Investigation on Effects of Roadside Solid Waste Dumping on the Flow of Traffic and Pavement Along Abuja-Keffi Expressway Abuja Nigeria

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ABSTRACT

In developing county, sustainable socio-economic development of every community depends much on the sustainability of the environment. The contamination of the environment by anthropogenic practices is globally known to impacts negatively on the environment. The disposal and management of municipal solid waste is a globally challenging issue especially in developing country like Nigeria due to its adverse environmental effects. Mankind depends on the environment to sustain their lives and that solid waste is one of the major environmental problems, other major environmental issues include flooding and desertification in Nigeria and many other developing and even developed countries are threatened by this. Municipal solid wastes consist of day-to-day consumed and discarded items such as food wastes, containers, product packaging and other miscellaneous like residential, commercial, electronic wastes, institutional and industries sources.

Population explosion, improved standards of living, change in social and family structure and urbanization made over previous years have brought about solid waste disposal problem particularly in Nigeria. The use of non-biodegradable by households and changes in usage pattern as new resources comes into use, have led to increase in the quantity and complexity of solid wastes available for disposal in various households. Management of these generated wastes, keeping the away from Nigerian highways has become a big challenge. The waste generated in the country has increased while containment is nonexistent as such, they have become hazards on populace, drainage system in neighborhood streets, roads, and highways.

An analysis of the effects of roadside dumping of these waste on highway pavement with Abuja-Keffi Expressway as case study, identifying sources of wastes, its types, classification, and categories. extensive review of collection, disposal, control measures and factors militating against management, how these affects structural integrity of road pavement.

This paper summarizes the stages of this project. It specifically outlines the field work and presents several data acquisition methods incorporated, with emphasis on how waste dumping led to weakening road subgrade strength, a measure using California Bearing Ratio Test (CBR) as well as increase in Optimum Moisture Content (OMC and Maximum Dry Density (MDD) of the pavement materials. Finally, the paper summarizes the waste management stages with emphasis on type, source, classification, control, effect on traffic and overall structural integrity of Abuja-Keffi Expressway.

1 INTRODUCTION

In developing county, sustainable socio-economic development of every community depends much on the sustainability of the environment. The contamination of the environment by anthropogenic practices is globally known to impacts negatively on the environment. The disposal and management of municipal solid waste is a globally challenging issue especially in developing country like Nigeria due to its adverse environmental effects. Mankind depends on the environment to sustain their lives and that solid waste is one of the major environmental problems, other major environmental issues include flooding and desertification in Nigeria and many other developing and even developed countries are threatened by this [1]. Municipal solid wastes consist of day-to-day consumed and discarded items such as food wastes, containers, product packaging and other miscellaneous like residential, commercial, electronic wastes, institutional and industries sources [2]. Location of the Abuja-Keffi Highway is shown in Fig. 1.

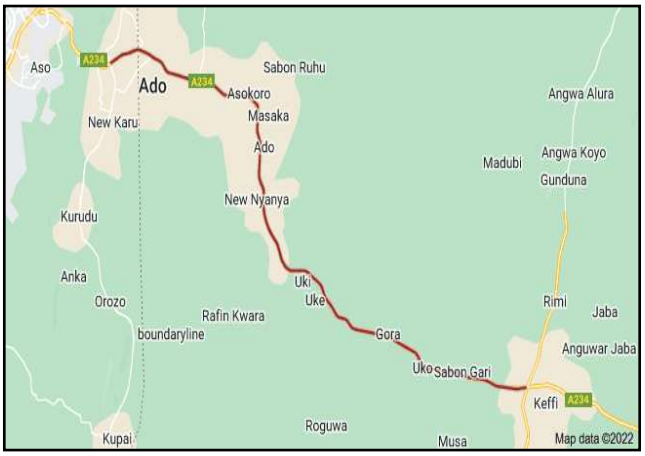

Fig. 1. Location Map of Abuja- Keffi Expressway

The Federal Government of Nigeria establishments were relocated to Abuja, the Federal Capital Territory (F.C.T) in the 1990s and today rapid expansion has exceeded the anticipated master plan of Abuja [3], with resultant evolution of suburbs which are characterized by unplanned growth in property resulting from absence of development control. Karu in the western zone of Nasarawa state began to swell with uncontrolled influx of people as early as mid-90s barely five years after the seat of government officially moved from Lagos to Abuja. Construction activities which broke ground in Abuja with the expansion of government and private businesses heightened demand for affordable accommodation by construction workers and other low-income working-class people. Karu with proximity to Abuja became the destination [4]. This suburb continued to experience higher rate of

growth, but the then old Plateau state and the current Nasarawa State government failed to come up with an immediate project to effectively address the system of waste management which soon became, but dirty environment to Abuja Environmental hazards of varying magnitude dangerously threaten human and animal lives in most urban centres in Nigeria [5]. Rapid urbanization, rural-urban migration, little or no town planning efforts coupled with attitudinal irresponsibility, lack of political will, ineptitude and graft have independently and collectively created environmental challenge in Nigeria resulting to human or solid waste decorating streets and public space everywhere in Nigeria [5].

Solid waste composition in developing countries like Nigeria is heterogeneous and mixed, the harmful components are made up of electronic waste (e-waste) and other hazardous left over. Electronic waste refers to end of-life electronic products including computers, printers, photocopy machines, television sets, mobile phones and toys which are made of sophisticated blend of plastics, metals, among other materials [6] [7], and observed that the number of electronic devices used per capita at the global scale is growing at a rate of about 4% and will continue to increase as it is becoming the fastest waste stream worldwide [8] [9].

Most developing nations are fast becoming an e–waste destination because most second handed electronics, substandard and recycled electronics from China, India and other Asian countries find fertile grounds in these countries and are patronized mostly by the low-income population. As a result of these ugly practices most municipal solid wastes contain high quantities of these e–wastes. There is therefore need for urgent and strict control measures by Nigeria government to regulate the importations of substandard electronics which have short life span.

The rapid population growth due to urbanization in suburbs of City of Abuja has resulted to difficult environmental management issues for agency providing solid waste management. Urbanization affects land-use, when not controlled causes the emergence of illegal structures and filthy neighbourhoods which is characteristic feature of most areas, especially Karu, therefore services such as waste collection becomes difficult and eventually leads to illegal dumping [10]. These illegal dumps, mostly along the roadside grow into mountain, open dumps in the middle of residential quarters and along the major roadways. Fig. 2 show open dump posing lot of health hazards, reducing the beauty and value of surrounding properties, parks, and recreation areas.

Fig. 2. Waste Dumpsite Along Abuja-Keffi Expressway

Generation and disposal of solid wastes in the world is a problem that continues to grow with urbanization, development of industrialization and growing population [11]. Groundwater pollution in Nigeria is mainly due to the process of industrialized urbanization that has progressively developed over time without regard for environmental consequences [12]. Increase in population, industrialization and technological revolution have resulted in the increase in waste generation with resultant production of wastes which have become too complex to manage and control [12]. Thus, pointed out that the impact of solid wastes in recent time on groundwater and other water sources has attracted a lot of attention because of its overwhelming environmental significance [13].

The problem of solid waste disposal in urban centres in developing countries is a major concern to government and this problem becomes worrisome in Nigeria where municipal waste generation is always on the increase because of increase in population pressure and socio-economic factors [14]. Solid waste was classified principally as garbage, ashes and rubbish. The garbage includes organic matter resulting from preparation and consumption of food [15]. Ashes include remains of cooking and heating process, and rubbish may be papers, rags, wood, leaves and other non-biodegradable materials such as glass, metal and polythene materials [16].

Solid waste classified as garbage, which include man made waste from food, rubbish comprised of non-biodegradable or non-decomposable waste either combustible (such as papers, wood, and cloths) or non-combustible (such as metals, glass, ceramics, and polythene). Ashes comprised of residues of combustible solid fuels, large wastes are made up of demolition and construction debris and trees, dead animals and finally sewage- treatment comprised of materials retained on sewage treatment screen, settled solid and biomass. The current state of plastic bag waste pollution in Nigeria is alarming, several environmental impacts including blockage of waterways and choking of animals, soils, and mosaic litters of pure water sachet in the landscape requires urgent attention [17].

In most cities of Nigeria, refuse is disposed indiscriminately, and it is very common to find the drainage lines being filled up with refuse. The refuse dump at roadside is a huge problem to road users and the environment. The ugly sight that welcomes guests as one approaches for instance, Karu, is becoming worrisome.

The entire length of Abuja- Keffi Expressway especially at Mararaba and other major link routes are often blocked by flood whenever there is heavy downfall. Therefore, there is need to assess the effects of municipal solid waste generation and management in Karu and Nyanya in Abuja [18]. The environmental impacts of roadside solid wastes dumping that characterized the Abuja-Keffi expressway as it affects the flow of traffic and the road pavement. The effects of roadside solid waste dumping are gradually affecting the society in many ways [19].

Most times the overflow of solid waste dumped on the roadside usually ends up in the drainages especially when the authority in charge of the disposal of this waste is not active enough to move the waste as prompt as it should be, while some members of the society see no harm in dumping their waste into the nearby drainages [20]. If the drainages that supposed to channel the flow of surface run-off are being used as refuse dumping ground, then the flow of water is obstructed, and the water then settles on the roads, it becomes a major problem since water into road pavement materials in base and subgrade leads to failures. Fig. 3 shows section of Abuja-Keffi Expressway with waste dump.

Fig. 3. Mixed Solid Waste Cleared from Drainage Channel on Abuja-Keffi Expressway

Water is the main contributor to the failure and damage of roads. Water can be in the form of ground water, surface water (streams and rivers) or rain, as runoff from the surrounding areas. In addition, water may flow laterally from the pavement edges, or it may seep upward from a high ground water table. These water flow can destroy the road in several ways:

1. reduction of base, subbase, and sub grade strength,
2. differential swelling in expansive sub-grade soils,
3. stripping of asphalt in flexible pavements,
4. frost heave and reduction of strength during frost melt, and
5. movement of fine particles into base or sub-base materials resulting in a reduction of the hydraulic conductivity considerably.

The road failure can be reduced if the flow of water is controlled. Minor damages can easily be repaired as part of the regular maintenance provided to the road and its structures. If the flow of water is not properly managed, the deterioration of the road will be more severe and occur more rapidly. This will lead to higher maintenance cost and in the worst cases result in serious failure which may obstruct the traffic flow.

Recently Nyanya is facing extensive water logging during the rainy season as result of a serious problem of poor drainage and waste management. Inadequate drainage problems become one of the most common sources of compliant from the residents of Nyanya and Karu in Abuja and this problem is becoming worse in recent year due to increase in population, as such proper waste management should be put into consideration as the population in this area is fast growing than expected. Poor waste management, especially the roadside waste dumping mainly causes severe flooding which creates damages and severe problems to the road pavement and road users.

In addition, deceases are spread easily and problematic to the populace, such as malaria, diarrhoea, cholera, etc., severely aggravated due to clogged drainage system.

2 PROBLEM STATEMENT

The challenge of waste management has been a raising concern for the Federal government, local authorities, environmentalists, researchers, and the communities at large. Throughout Nigeria there has been an increase in the amount of waste generated at household level yet there has not been the requisite collection and disposal services, let alone an effective waste management strategy to meet the growing challenge. Wastes if not properly managed has resultant effects which centres on pollution of land, air, and water. These resultant effects shall be vividly investigated in this research.

The constant overburden pressure imposed on the road due to daily traffic on this section of the road is a major problem which leads to the failure at these sections or area of the road. In addition, indiscriminate solid waste dump site on the roads poses a threat to drainages free flow, during rainy season waste are usually pushed into the drains which block the free flow of rainwater along the drain. The overflow of the rainwater accumulates on the road, impeding road traffic and also weakened the road pavement structural strength.

This research project work will focus on the effects of solid waste dump site on flow of road traffic and how it affects the road pavement structural strength. Definition of solid waste solid waste as generally known is any garbage, refuse, sludge from air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities etc.

2.1 Research Aim and Objectives

The aim of this research is to investigate the effect of roadside solid waste dump on flow of traffic and the pavement along Abuja-Keffi Express way. This aim will help to achieve the following objectives:

1. Determine the effects of roadside solid waste dumping on drains along the Abuja-Keffi Expressway at CH. 1+800 and CH.11+200.
2. Determine the effects of roadside solid waste dumping on flow of traffic along the express way
3. Determine the effects of roadside solid waste dumping on pavement condition along Abuja- Keffi Expressway at CH. 1+800 and CH.11+200.
4. Identify the reasons for roadside dumping along the highways.

2.2 Scope of the Study

This research examined literature review on effect of roadside solid waste dump on the traffic flow and the pavement along Abuja-Keffi express way at CH. 1+800 and CH.11+200.It is important to note that the definition of solid waste is not limited to wastes that are physically solid. Many solid wastes are liquid, semi-solid, or contained gaseous material. Solid waste is any material that is discarded by being: Abandoned:

The term abandoned means thrown away. A material is abandoned if it is disposed of, burned, incinerated, or sham recycled. But this project will focus specially on household solid waste that is waste from the community and how it affects roads traffic and the road pavement.

2.3 Justification of the Study

In Nigeria, proliferation of solid waste especially along the major motorways has recently been one of the three major environmental and social issues, including flooding and desertification. This study aimed at assessing the environmental and socio-economic impacts of the roadside solid waste dumping and burning as well as the perceptions of the various groups of road users. Several studies have been documented on the environmental and socioeconomic impacts of municipal solid waste, but it is rare to find any on the roadsides dumping and burning in this region.

There is evidence of indiscriminate discharge of garbage into drains and at times on the highway. In urban areas, Nigerian cities have been described as one of the dirtiest, the most unsanitary and the least aesthetically pleasing in the world [18].

Then, one begins to wonder the reason(s) behind those dirty habits of our people. Thus, this research will be of great importance as well as help to reduce environmental pollution and increase the life span of Nigerian highways.

2.4 Limitation

1. This area is highly populated; therefore, it was difficult to control effectively the practice of solid waste dump into the drains and on the roadside.
2. The biggest challenge is the location of the market along this expressway.
3. The inhabitability of the authority concerned to evacuate the waste as in when due.
4. No enforcement of indiscriminate solid waste dump along the expressways.
5. Ineffective public sensitization on the effects of roadside solid waste dump

3 LITERATURE REVIEW

Federal Government of Nigeria establishments were relocated to Abuja, the Federal Capital Territory (F.C.T) in the 1990s and today rapid expansion has exceeded the anticipated master plan [19], with resultant development of suburbs which are characterized by unplanned growth in property resulting from absence of development control. Karu in the western zone of Nasarawa state began to swell with uncontrolled influx of people as early as in the mid-90s barely five years after the seat of government officially moved from Lagos to Abuja.

Construction activities which broke ground in Abuja with the expansion of government and private businesses intensify demand for affordable accommodation by construction workers and other low-income working-class people. Karu with proximity to Abuja became the destination [20].

This suburb continued to experience a growth at geometric rate, but the then old Plateau State and the current Nasarawa State government failed to come up with an immediate project to effectively address what soon became, but dirty environment to Abuja.

3.1 Source of Waste

Table 1. Sources of Waste

S/N	Source	Typical waste generators	Types of solid wastes
1.	Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes).
2.	Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
3.	Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
4.	Institutional	Schools, hospitals, prisons, government centers.	Same as commercial.
5.	Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
6.	Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
7.	Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
8.	Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).

3.2 Types and Causes of Waste

The UK Environment Agency classifies waste as either controlled waste or non-controlled waste. Controlled waste includes waste generated from households (municipal solid waste), commercial and industrial organizations and from construction and demolition. Non-controlled waste includes waste generated from agriculture, mines and quarries and from dredging operations. Solid waste can be classified into different types depending on their source:

Household Waste is Generally Classified as Municipal Waste:

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing.

Industrial Waste as Hazardous Waste:

Industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous. Hazardous wastes could be highly toxic to humans, animals, and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g., gases. Household wastes that can be categorized as hazardous waste include old batteries, shoe polish, paint tins, old medicines, and medicine bottles. Hospital waste contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure. In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining, and rubber goods industries. Direct exposure to chemicals in hazardous waste such as mercury and cyanide can be fatal.

Biomedical Waste or Hospital Waste as Infectious Waste:

Hospital waste is generated during the diagnosis, treatment, immunization of human beings and animals and in research activities in these fields. It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner.

3.3 Waste Collection and Disposal

Collection and disposal of waste are some of the more visible signs of successful or unsuccessful solid waste management systems. If successful, the result is clean surroundings and good public sanitation; if unsuccessful, litter and poor public sanitation are everywhere which can be seen with the naked eye. Good public sanitation begins with a properly designed and operated waste collection and disposal system.

Domestic waste management, collection and disposal have always been a universal problem. Therefore, it is not associated only to developing countries like Nigeria. Refuse and domestic waste will not constitute a strange sight to Nigerians whose roads, streets and drainages are littered with tons of garbage from animal to human carcass. Lately however, a lot of concern has been expressed by the well-meaning residents that the battle against refuse, especially on the streets, roads, and avenues is not being prosecuted in a way to guarantee a healthy environment [22].

In some states of the federation, private sector waste disposal operators diligently visit homes and carry away filled refuse bags, load them into waiting trucks and cart them away for final delivery. This is the system that is being practiced in Lagos State. In some states where there are no private disposal operators, the state government makes provision for the collection and disposal through the waste management board. Such states include Ondo, Ogun, Nasarawa etc. In states where the waste management board is not efficient, refuse is dumped in open spaces, roadsides, drainages and at times inside the river. Waste disposal in some states, the disposal method employed includes landfill, incinerators, and recycling.

3.4 Waste Management in Nigeria

The Federal Government of Nigeria has promulgated various laws and regulations to safeguard the environment. These include Federal Environmental Protection Agency Act of 1988. The Federal Ministry of Environment administers and enforces environmental laws in Nigeria. It took over this function in 1999 from the Federal Environmental Protection Agency (FEPA), which was created under the FEPA Act. Pursuant to the FEPA Act, each state and local government in the country set up its own environmental protection body for the protection and improvement of the environment within its jurisdiction. Municipal solid waste management is a major responsibility of state and local governments.

Nigeria is presently experimenting with the privatization of this sector. The Federal Government has instituted National Integrated Municipal Solid Waste Management Intervention Programmed in seven cities of Nigeria. The seven cities are Maiduguri, Kano, Kaduna, Onitsha, Uyo, Ota, and Lagos. Lagos state government established municipal solid waste management policy to encompass private sector participation in waste collection and transfer to designated landfill sites.

Human and industrial wastes are not only toxic, but they are also in the league of silent killers. An editorial in the Punch online edition of Sunday, March 1, 2009, noted quite rightly that Nigeria "has now become a big dumping ground for all manner of items from used clothes and cars to second-hand televisions, refrigerators and computers. Some of these items that are not serviceable are further disposed of in waste dumps where they could pose a pollution threat to the environment and people". Improper waste disposal is significantly harmful to human health and the environment. In Nigeria, the commonest way of disposal of unserviceable items is to set them on fire. This could lead to the escape of dioxins into the atmosphere. Dioxins are carcinogenic and can cause endocrine disruptions. Other chemical contents could percolate into the soil and contaminate sources of water supply and edible plants [23].

Rapid urbanization and industrial diversification have led to generation of considerable quantities of municipal, plastic, hazardous and biomedical waste. Improper disposal of waste often results in spread of diseases and contamination of water bodies and soils. The impacts of these wastes on the economy cannot be ignored and managing them has become a major problem. Waste management is therefore the organized and systematic channeling of wastes through practically economically and technically appropriate recovery or disposal route in accordance with acceptable public safeguards. The post-independence era in Nigeria has witnessed series of political and socio-economic development [22].

Today, the nation comprises of 36 states and a Federal Capital Territory compared with initial four regions at independence in 1960 there is continuous increase in population, industrialization and enhanced research and commercial activities since petroleum was discovered in Nigeria, yet this growth has not been comparatively matched by an improvement in the quality of the urban environment. Instead, we have huge mounds of refuse and astronomical increase in the volume and diversity of solid waste that are generated and disposed carelessly in Nigeria.

3.5 Methods of Waste Management

Waste management is now tightly regulated in most developed countries and includes the generation, collection, processing, transport, and disposal of waste. In addition, the remediation of waste sites is an important issue, both to reduce hazards whilst operational and to prepare the site for a change of use (e.g., for building). The major methods of waste management are:

1. Recycling - The recovery of materials from products after they have been used by consumers.
2. Composting - An aerobic, biological process of degradation of biodegradable organic matter.
3. Sewage treatment - A process of treating raw sewage to produce a non-toxic liquid effluent which is discharged to rivers or sea and a semi-solid sludge, which is used as a soil amendment on land, incinerated or disposed of in land fill.
4. Incineration - A process of combustion designed to recover energy and reduce the volume of waste going to disposal.
5. Landfill - the deposition of waste in a specially designated area, which in modern sites consists of a pre-constructed 'cell' lined with an impermeable layer (man-made or natural) and with controls to minimize emissions.

Table 2. Waste Management Method Comparison

Option	Advantages	Disadvantages
Recycling	Conservation of resources Supply of raw materials to industry Reduction of waste disposed to landfill and incineration	Diverse range of processes Emissions from recycling process May be more energy used for processes than original manufacture Currently low demand for products Requires co-operation from individuals
Composting	Reduction of waste to dispose to landfill and incineration Recovery of useful organic matter for use as soil amendment Employment opportunities	Odours, noise, vermin nuisance Bio-aerosols—organic dust containing bacteria or fungal spores Emits volatile organic compounds Potential pathway from use on land for contaminants to enter food chain
Sewage treatment	Safe disposal of human waste	Discharges may contain organic compounds, endocrine disrupting compounds, heavy metals, pathogenic microorganisms
Incineration	Protects sources of potable water supply Reduces weight and volume of waste, about 30% is left as ash which can be used for materials recovery Reduces potential infectivity of clinical waste Produces energy for electricity generation	Odour nuisance Produces hazardous solid waste Discharges contaminated waste water Emits toxic pollutants, heavy metals, and combustion products
Landfill	Cheap disposal method Waste used to back fill quarries before reclamation Landfill gas contributes to renewable energy supply	Water pollution from leachate and run off Air pollution from anaerobic decomposition of organic matter to produce methane, carbon dioxide, nitrogen, sulphur and volatile organic compounds Emission of known or suspected carcinogens or teratogens (e.g. arsenic, nickel, chromium, benzene, vinyl chloride, dioxins, polycyclic aromatic hydrocarbons) Animal vectors (seagulls, flies, rats) for some diseases Odour, dust, road traffic problems

3.6 Stages in Waste Management

The various stages involved in Waste management are:

Generation: This is the stage when materials become waste and is discarded. The generation rate is often defined as the weight of material discarded as solid waste by one person in one day.

Storage: House storage, keeping solid waste in place or containers which is the responsibility of the individual members of the household while, Command storage, is the responsibility of the refuse collection agency.

Collection: This has to do with transportation of the solid waste from the point of storage to the point of disposal, two stages are involved in the collection stages; The direct collection, which makes use of only one means of transportation i.e. the Solid waste is picked up from the point of storage in a truck that takes it to the disposal site, The second stage collection carries the solid waste from the storage facility to the Transfer station, at the transfer station, the waste is loaded into the secondary stage, to transport the refuse to the Disposal site.

Disposal: The destination of solid waste, usually it is dumped on land at a tip, this may be done in an engineered and hygienic Way: - sanitary landfill or controlled tipping, or in a careless Way: - open tipping or crude dumping.

3.7 Environmental Impact of Roadside Dumping on Traffic and Highway

The disposal of municipal solid waste by the roadside along Abuja-Keffi highway has negative impacts on the general environment. The heaps of garbage emitting offensive stench welcoming guests as one enters Karu, spanning from Mararaba, One-man village, Ado, New Nyanya, Masaka, Kuchikau, Auta Balefi as well as cluster of other shanties at the Nasarawa State border with Abuja FCT made Karu a

twin-town, but dirty environment to Abuja. The mountains of refuse dumps which decorate the major roadsides on this highway serve as good breeding ground for rodents and snakes.

Fig. 4. Mixed Solid Wastes Removed from Drainage Channel on Abacha Road [24].

These rodents are known to be vectors of the deadly Lassa fever and the snakes are also known to be poisonous reptiles. Also, the biodegradable wastes serve as good breeding grounds for cockroaches, houseflies and create stagnant water which serves as breeding ground for mosquitoes. These spread various diseases like cholera, typhoid fever, malaria and yellow fever. It therefore impacts negatively on the health of the residents [24].

The garbage has been washed from the heaps of solid waste at the shoulder of the roads by rainstorm scattering all over the environment. Some of these solid wastes are being washed by rainstorm into the drainages/gutters that were made for free flow of water and end up blocking them preventing easy flow of water and subsequently lead to flooding of the highway and even people's homes. The blockage of the drainages by solid waste especially non-biodegradable materials such as plastics and polythene materials lead to a situation where stagnant water bodies and un-cleared drainage/gutters run right in front of living quarters and major highways as shown on Fig. 3 and Fig. 4 [24].

Fig. 5. Mixed Solid Wastes Removed from Drainage Channel on Abacha Road [24].

The blockage of drainages by debris moved from refuse dumps by runoff during storm is the major cause of flood in most cities. Empty sachet water disposed in gutters causes blockage of drainages which contributes to the high level of flood during heavy downpour, and this is the characteristic feature of Abuja-Keffi Expressway [25].

4 Research Methodology

Information on the roadside solid waste dumping was gathered through interviews and questionnaires with the road users, shop owners and from those living around this section of the road. Field observations and literature search was carried out. to check the method of waste disposal around this area. A household waste generation and disposal study were done on few houses, shops, offices, and market around the solid waste dumping site at km 7 + 800 and CH 11 + 200 along Abuja-Keffi highway of the Federal Capital Territory (FCT) Abuja, the Nigeria Capital. Social impacts and perceived environmental impacts from the waste disposal practice was assessed based on questionnaire and physical survey on some residents randomly selected.
Activities to be carried out include:

1. Identify the causes of poor waste management along the highway.
2. Analyze the effects of poor waste management on the flexible pavement.
3. Analyze Traffic count on the waste dumping areas on the highway.

The areas selected were the focus of this study. Questionnaires and oral interviews were generated, field observations towards getting an in-depth and holistic assessment of the effect of roadside solid waste dumping was carried out, CBR and Compaction test to check the strength of the pavement structure was also carried out on the sample collected from the section of the road where solid waste dump was located and the same test was also carried out on the section of the road without solid waste dump location, with necessary data collected for analysis.

4.1 Compaction Test

Compaction test is a laboratory test used to determine the Optimum Moisture Content (OMC) and Maximum Dry Density of the soil (MDD), utilizing the following Apparatus:

1. Mould
2. Scupper
3. Rammed
4. Spacers
5. Drying oven
6. Weighing balance
7. Curing machine
8. Shovel

4.1.1 Procedure

Disturbed pavement soil sample materials was obtained close to the solid waste dump at km 7 + 800 and CH 11 + 200 Along Abuja-Keffi Expressway.

The sample was carefully removed and wrapped in a cellophane bag and was taken to the laboratory as specimen for Compaction and CBR test. The test sample was sun dried for some days to remove excessive moisture. After attaining suitable moisture content, the sample was broken up; sieved through 4.75mm sieve to remove the coarse material. The sample was then properly mixed, carefully adding water, when mixing was completed; the weight of the empty compaction mould was taken and then the samples wash charged into the mould.

During compaction, sample was divided into 5 equal layers, compacted in succession, a mould layer after layer, each layer was rammed by 25 uniformly distributed blows of standard proctor compaction hammer and the final layer was levelled to the top of the mould. The weight of the mould with compacted soil sample was taken before extruding the compacted sample from the mould. A portion of the compacted soil sample was taken, the weight of the sample was taken, placed in the oven to determine its moisture content (MC). The sample was dropped into the moisture can and the weight of the sample was taken before dropping it in the oven.

The compacted sample was left in the oven for some hours to dry. The weight of the dry sample was taken in other to determine the

moisture content of the soil (MC). MC = weight of wet sample – weight of dry sample. This procedure was repeated until no change in unit weight on the compaction soil. Graph was plotted as moisture content against the corresponding dry density to determine the values of Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) respectively. The same test and procedure were carried out on the sample that was collected from the section of the road without roadside solid waste dump and the result was compared.

4.2 CBR Test

CBR (California Bearing Ratio) test was also carried out to evaluate the strength of the lateritic sub grade of the pavement. CBR test is the resistance to penetration to a standard cylindrical plunger of 49.6mm diameter and not less than 102mm long in a prepared soil specimen, expressed as a percentage of the established resistance of the same cylindrical plunger to various penetrations in crushed aggregates, notably 13.24KN at 2.50mm penetration and 19.96KN at 5.00mm penetration of the plunger in the material. utilizing the following Apparatus:

1. The CBR machine
2. Moulds
3. Rammed
4. Weighing balance
5. Dial gages
6. Drying oven
7. Mixing tray
8. Moisture cans

4.2.1 Procedure

To prepare the soil specimen for CBR TEST The wet disturbed soil sample was taken close to the roadside wastes dump at km7 + 800 and CH 11 + 200 along Abuja - Keffi Expressway and another sample was also taken from the other side of the road where there was no location of roadside solid wastes dump, and the samples were taken to the laboratory for compaction and CBR test. Samples were sprayed under the sun for some hours to get it dry. After that, the samples were broken up separately in such a way that the natural of the individual soil aggregate dose not reduced. Adequate quantity of the disturbed soil samples was sieved from the two different samples through 4.75mm sieve to remove coarse material.

Each sample of the soil were divided into 5 equal places; the samples were compacted into the CBR mould with the collar in position at equal 5 layers using 4.5kg rammer failing through 450mm height to give 25 uniformly distributed blows on the surface of the soil. The collar was removed after the compacting and the excess extrusion was trimmed off with straight edge before weighing.

The mould with prepared soil specimen was clamped to the base plate and the plunger was adjusted to contact the top of the soil. The dial gauges adjusted to zero (0s) before the plunger is released to get in contact with the soil sample. The plunger was made to penetrate the compacted soil from the top and the plunger loads were recorded at 0.25mm penetration to maximum of 7.50mm, the same procedure was carried out through the bottom of the sample by turning the sample upside for plunger to penetrate and the loads reading was recorded. It was notably at 25mm and at 50mm penetration at the top and bottom of the sample.

Graph was plotted as dial reading against penetration and a curve was generated through to the experimental points to determine the Optimum Moisture Content OMC of the soil. This procedure was repeated on the other sample that was collected from the section of the road without the roadside solid wastes dump and the result was compared.

4.3 Traffic Count

Traffic count was also taken into consideration. Automated Metro Count Luger was used to determine the flow of traffic on the section where wastes dumping site is located and at the section of the road without roadside solid wastes dump to determine the flow of traffic and compare results, utilizing the following:

1. Automated Metro Count Luger System
2. Cables
3. Clips
4. Laptop
5. Cellophane
6. Hand Digger

4.3.1 Procedure

The section of the road for traffic count was selected around the roadside waste dumping site at km7 + 800 and CH 11 + 200 Along Abuja-Keffi Expressway. And another section was selected where no roadside solid wastes dump was located. The automated metro count luger software was used to carry out this experiment by installing the software into a system. The luger was set, and a tube will be connected to the luger, the tube was laid across the road in such a way that the tires of the vehicle can encounter the cables.

Each car that passes across this section of the road must climb the tube and the sensor of the luger system automatically records the number of cars. Clips were used to pin the tubes on the road to avoid any shifting. The luger was covered with a cellophane paper and was buried in the ground for 3 days. At the end of 3 days, the luger was brought out and disconnected from the tube. Information from the counting machine (Luger) was downloaded on the system and data was analysed. The same procedure was repeated on the section of the road without roadside solid waste dump and the results were compared.

4.4 Waste Disposal Methods at Study Area

Questionnaires were distributed to the residence and traders along this study area where roadside solid waste is in other to analyse the method of waste disposal at the section around the roadside waste dumping area. The questionnaires were collected after completion and the responds was analysed in percentage (%) to check the mode of waste disposal around the roadside solid wastes dump and the possible suggestions on waste management system and how it affects the road pavement.

5 Results And Discussions

5.1 CBR and Compaction Test Results

CBR (California Bearing Ratio) test was carried out to evaluate the strength of the lateritic sub grade of the pavement. CBR test is the resistance to penetration to a standard cylindrical plunger of 49.6mm diameter and not less than 102mm long in a prepared soil specimen, expressed as a percentage of the established resistance of the same cylindrical plunger to various penetrations in crushed aggregates, notably 13.24KN at 2.50mm penetration and 19.96KN at 5.00mm penetration of the plunger in the material.

The main purpose of CBR and compaction test was to determine the Maximum Dry density (MDD) and Optimum Moisture Content (OMC). Compaction test is laboratory test used to determine the maximum dry density of the soil (MDD) of a given soil sample.

The result of compaction test carried out on the sample collected at the section of the road where roadside solid waste dump was located shows that the base and the subbase of the pavement in this section of the road has failed due to excessive water in the sub-base and base material. As a result of this, the CBR and Compaction test values recorded from the sample obtained closed to the solid waste dump were low compared to values obtained from the section of the road

where solid waste dump was not located. The result is as shown in table 3,4, 5.

Table 3. Compaction Test Results from Waste Dump Location

Sample Tag	A		B		C		D	
	A1	A2	B1	B2	C1	C2	D1	D2
Ave. bulk density (kg/m^3)	1359		1377		1404		1409	
Weight of water (g)	7.2	7.3	8.1	8	9	8.9	9.9	9.8
Weight of dry soil (g)	57.2	57.3	58.4	58.7	61.6	60.3	63.4	62.6
Moisture content (%)	12.6	12.7	13.9	13.6	14.6	14.8	15.6	15.7
Ave. moisture content (%)	12.7		13.8		14.7		15.7	
Dry density (kg/m^3)	1267		1274		1289		1283	

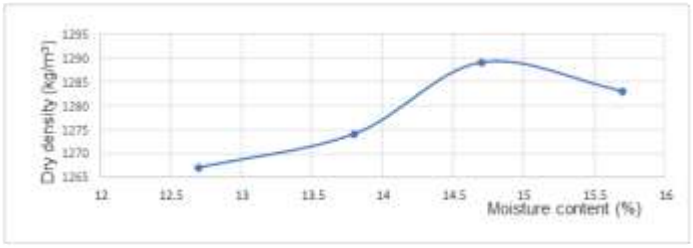

Fig. 6. Dry Density – Moisture Curve SNAD

Table 4. Compaction Test Results for Sample Collected from SNAD

Sample Tag	**A**		**B**		**C**		**D**	
	A1	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2**
Ave. bulk density (kg/m^3)	1579		1777		1943		1495	
Weight of water (g)	2.8	2.4	4.4	3.7	6.2	5.5	8.6	7.4
Weight of dry soil (g)	73.8	74.5	57.2	46.4	65.0	63.5	52.6	55.7
Moisture content (%)	3.8	3.2	7.7	8.0	9.5	8.7	16.3	13.3
Ave. moisture content (%)	3.5		7.9		9.1		14.8	
Dry density (kg/m^3)	1539		1708		1836		1384	

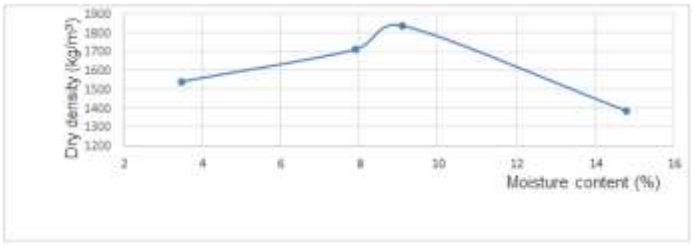

Fig. 7. Dry Density – Moisture Cure SAD

$$Moisture\ content = \frac{Weight\ of\ water}{Weight\ of\ dry\ soil} x100\% \quad (1)$$

$$Dry\ density = \frac{Bulk\ density}{100 + Water\ content} x100 \quad (2)$$

Graph of Dry Density (kg/m3) against moisture content (%), this is to determine the Optimum Moisture Content (OMC) of the soil sample collected closed to the roadside waste dump. The highest point on the graph is the (OMC) Optimum Moisture Content.

CBR values were recorded 39.2 Top and 36.0 Bottom at 25mm. At 50mm the CBR values were recorded 49.9 Top and 48.8 Bottom, notably 13.24KN at 25mm and 19.96KN at 50mm penetration of the plunger. The results from the tow different samples were compared and it was noticed that ground water seeps into the lateritic subbase and base material and this turned to weaken the pavement.

Table 5. CBR Test Results on Sample Collected Close to SAD

Plunger Penetration (mm)	**Load (KN)**			**CBR Values**
	Top	**Bottom**	**Average**	
0.0	0.0	0.0	0.0	
0.5	0.2	0.2	0.2	From equation (3) and Fig. 3, the CBR at penetration of 2.50m $= \frac{0.4}{13.24}$ x100% = 3.02%.
1.0	0.2	0.2	0.2	
1.5	0.3	0.3	0.3	
2.0	0.3	0.4	0.35	
3.0	0.4	0.5	0.45	CBR at penetration of 5.00mm $= \frac{0.67}{19.96}$ x100% = 3.36%
4.0	0.5	0.6	0.55	
5.0	0.6	0.7	0.65	
6.0	0.7	0.8	0.75	$CBR = 3.36\%$
7.0	0.8	0.9	0.85	
8.0	0.9	1.0	0.95	

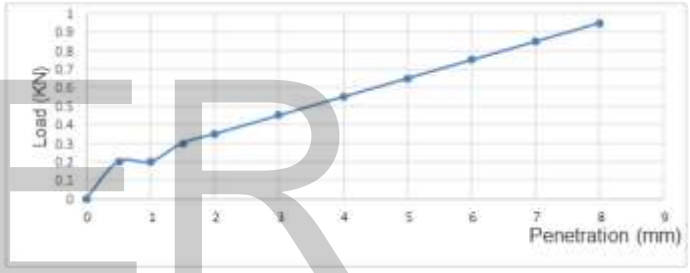

Fig. 8. CBR Plot for Sub-Base Material Close to SAD

Table 6. CBR Test on Sample Collected from SNAD

Plunger Penetration (mm)	**Load (KN)**			**CBR Values**
	Top	**Bottom**	**Average**	
0.0	0.0	0.0	0.0	
0.5	0.153	0.102	0.1275	From equation (3) and Fig. 4, the CBR at penetration of 2.50mm $= \frac{0.975}{13.24}$ x100% = 7.3%.
1.0	0.306	0.306	0.306	
1.5	0.510	0.442	0.476	
2.0	0.663	0.884	0.774	
2.5	0.782	0.952	0.867	
3.0	0.850	1.020	0.937	CBR at penetration of 5.00mm $= \frac{1.175}{19.96}$ x100% = 5.9%
3.5	0.884	1.088	0.986	
4.0	0.918	1.156	1.037	
4.5	0.952	1.224	1.088	
5.0	0.986	1.292	1.139	
5.5	1.020	1.326	1.173	$CBR = 7.3\%$
6.0	1.037	1.360	1.196	

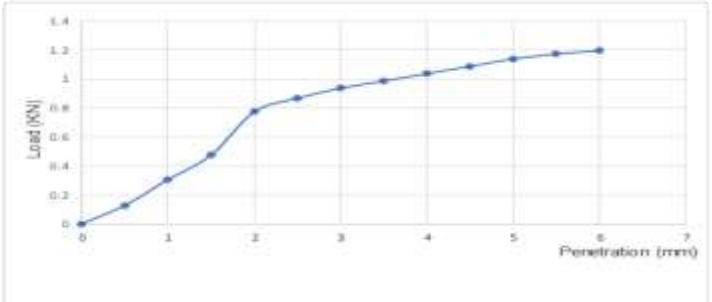

Fig. 9. CBR Plot for Sub-Base Material Close to SNAD

Table 3 to 6 shows the laboratory results of the CBR tests. The sub – base sample taken close to the SAD recorded CBR values of 3.02% and 3.36% for plunger penetrations of 2.50mm and 5.00mm respectively. The higher value of 3.36% serves as the accepted CBR.

For the SNAD, the CBR values were 7.3% and 5.9% at plunger penetrations of 2.50mm and 5.00mm respectively. The accepted CBR was therefore 7.3%. This value is more than twice the value of CBR for SAD. This shows that the sub-base had not as depreciated as with the pavement adjoining dumpsite.

Physical observation also of the various sections show that SAD exhibited failures which were visible as pavement cracks, worn out asphalt with potholes and cracked concrete drains and culverts.

The two laboratory results from the sub-base materials show that water from the drainage overflow due to blockage by solid waste dumps negatively affected the integrity of the flexible pavement of the highway in a profound way by causing failures at the sub-base and asphalt covering. This overflow kept the sub-base wet in a perennial manner.

Compaction test is a laboratory test used to determine the Optimal Moisture Content (OMC) at which a particular soil becomes denser and achieve its maximum dry density (MDD). Moisture content (MC) of the soil is the amount of water retained by a particular soil or the amount of water present in the soil sample.

From the table 7 graph of Dry Density (DD) against the Moisture Content was used to determine the Optimum Moisture Content (OMC) of the soil sample.

$$CBR = \frac{\text{Load causing penetration of 2.50mm (or 5.00mm)}}{\text{Load causing penetration of 2.50mm (or 5.00mm) in a standard crushed stone}} x100\% \quad (3)$$

The purpose of this test was to determine the percentage of OMC and MDD on the subbase material of the pavement.

On the section of the road without roadside solid waste dump, the CBR values were recorded 39.2 Top and 36.0 Bottom at 25mm. At 50mm the CBR values were recorded 49.4 Top and 48.8 Bottom, notably 13.24KN at 25mm and 19.96KN at 50mm penetration of the plunger. The results from the tow different samples were compared and it was noticed that ground water seeps into the lateritic subbase and base material and this turned to weaken the pavement.

The CBR test result for sub – base sample extracted close to the section of the roadside solid waste dump recorded a CBR value of 3.0% Top and 3.8% Bottom at 25mm and CBR value of 3.5% Top and 4.0% Bottom at 50mm plunger penetration. The average CBR value at 25mm was 3.4% and at 50mm was 3.9%. which is below BS recommendation of 30% for subbase. While the test result of the sample collected from the section of the road without roadside solid waste dump recorded a CBR value of 39.2% Top and 36.0% Bottom at 25mm and CBR value of 49.4% Top and 48.8% Bottom at 50mm plunger penetration.

While 49.4 for top and 48.8 for bottom was recorded at 50mm. The average CBR value at 25mm penetration was 55.6% and at 50mm was 49.1%, which is also below BS recommendation of 80% for base. The result signifies that the subbase lateritic material of this section on the road was affected by water due to inadequate flow of rainwater through the blocked drains. The base and the subbase material were weak, therefore the binder and the wearing course turned to get loosened. Cracks were noticed on the surface of the road and if adequate and timely care is not taken, the crack will expand into potholes. This result shows that water has affected the section where roadside solid waste dump is located due to blockage of the drainage because of solid wastes dumped by the roadside which usually overflows into the drainages.

5.2 Traffic Count

Traffic count was also taken into consideration. Automated Metro Count Luger was used to determine the flow of traffic on the section where waste dumping site is located and at the other side which was free of waste dumping to compare the rate of flow of traffic on both sides of the road along the selected area.

Table 7. Traffic on Abuja – Nyanya Expressway without Waste Dump

No. of days	Number of cars passed/hour	Average speed/hour
1	560	100km/hour
2	620	110km/hour
3	580	90km/hour

Table 8. Traffic on Abuja – Nyanya Expressway with Waste Dump

No. of days	Number of cars passed/hour	Average speed/hour
1	220	50km/hour
2	345	60km/hour
3	283	50km/hour

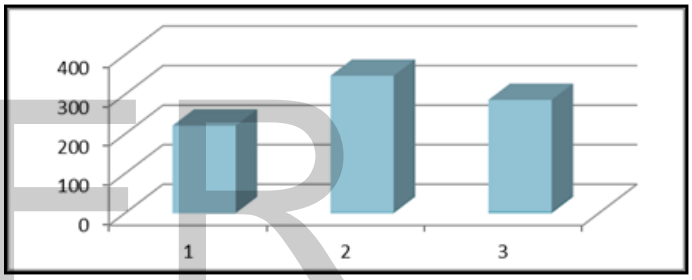

Fig. 10. Number of Cars per Hour at Waste Dump Site

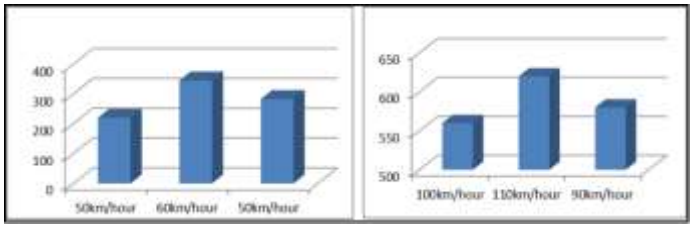

Fig. 11. Flow of Traffic Along Road Section Without Waste Dump

Chart A represent the result of traffic flow from both side of the road. Data obtained from the section of the road with the location of solid waste dump with the highest frequency of 345 cars with speed limit of 60 km/hour. While Chart B represent the result obtained from the section of the road without the location of solid waste dump. To compare the two results, the results shown low traffic flow on the section of the road due to solid waste dump site, and the failed section of the road which located around the solid waste because of the portholes around this section of the road. While the result obtained from the section of the road without the location of solid waste dump shown free flow of traffic of higher frequency of 620 cars / hour with speed limit of 110/km. This result shows that the solid waste dump site on the highway affects the flow of traffic.

5.3 Feedback from Questionnaire

Questionnaire was distributed to the residence and traders along this study area. To analyze the method of waste disposal at the section around the roadside waste dumping area samples of questionnaire was distributed around this area. The study shows that 50% of the

residence around this area dumped their waste into drainages, while 30% of the residence dumps their waste in the central waste dumping point through the local waste collector and 20% burnt their waste around their houses and the remaining burnt wastes are usually swept into the drains.

The questionnaire shows that the 50% of the residents dump their waste in the drain and 20% of the residents sweep the burnt part into the drain, this gives a total blockage of the drainage which blocks the flow of the surface runoff. This is a major problem as excessive water content in the pavement base, sub-base, and sub-grade causes' distress and lead to structural failure of the pavement, the life span of any road depends on the water content in base, subbase and sub grade. If excessive water is retained in the base and subbase, the pavement tends to lose it strength.

Table 9. Priority Concern on Roadside Waste Dump on Highway

S/No	Frequency	Priority Concern
1	50	Drainage
2	30	Traffic Jam
3	20	Littering
4	-	Others
Total	100	

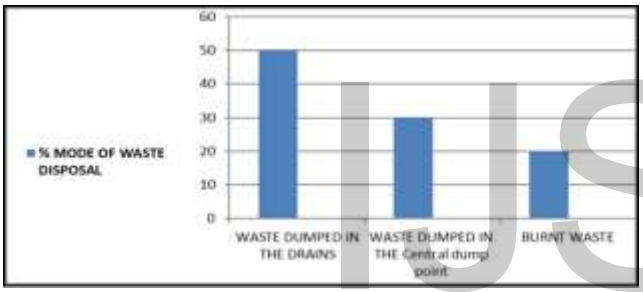

Fig. 12. Mode of Waste Disposal

From the results obtained from the resident through questionnaire on the priority concerned about the system of roadside solid waste dump on highways. 50% are on the opinion that wastes dumped on the highways turn to block the drains therefore obstruct the flow of surface water. While 30% responded that roadside solid waste dump constitutes traffic jam, and 20% were on the opinion that roadside solid waste dump litters the highway/environment. The result is as shown in table 10.

Majority of the residence disposes off refuse in any available place they can get without proper storage represent the mode of waste storage before disposal. The result above shown that only 6% stored their waste in plastic bags before disposal. 15 stored in the waste basket, while 79% responded as others. This result shown that the residence just carelessly packed their waste and disposed the result is as shown in table 11.

Table 10. Method of waste storage before disposal

S/No	Frequency	Mode of storage
1	6	Disposable bags
2	15	Waste basket
3	79	Others
Total	100	-

The table below showed the mode of waste disposal among the residents of this area. 2% disposed their waste into the nearby container. 33% disposed into the drainage, while 64% disposed the solid waste into any available open space. This result shown that more waste goes into the drain as waste disposed into an open space usually finds it ways into the drain through rainwater or through the air. The result is as shown in table 12.

Table 11. Mode of waste disposal

S/No	Frequency	Mode of disposal
1	2	Nearby container
2	33	drainage
3	64	Open space
Total	100	

The result showed frequency of 66% response to the location of central waste bin in the area, while 34% acknowledge that no location of central bin in the area. The result is as shown in table 13.

Table 12. Location of Central Waste Bin in Area of Study

S/No	Frequency	Waste bin location
1	33	yes
2	66	No
3	1	indecisive
Total	100	

The frequency of regular waste collection in the area shows that only 29% usually get regular waste collection while 71% do not get their waste moved regularly. This is one of the reasons why we see solid waste littered along the street/highways. When the authority concerned failed to clear the waste as in when due, it becomes a major problem. The result is as shown in table 14.

Table 13. Regular Waster Collection Service

S/No	Frequency	Regular waste collection
1	29	yes
2	71	No
Total	100	

93% responded to "yes" to the overflow of solid waste in the area, while none responded to "NO" 0% and 7 were indifference. This result simply showed that most time solid waste dumped on the street are left unattended to for a long period of time which result in to littering along the street, pushing into the drains and bad smell around the environment. The result is as shown in Table 15.

Table 14. Overflow of Waste from Disposal Point

S/No	Frequency	Overflow
1	93	yes
2	0	No
3	7	Indifference
Total	100	

the flow of traffic in the area, while 0% responded to No and 8% were indifference. This result showed that roadside solid waste dumping imposes a major problem to the society especially when it has not been handled properly. The result is as shown in Table 16.

Table 15. Does Overflow of waste affect traffic flow in this area?

S/No	Frequency	Overflow
1	92	yes
2	0	No
3	8	Indifference
Total	100	

Effective drainage around the dumping site, a total 89 responded no to this. This means that majority of the residence in this area dumped their waste in the drainage.

Table 16. Effective drainage system around the dumping site

S/No	Frequency	Overflow
1	2	yes
2	89	No (filled up with waste)
3	9	Indifference
Total	100	

5.4 Causes of Poor Waste Management

1. Lack of sensitization on the adverse effect of poor method of waste disposal.
2. The inability of the authority concerned to properly evacuate and dispose the waste effectively.
3. Lack of standard waste disposal system.
4. Lack of enforcement on indiscriminate waste dumping.

6. CONCLUSION

This research reviewed related literatures on effect of roadside solid waste dumping on pavement and traffic flow. Compaction test was carried out on the sample collected from the section of the road around the solid waste dump and another sample was also collected from the section of the road without roadside solid waste dump and results were compared. The main purpose of this test was to determine the percentage of OMC and MDD of the base and subbase of the pavement. CBR values were recorded 3.0 Top and 3.8 Bottom at 25mm and at 50mm the CBR values were 3.8 Top and 4.0 Bottom on the section of the road with roadside solid waste dump.

On the section of the road without roadside solid waste dump, the CBR values were recorded 39.2 Top and 36.0 Bottom at 25mm. At 50mm the CBR values were recorded 49.9 Top and 48.8 Bottom, notably 13.24KN at 25mm and 19.96KN at 50mm penetration of the plunger.

The results from the two different samples were compared and it was noticed that ground water seeps into the lateritic base and subbase material and this weakened the pavement structure. From the survey carried out on the mode of waste disposal among the resident around the solid waste dumping site, it was discovered that 50% of the populace dumped their waste into the drainage ditches and channels. Traffic count carried out on the section of the road with roadside solid waste dump and on the section of the road without solid waste dump shows that the rate of traffic flow is slow on the section where roadside solid waste dump is located.

This research has been able to investigate the effect of roadside solid waste dump on flow of traffic and the pavement structure and came up with the following findings:

1. Solid waste dumping on drains along the Abuja- Keffi Expressway at CH. 7+800 and CH.11+200, has led to blockade of the drains and in turn the overflowed refuse has impacted negatively on flow of traffic.
2. Roadside solid waste dumping along the road caused traffic gridlock along the freeway
3. Roadside solid waste dumping on the pavement led to the deterioration of the strength of the pavement, along Abuja- Keffi Expressway at CH. 7+800 and CH.11+200.
4. Some of the reasons for roadside dumping along the highways included:
5. Lack of adequate central dumping site.
6. Inability for the waste management official to evacuate the pile of waste in a timely manner
7. Lack of adequate sensitization

The CBR test result for base and subbase sample extracted close to the section of the roadside solid waste dump recorded a CBR value of 3.0% Top and 3.8% Bottom at 25mm and CBR value of 3.5% Top and 4.0% Bottom at 50mm plunger penetration. The average CBR value at 25mm was 3.4% and at 50mm was 3.9%.

While the test result of sample collected from section of the road without roadside solid waste dump show a CBR value of 39.2% Top and 36.0% Bottom at 25mm and a value of 49.4% Top and 48.8% Bottom at 50mm plunger penetration. While 49.4 for top and 48.8 for bottom at 50mm. The average CBR value at 25mm penetration was 55.6% and at 50mm was 49.1%. The test results obtained from the sample extracted from the section of the road with the location of roadside solid waste dump shows that the base and the subbase materials of the pavement is out of specification, referencing BS standard value of plunger penetration at 25mm and 50mm.

The result signifies that the base and subbase lateritic material in this section of the road was affected by water due to inadequate discharge of rainwater because of blocked drains. Due to the weakened base and subbase material, inadequate support to pave structure binder and wearing course were lacking and resulted to failure – raveling, rutting, stripping and fatigue. Cracks were visible on the pavement surface needing repair to avoid them leading to potholes. This result also show that water has affected sections where roadside solid waste dump is located due to drainage blockage because of the solid wastes dumped which overflows into the drainage path.

Traffic Count conducted at the section of the road where solid waste roadside dump is located shows that it affects the flow of traffic.

6.1 Recommendation

- All roadside waste dumping sites should be relocated to appropriate places away from the freeway.
- Provision of sufficient and adequate central dumping site due to high increase in population along this axis (Abuja – Keffi). There is need for proper and effective waste management in this area.
- Penalties should be placed on those who cultivate the habits of dumping waste into the drainages.
- Effective desilting of the drainages should be carried out frequently.

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Appendix

Questionnaire on solid waste disposal at Ch 7 + 00 and Ch 9 + 800 along Abuja – Keffi road, challenges and effect on road users.

Investigation on the effects of roadside solid waste dump on flow of traffic and pavement condition.

This questionnaire is mainly for academic research papers for post Graduate Degree in civil Eng'g, university of Abuja. Therefore, your sincere response are needed.

Survey Questionnaire:

A. Waste Generation and Disposal

1. In your opinion which of these is a priority concern about roadside waste dumping in the area (tick only)?

   Blocking the drainage ◯ Constituting Traffic Jam ◯ Littering and look bad ◯ others…….

2. What do you store your waste in before disposing in the central dumping site?
   Disposable Plastic bags ◯ Waste Baskets ◯ Others ◯

3. For each storage method write down the number of each used in a week.
   No. /Days
   a. Plastic bags ..... b. waste bin .....
   c. Others ……...

4. Do you select your waste? for example biodegradable and non-biodegradable before disposal? Yes ◯ No ◯

5. How do you dispose your generated waste?
   Nearby container Open spaces ◯ Drainage ◯ Others ◯

6. Can you roughly identify percentage composition of your generated waste?
   a. vegetable waste……% b. Plastic……% c. Paper ……..%
   d. Solids ……. % e. Others …… %

7. Are there any large bins in your area close to you? Yes ◯ No ◯

B. Garbage Collection Services

8. Do you have regular garbage collection in your area? Yes ◯ No◯

9. How often do they collect the waste?
   Daily ◯ Once a week ◯ Three Times a week ◯
   Once in a long time ◯

10. At the central dumping waste, do you have separate dumping bin for degradable and another for biodegradable? Yes ◯ No ◯

11. Do you usually have overflow of waste from the dumping point littering all over before collection? Yes ◯ No ◯

12. Does this littering of waste affect the flow of traffic around this area? Yes ◯ No ◯

13. Are you satisfied with your current waste collection service?
    Yes ◯ No ◯

14. Are you satisfied with the location of the dumping site?
    Yes ◯ No ◯

15. Would you like the dumping site to be moved to a suitable area rather than the roadside? Yes ◯ No ◯

16. If yes / No give your reasons ……
    ……

17. Please identify some of the major problems with the current location of the waste dumping site when it comes to traffic, drainages and the condition of the road around the dumping site, what are you more concerned about?

    Air pollution (unpleasant smell) ◯ Causing traffic Jam ◯
    Blocking the drainages ◯ Damage to scenic beauty ◯
    Damaging the road pavement ◯

18. Does the drainage around the dumping site flow effectively during rainy season?

    Yes ◯ No ◯
    If no, give possible reasons……
    ……