Determination of the Factors Affecting Plastic Waste Generation in Enugu Metropolis, Enugu State, Nigeria

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Abstract: **Sequel to the fact that plastic wastes exist virtually everywhere in Enugu Metropolis, this study was carried out to determine the factors affecting plastic wastes generation in the area. The study was carried out in the three Local Government Areas that make up Enugu Metropolis which include Enugu North L.G.A, Enugu South L.G.A, and Enugu East L.G.A. A total of 400 households were sampled to represent the total population of households in the study area. The data for the study was obtained through the distribution of 126,118 and156 questionnaires to households in Enugu North L.G.A, Enugu South L.G.A, and Enugu East L.G.A respectively. The factors affecting plastic waste generation were analyzed using Principal Component Analysis (PCA) to determine the principal factors affecting plastic waste generation in the area. Results of the analysis showed that the nature of plastics products, human factors, governmental factors, political factors, as well as the attitude of the citizens, are principal contributory factors to plastic waste generation in the area. These principal factors should be put into consideration in the development of plastic waste management strategies in Enugu Metropolis to ensure the efficiency and effectiveness of these management strategies.**

Keywords: **Plastic waste, Generation, Factors, Household, Attitude.**

I. INTRODUCTION

Plastics are used in almost every aspect of daily life, including the food and beverage packaging, footwear, textiles, agriculture, building/construction, health applications, home appliances. Currently, plastics are mostly preferred and used as a replacement for many other materials such as papers, leaves wood, metals, glass [24]. Over the past 50years, plastic production has risen from 15million tonnes in 1964 to 311million tonnes in 2014 [9], with the world plastic production reaching almost 350million tonnes in 2017 [20]. Plastic production reached 407million tonnes per annum globally and is expected to reach 1600 million tonnes per annum in 2050 if the production growth rate remains the same [18].

Owing to the increase in plastic production, 275million metric tonnes of plastic waste were generated in 192 coastal countries in 2010 with 4.8 to 12.7 million metric tonnes entering the ocean [12]. In Nigeria, 13,600 tonnes per year of plastic waste was generated from primary High-Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE) packaging [30]. Plastics have recently gathered global attention due to its ubiquity in the global economy as well as the low material recovery rates that they currently achieve and the environmental impacts associated with current disposal methods [18]. The attention in so many developing countries, including Nigeria, has been drawn to plastic waste due to its widespread littering on the land [29]. Plastic waste accounts for 15% of the total waste volume [2]. Polyethylene Terephthalate (PET) bottles and the Low-Density Polyethylene (LDPE) like water sachets and nylon are the most common plastic waste in our environment [19].

Viewed from the human/socioeconomic aspects, household income, household size [16,21], population density, slums, industrial units, and commercial establishments [25] are observed to affect plastic waste generation. Moreover, the unique characteristics of plastics contribute to the widespread utilization of plastic products. These include the availability of plastic products, low price of plastics [11,14], lightweight, convenience in usage [22], lack of alternative materials [4,27] affordability, safety[3]; comfort, durability, the cheap cost of plastics[7,10], ease of manufacturing [23], easy to use[8]. All these characteristics of plastics give them a big advantage over other materials, as they are used more frequently compared to other materials [15]. Some of the characteristics of plastics that make them mostly preferable also contribute to their persistence in the environment, as it takes a very long period to degrade, thereby posing threat to the ecosystem.

Despite the awareness about the usage of plastics and its environmental negative impact, people, irrespective of educational qualification and profession, use plastic products in their daily life activities [26]. Habits, norms, and situational factors seem to be especially predictive for plastic consumption behavior [13]. Due to the value-action gap, in which there is a discrepancy between people's environmental values and their corresponding actions, the environmental knowledge, and awareness of people may not lead to positive pro-environment behavior [5]. Uncontrolled consumerism, unregulated production and circulation of plastic products, and improper disposal and management of the final waste output have been identified to contribute to plastic waste generation [1].

With the ubiquity of plastic waste today in our environment, it is important to take cognizance of the various factors affecting plastic waste generation, as this will be useful in developing and ensuring effective management strategies.

II. MATERIALS AND METHODS

The research design adopted for this study was a survey research design. The study was carried out through the distribution of questionnaires to households in the three Local Government Areas that make up Enugu Metropolis which include: Enugu North L.G.A, Enugu South L.G.A and Enugu East L.G.A.

A total of 400 households, comprising 126,118 and156 households in Enugu North L.G.A, Enugu South L.G.A, and Enugu East L.G.A respectively, were sampled to represent the total population of households in the areas. Principal Component Analysis (PCA) was used to determine the major factors affecting plastic waste generation. Each component extracted, was named based on the loadings of variables that correlate strongly and more significantly with the individual components.

III. RESULTS AND DISCUSSION

3.1 Principal component analysis for factors affecting plastic waste generation in Enugu North LGA

From the total variance explained, four components were extracted which explained 88.606% of the overall variation. These components were used to explain and summarize the overall variation in the original set of variables. Variable loading on each component after rotation (Table 1) reveals the following:

3.1.1 Component 1

The first component was loaded strongly and more significantly on fourteen of the variables. This component can be viewed as a measure of little or no encouragement on waste reduction, lack of incentives for non-usage of plastic products, low cost of transportation in carriage, durability, resistance to heat, ability to preserve content, little or no encouragement on waste recycling, resistance to water, urbanization, non-provision of alternatives for plastic products, need for comfort, household income, social class, and the quest for cheap materials.. Considering the loadings of these variables, component 1 is an indication of the nature of plastics/governmental factors. It however implies that under component 1, governmental factors as well as the nature of plastics are the major contributory factors to plastic waste generation in the area. These are in line with the findings in [1, 8].

3.1.2 Component 2

The second component was loaded strongly and more significantly on sixteen of the original variables. It increased with increasing values for these variables which include: urbanization, resistance to air, need for longevity of packaged products, lack of financial resources, negligence on the impacts of plastic waste, adherence to western culture, inappropriate technologies for plastic waste recycling, non-provision of alternatives for plastic products, unregulated circulation of plastic products, convenience in plastic usage, need for comfort, ease of production, attitude of people, lightweight, ease of usage, and non-involvement of producers in policymaking. With these variable loadings, component 2 is an indication of attitudinal/governmental factors. It implies that the attitude of the public and the government are the major contributory factors to plastic waste generation in the area. The variables under these major factors coincided with [1, 5].

3.1.3 Component 3

The third component was loaded strongly and more significantly on eleven of the original variables. It increases with increasing values for these ten variables which include: negligence on the impacts of plastic waste, lack/inadequate policies on plastic waste generation, poor implementation of government policies, low level of awareness creation on the impact of plastic waste, unregulated production of plastic products, shift from the traditional way of living, consumption pattern, level of knowledge on the effects of plastic waste, increase in population, lack of alternatives to plastic materials, and lightweight [5, 6]. Based on the loadings of these variables, component 3 is an indication of attitudinal/political factors. It implies that both the attitude of the public as well as political factors are major contributory factors to plastic waste generation in the area.

3.1.4 Component 4

The fourth component was loaded strongly and more significantly on twelve of the original variables. It increases with increasing values for these ten variables which include: ease of production, shift from the traditional way of living, non-involvement of consumers in policymaking, household income, social class, a quest for cheap materials, availability of plastics products, lack of political will, ease of usage, non-involvement of producers in policymaking, household size, and low cost of plastic products [1, 25]. Based on the loading, component 4 is an indication of human/governmental factors. It implies that the public as well as the government are the major contributory factors in plastic waste generation in the area.

Table 1: Rotated component matrix in PCA for factors affecting plastic waste generation in Enugu North LGA

	Component			
	1	2	3	4
Little or no encouragement on waste reduction	.859			
Lack of incentives for non-usage of plastic products	.848			
Low cost of transportation in carriage	.846			
Durability	.821			

Resistance to heat	.803			
Ability to preserve content	.797			
Little or no encouragement on waste recycling	.788			
Resistance to water	.765			
Urbanization	.690	.513		
Resistance to air		.822		
Need for the longevity of packaged products		.808		
Lack of financial resources		.782		
Negligence on the impacts of plastic waste		.779	.502	
Adherence to western culture		.776		
Inappropriate technologies for plastic waste recycling		.739		
Non-provision of alternatives for plastic products	.503	.711		
Unregulated circulation of plastic products		.709		
Convenience in plastic usage		.670		
Need for comfort	.512	.647		
Ease of production		.614		.516
Attitude of people		.522		
Lack/inadequate policies on plastic waste generation			.793	
Poor implementation of government policies			.776	
Low level of awareness creation on the impact of plastic waste			.681	
Unregulated production of plastic products			.666	
A shift from the traditional way of living			.652	.524
Consumption pattern			.647	
Level of knowledge on the effects of plastic waste			.637	
Increase in population			.615	
Lack of alternatives to plastic materials			.612	
Lightweight		.511	.532	
Non-involvement of consumers in policymaking				.664
Household income	.634			.658
Social class	.645			.648
Quest for cheap materials	.559			.648
Availability of plastics products				.637
Lack of political will				.624
Ease of usage		.594		.623
Non-involvement of producers in policymaking		.532		.611
Household size				.564
Low cost of plastic products				.545

3.2 Principal component analysis for factors affecting plastic waste generation in Enugu South LGA

Three components were extracted from the total variance explained. These three components explained 89.305% of the overall variation in the original set of measured variables and were used to summarize the overall variation. Variable loading on each component after rotation (Table 2) reveals the following:

3.2.1 Component 1

The first component was loaded strongly and more significantly on twenty-five of the original variables. This component is viewed as a measure of little or no encouragement on waste recycling, low cost of transportation in the carriage, unregulated circulation of plastic products, shift from the traditional way of living, a quest for cheap materials, little or no encouragement on waste reduction, resistance to heat, durability, resistance to water, ease of usage, resistance to air, ease of production, lack of incentives for non-usage of plastic products, convenience in plastic usage, need for longevity of packaged products, lack of financial resources, non-involvement of producers in policymaking, non-involvement of consumers in policymaking, lack of alternatives to plastic materials, consumption pattern, low level of awareness creation on the impact of plastic waste, unregulated production of plastic products, lack of political will, low cost of plastic products, level of knowledge on the effects of plastic waste, adherence to western culture, and household size [6, 22]. Considering the loadings of these variables, component 1 is an indication of the nature of plastics/governmental factors. It however implies that under component 1, the nature of plastics and the government are the major contributory factors to plastic waste generation in the area.

3.2.2 Component 2

The second component was loaded strongly on twenty-four of the original variables. These include: little or no encouragement on waste reduction, resistance to heat, durability, resistance to air, ease of production, convenience in plastic usage, ability to preserve content, non-provision of alternatives for plastic products, negligence on the impacts of plastic waste, lightweight, need for comfort, need for longevity of packaged products, lack of financial resources, non-involvement of producers in policymaking, urbanization, lack/inadequate policies on plastic waste generation, non-involvement of consumers in policymaking, lack of alternatives to plastic materials, availability of plastics products, the attitude of people, household income, inappropriate technologies for plastic waste recycling, increase in population, and household size [17, 23]. Based on the loadings of these variables, component 2 is an indication of governmental/human factors. It implies that under component 2, both the government and the public are major contributory factors in plastic waste generation in the area.

3.2.3 Component 3

The third component was loaded strongly and more significantly on twenty-one of the original variables. It increases with increasing values for these fifteen variables. These include: shift from the traditional way of living, a quest for cheap materials, ease of usage, negligence on the impacts

of plastic waste, urbanization, lack/inadequate policies on plastic waste generation, consumption pattern, low level of awareness creation on the impact of plastic waste, unregulated production of plastic products, social class, availability of plastics products, the attitude of people, lack of political will, low cost of plastic products, household income, inappropriate technologies for plastic waste recycling, level of knowledge on the effects of plastic waste, increase in population, adherence to western culture, household size, and poor implementation of government policies [5, 6]. Based on the variables loading, component 3 is an indication of attitudinal/political factors, which imply that the attitude of the public and political factors are the major contributory factors in plastic waste generation in the area.

Table 2: Rotated component matrix in PCA for factors affecting plastic waste generation in Enugu South LGA

	Component		
	1	2	3
Little or no encouragement on waste recycling	.816		.
Low cost of transportation in carriage	.813		
Unregulated circulation of plastic products	.768		
A Shift from the traditional way of living	.760		.566
Quest for cheap materials	.750		.536
Little or no encouragement on waste reduction	.745	.508	
Resistance to heat	.710	.569	
Durability	.690	.540	
Resistance to water	.676		
Ease of usage	.662		.522
Resistance to air	.658	.574	
Ease of production	.616	.536	
Lack of incentives for non-usage of plastic products	.589		
Convenience in plastic usage	.580	.554	
Ability to preserve the content		.843	
Non-provision of alternatives for plastic products		.828	
Negligence on the impacts of plastic waste		.782	.539
Lightweight		.767	
Need for comfort		.759	
Need for the longevity of packaged products	.566	.712	
Lack of financial resources	.606	.670	
Non-involvement of producers in policymaking	.528	.664	
Urbanization		.663	.520
Lack/inadequate policies on plastic waste generation		.656	.575
Non-involvement of consumers in policymaking	.535	.649	
Lack of alternatives to plastic materials	.532	.618	
Consumption pattern			.731
Low level of awareness creation on the impact of plastic waste			.722
Unregulated production of plastic products	.500		.709
Social class			.703
Availability of plastics products		.517	.681
Attitude of people		.517	.681
Lack of political will	.567		.668
Low cost of plastic products	.623		.659
Household income		.502	.658
Inappropriate technologies for plastic waste recycling		.558	.633
Level of knowledge on the effects of plastic waste	.577		.633
Increase in population		.581	.618
Adherence to western culture	.559		.615
Household size	.502	.529	.570
Poor implementation of government policies			.545

3.3 Principal component analysis for factors affecting plastic waste generation in Enugu East LGA

Here, two components were extracted from the total variance explained which explained 89.848% of the overall variation in the original set of variables. These were used to summarize the overall variation. Variable loading on each component after rotation (Table 3) reveals the following:

Component 1

The first component was loaded strongly and more significantly on thirty-one of the original variables which include: unregulated production of plastic products, low cost of plastic products, poor implementation of government policies, urbanization, household size, level of knowledge on the effects of plastic waste, convenience in plastic usage, household income, lightweight, low level of awareness creation on the impact of plastic waste, unregulated circulation of plastic products, availability of plastics products, adherence to western culture, attitude of people, need for comfort, inappropriate technologies for plastic waste recycling, little or no encouragement on waste recycling, social class, consumption pattern, lack of alternatives to plastic materials, non provision of alternatives for plastic products, quest for cheap materials, shift from traditional way of living, lack/inadequate policies on plastic waste generation, lack of political will, increase in population, negligence on the impacts of plastic waste, ability to preserve content, ease of production, lack of financial resources, and need for longevity of packaged products [1, 25]. Based on the variable loadings, component 1 is an indication of human/political factors. It implies that under component 1, the public and political factors are major contributory factors to plastic waste generation in the area.

3.3.1 Component 2

The second component is loaded strongly on thirty-two of the original variables and increases with increasing values for these variables. These include: low level of awareness creation on the impact of plastic waste, unregulated

circulation of plastic products, availability of plastics products, adherence to western culture, attitude of people, need for comfort, inappropriate technologies for plastic waste recycling, little or no encouragement on waste recycling, social class, consumption pattern, lack of alternatives to plastic materials, non provision of alternatives for plastic products, quest for cheap materials, shift from traditional way of living, lack/inadequate policies on plastic waste generation, lack of political will, increase in population, negligence on the impacts of plastic waste, resistance to water, low cost of transportation in carriage, resistance to air, lack of incentives for non usage of plastic products, durability, non involvement of consumers in policy making, ease of usage, little or no encouragement on waste reduction, resistance to air, non involvement of producers in policy making, ability to preserve content, ease of production, lack of financial resources, and need for longevity of packaged products [5, 17]. This component is an indication of the nature of plastics/governmental factors based on the variable loadings. It implies that under component 2, the nature of plastics and the government are major contributory factors to plastic waste generation in the area.

Table 3: Rotated component matrix in PCA for factors affecting plastic waste generation in Enugu East LGA

	Component	
	1	2
Unregulated production of plastic products	.882	
Low cost of plastic products	.858	
Poor implementation of government policies	.844	
Urbanization	.842	
Household size	.831	
Level of knowledge on the effects of plastic waste	.823	
Convenience in plastic usage	.818	
Household income	.816	
Light weight	.815	
Low level of awareness creation on the impact of plastic waste	.792	.527
Unregulated circulation of plastic products	.787	.537
Availability of plastics products	.785	.528
Adherence to western culture	.771	.573
Attitude of people	.766	.523
Need for comfort	.761	.578
Inappropriate technologies for plastic waste recycling	.759	.537
Little or no encouragement on waste recycling	.754	.584
Social class	.743	.572
Consumption pattern	.740	.567
Lack of alternatives to plastic materials	.735	.569
Non-provision of alternatives for plastic products	.724	.621
Quest for cheap materials	.703	.644
A shift from the traditional way of living	.700	.647
Lack/inadequate policies on plastic waste generation	.695	.625
Lack of political will	.689	.630
Increase in population	.683	.604
Negligence on the impacts of plastic waste	.672	.658
Resistance to water		.860
Low cost of transportation in the carriage		.857
Resistance to air		.852
Lack of incentives for non-usage of plastic products		.851
Durability		.836
Non-involvement of consumers in policymaking		.830
Ease of usage		.826
Little or no encouragement on waste reduction		.818
Resistance to air		.813
Non-involvement of producers in policymaking		.812
Ability to preserve content	.556	.798
Ease of production	.569	.769
Lack of financial resources	.566	.761
Need for the longevity of packaged products	.673	.679

IV. CONCLUSION

The study revealed that plastic waste generation in Enugu Metropolis is influenced by the nature of plastics, human factors, governmental factors, political factors, as well as the attitude of people. The nature of plastics which include low cost, lightweight, convenience in usage, ability to preserve content, resistance to air and water, ease of production are the reason for the increased demand and usage of plastic products, which consequently has led to increased generation of plastic wastes. This is coupled with the human/attitudinal factors which include an increase in population, consumption pattern/attitude of people, negligence on the impact of plastic waste. Moreover, political and governmental factors, which include, but not limited to, lack of political will, unregulated production/circulation of plastic products, non-involvement of producers/consumers in policymaking, poor implementation of government policies, inappropriate technologies, have an effect on plastic waste generation in Enugu Metropolis. Therefore in developing and ensuring effective plastic waste management strategies in Enugu Metropolis, these identified factors should be given first consideration.

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