discarded as waste.

Construction waste means solid waste which is produced or generated during construction, remodeling, or repair of pavements, houses, commercial buildings, and other structures. Construction wastes include, but are not limited to lumber, wire, sheetrock, broken brick, shingles, glass, pipes, concrete, paving materials, and metal and plastics if the metal or plastics are a part of the materials of construction or empty containers for such materials. Paints, coatings, solvents, asbestos, any liquid, compressed gases or semi-liquids and garbage are not construction wastes.

Bulky Waste means business waste or domestic waste which by virtue of its mass, shape, size or quantity is inconvenient to remove in the routine door-to-door council service provided by the council or service provider;

Municipal waste means waste from households, as well as other waste which, because of its nature or composition, is similar to waste from household;

Universal waste transporter means a person engaged in the off-site transportation of universal waste by air, rail, highway, or water.

Liquid waste means any waste material that is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), as described in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods" (EPA Pub. No. SW-846).

Industrial waste water means the water or liquid carried waste from an industrial process. These wastes may result from any process or activity of industry, manufacture, trade or business, from the development of any natural resource, or from animal operations such as feedlots, poultry houses, or dairies. The term includes contaminated storm water and leachate from solid waste facilities.

Solid waste management facility means any solid waste disposal area, volume reduction plant, transfer station, or other facility, the purpose of which is the storage, collection, transportation, treatment, utilization, processing, recycling, or disposal, or any combination thereof, of solid waste. The term does not include a recovered materials processing facility or facilities which use or ship recovered materials, except that portion of the facilities which is managing solid waste.

Residual waste means low-level radioactive waste resulting from processing or decontamination activities that cannot be easily separated into distinct batches attributable to specific waste generators. This waste is attributable to the processor or decontamination facility, as applicable.
Industrial waste means any liquid, gaseous, radioactive, or solid waste substance resulting from any process of industry, manufacturing, trade, or business or from the development of any natural resource. inert waste means waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater.
Commercial waste means all solid waste generated by establishments engaged in business operations other than manufacturing or construction. This category includes, but is not limited to, solid waste resulting from the operation of stores, markets, office buildings, restaurants and shopping centers.
Yard waste means leaves, grass clippings, yard and garden debris and brush, including clean woody vegetative material no greater than 6 inches in diameter. This term does not include stumps, roots or shrubs with intact root balls.
Agricultural waste means biomass waste materials capable of decomposition that are produced from the Stormwater management system means a surface water management system that is designed and constructed or implemented to control discharges which are necessitated by rainfall events, incorporating methods to collect, convey, store, absorb, inhibit, treat, use, or reuse water to prevent or reduce flooding, over drainage, environmental degradation, and water pollution or otherwise affect the quantity and quality of discharges from the system.
Regulated Waste means liquid or semi-liquid blood or other potentially infectious materials; contaminated items that would release blood or other potentially infectious materials in a liquid or semi-liquid state if compressed; items that are caked with dried blood or other potentially infectious materials and are capable of releasing these materials during handling; contaminated sharps; and pathological and microbiological wastes containing blood or other potentially infectious materials.
Food Waste means waste food that is household waste or, as the case may be, commercial waste, and shall have the same meaning as that applying to Regulation 7 of the Waste Management (Food Waste) Regulations or, as the case may be, to Regulation 6 of the European Union (Household Food Waste and Bio-Waste) Regulations 2015 (SI 430 of 2015);
Industrial wastes mean the liquid wastes from industrial manufacturing processes, trade, or business as distinct from sanitary sewage
Infectious waste means solid waste that may contain pathogens with sufficient virulence and in sufficient quantity that exposure of a susceptible human or animal to the solid waste could cause the human or animal to contract an infectious disease.
Waste management (or **waste disposal**) includes the processes and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process and waste-related laws, technologies, economic mechanisms.
Solid waste may be defined as all discarded solid materials resulting from households, industrial, healthcare, constructional, agricultural, commercial, and institutional sources. Solid waste generated in a city is often referred to as municipal solid waste. In other literature and jurisdictions this category may exclude sewage, dissolved solids in water, and industrial waste. Thus, municipal waste in the context of developing countries may include waste that would not ordinarily be

considered municipal waste. *Solid or municipal solid waste management refers to the planning, financing and implementation of programs for solid waste collection, transportation, treatment and final disposal in an environmentally and socially acceptable manner. Failure to adhere to set standards at any of the various stages constitutes "poor solid waste management".*

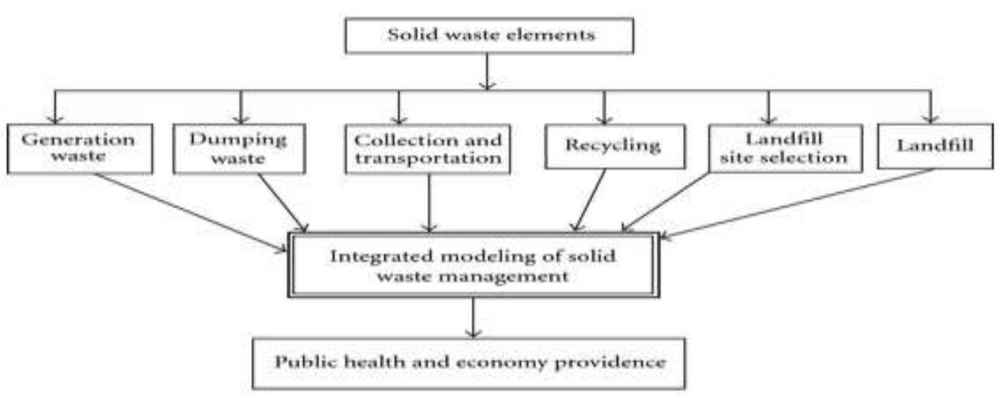
Literature Review

Solid waste management has become one of a major concern in environmental issues (Mazzanti & Zoboli, 2018). This is aggravated by the rapidly growing in population and amount of waste generated is increasing like never before (Kathiravale & Mohd Yunus, 2018). This is caused by the complex topography, weak administrative structures and the low local's income (Berkun et al., 2017). Integrated Sustainable Waste Management (ISWM) system was then introduced in 1995 to improve earlier system that neglect unique characteristics of a given society, economy and environment.

The conceptual framework

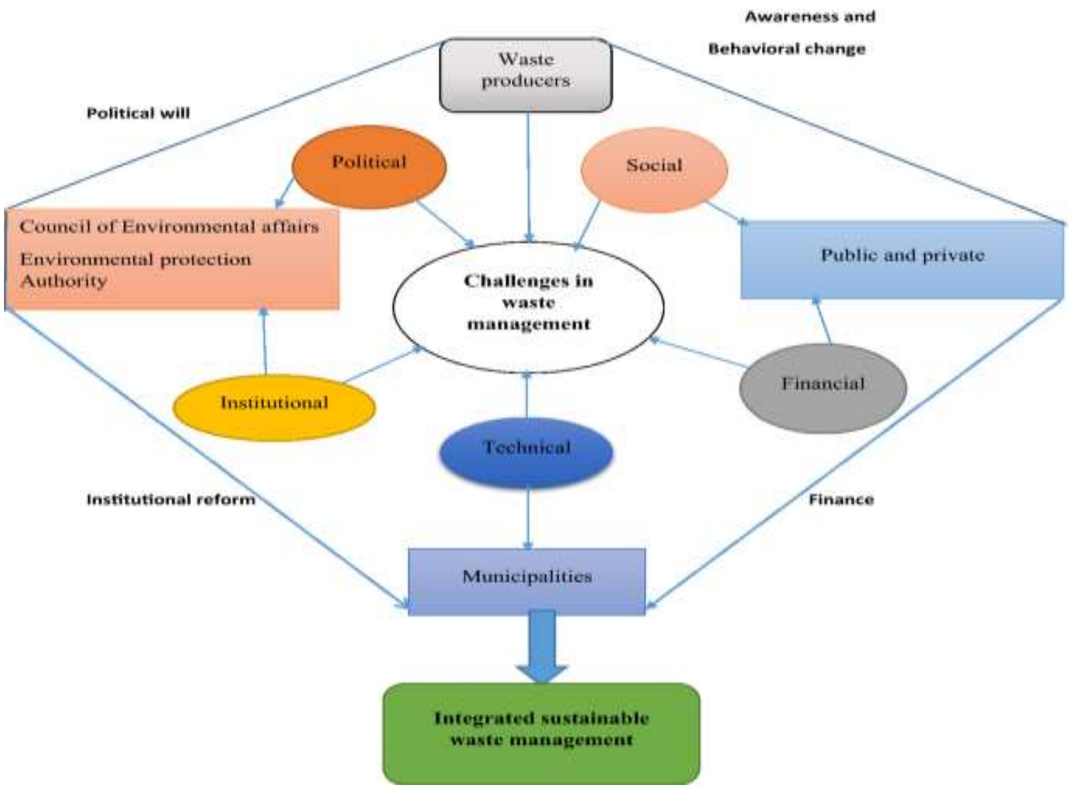
The interlinkage between poor solid waste management and adverse health outcomes may be overt and direct but may also be indirect and not obviously linkable to poor health outcomes of a population. This paper presents a framework to aid understanding the interlinkages between poor solid waste management and health, and gives the rationale for maintaining proper solid waste management as an investment in preventing ill-health and promoting wellbeing. The thesis discusses various concepts related to solid waste management, and how these independently and jointly impact on urban health making reference to developing country contexts. The concepts discussed are not entirely new but are applied to a context of a developing country urban setting where the challenge of solid waste management is growing without commensurate interventions to manage it. Finally, a discussion of the interlinkages and pathways between solid waste and the ill-health and how these can be exploited for implementation of cost-effective interventions is provided. The literature supporting the framework is summarized in two major categories: exposure to solid waste and the mechanism that bring about adverse health outcomes; and adverse health impacts. Under exposure, five categories of how individuals can be exposed are considered including: i) exposure to waste-by-waste generators; ii) exposure from handling waste among waste collectors; iii) pickers at dump sites; iv) living/working in neighborhoods of dumping sites and incinerators; and v) accumulation noxious substances such as heavy metals in the environment and subsequently in the food chain.

Conceptual Framework of Solid Waste Generation, Disposal, Management & Integrated Management



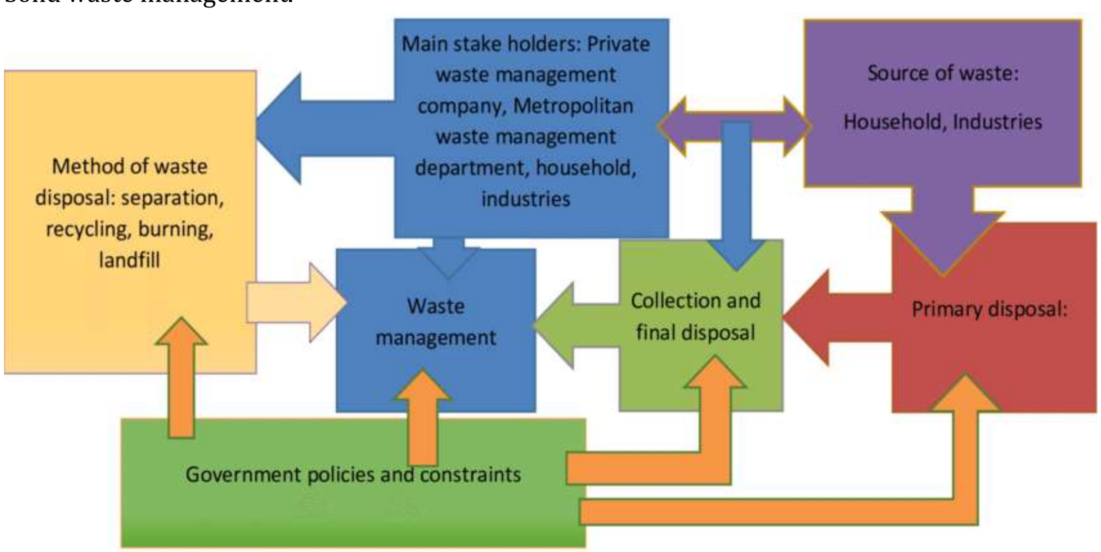
Source: Researcher's adapted framework from Ethernet. Fig. 1

Fig. 2. Conceptual Framework for Solid waste generation, disposal, management & Integrated Solid waste management.



Source: Researcher's adapted framework from Ethernet.

Fig 3 Conceptual Framework for Solid waste generation, disposal, management & Integrated Solid waste management.



Source: Researcher's adapted framework from internet.

From the above three, the researcher's conceptual frame work is as follows:

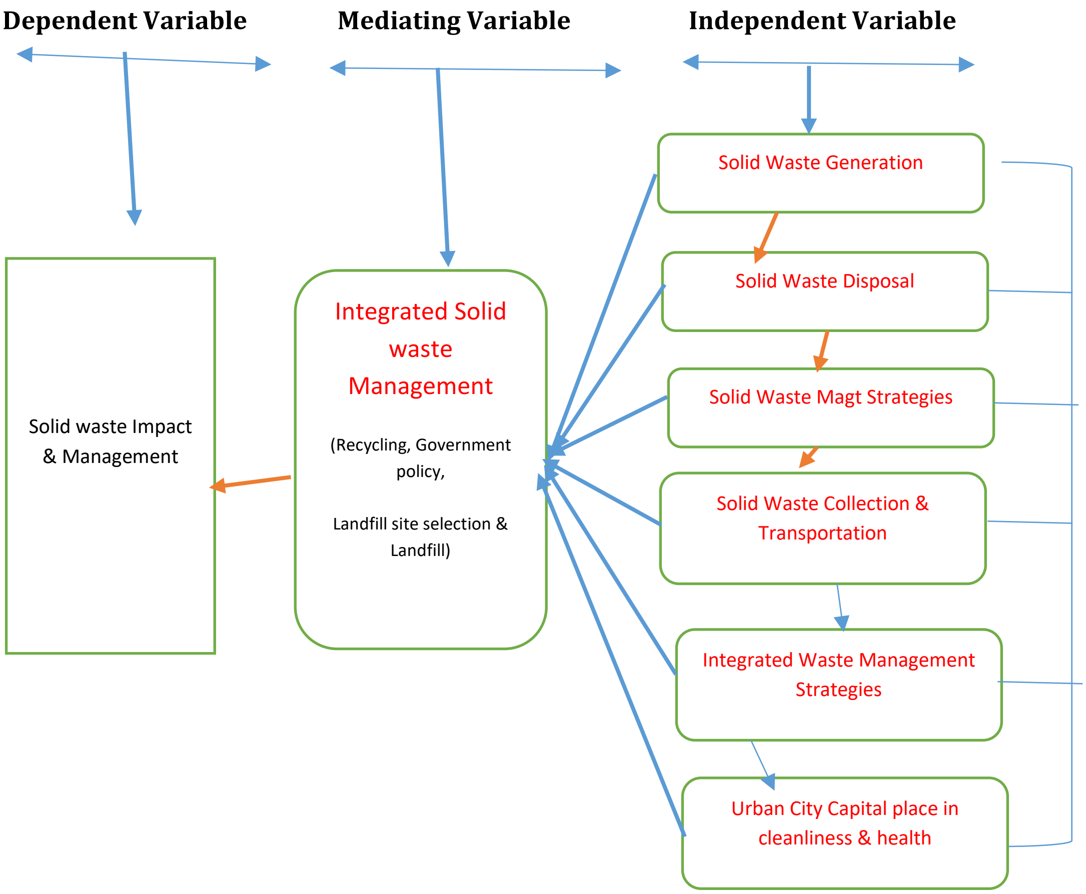


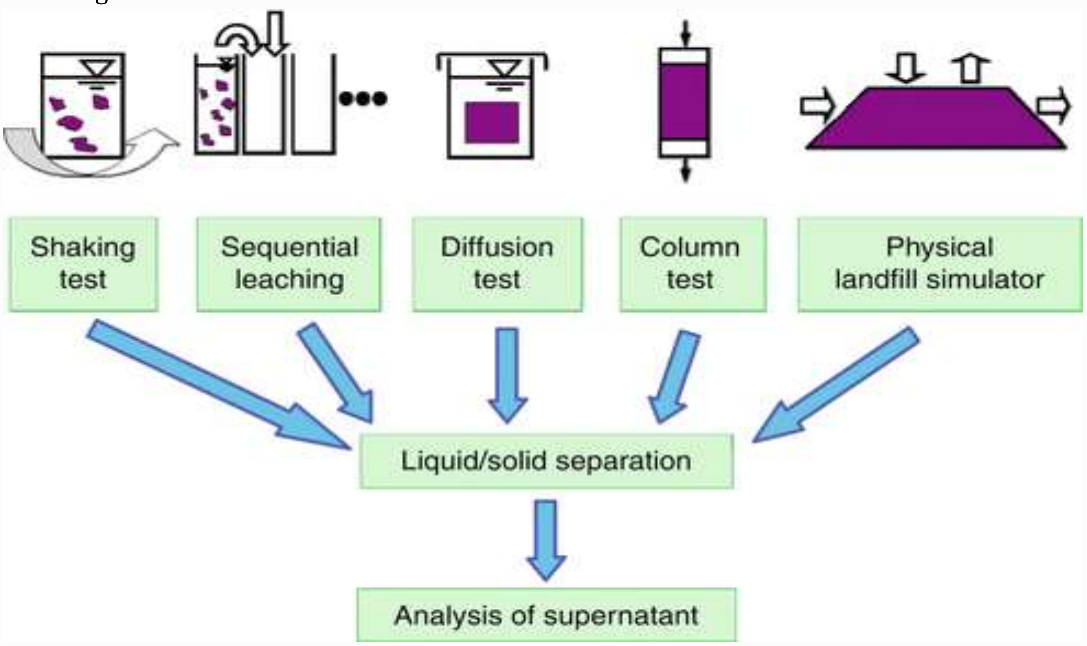
Fig. 4 Researcher's Conceptual frame work design

Discussion on the Dimensions of the Dependent & independent Variables from the conceptual framework

a. Solid Waste Generation

Waste generation is the most important aspect to look at in order to have effective solid waste management system. The generation of waste varies considerably between countries based on the culture, public awareness and management (Hazra, Goel, Wagner, Arnold & Magrinho et al., 2018). The generation of solid waste is the inevitable consequence of all processes where materials are used. Extraction of raw materials, manufacture of products, consumption, and waste management all generate wastes. The rate of material use today is so large, both with regard to the total amounts and seen as a *per capita* average, that the waste generated will impact on the environmental quality and human health worldwide if it is not managed properly. A few centuries, or even decades ago, the solid waste generated was a small fraction of what it is today, the drivers of the generation are primarily the increased availability of energy and secondly the population growth. Waste generation is also related to urbanization and global trade. Archeologists derive information of old times through the wastes that most old cities are built on. From the subsurface strata, it is possible to learn that waste generation has varied much over time, increased...

Fig 5 Waste Generation related to urbanization



b. Solid Waste Disposal

Garbage arising from human or animal activities, that is abandoned as unwanted and useless is referred as solid waste. Generally, it is generated from industrial, residential and commercial activities in a given area, and may be handled in a variety of ways. However, waste can be categorized based on materials such as paper, plastic, glass, metal and organic waste. Solid waste disposal must be managed systematically to ensure environmental best practices. Solid waste disposal and management is a critical aspect of environmental hygiene and it needs to be incorporated into environmental planning.

Information on waste generation is important to determine the most suitable waste disposal options. Improper waste disposal may cause pollution. The main purpose in implementing best practice for solid waste management is to prevent pollution. Pollution is a threat to human and other living organism (Morra et al., 2019; Liu & Morton, 2017). It may also damage the ecosystem and disrupt the natural cycle and climate on earth (Raga et al,2021). There are many disposal options available to suit the nature of waste and a country's preference and interest. It should be borne in mind that: -

A waste is anything humans do not want. Solid wastes are unwanted items that are not liquid or gas. Waste disposal involves removing a waste from the human sphere. This is often done by placing the waste in a landfill or burning it and placing the ashes in a landfill. Recycling involves processing a waste for use in manufacturing a new product. Reusing waste means using it again, either directly or after repair or improvement. Finally, source reduction involves not making waste in the first place.

Humans have disposed of waste since the creation of the species. Initially, this involved discarding an object at the point it became waste, in time and space. Where population centers developed, disposal became more involved. Waste had to be disposed of by combustion and/or deposition in an out-of-the-way place. In modern times, high population density, high waste generation, and toxic waste characteristics resulted in the need for sophisticated...

Despite the development of many waste disposal option, landfills remain the most prominent system applied worldwide (Shekdar, 2019; Hamer, 2020). Although a lot of improvement had been possible in the landfilling system and the regulation on the type of waste that can be treated at landfill is stringent, most of landfills operated remain primitive (Hamer, 2021).

According to **www.pulpandpaper.technology.com (2022**), Solid waste disposal management is usually referred to the process of collecting and treating solid wastes. It provides solutions for recycling items that do not belong to garbage or trash. Solid waste management can be described as how solid waste can be changed and used as a valuable resource.

Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn lead to pollution of the environment. Diseases can be spread by rodents and insects. The tasks of solid waste disposal management are complex technical challenges. They can also pose a wide variety of economic, administrative and social problems that must be changed and solved.

Methods of Solid Waste Disposal and Management: Here are the methods of solid waste disposal and management: - Solid Waste Open Burning; Sea dumping process; Solid wastes sanitary landfills; Incineration method; Composting process; Disposal by Ploughing into the fields; Disposal by hog feeding; Salvaging procedure; Fermentation/biological digestion.

Solid Waste Open Burning - Solid waste open burning is not the perfect method in the present scenario.

Sea Dumping Process This sea dumping process can be carried out only in coastal cities. This is very costly procedure and not environment friendly.

Solid wastes sanitary landfills -Solid wastes sanitary landfills process is simple, clean and effective. In this procedure, layers are compressed with some mechanical equipment and covered with earth, leveled, and compacted. A deep trench of 3 to 5 m is excavated and micro-organisms act on the organic matter and degrade them. In this procedure, refuse depth is generally limited to 2m. Facultative bacteria hydrolyze complex organic matter into simpler water-soluble organics.

Incineration method - Incineration method is suitable for combustible refuse. High operation costs and construction are involved in this procedure. This method would be suited in crowded cities where sites for land filling are not available. It can be used to reduce the volume of solid wastes for land filling.

Composting process - Composting process is similar to sanitary land-filling and it is popular in developing countries. Decomposable organic matter is separated and composted in this procedure. Yields are stable end products and good soil conditioners. They can be used as a base for fertilizers. Two methods have been used in this process: -Open Window Composting, Mechanical Composting

Disposal by Ploughing into the fields -Disposal by ploughing into the fields are not commonly used. These disposals are not environment friendly in general.

Disposal by hog feeding - Disposal by hog feeding is not general procedure in India. Garbage disposal into sewers including BOD and TSS increases by 20-30%. Refuse is ground well in grinders and then fed into sewers.

Salvaging procedure - Materials such as metal, paper, glass, rags, certain types of plastic and so on can be salvaged, recycled, and reused.

Fermentation/biological digestion - Biodegradable wastes are converted to compost and recycling can be done whenever possible. Hazardous wastes can be disposed using suitable methods.

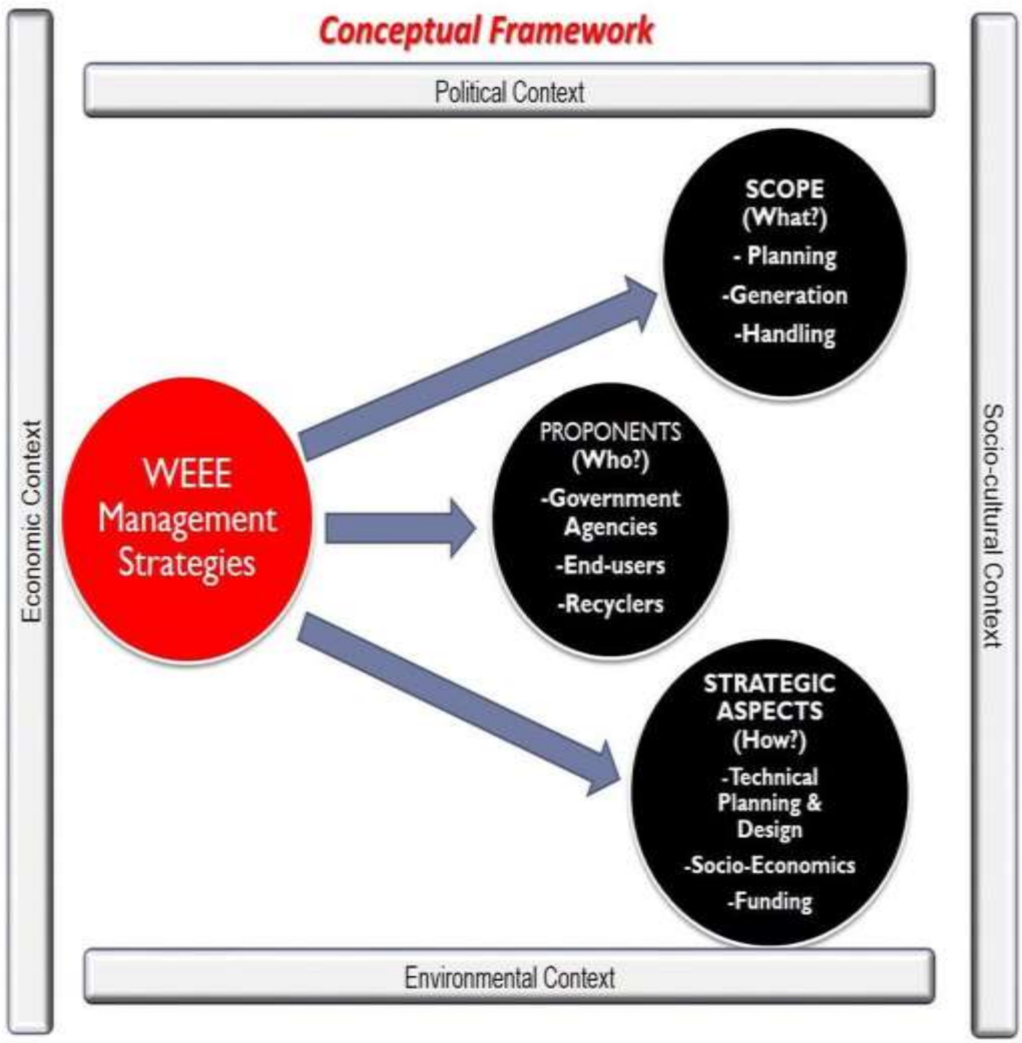
Solid Waste Management Strategies

Municipal solid waste is defined to include refuse from households, non-hazardous solid waste from industrial, commercial and institutional establishments (including hospitals), market waste, yard waste and street sweepings. Semisolid wastes such as sludge and nightsoil are considered to be the responsibility of liquid waste management systems. While hazardous industrial and medical wastes are, by definition, not components of municipal solid waste, they are normally quite difficult to separate from municipal solid waste, particularly when their sources are small and scattered. MSWM systems should therefore include special measures for preventing hazardous materials from entering the waste stream and to the extent that this cannot be ensured — alleviating the serious consequences that arise when they do. Finally, debris from construction and demolition constitute "difficult" categories of waste which also re-quire separate management procedures.

Management is a cyclical process of setting objectives, establishing long-term plans, programming, budgeting, implementation, operation and maintenance, monitoring and evaluation, cost control, revision of objectives and plans, and so forth. Management of urban infrastructure serv-ices is a basic responsibility of the municipal government. It is usually advantageous to execute service provision tasks in partnership with private enterprises (privatization) and/or with the users of services (participation), but the final responsibility remains that of the government.

Municipal solid waste management (MSWM) refers to the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste in urban areas.

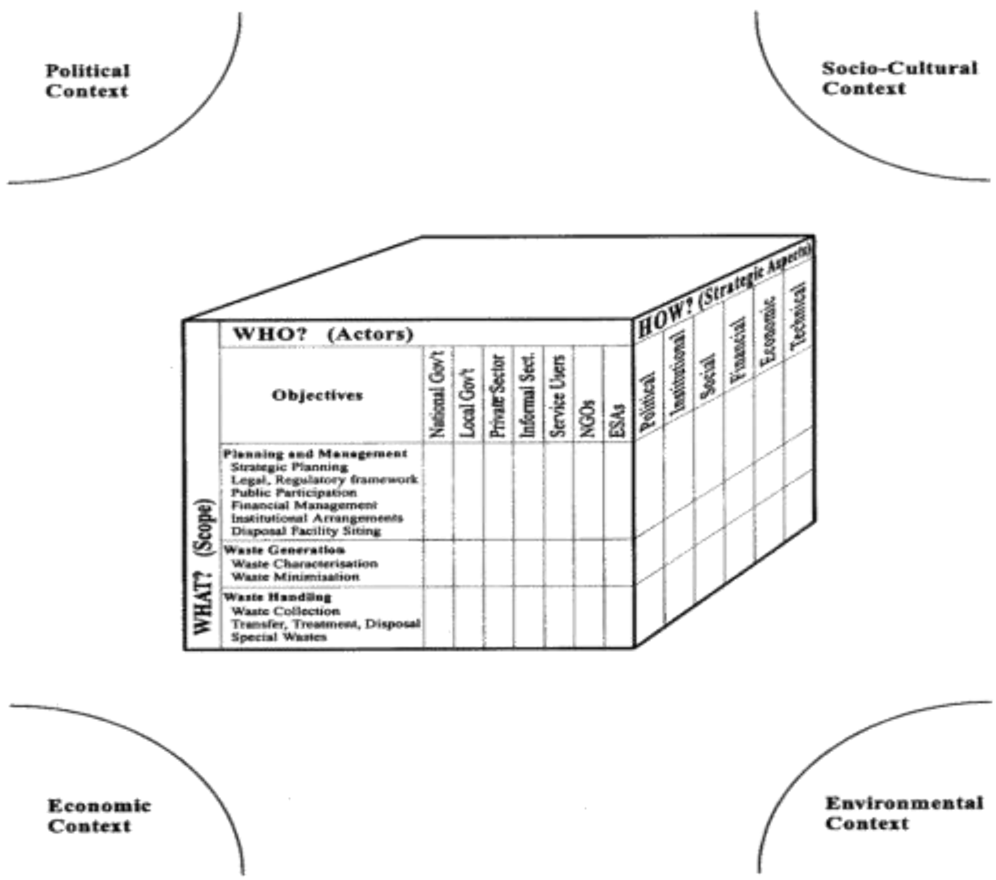
The concept municipal waste manage is as follows in fig.5



Source: Conceptual Framework for WEEE Management Strategies (adapted from "Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries" by Schübeler et. Al., 1996)

The explanation of this concept is further demystified in fig 6 below.

Figure 1: Structure of the Conceptual Framework



The conceptual framework — illustrated in Figure 5 & 6 is structured along three principal dimensions, corresponding to the questions: - ***What*** is the scope of waste management activities?; ***Who*** are the actors and development partners in the field?; ***How*** should strategic objectives and issues be addressed?;

a. What is the scope of waste management activities?

Within the overall framework of urban management, the **scope** of Municipal Solid Waste Management **MSWM** encompasses the following functions and concerns:

i. **Planning and Management -** Strategic planning; Legal and regulatory framework; Public participation; Financial management (cost recovery, budgeting, accounting, etc.); Institutional arrangements (including private sector participation); Disposal facility siting.

- **Waste Generation -** Waste characterization (source, rates, composition, etc.); Waste minimisation and source separation;

  Waste Handling - Waste collection; Waste transfer, treatment and disposal; Special wastes (medical, small industries, etc.)

b. Who are the actors and development partners in the field?

Actors and Partners - A wide range of individuals, groups and organisations are concerned with MSWM as service users, service providers, intermediaries and/or regulators. The interests, agendas and roles of these actors are briefly described below: -

Households, Communities and other Service Users - Residential households are mainly interested in receiving effective and dependable waste collection service at a reasonably low price. Disposal is not normally a priority demand of service users, so long as the quality of their own living environment is not affected by dump sites. Only as informed and aware citizens do people become concerned with the broader objective of environmentally sound waste disposal.

Other service users — including small and large scale industrial and commercial establishments and institutions — are similarly interested in reliable and affordable waste collection service. Commercial establishments are particularly concerned to avoid waste related pollution, which would inconvenience their customers. Industrial enterprises may have a strong interest in reducing waste generation and can play an active role in managing waste collection, treatment and disposal in collaboration with government authorities and/or specialised private enterprises.

Non-Governmental Organisations

Non-governmental organisations (NGOs) operate between the private and governmental realms. Originating outside of the communities in which they work, NGOs are motivated primarily by humanitarian and/or developmental concerns rather than an interest in service improvement for their own members. The self-creation of meaningful employment for members may also be a motivation for NGO formation.

NGOs may help increase the capacity of people or community groups to play an active role in local solid waste management by contributing to:- people's awareness of waste management problems; organisational capacity and the formation of community-based organisations (CBO); channels of communication between CBO and government authorities; CBO's voice in municipal planning and implementation processes; technical know-how of locally active CBO, and access to credit facilities;

NGOs may also provide important support to informal sector waste workers and enterprises, assisting them to organise themselves, to improve their working conditions and facilities, increase their earnings and ex-tend their access to essential social services such as health care and schooling for children.

Local Government

Local government authorities are generally responsible for the provision of solid waste collection and disposal services. They become the legal owner of waste once it is collected or put out for collection. Responsibility for waste management is usually specified in bylaws and regulations and may be derived, more generally, from policy goals regarding environmental health and protection. Besides their legal obligations, local governments are normally motivated by political interests. User satisfaction with provided services, approval of higher government authorities and financial viability of the operation are important criteria of successful solid waste management from the local government perspective.

The authority to enforce bylaws and regulations, and to mobilise the resources required for solid waste management is, in principle, conferred upon local governments by higher government authorities. Problems of-ten arise when local government's authority to raise revenues is not com-mensurate with their responsibility for service provision. Besides solid waste management, municipal governments are also responsible for the provision of the entire range of infrastructure and social services. Needs and demands for MSWM must therefore be weighed and addressed in the context of the needs and relative priorities in all sectors and serv-ices. To fulfil their solid waste management responsibilities, municipal governments normally establish special purpose technical agencies, and are also authorised to contract private enterprises to provide waste management services. In this case, local authorities remain responsible for regulating and controlling the activities and performance of these enterprises. Effective solid waste management depends upon the cooperation of the population, and local governments should take measures to enhance public awareness of the importance of MSWM, generate a constituency for environmental protection and promote active participation of users and community groups in local waste management.

National Government

National governments are responsible for establishing the institutional and legal framework for MSWM and ensuring that local governments have the necessary authority, powers and capacities for effective solid waste management. In many countries, responsibility is delegated with-out adequate support to capacity building at the local government level.

Private Sector Enterprises

The formal private sector includes a wide range of enterprise types, vary-ing from informal micro-enterprises to large business establishments. As potential service suppliers, private enterprises are primarily interested in earning a return on their investment by selling waste collection, transfer, treatment, recycling and/or disposal services. Operating in various forms of partnership with the public sector, they may provide capital, management and organisational capacity, labour and/or technical skills.

Informal Private Sector

The informal private sector comprises unregistered, unregulated activities carried out by individuals, families, groups or small enterprises. The basic motivation is self-organised revenue generation; informal waste workers are often driven to work as waste collectors or scavengers by poverty and the absence of more attractive employment possibilities. In some cases, informal waste workers belong to religious, caste or ethnic minorities and social discrimination is a factor which obliges them to work under completely unhygienic conditions as waste collectors or "sweepers". Their association with an activity which the public perceives to be filth-related tends, at the same time, to perpetuate discrimination against them.

External Support Agencies

Numerous bilateral and multilateral external support agencies (ESAs) are engaged in supporting MSWM in low-income countries. While some ESAs have acquired considerable expertise in the area of waste management, MSWM is often a component within a broader development pro-gramme aimed at improving urban management capacities and/or urban environmental protection.

How should strategic objectives and issues be addressed – Context?

Political Context

MSWM is influenced in numerous ways by the political context. The existing relationship between local and central governments (the effective degree of decentralisation, for example), the form and extent of citizens' participation in the public processes of policy making and the role of party politics in local government administration all affect the character of management, governance and the type of MSWM system which is possible and appropriate.

Socio-Cultural Context

The functioning of MSWM systems is influenced by the waste handling patterns and underlying attitudes of the urban population, and these fac-tors are, themselves, conditioned by the people's social and cultural con-text. Programmes to disseminate knowledge and skills, or to improve behaviour patterns and attitudes regarding waste management, must be based on sound understanding of the social and cultural characteristics.

Fast growing low-income residential communities may comprise a considerable diversity of social and ethnic groups, and this social diversity strongly influences the capacity of communities to organise local waste management. At the same time, urban communities often preserve rural traditions of mutual self-help and cooperation, which significantly enhance the potential for community-based waste management.

Economic Context

The character of waste management tasks and the technical and organisational nature of appropriate solutions depend a great deal on the eco-nomic context of the country and/or city in question and, in fact, on the economic situation in the particular area of a city. The level of economic development is an important determinant of the volume and composition of wastes generated by residential and other users, for example. At the same time, the effective demand for waste management services — the willingness and ability to pay for a particular level of service — is also influenced by the economic context of a particular city or area.

Environmental Context

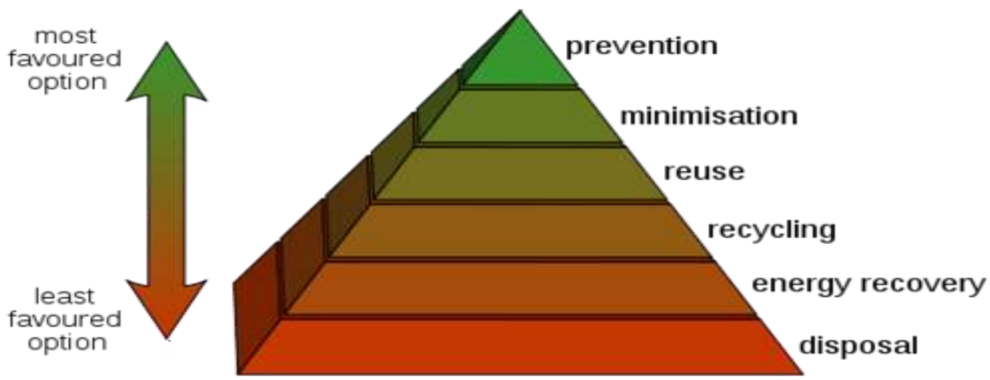
Firstly, at the level of the built environment, the size and structure of a settlement has an important influence on the character and urgency of waste management needs. In quite low-density semi-urban settlements, for example, some form of local or even on-site solution to the management of organic solid wastes may be more appropriate than centralized collection and disposal. In urban areas, the physical characteristics of a settlement — including such factors as density, width and condition of roads, topography, etc. — need to be considered when selecting and/or designing waste collection procedures and equipment such as containers and vehicles.

Secondly, at the level of natural systems, the interaction between waste handling procedures and public health conditions is influenced by climatic conditions and characteristics of local natural and ecological systems. The degree to which uncontrolled waste dump sites become breeding ground for insects, rodents and other disease vectors – and a gathering place for dogs, wild animals and poisonous reptiles – depends largely on prevailing climatic and natural conditions. In practical terms, climate determines the frequency with which waste collection points must be serviced in order to limit negative environmental consequences.

Finally, environment health conditions may also be indirectly affected through the pollution of ground and surface water by leachates from disposal sites. Air pollution is often caused by open burning at dumps, and foul odours and wind-blown litter are common. Methane, an important greenhouse gas, is a by-product of the anaerobic decomposition of organic wastes in landfill sites. In addition, waste dumps may also be a source of airborne bacterial spores and aerosols. The suitability of a disposal site depends upon many factors, including specific characteristics of the subsoil, ground water conditions, topography, prevailing winds and the adjacent patterns of settlement and land-use.

d. Other Solid Waste Management Strategies

The long-recognized hierarchy of management of wastes, in order of preference consists of prevention, minimization, recycling and reuse, biological treatment, incineration, and landfill disposal (see Figure 2.7).



[Figure 6] Hierarchy of Waste Management Figure shows the hierarchy of management of wastes in order or preference, starting with prevention as the most favorable to disposal as the least favorable option. **(Drstuey via Wikimedia Commons, 2022)**

Waste Prevention

The ideal waste management alternative is to prevent waste generation in the first place. Hence, waste prevention is a basic goal of all the waste management strategies. Numerous technologies can be employed throughout the manufacturing, use, or post-use portions of product life cycles to eliminate waste and, in turn, reduce or prevent pollution. Some representative strategies include environmentally conscious manufacturing methods that incorporate less hazardous or harmful materials, the use of modern leakage detection systems for material storage, innovative chemical neutralization techniques to reduce reactivity, or water saving technologies that reduce the need for fresh water inputs.

Waste Minimization

In many cases, wastes cannot be outright eliminated from a variety of processes. However, numerous strategies can be implemented to reduce or minimize waste generation. Waste minimization, or source reduction, refers to the collective strategies of design and fabrication of products or services that minimize the amount of generated waste and/or reduce the toxicity of the resultant waste. Often these efforts come about from identified trends or specific products that may be causing problems in the waste stream and the subsequent steps taken to halt these problems. In industry, waste can be reduced by reusing materials, using less hazardous substitute materials, or by modifying components of design and processing. Many benefits can be realized by waste minimization or source reduction, including reduced use of natural resources and the reduction of toxicity of wastes.

Waste minimization strategies are extremely common in manufacturing applications; the savings of material use preserves resources but also saves significant manufacturing related costs. Advancements in streamlined packaging reduces material use, increased distribution efficiency reduces fuel consumption and resulting air emissions. Further, engineered building materials can often be designed with specific favorable properties that, when accounted for in overall structural design, can greatly reduce the overall mass and weight of material needed for a given structure. This reduces the need for excess material and reduces the waste associated with component fabrication.

The dry-cleaning industry provides an excellent example of product substitution to reduce toxic waste generation. For decades, dry cleaners used tetrachloroethylene, or “perc” as a dry-cleaning solvent. Although effective, tetrachloroethylene is a relatively toxic compound. Additionally, it is easily introduced into the environment, where it is highly recalcitrant due to its physical properties. Further, when its degradation occurs, the intermediate daughter products generated are more toxic to human health and the environment.

Because of its toxicity and impact on the environment, the dry-cleaning industry has adopted new practices and increasingly utilizes less toxic replacement products, including petroleum-based compounds. Further, new emerging technologies are incorporating carbon dioxide and other relatively harmless compounds. While these substitute products have in many cases been mandated by government regulation, they have also been adopted in response to consumer demands and other market-based forces.

Recycling and Reuse

Recycling refers to recovery of useful materials such as glass, paper, plastics, wood, and metals from the waste stream so they may be incorporated into the fabrication of new products. With greater incorporation of recycled materials, the required use of raw materials for identical applications is reduced. Recycling reduces the need of natural resource exploitation for raw materials, but it also allows waste materials to be recovered and utilized as valuable resource materials. Recycling of wastes directly conserves natural resources, reduces energy consumption and emissions generated by extraction of virgin materials and their subsequent manufacture into finished products, reduces overall energy consumption and greenhouse gas emissions that contribute to the global climate change, and reduces the incineration or landfilling of the materials that have been recycled. Moreover, recycling creates several economic benefits, including the potential to create job markets and drive growth.

Common recycled materials include paper, plastics, glass, aluminum, steel, and wood. Additionally, many construction materials can be reused, including concrete, asphalt materials, masonry, and reinforcing steel. “Green” plant-based wastes are often recovered and immediately reused for mulch or fertilizer applications. Many industries also recover various by-products and/or refine and “re-generate” solvents for reuse. Examples include copper and nickel recovery from metal finishing processes; the recovery of oils, fats, and plasticizers by solvent extraction from filter media such as activated carbon and clays; and acid recovery by spray roasting, ion exchange, or crystallization. Further, a range of used food-based oils are being recovered and

utilized in "biodiesel" applications. Numerous examples of successful recycling and reuse efforts are encountered every day. In some cases, the recycled materials are used as input materials and are heavily processed into end products. Common examples include the use of scrap paper for new paper manufacturing, or the processing of old aluminum cans into new aluminum products. In other cases, reclaimed materials undergo little or no processing prior to their re-use.
Some common examples include the use of tree waste as wood chips, or the use of brick and other fixtures into new structural construction. In any case, the success of recycling depends on effective collection and processing of recyclables, markets for reuse (e.g. manufacturing and/or applications that utilize recycled materials), and public acceptance and promotion of recycled products and applications utilizing recycled materials.

Biological Treatment

Landfill disposal of wastes containing significant organic fractions is increasingly discouraged in many countries, including the United States. Such disposal practices are even prohibited in several European countries. Since landfilling does not provide an attractive management option, other techniques have been identified. One option is to treat waste so that biodegradable materials are degraded and the remaining inorganic waste fraction (known as residuals) can be subsequently disposed or used for a beneficial purpose.
Biodegradation of wastes can be accomplished by using aerobic composting, anaerobic digestion, or mechanical biological treatment (MBT) methods. If the organic fraction can be separated from inorganic material, aerobic composting or anaerobic digestion can be used to degrade the waste and convert it into usable compost. For example, organic wastes such as food waste, yard waste, and animal manure that consist of naturally degrading bacteria can be converted under controlled conditions into compost, which can then be utilized as natural fertilizer. Aerobic composting is accomplished by placing selected proportions of organic waste into piles, rows or vessels, either in open conditions or within closed buildings fitted with gas collection and treatment systems. During the process, bulking agents such as wood chips are added to the waste material to enhance the aerobic degradation of organic materials. Finally, the material is allowed to stabilize and mature during a curing process where pathogens are concurrently destroyed. The end-products of the composting process include carbon dioxide, water, and the usable compost material.

Incineration

Waste degradation not only produces useful solid end-products (such as compost), degradation by-products can also be used as a beneficial energy source. As discussed above, anaerobic digestion of waste can generate biogas, which can be captured and incorporated into electricity generation. Alternatively, waste can be directly incinerated to produce energy. Incineration consists of waste combustion at very high temperatures to produce electrical energy. The byproduct of incineration is ash, which requires proper characterization prior to disposal, or in some cases, beneficial re-use. It is widely used in developed countries due to landfill space limitations. It is estimated that about 130 million tons of waste are annually combusted in more than 600 plants in 35 countries. Further, incineration is often used to effectively mitigate hazardous wastes such as chlorinated hydrocarbons, oils, solvents, medical wastes, and pesticides.

Pros of Incinerators	Cons of Incinerators
The incinerated waste is turned into energy.	The fly ash (airborne particles) has high levels of toxic chemicals, including dioxin, cadmium and lead.
The volume of waste is reduced.	The initial construction costs are high.

Despite the advantages, incineration is often viewed negatively because of high initial construction costs, and emissions of ash, which is toxic (see Table 2.4). Currently, many 'next generation" systems are being researched and developed, and the USEPA is developing new regulations to carefully monitor incinerator air emissions under the Clean Air Act.

Landfill Disposal

Despite advances in reuse and recycling, landfill disposal remains the primary waste disposal method in the United States. As previously mentioned, the rate of MSW generation continues to increase, but overall landfill capacity is decreasing. New regulations concerning proper waste disposal and the use of innovative liner systems to minimize the potential of groundwater contamination from leachate infiltration and migration have resulted in a substantial increase in the costs of landfill disposal. Also, public opposition to landfills continues to grow, partially inspired by memories of historic uncontrolled dumping practices the resulting undesirable side effects of uncontrolled vectors, contaminated groundwater, unmitigated odors, and subsequent diminished property values.

Figure 7: Modern Landfill

Landfills can be designed and permitted to accept hazardous wastes in accordance with RCRA Subtitle C regulations, or they may be designed and permitted to accept municipal solid waste in accordance with RCRA Subtitle D regulations. Regardless of their waste designation, landfills are engineered structures consisting of bottom and side liner systems, leachate collection and removal systems, final cover systems, gas collection and removal systems, and groundwater monitoring systems. An extensive permitting process is required for siting, designing and operating landfills. Post-closure monitoring of landfills is also typically required for at least 30 years. Because of their design, wastes within landfills are degraded anaerobically. During degradation, biogas is produced and collected. The collection systems prevent uncontrolled subsurface gas migration and reduce the potential for an explosive condition. The captured gas is often used in cogeneration facilities for heating or electricity generation. Further, upon closure, many landfills undergo "land recycling" and redeveloped as golf courses, recreational parks, and other beneficial uses.

e. Integrated Solid Waste Management

Integrated solid waste management refers to the strategic approach to sustainable management of solid wastes covering all sources and all aspects, covering generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency. The integrated waste management strategy relies on handling waste in a four- pronged approach: waste minimisation, recycling (including composting), Energy Recovery, and finally as a last resort, landfill. The vast majority of households in Hampshire have access to kerb-side collection of recyclable materials. These include newspapers and magazines, cardboard, junk mail, food and drinks cans, and plastic bottles. These are taken to a Materials Recovery Facility (MRF) to be separated, sorted and sent for reprocessing.

The Importance of ISWM as a Waste Management Approach

With rapid population expansion and constant economic development, waste generation both in residential as well as commercial/industrial areas continues to grow rapidly, putting pressure on society's ability to process and dispose of this material. Also, inappropriately managed solid waste streams can pose a significant risk to health and environmental concerns. Improper waste handling in conjunction with uncontrolled waste dumping can cause a broad range of problems, including polluting water, attracting rodents and insects, as well as increasing floods due to blockage in drains.

Functional Elements of Integrated Solid Waste Management

The four components or functional elements of ISWM include source reduction, recycling and composting, waste transportation and landfilling. These waste management activities can be undertaken either in interactively or hierarchically. Following is brief discussion of each of these functional elements of ISWM:

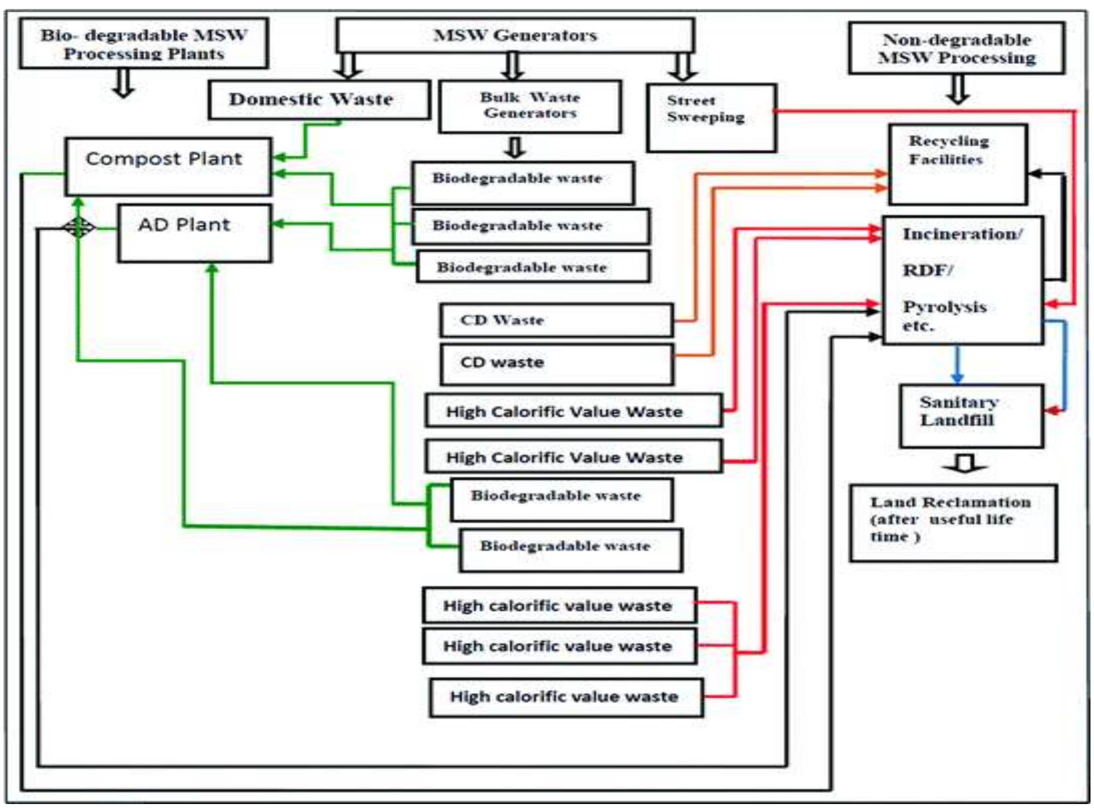
Source Reduction, also known as waste prevention, aims at reducing unnecessary waste generation. Source reduction strategies may include a variety of approaches, such as: products that are designed for recycling, durable, sustainable goods and, where possible, in concentrated form; reusable products, including reusable packaging, as reuse and increasingly becomes an important component of the circular economy; refurbishing of goods to prolong product life, another important element of the circular economy model; redesign of goods and utilize less or no packaging; reduction of food spoilage and waste through better attention to food processing and storage; avoidance of goods that don't last long and can't be reused or recycled, such as Halloween decorations; Waste source reduction helps us to lessen waste handling, transportation, and disposal costs and eventually reduces methane generation.

Recycling and Composting are crucial phases in the entire ISWM process. Recycling includes the accumulation, sorting and recovering of recyclable and reusable materials, as well as the reprocessing of recyclables to produce new products. Composting, a component of organics recycling, involves the accumulation of organic waste and converting it into soil additives. Both recycling and composting wastes have a number of economic benefits such as they create job opportunities in addition to diverting material from the waste stream to generate cost-effective sources of material for further use. Both recycling and composting also significantly contribute to the reduction of greenhouse gas emissions.

Waste Transportation is another waste management activity that must be integrated systematically with other waste management activities to ensure smooth and efficient waste management. Typically, this includes the collection of waste from curbside and businesses, as well as from transfer stations where waste may be concentrated and reloaded onto other vehicles for delivery to the landfill.

Waste Disposal, in particular through the use of landfills and combustion, are the activities undertaken to manage waste materials that are not recycled. The most common way of managing these wastes is through landfills, which must be properly designed, well-constructed and systematically managed.

An ideal conceptual framework for Solid Waste Management as in fig. 9



Municipal solid waste management is more of an administrative and institutional mechanism failure problem rather than a technological one. Until now, MSW management has been considered to be almost the sole responsibility of urban governments, without the participation of citizens and other stakeholders. The Centre and the Supreme Court, however, have urged that this issue be addressed with multiple stakeholder participation. Cities in India spend approximately 20% of the city budget on solid waste services.

Hazardous Wastes: -Hazardous wastes are those that can cause harm to human and the environment. **Characteristics of Hazardous Wastes**: **-**Wastes are classified as hazardous if they exhibit any of four primary characterises based on physical or chemical properties of toxicity, reactivity ignitability and corrosively **- Toxic wastes: -**Toxic wastes are those that are poisonous in small or trace amounts. Some may have acute or immediate effect on human or animals. Carcinogenic or mutagenic causing biological changes in the children of exposed people and animals. Examples: pesticides, heavy metals; **Reactive wastes: -**Reactive wastes are those that have a tendency to react vigorously with air or water are unstable to shock or heat, generate toxic gases or explode during routine management. Examples: Gun powder, nitro glycerin; **Ignitable waste: -** Are those that burn at relatively low temperatures (< 60 °C) and are capable of spontaneous combustion during storage transport or disposal. Examples: Gasoline, paint thinners and alcohol; **Corrosive wastes: -** Are those that destroy materials and living tissues by chemical reactions? Examples: acids and base; **Infectious wastes: -** Included human tissue from surgery, used bandages and hypoderm needles hospital wastes.

Sources of Hazardous Wastes: - Chemical manufacturing companies, petroleum refineries, paper mills, smelters and other industries. Plastic industries thousands of chemicals are used in industries every year. When used incorrectly or inappropriately they can become health hazards. PCBs (Polychlorinated biphenyls) are resistant to fire and do not conduct electricity very well, which makes them excellent materials for several industrial purposes. Rainwater can wash PCBs out of disposal areas in dumps and landfills thus contaminating the water.

Effects of Hazardous Wastes: - As most of the hazardous wastes are disposed off or in land, the most serious environmental effect is contaminated ground water. Once ground water is polluted with hazardous wastes, it is very often not possible to reverse the damage. Pesticides form residues in the soil that are washed into streams which then carry them forward. The residues may persist in PCBs (poly chlorinated biphenyls) are concentrated in the kidneys and liver and cause damage; they cause reproductive failure in birds and mammals. The soil or in the bottom of lakes and rivers. Exposure can occur through ingestion, inhalation and skin contact, resulting acute or chronic poisoning. Lead, mercury and arsenic are hazardous substances which can often refer to as heavy metals. Most of the lead absorbed by people is stored in the bones.

Control of Hazardous Wastes: **-** Common methods for disposing of hazardous wastes are land disposal and incineration Industries need to be encouraged to generate less hazardous waste in the manufacturing process. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing recycling and treating the wastes. Integrated pest management practices (IPM) reduce the usage of pesticides. Substitute the use of PCBs and vinyl chloride with chemicals that are less toxic. Polyvinyl chloride use can be lowered by reducing the use of plastics.

Industrial Wastes: - These contain more of toxic and require special treatment. **Source of Industrial Wastes**: **-** Food processing industries, metallurgical chemical and pharmaceutical unit's breweries, sugar mills, paper and pulp industries, fertilizer and pesticide industries are major ones which discharge toxic wastes. During processing, scrap materials, tailings, acids etc.

Effects of Industrial Wastes: -Most common observation is that the health of the people living in the neighborhood of dumping sites is severely affected. The exposure may cause disorders of nervous system, genetic defects, skin diseases and even caner. The liquid effluents discharged by the industries contain inorganic and organic pollutants and they enter into water bodies causing destruction of fish, formation of sediments, and pollution of ground water and release of foul odours.

Control of Industrial Wastes: - Waste minimization technologies have to be developed. Source reduction recycling and reuse of materials need to be practiced on a large scale. Hazardous waste should not mix up with general waste. Source reduction involves altering the design, manufacture or use of products and materials to reduce the amount and toxicity of materials that get thrown away. Local communities and voluntary organizations should educate the industrialists as well as the public about dangers of pollution and the need to keep the environment clean. Land filling, incineration and composting technologies to be followed. Biogas is obtained from solid waste treatment of industrial and mining waste is done for the recovery of useful products.

Agricultural Wastes - Sources - The waste generated by agriculture includes waste from crops and live-stock. In developing countries, this waste does not pose a serious problem as most of it is used e.g., dung is used for manure, straw is used as fodder. Some agro-based industries produce waste e.g., rice milling, production of tea, tobacco etc. Agricultural wastes are rice husk, degasses, ground nut shell, maize cobs, straw of cereals etc.

Effects of Agricultural Wastes: **-** If more C: N ratio wastes like paddy husk or straw may cause immobilization of nutrients if applied on the fields. It occupies to large land areas if not properly disposed.

Management of Agricultural Wastes:

Conversion of Waste to energy through: -(i) Gasification: - It is the process in which chemical decomposition of biomass takes place in the presence of controlled amounts of oxygen, producing a gas. This gas is cleaned and used in an internal combustion engine to produce electric power. Without clean up also, the gas can be used in boilers to produce electric power. This technology is highly suited to generate electric power from agricultural wastes like rice husks, groundnut shells etc. **(ii) Pyrolysis: -**It is similar to gasification except that the chemical decomposition of biomass wastes takes place in the absence or reduced presence of O_2 at high temp. Mixtures of gases result from decomposition including H_2, NH_4 Co, CO_2 depending on the organic nature of waste matter. This gas used for power generation.

Biogas production: - Animal wastes, food processing wastes and other organic matter are decomposed anaerobically to produce a gas called biogas. It contains methane and CO_2. The methane can provide gas for domestic use. The byproduct of this technology is slurry, settled out the bottom of the digester. This can be used as manure. Agricultural waste like corn cobs, paddy husk, bagasse of sugarcane, waste of wheat, rice and other cereals, cotton stalks, coconut wastes, jute waste etc. can be used in making of paper and hard board.

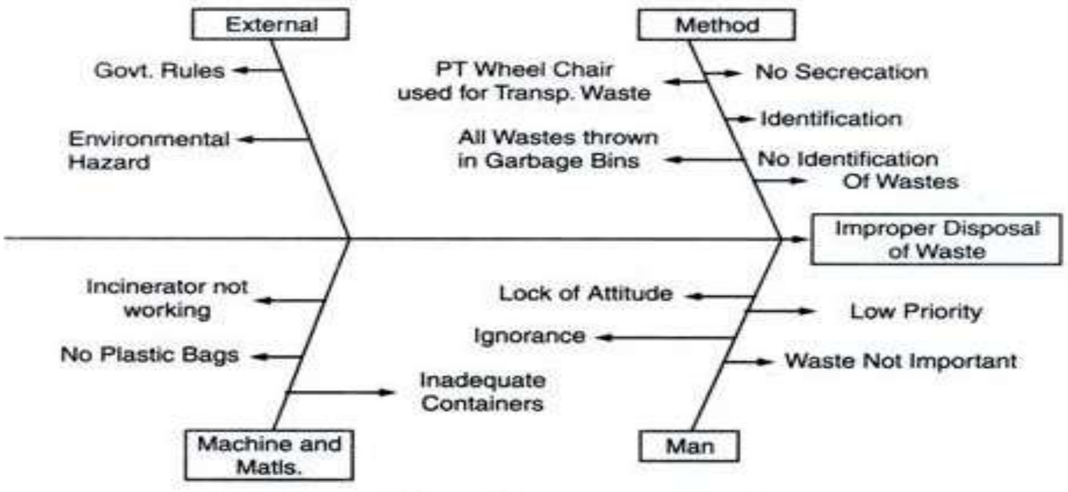
Bio-Medical Wastes: - Bio-medical waste means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological.

Segregation, Packaging, Transportation and Storage of Bio-medical waste: - 1. Bio-medical waste shall not be mixed with other wastes; 2. Bio-medical waste shall be segregated into containers/bags at the point of generation prior to its storage, transportation, treatment and disposal. The containers shall be properly labelled; 3. Notwithstanding anything contained in the Motor Vehicles Act, 1988, or rules there under, untreated biomedical waste shall be transported only in such vehicle as may be authorised for the purpose by the competent authority as specified by the government; 4. No untreated bio-medical waste shall be kept stored beyond a period of 48 hours. Provided that if for any reason it becomes necessary to store the waste beyond such period, the authorised person must take permission of the prescribed authority and take measures to ensure that the waste does not adversely affect human health and the environment.

Categories of Bio-medical Wastes: Table.3 Categories of Bio-medical Wastes

Option	Treatment and Disposal	Waste Category
Cat. No. 1	Incineration/deep burial	Human Anatomical Waste (human tissues, organs, body parts)
Cat. No. 2	Incineration/deep burial	Animal Waste Animal tissues, organs. Body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals/ colleges, discharge from hospitals, animal houses)
Cat. No. 3	Local autoclaving/micro waving/ incineration	Microbiology and Biotechnology waste (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biological, toxins, dishes and devices used for transfer of cultures)
Cat. No. 4	Disinfections (chemical treatment /autoclaving/ micro waving and mutilation shredding	Waste Sharps (needles, syringes, scalpels blades, glass etc. that may cause puncture and cuts. This includes both used and unused sharps)
Cat. No. 5	Incineration / destruction and drugs disposal in secured landfills	Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)
Cat. No. 6	Incineration, autoclaving/micro waving	Solid Waste (Items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, line beddings, other material contaminated with blood)
Cat. No. 7	Disinfections by chemical treatment autoclaving/ micro waving and mutilation shredding.	Solid Waste (waste generated from disposable items other than the waste sharps such as tubing, catheters, intravenous sets etc.)
Cat. No. 8	Disinfections by chemical treatment and discharge into drain	Liquid Waste (waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities)
Cat. No. 9	Disposal in municipal landfill	Incineration Ash (ash from incineration of any bio-medical waste)

Cat. No. 10	Chemical treatment and discharge into drain for liquid and secured landfill for solids	Chemical Waste (chemicals used in production of biological, chemicals, used in disinfect ion, as insecticides, etc)



Waste Management Flowchart

Waste Minimization:

Waste production can be minimized by adopting the 3 R's principle: Reduce, Reuse, and Recycle - Reduce the amount and toxicity of garbage and trash that you discard; Reuse containers and try to repair things that are broken; Recycle products wherever possible, which includes buying recycled products i.e., recycled paper books, paper bags etc; These are processes that involve integrated waste management practices (IWM). They can reduce the wastes generated by approximately 50%.

Reduce (Waste Prevention):

Waste prevention, or "source reduction," means consuming and discarding less, is a successful method of reducing waste generation. Backyard composting, double sided copying of papers, purchasing durable, long- lasting environmentally friendly goods; products and packaging that are free of toxics, redesigning products to use less raw material production and transport packaging reduction by industries are the normal practices used and have yielded substantial environmental benefits.

Reuse: - Reuse is the process, which involves reusing items by repairing them, donating them to charity and community groups, or selling them. Reusing products is an alternative to recycling because the item does not need to be reprocessed for its use again. Using durable glassware, steel using cloth napkins or towels, reusing bottles, reusing boxes, purchasing refillable pens and pencils are suggested.

Recycling: - The process of recycling, including composting, has diverted several million tons of material away from disposal. Recycled materials include batteries, recycled at a rate of 93%, paper and paperboard at 48%, and yard trimmings at 56%. These materials and others may be recycled through drop off centers, buy-back programs, and deposit systems. Recycling can create valuable resources and it generates a host of environmental, financial, and social benefits. Materials like glass, metal, plastics, and paper are collected, separated and sent to processing centers where they are processed into new products. The advantages of recycling are it conserves resources for future generation, prevents emissions of greenhouse gases and pollutants, saves energy, supplies valuable raw, materials to industries, stimulates the development of greener technologies, reduces the need for new landfills and incinerators

Exposure to solid waste

Exposure to solid waste may be obvious but may also be occult. Exposure to solid waste may take the form of bodily contact, penetrating injuries, inhalation, or ingestion. Exposure to solid waste is a function of how much solid waste is generated, how it is collected, transported, and the proportion disposed of safely. It is estimated that in developing countries, waste generated per capita per day is about 0.65 kg compared to 2.2 kg in Organization for Economic Cooperation and Development (OECD) countries. The African region contributes about 5% of solid waste generated globally, 44% by OECD and 12% by Latin America and the Caribbean Solid waste collection in low-income countries is less than 50% compared to about 98% in high income countries and in most cases, disposal is at open dumpsites or land fill with limited organized recycling **[unstats.un.org retrieved 3 March 2017**]. At a higher level, risk of exposure to solid waste is influenced by presence or absence of good policies and allocation of financial resources to manage it. Categories of people exposed to solid waste range from those who generate the waste, those who collect waste it, such as the municipal workers, those who pick waste for a living and those living or working near disposal site such as landfills or dump sites and incinerators. The literature reviewed here assesses the exposure to solid waste, the knowledge of exposure, risk perception and mitigation practices among the various actors outlined above.

Exposure to solid waste among waste generators

Exposure to solid waste may occur right from the point where the waste is generated. A good example is the medical waste. Medical personnel and hospital housekeeping staff are at higher risk of exposure to waste and infection from biological waste [USEPA, 2017]. While medical waste requires stringent management, it is not uncommon to find medical waste being handled like household waste [USEPA, 2017]. Sharp used medical equipment such as needles and scalpels are supposed to be disposed of in a safe "sharps "container but this is not always followed. Needle stick injuries from misplaced used needles are a common occurrence among health care providers [UNSD, 2017]. Additionally, other than penetrating injuries or cuts, medical waste and contaminated surfaces may have contained highly infectious microbial agents such as ebola virus and hepatitis B & C virus which can be transmitted to exposed workers [Czajczyńska, D.; Anguilano, L.; Ghazal, H.; Krzyżyńska, R.; Reynolds, A.J.; Spencer, N.; Jouhara, H. (September 2017]. Other forms of exposure to waste by generators may include industrial workers who do not wear protective gear and are at risk of getting exposed to waste generated from their workplace such as toxic chemical waste.

Exposure to solid waste among collectors

Occupational exposure to solid waste is a constant risk waste handlers are faced with. Exposure can happen depending on the level of protective ware, knowledge of risk, standards and practices of waste sorting and equipment available to such workers [United Nations Environmental Programme. 2017]. In many of the developing countries, municipal waste (which is a mixed bag of waste) is handled by cheaply hired workers with limited protective gear and limited appreciation of the risk involved in handling solid waste [United Nations Environmental Programme. 2017]. Often, they also have no legal protection and recourse in case of injury as their engagement terms are largely non-binding. Even where there are binding working relationships between the waste handler and employer such as the municipal councils, the challenge is that some of the effects of exposure may manifest long after the working relationship ceased to exist. The near absence of waste sorting and lack of protective wear put waste handlers at very high risk of exposure [Czajczyńska, D.; Anguilano, L.; Ghazal, H.; Krzyżyńska, R.; Reynolds, A.J.; Spencer, N.; Jouhara, H. (September 2017]. This is particularly important in developing countries where solid waste is often mixed with high risk waste such as medical waste especially from small facilities being disposed of as general municipal waste [Czajczyńska, D.; Anguilano, L.; Ghazal, H.; Krzyżyńska, R.; Reynolds, A.J.; Spencer, N.; Jouhara, H. (September 2017].

Living in neighborhoods of dumping and incinerator sites: -
In addition to enduring the nauseating and pungent smell and the unpleasant sight of rampant scavenging animals at dump sites, residents in the neighborhood of dumping sites have an ever-present risk of infection transmission through vectors and rodents that are abound at dump sites and inhalation of fumes from the burning waste [Encyclopedia Britannica}. The decomposing and festering solid waste attract all manner of vectors including common houseflies that are very efficient in transmitting disease-causing germs. Children living in such neighborhoods are exposed to a triple risk infectious diseases, injury and inhalation of dangerous fumes from the continuous burning of waste. However, due to the difficulties involved in quantifying the "dose" of exposure, the evidence linking residence near landfills and or dump sites and health outcomes remains weak (Chen, Dezhen; Yin, Lijie; Wang, Huan; He, Pinjing ; 2017).]. Other common sources of water include protected or unprotected springs. In such circumstances, potentially the risk of water contamination from waste disposed of upstream is high. Improper human fecal matter and waste from abattoirs disposal is poor in many places and yet these are a rich source of disease-causing bacteria posing a serious health risk to individuals using such contaminated water [Government of Montana. 2018]. On the other hand, it is often the case that solid waste containing noxious chemicals at dump sites is burnt and this process may produce toxic fumes which cause respiratory complications and allergic reactions in some people.

Exposure of solid waste to pickers and recyclers: -
In many African cities, solid waste dump sites are located on the outskirts of the city which are also home to a huge urban poor population often living in slums with no proper means of livelihood. Dumping sites are a source of economic livelihood to many who pick and retrieve articles that they consider valuable to them or the market for direct use or recycling [Kaufman, Scott M.; Krishnan, Nikhil; Themelis, Nickolas J. 2017*).*]. Retrieved articles range from clothes, household utensils, food, ornaments and scrap metal and plastics among others. The process of picking waste exposes such people to many risks including infection, respiratory complications from fumes and injury from sharp objects Kaufman, Scott M.; Krishnan, Nikhil; Themelis, Nickolas J. 2017]. Retrieved articles and food that find their way to the market puts a huge population at risk. In settings where women are the majority in the informal sectors, they are likely to also be over represented in the waste picking business. Similarly, get involved in waste picking and are likely to get disproportionately affected by injuries, respiratory complications and infections. Solid waste recycling has also been associated with health risk including physical injury, infections, and inhalation of particulate matter including bioaerosols [Nzihou, Ange; Lifset, Reid,2020)].

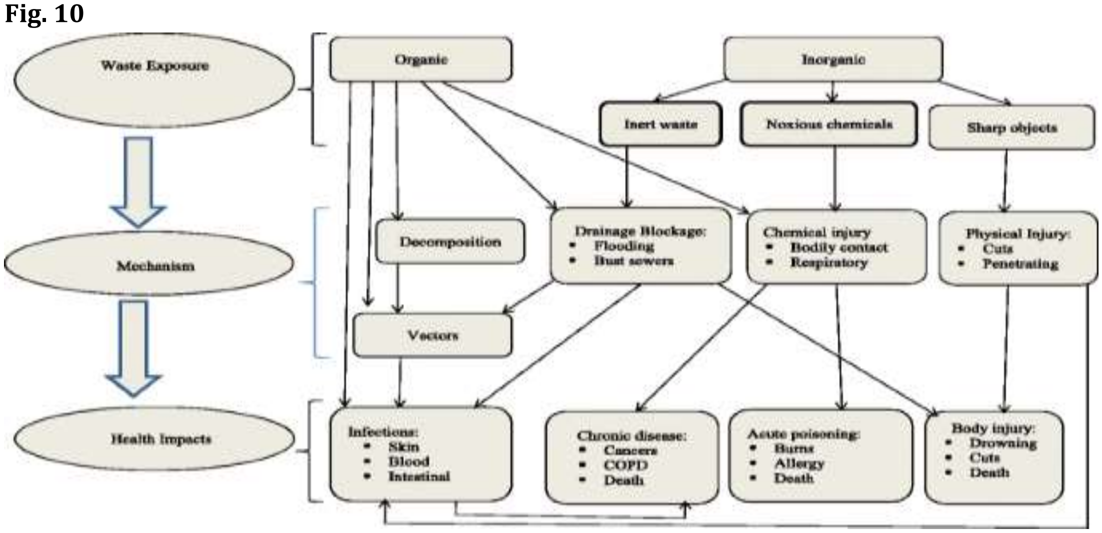
Accumulation of noxious chemicals in environment including food chain and air: -
In most of the developing world, sorting of waste is hardly practiced. Waste that by law is supposed to be managed in a stringent manner finds its way on dumping sites for general waste. In a study involving assessment of management of medical waste in 5 hospitals, it was reported that there was no sorting of waste and yet 26.5% of the waste was categorized as hazard [Montgomery County, Maryland. Division of Solid Waste Services. 2018]. Industrial effluents often discharge into rivers while medical waste is often mixed with household waste as well as electronic waste. Petroleum products including paints laden with lead are discharged in open spaces or water channels. While some of the chemicals discharged might have short-term effects on animal and plant life, others are carried through the food chain where they accumulate and have deleterious effects much later. Heavy metals such as lead, arsenic and mercury are of particularly high public health importance yet no clear measures are enforced to control their disposal and help limit environmental contamination ["Waste and Biomass Valorization". Springer. Retrieved 17 June 2021]. Poorly managed solid waste disposal systems

such as in compositing, sewage treatment and poor constructed landfills can all lead to environmental contamination and consequent exposure to the general public

Health impacts of exposure to solid waste: - The impact of solid waste on health is varied and may depend on numerous factors including the nature of the waste, duration of exposure, the population exposed, and availability of prevention and mitigation interventions R. Dhana, Raju (2021). The impacts may range from mild psychological effects to severe morbidity, disability or death. The literature on health impacts of solid waste exposure remains weak and inconclusive in many cases due the difficulties encountered in accurately ascertaining exposure, controlling for confounders, accounting for duration of exposure and inability to follow up those exposed to ascertain outcomes that do not manifest in the short term Tchobanoglous, G., Burton, F.L., and Stensel, H.D. (2003), retrieved, 2022. This notwithstanding, the literature review presented here sheds light on several pieces of evidence linking solid waste exposure and self-reported outcomes but also those where ascertainment of exposure and health outcomes were empirically confirmed.While certain health impacts might be immediate, obvious to discern and directly linkable to the solid waste exposure, others may be occult, longer term and difficult to attribute the effects to a particular type of waste Tchobanoglous, G., Burton, F.L., and Stensel, H.D. (2003), retrieved, 2022. This makes establishing the burden of disease attributable to solid waste and full epidemiologic spectrum of diseases emanating from the exposure a difficult undertaking often requiring large sample sizes and prolonged periods of follow-up Arancon, Rick Arneil D.; Lin, Carol Sze Ki; Chan, King Ming; Kwan, Tsz Him; Luque, Rafael (2013).

Figure 10, is a schematic conceptual representation of the linkages between exposure to the various types of solid waste, the pathways to negative outcomes and final impact on health. The representation here is only illustrative and not exhaustive. For ease of understanding, health impacts have been categorized into four:

Fig. 10



A framework for understanding the linkages between poor solid waste management and adverse health outcomes

a) Infection transmission: This could be bacterial, viral and other disease-causing organisms;
b) Physical bodily injury: These may include cuts, drowning, blunt trauma, and chemical or radiation injury. This may range from immediate skin or inhalation burns, to longer terms effects.

c) Non-communicable diseases- long term exposure may lead to cellular damage and development of cancer while other might result in bodily organ injury and damage.
d) Emotional/psychological effects (strong smells, unsightly waste as human body parts) One type of solid waste may lead to more than one health outcome directly or through an intermediate mechanism for example through vectors and other individual level predisposing factors.

Infections

Poorly managed medical waste, is a major source of infection for patients, health care workers, waste handlers and general public ["Pollution Prevention Case Studies". Washington, D.C.: U.S. Environmental Protection Agency (EPA). 2021].

Where all medical waste is properly disposed of, the risk of infection to the general public is limited, but remains substantial to providers and their clients. While protocols on handling medical waste exist in many settings, their implementation varies from one place to another depending on how stringently prevention of infection protocols are implemented and observed. Indeed, many health care personnel and medical waste handlers do not use personal protective gear *[* Henze, M.; van Loosdrecht, M. C. M.; Ekama, G.A.; Brdjanovic, D. (2018), Von Sperling, M. (2018)]. The risk of transmission of infection from medical waste is substantial including hepatitis B, ebola and Hepatitis C among others Von Sperling, M. (2018)]. Other important pathogens that can be transmitted from medical waste include pathogenic bacteria such one that causes tuberculosis, anthrax, pneumonia, meningitis, and infections of the gastro-intestinal system. Evidence shows that workers who handle medical waste are at a higher risk of nosocomial infections [Oxford Reference – Pyrolysis]. Decomposing organic waste is a rich medium or culture for growth of numerous micro-organisms many of which are diseases causing if passed on to humans. Also there is always a risk of transmission through vectors such as houseflies but also through human contacts as is the case with waste handlers who do not use protective wear and waste pickers who most of the time use bare hands [*Washington, D.C.: U.S. Environmental Protection Agency (EPA). 2021.*]. Additionally, articles retrieved from waste may be sold to unsuspecting public without undergoing thorough cleaning hence posing a risk of infection transmission.

Gastro-intestinal infections such as typhoid fever, polio virus infection, hepatitis E infection, and cholera are often transmitted through contaminated food or water. Toilet ownership in Kenya, for example, is very low with 12% of all households not having any form of toilet [*Washington, D.C.: U.S. Environmental Protection Agency (EPA). 2021.* Even those households with a toilet, many are not connected to the main sewer line. These result into fecal matter being disposed of in open spaces while other households do not have any form of toilet and thus dispose of fecal matter as general waste, popularly referred to as flying toilets or discharged into rivers [Panagos, Panos; Ballabio, Cristiano; Lugato, Emanuele; Jones, Arwyn; Borrelli, Pasquale; Scarpa, Simone; Orgiazzi, Albert o; Montanarella, Luca (9 July 2018)].

Main Types of Solid Waste Management Strategies for Municipal Governments

Some of the major types of solid waste management are as follows: - Municipal Solid Waste (MSW); Hazardous Wastes; Industrial Wastes; Agricultural Wastes; Bio-medical Wastes; Waste Minimization; The combined effects of population explosion and changing modern living standard have had a cumulative effect in the generation of a large number of various types of wastes. Solid waste can be classified into different types depending on their sources:

a. Municipal Solid Waste (MSW):

The term municipal solid waste (MSW) is generally used to describe most of the non-hazardous solid waste from a city, town or village that requires routine collection and transport to a processing or disposal site, Sources of MSW include private homes, commercial establishments and institutions, as well as industrial facilities. However, MSW does not include wastes from industrial processes, construction and demolition debris, sewage sludge, mining waste or agricultural wastes. MSW is also called as trash or garbage. In general, domestic waste and MSW are used as synonyms. The different types of domestic wastes generated and the time taken for them to degenerate is illustrated in the table given below.

Table 3. Domestic wastes and their degeneration time:

Common domestic wastes	Approximate time taken for degeneration
Organic kitchen waste vegetables, fruits	1-2 weeks
Paper, cardboard paper	15 days-1 month
Cotton clothes	2-5 months
Woolen clothes	about a year
Metal cans, tin, aluminium	100-500 years
Plastics	1 million years

Urban population slated to increase from the current 200 million to about 400 million by 2030, the challenge of managing municipal solid waste (MSW) in an environmentally and economically sustainable manner is bound to assume gigantic proportions.

The Functional Elements of MSW Management: -The municipal solid waste industry has four components: recycling composting, land-filling, and waste-to-energy via incineration. The primal) steps are generation, collection, sorting and separation, transfer and disposal/ utilisation. 1. Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown out or gathered together for disposal; 2. The functional element of Collection includes not only the gathering of solid waste and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station or a landfill disposal site; 3. Waste handling and separation involves activities associated with waste management until the waste is placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Separating different types of waste components is an important step in the handling and storage of solid waste at the source. The types of means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection, drop off and buy back centers; 4. Transfer and transport involves two main steps. First, the waste is transferred from a smaller collection vehicle to larger transport equipment. The waste is then transported, usually over long distances, to a processing or disposal site; 5. Today the disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost or other substances from various solid waste processing facilities. A modern sanitary landfill is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health or safety, such as the breeding of insects and the contamination of ground water. Municipal solid waste can be used to generate energy.

Hazardous Wastes: Hazardous wastes are those that can cause harm to human and the environment. Characteristics of Hazardous Wastes: **-**Wastes are classified as hazardous if they exhibit any of four primary characterises based on physical or chemical properties of toxicity, reactivity ignitability and corrosively: **-1. Toxic wastes:** Toxic wastes are those that are poisonous in small or trace amounts. Some may have acute or immediate effect on human or animals. Carcinogenic or mutagenic causing biological changes in the children of exposed people and animals. Examples: pesticides, heavy metals; **2. Reactive wastes: -** Reactive wastes are those that have a tendency to react vigorously with air or water are unstable to shock or heat, generate toxic gases or explode during routine management. Examples: Gun powder, nitro glycerin; **3. Ignitable waste: -**Are those that burn at relatively low temperatures (< 60 °C) and are capable of spontaneous combustion during storage transport or disposal. Examples: Gasoline, paint thinners and alcohol; **4. Corrosive wastes: -** Are those that destroy materials and living tissues by chemical reactions? Examples: acids and base; **5. Infectious wastes: -** Included human tissue from surgery, used bandages and hypoderm needles hospital wastes.

Sources of Hazardous Wastes: **-**Chemical manufacturing companies, petroleum refineries, paper mills, smelters and other industries. Plastic industries thousands of chemicals are used in industries every year. When used incorrectly or inappropriately they can become health hazards. PCBs (Polychlorinated biphenyls) are resistant to fire and do not conduct electricity very well, which makes them excellent materials for several industrial purposes. Rainwater can wash PCBs out of disposal areas in dumps and landfills thus contaminating the water. PCBs do not break open very rapidly in the environment and thus retain their toxic characteristics. They cause long-term exposure problems to both human and wildlife. Many household chemicals can be quite toxic to humans as well as wildlife. Most of the dangerous substances in our homes are found in various kinds of clearness, solvents and products used in automotive care. When these products are used incorrectly, they have the potential to be harmful.

Effects of Hazardous Wastes: **-** As most of the hazardous wastes are disposed off or in land, the most serious environmental effect is contaminated ground water. Once ground water is polluted with hazardous wastes, it is very often not possible to reverse the damage. Pesticides form residues in the soil that are washed into streams which then carry them forward. The residues may persist in PCBs (poly chlorinated biphenyls) are concentrated in the kidneys and liver and cause damage; they cause reproductive failure in birds and mammals.

Control of Hazardous Wastes: -Common methods for disposing of hazardous wastes are land disposal and incineration Industries need to be encouraged to generate less hazardous waste in the manufacturing process. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing recycling and treating the wastes. Integrated pest management practices (IPM) reduce the usage of pesticides. Substitute the use of PCBs and vinyl chloride with chemicals that are less toxic. Polyvinyl chloride use can be lowered by reducing the use of plastics.

Industrial Wastes: These contain more of toxic and require special treatment.

Source of Industrial Wastes: **-**Food processing industries, metallurgical chemical and pharmaceutical unit's breweries, sugar mills, paper and pulp industries, fertilizer and pesticide industries are major ones which discharge toxic wastes. During processing, scrap materials, tailings, acids etc.

Effects of Industrial Wastes: - Most common observation is that the health of the people living in the neighborhood of dumping sites is severely affected. The exposure may cause disorders of nervous system, genetic defects, skin diseases and even caner. The liquid effluents discharged by the industries contain inorganic and organic pollutants and they enter into water bodies causing destruction of fish, formation of sediments, and pollution of ground water and release of foul odours.

Control of Industrial Wastes:**-** Waste minimization technologies have to be developed. Source reduction recycling and reuse of materials need to be practiced on a large scale. Hazardous waste should not mix up with general waste. Source reduction involves altering the design, manufacture or use of products and materials to reduce the amount and toxicity of materials that get thrown away. Local communities and voluntary organizations should educate the industrialists as well as the public about dangers of pollution and the need to keep the environment clean. Land filling, incineration and composting technologies to be followed. Biogas is obtained from solid waste treatment of industrial and mining waste is done for the recovery of useful products.

Agricultural Wastes:

Sources of Agricultural Wastes: **-** The waste generated by agriculture includes waste from crops and live stock. In developing countries, this waste does not pose a serious problem as most of it is used e.g., dung is used for manure, straw is used as fodder. Some agro-based industries produce waste e.g., rice milling, production of tea, tobacco etc. Agricultural wastes are rice husk, degasses, ground nut shell, maize cobs, straw of cereals etc.

Principles of waste management

Diagram of the waste hierarchy fig 11

Waste hierarchy

The waste hierarchy refers to the "3 Rs" Reduce, Reuse and Recycle, which classifies waste management strategies according to their desirability in terms of waste minimisation. The waste hierarchy is the bedrock of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of end waste; see: resource recovery.[15] The waste hierarchy is represented as a pyramid because the basic premise is that policies should promote measures to prevent the generation of waste. The next step or preferred action is to seek alternative uses for the waste that has been generated i.e. by re-use. The next is recycling which includes composting. Following this step is material recovery and waste-to-energy. The final action is disposal, in landfills or through incineration without energy recovery. This last step is the final resort for waste which has not been prevented, diverted or recovered.[16][*page needed*] The waste hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management. The hierarchy represents the latter parts of the life-cycle for each product.

Life-cycle of a product*: -* The life-cycle begins with the design, then proceeds through manufacture, distribution, and primary use and then follows through the waste hierarchy's stages of reduce, reuse and recycle. Each stage in the life-cycle offers opportunities for policy intervention, to rethink the need for the product, to redesign to minimize waste potential, to extend its use.[16][*page needed*] Product life-cycle analysis is a way to optimize the use of the world's limited resources by avoiding the unnecessary generation of waste.

Resource efficiency: -Resource efficiency reflects the understanding that global economic growth and development cannot be sustained at current production and consumption patterns. Globally, humanity extracts more resources to produce goods than the planet can replenish. Resource efficiency is the reduction of the environmental impact from the production and consumption of these goods, from final raw material extraction to the last use and disposal.

Polluter-pays principle: -The polluter-pays principle mandates that the polluting party pays for the impact on the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the unrecoverable material.

Solid waste management practices:

Solid waste management practices greatly vary across regions, countries and even within country [www.siemens.com. from the original on 22 January 2021.]. Modern waste management approaches encourage reduced waste generation, re-use, recycling, composting, and safe disposal through landfills, however, these are often not practiced. In developing countries, a large proportion of waste is not re-used. Waste sorting is also rare and therefore this makes it difficult to re-cycle or compost.

Waste classification: -

Municipal solid waste is often categorized into two major groups: organic and inorganic. The organic municipal solid waste can further be divided into three categories: putrescible, fermentable, and non-fermentable. Putrescible wastes include products such as foodstuff that decompose fast. Fermentable wastes decompose rapidly, but without the unpleasant accompaniments of putrefaction while non-fermentable wastes tend to resist decomposition and, therefore, break down very slowly. Inorganic solid waste includes articles like metals, plastics, and other non-biodegradable materials. In terms of toxicity, some solid wastes are classified as hazardous including pesticides, medical waste, electrical waste, herbicides, fertilizers and paints and are recommended to be disposed of in special ways and not to be mixed with general municipal waste [[www.siemens.com. from the original on 22 January 2021]. Solid waste in developing countries characteristically has a high content of organic matter compared to that in developed countries. For example, studies conducted in the region estimated that in Juba South Sudan, organic waste constituted about 31% of all waste by weight 61% in Ghana [web.mit.edu. Retrieved 24 January 2021.] and 54% by weight in an Ethiopian town Jimma [Carroll, Gregory J.; Thurnau, Robert C.; Fournier, Donald J.2017]. The high organic content has implications for waste management including recycling, but also a potential source of ill-health if mismanaged.

f. Place of Urban City Abuja on the Health and Cleanliness of Abuja

With the development of industrialization, urbanization is expanding all over the world (Gollin D, Jedwab R, Vollrath D, 2016). Urbanization is an inevitable trend and essential requirement to advance the progress of human society (Zheng W, Walsh PP,2019), which boosts economic growth by expanding demand (Liu TY, Su CW, Jiang XZ 2015). Urbanization means the whole process of qualitative change from a rural lifestyle to an urban lifestyle (Guo J, Yu Z, Ma Z, Xu D, Cao S,2021), which is usually considered has important consequences for people's living standards and health (Biadgilign S, Ayenew HY, Shumetie A, Chitekwe S, Tolla A, Haile D, et al, 2019; Li X, Song J, Lin T, Dixon J, Zhang G, Ye H, 2016). Urbanization is the process by which there is an increase in the proportion of people living in urban areas. Urbanization is defined by the United Nations as movement of people from rural to urban areas with population growth equating to urban migration. However, the impact of urbanization on the health of residents is ambiguous (Liu M, Huang Y, Jin Z, Ma Z, Liu X, Zhang B, et al, 2017; Gu C. 2019). On the one hand, the progress of urbanization enables people to have more access to health services and provides better healthcare resources to them, which can improve the residents' health status (. Yang G, Wang Y, Zeng Y, Gao GF, Liang X, Zhou M, et al, 2015; Miao J, Wu X, 2016). On the other hand, urbanization is also related to sedentary, stressful lifestyles (Turan MT, Besirli A.2008), unbalanced nutrition Eckert S, Kohler S. 2014), and other environmental factors, such as air pollution (Diao B, Ding L, Zhang Q, Na J, Cheng J, 2020), which harms people's health. Therefore, there are two possible opposite impacts of urbanization on the health status, so the impact on the expenditure of health care is also uncertain. As an indispensable part of residents' daily life expenditure, health care expenditure consists of the spending on medicines, as well as medical and health services, which is one of the important indicators to measure the quality of life of residents (Kang SH, Ju YJ, Yoon HJ, Sang AL, Park EC, 2018). If the medical burden is too heavy, it will crowd out residents' consumption in other aspects, thus even restricting the economic development of a country. Considering the two potential opposite effects, the influence from urbanization on health care expenditure deserves further in-depth discussion.

Considering that urbanization has brought significant changes into residents' life, it is necessary to understand the relationship between urbanization and residents' health care expenditure, which is of great practical significance for urban management and policy development in China. In addition, with the increasingly prominent aging phenomenon, the improvement of average life expectancy also leads to the continuous increase of residents' healthcare expenditure (Matteo LD, 2005). In the context of a large aging population in China, whether the level of aging takes part in the influence of urbanization on medical expenditure should also be investigated. The impact of urbanization on human beings has two sides. Urbanization can provide more access to health services, better water quality, and sanitation infrastructure. However, urban environments can also lead to stressful lifestyles, nutritionally unbalanced diets, higher metabolic and cancer risks which relate to poor health (Ventriglio A, Torales J, Castaldelli-Maia JM, Berardis DD, Bhugra D. 2019).

Although much relevant literature has explored the relationship between urbanization and health care expenditure, there is still room for further research. First, whether urbanization has a positive or negative impact on health care expenditure, existing research assumes that the impact is linear. This assumption ignores the time-varying characteristics of time series and external structural mutations, which may lead to inaccurate results. With panel threshold regression model, we can draw more accurate conclusions and fill in the gaps in this field. Secondly, the research on urbanization and healthcare expenditure is mainly carried out in a certain city or province, lacking comprehensive analysis from the macro level. Finally, we examine whether urbanization has a different impact on healthcare expenditure across different regions.

In view of the literature reviewed, the following parameters have been considered for measurement of urbanization, in this study: ; Population size; population density; educational facilities; d. Electricity facilities; e. Availability of health services; f. Growth of number of Industries; g. Roofing types; h. Assets (i .e, T V, computer/ laptop, telephone/mobile phone and scooter/car); i. Percentage of Built- up area. The basis of selecting each of the urbanization parameters is discussed below: **Population Size and Population Density** The primary aspect of defining urbanicity is demographic aspect. The Census criteria of different countries have considered the demographics to delimit the urban areas. **Educational Facilities and Availability of Health Services:** The parameters such as educational facilities and Availability of health services are considered as it correlates of urbanicity by a number of researchers. (Yach et al,1990 ; McDade and Adair, 2001).**Electricity Facilities**: Facility of electricity connection is an indication of urbanization because electric transmission development starts from urbanized area and progresses towards rural area. **Growth of Number of Industries** Growth of number of Industries directly influences the economic growth. The economic growth of an area is closely linked with urbanization. **Roofing Types** In this study, roofing type has been selected to measure urbanization. **Assets** (i .e, T V, computer/ laptop, telephone/mobile phone and scooter/car)The standard of living is higher in urban areas compared to moderately urban or rural areas. Hence the possibility of owning the assets like T V, computer/ laptop, telephone/mobile phone and scooter/car increases as one moves from rural to urban areas. **Percentage of Built-up Area**: As the economic activities of an area increases, the agricultural area decreases and solid and permanent dwellings increase. **Development of Urbanization Scale for each of the Urbanization Parameter**: For each of the above urbanization parameters the scale is formed to assign the points from 1 to 10 by considering the extensivity of the data and the local and surrounding development in this study area.

The following are found to be associated with Urban Cities and thus the need for the intervention of the Urban Municipality: **- Environmental issues** are issues related to human impact on the living environment, habitats, land use and natural resources. The following alphabetical list shows some of the main known environmental issues by major topic title: **-** Air quality (air pollution, ozone pollution, ties to human health with asthma, diesel emissions, etc.); Biodiversity (conservation of biological diversity); Climate change (encompasses "global warming", greenhouse effect, loss of glaciers, climate refugees, climate justice, equity, etc);

Conservation (nature and animal conservation, etc.); Consumerism (linking the state of consumers within the economy to environmental degradation and social malaise, planned obsolescence); Deforestation (illegal logging, impact of fires, rapid pace of destruction, etc.); Desertification; Ecotourism; Endangered species (CITES, loss of species, impact of chemical use on species, cultural use, species extinction, invasive species, etc.); Energy (use, conservation, extraction of resources to create energy, efficient use, renewable energy, etc.); Environmental degradation; Environmental health (poor environmental quality causing poor health in human beings, bio-accumulation, poisoning); Environmental impact assessment (one major current form of assessing human impact on the environment); Food safety (including food justice, impacts of additives, etc.); Genetically modified organisms and other forms of genetic engineering or modification; Global environmental issues (in recognition that environmental issues cross borders); Global warming; Grassroots solutions (local and regional environmental issues solved from the bottom-up); Habitat loss (destruction, fragmentation, changed use); Intergenerational equity (recognition that future generations deserve a healthy environment); Intensive farming and biointensive farming; Invasive species (weeds, pests, feral animals, etc.); Land degradation; Land use / Land use planning (includes urban sprawl); Natural disasters (linked to climate change, desertification, deforestation, loss of natural resources such as wetlands, etc.); Nuclear energy, waste and pollution; Ocean acidification (includes algal bloom, coral reef loss, etc.); Over-exploitation of natural resources (plant and animal stocks, mineral resources (mining), etc.); Overfishing (depletion of ocean fish stocks); Ozone depletion (CFCs, Montreal Protocol); Pollution (air, water, land, toxins, light, point source and non-point source, use of coal/gas/etc., reclaimed land issues); Population growth and related issues, like overpopulation, access to reproductive control (reproductive health), etc.; Reduce, reuse, repair and recycle (ways to reduce impact, minimise footprint, etc.); Soil conservation (includes soil erosion, contamination and salination of land, especially fertile land; see also desertification and deforestation); Sustainability (finding ways to live more sustainably on the planet, lessening human footprint, increasing human fulfillment with less impact) (sustainable development and poverty alleviation); Toxic chemicals (persistent organic pollutants, prior informed consent, pesticides, endocrine disruptors, etc.); Waste (landfills, recycling, incineration, various types of waste produced from human endeavors, etc.); Water pollution (fresh water and ocean pollution, Great Pacific Garbage Patch, river and lake pollution, riparian issues); Water scarcity; Whaling (a specific issue due to its worldwide nature, treaties and persistent campaigns to prevent it; other cetaceans also impacted).

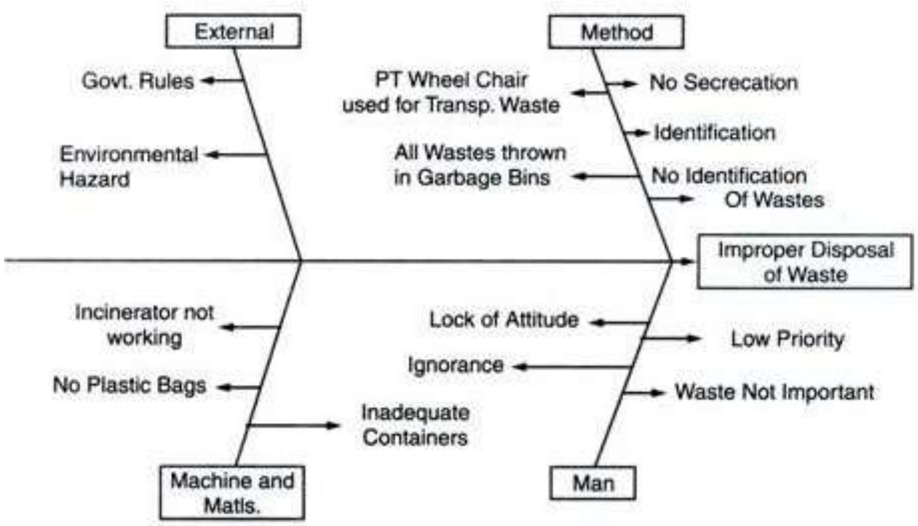
Theoretical Review

Theory of Solid waste and the wider development agenda

For health, environmental, and economic reasons, management of solid waste is and should be an important undertaking in any urban setting. There are wide variations in policies and practices in solid waste management between regions, countries, large and smaller cities and formal and informal areas within a city. While all urban centers face similar solid waste management challenges, the impact vary depending on how policies and practices are implemented. From the global development agenda perspective under the auspices of the Millennium Development Goals (MDGs), ensuring environmental sustainability (MDG 7), was identified as a key area. Review of progress on this MDG shows that an estimated 2.1 billion people gained access to improved sanitation between 1990

and 2015; elimination of ozone depleting substances; proportion of global population using open defecation halved since 1990; and proportion of urban population leaving in slums fell from 39.4 to 29.7% between 1990 and 2014 [www.mdpi.com. from the original on 11 October 2020].

Going into the new global dispensation, the Sustainable Development Goals (SDGs), the relevance of the issue of protecting the environment and preserving health through proper solid waste management in cities has become even more pronounced. The SDG agenda advocates for reduced generation of waste, and increased reuse and recycling. It touches on SDG3 (health lives and promote well-being); SDG6 (water and sanitation); SDG11 (making cities inclusive, safe, resilient & sustainable) and SDG 13 (combating climate change and its impact) [www.mdpi.com. from the original on 11 October 2020]. SDG 11, specifically has an indicator that relates to solid waste management: "percentage of solid waste regularly collected and well managed". However, like other prior social development agendas, the challenge may be located in the operationalization and implementation. In many countries in the developing world, management of solid waste is not mainstreamed, poorly funded and has always fallen below expectation [Walker, T. R. (2018).]. A review of evolution of policies, show that, Kenya for example, has made numerous efforts supported by policies, to manage solid waste in a sustainable way but in most cases implementation has been haphazard and fallen short. The potential consequences of this failure to manage solid waste forms the heart of this paper as illustrated in the framework, with particular focus on the health impacts.



Waste Management Flowchart

Waste Minimization:

Waste production can be minimized by adopting the 3 R's principle: Reduce, Reuse, and Recycle; that is - Reduce the amount and toxicity of garbage and trash that you discard; Reuse containers and try to repair things that are broken; Recycle products wherever possible, which includes buying recycled products i.e., recycled paper books, paper bags

etc. These are processes that involve integrated waste management practices (IWM). They can reduce the wastes generated by approximately 50%.

Reduce (Waste Prevention): **Waste prevention, or "source reduction," means consuming and discarding less, is a successful method of reducing waste generation. Backyard composting, double sided copying of papers, purchasing durable, long- lasting environmentally friendly goods; products and packaging that are free of toxics, redesigning products to use less raw material production and transport packaging reduction by industries are the normal practices used and have yielded substantial environmental benefits. Source reduction prevents emissions of many greenhouse gases, reduces pollutants the need saves energy, conserves resources, and reduces wastes for new landfills and combustors. It reduces the generation of waste and is generally preferred method of waste management that goes a long way toward saving the environment.**

Reuse: **Reuse is the process, which involves reusing items by repairing them, donating them to charity and community groups, or selling them. Reusing products is an alternative to recycling because the item does not need to be reprocessed for its use again. Using durable glassware, steel using cloth napkins or towels, reusing bottles, reusing boxes, purchasing refillable pens and pencils are suggested.**

Recycling: **The process of recycling, including composting, has diverted several million tons of material away from disposal. Recycled materials include batteries, recycled at a rate of 93%, paper and paperboard at 48%, and yard trimmings at 56%. These materials and others may be recycled through drop off centers, buy-back programs, and deposit systems.**

The 4Rs at Home and at the Office: Reduce, Reuse, Recycle and Recover!

The 4R's means **-Reducing, reusing, recycling and recovering reminding us of the importance of reducing our waste production on a daily basis and thus avoiding our contribution to the piles of materials found on landfill sites.**

Is the sequence of the 4Rs important?

We must first and foremost REDUCE our consumption. There is no need to manage wastes when we reduce because everything is taken care of at the source. In other words, buying less and reusing to the maximum reduces the contents in recycling bins. If the recycling bin is less full, automatically the environmental impact is reduced, because remember that the recycling process is not done without an impact on the environment. Sorting, cleaning, melting and transforming recyclables into new products use a lot of energy. That is why it is important to reduce and reuse as much as possible and to recycle as a last resort. **RECOVERING** is the last step! After having reduced, reused and recycled, it is important to recover! Recovering is the process of giving a value to a material believed to be waste. Recovering means to transform wastes into resources. The best example of recovering is composting. It transforms our fruit and vegetable wastes into rich soil conditioners, commonly known as compost. Take heed of the 4Rs… REDUCE consumption at the source; REUSE goods as much as possible to give them a longer life; RECYCLE to the maximum; RECOVER, that means composting putrescible wastes at home.

Here are simple and effective daily actions! Limit purchases, that's fundamental. The magic question: Do I really need it?; Opt for bulk products, thus limiting packaging needs; Give priority to durable goods (longer life span) and reusable products instead of buying disposable items; When buying a coffee, use a reusable container (thermos); Imagine the number of disposable cups that won't end up in a landfill site;

At the grocery, retail or convenience store, always bring reusable bags (canvas or other), thus saving on the use of plastic bags. **Useful tip**: Make sure to put reusable bags back in the car after each use. You will avoid the surprise of showing up at the grocery store without your bags!

At work, on a trip or at school, bring a zero-waste lunch box along with reusable containers, washable utensils, a water bottle and a small cotton towel. Make sure to compost fruit and vegetable skins. Avoid using Styrofoam or plastic glasses; instead use washable glasses; Opt for food or products that are produced locally or in Canada to reduce your ecological footprint; When no longer in need of a product (a piece of clothing, for example), find someone to give it to, otherwise, bring it to a thrift store or a clothing depot. What a good example of reusing! Instead of throwing away or recycling an appliance that won't work, have it fixe; During a house construction, try to recuperate as many materials as possible; Practice grass cycling… which consists of leaving grass clippings on the lawn when mowing; Commit to composting all fruit and vegetable scraps as well as any organic materials found in your backyard such as dead leaves or small twigs.

4Rs at the Office: Here are true-to-life actions you can take based on the 4Rs principles: - REDUCE – read emails on the monitor instead of printing them; REUSE – make recycled notebooks out of scrap paper; RECYCLE – After having reduced paper consumption and having reused it to the maximum, recycle it; RECOVER – make compost out of all my fruit and vegetable wastes at work or at home;

Action of Reduction! The first step towards reduction is certainly to reduce unnecessary purchases Opt for renting or purchasing reusable and more durable products; Unsubscribe to useless paper publications or give priority to electronic publications; Reuse the back of sheets of paper as scrap paper; Print back-to-back (set copier in back-to-back mode by default); Avoid changing garbage bags every night in the offices; During meetings, avoid bottled water. Use pitchers and reusable glasses instead (use tap water); Use a white board or projector instead of a flip chart pad (paper); Use reusable cups for coffee at the office; Opt for a zero-waste lunch using reusable plates, bottle and utensils;

Action of Reuse! Give away furniture and appliances that you don't use anymore; Reuse folders, portfolios, envelopes, paper clips, etc; Opt for reusable ink cartridges and rechargeable batteries; Use reusable bags for your purchases; Tips for Recycling at the Office; Two important elements for the success of recycling in the work place are **bin visibility and location**; Remove garbage

cans in offices and replace by recycling bins (should motivate employees to recycle more); Centralize bins in one section of the building: make sure that the recycling center is next to the garbage can; Place recycling bins in key locations: underneath cashes, near copier; Make sure that recycling bins are visible and well identified.
Steps to Reach Your Goals… One Step at a Time! i. Set up a green committee in your enterprise or organization. Involve key persons right from the start: management, janitors, etc; ii. Get involved: set up an environmental policy; iii. Prepare an action plan. Make a list of well-defined actions, but most importantly make sure they are achievable; iv. Assess activities and actions already existing; v. Identify: make a list of every possible activity; vi. Set your goals. For example, in one year, our organization seeks to reduce by at least 30% the amount of wastes produced; vi. Sensitize and educate; vii. Keep the staff informed on a regular basis and involved in its overall environmental performance (educational workshops, bulletin boards, newsletters, emails, etc.); viii. Inform the general public: enterprise exposure and positive influence on the community; ix. Provide a follow-up, give results, reevaluate if needed and seek continuous improvement; x. Celebrate your accomplishments!

Circular economy Theory of Solid Waste Management:
The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the **life cycle of products is extended.** In practice, it implies **reducing waste** to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possible. These can be productively used again and again, thereby **creating further value**.This is a departure from the traditional, *linear* economic model, which is based on a take-make-consume-throw away pattern. This model relies on large quantities of cheap, easily accessible materials and energy. Also part of this model is planned obsolescence, when a product has been designed to have a limited lifespan to encourage consumers to buy it again. The European Parliament has called for measures to tackle this practice.

Why do we need to switch to a circular economy? The world's population is growing and with it the demand for raw materials. However, the supply of crucial raw materials is limited. Finite supplies also mean some EU countries are dependent on other countries for their raw materials. In addition, extracting and using raw materials has a major impact on the environment. It also increases energy consumption and CO2 emissions. However, a smarter use of raw materials can lower CO2 emissions. The benefits - Measures such as waste prevention, eco-design and re-use could save EU companies money while also reducing total annual greenhouse gas emissions. Currently, the production of materials we use every day account for 45% of the CO2 emissions. Moving towards a more circular economy could deliver benefits such as reducing pressure on the environment, improving the security of the supply of raw materials, increasing competitiveness, stimulating innovation, boosting economic growth (an additional 0.5% of gross domestic product), creating jobs (700,000 jobs in the EU alone by 2030). Consumers will also be provided with more durable and innovative products that will increase the quality of life and save them money in the long term.

Actor-Network Theory on Waste Management:

This theory asserts that, in developing countries, territorial planners are confronted with rapid urbanization and its inherent solid waste management (SWM) which has increased public health risks, and generated environmental and socioeconomic problems too. Actions aimed at improving SWM practices, specifically those of developing countries, are negatively affected by resource scarcity, socio-economic inequality and excessive urbanization, among other cultural, social, political and economic aspects (Guerrero et al., 2018; Marshall and Farahbakhsh, 2017). Studies also show that in developing countries SWM decision-makers do not usually include these different dimensions (Achillas et al., 2018; Cheng et al., 2018; Karmperis et al., 2017). As a result it becomes critical to employ a systems approach in order to overcome obstacles for achieving a more sustainable SWM paradigm (Liu et al., 2011; Marshall and Farahbakhsh, 2017). Public education is usually excluded in the conception, planning, design, implementation and operation of SWM projects (Aini et al., 2021; Longe et al., 2019). In this regard, schools and universities can play a significant role by influencing environmental education and citizen responsibility (Armijo de Vega et al., 2018; Jain and Pant, 2017; Sobreiro and Jabbour, 2017). In addition, campuses can be considered as scale models of a city in all of its dimensions; civic behaviours that are practiced at schools and universities impact the context, culture and behaviour of not only students but also the greater educational community (Armijo de Vega et al., 2008, 2003; Bialowas et al., 2017; Jain and Pant, 2018; Maldonado, 2018). Waste generated on campuses can include ordinary, hazardous, foodservice, construction and demolition waste (CDW), e-waste and office and garden waste (Bialowas et al., 2017.

As an exploratory case study, and to achieve it there is need for generalization to Solid Waste Management (SWM) systems and thus the following questions became inevitable: - (i) Can decisions about SWM in the campus have been made through systemic processes? (ii) must the decision-makers have to apply a systems approach in their decisions? (iii) Is there an organized operative structure for SWM in the campus? and (iv) Which elements have triggered improvements in the SWM system in the campus?.

Related to the Actor-Network Theory (ANT), there are four constitutive elements: firstly, the Obligatory Passage Point (OPP) which correspond to the Actor-Network (A-N) that mobilizes the system and, in this case, corresponds to the main decision-maker; Secondly, the local network that involves the main A-N identified in relation to the milestones, whereas the global network involves A-N who are able to interfere with the system and even impact the local network when OPP is weakened. In the same way, A-N in local network is able to interact directly with A-N in the global. Thirdly, the dynamic between local and global networks is also described through "moments of translation"– as the fourth element - which are when the A-N align their interests, focusing them towards the generation of successful action (Callon, 2016; Gonzalez, 2017); these translations constitute the mechanisms through which the networks progressively take form based on power relationships (Stanforth, 2016). The result is a narrative report, as well as the trajectory of moments of translation that helps to understand the A-N relationships within the SWM system.

Evolving the Theory of Waste Management – Implications to waste minimization

The Theory of Waste Management is a unified body of knowledge about waste and waste management, and it is founded on the expectation that waste management is to prevent waste to cause harm to human health and the environment and promote resource use optimization. Waste Management Theory is to be constructed under the paradigm of Industrial Ecology as Industrial Ecology is equally adaptable to incorporate waste minimization and/or resource use optimization goals and values.

Waste Management Theory

Waste Management Theory (WMT) has been introduced to channel environmental sciences into engineering design. WMT is a unified body of knowledge about waste and waste management. It is an effort to organise the diverse variables of the waste management system as it stands today. WMT is considered within the paradigm of Industrial Ecology, and built side-by-side with other relevant theories, most notably Design Theory. Design Theory is a relatively new discipline, still under development. Following its development offers valuable insights about evolving technical theories. According to Love (2020), it is crucial to theory development to integrate theories from other bodies of knowledge, as well as the clarification of the definitions of core concepts, and mapping out key issues, such as domains, epistemologies and ontologies. At the present stage of WMT development, scientific definitions of key concepts have been offered, and evolving of WMT under the paradigm of Industrial Ecology is in progress. The basic proposal of WMT is that it is able to define waste unambiguously. Four waste classes have been defined (Table 8).

Table 8 Classes of waste (Pongrácz and Pohjola 1997 accessed May, 2022)

Class 1	Non-wanted things, created not intended, or not avoided, with no purpose.
Class 2	Things that were given a finite purpose, thus destined to become useless after fulfilling it.
Class 3	Things with well-defined purpose, but their performance ceased being acceptable due to a flaw in their Structure or State.
Class 4	Things with well-defined purpose, and acceptable performance, but their users failed to use them for their intended purpose.

The taxonomy of waste in Table 2.9 was formulated using an object-oriented modelling language, PSS which is based on the ontological commitment that every real thing can be formalised as an

object having four attributes: Purpose, Structure, State, and Performance (Pohjola and Tanskanen 1998). Using the taxonomy of Table 9 all of the problem waste definition areas defined in the Leipzig workshop were possible to identify as follows (Pongrácz et al. 2021):
Re-use happens when a thing that has just performed its purpose and momentarily no new purpose is assigned to it. This generally applies to wastes of class 2. A thing that has fulfilled its purpose is not necessarily useless. It is because usefulness is defined by structure and state, while re-use is subject of purpose. As long as structure and state allow performance with respect to the assigned purpose, re-usable things shall not be considered wastes. An empty bottle, whose Structure is undamaged is thus a useful non-waste.
End-of-life vehicles represent wastes of class 3. They are aggregate things composed of numerous structural parts. The loss of performance can be attributable to the inability of one or several structural parts to perform their purpose. Repair or changing the faulty structural parts can extend useful life.
In case the of owner abandonment despite of acceptable performance, the car represents waste class 4. Unless the owner argues that the car did not meet his expectations of superior performance usually attributable to newer cars. On the positive side, finding a new owner willing to tolerate the shortcomings of a new car would render it non-waste.
Demolition waste can be viewed as waste of class 2, one that has fulfilled its purpose. When a structurally intact tile is separated from the aggregate object of demolition waste, it can be assigned a new purpose and thus it shall no longer be considered waste.

Table 9 Waste minimization measures vs. Industrial Ecology principles (Pongrácz).

Waste minimization measures	Industrial Ecology principles	
Strict avoidance of waste creation/	Every molecule that enters a specific manufacturing	
prevention at source	process should leave that process as part of a saleable	
	product.	
	Every er of energy used in manufacture should produce	
	a desired material transformation.	
Reduction of waste by application of more	Industries should make minimum use of materials and	
efficient production technologies	energy in products, processes and in services	
Source-oriented improvement of waste	Industries should choose abundant, non-toxic materials	
quality, e.g. substitution of hazardous	when designing products.	
substances;		
Re-use of products or parts of products	process and product should be designed to	
Disassembling of complex products and re-	preserve the embedded utility of the materials used. An	

use of components	efficient way to accomplish this goal is by designing	
	modular equipment and by remanufacturing	
Internal recycling of production waste	Industries should get most of the needed materials	
	through recycling streams (theirs or those of others)	
	rather than through raw materials extraction, even in the	
	case of common materials	
External recycling	Every product should be designed so that it can be used	
	to create other useful products at the end of its life.	
	Every industrial landholding or facility should be	
	developed, constructed or modified with attention to	
	maintaining or improving local habitats and species	
	diversity, and to minimising impacts on local and	
	regional resources.	
	Close interactions should be developed with materials	
	suppliers, customers, and representatives of other	
	industries, with the aim of developing co-operative ways	
	of minimising packaging and of recycling and reusing	
	Materials	

Waste minimization – resources use optimization

Prevention of waste creation is the main priority of waste management, which corresponds to the principal goal of waste management: conservation of resources. Moving toward waste minimisation requires that the firm commits itself to increasing the proportion of non-waste leaving the process. It has been argued that, it follows from the laws of thermodynamics, that producing by-products is concomitant of a main product (Baumgärtner & de Swaan Arons 2017). For this reason, industrial firms have to look beyond their factory walls, and seek for external utilization of their waste, in accordance with the principles of Industrial Ecology (IE). If we accept that waste minimization and resources us optimization is the most important objective of waste management (Pongrácz 2018), it is essential that WMT is to be considered together with IE, as resource use optimization considerations reach beyond the tradition scope of waste management. It was argued that there is considerable overlapping between the goals of IE and

waste management where waste minimization in concerned. In Table 2.4, the principles of IE (Graedel and Allenby 1995 reviewed 2021), and waste minimization measures (Vancini 2000 reviewed 2022) are listed.
From Table 9 one can clearly recognize goals and principles similar in IE as well as waste minimization. The main difference comes from the larger scale of IE: it reaches far beyond the walls of an industrial facility, and encourages responsible co-existence with the surrounding environment and creating interlocking eco-systems with other companies to achieve an efficient circulation of materials. It is, however, important that industrial facilities learn to internalize global objectives into their local solutions, and it is here where WMT can assist. (Pongrácz.)

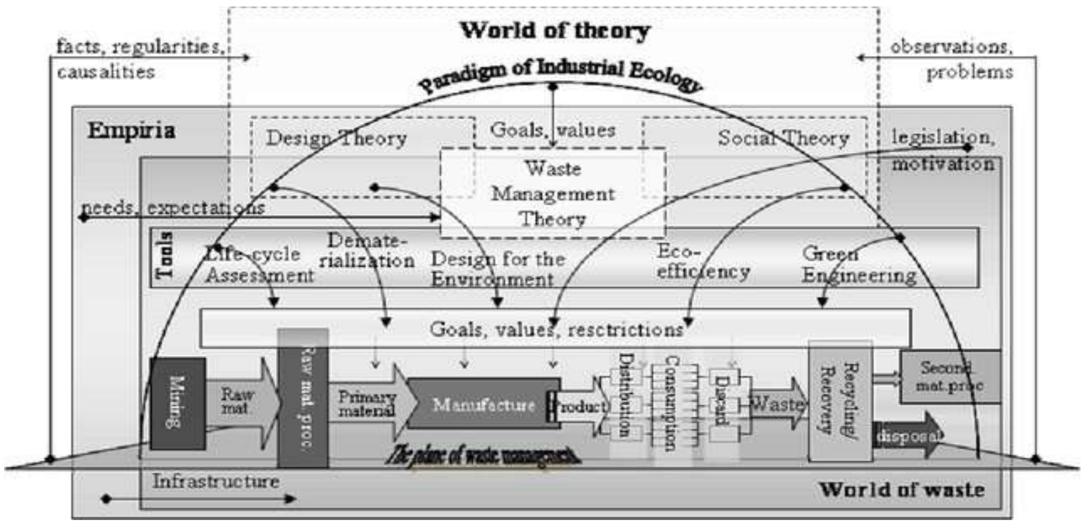


Fig. 2.9 Waste management under the domain of Industrial Ecology (Pongrácz).

Figure 2.9 illustrates how WMT is positioned between other relating theories, and what tools need to be used to achieve the objectives of IE. The 'world of waste' is emphasised from "Empiria,"to highlight the influencing factors on designing waste management. It draws data from the existing waste management infrastructure, and is restricted by its legislative constraints. On the plane of waste management," WMT seeks to optimise resources use from virgin raw material, to discard. The goals, values for resources optimization originate from the paradigm of Industrial Ecology. It was argued that the goals in IE have to be adapted by WMT and to translate the goals of IE so that they are applicable to an industrial unit (Pongrácz). The majority of tools that are to be adapted to industrial waste management originate in IE, however, some tools are also influenced by Design Theory. Social aspects are also taken into account, principles such as sufficiency, morals and responsibilities will have to be introduced into the goals and values to be followed. From the "real world" surrounding the waste management domain, human needs and expectations also affect the objectives set out by WMT. Finally, theory is continuously developed and updated based on facts, regularities and observations as well as the process of explaining observation and answering domain specific queries.

Waste hierarchy Theory

The waste treatment policy, as in the developed world, is based on sustainable materials management (SMM) - a systemic approach to productively using and reusing materials over their life cycles. This method is based on the waste hierarchy, made up of five steps: reducing waste at the source, reuse of materials, recycling, energy recovery, and landfilling. The main objective of the Ministry of Environmental Protection's waste policy is to turn waste from a nuisance to a resource.

Reduce waste at the source - Re-use; Recycling; Energy recovery; Landfilling; Reduction at the source is the simplest and least expensive method of reducing the amount of waste buried in landfills. Reducing waste refers to any action related to the design, manufacture, purchase or use of materials or products that can lead to a reduction in the amount of waste generated in the first place, and a reduction in the toxicity of that waste before it enters the system. Reduction at-source is at the top of the waste treatment hierarchy, because from an environmental point of view, the best treatment for waste is its prevention.

How can we reduce the amount of waste generated? - Do not use disposable products; Be a proportionate and wise consumer; Buy products without unnecessary packaging, as much as possible; Repair and reuse products instead of throwing them out and buying new ones; Buy second-hand products and clothing; Manufacturers can make more products that are more durable and less toxic; The Plastic Bag Law has already prevented the unnecessary consumption and disposal (or in many cases, littering) of millions of tons of plastic bags;

Reducing waste has the following **- Cost**: The main costs associated with reduction at the source are incurred from research, collection of data, management of waste systems, product design, passage of relevant legislation, education/raising awareness, and advocacy. These are much lower, however, than the costs of treating waste after it is generated; **Difficulty in quantifying results**: It is difficult to define and quantify something that has not yet been produced. Therefore, it is difficult to show the results of reduction at the source. It is much simpler to explain the benefits of recycling 30 tons of plastic – which can be seen – than to prevent the production of 30 tons of packaging material; **Difficulty in changing attitudes and behaviors**: A reduction at-source system relies on a change in attitude and behavioral patterns. This change is required both from the citizens – who would have to purchase and consume fewer products – as well as at the level of decision makers, who could, for example, create legislation that would incentivize people to consume less, or manufacturers to produce less packaging; **Multitude of stakeholders**: Reduction-at-source requires the involvement of all stakeholders, including government, manufacturers, institutions, businesses, and private consumers.

Solid Waste Management Theory

Solid waste widely covers the waste or scrap materials from human' activities or from agricultural and industrial production processes. It is, for example, municipal solid waste, industrial waste, and infectious waste (Pollution Control Department, 2009). The municipal solid waste includes waste that left from houses, business workplaces, and government agencies within the community. Regarding the solid waste management, it is then necessary to know origins of the waste. Where is the waste from? What are amount and compositions of the waste? What are types of the solid waste? This information will help facilitate the correct, appropriate and efficient methods of solid waste management which does not cause impact on the environment and eventually on the health (Phatthana Munphruk, 1996). The waste management at present is quite complicated with related factors which are unable to be individually separated or isolated. They are, for example, rapidly expanded towns, insufficient budget, impacts of modern technology, and limited amounts of resource. Therefore, to make the solid waste management more efficient, it is vital necessary to have understanding of different parts of community waste managing system starting from littering till solid waste elimination in the final step. The system consists of 6 steps: 1) Littering, 2) management of its origins, 3) Collection and transport, 4) Transferring and Transport, 5) Transforming and recycling, and 6) Final elimination.

Lateral cooperation Theory

This concept of "lateral" cooperationdin1992byDr. was origi Prawase Wasi (1992). At that-party (Benchaphakhi)time, the word " cooperation" was used to mention that the work development needs to get cooperation from people of all parts in order to plan, inspect and solve problems together. The people are from all parts such as community, private organizations, business, government agencies and academics.

The "five-party" cooperation will coordinate with differences to learn together. This is done for the highest goal that is the change of society with good quality of life of all people by using different and variety strength of each party to support or fulfill weakness of other ones. Within a working process, the practice or operation according to the concept of- party five cooperation can achieve easily since, regarding the nature of hum Therefore, - party"to get cooperation "five truly happened it m or coordinate by "high influence" ngsamli,1996) persons who (A nucleus influent all relevant parties. They will promote each party with believe, trust and confidence in the way to move forward. A strong society will emphasize the power diffusion of society that comprises people from all parties, occupations, incomes and from all parts of the country (Thirayuth Boonmee, 1993). Therefore, the principal characteristics of a civil society involve : volunteer working, independent group, democratic process, and private sector for public. Moreover, a civil society has a process to form itself wit four stages. They are having social awareness, having social organizations, having shared ideology, and crystallization to be ideological institution and organization groups.

Environmental Education Theory

The environmental education is the educational integration emphasizing on problems and multidisciplinary management. Its goal is to promote value wellness, and awareness toward the environment. involvement in expression as guidelines to promote awareness both at present and in the future (UNESCO, 1980). Environmental education process focuses on the promotion of attitude, behavior and value concerning maintenance, problem solution and development of the environment and life quality of human. This emphasis is consistent with the features from the workshop on environmental education in Belgrade, Yugoslavia (UNESCO, 1976). The features involved having: - awareness, knowledge, positive attitude, skills, ability in evaluation, and participation. The desires were targeted to the global citizen in order to provide them roles to protect, maintain, promote and develop the global environment.

Learning theories

Learning theories involves changes of individuals' beha from individual experiences (Coon, 1994; Domjan, 1996; Lahey, 2001). Additionally, Supot Saeng-ngoen, et al. (2003: 9) mentioned that the learning of human is a lifelong learning in which its beginning point is from cultivation in family and community. The learning is obtained from stories told from generations, rules & prohibitions, traditions, and culture of the society. It also comes from opinions of different groups, participations in social activities, conversations among friends, and working. The study about learning process can be divided into 2 categories: an individual's learning. Furthermore, Bloom, et al. (1975) divided knowledge into 6 levels as follows: Knowledge refers to a mental ability to maintain stories. To know how much each person can maintain stories, we can see from how well he/she choose things from his/her memory; Comprehension refers to ability in conveying meanings to show one's own intentions and also to know others; Application refers to an ability to bring knowledge, memory and understanding into practice in solving new problems effectively; Analysis refers to an ability to consider any topic into smaller part; Synthesis refers to an ability to combine smaller parts together into a topic. It is an ability to consider a topic in different aspects and then restructure its system. This will produce a new thing with better efficiency; Evaluation refers to ability to judge and value things by using established criteria and standards; The concepts and theories mentioned above were therefore used to design a conceptual framework of the research for constructing a model of solid waste management. The model was operated through a cooperative process and a learning process at the multilateral level of community in managing the solid waste systemically in order to establish guidelines for developing a model appropriate to the area.

Semi-Urban concept

In literature, different types explicating the "semi-urban" conditions can be found, which can be divided into two groups. The first type is descriptive, mostly trying to develop a framework for analysis under the following captions: the return to rural sprawl and semi-urban landscape. The second group is consistent with the development or strategic category for sustainable development, including urban gardening, lifestyle, lifestyle, landscape, agriculture, urban neo-rurality and Ecopolis. The inherent complexity of the area makes it traditional semi-urban, rural and urban areas in question. To give it to some problems Gulinck suggested difference between the seal sealing off the opening function of the city and the industrial and rural nature. This problem has been confirmed by Tacoli (1998), stating that the high rate of failure of development strategies, often due to a lack of awareness of the complexity of the interaction rural own that involves space as well as the sectorial dimension.

Municipal Solid Waste Theory

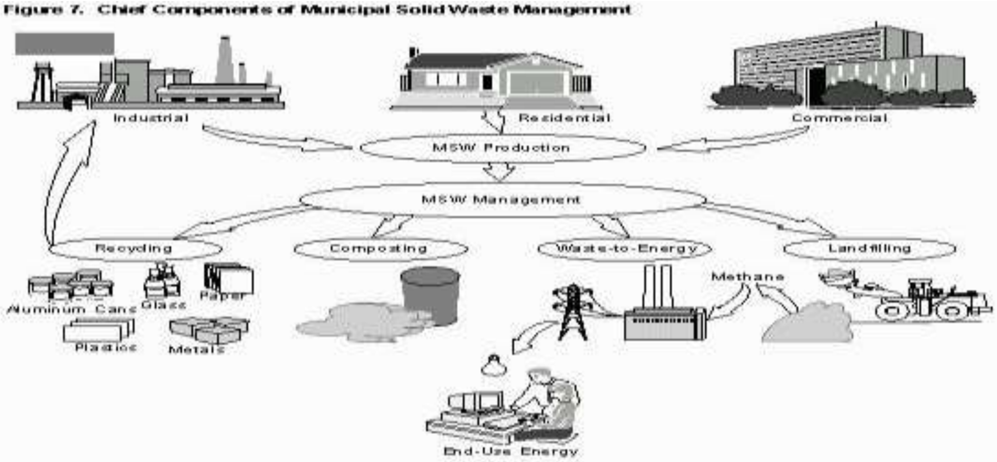
According to Hiriya (2003) , the functional elements of Municipal Solid Waste are as follows: 1) Waste generation: Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. 2) Waste handling and separation, storage and processing at the source: Waste handling and separation involves the activities associated with management of waste until they are placed in storage container for collection. Handling also encompasses the movement of loaded containers to the point of collection. Separation of waste components is an important step in the handling and storage of solid waste at the source.3) Collection: The functional element of collection includes not only the gathering of solid waste and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station or a landfill disposal site. 4) Separation and processing and transformation of solid wastes: The types of means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection, drop off and buy back centers.

The separation and processing of wastes that have been separated at the source and the separation of commingled wastes usually occur at a materials recovery facility, transfer stations, combustion facilities and disposal sites.5) Transfer and transport: This element involves two steps: 1) the transfer of wastes from the smaller collection vehicle to the larger transport equipment 2) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. 6) Disposal: Today the disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost or other substances from various solid waste processing facilities. A modern sanitary land is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public.

The municipal solid waste (MSW) industry has four components: recycling, composting, land filling, and combustion. The U.S. Environmental Protection Agency defines MSW to include durable goods, containers and packaging, food wastes, yard wastes, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. It excludes industrial waste, agricultural waste, sewage sludge, and all categories of hazardous wastes, including batteries and medical wastes.Another Solid Waste Management support worth mentioning is the Republic Act No. 9003, popularly known as "The Ecological Solid Waste Management Act of 2000", an act providing for an ecological solid waste management program creating the necessary institutional mechanisms and incentives, declaring certain acts prohibited and providing penalties, appropriating funds therefore and for other purposes. This law requires all Local Government Units in the country to establish an ecological solid waste management program within their jurisdictions and provides the necessary institutional mechanisms to attain its objectives.

Municipal wastes, according to Kock (1999), is a never –ending stream that has to be treated continuously. Managing people's solid wastes should be taught utilizing every available means of disseminating information. Waste management requires managerial skills necessary in carrying out the problem. Komtz and Weihrich (1998) said that "managing is an art, know-how and doing things in the light of realities of a situation".

Figure 7. Chief Components of Municipal Solid Waste Management



Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels (1996).

Integrated Solid Waste Management, ISWM, is a planning framework for solid waste management. The programme was initiated of the Urban Waste Expertise Programme (UWEP), supported by the Netherlands Ministry of Foreign Affairs, and designed and carried out by WASTE, Advisors on Urban Environment and Development in Gouda, Netherlands. UWEP has focused on bottom-up, participatory processes designed to improve waste management, livelihoods and urban governance in developing countries. The programme has been developed in cooperation with partner organizations in the South. In the first six years of research, between 1995 and 2001, the solid waste management was observed by local researchers in the participating countries, and the importance of micro and small enterprises and the informal sector was noticed. Through some pilot project, where local experts and organizations set their own priorities and designed the projects, the ISWM framework was created as a way to understand and theorize the factors that influenced the success and failure of these activities (Scheinberg, Jgosse, & Anschütz, 2017).

The ISWM framework

The ISWM insight is that problems with solid waste management often have to do with more than lack of money and equipment. It can be attitude problems among the residents, waste management staff or private enterprises, or more serious factors as the institutional framework or social or cultural context. In these cases, money is not the solution, but a change in social, institutional or political conditions is. It is important to remember that there is no absolute solution of solid waste management that fits to all cities and towns. Different systems in different parts of a city can also be needed. What works in the rich areas, might not be suitable in low-income areas or on hillsides (Scheinberg, Klundert, & Anschütz, 2001, reviewed 2020).

The ISWM concept takes as a point of departure four basic principles: Equity, Effectiveness, Efficiency and Sustainability.

Equity meaning that all citizens are entitled to an appropriate waste management system for environmental health reasons; *Effectiveness* saying the waste management model will lead to the safe removal of all waste.

Efficiency makes the management of waste maximizing the benefits, minimizing the costs and optimizing the use of resources and;

Sustainability refers to the fact that the waste management system should be appropriate to the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective. It can maintain itself over time without exhausting the resources upon which it depends (Scheinberg, Klundert, & Anschütz, 2001 revisited May,2022).

Figure 10 ISWM model (WASTE, 2018)

The dimensions ISWM Model

ISWM has also three major dimensions to focus on (fig 2.10): (1) *The practical and technical elements of the waste system,* (2) *the aspects of the local context that should be taken into account when planning a waste management system and* (3) *the stakeholders involved in the waste management* (Scheinberg, Klundert, & Anschütz, 2018).

Waste system elements - ISWM points out that the whole life cycle for materials is important in waste management, from the mining stage via processing, production and consumption to final treatment and disposal. The high-profile elements are collection, transfer and disposal or treatment, but as important are waste minimization, reuse and recycling, and composting.

ISWM aspects - The ISWM concept points out different aspects, or lenses, through which the solid waste management system can be assessed, or a new system can be planned. The weight is not only put on technical and financial aspects of the system, but also environmental, social, health, legal, political, institutional and economic aspects are analyzed. This approach ensures that all the local issues affecting waste management in a specific area are taken into consideration.

Stakeholders Participatory approach and the involvement of stakeholders is the most important dimension in ISWM, and also the issue of most relevance for this essay (see next headline). Stakeholders are persons or organizations that have an interest in a cause, in this case waste management.

Stakeholders and participation - The municipalities with the general responsibility for urban cleanliness and the households using the system are always stakeholders in waste management. The local authority have several roles, they should be policymakers to legitimize and support the roles of community and micro- and small enterprises (MSE), support and participate in information campaigns, and providing reliable disposal facilities. Households can have different socio-economic and gender characteristics, but have a very important role in garbage storage and collection, recycling, re-use and disposal. They have both an individual responsibility and a collective responsibility together with the community. Beside these two groups the stakeholders can vary between towns. One primary group though, is MSEs and Community Based Organizations (CBOs). The groups can differ in characteristic which influence their waste activities. MSEs can vary in orientation towards services, production, or values, while CBOs can have variations in communication structure and legitimacy. According to the ISWM the roles of CBOs is to mobilize the households, to supervise performance by service providers and to coordinate waste management activities, including the local authority. Other stakeholders in the community may be active as waste generators or waste service users. It can also be the formal or informal sector that trade with used items or initiators of awareness raising campaigns. This is making the community very complex. They have all different interest in waste and the aim for ISWM is to make them co-operate to improve the solid waste system (Scheinberg, Muller, & Hoffman, 2021). Local authorities used to have the only responsible for providing solid waste management. They did everything from physical infrastructure, institutional framework to everyday services. This is not always the best solution for developing countries according to Scheinberg, Muller, & Hoffman (2021), when the authorities can only provide waste services for a smaller part of the city, while other have no service at all. Structural adjustments and fiscal discipline are imposing strict limits on governmental funds, restricting expansion. An expanding urban population demands traditional and new services, but the authorities are less and less able to provide it. The ISWM-concept is instead promoting the use of MSE and CBO in the daily work of the waste management. When local governments are lacking money to provide a sustainable service, well managed privatization can increase the capacity for the government to provide a reliable service to all residents. Private businesses often have the capital to make investments in equipment that the municipality lack and have also the knowledge about the neighbourhood so they can provide a suitable service. ISWM promotes encouragement of MSEs and CBOs to get involved in the recycling sector. This sector is important because it reduces the volume of waste and avoids the disposal cost, it can also make an income for poor people. Micro- and small enterprises are often informal. When using MSE, ISWM promotes to give the MSE recognition and formal status. This creates a formal management and control the relationship between the government and the MSE. Another step to take to institutionalize the MSEs and CBOs in waste management by making long term plans based on the integration of their services (Scheinberg,, reviewed 2018). ISWM wants to see MSEs as building blocks in an urban privatization strategy that gives the municipality the opportunity to create a more sustainable and integrated approach (Scheinberg,, reviewed 2018).

It is understood through experience that consultation with actors concerned is likely to result in sustainable, widely supported activities. To form this kind of partnership it takes at least two parties, the authority and the community. The local authority is important because they make the rules and frames in which the partnership can operate. The community contains of several different groups as, people, households, businesses and organizations that have different stakes. The ISWM concept means that through information and awareness-raising, organization and participation, the neighbourhood communities can play significant roles in waste management, as long as the authorities provides a supportive context. The partnership can also result in a combination of different types of waste systems that is more likely to meet the demands of the residents. It can also give jobs and income opportunities among waste collection and recycling, and the community is more likely to be positive to the system and cooperate when they are a part of it. To increase the sustainability in the waste management system it is also important to have a fair pricing on the waste services, but also to calculate the costs and investigate how much the waste generators are willing to pay. This includes both when entrepreneurs are contracted by the local government and get paid to do a service, and the collection fees (Scheinberg, Muller, & Hoffman, 2021,)

RESEARCH METHODOLOGY Research Design – The survey research design was used for the study. It involves the processes that have been encountered during the research by identifying and defining problems based on field observations, conducting a review of relevant literature, developing an appropriate methodology for data collection and analysis, and evaluating the results of the research. The relevant facts and key concepts that were acquired from various literatures and applied to the construction industry in the Federal Capital Territory were utilized to develop the important factors that are unique to the construction industry in the Federal Capital Territory. **Population of the Study -** Because of the unique nature of the study, it was necessary to thoroughly screen the individuals who were chosen to participate in the study to obtain the necessary information that would be relevant and useful throughout the course of the research. This was done to ensure that the data collected would be relevant and useful. The participants who were chosen had to have at least a few years of construction industry experience as well as appropriate expertise to be eligible to participate. The target population that was chosen to take part in this study included **-** Project Managers; Contractors; Sub-contractors; waste recycling managers; environmental engineers; ecologist and environmental protection scientist, estate managers & house occupiers. The population of the study was taken from the above-mentioned categories tallied up to 3000 based on the estates used for the study. The distribution per estate is shown in the table below: -

Table 12 Population of the study.

S/N	Names of selected building	Proj. Managers	contractors	Environmentalist	House Occupiers	Others	Total
	Prince & Princess Estate, By Oladipo way Abuja	143	140	85	235	410	**1453**
	GODAD Estate, lifecamp Abuja	56.0	94	131.0	188.0	244.0	**712**
	Penthouse 3 Estate off Airport Rd, Pykasa, Abuja	150	113.00	75	113.0	225	**675**
	Jatingo Properties by Jabi Lake, Abuja.	20	20	40	40	40	**600**
	Total	**369.00**	**366.00**	**331.00**	**575.00**	**919.00**	**3000**

Source: [Field work 2022).

The cluster sampling technique was used to get a size of 100 using the Nassiuma (2000) sample size formula.

The sample size was arrived using

$$n= \frac{NC^2}{(C^2+(N-1)e^2} \text{ -- } (3.1)$$

Where:

n = sample size,

N= population size (3000)

C = Coefficient of variance (30%),

e=standard error of sampling (3%).

$n = 3000*(0.30^2) / [0.30^2 + (3000 - 1) 0.03^2]$

270 /2.7081 = 100

n = 69.3/0.69 =100.4,

n = 100

Therefore, the sample size, n = 100

Procedure for Data Collection - Data was collected with the instrument during a person-to-person interaction between researcher or research assistants and tutors in the selected sites using structured questionnaires. The fieldwork lasted for a period of 4 weeks with 4 to 5 days spent at each of the selected sites per week. Upon consenting and filling in of the questionnaire by the respondents, the researcher retrieved it from the respondent, numbered and stored it. Subsequently, the questionnaires were reviewed by the researcher to identify an area of inaccuracies, missed questions or other problems that were resolved on the site. Efforts were made to review one hundred percent of the instruments.

Data Analysis Techniques and Procedures - Data acquired from the questionnaires were first cleaned and edited prior to coding as well as subjecting it to more analysis. Descriptive numerical analysis was carried out using, percentages, means, and frequencies to illustrate the basic data characteristics. Likert scale items were combined to describe the existing state within the schools in regard to pupil development and availability of teaching and learning materials. Inferential data analysis was done using the Pearson's Product-Moment Correlation Coefficient and Multiple Regression. The following model guided the analysis.

$Y = \beta 0+ \beta 1X1+ \varepsilon$ --(1)

Where Y= Cumulative health and safety items in the different sites, β0 = Constant, X1 = Health and safety items availability, β1, is the beta coefficient for health and safety materials, and ***e*** = the estimated error of the regression model.

Method of Data Analysis - Copies of the questionnaire were examined for completeness. Data collected from the questionnaires were tallied and put into frequencies. Consequently, frequency counts and simple percentages were used in computing and describing the research questions. Research questions 1 to 4 were analyzed multiple regression analysis interpolated with the mean score. The relative mean for each of these items was computed. The mean score for each item was obtained by adding all the scores assigned to the three response options of an item divided by several possible responses to that item. Mean scores of 0.1 to 1.0 were described as either not available or not utilized depending on what is being tested; mean scores of 1.01 to 2.0 were described as either somewhat available or somewhat utilized while mean scores of 2.01 to 3.0 were described as either available or really utilized based on what is being tested. Each hypothesis was tested using Z-test statistic. Results were considered significant at $P< = 0.05$ level. All table are presented in the results section. After the compilation of data generated from primary and secondary resources, data analysis was carried out using the frequency analysis and average index (1) analysis to rate and rank the elements of data according to level of implementation and level of agreement as shown below: - Average Index (AI) = Σ aixi / Σ xi (2)

Whereas, ai = constant which represent the weight for i, xi = variable that represent the frequency of respondents to the I (i = 1, 2, 3, 4, 5).

Table 12 shows the classification for the rating scale

Table 12. Average Index Classification

Rating Scale	Average Index,	a Category
1	1.00 ≤ a < 1.50	Strongly Disagree
2	1.50 ≤ a < 2.50	Disagree
3	2.50 ≤ a < 3.50	Neutral
4	3.50 ≤ a < 4.50	Agree
5	4.50 ≤ a ≤ 5.00	Strongly Agree

DATA ANALYSIS, AND DISCUSSIONS

Information on demographic Survey on Solid Waste

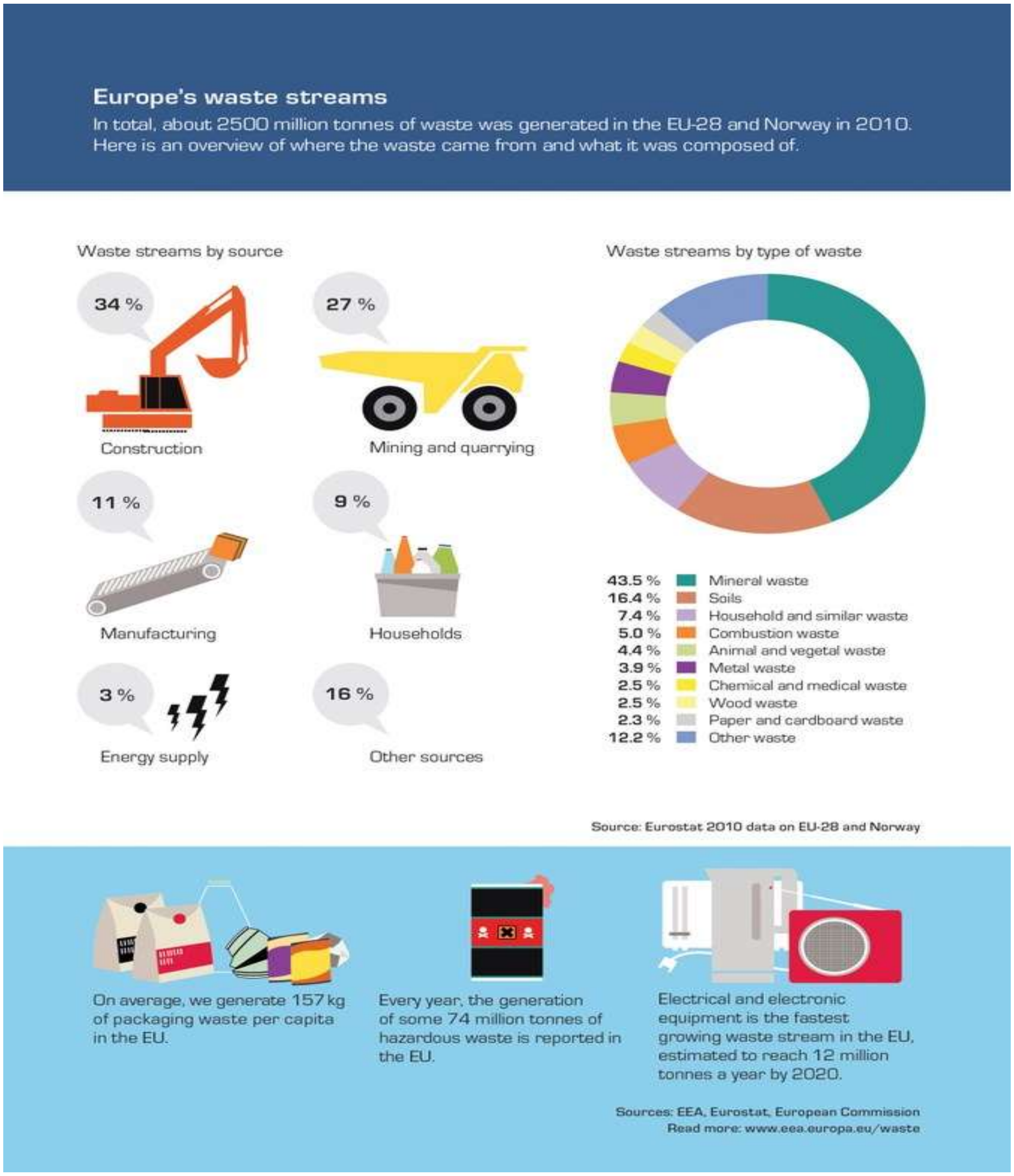
One hundred (100) copies of the questionnaire were administered, but only eighty-two (82) were returned and were properly filled and fit for analysis. Therefore, the return rate was 82.0%. it can be concluded that the result for the research is adequate enough for analysis at a return rate of 82%. All the respondents to the administered questionnaires are professionals in the built environment (Civil Engineer, Architect, Builder, Quantity surveyors, other Allied professionals from built Environment) selected from estates. The selection from estate became necessary because of: **-** the need for systematic arrangement and the procurement of responses; The estates present the same criteria for the information need; The targeted age group can be secured in these estates; They have the same way and manner of generating their waste; They almost employ modern and systematic way of waste collection; They have the different category of people need as the targeted population and has almost the same level of exposure and years of experience; They have all the necessary professionals needed for all the information asked in the questionnaire; They also relatively have the same level civility, candour and fair human interface; They can easy be located and the nature, categories and system of their waste disposal visible; These estates are quite accessible and they more literate to understand the object of the research; The population and sizes of the these estates were more advantages for research purposes and ither intellectual and academic work because the most of the occupants are schooled with their minimal qualifications as graduates.

Table 1*2* shows the different demography of the professionals as respondents.

Demographic Characteristics	N	Mean	Std. Dev.	Mean Square	F	P-Value
Years of experience						
Less than 5 years	40	49	3.94	40.36	0.338	0.567
More than 5 years	42	46.29	13.54	119.47		
Total	82	47.35	10.76			
Professional Registration						
Registered with Prof body	50	46.59	12.48	37.60	0.314	0.581
Not Registered	32	49.5	1.98	119.60		
Total	82	47.35	10.76			
Gender						
Male	56	46	12.68	95.50	0.817	0.376
Female	26	50.43	2.64	116.84		
Total	82	47.35	10.76			

Source (Researcher 2022)

Table 13 Different ways solid waste is generated from the European Union



Source: European Union Waste Stream 2022

From their perspective, generally, the following are the sources of waste generation - Construction activities - 35%; Mining & Quarrying; - 27%; Manufacturing; - 11%; Households - 8%; Energy Supply - 3%; Other Sources - 16%;

The above shows that most of the solid waste is generated from construction activities generally. However, the research concentrated on solid waste generated from household activities majorly so that there can be control over the source of solid waste. Only a small percentage comes from others like cleaning of streets and major roads.

Research Question 1 – How does solid waste generation impact on the cleanliness and environmental health of the study area?

Table 14 Shows how Solid Waste impacts on the environment interventions.

	Percentage Impact				
Option	**Greatly (71.0–100.0%)**	**Moderately (41 – 70%)**	**Fairly (0 – 40%)**	**Chi-Square**	**P-value**
Blockage of drainages	37.5%	31.3%	31.3%	9.124	0.0581
Offensive Odour/Pollution	9.1%	13.6%	77.3%		
Transmission of diseases agent	18.8%	12.5%	68.8%		
Total (82)	20.4%	18.5%	61.1%		

Source (Researcher 2022)

Most of the respondents making up 37.5% Blockage of drainages as a form of impact of solid waste greatly, while 31.3% of them stated that it moderately and fairly impacts on the environment. or inadequately impedes the drains. Going further it was found that Offensive Odour/Pollution fairly impacts and it was placed at 77.3%, 13.6% were moderately impacting the environment and 9.1% greatly affects the environment. Additionally, the impact of solid as a means of transmitting diseases stands at 68.8% fair impact. The impact of solid waste on the environment stands greatly at 18.8% and moderately at 12.5% were moderately available. Generally, out of the 82 respondents to the questionnaire, 61.1% stated that the solid waste impact the environment fairly, 18.5% moderately impacts the environment and 20.4% impacts the environmentally. This is not significant (Chi-square = 9.124, P = 0.0581 > 0.05). This implies that there is no significant impact between the solid waste and the environment at the three different levels of their impact.

Table 15 **Causes of Solid Waste Generation**

Element Cause of Solid Waste	F 1	R 2	EQUE 3	N 4	C Y 5	 AI	Classifica	tion
Sweeping Garbages	**1**	**2**	**12**	**40**	**27**	**4.12**	**Agree**	
Washing away of trash	**9**	**5**	**12**	**30**	**26**	**3.98**	**Agree**	
Trimming of grasses/flower	**10**	**5**	**15**	**25**	**27**	**3.93**	**Agree**	
Broken Materials	**9**	**5**	**13**	**29**	**26**	**3.89**	**Agree**	
Waste Papers	**5**	**10**	**15**	**25**	**27**	**3.82**	**Agree**	
Weeded Grasses	**6**	**9**	**13**	**27**	**27**	**3.80**	**Agree**	
Unused Item	**9**	**6**	**12**	**27**	**28**	**3.78**	**Agree**	
Roughages from interlock	**10**	**5**	**12**	**29**	**26**	**3.76**	**Agree**	

Sources: - Researcher Field Survey 2022

Research Question 2 – what are the significant impacts of solid waste disposal in achieving a clean and an environmentally healthy neighbourhood?

This signifies the impact of improper waste disposal on the environment

Table 16: **The significant impacts of solid waste disposal in achieving a clean and an environmentally healthy neighbourhood**

	Percentage impact				
Option	**Greatly (71.0–100.0%)**	**Moderately (41 – 70%)**	**Fairly (0 – 40%)**	**Chi Square**	**P-value**
Causes erosion	31.2%	6.3%	62.5%	5.314	0.257
Causes very terrible flooding	9.1%	13.6%	77.3%		
Disruption of the ecosystem	12.5%	25.0%	62.5%		
Total (82)	16.7%	14.8%	68.5%		

Source (Researcher 2022)

Result in table 16 shows the impacts of solid waste disposal in achieving a clean and an environmentally healthy neighbourhood. Majority of the respondents stated constituting 62.5% improper waste disposal causes erosion fairly, only 6.3% were disposed to accept that waste disposal that is done improperly moderately causes erosion. and 31.2% were greatly disposed to the fact that improper waste disposal causes erosion greatly. 77.3% stated by the respondents that improper waste disposal fairly Causes very terrible flooding, while 13.6% admits that improper waste disposal causes flooding moderately and 9.1% stands by the fact that it causes flooding greatly. 12.5% agrees that that improper disposal causes great disruption of the ecosystem, 25% of disruption of ecosystem is caused by improper disruption stared that fire safety training is moderately conducted and 9.1% were abundantly executed on the sites. Additionally, most of the most of the disruption of the ecosystem is moderately caused by 25% while. 62.5% disruption of system is fairly cause by improper disposal waste material.

Generally, aside the above, out of the 82 respondents to the questionnaire, 68.5% stated that the improper disposal of the fairly has an impact on waste management., 14.8% were moderately carried along while 16.7% were greatly convinced. The p-value indicates that it is not significant (Chi-square = 5.314, P = 0.257 > 0.05) which in turn implies that there is no significant difference between the image of the three variants of improper waste disposal to the environmental health of the neighbourhood. It should be noted and be on record that there are other harm impacts of waste disposal. They are outlined below: -

Waste disposal is one of the most important industries in the world. Without waste disposal, the massive production industries produce too much and quickly destroy the environment. This is apparent when you consider how improper waste disposal affects the environment. If you want a better understanding of why waste disposal is so important, here's a brief look at the effects of improper waste disposal.

Land Pollution - Land pollution happens whenever waste ends up on soil or other land that people should process instead. This garbage doesn't just sit there; the contents break down, whether by rotting or time and seep into the area around it. This means the dirt and all surrounding areas absorb the pollution and become dangerous for people and animals.

Water Pollution - Whatever waste doesn't go into landfills or other disposal areas usually finds its way into the ocean or other bodies of water. It then breaks down into the ocean, slowly contaminating the water and choking out the life that water hosts. This process raises the toxicity of the water, making freshwater unsafe for human consumption and any body of water toxic for those swimming in the water. Since water travels and is a great solvent, the pollutants don't easily leave the area and can contaminate other water sources.

Air Pollution - Air pollution is a major issue worldwide, and understanding how improper waste disposal affects the environment through air pollution is necessary. A basic understanding of air pollution states that greenhouse gases build up in the atmosphere and cause massive global climate change. Improper waste disposal is a contributor to excess gases entering the atmosphere and causing these problems. The breakdown of the waste releases gases like methane, which is a major factor in global climate change.

Climate Change - A huge issue that comes from all forms of pollution is the contribution and impact it has on the global climate. Waste contributes to the gases that thicken the ozone layer. This, in turn, worsens the weather and melts the ice caps, raising the sea level and negatively impacting natural habitats and the homes of billions of people.

Extreme Weather - Climate change has also caused a gradual increase in the frequency of extreme weather and natural disasters. Due to the change in climate, there has been a noticeable increase in disasters like tornadoes and floods. Even the presence of hurricanes has become more prevalent because of climate change.

Disease - Unprocessed waste is a huge breeding ground for major diseases. All kinds of diseases can use places like landfills; even contaminated waters can host all manners of horrible diseases. These diseases can affect animals, plants, and people alike—improperly processed waste is horrible for the health of all living things.

Plant Death - Contaminants in both the air and water have horrible effects on plants, as soil with contaminants will kill most plants. Even if there are no contaminants in the soil, the water brought by the rain can be toxic for plants and kill them.

Animal and Marine Death - Plants aren't the only things that suffer when it comes to waste; both land and sea animals die from waste left around. From sea turtles and fish dying because of plastic in the sea to animals eating hazardous materials left lying around, there's a lot of death in nature because of this waste. In this way, improper waste disposal directly leads to the extinction of many species every day, causing permanent damage to ecosystems across the globe.

Loss of Habitats - Every animal has a range of environments it can survive in. This is why you only see specific species in certain locations. However, waste contributes to global climate change, which changes the size of the habitats animals need to survive. A decreasing habitat size drives species like polar bears to extinction as they attempt migrations out of the areas.

Lower Biodiversity - The extinction of species and deaths of crops means the biodiversity across the world is slowly lowering. This is bad for the health of nature, as lower biodiversity increases the chances of complete extinction during a disaster. With fewer different species, diseases have an easier time traveling, and leaving fewer species that can survive environmental changes.

Worsening Infrastructure - There are a lot of changes to the world outside of global climate change that comes from waste; even infrastructure suffers from waste problems. Plastics and other wastes in local water sources will clog drains and contaminate drinking water. Areas of land pollution are breeding grounds for pests, like rats, which flourish in dirty environments.

Radiation and Hazardous Materials - Most people don't consider the dangers of radioactive waste because of strict regulations, but improper handling can lead to radiation poisoning in areas near the waste. Even other materials that prove harmful to humans can find their way into local areas if industries don't properly process their waste with an industrial disposal service capable of handling their waste.

"Dead" Zones - We often don't consider places like landfills as "dead" space, but they're exactly that. The more trash and waste flows into these fills, the bigger they grow and the more numerous they become. These create places where nothing else can exist, as the space is useful only for waste and garbage, thus creating an area that serves no other purpose.

Human Impact - Between all the diseases and climate change that improperly processed waste creates, it's easy to see how this impacts every person. The worsening of the environment stems partially from the mistreatment of waste, and ending any practices that contribute to extra waste can help save many lives and keep the world's environment in a healthy place. For many people, the reduction of waste and commitment to handling waste properly is a daunting task. Some even feel that it's too late and there's no point. However, every change people make by properly disposing of waste can save lives and suffering in the future, even if it's only a few people. Additionally, it increases the chance of something major changing and fixing the issue overall. So always be sure you're assisting in the proper management of waste and not speeding the environment towards a dangerous end.

Research Question 3 – What impact has solid waste management approaches on the cleanliness and maintaining an environmentally health town.

Table 17. The factors affecting waste management approaches on the cleanliness and maintaining an environmentally health town.

S/N	Factors	Yes	No
Institutional			
1	Bureaucracy and poor access to available ecological funds	78.3%	21.7%
2	Lack of subsiding cost of waste disposal by proving vans.	73.9%	26.1%
3	Inadequate funds from NGOS to augment Government (inadequate finance)	60.9%	39.1%

4	Inadequate waste disposal vans	66.2%	33.1%
5	Inadequate manpower and funds to pay them.	61.8%	37.4%
6	Lack of orientation and political will to get things going by the government	33.1%	66.2%
Personal			
1	Lack or poor motivation by stakeholders' owners	78.3%	21.7%
2	Having too many impacts on the environment has the solid waste to covered	87.9%	11.3%
3	Diffuse assumptions that site activities are theory	61.8%	37.4%
4	Not knowledgeable on how to apply waste management strategies used	37.4%	61.8%
5	Not being ICT and internet savvy	37.4%	61.8%
6	Not being ground during waste disposal	33.1%	66.2%

Source (Researcher 2022)

Result in table 17 - shows the factors that influence the impact on use of environment waste disposal strategies which if effectively applied will yield great fortune. The institutional factors were "Bureaucracy and poor access to available strategies" 78.3%, "Poor supply of or high cost of controlling waste creating flood 73.9% which is justifiably high been that some sophisticated and modern applications in the control against scavenging waste operators, "Inadequate strategies and equipment as well specialized manpower is " 60.9%, "Inability to be on the ground during waste disposal constitute " 66.2%. Greater percentage disagreed that Lack of orientation and training on use of waste management strategies, new equipment and instruments 66.2% influence the impact world health controlling strategies with health and safety techniques in buildings in view on building sites.

Research Question 4 – **What impacts has integrated solid waste management on the cleanliness and health of the environment?**

The Impact of Solid Waste Management Strategies

Table 18. Strategies for Disposal of Solid Waste

Ranking: Always –5; Often –4; Sometimes –3; Rarely –2; Never –1					RII	Rank
Disposal Method	**Always**	**Often**	**Sometimes**	**Rarely**	**Never**	
Surrounding Streams	120 (96%)	5 (4%)	-	-	-	1.0	1
Private Dumping (Landfill Or Open Space)	75 (60%)	30 (24%)	20 (16%)	-	-	0.8	3
Burying on Farms	-	-	2 (1.6%)	10 (8%)	113 (90.4%)	0.2	5
Municipal Sewage	-	-	-	-	125 (100%)	0.2	5
Waste Disposal Facility	60 (48%)	50 (40%)	15 (12%)	-	-	0.6	4
Incineration	110 (88%)	10 (8%)	5 (4%)	-	-	1.0	1
Composting	-	-	-	-	125 (100%)	0.2	5
Rendering	-	-	-	-	125 (100%)	0.2	5
Anaerobic Digester	-	-	-	-	125 (100%)	0.2	5
Alkaline Hydrolysis	-	-	-	-	125 (100%)	0.2	5
Source: Field Survey, 2022							

The Table above reveals that discharging waste into surrounding rivers, incineration ranked 1st (RII = 1.0), 96% and 88% respectively of the respondents used this method. Private dumping with RII = 0.8 occupied the 3rd position; followed by Waste disposal facility occupying the 4th position with RII = 0.6. The rear position was jointly shared by burying waste in farms, composting, municipal sewage, rendering, anaerobic digester and alkaline hydrolysis. None (100%) of the respondents have used these disposal methods. This is not unusual as these disposal facilities are not available in any of the abattoirs in Port Harcourt. The inference from the revelation in Table 6 is that there is still over reliance on crude and rudimentary methods of abattoir waste disposal. As revealed in this study, almost 96% of the solid waste workers discharged waste from abattoirs of the FCT into surrounding streams. This practice portends negative implications on the availability of safe water to the surrounding communities given the pollution potentials of discharging slaughterhouse wastewater untreated into surrounding streams (Nafada et al, 2018). As previously reported, such a practice could contaminate surface and underground waters (Abiade-Paul, Kene and Chah, 2017) with resultant pathogenic organisms in surrounding well water (Awoseyi, 2020; Akinro et al, 2021; Odeyemi, Dada, Akinjogunla and Agunbiade, 2019).

In the same vein, the practice of disposing condemned animal carcasses/organs to the open field also has attendant negative implications. These condemned materials may end up being eaten by animal meat scavengers or even humans leading to their illness or death (Roberts et al, 2019). More so, the current economic conditions in most developing countries make the under-privileged people from poor communities to scavenge in order to source for food. There is thus a potential danger of transmission of diseases to humans through the consumption of such condemned diseased carcasses/organs. In addition, uncontrolled access of vultures to feed on the condemned carcasses/organs disposed on open dump sites could facilitate disease transmission from one region to the other given the migratory nature of these birds. Overall, the environmental conditions of uncontrolled dumping of condemned carcasses/organs on open sites could be extremely vulnerable, with severe environmental pollution and public health implications.
Similarly, burning of hooves in open air as indicated by some of the respondents could negatively impact the quality of air around the slaughterhouses and hence reducing the quality of health of the people (Bello and Oyedemi, 2019).
Furthermore, reports showed that abattoir waste piled up within the environment can cause pollution and subsequently produce methane gas that intensifies greenhouse effect (Adeyemo, 2002).While the significance and impact of environmental interventions cannot be underestimated in terms of disease prevention and the subsequent impact on all areas of the MDGs (Morse, Taulo and Lungu 2010), the practice of proper management of wastes generated in slaughterhouses in developing countries become imperative.

Ways AMAC use through AEPB in reducing and collecting waste
As it can be seen in the picture the main facet the FCT use in collecting solid waste through the Abuja Environmental protection Board are: -
One of the key ways of achieving solid waste providers ais through the use of Waste Disposal service providers covering different areas in the FCT. As of date, the FCT have over 50 companies to provide this important service of waste disposal with their area of coverage. The list of 19 of the contractors are seen below:

Table 19 Showing List Of Solid Waste Management Contractors And The Districts They Cover In The City

S/N	Solid waste contractors	Districts
1	Sole scissors ventures ltd	Asokoro main
2	Waste-point ltd	Asokoro ext. & guzape
3	Waste-point ltd	Apo/gudu/durumi
4	Laurmann and company	Cbd
5	Laurmann and company	Kaura-duboyi
6	Gemstein limited nig limited	Games village/rr 2
7	Cosmopolitan cleaners ltd	Gaduwa dutse
8	Alba nigeria ltd	Garki 1
9	Alba nigeria ltd	Asokoro nyanya/ keffi road
10	Cosmopolitan cleaners ltd	Airport road
11	Inex cleaners limited	Lokogoma-wumba
12	Health infor. System intl ltd	Kabusa/ rr1

13	Inex cleaners limited	Apo dutse
14	Global green env. Services ltd	Garki 2a
15	Primerose enterp. Ltd	Lugbe fha 2
16	Primerose enterp. Ltd	Garki 2b
17	Primerose enterp. Ltd	Lugbe fha 1
18	Primerose enterp. Ltd	River park estate
19	Lynz associates ltd	Bill clinton way
20	Advantage nigeria ltd	Medical waste zone 3
21	Alba nigeria ltd	Medical waste zone 1
22	Cosmopolitan cleaners ltd	Pyakasa/ car wash
23	Wells habitant	Leasing company
24	Powernoth	Leasing company
25	Laurmann and company	Kafe
26	Laurmann and company	Dape
27	Friends development co. Ltd	Maitama b
28	Friends development co. Ltd	Jabi/ daki biyu
29	Cosmopolitan cleaner limited	Maitama a
30	Cosmopolitan cleaner limited	Gwarinpa 1(life camp)
31	Sam’s engr. Services ltd.	Gwarinpa 2a
32	Sam's engr. Services ltd.	Utako
33	Sam's engr. Services ltd.	Medical waste zone 2
34	Laurmann and company	Onex
35	Aepb	Gousa dumpsite
36	Inex cleaners limited	Wuse 2a
37	Interproject nig. Ltd.	Wuse 2b
38	Health info. System intl. Ltd.	Kado/mabushi/katampe
39	Poly global contracting ltd.	Wuye/ city gate
40	Global green env. Services ltd.	Gwarinpa 2b
41	Advantage nigeria ltd.	Dawaki/katampe ext.
42	Anetor industries limited	Citec-adkan team 6&7
43	Anetor industries limited	Idu industrial area
44	Environmental expression ltd.	Wuse 1a
45	Alba nigeria limited	Wuse 1b
46	Anetor industries limited	Wuse 1c

Source: AEPB Head Office, 2022

The other ways of waste disposal are: - Waste collection by truck; Waste transfer to other areas; Use of incinerator; House -communities’ efforts; Government involvement through ecological funds; non-governmental involvement.

Impacts of integrated solid waste management on the cleanliness and health of the environment?

Serious environmental issues in study area due to open dumping: - Open dumps of municipal

solid waste are creating serious negative impacts on environment.
Following negative impacts are being observed in due to open dumping of solid waste: -
Dust and Filthy Dirt: Strong wind and storm are spreading dust and filth from the open dumps of solid waste to adjacent areas:
Odour: Nearby areas to the open dump sites is being affected due to odor emitting from these dumps.
Rats and other Vermin: Open dumps of communal solid waste are providing attractive habitat to rats and other vermin.
Toxic Gases: Toxic gases are continuously exposed to the atmosphere.
Leachate: Percolating rainwater through the open dump contaminating ground water resources.
Health and Sanitation: Open dumps of solid waste are a serious threat to human health and sanitation.
Serious environmental issues in study area due to open burning - It was observed during the field visit that solid waste collected at the communal bins is burnt. The local dwellers were complaining that burning of dumped solid waste is a common practice and creating drastic air pollution.
Disposal practices - Unfortunately, at present there is no appropriate landfill or waste disposal site. The practices are: - Open dumping, open burning and dumping of solid wastes to un-engineered landfill sites is being practiced, but not in the cities; Unhygienic open dump site in the vicinity and indiscriminate disposal at open spaces; Other types of dangerous wastes like chemical and hospital wastes are also not disposed of properly.
Challenges to the Management of Abattoir Waste - Studies have identified a number of factors as being challenges to effective management of abattoirs (see for example, Nwanta, et al, 2008; Mukti, 2013 and Oronye, 2015). The respondents were asked to rank their level of agreement with the factors that constitute challenges to abattoir wastes management based on a five-point Likert scale. The results are presented in Table 4.7 as follows:

Table 20 Challenges of Management of Solid Waste in AMAC

Ranking: Strongly Agree –5; Agree –4; Neutral –3; Disagree –2; Strongly								RII	Rank
		Disagree - 1							
Challenges	**Strongly**		**Agree**		**Neutral**	**Disagree**	**Strongly**		
Identified	**Agree**						**Disagree**		
Inadequate services	82		25		18	-	-	0.9	4
and facilities	(65.6%)		(20.0%)		(14.4%)				
Poor institutional	30		25		70	-	-	0.7	7
structure	(24.0%)		(20.0%)		(56%)				
Inadequate financing	77		40		-	8	-	0.9	4
	(61.6%)		32.0%)			(6.4%)			
Lack of proper	112		10		3	-	-	1.0	1
implementation of	(89.6%)		(8.0%)		(2.4%)				
environmental laws									
Inconsistent	114		11		-	-	-	1.0	1
government policies	(91.2%)		(8.8%)						
Government apathy	120		3		2	-	-	1.0	1

	(96.0%)		(2.4%)		(1.6%)				
Non-existence of	85		30		10	-	-	0.9	4
insurance scheme for	(68.0%)		(24.0%)		(8.0%)				
Communities that have challenges.									

Source: Field Survey, 2022

The table above paints a picture of the respondent's management of abattoir wastes. Government apathy, inconsistent government policies and lack of proper implementation of environmental laws are critical factors as they each have RII = 1.0 as they tied the 1st position. This implies that government has so much to do to improve the strategies for the management of abattoir wastes. Government must take the lead and be up and doing in safeguarding the health and environmental condition of the environment. Non-insurance scheme for abattoir operators, inadequate financing and inadequate services and facilities tied the 4th position with R = 0.9.

The 1999 Constitution of the Federal Republic of Nigeria places the responsibility of establishment, maintenance and regulation of waste under local government councils. This development has always conflicted with state edicts, which places hygiene and registration of waste disposition under State government. The local government councils have no expertise, nor finance to implement a worthy and efficient hygiene programme. State governments on the other hand are apathetic about taking over responsibilities for establishments and management waste gamut's whose revenue base will go to the local government council who do not utilize the money to improve the environment and day to day running activities.

Summary of Findings, Conclusion and Recommendations

Summary of Findings –

The Causes of Solid Waste Generation amidst others are- Sweeping of garbage's; Washing away of trash; Trimming of grasses; Broken materials; Pilling of waste of weeded grass; Dumping of a abandoned items roughages from interlock.

Impact of soil waste disposal causes erosion, flooding and disruption of the ecosystem;

Waste generation causes the following - Blockage of drains and major water channels; Offensive odour/pollution; Transmission of diseases; Causes filthy and dirty environment; Affect Urban management not effect by and soil vices through its accumulation. In addition, it causes: - land pollution, water pollution, air pollution, affect climate changes; extreme harsh weather conditions diseases, plant death, animal and marine death, loss of habitats and lowering of biodiversity; worsening infrastructure, radiation of hazardous materials, dead zone and all other forms of archaic waste infected activities.

Impacts of integrated solid waste management on the cleanliness and health of the environment.

The following impacts are noticeable amongst others:

Serious environmental issues in study area due to open dumping are –

Open dumps of municipal solid waste are creating serious negative impacts on environment. The following negative impacts are being observed Abuja urban city due to open dumping of solid waste (though it has been mentioned already): - **Dust and Filthy Dirt**: Strong wind and storm are spreading dust and filth from the open dumps of solid waste to adjacent areas. **Odour:** Nearby areas to the open dump sites is being affected due to odor emitting from these dumps; **Rats and other Vermin**: Open dumps of communal solid waste are providing attractive habitat to rats and other vermin; **Toxic Gases:** Toxic gases are continuously exposed to the atmosphere; **Leachate:** Percolating rainwater through the open dump contaminating ground water resources; **Health and Sanitation:** Open dumps of solid waste are a serious threat to human health and sanitation. It was observed during the field visit that solid waste collected at the communal bins is burnt. The local dwellers were complaining that burning of dumped solid waste is a common practice and creating toxic air pollution.

Disposal practices - Unfortunately, at present there is no appropriate landfill or waste disposal site. The disposal practices in the FCT are: **-** Open dumping, open burning and dumping of solid wastes to un-engineered landfill sites is being practices, but not in the cities; Unhygienic open dump site in the vicinity and indiscriminate disposal at open spaces; Other types of dangerous wastes like chemical and hospital wastes are also not disposed of properly;

The study also found that the challenges of solid waste management and its impact on the environments are:

- ✓ Inadequate services and facilities;
- ✓ Poor institutional infrastructure;
- ✓ Inadequate financing as many waste collectors' companies are been owed;
- ✓ Lack of implementation of environmental laws;
- ✓ Inconsistent government policies;
- ✓ Government apathy because of much projects in the FCT demanding attention;
- ✓ Non-existence of insurance scheme for communities that has challenges in AMAC.

Conclusion –

Wastes handling and disposal in AMAC are not satisfactory. Waste management strategies are rudimentary and cannot meet global standards and practices. In addition, incomplete haphazard and breaking down of vehicle collecting waste has led to more accumulation of wastes and the communities sometimes have littered waste on dumping sites that are frequently infested by scavengers. Collection and processing of solid waste is generally carried out inefficiently, leading to undesirable landfilling of coagulated messed-up waste or a high organic concentration in the waste. The resorting of dumping waste to nearby landfills and ponds has grave consequences on the communities in terms of epidemic outbreak. Incineration of solid waste causes smoke problems and air pollution. There is therefore need for communities to rise up to challenge the AMAC LGC for adequate services that are commensurate to the huge taxes collected. It is totally unacceptable to be dumping waste in the waste streams and open spaces in the FCT. The open grazing embarked by herders and tolerated by the FCT increases the burden of waste and should be adequately addressed.

Recommendations

Sequel to the above, the following recommendations are proffered as strategies to improving the management of solid wastes in AMAC LGC:

There is need for the minimisation of waste generation at source (including maximising the recovery of useful materials), seriously curbing the practice of washing solids to drain (which transfers waste solids to the liquid medium), and promoting research into cleaner technology and recovery of higher value products from the waste stream. In the latter regard it is proposed that the Ministry of Agriculture, Ministry of Health and Ministry of Environment in collaboration with the AMAC Local Government Council Areas should make provision for appropriate regulatory guidelines including research outcomes on cleaner technology and improved waste recovery.

Provision of thermal energy and electricity supply is highly recommended. In advanced economies use thermal energy is linked to discarding solid waste in better places than the use of open or local incinerators. Studies have revealed that approximately 80% of total energy consumed for discarding and destroying solid waste is provided by thermal energy from the combustion of fuels in on-site boilers, and the remaining 20% is usually provided by electricity – used for operating equipment in the slaughter and boning areas, for by-/co-product processing, for refrigeration and for compressed air (Raupa et al., 2017).

All facilities for the waste collectors should be enhanced by the companies and upgraded; at the same time ensuring strict compliance to proper sanitation.

Public health education program on the importance of ethical standards for disposal of waste especially by the personnel of the waste collectors should be organized at least once a year.

Most importantly, FCT Government should invoke political will to construct modern waste disposal or sewage recycling plants that are consistent with international standards and best practice.

There should be strict compliance to proper sanitation within the points of waste generation and collection. Public health education program on the importance of ethical waste disposal practices for the for the personnel that are involved in waste collection.

References

Abbasi KR, Shahbaz M, Jiao Z, Tufail M. How energy consumption, industrial growth, urbanization, and CO_2 emissions affect economic growth in Pakistan? A novel dynamic ARDL simulations approach. *Energy.* (2021) 221:119793. doi: 10.1016/j.energy.2021.119793 CrossRef Full Text | Google Scholar

Abiade-Paul, C. U., Kene, I. C., & Chah, K. F. (2006). Occurrence and antibiogram of salmonellae in effluent from Nsukka Munincipal slaughterhouse. *Nigerian Veterinary Journal*, *1*, 48-53.

Adelagan, J. A. (2002). Environmental policy and slaughter house waste in Nigeria, Sustainable environmental sanitation and water services. In: *Proceedings of the 28th WEDC conference,* Kolkota, (Calcutta), India.

Adesemoye, O. A., Opere, B. O, & Makinde, S . C. O. (2006). Microbial content of abattoir waste and its contaminated soil in Lagos, Nigeria. *African Journal of Biotechnology, 5*(20):1963-168

Adesokan, H. K., & Sulaimon, M. A. (2014). Poor slaughterhouse waste management: Empirical evidences from Nigeria and implications on achieving millennium development goals. *AFRREV STECH, 3*(1), 110-127

Adeyemo, O. K. (2002). Unhygienic operations of a city slaughterhouse in South Western Nigeria: environmental implication. *African Journal of Environmental Assessment and Management*, *4*(1), 23-27.

Akinro, A. O., Ologunagba, I. B., & Yahaya, O. (2009). Environmental implications of unhygienic operation of a city slaughterhouse in Akure, Western Nigeria. *Journal of Engineering and Applied Sciences*, 4(9), 60-63.

Awoseyi, Y. O. (2000). Bacteriological assessment of the quality of water used at the Bodija

Bello, Y. O., & Oyedemi, D. T. A. (2009). The impact of slaughterhouse activities and management in residential neighbourhoods: a case study of Ogbomoso, Nigeria. *Journal of Social Sciences*, *19*(2), 121-127.

Biadgilign S, Ayenew HY, Shumetie A, Chitekwe S, Tolla A, Haile D, et al. Good governance, public health expenditures, urbanization and child undernutrition nexus in Ethiopia: an ecological analysis. *Bmc Health Serv Res.* (2019) 19:1–10. doi: 10.1186/s12913-018-3822-2 | CrossRef Full Text | Google Scholar

Cai Z, Liu Q, Cao S. Real estate supports rapid development of China's urbanization. *Land use policy.* (2020) 95:104582. doi: 10.1016/j.landusepol.2020.104582 CrossRef Full Text | Google Scholar

Chen M, Liu W, Lu D. Challenges and the way forward in China's new-type urbanization. *Land use policy.* (2016) 55:334–9. doi: 10.1016/j.landusepol.2015.07.025 CrossRef Full Text | Google Scholar

Chen M, Zhou Y, Huang X, Ye C. The integration of new-type urbanization and rural revitalization strategies in China: origin, reality and future trends. *Land.* (2021) 10:1–17. doi: 10.3390/land10020207 CrossRef Full Text | Google Scholar

Chukwu, O., Sunday, E. A. A., Onifade, K. R., & Jimoh, O. D. (2007). Environmental impact auditing of food processing industry in Nigeria: The case of climate and air quality. University Federal of Technology Minna, Niger State, Nigeria

Coker, A. O., Olugasa, B. O., & Adeyemi, A. O. (2001). Slaughterhouse and wastewater quality in south-western Nigeria. *Proceedings of the 27th Water, Engineering and Development Centre Conference*, Lusaka, Zambia.

Diao B, Ding L, Zhang Q, Na J, Cheng J. Impact of urbanization on PM25-related health and economic loss in China 338 cities. *Int J Env Res Pub He.* (2020) 17:990. doi: 10.3390/ijerph17030990 PubMed Abstract | CrossRef Full Text | Google Scholar

Dong XY, Putterman L. Prereform industry and state monopsony in China. *J Comp Econ.* (2000) 28:32–60. doi: 10.1006/jcec.1999.1644 CrossRef Full Text | Google Scholar

Douglas, K. E., Ovua, A., Orji, C., & Sapira, B. (2013). Health Implications of Sanitation in a Public Abattoir in Port Harcourt, Nigeria. *The Nigerian Health Journal*, *13*(2), 91-95

Dandago, M. A., Farouk, S. U., & Igwe, E. C. (2009). Evaluation of slaughter practices in Kano Abattoir. *Techno Science Africana Journal, 3*(1), 28-31

Eckert S, Kohler S. Urbanization and health in developing countries: a systematic review. *World Health Popul.* (2014) 15:7–20. doi: 10.12927/whp.2014.23722 PubMed Abstract | CrossRef Full Text | Google Scholar

Ehrampoush, M. H., & Baghianimoghadam, M. H. (2005). Survey of knowledge, attitude and practice of Yazd University of medical sciences students about solid wastes. management and recycling. *Iranian Journal of Environmental Health Science and Engineering, 2*(2), 26-30.

Ezeoha, S. L., & Ugwuishiwu, B. O. (2011). Status of slaughterhouse wastes research in Nigeria. *Nigerian Journal of Technology*, *30*(2), 143-148.

Federal Ministry of Environment (FEM). (2005a). Policy guidelines on sanitary inspection of premises, 9-10

Federal Ministry of Environment (FEM). (2005b). National environmental sanitation policy, 14-16

FEPA. (1991). *National environmental protection (effluent limitation) regulations (S.1.8),*

FEPA, FGPL, Lagos, Nigeria

Festino, C., & Aubart, C. (1986). *Épuration d'effluentsetvalorisationénergétiqueliquide de déchets solides d'abattoir*130-131:57*par*-67 *voie ana*

Food and Agricultural Organizations (FAO). (2010). *Abattoir development: options and designs for hygienic basic and medium-sized abattoirs*. Bangkok, Thailand: RAP Publications.

Gollin D, Jedwab R, Vollrath D. Urbanization with and without industrialization. *J Econ Growth.* (2016) 21:35–70. doi: 10.1007/s10887-015-9121-4 CrossRef Full Text | Google Scholar

Gu C. Urbanization: positive and negative effects. *Sci Bull.* (2019) 64:281–3. doi: 10.1016/j.scib.2019.01.023 CrossRef Full Text | Google Scholar

Guo J, Yu Z, Ma Z, Xu D, Cao S. What factors have driven urbanization in China? *Environ Dev Sustain.* (2021) 1–19. doi: 10.1007/s10668-021-01714-4 CrossRef Full Text | Google Scholar.

Henderson JV, Quigley J, Lim E. *Urbanization in China: Policy Issues and Options*. Providence: Unpublished manuscript, Brown University (2009).PubMed Abstract | Google Scholar

Hwa, T.J. (2007). Overview of solid-waste management in Asian countries. In: solid waste management: issues and challenges in Asia, *Report of the APO survey on solid-waste management* 2004–05, 3 –7.

Igwe, E. C. (2005). Adamawa State meat industry. In: E. C. Igwe, S. I. Mshelia & M. Y. Joda (Eds.), *Agriculture in Adamawa State*. Yola, Nigeria: Paraclete Pub.

Ikeme, A. I. (1990). *Meat science and technology: A comprehensive approach*. Onitsha, Nigeria: African FEP Publishers

Jukna, C., Jukna, V., Korsukovas, A., Sargiuniene, J., & Skemaite, M. (2006). Freezing and storage influence on meat quality. *Veterinarijairzootechnika*, *33*(55), 39-42 (in Lithuanian; English abstract)

Kang S.H, Ju YJ, Yoon HJ, Sang AL, Park EC. The relationship between catastrophic health expenditure and health-related quality of life. *Int J Equity Health.* (2018) 17:1–8. doi: 10.1186/s12939-018-0883- PubMed Abstract | CrossRef Full Text | Google Scholar

Koenig, A., & Yiu, W. C (1999). Waste management in Hong Kong abattoirs. *Wat. Sc. Tech. 1*, 379-387 Liu TY, Su CW, Jiang XZ. Is economic growth improving urbanisation? A cross-regional study of China

Urban Stud. (2015) 52:1883–98. doi: 10.1177/0042098014540348 PubMed Abstract | CrossRef Full Text | Google Scholar Li X, Song J, Lin T, Dixon J, Zhang G, Ye H. Urbanization and health in China, thinking at the national, local and individual levels. *Environ Health-Glob.* (2016) 15:113–23. doi: 10.1186/s12940-016-0104-5 PubMed Abstract | CrossRef Full Text | Google Scholar

Liu M, Huang Y, Jin Z, Ma Z, Liu X, Zhang B, et al. The nexus between urbanization and PM2. 5 related mortality in China. *Environ Pollut.* (2017) 227:15–23. doi: 10.1016/j.envpol.2017.04.049 PubMed Abstract | CrossRef Full Text | Google Scholar

Matteo LD. The macro determinants of health expenditure in the United States and Canada: assessing the impact of income, age distribution and time. *Health Policy.* (2005) 71:23–42. doi: 10.1016/j.healthpol.2004.05.007 PubMed Abstract | CrossRef Full Text | Google Scholar

Meadows, R. (1995). Livestock legacy. *Environmental Health Perspectives*, *103*(12), 1096-1100

Miao J, Wu X. Urbanization, socioeconomic status and health disparity in China. *Health Place.* (2016) 42:87–95. doi: 10.1016/j.healthplace.2016.09.008; PubMed Abstract | CrossRef Full Text | Google Scholar

Mmom, P. C (2003). *The Niger Delta: A spatial perspective to its development*. Port Harcourt, Nigeria: Zelon Enterprises.
Morse, T. D., Taulo, S., & Lungu, K. (2010). Gap analysis of research needs in environmental Health, Malawi. *Report to the National Commission of Science and Technology*, pp. 1 – 24, 2010. Retrieved from http://www.ncst.mw/pdf/Environmental%20Health.pdf
Mukti, S. A. (2013). Solid waste management in Dhaka City: Problems and prospects. *International Journal of Innovative Research & Development, 2*(11), 33-37
Nafada, W. D., Ajayi, I. E., Shawulu, J. C., Kawe Tags, S. Z. (2012). Bacteriological quality of abattoir effluents discharged into water bodies in Abuja, Nigeria. *Veterinary Science, 9*, 15-19
Nwanta,J. A., Onukwe, J. I., Ezenduka, V. E., Phil-Eze, P. O., & Egege, S. C. (2008). . Abattoir operatives and waste management in Nigeria: A review of challenges and prospects, 7(2), 87- 94.
Odeyemi, A. T., Dada, A. C., Akinjogunla, O. J., & Agunbiade, O. R. (2011). Bacteriological, physicochemical and mineral analysis of water used in slaughterhouses in Ado-Ekiti, Southwest Nigeria. *Journal of Microbiology and Biotechnology Research*, *1*(2), 14-20.
Olawuni, P. O., Daramola, O. P., & Soumah, M. (2017). Environmental implications of abattoir waste generation and management in developing countries: The case of Lagos State Abattoir in Agege, Nigeria. *Greener Journal of Social Sciences*, *7* (2), 7-14
Oronye, E. D. (Challenges of abattoir waste management in Jalingo Metropolis. International *Journal of Research in Geography (IJRG)*, *1*(2), 2015, 22-31
Osemwota, I. O. (2010). Effect of abattoir effluent on the physical and chemical properties of soils. *Environ Monit. Asses 167*, 399-404
Osibanjo, O., & Adie, G.U. (2007). Impact of effluent from Bodija slaughterhouse on the physicochemical parameters of Oshunkaye stream in Ibadan City, Nigeria. *African Journal of Biotechnology*, 6(15), 1806–1811.
Quinn J.M. and P.N. McFarlane (1989). Effects of slaughterhouse and dairy factory wastewaters on epilithon: A comparison in laboratory streams. *Water Research*, *23*, 1267-1273
Sangodoyin, A. Y., & O.M. Agbawhe, O. M. (1992). Environmental study on surface and groundwater pollutants from abattoir effluents. *Bioresource Technology 41,* 193-200
Sayed, S. K. I. (1987). *Anaerobic Treatment of slaughterhouse Wastewater using UASB Process*. Ph.D Thesis.Wageningen, The Netherlands: Agricultural University of Wageningen
Shuval, H. T. (1972)**.** *Advances in Water Pollution Research*. Oxford: Pergamon Press
Tritt, W. P., &Schuchardt, F. (1992). Materials flow and possibilities of treating liquid and solid wastes from slaughterhouses in Germany. *Bioresource Technology, 4,*235-245
Turan MT, Besirli A. Impacts of urbanization process on mental health. *Anatolian J Psychiatry.* (2008) 9:238–43. doi: 10.5801/ncn.v14i2.58; CrossRef Full Text | Google Scholar
Western Cape Government (South Africa). (nd). The mni guide to the management of abattoir waste. Retrieved from http://www.westerncape.gov.za/eadp/files/atoms/files/Abattoir%2520Waste%2520Management%2520Guide_A5%2520Mini%2520Guide_Web.pdf
Wirth L. Urbanism as a way of life. *Modernity: Cultural modernity.* (1999) 2:47. PubMed Abstract | Google Scholar
World Bank. (1998). Poor management of processing wastes. Environmental assessment: Pressure state response indicators. *Pollution Prevention and Abatement Handbook*, 1998.
Yakowitz, H. (1988). Policy development issues with respect to contaminated soil sites. In: Contaminated soil '88 (eds. K. Wolf, W J Klewer Academic Publishers
Yáñez, L., Ortiz, D., Calderón,&DíazJ-.Barriga,Batres,F. (2002): Overview of human health and chemical mixtures: Problems facing developing countries. *Environmental Health Perspectives, 110*(6), 901-909.
Yang G, Wang Y, Zeng Y, Gao GF, Liang X, Zhou M, et al. Rapid health transition in China, 1990–2010: findings from the global burden of disease study 2010. *Lancet.* (2013) 381:1987–2015. doi: 10.1016/S0140-6736(13)61097-1 PubMed Abstract | CrossRef Full Text | Google Scholar
Yang Y, Liu J, Lin Y, Li Q. The impact of urbanization on China's residential energy consumption. *Struct Change Econ D.* (2019) 49:170–82. doi: 10.1016/j.strueco.2018.09.002 PubMed Abstract | CrossRef Full Text | Google Scholar
Yeh AG, Xu J, Liu K. *China's Post-reform Urbanization: Retrospect, Policies and Trends.* London: IIED (2011). Google Scholar
Zhang L, Zhao S. Reinterpretation of China's under-urbanization: a systemic perspective. *Habitat Int.* (2003) 27:459–83. doi: 10.1016/S0197-3975(02)00071-1 CrossRef Full Text | Google Scholar
Zheng W, Walsh PP. Economic growth, urbanization and energy consumption—A provincial level analysis of China. *Energ Econ.* (2019) 80:153–62. doi: 10.1016/j.eneco.2019.01.004 CrossRef Full Text | Google Scholar
Zhou Y, Wushouer H, Vuillermin D, Ni B, Guan X, Shi L. Medical insurance and healthcare utilization among the middle-aged and elderly in China: evidence from the China health and retirement longitudinal study 2011, 2013 and 2015. *BMC Health Serv Res.* (2020) 20:1–9. doi: 10.1186/s12913-020-05522- PubMed Abstract | CrossRef Full Text | Google Scholar