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Plastic wastes separation practice and disposal mechanism by households, hospitals, markets and waste management body

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ABSTRACT

This study was carried out to reveal the plastic wastes separation practice and disposal mechanism as well as awareness of the negative impact of plastic wastes on the environment, in Makurdi area of Benue State, Nigeria. Questionnaires were administered to 468 individual respondents in 6 sub-locations of the city. Inquisition was also made from 10 hospitals, 6 market centers and the waste management body. The results revealed that 81.2% of the respondents do not separate plastic wastes from other waste stream. All the hospitals and markets do not sort at all. The government agency responsible for the final management of the waste stream does not have a practice of sorting plastic wastes from the whole waste collected with a view to achieving material and energy recovery. The most adopted methods of disposal for plastic wastes by all the stakeholders considered are dumping/burning and dumping. 50.4% of the respondents adopted dumping/burning as a disposal method for plastic wastes while 19.2% burn theirs. Although almost 50% of the population examined for the study claimed to be aware of the dangers of plastic wastes, there is still indifference in the way these wastes are handled as can be observed by the indiscriminate dumping of these wastes, creating litters around the environment. These result revealed a need for the development of a proactive and sustainable management system involving individuals, businesses, hospital managements and waste management body that will protect the environment and enhance resource and energy recovery from plastic wastes.

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INTRODUCTION

In recent times, municipal solid waste (MSW) has become a major environmental concern all over the world. In Nigeria, the annual estimate of solid wastes generated is about 32 million tons (Bakare, 2016). Generally, plastic wastes account for 11% of total MSW generated (Kunwar *et al.*, 2016). Over the years, the plastic industry has grown drastically in the production of synthetic polymers like polyethylene terephthalate (PET), polyethylene (PE), polyvinyl chloride (PVC) polypropylene (PP) and polystyrene (PS). These plastic materials play important roles in different day-to-day activities of people and industries. The current popularity and prevalence of plastic usage is due to their wide range of suitable properties (low density, resistance to corrosion, durability, etc.) and low cost of production. These have them successfully able to

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replace previously dominant materials like wood, ceramics and metal in some applications (Wong *et al.*, 2015). Industrial and household applications of plastic or reinforced plastic materials are seen in packaging, kitchen and toilet wares, clothing, appliances, aerospace parts, electrical and vehicle equipment. Plastics are also noticed to be of good application in hospitals. Regular plastic utilization in medical facilities include catheters, syringes, cannulas, plastic aprons, blood given sets, intravenous infusion sets, etc. When customers come to the markets to get stuffs, the traders usually package purchased goods with plastic bags. Some of these packaging materials end up as part of the waste stream generated. Also, the traders themselves consume food, water and soft drinks that are packaged with plastic containers, bottles and sachets. Most of these waste products and packaging are made from LDPE, HDPE and PET which are thermoplastics that can be re-molded into other materials that can be reused in other forms. Municipal plastic wastes consist primarily of LDPE, HDPE, PET, PP, PS and PVC and about 50-70% of the total plastic wastes is packaging materials derived from these types of plastics (Kunwar *et al*., 2016). On average polyethylene makes up the greatest fraction (69%) of plastic wastes, especially plastic bags (Zhou *et al*., 2014). Plastics are obtained by the synthesis of chemicals derived from natural gas/ crude oil (ACC, 2005; Al-Salem, 2010). The production process for plastics starts with the distillation of crude oil in a refinery. This allows the heavy crude oil to break down into lighter components referred to as fractions. One of these fractions, naphtha, is an important feedstock of choice for plastic production (PlasticsEurope, 2018) by many; however, most plastics are produced in the US from natural gas. Naphtha is processed in furnaces with high temperatures to obtain ethane and propane which are subsequently cracked into ethylene and propylene respectively to produce plastic polymers (polyethylene and polypropylene). Many of the other plastics available for use today are made from these polymers (Plasticisrubbish, 2013).In order to enhance the durability and strength of plastics or to introduce some specific characteristics, certain additives are added during the manufacturing process. These additives are responsible for many of the issues related to plastic utilization (Elias, 2000; Meeker *et al.*, 2009; Thompson *et al.*, 2009). Plastics may be convenient and durable for everyday use by individuals, markets, hospitals, etc., however, it is impossible to continue to overlook their negative environmental and health impacts. Plastics are non-biodegradable and as such continue to pile up in the environment and creating enormous amount of trash across the world. In developing countries with inadequate and less advanced waste management system and facilities, dealing with increasing plastic wastes generation resulting from increased utilization and production of plastic materials is a problem that is a cause for serious concern (Koushal *et al.,* 2014). The problem with plastic is not the material in itself, but the misuse by consumers and ineffective or lack of recycling policies. For example, in Nigeria, potable water and other food products are packaged in sachets and bottles made from thermoplastic materials. The increased demands for these products have given rise to enormous plastic waste generation. As a result of improper disposal, these wastes often end up on the streets and clog mini-waterways, creating a perfect breeding habitat for mosquitoes that are responsible for spreading malaria parasites, which is a major cause of illness and death on the African Continent (Olusunmade *et al.,* 2018a). Eventually, these plastic wastes make their way to larger bodies of water such as oceans and seas, posing serious long-term threats to aquatic life due to their non-biodegradable nature. It is estimated that annually, over 8 million tons of plastics end up in the oceans and that up to 80% of all ocean litters are made of plastics. This phenomenon threatens the survival of aquatic lives and negatively impact tourism, resulting in a damage of not less than $8 billion to the marine ecosystem (UNEP, 2018). In addition, inadequate management of plastic wastes brings about sustainability problem as a result of loss of scarce and valuable resources derived from petroleum (Brems *et al.,* 2013; Lopez *et al.,* 2018). On the other hand, the emissions from open burning of these wastes results in air pollution and also contribute to greenhouse effect, which is responsible for the depletion of the ozone layer and consequently global warming that the earth is currently experiencing. Therefore, the challenge of

plastic wastes management is of urgent concern in both developed and developing countries of the world, because of its huge volume and severe environmental impact (Berkum *et al.,* 2005; Jambeck *et al.,* 2015) especially in marine environments (Moore, 2008; Gwada *et al.,* 2019). Consequent to this fact, the theme of environmental day for 2018 was "*Beat Plastic Pollution.*" This was with a view to encourage governments, industries, corporate bodies and individuals on the need to take proactive steps in curtailing the deleterious environmental consequences of irresponsible handling and disposal of plastic wastes. Many developed cities, as a way of addressing the problem associated plastic wastes, have resulted to separating the different elements found in waste stream to enable the diversion and recovery of valuable resources, thereby reducing the amount of materials taken to landfill. The recovered materials can then be recycled for other usage. Effective pre-treatment and sorting operations for plastic waste divert this valuable resource from landfill to deliver material with the required market driven qualities for recycling and energy recovery (Capel, 2008; PlasticsEurope, 2013). According to Capel (2008), European citizen have now seen the importance of sorting wastes most especially at household level. The idea is to separate as much useful items as possible and deal with them in the most appropriate manner. It is important for the city waste management body to develop a system and programs that will create opportunities to recover plastic materials for recycling and energy generation. These prevent plastic wastes from ending up as litters in streams, as well as saving valuable resources, conserving energy and reducing greenhouse gas emission (MLS, 2018). This is the method obtainable in developed cities. For instance, the recycling programs in New York City collect paper, metal, glass and glass. Targets are set by the city council for recycling and public enlightenments of recycling practices and this is achieved through the establishment of outreach and education office (DSCNY, 2006). Several strategies are been pursued by the City of New York to improve waste management practices by encouraging residents and businesses to divert organic materials from landfills, increasing capture rates for recycling and addressing obstacles associated with waste to energy(CNY, 2014). The Environmental Protection Department in Hong Kong launched a Program on the separation of domestic wastes at the source. Residential Property Management Companies (RPMCs) are encouraged to make available facilities for waste separation on building floors, making it convenient for residents to easily support the program (EPD, 2012). Public participation in recycling and waste recovery is also encouraged by the government through the establishment of community recycling network responsible for providing collection points for recyclables. Since 1996, efforts had been made by the city of Beijing to practice source separation of wastes. A goal to achieve 50% separation rate by 2008 established was achieved, according to the City's Municipal Administration Commission (BMAC), in 2007 with the participation of 4.7 million people. By 2006, 1.638 million tons of material was recycled by the city, resulting in a saving of $1.43 million. An informal system of "waste pickers" is the bed rock of Beijing's recycling sector. This system has about 300,000 individuals who pick up materials from landfills; go from door to door to collect plastic bottles and other recyclables and thereafter recycle these items. About 30% of the total wastes in the city is removed and recycled by this system and it provides living income for many (Cohen *et al.*, 2015). Consequent to the negative implication of plastic wastes on the environment (Gregory, 2009; Olusunmade *et al.,* 2018b), it is important to understand how individual communities handle the wastes of plastic materials. This study therefore examined the plastic wastes separation practice and disposal mechanism by households, market centers, hospital facilities and waste management body; awareness of the negative impact of plastic wastes on the environment and the effect that the level of education of the respondents had on their attitude and choices, in Makurdi City. Currently, there is no study on this subject as far as the waste management system of the city is concerned. Makurdi is the largest city in Benue State, with a population of approximately 405,000 people. The demographic information of the study area, based on the information obtained from individuals in various households in Makurdi is presented in Table 1. It can be seen that 56.2% of the respondents were males while 43.8% are

females, majority of the sample population (37.6%) are in the age range of 16-29 years and 47.2% had or undergoing tertiary education. Also, most (40.6%) of the respondents live in a face-to-face apartment (tenement buildings where occupants have one or two rooms but have to share toilet and kitchen facilities.) and that students constitute a larger proportion (26.5%) of the respondents. This study has been carried out in Makurdi City, Benue State, Nigeria in 2019.

MATERIALS AND METHODS

Study Area Description

Makurdi is the capital of Benue State in Nigeria, located in the middle belt along the Benue River. It is situated at elevation of 104m above sea level and located at 7.73 latitude and 8.52 longitudes. The city is a local trade center for yams, sorghum, millet, rice, cassava, shea nuts, sesame oil, peanuts and soybeans.

Table 1: Demographic information of the study area

		Gender		Total	Education		
Profile	Category	Male(n=263)	Female(n=205)	(n=468)	Primary (n=73)	Secondary (n=174)	Tertiary (n=221)
Age (Years)	<16	24(9.1%)	12(5.9%)	36(7.7%)	12(16.4%)	16(9.2%)	8(3.6%)
	16-29	98(37.3%)	78(38.0%)	**176(37.6%)**	12(16.4%)	76(43.7%)	88(39.8%)
	30-39	80(30.4%)	64(31.2%)	144(30.8%)	19(26.0%)	51(29.3%)	74(33.5%)
	40+	61(23.2%)	51(24.9%)	112(23.9%)	30(41.1%)	31(17.8%)	51(23.1%)
		56.2%	43.8%				
Education	Primary	34(12.9%)	39(19.0%)	73(15.6%)			
	Secondary	96(36.5%)	78(38.0%)	174(37.2%)			
	Tertiary	133(50.6%)	88(42.9%)	221(47.2%)			
Occupation	Student	76(28.9%)	48(23.4%)	124(26.5%)	12(16.4%)	46(26.4%)	66(29.9%)
	Govt. Employed	49(18.6%)	39(19.0%)	88(18.8%)	10(13.7%)	22(12.6%)	56(25.3%)
	Private Business	74(28.1%)	48(23.4%)	122(26.1%)	21(28.8%)	46(26.4%)	55(24.9%)
	Trading	49(18.6%)	65(31.7%)	114(24.4%)	29(39.7%)	48(27.6%)	37(16.7%)
	Others	15(5.7%)	5(2.4%)	20(4.3%)	1(1.4%)	12(6.9%)	7(3.2%)
Accommodation	Face-to-Face	106(40.3%)	84(41.0%)	190(40.6%)	44(60.3%)	85(48.9%)	61(27.6%)
	Self-Contained	84(31.9%)	68(33.2%)	152(32.5%)	16(21.9%)	52(29.9%)	84(38.0%)
	2/3 Bedroom	73(27.8%)	53(25.9%)	126(26.9%)	13(17.8%)	37(21.3%)	76(34.4%)

Note: Self-contained apartment is a single room with its own toilet/bathroom and kitchen. 2/3 bedroom apartment has two or three bedrooms and a sitting room with toilets/bathrooms, kitchen and probably storage space.

Table 2: Study city sub-locations and other areas covered

SN	**Sub-Location**	**Other Areas covered**
1.	Wadata	Lobi
2.	North-Bank	North-Bank II and Federal Low Cost
3.	High-Level	Idye
4.	Modern Market	Ankpa Quarters
5.	Wurukum	Logo, Akpehe,Gyado Villa, Gadi, Benue State University
6.	Kanshio	Apir, Welfare Quarters

Table 3: Questionnaires distribution

SN	**Sub-Location**	**Number of Questionnaires Administered**
1.	Wadata	78
2.	North-Bank	87
3.	High-Level	94
4.	Modern Market	68
5.	Wurukum	88
6.	Kanshio	53

Research design and sampling

Social survey was used as the research design targeted at residents of Makurdi City. The total population of the city is 405,000. The city was divided into 6 major sub-locations (most popular) from which data were obtained namely High-Level, Modern Market, Wurukum, Kanshio, Wadata and North-Bank. Each of the sub-locations consists of smaller areas shown in Fig. 1 and these are indicated in Table 2. Questionnaires were administered to individuals in different households in these areas. Random sampling method was used to distribute the questionnaires to the 6 sub-locations. The sample size for the study was determined using Cochran's Eq. 1 (Gwada *et al.*, 2019).

$$n = \frac{Z^2 p(1-p)}{e^2} \quad (1)$$

Where,

n= sample size required

p= proportion of population

e= margin of error

Z= standard normal deviation

At 95% confidence level and 5% margin of error, Z=1.96 and p=0.5, the value for n is 385. Considering the population of Makurdi, a sample size of 385 is required to represent the entire population. However, 468 questionnaires were shared among the 6 sub-locations in proportions shown in Table 3.

Interviews were conducted with some staff member of 10 hospitals, traders in 6 market centers and waste management personnel of the city. The purpose of the questionnaires administered and interviews conducted were to determine how plastic wastes generated were being handled and disposed

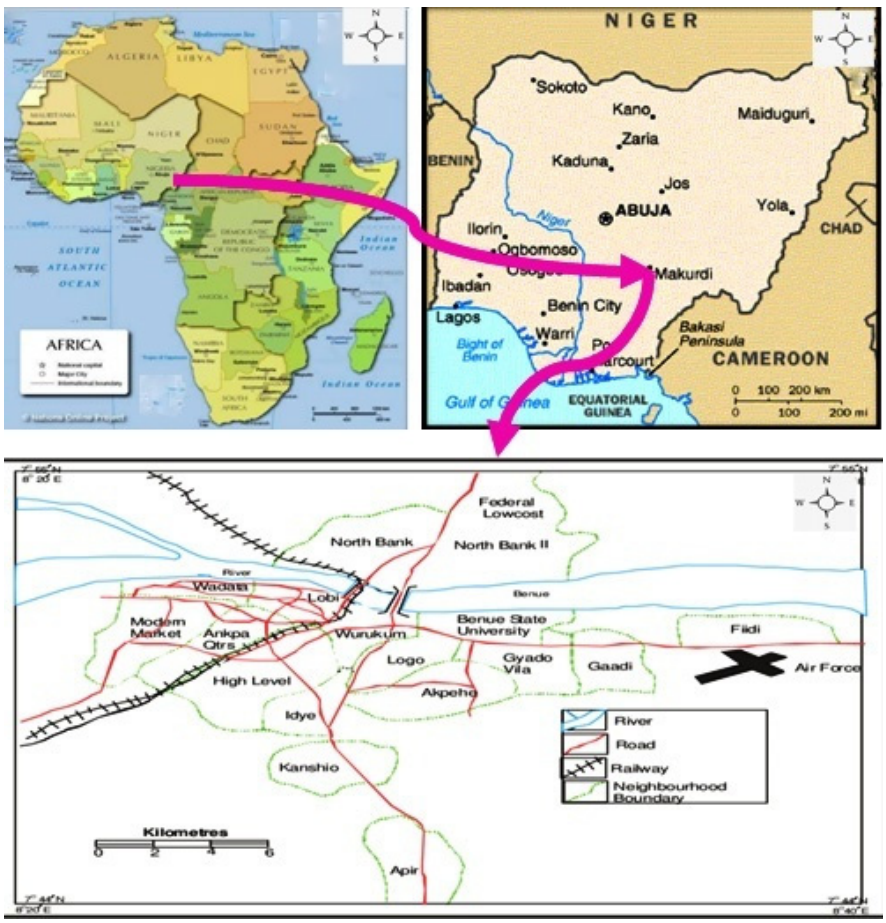

Fig. 1: The geographic location of the study area in Makurdi City, Benue State, Nigeria

by households, hospitals, market centers and by the city through the waste management agency BENSESA (Benue State Environmental Sanitation Agency).

Data Analysis

Descriptive and inferential statistics was used to analyze the data using simple percentage and frequencies. Meanwhile, Pearson Chi Square statistic was used to establish if a significant relationship exist between the variables. The test was done at 5% (0.05) probability value. A value greater than 5% means no significant relationship existed between the variables and therefore an acceptance of the null hypothesis. While a value less than 5%

Table 4: Plastic wastes separation practice

		Separate Plastic		**Why not separate**		**If told to separate**		**Importance of separating**	
Profile	Category	Yes	No	Not Necessary	No Idea	Will	Will Not	Know	Not Know
Gender	Male(n=263)	53 (20.2%)	210 (79.8%)	122 (57.5%)	90 (42.5%)	198 (75.3%)	65 (24.7%)	107 (40.7%)	156 (59.3%)
	Female(n=205)	35 (17.1%)	170 (82.9%)	80(46.8%)	91 (53.2%)	146 (71.2%)	59 (28.8%)	60 (29.3%)	145 (70.7%)
Age(Years)	<16 (n=36)	12 (33.3%)	24 (66.7%)	11 (45.8%)	13 (54.2%)	29 (80.6%)	7 (19.4%)	13 (36.1%)	23 (63.9%)
	16-29 (n=176)	35 (19.9%)	141 (80.1%)	75 (52.4%)	68 (47.6%)	135 (76.7%)	41 (23.3%)	64 (36.4%)	112 (63.6%)
	30-39 (n=144)	27 (18.8%)	117 (81.2%)	70 (59.3%)	48 (40.7%)	107 (74.3%)	37 (25.7%)	58 (40.3%)	86 (59.7%)
	40+ (n=112)	14 (12.5%)	98 (87.5%)	46 (46.9%)	52 (53.1%)	73 (65.2%)	39 (34.8%)	32 (28.6%)	80 (71.4%)
Education	Primary (n=73)	8 (11%)	65 (89.0%)	35 (53.8%)	30 (46.2%)	54 (74.0%)	19 (26.0%)	11 (15.1%)	62 (84.9%)
	Secondary (n=174)	31 (17.7%)	143 (82.2%)	71 (49.3%)	73 (50.7%)	119 (68.4%)	55 (31.6%)	50 (28.7%)	124 (71.3%)
	Tertiary (n=221)	49 (22.2%)	172 (77.8%)	96 (55.2%)	78 (44.8%)	171 (77.4%)	50 (22.6%)	106 (48.0%)	115 (52.0%)
Location	High-Level (n=94)	20 (21.3%)	74 (78.7%)	47 (63.5%)	27 (36.5%)	84 (89.4%)	10 (10.6%)	42 (44.7%)	52 (55.3%)
	North-Bank (n=87)	11 (12.6%)	76 (87.4%)	45 (59.2%)	31 (40.8%)	65 (74.7%)	22 (25.3%)	23 (26.4%)	64 (73.6%)
	Modern Market (n=68)	19 (27.9%)	49 (72.1%)	22 (44.9%)	27 (55.1%)	45 (66.2%)	23 (33.8%)	28 (41.2%)	40 (58.8%)
	Kanshio (n=53)	10 (18.9%)	43 (81.1%)	34 (79.1%)	9 (20.9%)	41 (77.4%)	12 (22.6%)	20 (37.7%)	33 (62.3%)
	Wadata (n=78)	12 (15.4%)	66 (84.6%)	6 (8.8%)	62 (91.2%)	37 (47.4%)	41 (52.6%)	23 (29.5%)	55 (70.5%)
	Wurukum (n=88)	16 (18.2%)	72 (81.8%)	48 (65.8%)	25 (34.2%)	72 (81.8%)	16 (18.2%)	31 (35.2%)	57 (64.8%)
Living Condition									
Occupation	Student (n=124)	29 (23.4%)	95 (76.6%)	47 (49.0%)	49 (51.0%)	100 (80.6%)	24 (19.4%)	47 (37.9%)	77 (62.1%)
	Govt. Employed (n=88)	14 (15.9%)	74 (84.1%)	46 (62.2%)	28 (37.8%)	70 (79.5%)	18 (20.5%)	42 (47.7%)	46 (52.3%)
	Private Business (n=122)	28 (23.0%)	94 (77.0%)	53 (55.2%)	43 (44.8%)	89 (73.0%)	33 (27.0%)	46 (37.7%)	76 (62.3%)
	Trading (n=114)	13 (11.4%)	101 (88.6%)	44 (43.6%)	57 (56.4%)	68 (59.6%)	46 (40.6%)	27 (23.7%)	87 (76.3%)
	Others (n=20)	4 (20.0%)	16 (80.0%)	12 (75.0%)	4 (25.0%)	17 (85.0%)	3 (15.0%)	5 (25.5%)	15 (75.0%)
Accomodation	Face-to-Face (n=190)	24 (12.6%)	166 (87.4%)	85 (50.6%)	83 (49.4%)	129 (67.9%)	61 (32.1%)	42 (22.1%)	148 (77.9%)
	Self-Contained (n=152)	29 (19.1%)	123 (80.9%)	63 (50.8%)	61 (49.2%)	123 (80.9%)	29 (19.1%)	66 (43.4%)	86 (56.6%)
	2/3 Bedroom Flat (n=126)	35 (27.8%)	91 (72.2%)	54 (59.3%)	37 (40.7%)	92 (73.0%)	34 (27.0%)	59 (46.8%)	67 (53.2%)

indicate a significant relationship between them, and therefore an acceptance of the alternative hypothesis that a relationship exists between the tested observations.

RESULTS AND DISCUSSION

Plastic wastes separation

Separation means isolating plastic wastes from other waste for the purpose of recycling or for disposing these wastes using a different method, due to its non-biodegradable nature. In this study, 18.8% of the respondents claim to sort the plastic wastes from other wastes at home while the vast majority (81.2 %) do not sort. As to why they do not sort plastic wastes, 52.7% feels it is not necessary while the others (47.3%) do not have any idea as to why?. 64.3% do not know the importance of separating plastic from other wastes, however, majority of the respondents (73.5%) are willing to do so if told to do so. Table 4 showed the effect of gender, age, education, location and living condition (based on the type of occupation and accommodation of the respondents)on separation practice for plastic wastes.

Table 4 showed that 20.2% of male and 17.1% of female respondent respectively carryout separation of plastic wastes from other wastes. Although the percentage of males that separate plastic wastes from other wastes was more than that of the females, the associated probability (P) value based on Pearson Chi Square statistic is 0.398 which is greater than 0.05, hence, there is no relationship between gender and plastic wastes separation practice. Gender constitutes a significant factor on the awareness or knowledge of the importance of separating plastics from other household wastes, with a P value of 0.011. This meant that more males (40.7%) than females (29.3%) are aware of this importance on plastic wastes separation. This difference could be attributed to the fact more males (50.6%) have higher form of education (tertiary) than females (42.9%) as can be observed from Table 1. 33.3%, 19.9%, 18.8% and 12.5% of the respondents within the age range of less 16, 16-29, 30-39 and above 40 years respectively carryout separation of plastic from other wastes. Since the associated P value is 0.045, there is significant relationship between age and plastic wastes separation practice. However, more of this separation practice is done by respondents who are below 16 years of age. With regards to the knowledge of the respondents on the importance of separating plastic wastes, age plays no significance (P=0.280). Education played no significant role in the plastic wastes separation practice of the respondents (P=0.096), although 11%, 17.8% and 22.2% of the respondents with primary, secondary and tertiary education respectively carryout separation. However, the effect of education is significant on the knowledge of the respondents on the importance of separating plastic wastes (P=0.000), with 48.0% of respondents with tertiary education been aware of the importance of separating plastic wastes from other household wastes. Location played no significant role in the plastic wastes separation practice of the respondents (P=0.230). The same is also true on the knowledge of the respondents on the importance of separating plastic wastes (P=0.115). The occupation of the respondents did not have a significant effect on the separation of plastic wastes from other household wastes (P=0.104). Regarding the knowledge of the respondents on the importance of separating plastic wastes, however, occupation type is a significant factor (P=0.007), with 47.7% of those that are employed by the government been aware of this importance. Accommodation type of the respondents is of significance when it comes to plastic wastes separation practice from other wastes (P=0.003). 27.8% of the respondents that live in 2/3 bedroom flats, 19.1% of those that live in self-contained apartment and 12.6% of the respondents that live in face-to-face apartments carryout separation practice. The significance of accommodation is also noticed in the knowledge of the respondents on the importance of separating plastic wastes (P=0.000) with 46.8% of those living in 2/3 bedroom flats been aware of this importance. The plastic wastes generated from the 6 markets centers and the 10 hospitals considered for this survey were also un-sorted from other wastes. The entire waste streams from these facilities are collected in mixed-state by the waste management personnel. The system of waste collection used by the waste management body and the private waste collectors is partly responsible for why sorting of plastic wastes is not properly carried

out. There are no separate containers for plastic or other recyclable wastes. As a result, even the few sorted out plastic wastes get mixed with the other waste stream eventually. It was also discovered that the waste management body does not carry out sorting for plastic wastes at the permanent waste disposal sites. The entire waste stream is land-filled together. It is obvious that the current system of wastes collection in Makurdi City does not encourage separation of plastic wastes from households, market places and hospitals because separate containers are not provided for collecting these wastes. It becomes important to educate the stakeholders on the need for separating plastic wastes from other wastes, as majority of the respondents do not understand the importance of doing so, by highlighting the good that can still be derived from these wastes. The problem resulting from this type of wastes in landfill should also be communicated. The establishment of recycling facilities in the city should be given a priority. The understanding of the challenges and opportunities that plastic wastes presents will encourage more stakeholders to key into the program of separating plastic wastes from other wastes. Community plastic collection centers should be established where individuals and organizations can deposit plastic wastes and get paid per unit kg. Reward can also be extended (e.g. reduced waste collection fee) to stakeholders who separate plastic wastes at the point of generation. These can serve as motivations leading to better separation practice. The willingness shown by majority of the respondents to carryout separation practice showed that good planning and arrangement by the waste management agency and proper incentives will lead to high diversion rate of plastic wastes from our landfills.

Disposal mechanism

As shown in Fig. 2, majority (50.4%) of the individual respondents disposed their plastic wastes by dumping/burning. 72.2% of the respondents affirmed that waste collectors (private or government owned) do not come to their area of residence. As a result, 68.6% of the respondents dump their wastes in unapproved dumpsites while only 31.4% dump in approved sites. The individuals carry their wastes to unapproved dumpsites and dump them openly on the ground, creating a messy sight. 19.2% of the respondents admitted to burning their plastic wastes as a means of disposal. Burning also happened at some dumpsites. Table 5 showed the effect of gender, age, education, location and living condition of the respondents on their disposal methods and dumping locations for plastic wastes.

The preferred method of disposal for plastic wastes by the male (48.7%) and female (52.7%) respondents is dumping/burning. However, gender really did not have any significance on the choice of disposal methods by the respondents (P=0.240). On the other hand, the significance of gender was seen (P=0.040) in the choice of location where

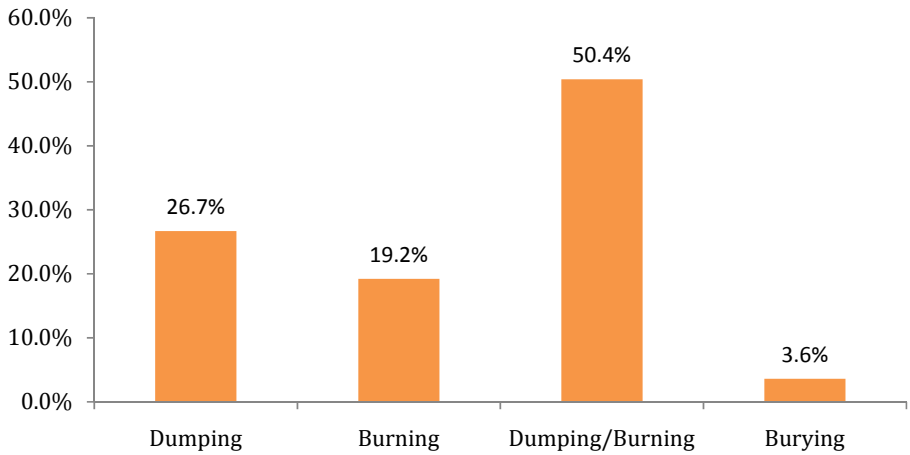

Fig. 2: Methods of plastic wastes disposal

Table 5: Disposal methods and dumping locations for plastic and other wastes in Makurdi

		Disposal Method					Dumping Location		
Profile	Category	Dumping	Burning	Dumping/Burning	Burying		Approved Dumpsites	Unapproved Dumpsites	
Gender	Male(n=263)	66 (25.1%)	59 (22.4%)	128 (48.7%)	10 (3.8%)	263 (100%)	85 (35.6%)	154 (64.4%)	239 (100%)
	Female(n=205)	59 (28.8%)	31 (15.1%)	108 (52.7%)	7 (3.4%)	205 (100%)	52 (26.4%)	145 (73.6%)	197 (100%)
Age(Years)	<16 (n=36)	8 (22.2%)	8 (22.2%)	19 (52.8%)	1 (2.8%)	36 (100%)	11 (31.4%)	24 (68.6%)	35 (100%)
	16-29 (n=176)	41 (23.3%)	30 (17.0%)	103 (58.5%)	2 (1.1%)	176 (100%)	53 (31.4%)	116 (68.6%)	169 (100%)
	30-39 (n=144)	40 (27.8%)	26 (18.1%)	71 (49.3%)	7 (4.9%)	144 (100%)	39 (29.5%)	93 (70.5%)	132 (100%)
	40+ (n=112)	36 (32.1%)	26 (23.2%)	43 (38.4%)	7 (6.3%)	112 (100%)	34 (34.0%)	66 (66.0%)	100 (100%)
Education	Primary (n=73)	29 (39.7%)	15 (20.5%)	26 (35.6%)	3 (4.1%)	73 (100%)	16 (24.2%)	50 (75.8%)	66 (100%)
	Secondary (n=174)	36 (20.7%)	38 (21.8%)	92 (52.9%)	8 (4.6%)	174 (100%)	51 (30.7%)	115 (69.3%)	166 (100%)
	Tertiary (n=221)	60 (27.1%)	37 (16.7%)	118 (53.4%)	6 (2.7%)	221 (100%)	70 (34.3%)	134 (65.7%)	204 (100%)
Location	High-Level (n=94)	30 (31.9%)	14 (14.9%)	48 (51.1%)	2 (2.1%)	94 (100%)	40 (48.8%)	42 (51.2%)	82 (100%)
	North-Bank (n=87)	22 (25.3%)	27 (31.0%)	32 (36.8%)	6 (6.9%)	87 (100%)	29 (35.8%)	52 (64.2%)	81 (100%)
	Modern Market (n=68)	13 (19.1%)	12 (17.6%)	42 (61.8%)	1 (1.5%)	68 (100%)	32 (47.1%)	36 (52.9%)	68 (100%)
	Kanshio (n=53)	19 (35.8%)	9 (17.0%)	25 (47.2%)	0 (0.0%)	53 (100%)	8 (15.1%)	45 (84.9%)	53 (100%)
	Wadata (n=78)	13 (16.7%)	19 (24.4%)	38 (48.7%)	8 (10.3%)	78 (100%)	11 (15.1%)	62 (84.9%)	73 (100%)
	Wurukum (n=88)	28 (31.8%)	9 (10.2%)	51 (58.0%)	0 (0.0%)	88 (100%)	17 (21.5%)	62 (78.5%)	79 (100%)
Living Condition									
Occupation	Student (n=124)	29 (23.4%)	22 (17.7%)	70 (56.5%)	3 (2.4%)	124 (100%)	40 (34.2%)	77 (65.8%)	117 (100%)
	Govt. Employed (n=88)	22 (25.0%)	15 (17.0%)	49 (55.7%)	2 (2.3%)	88 (100%)	32 (41.6%)	45 (58.4%)	77 (100%)
	Private Business (n=122)	32 (26.2%)	20 (16.4%)	65 (53.3%)	5 (4.1%)	122 (100%)	37 (32.5%)	77 (67.5%)	114 (100%)
	Trading (n=114)	34 (29.3%)	28 (24.6%)	45 (39.5%)	7 (6.1%)	114 (100%)	21 (19.4%)	87 (80.6%)	108 (100%)
	Others (n=20)	8 (40%)	5 (25.0%)	7 (35.0%)	0 (0.0%)	20 (100%)	7 (35.0%)	13 (65.0%)	20 (100%)
Accomodation	Face-to-Face (n=190)	52 (27.4%)	50 (26.3%)	81 (42.6%)	7 (3.7%)	190 (100%)	42 (23.7%)	135 (76.3%)	177 (100%)
	Self-Contained (n=152)	39 (25.7%)	22 (14.5%)	86 (56.6%)	5 (3.3%)	152 (100%)	41 (28.5%)	103 (71.5%)	144 (100%)
	2/3 Bedroom Flat (n=126)	34 (27.0%)	18 (14.3%)	69 (54.8%)	5 (4.0%)	126 (100%)	54 (47.0%)	61 (53.0%)	115 (100%)

respondents dump their plastic wastes. 35.6% of males dump their wastes in approved dumpsites while 64.4% dispose of their wastes at unapproved sites. The values are 26.4% and 73.6% respectively for female respondents. The fact that more males than females dump wastes in approved sites may be attributed to more males having tertiary education and been more aware of the negative environmental impact of these wastes than their female counterparts. Across the age range of the respondents, dumping/burning is the most used method of wastes disposal, although age plays no significance in this choice (P=0.082).Age also plays no significance (P=0.913) in the choice of the location where wastes are dumped. However, 34.0% of the respondents that are 40 years and

Table 6: Presence of waste collectors in the 6 sub-locations of Makurdi

Location	Do waste collectors come to your area		Is your area badly affected by plastic wastes lying around		Total
	Yes	No	Yes	No	
High-Level (n=94)	38 (40.4%)	56 (59.6%)	62 (66.0%)	32 (34.0%)	94 (100%)
North-Bank (n=87)	16 (18.4%)	71 (81.6%)	54 (62.1%)	33 (37.9%)	87 (100%)
Modern Market (n=68)	36 (52.9%)	32 (47.1%)	25 (36.8%)	43 (63.2%)	68 (100%)
Kanshio (n=53)	9 (17.0%)	44 (83.0%)	40 (75.5%)	13 (24.5%)	53 (100%)
Wadata (n=78)	10 (12.8%)	68 (87.2%)	63 (80.8%)	15 (19.2%)	78 (100%)
Wurukum (n=88)	21 (23.9%)	67 (76.1%)	53 (60.2%)	35 (39.8%)	88 (100%)

above dump wastes in approved sites. Education is significant in the choice of the respondents as to the method adopted for wastes disposal (P=0.040). Irrespective of educational level of the respondents, the preferred option is dumping/burning with more of the respondents with tertiary education (53.4%) going for that method of disposal. Education, however, do not play a significant role in the choice of dumpsites used by the respondents (P=0.300) to dispose their wastes although more of the respondents with tertiary education (34.3%) use the approved dumpsites. This may be attributed to difficulty in accessing the approved sites due to inadequate waste collection system in the city (shown by 72.2% of the respondents not having waste collectors operating in their location of residence), thereby compelling residence to dump wastes at unapproved sites. Location of residence of the respondents is of significance in their method of wastes disposal (P=0.000), with many choosing dumping/burning. In Modern Market area, 61.8% of the respondents adopted this method of disposal. The significance of location is also true for where the respondents dispose of their wastes (P=0.000). In High-Level, 48.8% of the respondents dump their wastes in approved while 51.2% used unapproved sites. In Kanshio and Wadata the percentage of respondents that used approved sites for dumping is 15.1% and the value for those that used unapproved sites is 84.9%. No wonder these areas are badly affected by plastic wastes lying around on the streets as affirmed by 80.8% of respondents in Wadata and 75.5% of respondents in Kanshio.

The fact that more respondents in High-Level (40.4%) and Modern Market (52.9%) attested to the operation (or presence) of wastes collectors in their areas justify why the number of those that dispose wastes in approved dumpsites is higher in these areas in comparison with other areas. Table 6 showed the presence or absence of the activities of waste collectors as well as plastic wastes lying around in the 6 sub-locations of Makurdi.

Occupation type did not have a significant effect on the disposal method adopted by the respondents (P=0.288) whereas it is significant when it comes to the choice of the respondents on where to dump their wastes (P=0.022). 41.6% of respondents that are employed by the government, most of who had tertiary education, dispose their wastes in approved dumpsites. For respondents that are traders, many of whom do not have tertiary education, only 19.4% dump their wastes in approved dumpsites. The type of accommodation did not have a significant effect on the disposal method adopted by the respondents (P=0.053) whereas it is significant when it comes to the choice of the respondents on where to dump their wastes (P=0.000). 47.0% of respondents that live in 2/3 bedroom apartments dispose their wastes in approved dumpsites whereas only 23.7% of respondents that live in face-to-face apartments did so. The plastic wastes from the 10 hospitals and 5 of the markets are collected by the waste management personnel and thereafter taking to their disposal sites. In the 6th markets surveyed, some of the traders disclosed that the wastes are thrown in the river Benue which flows behind the market. As a result of ineffective waste collection system and indiscipline on the part of the people, most undeveloped landed properties have become refuse dumps creating obscene sights. The problem of indiscriminate dumping of wastes could be attributed to the fact the designated waste

Table 7: Awareness of negative environmental impact and danger of improper disposal of plastic wastes

		Heard of negative of plastic wastes on the environment		Awareness of danger of improper handling of plastic wastes		Total
Profile	Category	Yes	No	Yes	No	
Gender	Male(n=263)	144 (54.8%)	119 (45.2%)	130 (49.4%)	133 (50.6%)	263 (100%)
	Female(n=205)	82 (40.0%)	123 (60.0%)	65 (31.7%)	140 (68.3%)	205 (100%)
Age(Years)	<16 (n=36)	13 (36.1%)	23 (63.9%)	14 (38.9%)	22 (61.1%)	36 (100%)
	16-29 (n=176)	83 (47.2%)	93 (52.8%)	69 (39.2%)	107 (60.8%)	176 (100%)
	30-39 (n=144)	81 (56.2%)	63 (43.8%)	66 (45.8%)	78 (54.2%)	144 (100%)
	40+ (n=112)	49 (43.8%)	63 (56.2%)	46 (41.1%)	66 (58.9%)	112 (100%)
Education	Primary (n=73)	22 (30.1%)	51 (69.9%)	20 (27.4%)	53 (72.6%)	73 (100%)
	Secondary (n=174)	66 (37.9%)	108 (62.1%)	65 (37.4%)	109 (62.6%)	174 (100%)
	Tertiary (n=221)	138 (62.4%)	83 (37.6%)	110 (49.8%)	111 (50.2%)	221 (100%)
Location	High-Level (n=94)	59 (62.8%)	35 (37.2%)	40 (42.6%)	54 (57.4%)	94 (100%)
	North-Bank (n=87)	45 (51.7%)	42 (48.3%)	34 (39.1%)	53 (60.9%)	87 (100%)
	Modern Market (n=68)	37 (54.4%)	31 (45.6%)	29 (42.6%)	39 (57.4%)	68 (100%)
	Kanshio (n=53)	29 (54.7%)	24 (45.3%)	27 (50.9%)	26 (49.1%)	53 (100%)
	Wadata (n=78)	22 (28.2%)	56 (71.8%)	24 (30.8%)	54 (69.2%)	78 (100%)
	Wurukum (n=88)	34 (38.6%)	54 (61.4%)	41 (46.6%)	47 (53.4%)	88 (100%)
Living Condition						
Occupation	Student (n=124)	61 (49.2%)	63 (50.8%)	54 (43.5%)	70 (56.5%)	124 (100%)
	Govt. Employed (n=88)	56 (63.6%)	32 (36.4%)	50 (56.8%)	38 (43.2%)	88 (100%)
	Private Business (n=122)	62 (50.8%)	60 (49.2%)	54 (44.3%)	68 (55.7%)	122 (100%)
	Trading (n=114)	37 (32.5%)	77 (67.5%)	30 (26.3%)	84 (73.7%)	114 (100%)
	Others (n=20)	10 (50.0%)	10 (50.0%)	7 (35.0%)	13 (65.0%)	20 (100%)
Accommodation	Face-to-Face (n=190)	69 (36.3%)	121 (63.7%)	62 (32.6%)	128 (67.4%)	190 (100%)
	Self-Contained (n=152)	74 (48.7%)	78 (51.3%)	60 (39.5%)	92 (60.5%)	152 (100%)
	2/3 Bedroom Flat (n=126)	83 (65.9%)	43 (34.1%)	73 (57.9%)	53 (42.1%)	126 (100%)

collection and evacuation centers are far from many households in the city and waste trucks of the waste management agency and private wastes collectors do not embark on house-to-house waste collections in most parts of the city. Talking about indiscipline, in some areas where private waste collectors operate, some individuals do not even patronize them because they do not want to pay waste collection fees. They prefer to dump their wastes at unapproved locations because it costs them no fee. This constitutes a lack of regard for the environment and the well-being of the people. Also discovered was the fact that waste management has only two final dumpsites, where the collected wastes are taken. As a result of the small capacity of these sites, they get easily filled. A visit to one of the approved dumpsites used by the government agency in charge of sanitation (BENSESA) and private service providers revealed the inadequacies of the system of plastic wastes disposal. The area is not even a standard landfill site and is not well taken care of.

The area is overgrown with bushes. As a result, on many occasions, the wastes get disposed of near the Benue River, by some of the few available private service providers and even waste management personnel. This means directly introducing plastic wastes into an environment where they threaten the survival of aquatic life and pose danger to humans that consume them. The city waste management board does not have a system for recycling plastic wastes for the purpose of material and energy recovery which is now the standard practice in developed societies. The method of disposal for

plastic wastes as well as other waste by the waste management body of the city is landfill while some individuals and market places also result to open burning. Since there are toxins released from the plastic wastes during incineration, neither people nor the environment is safe. Some of these toxins cause cardiovascular problems or diabetes others are endocrine disruptors and can alter genitalia development in newborns and reproductive abnormalities (Thompson *et al.,* 2009; Gorman, 2017). Adoption of disposal methods which are more environmentally friendly and that result in energy recovery will significantly reduce the amount of plastic wastes that end up in landfill. As had been applied in some cities like Beijing, gasification technology can be applied as a way of disposing plastic wastes (particularly unrecyclable ones) leading to energy gain in terms of electricity generation which will benefit the city. Gasification of plastic wastes though a thermal degradation process prevents dioxin formation and reduces acidic gas emission due to its higher temperature and reduction conditions (Malkow, 2004).Capturing more household, hospitals and market areas in plastic wastes collection services will drastically reduce indiscriminate littering of the environment with these wastes. Introduction of stiff punishment will also curb indiscriminate disposal of plastic wastes and other wastes all over the places. This can be done in collaboration with community associations (e.g. landlords/tenants associations and market associations) who may easily identify violators. Awareness of the existence of punishment will make individuals and community associations more proactive in preventing indiscriminate disposal of wastes within their domain. This will result in a cleaner and safer city for the entire populace.

Awareness on Impact of plastic wastes

This study showed that 48.3% and 41.5% of the respondents claimed to have heard of the negative impact plastic wastes on the environment and the danger of improper disposal of these wastes respectively. Despite this, 63.5% of the respondents admitted to the fact that their areas are badly affected by plastic wastes lying around on the streets. This showed that these wastes are not properly handled by majority. Table 7 showed the effect of gender, age, education, location and living condition of the respondents on their awareness of the negative impact plastic wastes on the environment and the danger of improper disposal of these wastes.

Gender constitutes a significant factor on the respondents awareness of the negative impact of plastic wastes on the environment (P=0.002) and the danger of the improper disposal these wastes (P=0.000). The male respondents are more aware of the negative impact of plastic wastes on the environment (54.8%) than their female counterparts (40.0%). Also, on the danger of improper disposal of plastic wastes, more males (49.4%) than females (31.7%) have the knowledge. Age was not significant factor on the respondents awareness of the negative impact of plastic wastes on the environment (P=0.078) and the danger of the improper disposal these wastes (P=0.660), although, 56.2% and 45.8% of respondents in age range of 30-39 have heard of the negative impact of plastic wastes on the environment and the danger of improper disposal of these wastes respectively. The level of education of the respondents was significant on their awareness of the negative impact of plastic wastes on the environment (P=0.000) and on the danger of improper disposal of these wastes (P=0.001). 62.4% and 49.8% of the respondents with tertiary education are aware of the negative impact of plastic wastes and the danger of improper disposal of these wastes respectively, which are higher in comparison with the values for those respondents with primary and secondary education. This showed a direct relationship between the level of education of the respondents and their awareness level of negative environmental impact and danger of improper disposal of plastic wastes. The location of residence of the respondents was a significant factor on their awareness of the negative impact of plastic wastes on the environment (P=0.000) with 62.8%, 54.7%, 54.4% and 51.7% of the respondents in High-Level, Kanshio, Modern Market and North Bank respectively being aware of this negative impact. However, location of the respondents does not affect their knowledge of the danger of improper disposal of plastic wastes (P=0.231). Occupation of the respondents affects their awareness of the negative impact of plastic wastes

on the environment (P=0.000) and their knowledge of the danger of improper disposal of plastic wastes (P=0.000). 63.6% and 56.8% of respondents that work for the government are aware of the negative impact of plastic wastes on the environment and of the danger of improper disposal of these wastes respectively.

This can be attributed to the educational level of these respondents, more of whom had tertiary education.

The same significance is seen in the type of accommodation of the respondents on their awareness of the negative impact of plastic wastes on the environment (P=0.000) and of the danger of improper disposal of these wastes (P=0.000). For respondents that lived in 2/3 bedroom apartments, 65.9% and 57.9% are aware of the negative impact of plastic wastes on the environment and of the danger of improper disposal of these wastes respectively. Although almost 50% of the population examined for the study claimed to be aware of the dangers of plastic wastes, there is still indifference in the way these wastes are handled as can be observed by the indiscriminate dumping of these wastes, creating litters around the environment. There is urgent need of translating the awareness into actions. There is also a need to continuously create more awareness on the subject to the unaware stakeholders. This can be done through mass media (e.g. radio and television), campaigns in public areas and market places particularly in the local languages that the people can readily and easily understand. Meetings can also be arranged with hospital managements and business organizations on the need for adoption and enforcement of responsible plastic wastes management. All hands must be on deck by individuals, businesses, hospital managements and waste management body to see to it that the problem is addressed squarely to save the city and by extension the global environment from plastic wastes.

CONCLUSION AND RECOMMENDATION

This study showed the attitude of individuals, hospital managements, market places and waste management body to the treatment of plastic wastes in Makurdi city of Benue State, Nigeria. It revealed that vast majority of the people and organizations concerned do not handle these wastes properly. The results revealed that 81.2% of the respondents do not separate plastic wastes from other waste stream. All the hospitals and markets do not sort at all. The government agency responsible for the final management of the waste stream does not have a practice of sorting plastic wastes from the whole waste collected with a view to achieving material and energy recovery. The study revealed that gender, education, location of the respondents do not have any significance on separation practice of plastics from other wastes, whereas, their age and living condition constitute a significant factor on separation practice. On the knowledge of the respondents of the importance of plastic wastes separation from other wastes; gender, education and living condition play a significant role while age and location are of no significance. The adopted methods of disposal for plastic wastes by all the stakeholders considered are open burning and landfill. Plastic wastes of 26.7% of the respondents end up in approved or unapproved dumpsites while 50.4% of the respondents adopted both dumping and burning of these wastes. As a result of ineffective wastes collection system in the city, determined by the fact that 72.2% of the respondents affirmed that waste collectors do not get to their areas, they (68.6%) have resulted to dumping wastes at unapproved sites. As a result majority of the respondents (63.5%) expressed that their areas are badly affected by plastic wastes lying around on the streets, which is dangerous to the environment and the health of the inhabitants of such locations. It was clear from the study that gender, age and living condition of the respondents do not have any significance on choice of disposal method for plastic wastes, whereas, their education and location of residence constitutes a significant factor on disposal method. On the choice of dumpsites used by the respondents to dispose of plastic wastes; gender, location and living condition played a significant role while age and education are of no significance. Although almost 50% of the population examined for the study claimed to have heard of the negative impact of plastic wastes on the environment and 41.7% of them are also aware of the dangers of improper disposal plastic wastes, there is still indifference in the way these wastes are handled as can be observed by the indiscriminate dumping of these wastes, creating

litters around the environment. This indicated a need for continuous education of the populace on the subject matter, possibly in local languages of the people. This study showed that gender, education, location and living condition of the respondents are of significance on the level of awareness of the respondents on the negative impact of plastic wastes on the environment whereas age of the respondents was of no significance. On the knowledge of the respondents about the danger of improper disposal of plastic wastes, age and location of residence of the respondents played no significant role whereas their gender, educational level and living condition are very significant.

This study revealed that plastics still constitute a significant and conspicuous portion of the waste stream generated in the city. This does not make environmental sense considering their negative impact. Besides the environmental concern, continuous disposal of plastic wastes in landfill amount to economic wastefulness. Most of the plastics in the waste stream in Makurdi are thermoplastics, which have the properties of being reformed to produce other plastic products or with some other materials to produce composite materials. These can be used for engineering purposes such as building and construction application e.g. fencing, furniture, etc. It is therefore important to recycle as much as we can. The fact that plastics have their origin from petroleum shows that they possess some energy trapped within, which is lost when we just dispose of them in landfill. Gasification of the unrecyclable portion of the plastic wastes will enhance the utilization of the inherent energy in them to generate heat and electricity. The by-product of gasification of the plastic wastes can also be adapted as aggregates for concrete product formation. All these will add usefulness to the plastic wastes, change the people's irresponsible handling of these materials and ultimately lead to the protection of the environment. It is high time that we begin to see plastic wastes as a resource and not as "wastes". This understanding will really change the perception and attitude of all stakeholders; individuals, government, hospitals, businesses, etc.; on the handling and management of plastic wastes. It is imperative that the waste management body in the city designs an efficient system for collection and disposal of these wastes that will benefit the environment and create opportunities for resource and energy recovery from them.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

ABBREVIATION

$	US Dollar
%	Percentage
ACC	American Chemistry Council
BENSESA	Benue State Environmental Sanitation Agency
BMAC	Beijing Municipal Administration Commission
CNY	City of New York
DSCNY	Department of Sanitation, City of New York
EPD	Environmental Protection Department
Fig	Figure
HDPE	High density polyethylene
LDPE	Low density polyethylene
MLS	Marine Litter Solutions
MSW	Municipal solid waste
PE	Polyethylene
PET	Polyethylene terephthalate

PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
RPMCs	Residential Property Management Companies
US	United States of America
n	Sample size required
p	Proportion of population
e	Margin of error
Z	Standard normal deviation
P	Pearson Chi-Square probability value

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