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Rethinking Solid Waste Disposal, Ecosystem Upsetting: Impacts on Soil Productivity in Southeast, Nigeria

Osuji E. E.[1,*], Opaluwa H. I.[2], Ben-Chendo G. N.[3], Ukoha I. I.[3], Nwachukwu E. U.[3], Osuji M. N.[3], Ibeagwa O. B.[3], Iroegbu C. S.[1], Orji J. E.[1], Anyanwu U. G.[3], Okpara B. O.[4], Ahamefule B. A.[4], Nse-Nelson F. A.[4], Nzeakor F. C.[5], Offor E. I.[4], Iwezor-Magnus D. N.[4], Maduike I. A.[3], Obi-Nwandikom C. O.[3]

[1]Department of Agriculture, Alex Ekwueme Federal University Ndufu-Alike, Nigeria
[2]Department of Agricultural Economics and Extension, Prince Abubakar Audu University, Nigeria
[3]Department of Agricultural Economics, Federal University of Technology, Nigeria
[4]Department of Agricultural Economics, Michael Okpara University of Agriculture, Nigeria
[5]Department of Agricultural Extension and Rural Development, Michael Okpara University of Agriculture, Nigeria

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Abstract An examination of solid waste disposal in Southeast Nigeria was conducted, considering its ecosystem disturbances and impacts on soil productivity. A total of 416 respondents were selected using a multi-stage and purposive sampling technique. Data were collected using a structured questionnaire and interview schedules. Data collected were analyzed using descriptive statistics, charts, principle component analysis and a probit regression model. Results show respondents produced various forms of solid wastes such as kitchen/food waste (100%), paper/cellophane (77%), textile (52.2%), and plastic (98.3%). About (70%) of the respondents produced solid waste at a maximal level, (21%) at minimal and (9%) at moderate levels. Major hazards caused by poor solid waste disposal include health issues (100%), land pollution/soil productivity loss (99.5%), climate change (99%), and air pollution (98.3%). Waste disposal in the zone includes open burning (17%), dumping in gutters and water bodies (9%), storage in tanks/landfills (17%), and dumping at designated sites (22%). Solid waste disposals could be improved via public awareness, government policy formulation, and implementation. Age, gender, distance to designated refuse sites, education, participation in waste disposal training, and solid waste disposal laws were significant determinants of solid waste disposal in southeast, Nigeria. The study implies that inefficient solid waste disposal disrupts ecosystems and biodiversity and causes health-related issues. Good environmental policies should be formulated and enacted to abate indiscriminate dumping of solid wastes in undesignated locations and sites in Southeast, Nigeria.

Keywords Solid Waste Disposal, Management, Ecosystem, Biodiversity, Soil Productivity

1. Introduction

Globally, solid waste disposal has been a source of

concern arising from economic development, population growth, urbanization, industrial and institutional growth, and trade expansion coupled with improved lifestyles [1]. Surprisingly this has resulted in high heaps of solid wastes dumped and littered across cities, regions, towns, locations, places, etc. In Nigeria, for instance, there has been increased dumping of solid wastes (both biodegradable and non-biodegradable) such as food waste, organic waste, paper, plastic, glass, textile scraps, and other items littered across the various states of the federation [2]. Dumping of non-biodegradable wastes makes the environment unhealthy creating an unhygienic atmosphere while biodegradable wastes, on the other hand, decompose easily, projecting foul odors and uncontrolled odour throughout the environment and their surroundings. This has exacerbated environmental concerns, upsetting the ecosystem and biodiversity and impeding agriculture (especially crop production and other environmental activities). Crop farmers who depend entirely on land cultivation are now facing serious reduction in yield, output and productivity resulting in a loss in economic benefits and returns from their crop production [3]. Also other land/soil users have equally been deprived of their ecosystem operations and activities resulting in production losses. The World Bank estimated that the amount of urban household solid waste in Nigeria is about 3.5 million tons per day, and that by 2025, this amount would increase to almost 6.1 million tons per day [4].

Currently, the Southeast region in Nigeria is faced with rapid urbanization and this has accelerated increase in demand for goods and products which has induced increases in the number of solid waste products in the region (See Figure 1) [5]. This increased dumping of solid waste is the main cause of environmental pollution (water-air-land), biodiversity loss and reduction in crop production. Solid waste poses serious environmental risks and contributes to highly unpleasant living conditions and environmental hazards [6]. According to technical literature, several negative consequences of solid waste have been documented; indiscriminate and careless waste disposal at undesignated refuse dumps or into waterways polluting our water supplies, particularly water sources such as rivers, dams, streams, etc. contaminating our drinking water and affecting crop irrigation thereby negatively influencing yield of agricultural crops. Other groundwater sources such as wells and boreholes may also be contaminated in the process resulting in soil-water pollution inhibiting plant growth and development [7].

Solid waste disposal practices have been observed to create conducive environments for the proliferation of various pests, including rats, snakes, and insects, such as cockroaches and can serve as good breeding grounds for disease transmissions (leptospirosis and salmonella) among crop farmers, and soil users which could affect their health being and indirectly their crop production and other soil uses [7]. Flies, rodent animals, and vermin are easily drawn to decomposing organic waste, feasting on them and thus becoming agents of waste littering and distribution across the neighbourhood and surrounding environments. Poor disposal of solid waste contaminates the serene environment, thereby exacerbating air pollution which inhibits normal air breathing and uptake of oxygen. Acute Flaccid Myelitis (AFM), Anthrax, Chickenpox (Varicella), Influenza, Meningitis (Neisseria meningitidis), Measles (Rubeola), and Middle East Respiratory Syndrome are among the airborne infections that are brought on by careless disposal of solid waste [8]. Poor solid waste management causes major health problems that can occasionally result in the death of crop producers and soil users.

Figure 1. Indiscriminate Solid Waste Disposal

Similarly, soil productivity is damaged and affected by incessant dumping of solid wastes; for instance, soil texture, moisture, nutrient capacity and vegetative qualities are negatively impacted by poor solid waste disposal. This equally affects the generality of ecosystems, agricultural lands, biodiversity, and other environmental concerns [9].

Soil users in Southeast Nigeria have suffered immensely owing to the indiscriminate waste disposal and poor management of solid wastes, a practice that has become a culture among the populace. This has caused a huge deficit in their day-to-day soil operations and economic activities. The productivity of the soil in the region has remained low, impoverished and depleted due to the contaminated soils by indiscriminate waste deposits. However, various governments in Southeast Nigeria have failed in their bid to tackle the issue of indiscriminate dumping of solid waste in the region. This stems from lack of government commitment in formulating policies guiding solid waste management and disposal systems [10]. This further has made the populace see indiscriminate waste disposal as a norm and culture since offenders are not cautioned or punished by any existing laws. Even when designated refuse sites are provided by the government; these defaulters seem to continue to dump solid waste indiscriminately.

Considering the above circumstances, efficient management and disposal of solid wastes has become a severe problem regarding its environmental hazards, health challenges, and impacts on soil users. However, little research has been conducted in Nigeria regarding the issue of solid waste disposals, but surprisingly none of these studies have been conducted in Southeast, Nigeria; hence the wide and existing gap in knowledge and motivation for the study. In this research paper, we investigated 'rethinking solid waste disposal, upsetting of the ecosystem; impacts on soil productivity in Southeast Nigeria,' filling a critical knowledge gap that has not been addressed in prior literature.

2. Materials and Methods

2.1. Study Area

The study was carried out in Southeast, Nigeria. The Southeast region of Nigeria comprises the five states of Abia, Anambra, Ebonyi, Enugu and Imo States. It is one out of the six geopolitical regions in Nigeria. The region has a population of about 22 million people, comprising around 10% of the total population of the country [11]. People of this region engage in various occupations, such as civil service, private service, trading, and agriculture, while others are self-employed, artisans, etc.

2.2. Sample Selection

Multi-stage and purposive sampling techniques were employed for sample selection. In the first stage, three states out of the five states were purposively selected from the zone consisting Imo, Enugu, and Ebonyi. The selection was based on the dense population of these states, industrial activities, location of higher institutions, high solid waste production coupled with its commercial and market structures.

The second stage involves a random selection of two local government areas (LGAs) from each of the states making six LGAs. These LGA's are reputedly known for high solid waste production. Since the target population is not documented, the third stage involves a random selection of 80 respondents from the six LGA's making a sample size of 480 respondents.

2.3. Data Collection

Primary data were used for the study. The term "primary data" refers to cross-sectional data that was gathered using the survey tool (questionnaire). The researchers created the questionnaire following the specific objectives of the study. Out of the 480 questionnaires distributed, only 416 were deemed useful for data analysis based on the information provided by the respondents.

Others were invalid owing to mistakes and missing data found. To standardize the questionnaire and confirm its reliability and content validity, a pilot survey was carried out in the chosen states prior to the real data collection. The questionnaire's test-retest reliability produced a correlation coefficient of 0.90 and was significant at the 1% and 5% levels. This demonstrated the questionnaire's general sufficiency and dependability for the collection of actual data. To guarantee complete adherence, correctness, and appropriateness of information from the respondents, the researchers directed the questionnaire's completion.

2.4. Data Analysis and Model Specification

Data collected were analyzed using descriptive statistics, charts, principle component analysis and a probit regression model. The principle component analysis was specified as follows;

$$Y1 = a11x11 + a2x2 + \ldots + a1nxn \quad \text{------} \quad (1)$$

$$Yg = ag11xg11 + ag2x2 + \ldots + agnxn \quad \text{---------} \quad (2)$$

where, Y1, . . . , Yg represent the principal components, PC1 and PC2 which are uncorrelated. a2, . . . , a_g represent the correlation coefficients. While x, . . . , xg represent the solid wastes produced.

The principle component analysis was performed to reduce the various solid waste products into sizeable units to enhance interpretation of the data.

The probit regression analysis explains the variables (X's) that better explain the classification of respondents in the Y categories. The probit regression model was stated as

follows,

$$\Pr (Y = 1) / X) = \Theta (X^T B) \text{ -----} \quad (3)$$

$$Y^* = X^T B + \varepsilon \text{ -----} \quad (4)$$

where $\varepsilon \sim N(0, 1)$

Transposing, we have;

$$Y = \{1\ Y^* > 0\} / \{0 \text{ otherwise}) = \{1\ X^T + \varepsilon > 0\} / \{0 \text{ otherwise}) \ldots\ldots \quad (5)$$

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}) + ei \text{ -----} \quad (6)$$

where

Y = Dependent variable having binary values (1, 0).

1 = (refers to household heads that attended/participated in solid waste disposal training)

0 = (refers to household heads that did not attend nor participated in solid waste disposal training)

Other exogenous variables include;

X_1 = Age (years)

X_2 = Gender (Male =1, Female = 0)

X_3 = Household size (No. of persons)

X_4 = Distance to designated refuse site (Km)

X_5 = Level of education (Years spent)

X_6 = Marital status (Married=1, 0 = Single)

X_7 = Income (Naira)

X_8 = Culture (Observed =1, Otherwise = 0)

X_9 = Solid waste disposal laws (Observed = 1, Otherwise = 0)

X_{10} = Occupation (Trading = 1, Otherwise = 0)

e = error term

3. Results and Discussion

3.1. Socio-Demographic Characteristics of Respondents

The socio-demographic characteristics of respondents are presented in Table 1. The table reveals that the majority of the respondents fell within the age bracket 50 – 59 years with a mean age of 54 years. This indicates that the respondents are in their productive age and this indicates that they are mature enough to handle their waste disposal and preserve their environment. Gender analysis shows that the respondents were mainly male with 70.7% compared to female with 29.3%, it could not be deduced that the male respondents are more efficient in waste disposal management [12]. About 84% of the respondents were married with children. This indicates that the married folks dominated the states compared to the singles, 16.3%. This further shows that; the married respondents are matured, and responsible for solid waste disposal and environmental management [12].

Table 1. Socio-demographic characteristics of respondents

Socio-demographic factors	Frequency	Percentage
Age		
20 – 29	27	6.5
30 – 39	46	11.1
40 – 49	136	32.7
50 – 59	196	47.1
60 – 69	09	2.2
70 – 79	02	0.5
Mean Age	54	
Gender		
Male	294	70.7
Female	122	29.3
Marital Status		
Married	348	83.7
Single	68	16.3
Household Size		
1 – 5	189	45.4
6 – 10	212	50.9
11 – 15	15	3.6
Mean Household Size	8	
Education Status		
0 (No Formal Education)	15	3.6
1 – 6 (Primary School)	98	23.6
7 – 12 (Secondary School)	102	24.5
13 – 18 (Tertiary)	201	48.3
Mean Education	15.2	
Occupation		
Agricultural activities	17	4.1
Trading	201	48.3
Artisans/self-employed	71	17.1
Government civil service	77	18.5
Private establishments	42	10.1
Others	8	1.9
Income		
₦0-50 000	-	-
₦50 000 – 100 000	99	23.8
₦100 000 – 150 000	105	25.2
₦150 000 – 200 000	179	43.0
₦200 000 – 250 000	29	6.9
₦250 000 – 300 000	4	0.9
Mean Income	186 000	
Training on waste disposal & management		
Participated	244	58.7
Otherwise	172	41.3

A majority of the respondents, (51%) had household sizes of 6 – 10 persons, with a mean household size of 8 persons. This indicates that the respondents had a large number of families that can help in solid waste disposal and environmental control [13]. Analysis of education reveals that the majority of the respondents, 48.3% attended tertiary institutions and this symbolizes a great tool in solid waste disposal and management. Occupation analysis shows that the majority of the respondents, 48.3% are market traders, followed by government civil servants (18.5%), and artisans (17.1%), respectively. This indicates that the respondents were engaged in various occupations to earn a living and pay bills [13]. Also the type of occupation engaged by respondents determines the types of solid waste produced in the states. More especially, market traders have the highest share in solid waste production in the states.

The monthly income earned by respondents shows that the majority earned between ₦150 000 – ₦ 200 000 per month with a mean income of ₦186, 000. The amount is relatively reasonable to sustain an average living standard. It generally indicates that families with high-income levels generate more solid waste produce than families with lesser income [14]. Higher incomes encourage more expenses in buying more household items which in turns results in solid waste products per time. About 59% of the respondents participated in solid waste disposal and management training compared with 41.3% who did not participate. Active participation in solid waste disposal and management training helps household heads to manage their waste disposals efficiently.

3.2. Forms of Solid Waste Produced in Southeast, Nigeria

The forms of solid waste produced by respondents are presented in Table 2. The table shows that the respondents produced various forms of solid waste both biodegradable and non-biodegradables. It reveals that all the respondents produced kitchen/food wastes and tin cans. Kitchen/food wastes refer to solid waste products derived from the kitchen. These wastes occupy over 70% of wastes produced by families on a daily basis. Tins/cans are solid wastes obtained from emptied food tins and canned foods and drinks; these are non-biodegradable solid waste produced by every household on a daily basis [15].

The majority of Nigeria imported food items come in tins and cans which serve as a preservation mechanism against spoilage and are also necessary for long-lasting duration. Their outright usage results in solid waste products which occupy a central space in littering and defacing the environment. Paper/cellophane waste was produced by most households (77%) and refers to solid waste products derived from carbon-paper materials [15]. This refers to ripped and/or filthy papers that have been thrown out or disposed from homes, workplaces, schools, markets, etc. Sometimes, these papers and cellophanes wrap litters around our surroundings and environments causing the environment to look messy and unkempt. About 52.2% of respondents indicated textile waste; these are wastes derived from pieces of unused clothing materials more specifically from tailoring shops, fabrics and fashion outfits centers, furniture and shoe-making shops [16]. Other textile wastes result from synthetic and non-synthetic textile materials such as wool, silk, cotton, flax, jute, asbestos, tires, glass fiber, nylon, polyester, acrylic, etc. These waste litter all over the environment creating a messy scene and an eyesore.

Table 2. Forms of solid waste produced in Southeast, Nigeria

Forms of Solid Waste	*Frequency	Percentage
Kitchen/ Food	416	100
Paper / cellophane	320	76.9
Textile	217	52.2
Plastic	409	98.3
Leather	405	97.4
Wood	199	47.8
Glass/bottles	391	93.9
Metals	112	26.9
Feces in septic tanks	78	18.8
Organic	102	24.5
Damaged electronics/gadget	261	62.7
Chemical/industrial	192	46.2
Tins/cans	416	100

*Multiple responses

Plastic waste was present in 98.3% of households, and refers to wastes derived from plastic materials or items. In Nigeria, most food items come in plastic containers, these include plastic foods and drinks and their consumption by households entails solid waste products which are being discarded carelessly in our environments and surroundings [16]. Leather waste was produced by 97.4% of the respondents and refers to waste obtained from artisans mostly in furniture and shoe/slippers-making shops and centers. Also leather wastes are obtained from bags and accessory making shops and as well as other industries involved in leather usage. These leather wastes are mostly tiny pieces and unused leather materials after useful parts have been taken or cut off to make leather products. Sometimes these leather wastes are from spoilt leather seats, cloths, bags, footwear, and any other in-utility leather materials or products [17].

Wood wastes were declared by 48% of the respondents; these respondents are artisans who work in wood industries and specialize in wood carvings and splitting. Wood wastes also include waste obtained from wood-producing industries like timber shades; inform of wood debris, dust and wood ashes. Other wood wastes result from furniture-making outlets and centers. Glass/bottles are

solid waste produced by 94% of the respondents. They represent waste gotten from broken glasses and bottles from various homes, offices, market places, food and drink centers, etc. that litters in our surroundings and environments causing a menace to the environment and residents as well. Sometimes, these broken glasses and bottles result from bottled drinks and window glass industries [17].

The production of metal waste was declared by 27% of respondents, these wastes are obtained from metallic substances and materials most especially from artisans who engaged in iron/metal carvings, and goldsmiths. More so, this waste results from wielding artisans and industries who deals on heavy metals and irons. Hence, unused and carved out metals are seen as solid waste which could be dangerous and harmful to the environment and humans. Feces in septic tanks were produced by 19% of the respondents. They are solid excretory products evacuated from the bowels of humans. This wastes when exposed or leaked out from the septic tanks and soak-away are hazardous [18]. It decomposes easily to become toxic substances that are unhealthy to surrounding environments and humans. Organic wastes refer to agricultural waste and were produced by 25% of the respondents. These wastes results from post-harvest crop debris, unused manures, uprooted grasses and weeds, animal fodders, plant leaves, fallen tree leaves and flowers, and in most cases wastes produced from the kitchen. These wastes litter our environments making it untidy and dirty [19].

About 63% of respondents declared to produce electronics/gadget accessories as solid waste, these wastes refer to damaged electronics and gadgets such as electric irons, fridges, freezers, televisions, wall clocks, satellite dishes, computers, radios, phones, batteries, and all other electrical gadgets found in our homes, offices, schools, hospitals, and all over our work places. These solid wastes occupy spaces in our surroundings and environments. Chemical/industrial waste was produced by 46.2% of the households and is derived from artisans, self-employed paints dealers and chemical factories and fertilizer producing industries established in the states. These solid wastes sometimes find their way to the water bodies (streams, rivers, lakes, oceans, etc.) polluting our waters, making it unsafe for drinking and killing our aquatic animals such as fishes and others [19].

3.3. Perception of Solid Waste Production in Southeast, Nigeria

The perception of solid waste production in Southeast, Nigeria is presented in Figure 2 in (pie chart). The respondents were asked on how they perceived the current solid waste being produced in the states. The chart reveals that the majority of the respondents, 88% perceived that solid waste production in the states is increasing intensely over time. This could result from increasing population growth, urbanization, over dependence on imported food items, lack of government policies and unhealthy attitudes and behaviors of households to solid waste disposal and management [20]. About 9% of the households indicated that solid waste production in the states is decreasing rapidly, this is in contrast to 3% who thought that solid waste production in the states remains unchanged, that is; it is neither increasing nor decreasing. These latter perceptions of the respondents could result from their standpoint of reasoning and absolute observations which involves their unbiased opinion towards solid waste production in the states.

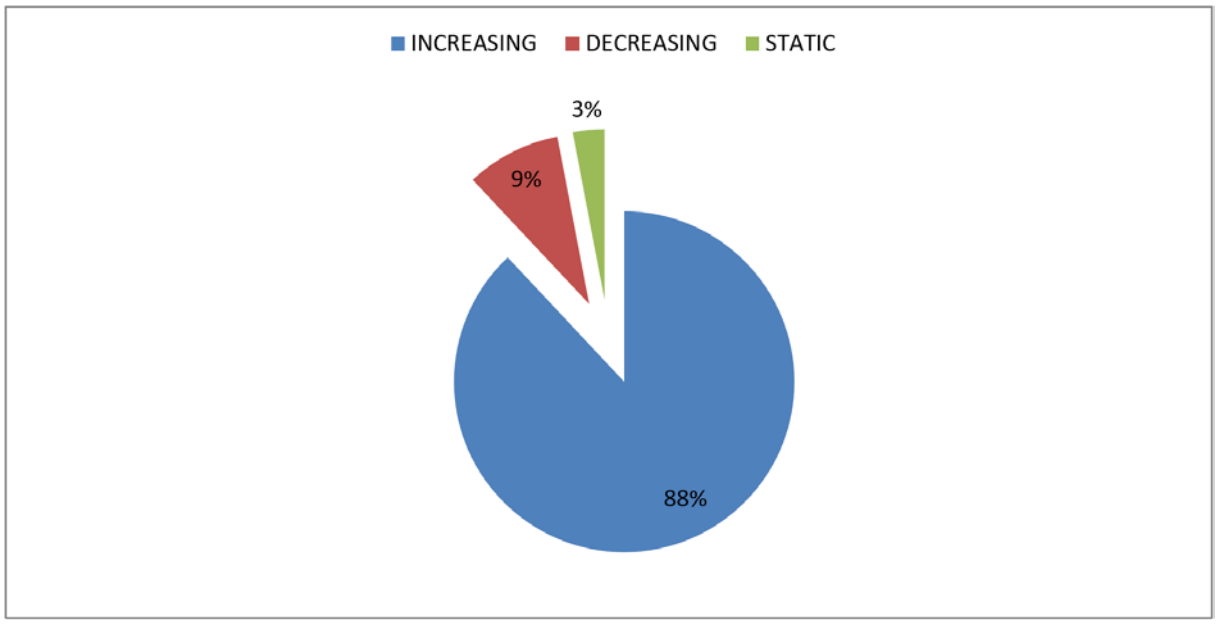

Figure 2. Perception of Solid Waste Production in Southeast Nigeria

However, the varied perceptions of the respondents indicate that they are all in tandem with the existing solid waste production in the states but from the researchers' investigation and observation during the period of study survey, it is clearly seen that solid waste production in the sampled states is increasing per day/per time and this agrees with the majority line of thoughts and postulations. This is evidently seen in solid waste materials and substances littered all over the states without recourse to its negative implications to the human health, the surroundings and the environment [21].

3.4. Solid Waste Production Levels in Southeast, Nigeria

The solid waste production levels in Southeast, Nigeria is presented in Figure 3 (pie chart). The chart reveals that about 9% of the respondents produced solid waste at moderate levels; this implies that the wastes produced by these households are neither high nor low but modest. Going further, 21% of the respondents produced solid waste at minimal levels; this implies that these households produced solid waste at the least possible levels.

This could result from their socio-demographic dispositions such as education, age and active participation in solid waste disposal training and seminars [22]. However, the majority of the respondents, 70% produced solid waste materials at maximal levels; this indicates that these respondents produced solid waste in large possible quantities. This could possibly be due to ignorance, low education, high consumption of commodities, and inexperience in solid waste production and management [22].

3.5. Rotated Component Matrix on Solid Waste Produced in Southeast, Nigeria

The rotated component matrix on solid waste produced in Southeast, Nigeria is presented in Table 3. It indicates that 13 different variables (solid wastes generated) were rotated, and that only significant factor loading values larger than 0.5 were taken into account for selection and interpretation in the study. Note, that the respondents' solid waste production was divided into PC1 and PC2, respectively, PC1 refers to biodegradable wastes and PC2 non-biodegradables. PC1 includes kitchen/food waste and organic wastes whereas paper, plastic, glass, and cans/bottles and tins/cans make up PC2.

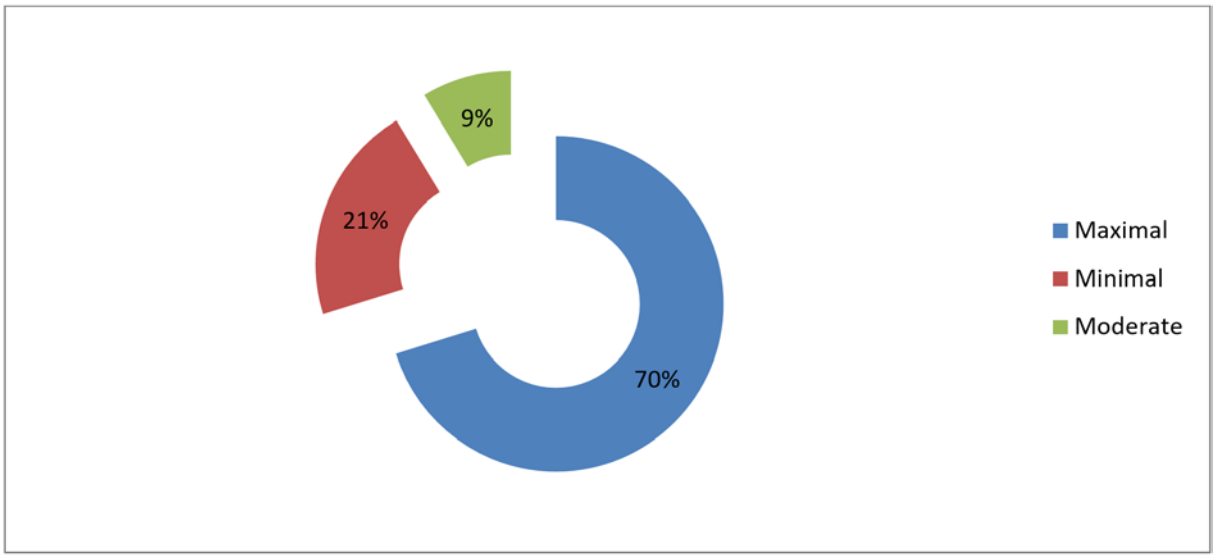

Figure 3. Solid Waste Production Levels in Southeast, Nigeria

Table 3. Rotated Component Matrix on Solid Waste Produced in Southeast, Nigeria

Rotated Solid Waste	Component	
	PC1	PC2
Kitchen/ Food	0.801*	
Paper		0.703*
Textile		0.409
Plastic		0.855*
Leather		-0.431
Wood		0.311
Glass/bottles		0.674*
Metals		-0.411
Feces in septic tanks	-0.378	
Organic	0.789*	
Damaged electronics/gadgets		0.408
Chemical/industrial		-0.321
Tins/cans		0.772*
% of rotation variance	21.9	18.2

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

* signifies components with score of 0.5 and above and selected components.

The component matrix generated by PCA revealed that PC1 accounts for 21.9% of the total variance with high positive loadings of kitchen/food waste and organic wastes and PC2 equally accounts for 18.2% of the total rotation variance with high positive loadings of paper waste, plastic waste, glass/bottle waste, and tins/cans [23]. Kitchen/food waste has a substantial value of 0.801 (See Table 3). These are remnants of food that have been cooked, such as vegetable and yam peelings and plate scraps. This indicates waste created during tasks performed in commercial kitchens, such as cooking meals, washing dishes, and handling leftovers from food eateries [24]. Other examples of these include unsold food from retail food establishments, plate waste, uneaten prepared food, or kitchen trimmings and domestic by-products. A large value of 0.789 applies to organic waste. These are wastes and plant remnants left over from agricultural operations and activities, including unused manures, decomposed feed, grass, and flowers and leaves left on the ground.

Organic waste can also be produced from decaying plants and animals, and also from drug of pigs, chickens, goats, rabbits, and cows. They are also supplementary waste products from horticultural and agricultural operations. Crop portions that are not utilized for human or animal benefits are known as organic wastes [24]. The significant value of paper waste was 0.703. In Nigeria, paper makes up around 26% of all solid waste; this includes papers that have been rejected or thrown away. In many businesses and workplaces, paper waste is a serious issue. Up to 70% of a company's total waste may consist of paper due to printing errors, junk mail, billings, and packaging. A considerable value of 0.855 was assigned to plastic garbage. Plastic trash is a collection of plastic items, materials, substances, and plastic particles that were poorly disposed. According to their size, plastic wastes are divided as micro, meso, and macro detritus [20]. They come from businesses that produce food and drinks as well as from water and beverage firms [19]. The substantial value of 0.674 was assigned to glass/bottle waste. Anything made of glass or a bottle that has been abandoned after serving its intended purpose is referred to as glass/bottle waste. Glass/bottle wastes also come from cosmetic goods like fragrances, including drink bottles, food containers, and jars [20].

Additionally, it originates from businesses that manufacture glass windows and doors called Aluminum Glass (Almaco). Bottles of wine, spirits, and alcoholic beverages are examples of other containers that contain glass or bottles, as well as bottles of soft drinks and beers. Tin/cans waste has a significant value of 0.772. This represents wastes gotten from food packages, and drinks. This occurs when the food/drink contents in tins/cans have been used up and its containers disposed carelessly [15].

3.6. Hazards of Solid Waste on the Human Health, Ecosystem and Soil Productivity

The major hazards of solid waste on the environment and soil productivity are presented in Table 4. The Table reveals that all the respondents viewed health issues as one of the most dangerous hazards caused by poor solid waste disposal. Cholera, measles, acute flaccid myelitis, and malaria are just a few of the vector-borne diseases that can spread through the air, water, or land as a result of improper solid waste disposal [25]. Solid waste allows drains to clog, which leads to stagnant water that encourages the development of insects and animals such as mosquitoes, cockroaches, and rats, which in turn leads to the spread of diseases like malaria, dengue fever, and food poisoning [25].

Table 4. Hazards of Solid Waste on Human Health, Ecosystem and Soil Productivity

Hazards of Solid Waste	*Frequency	Percentage
Health issues	416	100
Land Pollution/Soil productivity loss	414	99.5
Water Pollution	217	52.2
Air Pollution	409	98.3
Expenses on health treatments	405	97.4
Spreading of diseases/germs	399	95.9
Blockage of water drains	391	93.9
Climate change	412	99.0
Defacing of the environments	78	18.8

Source: Omang et al., [13], Fadhullah et al., [16]

*Multiple responses (Frequency)

About 99.5% of the respondents indicated land pollution/soil productivity loss as a major hazard caused by poor solid waste disposal. Indiscriminate solid waste disposal defaces the environment making it unhealthy for healthy living. Dumped hazardous substances pollute and disintegrate the land, ecosystems and biodiversity causing environmental deficits and poor productivity of the soil. It disrupts soil physical, chemical and biological properties thus making the soil infertile and unproductive [13]. Water pollution was identified by 52.2% of the households. Poor solid waste disposal pollutes the water bodies (lakes, streams, rivers, oceans) through the release of hazardous and poisonous chemicals and substances thus making the water unsafe for drinking and other domestic use purposes [16]. Polluted water bodies kill aquatic animals such as fishes, etc. potentially leading to possible extinction and close-end on the part of household fishermen. Dumping of solid waste blocks water drains and exacerbates the spread of water-borne diseases such as cholera, diarrhoea, dysentery, etc. Indiscriminate solid waste disposal distorts carbon dioxide and oxygen distribution and triggers air-borne diseases such as acute flaccid myelitis (afm), anthrax, chickenpox (varicella), influenza, meningitis (neisseria meningitidis), measles (rubeola) and middle east respiratory syndrome [5].

These diseases affect the lungs and respiratory tracts and systems and sometimes cause cancer of the lungs. Expenses on health treatments were indicated by 97.4% of the respondents. No doubt, indiscriminate solid waste disposals affect human health resulting in health failures, sicknesses, diseases, infections and numerous health issues and challenges. Households who suffer these illnesses visit hospitals, clinics, pharmacy shops and health centres and spend money in treating themselves and their family members [13]. About 96% of the respondents indicated spreading of diseases/germs. Spreading of diseases/germs emanates from indiscriminate solid waste disposals and poor waste management. Dumped solid wastes that have stayed for a long time undergo rapid and uncontrolled decomposition and build up micro-organisms and vectors which causes disease spreads and germs. These result in ill-health and other health issues and challenges. Blockage of water drains was attested by 94% of the respondents [26]. Solid waste blocks water drainages and passage-ways causing environmental hazards. This obstruction results in water percolation, flooding, and swamping of the environment and surrounding areas. These flood waters push through agricultural farmlands, destroying planted crops and impairing soil productivity [16].

Ninety-nine percent of the families identified climate change as one of the major risks caused by poor solid waste disposal. About 9% of the methane emissions resulting from the disposal of industrial and home-made solid waste are partially responsible for climate change. These greenhouse gases ascend into the atmosphere, where they trap heat, leading to significant climate alterations. These shifts in climate conditions exert adverse impacts on soil productivity [27]. More so, solid waste is a significant contributor to the production of greenhouse gases (GHGs), accounting for around 5% of GHGs in the form of carbon dioxide, methane, and nitrous oxide. Anaerobic degradation of garbage in landfills also contributes to the release of nitrous oxide. These put together causes climate change [27]. About 19% of the households indicated defacing of the environment, solid waste defaces the environment, depriving it from its original form, nature and beauty. It complicates the environment and renders it untidy, unclean, littered and messy. It denigrates the beauty of the environment, ecosystems and biodiversity [18].

3.7. Solid Waste Disposal and Management Systems in Southeast, Nigeria

The solid waste disposal and management systems in Southeast, Nigeria are presented in Figure 4. The figure shows that 17% of the respondents dispose their solid wastes via burning. Burning of solid waste is still in existence and being practiced by many households in Southeast Nigeria. This involves the gathering of solid waste materials and substances and setting them on fire to burn out to ashes and charcoals. This form of waste disposal and management constitutes harm and danger to the environment, living surroundings and human beings and should be discouraged [28].

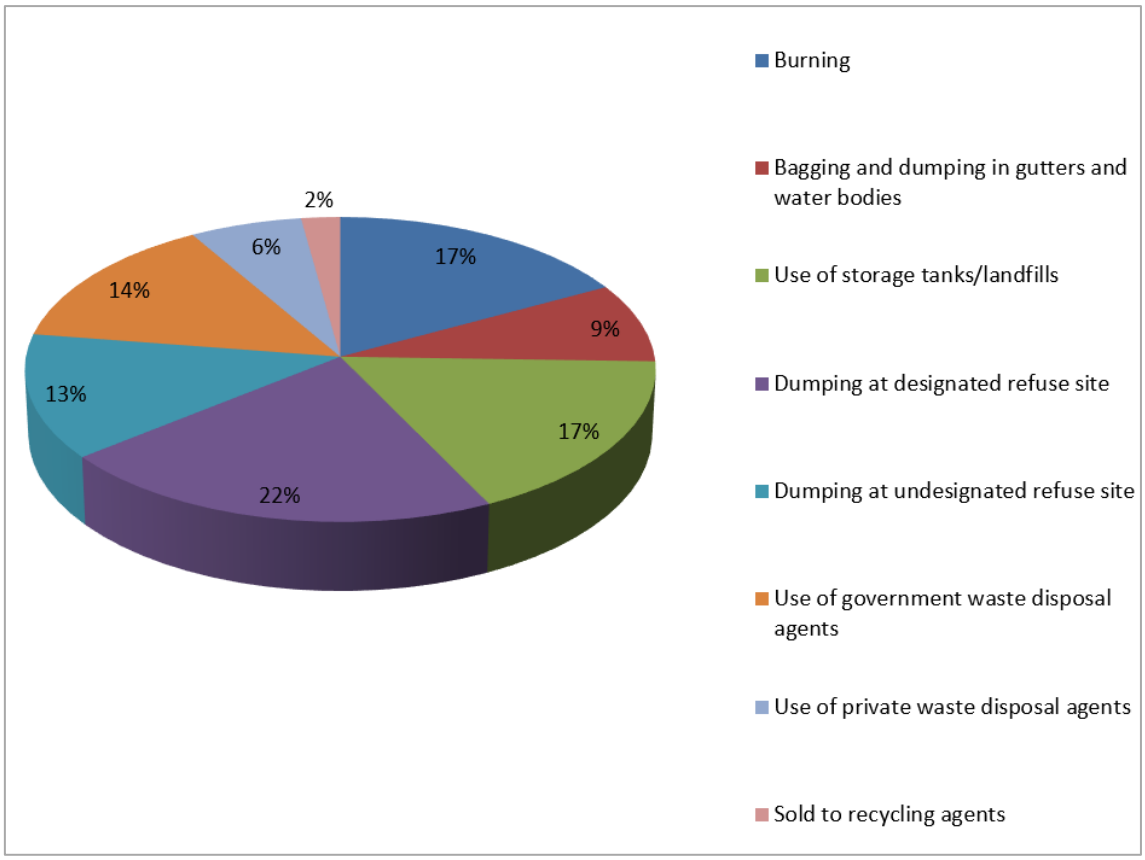

Figure 4. Solid Waste Disposal and Management Systems in Southeast, Nigeria

Bagging and dumping in gutters and water bodies was done by 9% of the respondents. The respondents indicated bagging and dumping in gutters and water bodies as their safest means of solid waste disposal and management. This form of solid waste disposal and management obstructs water drainage systems and channels and pollutes our water bodies in general [12]. About 17% of the respondents reported the use of storage tanks/landfills as their solid waste management procedure. These groups of persons prefer to dispose of their solid refuse in tanks and landfills. This waste management system causes environmental pollution and destroys the land surface [4]. Dumping at designated refuse sites was indicated by 22% of the respondents. This involves visiting designated refuse sites to dispose of their solid wastes. The designated refuse sites are usually cited outskirt of the living environment and homes [13].

Dumping at undesignated refuse sites was indicated by 13% of the respondents. This indicates that these people dump their solid wastes indiscriminately on the streets, gutters, walk-ways, and surroundings. These could be due to the designated refuse sites being located far from their homes and houses and also from poor waste disposal attitudes. About 14% of the respondents used government waste disposal agents; this involves disposing of their solid wastes with assigned government waste disposal agents who visit the neighborhoods', streets, homes, houses, compounds, etc. to collect people's wastes for proper disposal. The use of government waste disposal agents is seemingly an efficient waste disposal system in Nigeria [28]. Private waste disposal agents were used by 6% of the respondents, this involves making use of private waste disposal agents who visit the neighborhoods', streets, homes, houses, compounds, etc. on scheduled week days and time to pick up refuse wastes. This system of waste disposal is funded by the respondent's paying a certain agreed amount of money to dispose their solid waste products. About 2% of the respondents sold their solid waste products to refuse recycling agents who recycle the waste products into useful materials [24].

3.8. Suggested Mechanisms on Solid Waste Disposal and Management in Southeast, Nigeria

Suggested mechanisms on solid waste disposal and management are presented in Figure 5. The bar chart shows that 17.1% of the respondents identified public awareness as an effective solid waste disposal and management system. This indicates creating general public awareness and campaigns on effective, and efficient waste disposal and management systems is a good approach. Public awareness should be created using various media such as television, radio, billboards, flyers, talk shows, debates, and other multi-media's channels in educating households on dangers and consequences of poor solid waste disposal and management [18].

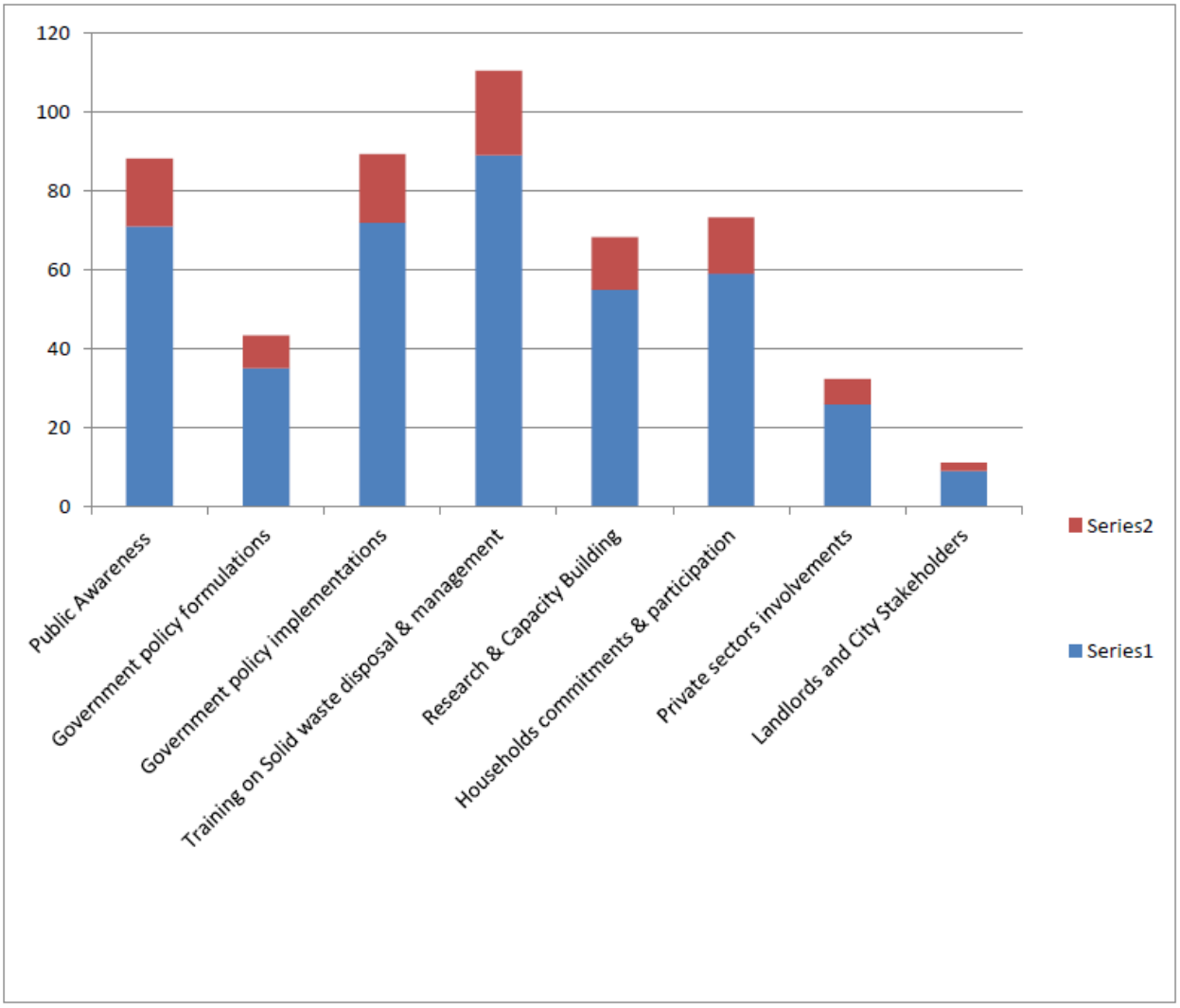

Figure 5. Suggested Mechanisms on Solid Waste Disposal and Management in Southeast, Nigeria

Government policy formulations were indicated by 8.4% the respondents, this involves the government formulating effective policies and strengthening existing ones on solid waste disposal and management. For instance, effective policies on providing designated sites for solid waste disposal and punishing offenders who dumps solid waste refuse indiscriminately will chart a new course in solid waste management and proper disposal [16]. About 17.3% of the respondents advocated government policy implementations for efficient waste disposal and management. This indicates the implementation of government policies on solid waste disposal and management. Thus government should not only stop at policy formulations but should as a matter of urgency implement those policies into fruition and realization of its intended objectives. Training on solid waste disposal and management was indicated by 21.4% of the respondents, this involves organizing trainings, seminars, symposiums, conferences, etc. on solid waste disposals and management systems. Such trainings impact new knowledge and educate the rural-urban dwellers and households on various ways and methods in managing solid wastes within and around their neighborhoods [21].

Research and capacity building was indicated by 13.2% of respondents, this involves investigations in research and capacity building surveys poised in innovating new ways, patterns, and scientific and modern improved waste management provisions and systems. Instead of recycling our old waste management systems, new and proven methods should be developed via research studies and integrated efficiently into good use [17]. About 14.3% indicated households' commitments and participation; this entails household heads fully participating as stakeholders in solid waste disposal and management. Household heads should not leave it for government or the private sectors alone but should be committed and dedicated in ensuring proper solid waste disposals around and within their neighborhoods without fear or compromise [6]. Private sectors involvements were indicated by 6.3% of the respondents, this involves the private sectors assisting in ensuring serene and clean environments and surroundings by championing and supporting efficient and effective

solid waste disposal and management systems in Southeast, Nigeria. Their participation will boost government's efforts in tackling solid waste disposal issues in Nigeria.

Consequently 2.2% of the respondents indicated landlords and city stakeholders' commitments; this entails; the involvement and participation of landlords (house-owners) and city stakeholders in ensuring that solid wastes are properly disposed and managed starting from their owned houses, buildings, homes, and compounds along with around their neighborhoods and extended surroundings and environments.

3.9. Determinants of Solid Waste Disposal and Management in Southeast, Nigeria

Determinants of solid waste disposal and management in Southeast, Nigeria are presented in Table 5. The results show that the log-likelihood value of 170.07 was highly significant at 1% level of significance; this analysis only determine which variables are related to respondents that attended waste disposal training from those that did not. The R^2 value of 0.8709 indicates that 87% of the total variation in the dependent variable could be explained by the independent variables investigated.

The coefficient of age was positive and significant at 1% level of significance; this indicates that increase in age of the respondents increases their ability for proper waste disposal and management. This indicates that as the respondents advance in age, it is more likely that they belong to the group that attended waste disposal training [16]. The coefficient of gender was positive and significant at 5% level of significance; this indicates that the male respondents attended waste disposal training more than their female counterparts [5]. Distance to designated refuse sites has a negative coefficient and was significant at 1% level of significance. This indicates that increase in distance to designated refuse sites decreases respondents' ability in managing their waste disposals. This could imply that those that did not attend waste disposal training find it difficult to access distant refuse dumping sites to dispose of their solid wastes; rather they dump it indiscriminately in the gutters, streets, water bodies, empty spaces and bushes around their neighbourhoods and environment [29].

Education is positive with a significant coefficient value at 1% level of significance. This indicates that the educated households attended waste disposal training more than the uneducated ones. Education is described as the bridge that separates the literate from ignorance and sets them apart for positive innovations, and new ways of doing things. Thus, in this regard the educated household heads tend to manage and dispose of their solid wastes properly than the uneducated ones [25].

The coefficient of marital status was positive and significant at 1% level of significance; this indicates that married people were more represented in the group that attended waste disposal training. The coefficient of enforcement of solid waste disposal laws was positive and significant at 1% level of significance. This indicates that household that attended waste disposal training is more likely to enforce the solid waste disposal laws [29,30].

Table 5. Determinants of Solid waste disposal and management among households

Variables	Coefficients	Z-values	Std. Error
Constant	3.806	2.079**	1.830
Age	4.034	4.011***	1.005
Gender	0.716	2.099**	0.341
Household size	-0.703	-0.550	1.278
Distance to designated refuse site	-0.529	-3.850***	0.137
Education	0.757	4.420***	0.171
Marital status	0.884	3.401***	0.259
Income	-0.447	-1.200	0.373
Culture	-0.977	-0.501	1.950
Solid waste disposal laws	0.834	4.020***	0.207
Occupation	-0.232	-1.003	0.231
Log likelihood	170.07***		
Pseudo (R^2)	0.8709		
N	416		

Note: Statistical significance at 1% ***, 5%** and 10%*

4. Conclusions and Recommendation

The rate of solid waste produced in Nigeria has become a major issue of concern and this stems from increasing population growth, urbanization, rapid industrial and commercial growth as well as springing institutions and establishments across the Southeast, Nigeria. If this is not tackled, solid waste production in Nigeria will continue to increase in the coming decades. The findings of the study indicate that the respondents are in their prime age, mainly males, married, educated, and engaged in trading as a major occupation. Various forms of solid waste are produced in Southeast, Nigeria and this includes kitchen/food wastes, paper/cellophane, textile, plastic, leather, wood, etc. This solid waste was divided into biodegradable and non-biodegradable waste.

The majority of the respondents were of the opinion that solid waste production in Southeast Nigeria is increasing per time. The levels of solid waste were isolated into minimal, maximal and moderate production with 70% of the households producing at maximum. A major hazard caused by poor solid waste disposal includes health issues, land pollution/degradation, water pollution, air pollution, disease spreads, climate change and storm drain blockage. Results equally show that different households disposed of their solid wastes differently such as open burning, use of storage tanks/landfills, bagging, use of government designated sites, dumping in gutters and water bodies, etc. Age of households, gender, distance to designated refuse sites, education, participation in waste disposal training, marital status and solid waste disposal laws were major significant determinants of solid waste disposal and management among respondents in southeast, Nigeria.

The study is of several significances because it highlighted the forms of solid wastes produced in Southeast, Nigeria and their various components, knowing these solid waste products will help residents in the zone to minimize solid waste generation because the residents may be unknowingly generating these waste products. This study found that solid waste generation in the zone is increasing over time arising from increasing population growth, urbanization, over dependence on imported food items, lack of government policies and unhealthy attitudes and behaviors of households to solid waste disposal and management, with these developments, efforts of government in formulating and enacting formidable policies addressing the above challenges and issues is paramount in the study. Indiscriminate solid waste disposals have severe consequences on human health, ecosystem and soil productivity, therefore, educating the household heads, residents, inhabitants through workshops, conferences, seminars, symposiums, etc. as recommended in this study will change the narrative regarding waste disposals and help reduce the negative impacts and severe consequences. Furthermore, the study is quite important because it revealed poor solid waste disposal and management systems in southeast, Nigeria highlighting its negative consequences, with this in mind, persons and individuals responsible for such disposals will have rethink and this will chart a new course in solid waste disposal systems in southeast, Nigeria. The study also recommended various mechanisms in combating poor solid waste disposal such as creating general public awareness and campaigns, government policy formulations, research and developments, private and stakeholders' involvements, capacity training engagements, etc. as a necessary end in reducing indiscriminate solid waste disposals in the zone. Again, combined efforts of governments and private stakeholders are needed in implementing new solid waste disposal policies and strengthening existing ones to abate indiscriminate dumping of solid wastes in undesignated centers and sites in Southeast States.

REFERENCES

[1] Aliyu, A.A., and Amadu, L. "Urbanization, cities, and health: The challenges to Nigeria - a review". *Annals of African Medicine*, vol. 16, no. 4, pp. 149-158, 2017. doi: 10.4103/aam.aam_1_17.

[2] Hussein, I.A., and Mona, S.M.M. "Solid waste issue: Sources, composition, disposal, recycling, and valorization". *Egyptian Journal of Petroleum*, vol. 27, no. 6, pp. 1275-1290, 2018. https://doi.org/10.1016/j.ejpe.2018.07.003.

[3] Margaret-Popoola, B. "Biodegradable Waste". *Intech Open*. vol. 12, no. 2, pp. 21-35, 2023. doi: 10.5772/intechopen.107910

[4] Worldbank, "Bridging the gap in solid waste management: governance requirements for results". vol. 2, no. 1, pp. 12-16, 2021. https://www.worldbank.org/en/topic/urbandevelopment/publication/bridging-the-gap-in-solid-waste-management

[5] Ferronato, N., and Torretta, V. "Waste mismanagement in developing countries: A review of global issues". *International Journal of Environmental Research and Public Health*, vol. 24, no. 16, pp. 1060, 2019. doi: 10.3390/ijerph16061060.

[6] Nwosu, A.O., and Chukwueloka, E.H. "A review of solid waste management strategies in Nigeria". *Journal of Environment and Earth Science*, vol.10, no. 6, pp. 132-139, 2020. DOI: 10.7176/JEES/10-6-11

[7] Zawde, T.T., Zemenu, A.T., and Mohamed, A.I. "Assessment of solid waste management practices in Kebridehar city Somali regional state, Ethiopia". *Heliyon*, vol. 8, no. 9, pp. 12-16, 2022. https://doi.org/10.1016/j.heliyon.2022.e10451

[8] Odonkor, S.T., and Sallar, A.M. "Correlates of household waste management in Ghana: Implications for public health". *Heliyon*. vol. 7, no. 2, pp. 45-49, 2021.

[9] Abrhame, E. "Assessment of municipal solid waste management practices: A case study of Bishoftu City

Administration Addis Ababa, Ethiopia". vol. 2, no. 1. pp. 10-20, 2018. Available at: http://etd.aau.edu.et/bitstream/handle/123456789/13154/Endalkachew Abrhame.pdf

[10] Krystosik, A., Njoroge, G., Odhiambo, L., Forsyth, J.E., Mutuku, F., and LaBeaud, A.D. "Solid wastes provide breeding sites, burrows, and food for biological disease vectors, and urban zoonotic reservoirs: A call to action for solutions-based research". *Frontier in Public Health*, vol. 17, no. 1, pp. 405-410, 2020. doi: 10.3389/fpubh.2019.00405.

[11] Dida, G.O., Gelder, B.D., and Anyona, N. "Presence and distribution of mosquito larvae predators and factors influencing their abundance along the mara river, Kenya and Tanzania". *SpringerPlus.* vol. 4, no. 136. pp. 33-39, 2015. https://doi.org/10.1186/s40064-015-0905-y

[12] Solgi, E., Sheikhzadeh, H., and Solgi, M. "Role of irrigation water, inorganic and organic fertilizers in soil and crop contamination by potentially hazardous elements in intensive farming systems: case study from Moghan agro-industry". *Journal of Geochemical Exploration, vol.* 185, no. 5, pp. 74–80, 2018.

[13] Omang, D.I., John, G.E., Inah, S.A., and Bisong, J.O. "Public health implication of solid waste generated by households in Bekwarra local government area". *African Health Science*, vol. 21, no. 3, pp. 1467-1473, 2021. doi: 10.4314/ahs.v21i3.58.

[14] Jerin, D.T., Sara, H.H., Radia, M.A., Hema, P.S., Hasan, S., Urme, S.A., Audia, C., Hasan, M.T., and Quayyum, Z. "An overview of progress towards implementation of solid waste management policies in Dhaka, Bangladesh". *Heliyon*, vol. 10, no. e08918, pp. 34-50, 2022.

[15] NPC, Reports of national population census, Abuja, Nigeria, 2022.

[16] Fadhullah, W., Imran, N.I.N., and Ismail, S.N.S. "Household solid waste management practices and perceptions among residents in the East Coast of Malaysia". *Pubulic Health*, *vol.1*, *no.* 22, pp. 10190, 2022. https://doi.org/10.1186/s12889-021-12274-7

[17] Chukwuma, B.D., Anthony, C.I., Kevin, C.D., Kenechi, C.D., Irene, A.M., Ugochukwu, C.M., Ijeoma, C.M., Emmanuel, U.N., Ikechi, U.N.O., and Ernest, N. "Environmental sanitation practices: a case study of solid waste management in semi-urban communities in Orlu, Imo State Nigeria". *Occupational Diseases and Environmental Medicine*, vol. 5, no. 5, pp. 88-105, 2017. doi: 10.4236/odem.2017.54009.

[18] Debrah, J.K., Dinis, D.G., and Vidal, M.A.P. "Raising awareness on solid waste management through formal education for sustainability". A developing countries evidence review. Recycling, vol. 6, no. 1, pp. 10006, 2021. https://doi.org/10.3390/recycling6010006

[19] Kaoje, A.U., Sabir, A.A., Yusuf, S., Jimoh, A.O., and Raji, M.O. "Residents perception of solid waste disposal practices in Sokoto Northwest, Nigeria". *African Journal of Environmental Science and Technology*, vol.11, no. 2, pp. 94-102, 2017.

[20] Ütebay, B., Çelik, P. and Çay, A. "Textile wastes: status and perspectives. *IntechOpen*, vol. 14, no. 3, pp. 10-15, 2020. doi: 10.5772/intechopen.92234, 2020.

[21] Patti, A., Cicala, G., and Acierno, D. "Eco-sustainability of the textile production: waste recovery and current recycling in the composites world. *Polymers*, vol. 30, no. 1, pp. 134-140, 2020. doi: 10.3390/polym13010134.

[22] Bahillo, A., Armesto, L. Cabanillas, A. and Otero, T. "Thermal valorization of footwear leather wastes in bubbling fluidized bed combustion. *Waste Management, vol.* 24, no.9, pp. 35-44, 2004. doi: 10.1016/j.wasman.2004.07.006.

[23] Phuong, N.T.L., Yabar, H., and Mizunoya, T. "Characterization and analysis of household solid waste composition to identify the optimal waste management method": a case study in Hanoi City, Vietnam. *Earth*, vol. 2, no. 4, pp. 1046–1058, 2021. https://doi.org/10.3390/earth2040062

[24] Hoornweg, D., and Bhada-Tata, P. "What a waste: A global review of solid waste management urban development series". Knowledge papers no. 15. © World Bank, Washington, DC. https://openknowledge.worldbank.org/entities/publication/1a464650-9d7a-58bb-b0ea-33ac4cd1f73c, 2012.

[25] WHO,"Hazards of solid waste; health evidences and implications, *World Health Organization, United Kingdom*", 2021.

[26] Udofia, E.A.. Gulis, G., and Fobil, J. "Solid medical waste: a cross sectional study of household disposal practices and reported harm in Southern Ghana". *BMC Public Health*, vol. 17, no. 464, pp. 122-132, 2017. https://doi.org/10.1186/s12889-017-4366-9

[27] IPCC, "Climate change in Africa. Issues and challenges", 2022. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

[28] Joshua, O., Babayemi, M.B., and Ogundiran, O.O. "Current levels and management of solid wastes in Nigeria". *Environmental Quality Management*, vol. 26, no. 3, pp. 29 – 53, 2017. https://doi.org/10.1002/tqem.21498

[29] Yoada, R.M., Chirawurah, D., and Adongo, P.B. "Domestic waste disposal practice and perceptions of private sector waste management in urban Accra". *BMC Pub Health*, vol. 14, no, 697, pp. 2-10, 2014. https://doi.org/10.1186/1471-2458-14-697 2014

[30] Ashani, P.N., Shafiei, M., and Karimi, K. "Biobutanol production from municipal solid waste", technical and economic analysis. *Bioresource Technology*, vol. 308, no. 123267, pp. 51-62, 2020.