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PROSPECTS AND CHALLENGES OF USING COMMINGLED PLASTIC WASTE MATERIALS IN PLASTIC PRODUCTION PROCESSES IN METROPOLITAN LAGOS, NIGERIA

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Abstract

Use of plastics, a non-bio degradable element, is on the increase, globally; and this material could cause huge environmental problems when disposed improperly. However, most species of plastic wastes are recyclable with huge benefits. Lagos State with a population of over 12 million people generates a huge amount of plastic waste. This study assessed the perception of the manufacturers of plastic products in Lagos State with regard to the use of comingled recycled plastic wastes in production. The objective of this study was to proffer solutions that could: promote environmental ambience of Lagos State, and also engineer price reduction of locally produced plastic goods in Nigeria through a reduction in the cost of raw materials input by encouraging the use of recycled plastic material. Purposive Sampling technique was used in selecting operationally active plastic manufacturing companies in metropolitan Lagos for sampling. Seventy -five companies were sampled for interview using structured questionnaire. Data collected were analysed using frequency counts, percentages, and Pearson Product Moment Correlation Coefficient. This study revealed that majority (91.7%) of the plastic manufacturers in Lagos State adopted recycled plastic waste materials in production. However, recycled plastic waste material is in short supply for use by the manufacturers. The implication of this finding is that more employment opportunities exist in this informal sector in Lagos State. The study concluded that the output of large-scale recycling of plastic wastes in Lagos State has an existing potential market to feed. The study recommended that State government and the Local Community Development Authorities should synergize to organize plastic waste recyclers in Lagos State into a semi-formal structured business operation for bankability and increased output to serve the currently under-served plastic manufacturers.

Keywords: Comingled Plastic Waste, Plastic Waste, Recycled Plastic Waste, Lagos State

INTRODUCTION

Use of plastic product is globally on the increase. Plastics are non-bio degradable elements and could cause huge environmental problems when disposed improperly. However, most types of plastic wastes (PWs) are recyclable. Waste recycling is generally acknowledged to be a best practice standard in contemporary urban environmental management procedure, as it provides immense benefits. European Commission DG Environment (2011) confirmed that

recycling is at the centre stage of environmental policy in European countries with 24% of collected plastics being recycled annually. The benefits of waste recycling can be grouped into environmental, economic, and resource conservation sub-classes.

Plastic waste recycling (PWR) is a sub-set of general waste recycling activities. Recycling is a process whereby discarded products and materials are reclaimed or recovered, refined or reprocessed and converted into new or different products (Agbaeze, Onwuka & Agbo, 2014). Recycling of PW can be developed into an important sector in a state economy. When the sector is developed, it has the capacity to create wealth, jobs for the teaming population of youths in the state, reduce urban waste management cost for all stakeholders, and promote general urban sanitation condition in the state. Existing studies point to cost advantage of use of recycled plastic raw materials in production over the use of 100% virgin resins in the production of new plastic products. There is abundance of PW in Lagos State, and PW scavengers operate in the state, but it is not clear in literature whether enough of PW in Lagos State is being recycled in the making of new plastic products by the product manufacturers.
Perhaps, most plastic manufacturers in Lagos State are hindered in some way from using recovered PW in production of new items. So, what are the challenges facing plastic products manufacturers in the use of Commingled Recycled Plastic Waste Material (CRPWM) in Lagos State? This paper aims at assessing the perception of the manufacturers of plastic products in Lagos State towards the use of CRPWM in production process with the objectives of promoting the environmental condition of Lagos State and the reduction of the price of locally produced plastic goods in Nigeria through a reduction in the cost of raw materials input.

LITERATURE REVIEW

In the campaign for cleaner urban environment in Nigeria through PW recycling, it is important to evaluate through empirical review process, the prospects of PWR and the activities involved in the process both for in-house plastic waste generated in virgin plastic production processes and stained comingled PW collections. It is equally important to undertake a detailed theoretical review of the challenges, cost, and benefits derivable from PWR practice. First, activities involved in PWR process differ according to the source of the PW to be recycled. Plastic wastes can be collected from either an in-house production source in the form of production scraps and off-cut materials or from general waste dumps sites, dustbins or from the open space litters. Consequently, activities carried out in the process of recycling plastic waste from in-house sources are first reviewed. Activities involved in recycling of CMPWMs are then reviewed.

In a plastic manufacturing factory, in-house generated plastic waste is recycled through a simple, and less expensive Plastic Recycling Value Chain as shown in Figure 1.

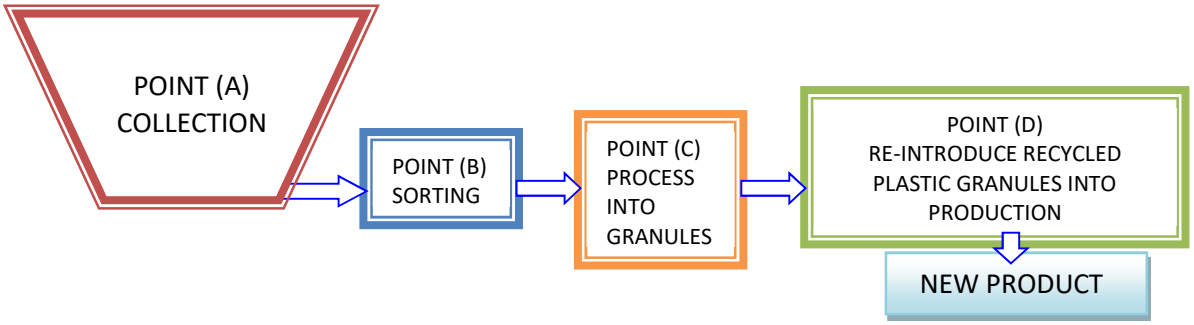

Figure 1: Plastic recycling value chain using in-house generated plastic wastes

At point (A), production off-cuts, and scrap production outputs are collected together, usually in a mixed junk, without regards to material types and colour but simply according to production batches. Gathering of assorted types of PWMs together brings about the need for sorting before recycling process. Sorting is done at point (B) according to specific material types for example: Polyethylene (PE) – includes low density (LDPE), linear low density (LLDPE), and high density (HDPE). Polyethylene products are mostly used for wrapping and packaging; Polypropylene (PP) also used for wrapping and packaging where attraction and high transparency are needed, Polyvinyl Chloride (PVC) mostly used for fluids transportation channels (pipes), electric cable insulation covering, carpets and floor tiles.

After sorting, each type of plastic material is heated up, pelleted and granulated into small grains at point (C) ready to be mixed with virgin resin and introduced into the production process at point (D) from where new products emerge once more. The sequence of activities described above represents a simple PWR process which is found in an ancillary plastic recycling plant which supports the major production lines for operational efficiency. However, recycling of comingled plastic waste (CPW) demands a more rigorous process as the simple PWR process illustrated in Figure 1 is inadequate to handle PWs recovered from different (commingled) consumption points. Container Recycling Institute (2015) stated that Polyethylene terephthalate (PET) bottles collected through commingled collection systems usually require additional sorting by recyclers or are simply too contaminated for high-end uses. To be able to deliver recycled PWM of useful quality, the processes described in Figure 1 is usually upgraded by introducing washing and drying stages to take care of dirt, prints, paper labels and contaminants. The additional treatment usually translates into higher cost (water, electrical energy, labour and time). The expanded plastic recycling value chain for processing comingled plastic wastes is presented in Figure 2.

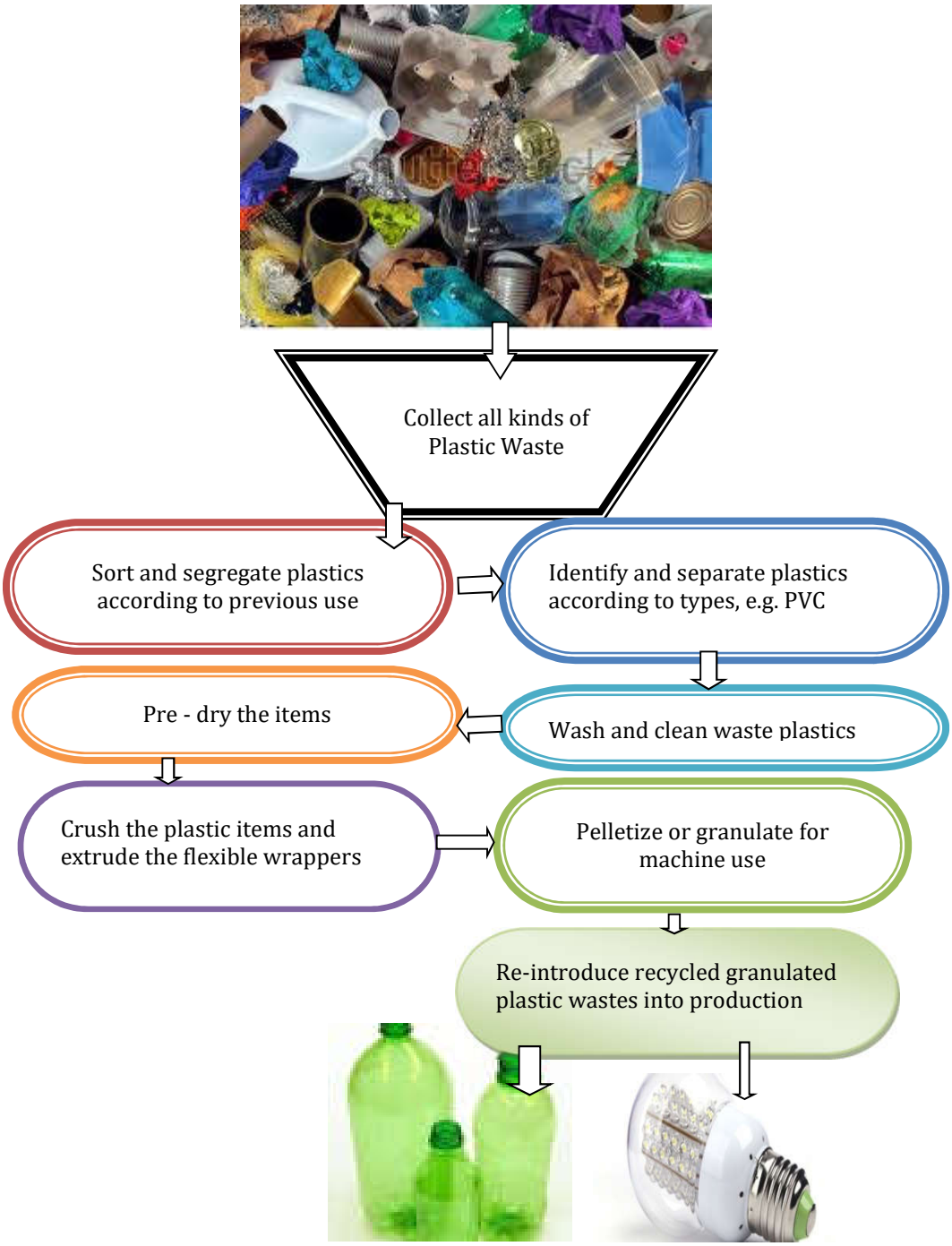

Figure 2: Plastic Recycling Value Chain Using Comingled Plastic Wastes

The sequence of activities involved in the recycling of in-house generated PW as depicted in Figure 1 is simpler than that of CPW shown in Figure 2. The additional activities of sorting according to previous use and type of plastic materials, washing, drying, crushing and extrusion usually add to the cost. The activities performed in Figure 2 are far in excess of those in Figure 1, and these activities are significantly value additive in nature regardless of whether they are performed by the plastic waste scavengers, the vendor or the manufacturers that use plastic wastes as raw materials. Sorted plastic wastes sell at higher price per kilogramme than the comingled plastic wastes.

Just like in any other economic activity, PWR has its own costs. According to Global Alliance for Incinerator Alternatives (GAIA) (2018), once plastics are in the environment, they cannot be removed. They simply appear in a different (and often more harmful) form over time - whether through anthropogenic intervention (with incineration or plastic roads and building materials) or through environmental conditions (such as weathering and photodegradation). Consequently, plastics litters in the environment need to be managed in order to reduce environmental harm. Several proposals have emerged across the globe to address the plastic pollution crisis. The proposals include: incineration - "waste to energy" or "plastic to fuel", biodegradable and compostable plastics, plastic recycling without significant reduction, as well as chemical recycling. GAIA (2018) averred that most of these processes pollute the environment, and impose huge costs on the society because each of the processes is resource and energy-intensive, expensive, and none of them functions as closed-loop systems including PWR. Recycling of PW involves huge capital investment, and requires high technological input especially when being carried out on a large scale.

Plastic waste recycling operations have negative effects on the immediate neighbourhoods of its operations, as they cause environmental pollution. Furthermore, government incurs some costs in formulating waste collection and recycling policy and in providing an effective regulatory structure to superintend behaviour and compliance for sustainable recycling operations. The ultimate environmentally friendly solution to the plastic pollution crisis should be searched for in the direction, prevention, significant reduction in the use of plastic materials especially for packaging. Nevertheless, there are economic and environmental benefits to be derived from recycling of plastic waste after surmounting the associated challenges.

Challenges of Recycling Plastic Waste

The challenges faced in the recycling of PWMs start from the fact that plastics and polymer products are of large family of species. The numerous types within the family render proper classification/segregation of plastic wastes a time-consuming job. It is important to note that achieving quality output of the recycled materials requires proper sorting to be made regardless of the time involved. The need for adequate and accurate sorting of CPWs into distinct types arises from the fact that there is a significant difference in the structural and thermal properties among the various types of plastics and polymer products in a comingled pack from various waste generation sites across the urban space. Prata, Patricio Silva, da Costa, Mounreyrac, Walker, Duarte, and Rocha-Santos (2019) acknowledged that recycling of plastics is a complex process comprised of multiple stages.

The existence of multiplicity of PWs generation sites entails complex transportation planning considerations in the process. Moreover, companies that use plastic packaging materials adopt different ways of branding their products. Some print directly on the plastic containers, while others use paper or other types of flimsy printed and pasted labels. Regardless of the mode of branding in use, dealing with prints, labels and contaminants on PW products is difficult, costly and time wasting. However, perseverance in dealing with the highlighted challenges in PWR practice yields significant economic benefits in excess of the challenges faced.

Benefits of Recycling Plastic Waste

Benefits of recycling wastes are well documented in existing literature. European Environmental Agency (2011) revealed that recycling of wastes contributes to green economy in several ways, including enhancing resource efficiency, reducing environmental impacts

from raw material extracts, generating jobs and business opportunities, and ensuring secure supplies of essential resources. New Jersey Waste-Wise Business Network (2013) reported creation of 27,000 jobs, savings in cost of disposal, reduction in needed waste services and revenue from the sale of recyclables as economic benefits of recycling of waste materials including plastic items in the state. Shahzad, Zafar, Nizami, and Rehan (2016) found municipal solid wastes generated in Makkah usually comprise, cardboard (6.6%), metals (1.9%), aluminium (0.81%), and that recycling only 12.21% of Makkah MSW, theoretically delivers an estimated 140.1 thousand Mt.CO2 eq. global warming potential (GWP) with savings of 5.6 thousand tons emission of CH4 (a major GHG). The value of revenue based on carbon credit and landfill diversion is 12.2 and 67.6 million Saudi Arabian Riyal (SAR) respectively. It claimed that net revenue of 113 million SAR equivalent of $ 30.12 million US Dollars will be added to the national economy every year only from recycling practices in Makkah city.

Raw materials gotten from recycled plastic wastes (RPWs) may not compete with virgin raw materials in terms of structural integrity; however, it can safely be mixed with plastic raw materials of virgin source in the production process. Mixing RPW material in measured amount with virgin material has been identified as a production cost reduction strategy which does not compromise the product quality (McGregor, 2009). Miller (1994) cited in Agbaeze, Onwuka and Agbo (2014) suggested that using the appropriate primary recycling technique rather than the secondary approach can reduce the use of virgin materials in making a plastic product by 20 – 90 %. Primary recycling approach is also known as closed loop recycling method. In primary recycling process, post consumers waste (wastes materials discarded by consumers) are recycled to produce new products of the same type for example, PWMs into new plastic products).

Considering the environmental and economic impacts, Prata, Patricio Silva, da Costa, Mounreyrac, Walker, Duarte, and Rocha-Santos (2019) concluded that recycling is the preferred method of waste management as it saves resources and energy, reduces pollutant emissions, reduces the need for landfills, creates jobs and improves local economies, reduces imports of resources, and generally improves the environment. Therefore, even though recycling is expensive, it benefits the society and is less expensive than the alternatives. United Nations Environment Program (UNEP), 2014 argued that good management of PW through recycling practices cuts costs, and recovers the resources locked up in PW. It concludes that with good plastics cycling management, consumer goods companies in US could save up to US$4 billion per year

Deductions from the foregoing discussions suggest that PWR practice could generally lead to: better environmental ambience, and could also systematically provide a self-financed means of managing waste collection and disposal in an urban environment. In addition, it could also open new investment opportunities to the attraction of both local and foreign investors, thereby creating direct and indirect employment opportunities, and stimulating further research to promote growth of subsidiary industries.

METHODOLOGY

Survey Technique and Data

The study is a cross-sectional survey method using quantitative techniques in exploring data from plastic products manufacturers in Lagos State. Data used in this study were collected from primary and secondary sources. Structured questionnaire and personal interviews were

employed in primary data gathering protocol, while secondary data were extracted through review of relevant existing literature. Purposive sampling technique was used in selecting the respondents of the study.

Instrument Design and Data collection

The data collection instrument used was designed to collect data on the following points: used recycled plastic wastes in existing production process, source of the recycled plastic material used and plastic product lines amenable to use of recycled plastic as raw material, (here, the respondents were asked to provide amenability ranking for the company's plastic product lines using a 3 point measurement scale.

Sampling Techniques and Sample Size

Purposive Sampling techniques (Tashakkori & Teddlie, 2003a, p. 713 cited in Teddlie, and Yu, 2007) was used in selecting the sampled plastic manufacturing companies in metropolitan Lagos because many of the operators as at the time of this survey were found in reconnaissance survey to be out of operation or running below installed capacity. The need to interview respondents from companies in active operation was a specific purpose which could not be achieved by randomization. However, the purposive determinants for selecting the respondents were: (a) the respondent's employer company being in active production, and (b) the respondents' willingness to participate in the study. Seventy-five sets of questionnaire were sent out to the respondents comprised of Plant Managers, Production Managers, Quality Control Managers, and Cost Accountants, Sixty four sets (85%) were returned out of which four were rejected due to scanty information, while analysis was based on sixty sets.

RESULTS AND DISCUSSIONS

Analysis was based on 60 sets of instrument accepted after screening. The results of the analysis are presented and discussed below. The first result showed the industry's plastic waste recycling descriptive as indicated in Table 1.

Table 1: Frequency distribution of plastic products manufacturers' perceptions towards plastic waste recycling

Sub variables	Freq.	Valid (%)
(a) Use recycled plastic raw materials in production		
Yes	55	91.7
No	5	2.3
Total	**60**	**100**
(b) Source of recycled plastic raw material used		
Produced In- house	12	20
Sourced from local market	38	63.3
Purchased from abroad	5	8.3
Missing	5	8.3
Total	**60**	**100**
(c) Awareness of economic and environmental		
benefits of embracing plastic waste recycling		
Yes	59	98.3
Missing	1	1.7
Total	**60**	**100**

(d) Do you have enough supply of recycled plastic waste?		
No	**52**	86.7
Yes	3	5
Missing	5	8.3
	60	**100**
(d) Willingness to commence recycling if the company has not been doing so		
Yes	4	6.7
No	1	1.7
Missing	55	91.6
Total	**60**	**100**

Source: Field Survey, 2019

Results shown in Table 1 indicate that well over 91% of plastic manufacturers in Lagos State make use of recycled plastic raw materials in production; majority of the companies (63.3%) that use recycled plastic waste to produce new items buy recycled plastic wastes from local sources; while, 20% and 8.3% of the other companies equally using recycled plastic waste materials source their supply from in-house and foreign importations respectively. This implies that recycled plastic has a good market among the plastic manufacturers in Nigeria. This is further collaborated by the fact that over (86%) of the companies using RPWMs in production claimed not to have adequate supply of the material. From the result in Table 1, nearly all the respondents (98.3%) are aware of the economic and environmental benefits of PWR. This awareness tends to suggest that PWR practice will be sustained in the companies that engage in the practice since the benefits are already appreciated by the senior staff members some of who are in a position to influence organizational decisions. Going forward, it is necessary to find out the specific plastic products which are amenable to the use of RPW in their production. This enquiry was focused at ascertaining the sustainability of the demand for PW by the manufacturers. The result of the responses made on 3 equal distance points Scale measurement for the amenability of various plastic products to use of RPWMs is shown on Table 2.

Table 2: Frequency distribution of amenability of production of plastic items to use of RPWMs

Plastic Products	V.A (Count/%)	A (Count/%)	N.A (Count/%)	Missing System (Count/%)	Total (Freq/%)
Jerry Cans/ Kegs	17(28.3%)	12(20%)	26(43.3%)	5(8.3%)	60(100%)
Plates, Spoons, and Cups	30(50%)	24(40%)	1(1.7%)	5(8.3%)	60(100%)
Plastic Bottles	Nil	Nil	55(91.7%)	5(8.3%)	60(100%)
Buckets/Bowls	29(48.3%)	26(43.4%)	Nil	5(8.3%)	60(100%)
Sachets/bags, and wrappers	19(31.7%)	30(50%)	6(10%)	5(8.3%)	60(100%)
Mats	Nil	Nil	55(91.7%)	5(8.3%)	60(100%)
Hose/Ropes	Nil	Nil	55(91.7%)	5(8.3%)	1(100%)
Foot wears	22(36.7%)	33(55%)	Nil	5(8.3%)	60(100%)
Plastic Sheets	Nil	Nil	1(100%	5(8.3%)	1(100%
Chairs &Tables	20(33.3%)	30(50%)	5(8.3%)	5(8.3%)	60(100%)

Legend: V.A = Very Amenable, A= Amenable, N.T= Not Amenable
Source: Field Survey, 2019.

Information given on Table 2 shows the extent to which each of the ten plastic goods covered in this study is amenable to use of RPWMs in its production. A cursory look at the table shows that most of the plastic products surveyed were substantially amenable to the use of RPWMs in their production given the existing technology and systems of operation in the plastic manufacturing industries in Lagos State, Nigeria. Although, as indicated on Table 2, the amenability of production of different types of plastic products to the use of RPWMs varied between about 48% - 91% for six of the plastic items investigated, nevertheless, the table also showed that plastic items such as mats, hose/ ropes, and plastic sheets are not amenable to use of RPWMs as raw material for their production. This finding points to the possibility of plastic consumer benefits which can arise from lower product prices as a result of the use of RPWMs in local production of plastic goods as United Nations Environment Program (UNEP) (2014) already averred that PWR practices cut costs among other benefits.

After the production lines amenability analysis, the study explored the relationship between production cost and use of RPWMs using Pearson Product Moment Correlation Coefficient. Result of the analysis is shown as correlation values between the plastic materials production cost and introduction of RPWMs into the raw materials used for production on Table 3.

Table 3: Correlation of Plastic Materials Production Cost and use of Recycled Plastic Waste Variables

Independent Variables	Production Cost	Use of Recycled Plastic Waste
1. Production Cost	1	
2. Use of Recycled Plastic Waste	- 0.416*	1

*Correlation is significant at the 0.01 level (2-tailed)

Table 3 shows that production cost of plastic goods negatively correlates with use of recycled plastic waste materials at correlation coefficient (r) value = -.416 for all respondents (n) = 75, $p<.05$, and (r^2) = 0.173. Multicollinearity does not exist as the variables are not highly correlated.

Deductions from Correlation Analysis

Result of the correlation analysis showed the degree of the strength and direction of the relationship between production cost for plastic goods and the use of recycled plastic waste materials with virgin resins as raw materials. The negative value indicates that the two variables move in opposite directions, which implies that production cost goes down with introduction of RPWMs into the raw materials batch, with (r^2) = 0.173, it implies that 17.3% reduction in cost of could be achieved as a result of the use of RPWMs. However, oral interview with some of the respondents with engineering background (Plant Manager and Production Managers) revealed that there is a limiting point beyond which further increase of RPWMs in raw materials batch starts to create other technical problems in the production machines which invariably translates to cost increase. This finding conforms with a prior expectation of this study which anticipates price of locally produces plastic would decrease when producers use a blend of RPWMs with virgin resins as raw materials for production of new plastic items.

CONCLUSION AND RECOMMENDATIONS

This study concludes that the use of recycled plastic materials is common among plastic products manufacturers in Lagos State. It was further concluded that, since plastic products manufacturers in Lagos State make use of recycled plastic materials from multiple sources including local out sourcing, that the output of large scale/industrial recycling of plastic wastes in Lagos State has potential market already in existence. Commercial recycling of plastic waste in Lagos state will create thousands of employments, promote environmental cleanliness, create wealth in addition to opening downstream plastic materials technology i.e. production and use of plastic derivatives components in construction industry.

Recommendations

This study makes recommendation as follows for strategic promotion and sustainability of PWR practice in Lagos State:

i. Government needs to vigorously enforce the existing legislation on plastic waste collection codes in manner that; homes, offices, hotels, restaurants, eateries, event centres, churches, mosques, stadia, markets, shopping malls/Complexes, major bus – stops are provided with on separate collection bins plastic wastes so as to aid the PW recycling process.

ii. State government in consultation with Local governments need to establish adequate number of plastic waste transition centres (PWTCs) in each of the local government units to ease the existing transportation challenges arising from multiple collection points in every neighbourhood. The actual number of PWTCs to be provided in each case depends on population and plastic waste generation capacity of the area which can be revealed by further empirical study.

iii. The State government in collaboration with Local Community Development Areas (LCDAs) should register and support plastic waste recyclers to organize into a formal structure for bankability.

iv. To this effect, this paper finally suggests the creation of Special Purpose Vehicles (SPVs) for plastic waste recycling or effective start-up of plastic waste recycling in Lagos State. The paper specifically proposes that the Plastic Waste Recycling Special Purpose Vehicles will consist of unemployed educated youths in each of the local government areas to be mobilized into Plastic Wastes Recyclers Cooperative Societies. The government will support the activities of these PWRCS and supervise them through a Technical Committee comprising members from Lagos State Waste Management Authority (LAWMA), Ministry of Agriculture and Cooperatives, Board of Internal Revenue, and Ministry of Health. Creating of PW recycling infrastructure of the structure and magnitude recommended in this paper in recovering increasing quantity of PWMs from the waste stream in Lagos and add value to the local economy of the state through adequate supply of RPWMs to plastic manufacturing companies in Lagos State.

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