



An Appraisal of the Waste Crisis, Urban Floods and Municipal Solid Waste Management in Port Harcourt City, Nigeria

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Abstract

Solid Waste Management (SWM) system has become one of the contemporary issues of the 21st century at all levels. SWM value chain from generation, storage, collection, transportation to disposal requires proper and efficient control. The volume of waste that is generated should be minimized, storage containers should be adequate and suitable, collection should be frequent, transportation vehicles should be appropriate for the purpose and disposal of wastes should be at dumpsites. Municipal Solid Waste management for that matter has become problematic with Port Harcourt as the city is being inundated with so much filth which has proven to be very difficult and seemingly impossible for the municipal authorities to tackle. Efficient MSWM systems require professional management, supported by an informed population and appropriate legislation and policies. This narrative deals to review different waste fractions showing how several sources of pollution are affecting the environment, population health, and sustainable development. This calls for scholars and stakeholders to quantify the comprehensive impacts and plan for integrated solid waste collection, disposal and treatment systems, to improve environmental sustainability at all levels.

Keywords: Municipal Solid Wastes; Environmental Contamination; Public Health; Waste Generation, Solid Waste Management; Urban Flooding, Environmental Sustainability

Introduction

Background of the Study

One major problem of urbanization is solid waste generation. Because of the increasing population and the increasing waste generation rates due to increased consumption of a range of products and its associated packaging, heaps of MSW along major roads, stream channels, riverbanks and in open spaces are very common in Nigeria especially in Port Harcourt metropolis [1,2]. Municipal Solid Waste Management (MSWM) in Port Harcourt is characterized by indiscriminate dumping of wastes. Waste is

generated in all sorts of ways and its composition and volume largely depend on consumption patterns and on industrial and economic structures [3]. It is estimated that 2000 tonnes of domestic waste is generated daily from the entire Port Harcourt city, of which 15% ends up in waste dumpsites, open spaces, market places and street corners (Igoni and Harry, 2017). This uncontrolled dumping has led to blockages of storm water drains, surface and groundwater pollution resulting to environmental degradation, destruction of the ecosystem and poses great risks to public health thus defacing the aesthetics of the garden city status. The waste stream is mixed with high organic content in addition to broken glasses, aluminium, paper, wood, plastics, grease, oil,

scrap materials, industrial wastes, medical wastes, polythene bags etc. These wastes originate from a range of sources including household, industries, business centres, hospitals, clinics, markets, abattoirs, etc.

Statement of the Problem

Urbanization and industrial development is seen as an economic transformation, a breakthrough to poverty alleviation and inflation reduction, it is also expected to help narrow the gap between nations or individuals [4], but it has been identified as playing a negative role in solid waste management due to volume and variety of wastes generated resulting from increased flows of goods and services, changing lifestyle and consumption pattern [5-8]. Such development in most cases alters the subsisting equilibrium leading to a situation that negatively impact human existence. This may be due to lack of waste management methods and ideologies by statutory authorities and stakeholders.

In recognition of the monumental challenges of MSW management, Governments in Nigeria particularly in Rivers State have attempted to tackle waste management issues through the “task force” approach. This involves:

- (i) Designation of solid waste collection centres on major roads and public markets; and
- (ii) Use of local contractors/agencies to evacuate the wastes generated.

This is because wastes are dumped into drainages (Figures 1 & 2) that block the free flow of runoff water and this practice gives rise to flooding (Figures 3 & 4) and the communities are adversely affected. Some people dump their wastes on the road side (Figure 5), thereby reducing the width of the road and aesthetics of the cities especially in developing countries. This is evident as you walk across the nooks and crannies of most cities in Nigeria; where you find heaps of refuse littering the entire landscape, roadsides, parks, gardens, commercial centres and other areas [2,9-12].



Figure 1: Wastes clogging stream channels at Ntawogba creek along Ikoku/Olu-Obasanjo Road.



Figure 2: Wastes clogging stream channels at Ntawogba creek along Ikoku/Olu-Obasanjo Road.



Figure 3: Flooding of some parts of Port Harcourt: (a) Evo Crescent, GRA Phase 11 (JULY 2017); (b) Omoku Street/Olu Obasanjo Road.



Figure 4: Winners Chapel along Airport/Ikwerre Road in Port Harcourt.



Figure 5: Wastes heaps dumped on major streets in Port Harcourt around Rumuola axis.

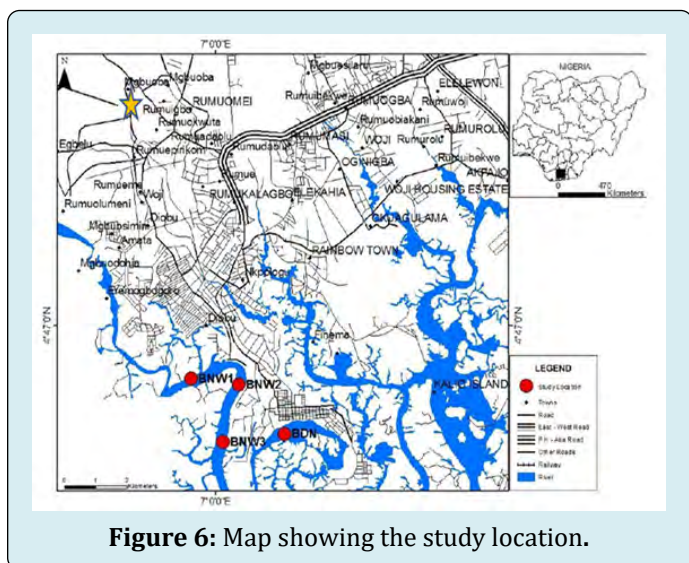
Aims and Objectives of this Review

The overall aim of this review is to collate into one readable document the current status of waste crisis, urban flooding as well as Waste Management options in Port Harcourt city. Some specific objectives of this review are to:

1. Analyse current practices of waste management and waste disposal patterns in the Port Harcourt metropolis environment;
2. Highlight problems faced by poor practices of waste handling and disposal in Port Harcourt metropolis;
3. Identify the impacts of waste mismanagement particularly focusing on environmental contamination, social issues and associated health risks;
4. Analyse the environmental impacts due to unsustainable management of municipal solid wastes in Port Harcourt metropolis; and
5. Proffer views for improvement of waste management system in Port Harcourt metropolis.

Study Area

The study area for this review article is the Port Harcourt metropolis (Figure 6). Port Harcourt is situated within the Niger Delta region at the southernmost part of Nigeria.



It has a plain topography and about 5m above sea level. This plain is well drained and provides several connections with the sea (Gulf of Guinea) by a large number of creeks and channels [2]. Administratively, Port Harcourt is made up of two local government authorities namely the Port Harcourt City Local Government and Obio/Akpor Local Government Councils. Port Harcourt, the capital city/seat of government of Rivers State is also the hub of the oil and gas industry in Nigeria. The activities of these oil companies generate solid, liquid and gaseous wastes such as drill cuttings, fluids,

lube oil, paper printer cartridges, food and refuse wastes, batteries, tyres, associated gas, scrap metal, produced water etc. Port Harcourt at its establishment in 1912, was 30,000 acres (315km²) but since has expanded due to rapid growth in population, uncontrolled development which began to take place as many native villages gradually develop into suburban residential areas. At present, Port Harcourt is characterized by rapid population (with over 2 million people) and good roads network.

Four streams drain into the Port Harcourt metropolis connecting to several creeks that leads to the sea. The main stream channels include Ntawogba creek, Woji creek, Elekahia/Nwaja creek, Rumuebekwe/Elelenwo creek etc. The Ntawogba creek is a black water stream with its head water draining the Ora-Azi forest and meanders through the densely Port Harcourt city into the Bonny Estuary. The creek flows in a South Easterly direction and it runs through areas including the Sanni Abacha (GRA phase 3), Olu-Obasanjo, Okija and Afam streets. The creek also runs through Aba Express road by the Federal Road Safety building and Amassoma Street in the old GRA area of Port Harcourt. It is exposed to increasing amount of urban waste as it flows seaward, which are mainly from garages, domestic discharges, wastes from markets and construction sites [13]. Woji creek is located in the Western parts of Port Harcourt city. This is a long and narrow shaped catchment. The creek flows towards the South East draining areas like Rumuokoro, Eliozi, Port Harcourt-Aba Expressway by Genesis Hotel, Rumuobiakani and Trans Woji bridge areas, it passes through Abuloma and eventually discharging into the Bonny River. Elekahia/Nwaja creek is located in the western part of the city of Port Harcourt in Rivers State. The creek drains towards the southeastern direction. The creek drains the major Port Harcourt -Aba express road near the Rivers State Independent Electoral Commission office, the Mobile police barrack (Mopol 19), Rumukalagbo town, Nwaja bridge and Nkpogu sand fill emptying into the Bonny river. The Rumuebekwe/Elelenwo creek flows in the South Eastern direction and drains Rumuokrushu, Elelenwo, Rumuebekwe and Trans Woji road emptying into the Bonny River. It shares same characteristic with Woji creek.

The management of Municipal Solid Waste (MSW) has traditionally been the exclusive responsibility of the local or municipal governments. However, in 1986, the Rivers State Environmental Sanitation edict was enacted and from 1989, in line with Agenda 21 which emphasizes the need for all countries to maintain the quality of the Earth's environment and especially achieve environmentally-sound and sustainable development that the Rivers State Refuse Collection and Disposal Law of 1991 as well as the Rivers State Environmental Protection Agency Law of 1991 was established; giving power to the state government to create

particular parastatals to manage MSW thus eroding the traditional functions of local government councils in conflict with paragraph (h) of the fourth schedule of the Nigerian Constitution which maintains the *status quo* of management of MSW to local government authorities.

The Rivers State Environmental Sanitation Authority (RSESA), a parastatal under the Rivers State Ministry of Environment established to manage the solid wastes generated within the metropolis and its environs was now replaced with the re-establishment of Rivers State Waste Management Agency Law (No.2 of 2014). The law governs waste management services which include the collection, handling, storage, transportation, treatment and disposal of wastes and the operation of waste management facilities. They provide places and or large bins at market places and street corners and road junctions for residents to dump their household wastes which are then evacuated by waste disposal contractors by methods described by Ayotamuno and Gobo [14].

In 2002, the Port Harcourt metropolis was demarcated into twelve distinct zones as a means of tackling solid waste generation, collection and management, for each local contractor (Table 1). This approach has been counter-productive in the long run as it has created more problems due to lack of proper coordination on the part of responsible agencies. Solid wastes dumped along streets are usually left over for a long time to decompose naturally by microorganisms, eaten by animals, picked by scavengers or washed away by the floods into drainages, larger creeks and rivers thus affecting the aesthetics of the city and the surface water quality [11,15-17]. This is because most of more than 200-250 tons of solid wastes generated in the city centre every day are not collected. As a result, the uncollected wastes, which is often also mixed with human and animal excreta, is dumped indiscriminately in the streets and in drains, so contributing to flooding, breeding of insects (especially mosquitoes) and rodent vectors and the spread of diseases.

1	Borokiri, Old Port Harcourt Township, Station Bus Stop;
2	Marine Base, Eastern By-pass, Ogbunabali, Amadi Flats, Old GRA;
3	Garrison, Trans-Amadi, Amadi-Ama, Abuloma;
4	Station Road, Harbour Road, Industry Road, Abonnema Wharf, Isaac Boro Park
5	Mile 1, II and III;
6	Elekahia, Rumumasi, Rumubiakani, Rumuogba;
7	Air Force Junction, Okporo Road, Rumuodara, Rumukrushu, Oil Mill Junction (Eledenwo);
8	Artillery Junction, Rumuibekwe, Woji;
9	Rumuola, Rumuokwuta, Rumuigbo; and
10	Leventis Motors area, D-line, GRA Phases 1, 11 and 111, Presidential Hotel, Rumuola Junction;
11	FGC, Rumuokoro, Rumuodumaya; and
12	RSU, Rumueme, Wimpey Junction, Rumuokwuta Junction.

Table 1: Distinct Zones demarcated for wastes collection and disposal in Port Harcourt City

Source: Rivers State Government (2008).

Waste Management, Climate Change, and Energy

Proper waste management is the set of provisions for the collection, transportation and environmentally sound disposal of waste. Waste management is one of the major challenges of urban management in Sub Saharan African countries particularly in Nigeria. The current difficulties in the management of solid waste are the result of poor mastering of concepts, approaches and techniques [18]. Many developed countries have employed advanced technologies such as incineration with energy recovery; sanitary landfilling; and more recently, anaerobic digestion; environmentally sound composting; and plasma gasification,

as well as developed best practices for dealing with MSW [19,20].

The disposal of solid waste produces greenhouse gas emissions in a number of ways. First, the anaerobic decomposition of waste in landfills produces methane, a greenhouse gas, 21 times more potent than carbon dioxide. Secondly, the incineration of wastes also produces carbon dioxide as a by-product. Additionally, in transporting wastes for disposal, greenhouse gases are emitted due to the combustion of fossil fuels. Finally, fossil fuels are also required for extracting and processing the raw materials necessary to replace those materials that are being disposed with new products.

The Way Forward

Waste prevention and recycling jointly referred to as waste reduction help us better manage the solid waste we generate. But preventing waste and recycling also are potent strategies for reducing greenhouse gas emissions and conserving energy. However, waste prevention and recycling reduces methane emissions from landfills. Waste prevention and recycling (including composting) divert organic wastes from landfills, thereby reducing the methane released when these materials are decomposed. This same process further reduces emissions from incinerators. Recycling and waste prevention allow some materials to be diverted from incinerators and thus reduce greenhouse gas emissions from the combustion of waste. Recycling saves energy because manufacturing goods from recycled materials typically requires less energy than producing goods from virgin materials. This also reduces emissions from energy consumption. Waste prevention is even more effective at saving energy because when people reuse things or when products are made with less material and/or greater durability, less energy is usually needed to extract, transport, and process raw materials and to manufacture replacement products. What's more, when energy demand decreases, fewer fossil fuels are burnt and less carbon dioxide is emitted to the atmosphere. Increases storage of carbon in trees help absorb carbon dioxide from the atmosphere and store it in wood, in a process called carbon sequestration. Waste prevention and recycling of paper products allow more trees to remain un-harvested, where they can continue to remove carbon dioxide from the atmosphere.

Wastes Generation and Estimated Quantities In Port Harcourt City

Solid waste generation rates estimate the amount of waste created by residences or businesses over a certain amount of time (day, year, etc.). Waste generation includes all materials discarded, whether or not they are later recycled or disposed in a landfill. Poor handling, evacuation and disposal of waste have numerous negatives impacts on the city's environment such as proliferation of mosquitoes and flies, bad odors, visual pollution. These negative impacts on the environment in turn have several impacts on the health of the city residents. Piles of garbage, trash along roads, block riverbeds and therefore threaten health and of residents due to improper disposal of wastewater

Methods for estimating wastes generation in Port Harcourt city

Waste quantities are usually estimated on the basis of past records of waste generation. The methods commonly used to assess the quantities are (i) load count analysis; (ii)

weight volume analysis; and (iii) material balance analysis. There are number of procedures to obtain samples from the municipal solid waste. In order to estimate solid wastes generated, the product is determined by the total number of containers, their volumes, and the average density of the solid waste, divided by the product of the determined average number of days required to fill a container and the population of the study area, this gives you the per capita generation rate. Structured questionnaire, key information interview (KII), field observation, and focus group discussion (FGD) method can be used to collect data from people within the study area. From the wards/communities, individual houses are selected randomly to collect the primary data.

Estimated Waste Generation Quantities in Port Harcourt city

Previously, Environmental Sanitation Authority in Nigeria made use of sanitary inspectors or public health workers to monitor waste generation and management. This method for some time now has not been operational and the issue of sanitation in the metropolis has been left to inexperienced contractors who rather see solid waste management simply as moving from one dump site to another. Generally, waste of all types are primarily the creation of human activity, therefore it is expected that the more people are living in a particular physical space for one activity or the other, the more acute we experience the problem of waste generation and management in such areas. Population therefore constitute a vital component of urban solid waste generation, management and disposal. The estimated population of Port Harcourt as at 2003 was about 1,356,000 with an estimated municipal solid waste generated as 1, 393,880 kg/day with each of the zones in the metropolis on average generating 199,126 kg/day with approximately 1.03 kg/person /day [14]. Waste generation estimates in 2002 analysis show that the average daily waste generation varied between 900 metric tonnes during the dry season (December-February) and 1350 tonnes during the wet season (June-October). This is approximately 0.9-1.1 kg/per person per day and 1.25kg/capita/day at an estimated population of 1.23 million in 2000 for Port Harcourt city Local Government [14,21] estimates that between 2002 and 2003 approximately 200,000 tonnes of wastes was disposed of in burrow pits and wetlands in the Eleme environment near Port Harcourt. Presently, a total of 1,917,524 kg of solid waste is generated on a daily basis in 2017 while it is estimated that over 2,160,000 kg of waste per day is generated in 2018. Igoni [22] however puts at 1,947 tonnes per day for a per capita waste generation rate of 1.11 kg/day. According to him, the management of waste in Port Harcourt is at best a mere collection and disposal of the waste, which are improperly done. The generation of MSW all over the world has attained frightening levels, at an annual rate of 1.3 billion tonnes, with a projection of 2.2

billion tonnes by 2025 [23]. This may not be unconnected with increasing populations, as of course, it is the humans and their activities that generate the wastes. Khatib [24], stated that population growth and urbanisation give rise to increased generation rates and complexity of MSW, putting pressure on existing waste management facilities. These, together with the attendant adverse effects of improperly managed MSW on public health and the environment, are some drivers for the continued desire to ensure safe and efficient management of this waste stream

Environmental Problems Associated With Waste Crisis

General

Protection of the environment throughout the waste chain, especially during treatment and disposal is key goal to municipal solid waste management. Until the environmental sanitation emerged, most wastes were disposed of with little or no control to land, as open dumping to air, by burning or evaporation of volatile compounds; or to water, by discharging solids and liquids to surface water or the ocean. Moving towards modern disposal system has generally followed a step-by-step process, first by phasing out uncontrolled disposal methods, then introducing gradually environmental standards for a disposal facility. In the process, controlling water pollution and methane emissions from sanitary landfills, and air pollution from incinerators is achievable. Agricultural activities such as fertilizer and chemical applications to soil and crop fields have also proved to be hazardous to open and subsurface water resources.

The rapid growth of industries, lack of financial resources, inadequately trained manpower, inappropriate technology and lack of awareness of the community are the major constraints of waste management. Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed of, which can pose risks to the environment and to public health [25,26]. More than 200-250 tons of wastes are generated in Port Harcourt city every day. Typically, one to two-thirds of the solid waste generated is not collected on a regular basis but end up been thrown into drainage systems especially during flash floods [27]. As a result, the uncollected waste, which is often also mixed with human and animal excreta, is dumped indiscriminately in the streets and in drains, so contributing to flooding, breeding of insect and rodent vectors and the spread of diseases [27,28]. Most of the Municipal solid wastes in the Port Harcourt city area is collected from the land in a more or less uncontrolled manner. A considerable portion of wastes, 40-60%, are not properly stored, collected or disposed of in the designated places for ultimate disposal [27]. Such inadequate waste disposal creates serious environmental problems that affect

the health of humans and animals and furthermore, cause serious economic and other welfare losses (Figure 7).

Waste Generation, Collection and Disposal

Municipal Solid Wastes (MSW) are wastes that are generated from residential, commercial, industrial, institutional, construction and demolition process and municipal services [8,29]. Key generation areas of wastes in Port Harcourt are the high commercial and industrial complexes of Trans Amadi and Onne Port as well the Port Harcourt city centre. The focus of waste management in Port Harcourt is on waste collection from households and the subsequent transport to a dumpsite where waste is offloaded and dumped untreated. There is also an emergence of recycling culture driven by poverty and the demand for product by manufacturers. The waste pickers get some financial value of the recyclables. In some cases, this practice by the informal sector involves separation or sorting of some fractions of the wastes at the waste dumpsite. Government involvement in the recycling industry is very low but in developed countries recycling is subsidized by governments because waste picking is a form of recycling.

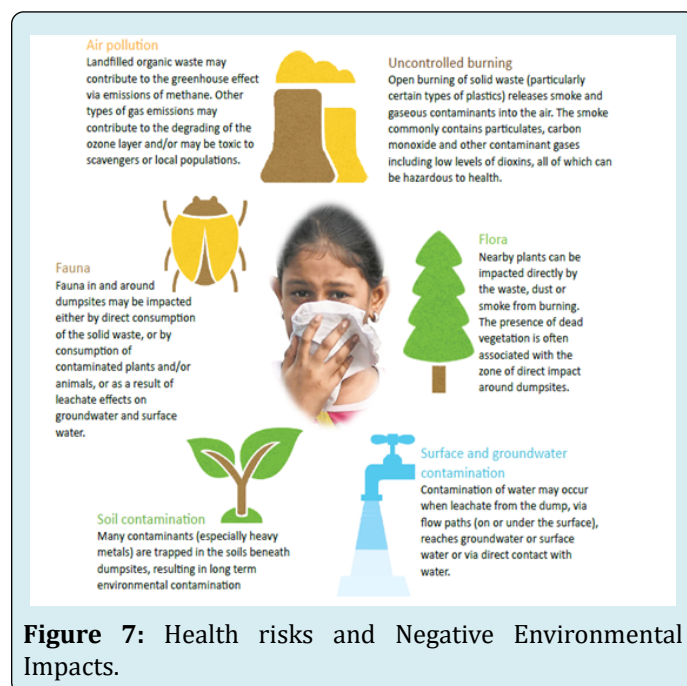


Figure 7: Health risks and Negative Environmental Impacts.

It is estimated that up to 2% of the population (up to 40,000 people) in developing countries survive through informal recovery practices [30]. Waste pickers play an important role in collecting recyclable materials and convert wastes into productive resources.

Waste collection typically covers the stage in the waste management system where waste is presented from the

point of generation to the point of transfer. In Port Harcourt, household coverage is low and people either practice river dumping, dispose in gutters (water drainage channels), burn or bury their wastes while some use plastic bags to dispose of wastes at staging stations or undesignated areas of the city where wastes are dumped at street corners along major streets intersections for collection thus defacing the aesthetics of the garden city status of Port Harcourt.

Urban Flooding

Urban flooding refers to the inundation of sections of urban areas [31]. This is caused by high intensity rainfall and prolonged rainfall leading to development of flash floods. Growing urban population results in large areas of land surface covered with roofing materials, concrete and bitumen pavement which reduce infiltration of rain water and increases runoffs leading to floods in the cities with adverse economic and health impact. This type of flooding is associated with the absence of runoff controls or defective runoff controls or misuse or urban drainage channels. The major cause of flooding in Port Harcourt is ranked 15.74% due to the absence of/inadequate drainage facilities resulting to flash floods [31]. Storm water drainage system is made up of gutters, manholes, curb inlets, roadsides culverts etc which aid to carry storm water to natural drains or rivers or other nearest water bodies. In some cases, drainage facilities may either not be large enough or insufficient to accommodate the excess run off or not properly sloped. It is possible that the drainage facilities as at the time it was designed was adequate but as urbanization increases surface runoff, the carrying capacities have turned out to be inadequate. Also economic development may intercept with natural pathways of storm water which in most cases may trap surface water especially in low-lying areas where there are no drains to convey surface runoff to natural drains.

Blocked drainage systems particularly contribute about 14.97% of flooding in Port Harcourt due to anthropogenic activities [27,31]. Where drainage facilities are available, some have been blocked by the introduction of wastes and debris. These blocked drainage facilities increase surface runoff by reducing the drainage capacities to carry storm water. This is aggravated by inadequate clearing or desilting and maintenance of the drainage channels causing increased flooding at which the floodwaters reach rivers and streams exceeding the natural capacities of these rivers and creeks [27]. Affected communities in Port Harcourt are Rumuepirikom, Mgbuosimiri, Rukpokwu etc because they reside close to water bodies. Economic development and inappropriate town planning have led to an explosion of poorly planned construction that has caused perennial flooding in Port Harcourt especially in areas like NTA/Choba road, Mgbuoba zone and Eneka communities that appear to

be worst affected.

Urbanization has brought about changes in land-use and built up environments which reduce infiltration and percolation. Construction of impervious surfaces have increased surface run-off which is generated faster than they are evacuated. Impervious surfaces exacerbate river flooding by increasing the rate at which storm water reach natural drains and making these floodwaters to reach rivers at the same time. Flash flood and flood pondage also occur in Port Harcourt metropolis due to the fact the designed capacities of available drainage facilities which were constructed years ago cannot cope with the increased volume of surface run-off generated presently as a result of impervious surfaces.

Uncontrolled urbanization, cementation/pavement of surface soils, insufficient drainage systems and blocked drainage facilities etc, flood disasters have been identified as contributory to flooding. Floods have been regarded as man-made disaster in Port Harcourt metropolis because residents have subjected themselves to flood risk by practices such as build houses in flood paths and floodable areas, constructing roads without drainage systems, blocking available drainage facilities with wastes etc.

Several other factors identified as the major causes of urban flooding include absence of/inadequate drainage facilities, heavy rainfall, blocked drainage systems, impervious surfaces, inappropriate town planning/uncontrolled urbanization, poor drainage network, flat terrain, climate change and unplanned development on flood plains. Apart from heavy rainfall (which is a meteorological factor and cannot be influenced), characteristic/qualities of the drainage system contribute to almost 50% of the factors influencing flooding in Port Harcourt [31]; therefore it is suggested that the following should be enforced for healthy environment.

Community participation in flood prevention, control and mitigation is very important. Residents in all part of Port Harcourt can form a Joint Task Force (in their various streets) to ensure that drainage facilities (gutters) are regularly cleaned up to allow the free flow of flood waters. A penalty must be imposed so that anyone who defaults must pay a fixed amount of money to ensure its full implementation. These Joint Task Forces can be absorbed by the Local Government Authorities to help monitor and maintain clean drainage facilities in all the zones.

Demolition of illegal structures that are built on the pathways of flood waters which obstruct their flow should be demolished. This would reduce the increased rate of uncontrolled urbanization/urban creep and decongest Port Harcourt city.

Environmental Pollution

The current situation of the environment in Port Harcourt is closely related to a situation where it has become impossible to employ waste management solutions. The decomposition of solid waste in waste dumps coupled with the organic elements they contain under the action of water, air and the temperature is likely to cause immediate or distant incalculable dangers to the environment. This is because there are no designated dumpsites for wastes disposal in Port Harcourt, rather you have receptacles created as emergencies littered at major streets and roads within the metropolis. Liquid wastes are also significant dangers to the environment including pollution of soil, water and air. Some waste pollutants such as heavy metals and hydrocarbons are likely to accumulate in wildlife, flora and in the food chain [32] (Figure 7). Uncontrolled disposal generates serious heavy metals pollution occurring in the water, soil, and plants [33], open burning is cause of CO, CO₂, SO, NO and other pollutant emissions that affect the atmosphere [34], waste picking within open dump sites pose to serious health risk people working on these areas [35] release of solid waste in water bodies improve the marine litter globally, enhancing environmental contamination [36].

During the rainy seasons, there is percolation/ stagnation and infiltration of wastewater that influence the degradation of components of the environment (ecosystem degradation) which eventually results to soil pollution [37] Plastic bags and bottles are waste that constitute especially a permanent danger to natural resources and animals. Plastics are non-biodegradable material and if poorly managed, can pollute the soil, attack vegetation, reduce infiltration of rainwater, clogged pipes and drains discharge storm water and wastewater [38,39]. Airborne dust affect the respiratory and cardiovascular volatile organic compounds ranging from odour annoyance to the carcinogenic effects; hydrochloric acid is a potential irritant to skin, eyes and respiratory tract, causing respiratory and cardiovascular diseases and cancer. Discharging, methane, abundantly generated by the decomposition of organic matter contributes significantly to the greenhouse effect and is explosive in certain concentrations. The formation of a biogas in landfills contain about 40% to 60% of methane, the remainder being carbon dioxide, nitrogen, hydrogen sulfide, and various acids or more are less volatile [40,41].

Water is a natural resource essential to life. But in an unhealthy environment, water becomes directly or indirectly a cause of illness or death. Mismanagement of waste causes pollution of groundwater. Humans may be infected by pathogens from wastes by drinking contaminated water or by eating seafoods that have concentrated harmful organisms they have extracted from contaminated water. Foods

that have been irrigated with untreated sewage, fertilized with untreated excreta or processed with contaminated water are also an indirect source of risk [42]. Plants growing in a municipal solid waste landfill and its vicinity contain contaminated heavy metals that can affect the food chain. Most of the heavy metals come from soils and partly from water and air [43]. Microorganisms may seep through some soils for long distances until they reach a body of surface water or groundwater and cause contamination. Leaking septic tanks and inadequate latrines may contaminate nearby drinking-water sources. Wastewater stagnation and infiltration, lack of maintenance and failures of sanitation facilities causes more pollution and proliferation of disease vectors (malaria, diarrhea, cholera, amoebiasis 44,45). Despite the fact that some forms of water pollution can occur through natural processes, it is mostly as a result of anthropogenic factors. These anthropogenic factors including agricultural activities, industrial discharges and domestic wastes contribute as sources of water pollutants [46] which affect the quality of water available for plant, animal and human use [47].

Aesthetics

Some wastes are disposed in vacant lots, low-lying areas, pond or rivers but a large percentage is deposited into roadside drainage ditches and storm sewers. In the prevailing system of collection, households are supposed to deposit their solid wastes in the communal bin. When the communal bins are placed at far distance, households usually throw their garbage at any convenient point like nearby road, ditches, ponds, lakes, or surface drains [48]. The final disposal of solid waste is being done by uncontrolled dumping of collected garbage in low-lying land or in an open boundary water body), such uncontrolled disposal of solid waste contributes to localized flooding through clogging of drains which in most cases is a public nuisance. It encroaches on roadways, diminishes aesthetic values and causes unpleasant odour and irritating dust. Organic portion of solid waste ferments and favours fly breeding. As a result of this uncontrolled disposal of solid wastes and irregular removal of desilted wastes degrade of the quality of urban environment [2,49]. A preventive waste management approach focused on changes in lifestyles and in production and consumption patterns offers the best chance for reversing current trends [49,50].

Malodor from the wastes creates an unhygienic ambience for everyone such as respiratory congestion or discomfort etc. Unplanned disposal of waste is a big threat to people's health. Severe odor and unpleasant aesthetic problems may result from uncollected wastes which are often mixed with animal and human excreta are usually thrown in an indiscriminate manner in both the streets and drains which contribute to flooding, insect breeding, rodent vectors and the ultimate spread of diseases [51-53]. Unplanned disposal

of waste and transportation where people they throw their household wastes on the drain or open places may lead to environmental pollution. In most cases obstructs the mobility of people by blocking the road.

Health Risks Related To Municipal Solid Waste Management

One of the main causes of environmental degradation is improper waste management in the disposal of solid wastes [54]. It is a major cause of pollution and outbreak of diseases in many parts of the world. The waste is deposited around most areas of the city in undesignated plots or receptacles as mountainous heaps and poses varied health, safety and environmental hazards. Some social impacts of the crises are destruction of environmental aesthetics; blocking of drains; effusion of offensive odours, invasion of the city by vultures, flies, mosquitoes, rats and cockroaches and obstruction of human and vehicular traffic. Leachate contamination of surface water is a major environmental concern. The heavy rains in the metropolis within the period of the rainy seasons (usually between May and June) facilitates rapid degradation of the organic matter; and leachate formation and transport into surface and ground waters results in contamination of the receiving water bodies [55]. Also, open burning of the waste releases emissions that are damaging to the atmosphere; cause respiratory diseases such as asthma and bronchitis in humans. Burning chlorinated wastes at low temperatures can be seen to release toxins such as dioxins and furans which are carcinogenic.

The accumulation of wastes in the street increases contact possibilities and offers very good conditions for the propagation of germs, insects, rats and other disease vectors. Where sanitation infrastructure is insufficient, most of these uncollected wastes which are often mixed with animal and human excreta are usually thrown in an indiscriminate manner in both the streets and drains which contribute to flooding, insect breeding, rodent vectors and the ultimate spread of diseases [56]. Uncollected wastes often clog drains and cause the stagnation of water, the breeding of mosquitoes or the contamination of water bodies from which the population normally takes water for consumption, cooking and cleaning. Direct or indirect contact with these vectors or being bitten by certain insects can cause dangerous bacterial, viral and parasitic diseases [56].

Health problems associated with open dumpsites are related to emissions such as, POPs (persistent organic pollutants), heavy metals and VOC (volatile organic compounds) as a result of uncontrolled decomposition of biodegradable wastes. Other health risks depend on the practices and the types of wastes disposed in each dumpsite, as well as the environmental and social conditions of the

area emissions from waste decomposition namely leachate and biogas. Open burning and animal feeding may increase health risks substantially either by direct emission of dangerous pollutants and transfer of pollutants to the food chain. Uncontrolled disposal of hazardous and healthcare wastes as well as manual on-site treatment and disposal of e-waste by informal workers may result in increases in health risks and negative environmental impacts [57]. Maintaining healthy conditions in cities, particularly through a good waste collection service is very necessary, because uncollected solid waste blocks drains, and causes flooding and subsequent spread of waterborne diseases.

Environmental pollution due to indiscriminate waste dumping affects health through both short and long-term effects [58,59]. Examples of short-term effects are congenital anomalies, asthma and respiratory infection [60,61]. Long-term health effects related to waste exposure include chronic respiratory and cardiovascular diseases, cancer and even brain, nerves, liver, lymphohematopoietic or kidneys diseases [62]. Poor waste management poses a great challenge to the well-being of city residents, particularly those living adjacent to dumpsites due to the potential of the waste to pollute water, food sources, land, air and vegetation [15,29,63-65]. The poor disposal and handling of waste thus leads to environmental degradation, destruction of the ecosystem and poses great risks to public health [66].

Solutions to Manage Urban Wastes and Urban Floods

Resource management (valorization of recyclables and organic materials)

The priorities of good resource management are expressed by the '3Rs' – reduce, reuse, recycle. This can be further split between 'dry' recyclables and bio-solids or organic wastes. 'Closing the loop' by returning both materials and nutrients to beneficial use or by preventing waste littering all over the ground, and strive for high rates of organics recovery, reuse and recycling can contribute to resource management of wastes.

- Reduce the quantities of waste being generated. This is the new focus of modernization in developed countries; but it is important also for rapidly growing cities in middle and low-income countries to bring their waste growth rates under control.
- Reuse waste products that can be reused, repaired, refurbished, or remanufactured to have longer useful lives.
- Recycle materials that can be extracted, recovered and returned to industrial value chains, where they strengthen local, regional and global production. Return nutrients to the soil, by composting or digesting

organic wastes as 'bio-solids including plant and animal wastes from kitchen, garden and agricultural production, together with safely managed and treated human excreta. These are sources of key nutrients for the agricultural value chain, and their proper utilization is important to food security and sustainable development. Other waste treatment options like composting, use of incinerators, or use of Waste-to Energy power plants, bio-methanation etc can be employed as solutions to SWM problems. These treatment of waste options can bring about waste minimization..

Corporate Social Responsibility (CSR)

This is "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis". Besides gaining profits, a company should be involved in the development of the community in which it operates" [67]. This is because industrial wastes and toxic inorganic chemicals are obtained from large factories, manufacturing industries and exploration/mining companies. Therefore, the ecosystems of watersheds, inland waterways, shoreline and coastal creeks close to these anthropogenic activities are at constant risk of pollution and degradation

Extended Producer Responsibility

(EPR) is thus a necessary step, if the industry is to become a more responsible and trustworthy corporate citizen. As a market-oriented policy instrument, when applied to products that have reached the end of their useful lives, EPR requires procedures to internalize waste management costs, creating an incentive for them to redesign products that will reduce material use and improved energy efficiency and recyclables [68]. EPR can be applied to post-consumer wastes which place increasing physical and financial demands on municipal waste management [69]. According to Rossem, et al. [70] effective implementation of EPR should bring the achievement of two main environmentally-related goals, namely: design improvements of products (in this sense the EPR system should provide incentives for manufacturers to improve products and systems surrounding the life cycle of products) This will involve effective collection, environmentally-sound treatment of collected products and high use of products and materials in the form of re-use and recycling and then, high use of product and material quality through effective collection and re-use or recycling.

According to Jessen [71,72], Zero Waste System approach could be a discipline required to create a more sustainable interaction with our natural environment including the principles of conserving resources, minimizing pollution, maximizing employment opportunities, and providing the greatest degree of local economic self-reliance." This can be

achieved through producer responsibility where producers must share responsibility with consumers for recovering their products and ensuring that they are recycled and not wasted; also producers need to contribute to the "closing the loop" process by using the materials collected in local recycling programmes to manufacture new products.

Government Responsibilities to Waste Management

The government of Rivers State needs to ensure that people fully comply with all legislations and regulations governing solid waste generation and disposal in particular and the environment in general. Defaulters should be tried and convicted in accordance with extant laws to serve as a deterrent. Communal refuse dumps or receptacles should be provided in large quantity and also placed closer to the residential and commercial areas than is the practice. Evacuation of the deposited wastes should be done daily and regularly. There is also need to improve the road infrastructure especially in the sub-urban or slum areas of the state. This will enable solid waste collection trucks to have easy access to these hitherto under-served areas.

The issue of training and monitoring of refuse collectors in the state is very important. Some of the officers of the waste management authorities and sister agencies have little or no technical knowledge or training in environmental engineering. Lack of trained personnel is worsened by the appointment of politicians to the top management of these agencies and as waste contractors. The professionals in these concerned agencies should be allowed to man them for efficiency.

The scavengers should be organized into a union and registered. They should have identification cards. They should be trained and strictly monitored. If they are organized they can assist in evacuating solid wastes from individual residences and business premises. To make this work, there is need for government to establish solid waste collection centres for recyclable materials and exempt the scavengers from tax. Providing them with uniform may be helpful as well.

Government should initiate and sustain user participation. This may include involving users in monitoring and implementation of solid waste collection and disposal services through neighbourhood committees, local councils, etc; establishing communication channels between community leaders/landlords and users through complaint desks, information sharing, meetings, neighbourhood committees, etc; raise awareness and mobilize stakeholders (such as community leaders, landlords, religious leaders, itinerant waste buyers, informal waste pickers, etc) to build

a basis for collective participation. This could be achieved by using clear simple messages and popular channels such as television, radio, churches, schools, bill boards, newspapers, community based organizations (CBO^s), fliers etc. The media organizations should present environmental and public health education programmes that emphasize the implications of poor sanitation. Such programmes should be presented in the various local languages in the state and the common Pidgin English. Such presenters should have a good knowledge or understanding of the issues at stake. The use of dramas, commentaries, documentaries, etc, should be part of the strategies to be used. A key element in influencing the adoption of responsible environmental behavior is improved, consistent and regular awareness building.

The state government may need to consider instituting awards for the neatest community or street. This could be done through the local councils in conjunction with religious leaders in such communities. A weekly inspection of the areas should be done while the award could be done monthly. There is need for government to re-introduce the use of sanitary inspectors as was the case before the use of taskforce. Cover all trucks during transportation.

There is also need to raise awareness about waste reduction, reuse, recovery/recycling and handling of hazardous and non-hazardous wastes. The inadequate space and local communities' resistance to locate landfills in their area should drive all stakeholders to consider waste minimization. This is in addition to the environmental effects of disposed wastes. Aside improving the road infrastructure, there is need to plan and implement waste collection services to cover unserved or underserved areas. Private sector participation should be allowed.

Government should promptly evacuate refuse gathered during the monthly environmental sanitation. One of the problems confronting solid waste management agencies in the state is funding. The government may need to increase its budgetary allocation to the solid waste management agencies, ensure individuals and business owners and companies pay special fees proportional to the wastes they generate. The option of payment of fine for offenders of solid waste or environmental laws should be strictly and transparently enforced. Respondent's willingness to pay for solid waste collection services need to be harnessed by the government. The government should partner with churches in the state to help educate members on their civic, moral and religious duty to keep both private and public spaces clean.

Conclusion

A good solid waste management system is like good health; if you are lucky to have it, you don't notice it; it is

just how things are, and you take it for granted. On the other hand, if things go wrong, it is a big and urgent problem and everything else seems less important. Managing solid waste well and affordably is one of the key challenges of the 21st century, and one of the key responsibilities of all stakeholders and government. It may not be the biggest vote-winner, but it has the capacity to become a full-scale crisis, and a definite vote-loser, if things go wrong.

However, solid waste management system, has no perfect solutions, but also no absolute failures, the specific technical and economic approaches that work in a particular country may not work in another country. There is only one sure winning strategy, and that is to understand and build upon the strengths of your own city, to identify, capitalize on, nurture and improve the indigenous processes that are already working well. These may well be outside the 'formal' waste management system provided by the city. Therefore to facilitate actors, the citizens, non-governmental organisations, the formal and informal private sector, and indeed the government needs to make their own decisions and to take steps in developing a solution appropriate to their own city's particular circumstances and needs.

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