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Municipal Solid Waste Disposal in Mangrove Forest: Environmental Implication and Management Strategies in the Niger Delta, Nigeria

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Abstract

Niger Delta is an oil rich region situated in the southern part of Nigeria. It is made up of nine states which hosts oil industries. There are a handful of businesses (super market, manufacturing companies, etc.) that service the over 40 million people living in the cities. This situation had led to the increase in solid waste in the city. Because of the problem of over population, and poor waste management strategies (e.g., lack of recycling habit and lack of equipment) the mangrove forest had become a dumping ground for waste. This action has impacted the health of aquatic and terrestrial organisms, and has created a public health disaster for citizens because of increase in heavy metal concentration up the food chain. This chapter therefore, identifies poverty, lack of planning, poor behavior and poor technology as key factors affecting effective waste management in the Niger Delta. It suggests that good waste management system can be worked out if there is coordination between research institution and government in the implementation of recommendation by research institutes. Attitudinal change is also necessary on the part of citizens and government to enable a healthy interaction for the purpose of managing waste effectively.

Keywords: solid waste, mangrove forest, recycling, heavy metal, open dump, Niger Delta, city planning

1. Introduction

Municipal refers to a city, but when a city is very large it becomes a metropolis. According to [1] government performs two kinds of functions: (1) supply of goods and services within municipality and (2) conflict management. For instance, the sitting of garbage dump site can lead to conflict, which is to be resolved by the municipality. Other functions of a municipal government are police, fire protection, and street maintenance. In the area of conflict management municipal government takes care of the sitting of garbage dump sites within the city to prevent clash of residents over land ownership rights. The government also decides on the number of garbage collection per week, and the disposal mechanisms to ensure a clean and healthy city for people to live in.

Waste on the other hand, is an unwanted residue that is no longer useful to the system, but useful to another system. Municipal solid wastes are non-liquid wastes that are by-products of manufacturing and processing industries that are within the city. Solid waste are every day materials and occur as follows: paper (50.7%), food waste (19.1%), metal (10.0%), glass (9.7%), wood (2.9%), textiles (2.6%), leather and rubber (1.9%) plastics (1.4%) and miscellaneous (1.7%). Lack of monitoring of waste movement in municipality can lead to indiscriminate disposal of waste, for example, waste is dumped without restriction in mangrove forest and rivers **Figure 1**. This is a problem that has been noticed in the course of our field work, but had remained unreported in the literature. This work is thus one of the first to report the problem of refuse disposal in mangrove forest in the Niger Delta. Mangroves are resilient [2, 3] and could withstand some level of pollution [4]. They are also a zone of high litter decomposition [5] as a result of the proliferation of microbial activities on forest floor [6]. This ability had made the mangroves to survive in the face of intense environmental pollution [4], but the effect of waste disposal on mangrove growth remains to be seen. This is because harmful heavy metals from non-biodegradable substances in the waste (e.g., plastics) can impede their growth. However, mangroves act as natural environmental biogeochemical barriers to pollutants generated in solid wastes disposal sites through mechanisms occurring at root level [7]. Mangrove roots produce oxygen to cope with the anaerobic condition of the soil. The creation of oxidized rhizosphere fixes heavy metal under non-available forms [8]. The large adventitious root system also restricts the movement and physical distribution of heavy metals. This prevents pollutant remobilization. Mangrove sediments effectively retain heavy metals by preventing migration. The heavy metals are prevented in the rhizosphere sediments under very refractory chemical forms, unable to be absorbed by plant roots. This thus, blocks the intoxication of the mangrove trees [7]. In addition mangroves root have a shutting down mechanism, which prevents the absorption and uptake of harmful pollutants, just as it shuts down the intake of excess salt when in saline environment.

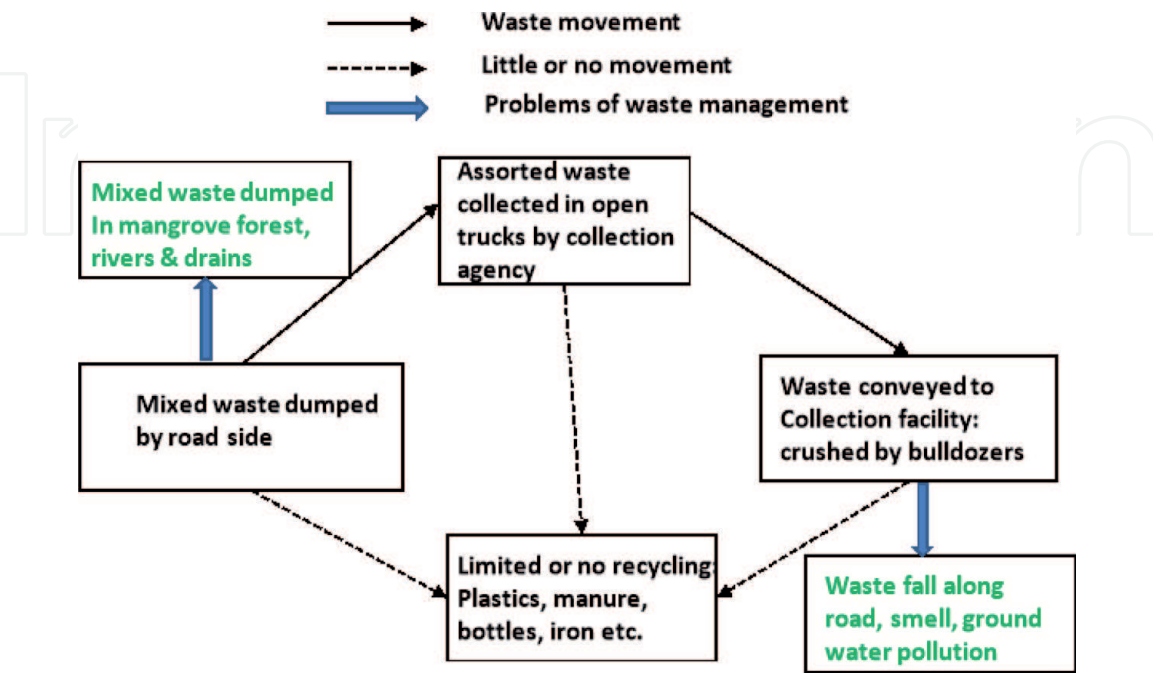


Figure 1. Waste management strategy in cities in the Niger Delta, Nigeria. It shows the inefficiency in waste management leading to individualistic management resulting to mangrove forest and river pollution.

The disposal of solid waste in mangrove forests and wetland areas is as a result of ignorance of its health effect. It is also due to overwhelming production of waste from highly populated city dwellers with little or no technology to handle the waste surge. High generation of waste is usually prevalent amongst the low income class people who generate more waste than they can handle, they thus resort to self-help by disposing the waste themselves into drains during rain fall, into river and in mangrove forest. This situation had been going on for many years, especially in areas of the city such as waterfront and coastal towns inhabited by people of low income class. Those living at the water front are not considered in municipal waste disposal planning. They are also not considered in the planning of waste collection within and around the city. Since they are left out, they manage their own waste by themselves. This is because the waste management design in the region is faulty, and is the cause of negative feedback of excess unmanageable waste, which litters the streets of the city (**Figure 1**). This chapter has identified some problems of effective waste management, and had proffered some solutions towards resolving them.

2. Causes of high waste generation in cities in the Niger Delta

There are several causes of high waste generation in municipal areas in the Niger Delta, some include: (1) over population (2) poor town planning (3) lack of technology (4) Poor waste management habit and (5) Lack of sorting and recycling culture. Details of these factors are given below.

2.1 Over population

Nigeria's population is over 200 million making it the most populous black nation on earth. Out of this number, one-fifth (i.e., 40 million) lives in the southern part of the country known as the Niger Delta region [9]. Each family in the region is made up of an average of six persons. The waste production per person, multiplied by the entire population gives a staggering figure of waste. In the Niger Delta, one person produces approximately 1 kg of waste per day, multiplying this figure with the population size gives an approximate waste load of 40 million kg produced each day for the entire region. With inadequate facility, lack of manpower and poor waste management strategy, it is only one fifth (8 million kg) of the waste that is eventually evacuated daily leaving behind 32 million kg of waste that is not collected and left to litter the streets of the city. Abandoned wastes are scattered by rain and wind and carried into public drains. This blocks the free flow of water leading to flooding.

Another cause of the increase in population is the migration of people into the cities of the region in search of white collar jobs, which had led to the multiplication of the number of persons already in the city. The Niger Delta serves as the treasure base and the melting pot of the nation because of the abundance of industries, which attracts people from all works of life. It has refineries, oil companies, ports authority, fertilizer company, cement factory, etc. This had attracted people from other regions to migrate into the city in search for jobs. The average rural-urban migration rate is about a 1000 persons per day, which further increase the population. The numbers of persons that come into the cities outnumber the number of persons that go out of the cities. Out of the population that comes in about 2% remain and look for jobs or start small scale business, which generate waste. This adds to the total waste load of the cities in the Niger Delta. Furthermore, lack of data of the population growth rate, migration and emigration rate and waste production had complicated the process of effective waste management by waste



Figure 2.

(a) Waste dump site near former mangrove forest taken over by *nypa* palms at Eagle Island, Niger Delta, Nigeria. (b) Plastic waste in early recruiting mangrove seedling (*Rhizophora* spp.) brought in by tidal current. (c) Waste washed ashore by tidal current at Eagle Island. (d) Plastic waste recovered from the sea near Eagle Island placed near a mangrove forest awaiting transfer to plastic recycling company.

management agencies in the region. This is because for effective waste management each region should have been divided into sub-districts, and the population known to enable waste managers to understand the waste dynamics. This will help them to plan the number of trips of waste trucks that can completely evacuate waste from the district. Improper waste management in the face of over population is the main reason why people have resorted to self-help, by disposing waste in swamps, rivers and mangrove forest (**Figure 2a**).

2.2 Lack of proper town planning practice

Planning simply means to clarify one's objective and to determine actions that should be taken by whom, when, by what methods and at what costs in order to achieve the desired goal. It is also the evaluation of alternative choice, strategy, solution, plan, implementation and review. Planning is functional when it develops an appropriate course of action for decision makers. The purpose of planning is to provide for the "urban citizen" an environment suitable for human habitation. This is because the price to pay for lack of planning is huge and can affect the waste management process [10]. Lack of municipal planning can lead to the proliferation of slums, congestion, noise, waste, air and water pollution, overcrowding, inadequate school, unemployment, inadequate municipal services (e.g., waste disposal sites and recycling facilities), disease proliferation, crime, ugliness and a host of other societal ills.

Adequate physical planning aims to control physical development of communities thus, avoiding the major social and economic cost of non-planning such as inadequate waste management system leading to unhygienic conditions and flooding in cities, which erodes major road network. Furthermore, physical planning bears a distinct relationship to many other governmental functions [10, 11].

For instance, the decision about the patterns and locations of waste processing facility will involve not only the local planning agency, but also federal and state ministry of environment, environmental protection agency, public works and city engineers. This is because the location of a waste facility will have ripple effect on other facilities in the city, for example it will have an impact on the location of other land uses, and will affect the land use policies of communities throughout a given metropolis [12, 13]. Decision about the proper location of industry can have a major impact on employment and income levels, and thus the buying power and waste generation capacity. All of these interrelationships imply a need for some coordination amongst different municipal activities. Planning theory postulates standard for the location and space requirement of different land uses such as waste facility, housing, esthetics, recreation, industry, etc. on “design concept” [14]. There is a belief that different land uses should be kept separate, and density low. It is believed that an improvement in the physical will lead to an improvement in all the social and economic problems besetting urban communities.

A classic example of the nature of planning is the “zoning ordinance”, which is a municipal law that divides the municipal area into district, within the district standards and restrictions are established for the use of land. For instance areas are designated as residential, industrial, recreation, and municipal waste collection facility (MWCF).

Waste generation can also be affected by pattern of street layouts. This is under the purview of ‘sub-division regulation’, which is a municipal law that controls the development of new residential area. This involves the width and pattern of streets, size of drainage facilities, sewage and water system and waste disposal site. Building code can also be used to manage waste generation and disposal system. It is an implementation device of planning. The enforcement of code is providing for the municipal standards for the structures and facilities for building as part of the municipal. The purpose of code enforcement is to safeguard health. Modern method of city planning is the use of Geographical Information System (GIS) to identify locations for establishing waste disposal facilities that will not affect esthetics and property value [15].

2.3 Lack of municipal waste recycling and treatment facilities

Central waste treatment and recycling facility is important in managing waste coming from different parts of the city [16]. The problem is that in the Niger Delta this facility is non-existent, thus waste collected from several locations are usually disposed off on open virgin land, crushed with bulldozers and mixed with soil to form compost (**Figure 1**). The waste is picked up by the side of the road and driven to such locations. Since the waste generation data is not available it becomes a problem for those evacuating the waste to know the carrying capacity of the trucks and the number of trips to go. This leads to the overloading of the pay load resulting in the waste falling off on the road when the waste is being driven to the crushing facility. In addition, after collection some waste still remain behind on the road for days because the truck had been filled beyond capacity. This type of waste management practice is open disposal, which is ancient and had been phased out in many parts of the world. This method is unhygienic because it is often situated around human habitation. It introduces pest and diseases through rodents and flies. The smell coming from such location is nauseating. This reduces the esthetic values of the city. The idea of establishing recycling facilities across the Niger Delta had been in the drawing board for decades without being implemented, which is as a result of bureaucratic bottlenecks in government. Currently it is only private investors that are making attempts to establish such facilities. Plastic products are

the major recycled waste product in the region [17] (**Figure 2d**). This is because of the millions of plastic materials that are evacuated from the surrounding drain-ages and water bodies (**Figure 2b, c**). The reason for high plastic waste retrieval from the environment is because of the monetary reward of \$0.3 offered for 1 kg of plastic waste recovered. In fact, the most priced plastic materials in the region are those that are made up of high density polyethylene (HDPE), which is used in the production of plastics, bottles, corrosion-resistant piping, geo-membranes and plastic lumber, etc. The retrieved materials are compressed and exported out of the country to generate foreign exchange.

2.4 Poor waste management habit

There is no waste sorting culture in the region, which creates problem in the effective management of waste. This is because collected waste at different sites are all mixed up at home by residents and dumped by the road side for collectors to pick. There is no separation of waste into different types as practiced in developed societies (**Figure 3a, c**). Lack of waste separation creates problem for collectors who do not have the training or the equipment for separating the waste into its parts before final disposal in landfills [18]. Gross ignorance and helplessness in waste management had made a lot of people to become waste distributors, who pass on waste from one place to another in the name of management. They do this by pouring waste in restricted places under the cover of darkness or sometimes in the open without being confronted. Favorite areas of waste disposal in some cities in the



Figure 3.
(a) Giant silo bin used to collect and convey building waste at a building renovation site. (b) Indoor waste disposal unit installed in a room to collect house hold waste, which will be channeled out into a silo bin placed outside for onward collection and disposal by waste agent at a building facility in Saint Louis USA. (c) Type I (rubbish, e.g., paper) waste collected and sorted for recycling (green silo).

Niger Delta are along roads. This is done to seek attention from the government or waste agency (**Figure 2a**) to come and evacuate pile of waste in their neighborhood. They also dump waste during heavy rainfall inside drains so that it will be flushed away by water into adjoining river. Wastes are also poured on farm and mangrove forest to conceal their action from the municipal authority. A favorite place where waste is usually dumped is at the foot of plantain and banana trees. This is because there is an erroneous belief that the waste act as manure for the growth of the plants. Dumping of waste in drainages blocks the free movement of waster leading to flooding problems. People also buy goods they do not need, which end up at the dump site. Poor income makes some people to buy sub-standard products that have low life span, resulting to wastage. These products become non-usable when used for a short time leading to their disposal in refuse dump.

2.5 Poor recycling culture

There are a lot of people who do not understand the principle of recycling, and do not care to know its importance. Rather local people are more interested on how to survive the difficult times. Some people think recycling is to pile up unused goods in their store house rather than giving it out to a recycling agency for the manufacture of new goods. Recycling is the re-use of waste for other beneficial products (**Figure 3c, d**). Recycling is beneficial in several ways: (i) it provides jobs, (ii) reduces waste volume for disposal, (iii) extends the life span of a land fill and (iv) used to manufacture new products. People do not have the habit of recycling goods because of their belief in conservatism in the ownership and use of goods. This means they buy only what they need, which help to prevent wastage of resources. They therefore buy goods they can consume without much left over. The method of gathering and disposing waste also makes it extremely difficult to recycle the waste. It is very difficult to sort and re-use a combination of liquid and dry waste in a dump site. Most refuse dump sites are made up of all waste types, i.e., type 0–type 6 wastes, which include a combination of paper, broken bottles, metal, wood, food items, hospital waste, kitchen waste, etc. The mixing of the waste at the beginning and the combined disposal of the waste had made the sorting process to be very difficult. This overwhelms the waste agents who have no option than to process the waste as it is, using bulldozers rather than carrying out a recovery operation for the purpose of recycling [19]. In the Niger Delta, the major recycled waste is plastics (**Figure 2d**). This is common because of the monetary value attached for its recovery, and a major driving force is poverty. This is because people that are well to do not scavenge for plastics products for financial gain. Rather many jobless individuals had made it their job by searching for plastics in every conceivable place such as drainage, river, swamp and refuse dump sites. They take great risk to collect plastic products and send them to the manufacturing companies who use them for producing plastic products for pecuniary gains. These groups of scavengers are sometimes destitute who have no home but sleep on the streets. They take great risk to their health and lives to recover the plastics and sometimes bottle products by using their bare hands or iron rod to rummage through the piles of refuse at the dump sites.

2.6 Lack of technology

The problem of third world nations is technology, which affects the pace of development in all fields of life, and waste management is not an exception. The ancient method of waste disposal being open dump is still practiced in many places in the region. In this methods open trucks are still used to evacuate waste from the streets. The disadvantage of this method is that it leads to the scattering of waste materials along the streets of the city. This occurs when open trucks are used to

convey waste to waste collection facility. The trucks are often overloaded leading to some of the waste being blown away by wind thereby littering the streets. It is also unhygienic for motorists who are made to endure the stench when the truck comes closer to them. The modern method of using home garbage receptacle such as trash chutes, (**Figure 3b**) silo bins (**Figure 3a, c**) and silo disposal trucks is not used due to paucity of funds to acquire them for use in the municipality. This method was used in the past, but because of lack of maintenance culture and continuity in governance has made the whole equipment that was initially acquired by previous governments amounting to millions of dollars to go moribund after its abandonment. Presently there are constructions of concrete waste disposal sites around the cities where people go to dump their waste. This method is also problematic because it is still an open dump, which reduces the esthetic value of the city. Waste materials can also be carried away by wind and water especially during heavy rainfall leading to flooding. It discourages waste sorting because the different wastes are mixed up before their deposition at the dump site (**Figure 2a**).

3. Waste management strategies in municipal areas in the Niger Delta

Different cities in the Niger delta have their way of managing waste, but collectively the major management methods adopted in most areas is individual and group management. Individual residents manage their garbage and trash. Different occupants of a house work as a group to manage their waste system. For instance, they perform rotational sweeping, collection, dumping and burning of waste in open spaces designated for that purpose. People living in a given area contribute money, which they use to hire and pay agents or private refuse collectors. The waste are put in drums or bins and later disposed off by the paid agents, who comes weekly to collect and dump the waste in approved dump site. Local government manages waste in their various jurisdictions especially in their headquarters. The local government has the constitutional role of waste management, which is part of their social responsibility. Market operators and indigenous manufacturers also manage their own waste. The problem is that private individuals use open spaces such as mangrove forest or wilderness (**Figure 2a–c**) as sites to dispose off their waste. This is because they do not have waste collection and disposal system. They dump waste such as animal carcasses, metal scrap, vehicle junks, plastics, etc. Similarly, domestic, industrial and biomedical wastes are all dumped together at dump sites. Hazardous and radioactive wastes are often dumped together, which is dangerous to public health and safety. Domestic and industrial liquid wastes are indiscriminately discharged or find their way into streams and rivers, which serve as drinking water for a large section of the rural and urban inhabitants.

4. Reasons for ineffective waste management practice in Nigeria

There are several reasons for poor waste management in Nigeria, they include, lack of reliable research data on waste. There were limited data in the past, but of recent more scientist and waste management scholars had written their dissertations on waste management. However, the problem is that the results of these studies had not been adopted and implemented by the government; the researches only end up in the shelves of libraries in the various high institutions. For proper waste management, in Nigeria there should be a meeting point between theory and practice. Agencies should be set up to create a cross fertilization of ideas between higher institutions and government agencies. This will help in the implementation

of recommendations from the different studies. This is because many of the studies had gone to great lengths to collect long term data, which if implemented will help government in planning for effective waste management system for the municipalities and entire region at large.

Lack of sorting culture is also impeding the progress of waste management in the Niger Delta. People do not take it as a responsibility to separate their waste before disposal. They feel that it is a waste of time since the receivers of the waste do not care and will not sort the waste at their collection facility. Irregular collection and unhygienic disposal by private waste collectors are also some problems of ineffective waste management. Poverty is an overriding factor that had affected waste management. This is because even when rules of proper waste disposal are stipulated by the government many people do not follow such instructions because they lack the money to buy the waste containers for the collection of their waste. Government alone cannot be held responsible for poor waste management because many people exhibit poor attitude towards waste collection by not wanting to pay for waste management services. This may be attributed to lack of awareness on the dangers of improper waste management, and lack of community awareness of the economic value of waste recycling. There is also a craze for fashion which has made people to generate more waste than they can manage; especially women who adopt some fashion trend that is antagonistic to the local culture in terms of clothing and beautifying materials, which they later dispose into open dump or drain. A typical example is artificial hair, which in recent times had littered the streets of most cities. Similarly, make-up chemicals are flushed down the drain and can enter the river thus polluting the surface and ground water systems. This has a negative feedback because it can come back to humans through the food chain or drinking water causing health effects. Lastly, apart from the inaction of government and the poor attitude of citizens, there is also nonchalant attitude by industrialists and manufacturers, who are more interested in making profits than giving back to their host communities through the provision of social amenities such as waste bins and payment for waste evacuation.

5. Mangrove forest as refuse dump site

Waste get into mangrove forests through two means: (1) through tidal flushing (**Figure 2b, c**) and (2) through disposal by humans (**Figure 2a**). Tide washes ashore buoyant debris from far and wide. The debris accumulates at the edges of the sea and inside mangrove forest. These kind of waste are usually materials picked by tides from elsewhere such as leaves, branches of trees, plastics, carcasses, etc. (**Figure 2c**) while waste dumped by humans are mainly municipal waste such as household and industrial items such as food, paper, clothes and plastics, industrial waste, agricultural waste and market or commercial waste, majority of which are made of organic products [20].

Mangrove forests are found at the interface between the land and the sea. They are thus recipients of waste from both the land and the sea. They are usually seen and considered as waste land because of activities that go on in the mangrove forest are often not supervised. People who dispose refuse or cut the trees are not punished making others to do the same. Mangrove forests serve as homes for many people who clear and erect their houses. Those who live close to or inside the mangrove forest dispose their waste right in the forest since waste management agents do not come to evacuate their waste. Since mangrove areas are not under the jurisdiction of waste management agents, the people manage their waste by throwing them wherever they want. Mangrove trees are also cut and used as firewood to generate energy [21] and their cuttings act as waste that litter the forest floors.

6. Comparison of heavy metal concentration in soils at dump sites situated in mangrove and non-mangrove forest

6.1 Materials and methods

A study was done to compare the heavy metal content of soils collected from dump sites located in mangrove and non-mangrove forests. A total of 16 soil samples were collected randomly in a block design. The soil samples were collected 5 cm below the surface with a soil augur and placed in a cellophane bag and transported in cooler to the laboratory for physicochemical analysis.

6.2 Results

The result indicates that there was no significant difference in heavy metal concentration ($F_{1, 58} = 0.24, P > 0.05$) in soils collected from dump sites in mangrove and non-mangrove soils. Copper, lead and zinc had higher concentrations in non-mangrove soils whereas cadmium had the highest concentration in mangrove soil (**Figure 4**). Dump sites contain all kinds of waste such as domestic, industrial, hospital, municipal and electronic waste (e-waste). These materials had made the heavy metal concentration to be high in both soils, which is not good for the ground water aquifer and organisms that inhabit the soil. Arsenic is a poisonous chemical that has teratogenic effect on man. The result of heavy metal concentration from e-waste in mangroves and farm soil further illustrate the ability of mangrove forest to retain high heavy metal concentration, which is far above the required standards (**Table 1**). Waste materials that have high arsenic content can be disastrous to organisms that reside in the forest. The problem is

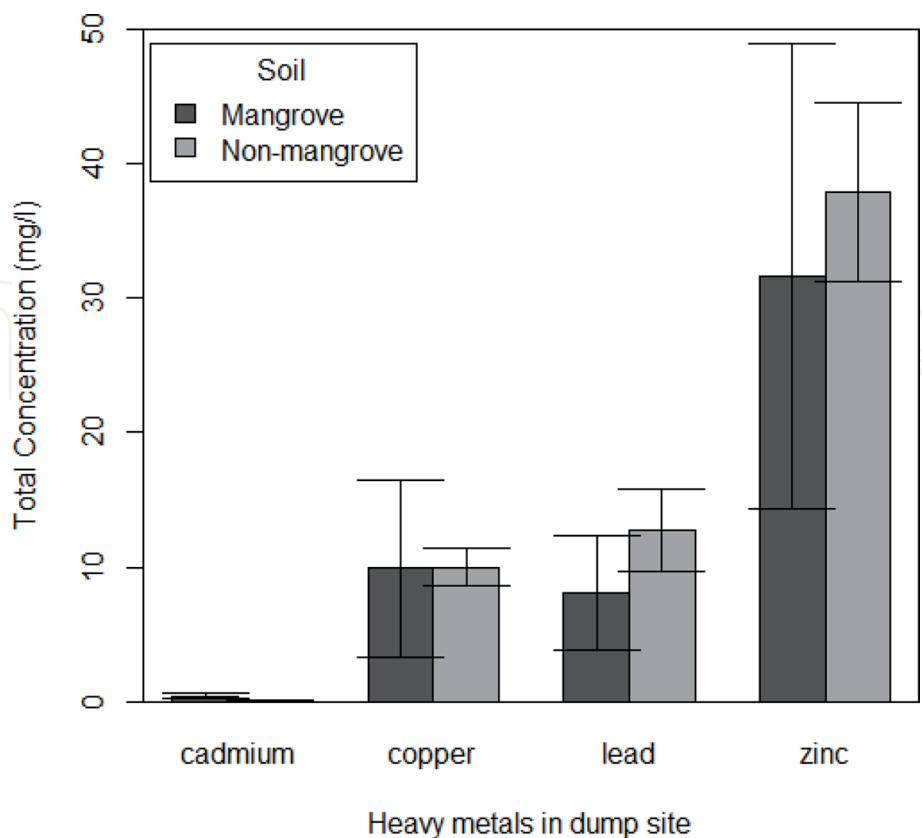


Figure 4. Heavy metal concentration in soils collected from dump sites situated in mangrove and non-mangrove forest in selected sites in the Niger Delta, Nigeria.

Heavy metals	FMENV limit (mg/l)	Farm soil	Mangrove soil
		Conc. (mg/l)	Conc. (mg/l)
Arsenic	0.05	2.31 ± 1.41	0.80 ± 0.47
Cadmium	0.01	0.04 ± 0.03	0.09 ± 0.04
Lead	0.05	3.38 ± 0.74	4.36 ± 0.88
Zinc	0.05	23.62 ± 2.85	21.32 ± 6.75
Copper	0.05	16.77 ± 11.48	21.86 ± 18.20
Nickel	0.05	3.55 ± 1.06	23.18 ± 14.47

Table 1.
Comparison of heavy metal concentration from study and Federal Ministry of Environment (FMENV) maximum concentration for ground water protection.

that some organisms that are found in the mangrove forest are consumed by man. For example crabs, periwinkle, fish, etc. Another study using crab shell and tissue (*Goniopsis pelii*) show that the distribution of heavy metals in the body parts was highest in claw tissue: zinc (1894.5 mg/l), cadmium (28.0 mg/l), lead (283.0 mg/l) followed by gills: zinc (116.0 mg/l), cadmium (12.0 mg/l), lead (173.5 mg/l), and gut: zinc (38.0 mg/l), cadmium (2.8 mg/l), lead (27.4 mg/l). This can be attributed to accumulation of heavy metals that come from e-waste (mobile phones) in mangrove forest soil (*in press*). This can lead to biomagnification in man thereby causing health problems. It is also environmentally damaging when pollutants enter the food chain.

7. Discussion

Management of solid waste is a problem for most cities in Africa. This chapter has discussed four key causes of solid waste management problem in Nigeria, they are: behavioral, poor technology, poverty and poor town planning amongst others. The lack of knowledge in the management of waste by individuals magnify at municipal level leading to larger waste management problems. The best strategy to tackle this problem is a change of attitude of individuals, through deliberate decision to do things right. In addition, government can assist by embarking on intensive enlightenment campaign and provision of sophisticated waste evacuation equipment. Furthermore, stiff penalties should be put in place for defaulters as a means of deterrence (**Figure 5**). This is because poor technology and lack of technical skill are problems of third world countries. This makes it cumbersome to manage waste effectively in a highly populated country such as Nigeria. Nigeria does not lack manpower, but lacks the technology to adequately manage solid waste. Presently attempts are being made by private individuals to establish waste management and recycling facilities in several parts of the country. Similarly few state governments are making attempts at establishing waste treatment facilities in their states. It takes the will power and availability of funds to accomplish this aim.

Poverty is a problem that affects almost every aspect of life in the country, even when there is the will to pursue good waste management methods, the funds to acquire equipment to carry out the process is lacking. The establishment of a waste treatment facility is a gigantic project that requires government assistance and input to be successful. This is because of other aspects of the project that require huge financial commitment, e.g., purchase of land, good road network,



Figure 5.
Enlightenment campaign against waste disposal in rivers and a mangrove forest at Eagle Island, Niger Delta, Nigeria.

proper city planning and employment of skilled waste managers, which go beyond what an individual can do. However, the government is well positioned to execute such gigantic projects. For government to acquire land and to use the state's resources to establish waste facility will not be a problem as compared to what an individual will do. For example, because of the land use system, land acquisition by a private person is more cumbersome and costly than when done by the state government.

Planning also plays a key role in proper waste management. Most communities in Africa are built from communal land allocation without proper design such as surveying and land allocation to ensure the sitting of important municipal facilities at specific location. This makes the distribution of properties and facilities to be haphazard. For instance there are some places that are difficult to locate because there are no street names or street numbers. This affects the sitting of waste facility because central areas that are supposed to be preserved for public use have been taken over and houses built by private individuals. Lack of town planning thus affects the sitting of projects that will be beneficial to the people. Furthermore, solid waste treatment facilities are usually sited in locations that are inaccessible by waste agents who burn a lot of fuel and add mileages to convey waste to disposal facility. The solution to this problem is the reorganization of the town to reflect proper town planning for old municipality and the establishment of a well-planned city for new towns that are springing up from the suburbs. This involves the establishment of direct road link to waste facilities that are far away from human habitation.

8. Conclusion

Based on the study carried out, it is important to note that disposal of refuse in mangrove forest has a boomerang effect. This is because heavy metals and other pollutants from the waste percolate into ground water to contaminate the drinking water source in nearby communities. It is also known that mangroves serve as the food basket of the sea, and any pollutant that enters into it will be

redistributed back to man through the food chain. Although, mangroves are resilient, and can withstand pollutants but their resilience should not be taken for granted because it can lead to ripple effect that will eventually affect mans' health especially in the aspect of increase in heavy metals up the food chain through biomagnification.

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