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Waste to Wealth: A Case Study of the Ondo State Integrated Wastes Recycling and Treatment Project, Nigeria

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Abstract

The Ondo State Integrated Waste Recycling and Treatment Project, came into existence in June 2006 with the commissioning of the project office complex along Igbatoro Road, Akure by the Nigeria President, Chief Olusegun Obasanjo. The Project started operation in December 2006 with the aim of minimising solid waste in Akure and its environs. Since its inception, OSIWRTP has recorded huge successes in transforming the waste generated in Ondo State to wealth by the development of various valuable products using the basic concepts of sustainability: social progression, technical and technological improvements, environmental protection and economic development. Such waste is been generated from agricultural waste, nylon and plastic waste and foundry (metal) waste. Several techniques have been used to transform the waste into profitable products e.g. using anaerobic digestion (biogas) to produce energy and fertilizer; composting for soil conditioner; scrap iron for foundry products and other recycling techniques for solid wastes. The main output of OSIWRTP as at today are fertiliser, foundry materials and other recycled materials depending on the availability of wastes, and according to demands and need.

Keywords: Waste, Sustainability, Renewable Energy, Fertilizer

1. Introduction

The problem of solid waste disposal has become one of the most serious environmental problems facing many cities in Nigeria. In recent years, there has been a phenomenal increase in the volume of wastes generated daily in the country. This is due to a number of reasons including the increasing population growth rate, increasing urbanisation, industrialisation and economic growth. In addition, many urban areas of Nigeria lack effective waste management systems. As a result, most urban households resort to the haphazard dumping, burn and/or burying solid waste. The common arrangement in the few urban communities where a system is in place, is for waste management authorities to collect refuse from households and public containers on a regular basis using collection trucks. Unfortunately, operations managed by of the waste management authorities has mostly been inefficient and ineffective as evidenced by mounds of decomposing refuse that have become a regular site in many urban areas. This situation has was also been compounded by the reluctance of many Nigerian households to pay for waste disposal services for reasons of inability to pay and willingness.

Urban solid waste management in Nigeria is constitutionally the responsibility of the third tiers of government; that is, the local government (Federal Republic of Nigeria, 1999). Financial, material and human resources that have been committed to waste management by this tier of government have not matched this responsibility. This is evident by the reasons indicated earlier, the poor management of many landfill sites and soil and groundwater pollution due to often mixing of household, industrial and toxic waste (UNEP, 2000). In view of the environmental situation described above in many urban areas, Many Nigerian cities have been described as dirty, unsanitary, and aesthetically displeasing in the world (Mabogunje, 1996).

As a result of the failures recorded by local governments in solid waste management, many state governments have put in place bodies that are regional in outlook (that is, covering more than one local government). For example, in Oyo state, the Ibadan Waste Management Authority was established in 1996 to oversee all the local government areas within the Ibadan region (Oyo State of Nigeria, 1996). Lagos State established the Lagos State Waste Disposal Board (Adefemi, 1980). Similarly, Ondo State Waste Management Authority (OSWMA) was established in 1999 (Ondo State of Nigeria, 1999). The desire of the Ondo State Government to derive value from waste while at the same time effectively protecting the environment led to the creation of the Ondo State Integrated Wastes Recycling and Treatment Project (OSIWRTP) out of OSWMA.

OSIWRTP came into existence in June 2006 with the commissioning of the project office complex along Igbatoro Road Akure by the Nigeria President, Chief Olusegun Obasanjo. The Project started initial operation in December 2006 with an initial staff complement of 84. Essentially, OSIWRTP was established by the Ondo State Government to promote the possible profitable and safe handling and recycling of every type of waste generated within the State. This mandate involves designing and promoting policies and programmes to encourage source separation, the development of pilot schemes to encourage and promote waste recycling, the building of local/national markets for recycled products, and collaboration with other appropriate government agencies to regulate the safe handling, disposal and treatment of different waste within the State. The result expected is to mitigate soil, water and air pollution that is usually associated with the improper handling and disposal of wastes. To achieve this, a re-organization of the entire existing solid waste management system was undertaken. Firstly was the formulation of policy and putting in place institutional and legal instruments for the management of the state environment.

Secondly, local fabricators were identified and trained to fabricate machinery required to convert (i) organic matter into organic and organic-mineral fertilizers, (ii) soft and hard plastics into pellets that serve as raw material for ancillary plastic industries, and (iii) metal scrap into ingots and finished products. In implementing this strategy, a number of stakeholders played a major role and they were integrated through consultations. These efforts brought out some valuable short term and long term gains. The short term gains included employment generation, reduction the cost of in waste disposal, improved cleanliness which made Akure the second cleanest city in Nigeria, and development of technical and entrepreneurial skills among local workers. The long term benefits include health improvement, food security, local resourcing of raw materials for small scale industries, promotion of this technology to other parts of the country and West African region in general.

2. Overview of the Study Area

Ondo State Integrated Wastes Recycling and Treatment Project (OSIWRTP) are located along Igbatoro Road, Akure in Ondo state. Akure is the capital of Ondo State and it is located in South Western Nigeria. The state has eighteen (18) local government areas and a land area of 13,595km^2. Ondo State lies between longitudes 4^0 30^1 and 6^0 East of the Greenwich meridian 5^0, 45 and 8^0 15 North of the Equator. This means that the state lies entirely in the tropics.

Figure 1: Map of Nigeria Showing the Position of Akure in Ondo State.

Between 1992 and 2002, the population of Akure grew from 2, 312, 535 to 2, 983, 433. The projected figures for 2012 and 2022 are 3, 856, 469 and 4, 984, 900 people respectively. Most of the population lives in rural areas with a rural/urban population ratio of 61/39. Rural to urban migration continues to increase with people moving to urban area for white collar jobs and better social amenities. Ondo State is endowed with an abundance of natural resources – bitumen deposits and liquid natural gas, extensive tropical forest reserves and a natural port and river. Akure is the key trading centre for a farming region that grows yams, cassava, maize, bananas, rice, palm oil, okra, and pumpkins; Cocoa is the most important locally commercial crop produced for export and followed by cotton and palm.

OSIWRTP presently occupies a one hectare of land area, which is divided into 9 sections that are interconnected by a good intra-road network. The sections include: The Administrative building, the security and generator house, the nylon and plastic wastes pre-processing plant, the foundry (metal) waste processing, the organic waste (compost) milling plant section, compost windrow/curing bay section, waste off-loading and sorting area, workers' rooms, and production (works) attendants relaxation building. Provisions were made for alternative 500 KVA generators, to complement the irregular national grid power supply, and two bore holes (one specifically dedicated to serve the compost windrow) were each connected to 24,000 litres overhead water tank.

3. Sources and Characteristics of Waste in Akure

The amount of solid waste generated in Akure has increased steadily over time, from an estimated quantity of 60, 000 metric tons per year in 1996 to 75,000 metric tons in 2006 because of the increasing population, industrial and economic development. While the population of Akure was about 283,108 in 1996, it increased to approximately 353, 211 in 2006. In 2004 government conducted a feasibility study of waste management in Ondo State. The study revealed that most of the waste arises from households, abattoirs, poultries, piggeries, markets and small scale industries with a total generation of 280 tons per day. However the total assessment revealed that about 80% of the total

waste is organic in nature, followed by plastic/nylon, 15.72% and about 1% metal (Sridhar et al 2004). Recently there has been a considerable increase in plastic and paper in the recycled portion. The reason is due to the high demand for sachet water due to lack of potable water in Akure and the increase in use of packaging materials such as Polyethylene terephthalate (PET) bottles and bags. Of note a major proportion of the current useful industrial solid wastes are recyclable plastics waste, originating from sachet water production companies. Table 1 shows the mains source of solid waste generated in south western Nigeria where Akure is located. Solid waste in Akure typically consists of 70.3% from Domestic waste and while 18.6%, 6.3% and 4.8% commerce, agriculture and industrial waste respectively.

Table 1: Main Sources of Municipal Solid Wastes (MSW) in South Western Nigeria

City	Sources of waste%			
	Domestic	**Commerce**	**Agriculture**	**Industrial**
Abeokuta	73.80	17.50	8.20	0.50
Ado-Ekiti	78.90	14.30	4.10	2.70
Akure	70.30	18.60	6.30	4.80
Ibadan	66.10	20.30	2.20	11.40
Igede-Ekiti	75.10	11.00	12.40	1.00
Ijebu-Ode	79.50	14.00	3.50	3.00
Ile-Ife	67.40	28.40	1.00	1.10
Iyin-Ekit	79.60	2.20	11.60	6.60
Ode-Omu	91.20	1.80	5.90	1.10
Osogbo	68.20	23.50	2.10	6.20
Oyo	90.50	6.50	2.00	3.00
Mean	76.42	14.37	5.39	3.76

Source: Adewumi et al (2005)

Table 2 shows that the average biodegradable solid waste generation rate in Akure was 46,271metric tonnes per year in 2003, while Table 3 summarizes municipal solid waste constituents in Akure and for some neighbouring cities. From 1999 to 2006 however, the amounts of plastics, paper and cardboard wastes have increased as a result of the increased amount of packaging and wrapping material in the waste.

Table 2: Biodegradable Solid Wastes Generated from Domestic Activities in Some Cities and States of South Western Nigeria.

City/State	Population(year 2003)	Biodegradedable wastes(Metric tonsT per week)
Akure	316,925	46,271
Ibadan	1,650,806	33,050
Ijebu-Ode	330,799	54,773
Osogbo	253,430	38,852
Oyo	371,355	69,128

Source: I.K. Adewumi et al (2005)

Table 3: Constituents of Municipal Solid Waste Generated in Akure and Some South Western Nigerian Cities

City	Garbage	Paper	Sand (grit)	Plastic	Glass	Metal-scraps
Ile-Ife	77.9	5.3	7.5	7.3	1.1	0.8
Oyo	62.1	18.5	4.3	10.6	1.4	3.1
Ijebu-Ode	58.7	19.6	4.7	14.7	1.8	0.5
Akure	59.5	14.5	11.0	1.7	6.3	7.2
Ado-Ekiti	60.4	21.4	11.5	4.3	2.2	0.2
Abeokuta	57.8	26.2	3.4	8.7	2.2	1.6
Ibadan	64.9	14.2	6.5	9.9	1.7	2.9
Osogbo	58.2	17.8	9.9	12.1	0.6	1.4
Iyin-Ekiti	60.9	15.3	18.6	14.0	0.8	0.4
Igede-Ekiti	58.1	19.3	17.7	3.6	1.1	0.2
Odeomu	47.8	37.7	12.3	1.2	0.4	1.4
Mean	**60.5**	**19.1**	**9.8**	**7.1**	**1.7**	**1.8**

Source: Adepetu et al (1999) as adapted from I. K. Adewumi (2001)

4. Waste Management in Akure Before the Creation of Osiwrtp

Traditionally in south western Nigeria, the Aatan (Dung hill) was where refuse dumps accumulated. With modernization, dustbins replaced the Aatan. At the time each household was expected to carry its refuse to a dumping area, where the refuse was burnt or collected for disposal at a central location. This process has become such a problem that refuse dumps were to be found at various unsightly locations within urban areas. Initially in Akure, the local government authority was solely was responsible for waste collection, transportation disposal and street sweeping until 1999 when OSWMA was established as a state government intervention agency. From 1999 curbside and door-to-door collection using government supplied storage facilities or dustbins has replaced the communal system. This has however been without source separation. The dimensions and numbers of collections containers/dustbins varied according to the waste quantity and population. Solid waste in containers were collected and transported to an unsanitary landfill using trucks. Leakage of leachate and drop-off wastes from these transporting vehicles constituted major problems for Akure in terms of street cleaning, foul odours and the attraction of insects. Findings also showed that the collection efficiency in Akure was generally low, due to lack of adequate machineries and the attitude of the majority of the populace who were unwillingly to pay for waste collection services. Mixing wastes during storage and collection also pose serious challenges to effective waste management within the city. However with the establishment of OSIWRTP it became increasingly obvious that programmes had to be designed/initiated that will promote source separation. This was very important in guarantying sustainability of the Waste-to-Wealth project.

After the creation of the Ondo State Waste Management Authority in 1999, a landfill or dumpsite was used as the location for all municipal solid waste disposals within Akure. Solid wastes were disposed, spread and compacted in an uncontrolled manner and cover material was not applied regularly onto the landfill. In addition, there were no drainage and seepage control facilities in the area. Because of insufficient gas collection systems at the landfill sites,, burning of wastes was general operation, resulting into a risk to public health. Although land filling is generally regarded as one of the least costly options of municipal solid waste disposal, allocation of land for waste disposal was practically be impossible in the long run due to urbanization. On-site material recovery was done by scavengers who salvaged glass, plastics, and metals, among other things. These individuals were often exposed to health hazards due to often unavailability of proper equipments. The system of waste management by OSWMA was clearly inefficient, unhygienic and inadequate for Akure and therefore, there is need for a more efficient and integrated system.

5. Waste to Wealth Activities of Osiwrtp

5.1. Solid Waste Collection Practice

With the creation of the Ondo State Integrated Wastes Recycling and Treatment Project (OSIWRTP), the already household solid waste collection system was utilized. Household collection was divided into two types, door-to-door and transfers point's collection. In high-income areas, the collection was mainly door-to-door. During typical solid waste collection, one of the collector crew walks along the street alerting households by using an alarm, or an alarm is sounded from the truck, for household to bring their wastes out for collection. The crew members load the wastes from the bins and containers, unto the collection trucks and return the containers to the owners. The waste is later transported to the landfill site of OSIWRTP at Igbatoro road for sorting and recycling. The collection activities are usually carried out by house servants under the supervision of women or the women themselves. The charge incurred for this service is the responsibility of households. Household are charged depending on house/property type) for waste collection and transportation, but for waste disposal/treatment no fee is being charged or paid.

5.2. Recycling Activities

The recyclable materials in Akure are organic matters (kitchen, yard waste and animal dings), paper, cardboard, metals, plastics, and glass. These recyclable materials are sorted on-site by OSIWRTP employees before they are transferred to various units. Although Waste separation after collection is an expensive and difficult process, OSIWRTP employees are well educated on the issue of solid waste management and source separation. However, a public awareness program that informs the public about the need for source separation is on-going in the State. Also one on one campaign about waste management awareness has been conducted for several communities.

(a) **Turning waste into organo-mineral fertilizer:** Composting is seen as a method of converting organic waste from landfills while creating a product, at relatively low-costs, that is suitable for agricultural purposes (Eriksen et al., 1999;Wolkowski, 2003). Composting is the preferred method of solid waste recycling in Akure. Turning waste into organo-mineral fertilizer for agricultural use has impacted positively and significantly on urban/rural. In Akure the process of composting involves semi-mechanical windrow, curing and milling operations. Machines have been fabricated for the processing of the waste to organic fertilizer. A mixing machine was also fabricated by to mix organic fertilizers with a percentage of inorganic fertilizers for better quality. Daily production output averages 5 tons of organic/organo-mineral fertilizer. Though bulk markets are yet to be fully developed for this product, this potential exist

Figure 2: Organic Fertilizer Produced By OSIWRTP

(b) **Turning plastic waste to wealth:** Nylon/plastics contribute to the increasing volume of solid waste in Akure. In 2004 (Sridhar et al 2004), Nylon/plastics amounted to about 15.72% of the total waste generated in Akure. In the plastic waste streams, polyethylenes and polypropylene form the largest fractions, followed by Polyethylene terephthalate (PET) which are presently not being processed. Lesser amounts of a variety of other plastics are also found in the plastic waste streams. In Akure, recycling of plastics involves mechanical recycling processes whereby plastics are shredded to smaller particles and are converted to pellets (Figure 3). These pellets are sold to other recycling companies in Lagos, Oyo and Anambra States for further processing. Increasingly, it is becoming difficult for the Project to meet high market demands for Pellets..

Figure 3: Piles of Plastic for Recycling

(c) **Turning metals scraps into waste:** Scrap metals are turned into ingots by melting the metal, pouring the liquid metal into moulds, and then removing the moulds when the metal is formed. The most common metal alloys produced from this process are aluminium and cast iron. However, other metals, such as steel, magnesium, copper, tin, and zinc, can also be processed. The melting is performed in a furnace. Furnaces are refractory lined vessels that provide the energy required to melt metals. Modern furnace types include electric arc furnaces (EAF), induction, cupolas, reverberatory, and crucible furnaces. For low temperature melting point alloys, such as zinc or tin, melting furnaces develop to temperature of about 327 degrees Celsius. Electricity, propane, or natural gas is usually used for these temperatures. For high melting point alloys such as steel or nickel based alloys, the furnace must be designed for temperatures over 3600 Celsius. Virgin material, external scrap, internal scrap, and alloying elements are used to charge the furnace. Virgin material refers to commercially pure forms of the primary metal used to form a particular alloy. Prior to pouring the liquid metals, the foundry produces a mold. The molds are constructed by different processes dependent upon the type of foundry, the metal to be poured, the quantity of parts to be produced, the size of the casting and the complexity of the casting. The different processes include:

- Sand Casting - Green or Resin bonded sand mold.
- Lost Foam Casting - Polystyrene pattern with a mixture of ceramic and sand mold.
- Investment (Lost Wax) Casting - Wax or similar sacrificial pattern with a ceramic mold
- Plaster Casting - Plaster mold
- V-Process Casting - Vacuum is used in conjunction with thermoformed plastic to form sand molds. No moisture, clay or resin is needed for sand to retain shape.
- Die Casting - Metal mold.
- Billet (Ingot) Casting - Simple mold for producing ingots of metal normally for use in other found

In the OSIWRTP, Sand Casting is used in the recycling process and pouring is accomplished using gravity. Cast metal (steel) is presently the feedstock. Man-hole and pipe couplings cast-iron products are currently the output of the melting project.

(d) **Turning landfill gases into renewable energy:** Municipal solid waste landfills are the largest sources of human-created methane emissions. A methane emission from landfills has a significant energy resource. Landfill gases (LFG) are created from solid waste decomposition. Landfill gas is about 40-60% methane, with the remainder being mostly carbon dioxide (CO_2). Landfill gas also contains varying amounts of nitrogen, oxygen, water vapour, sulphur and a hundreds of other contaminants most of which are known as "non-methane organic compounds" or NMOCs. Inorganic contaminants like mercury are also known to be present in landfill gas. Sometimes, even radioactive contaminants such as tritium (radioactive hydrogen) have been found in landfill gas. Methane is important for electrical generation by burning it as a fuel in a gas turbine or steam boiler. Biogas (such as methane) is ranked low in priority in Nigerian energy policies. Meanwhile, biogas activities in OSIWRTP are yet to begin, but a lot of research has been conducted on the development of small scale digesters using biogas. If the total potential of methane were exploited, it is estimated that Akure could produce 30% of its present electricity consumption from biogas.

6. Economic Value of Waste to Wealth in Akure

Pollution abatement, energy saving, social benefits and economic benefits are the primary indices that will measure the advantages of the waste to wealth activities of OSIWRTP when fully made operational. The expected primary source of income is from the organic fertilizer. Also, pelletized plastic are currently been sold to some recycling companies outside of the State. The recycled metal scraps are to be sold to the Government – Ministry of Works and Public Infrastructures and the Ondo State water corporation. Other recyclable materials collected from within Akure are sold to scrap dealers or recycling factories. This has aroused significant interest within the small scale entrepreneurs in Akure, with two (2) polyethylene waste recyclers springing up in 2007 and approximately ten (10) scrap dealers. These scrap dealers purchase recycling materials from at the OSIWRTP site.

7. Conclusions and Recommendations

Generation of waste is a daily affair. Its management ought not to be a problem if correct approaches are employed. A great challenge facing the global community today is to make the industrial economy more like the biosphere, that is, more of a closed system. This would save energy, reduce waste and pollution and reduce costs. In short, it would enhance sustainability whereby employment generation and cost recovery will occur. The most realistic solution to sustainable environmental development in the country is to ensure that our resources including waste which offer the most environmental and economic gain without compromising the ability of future generations. In conclusion the study establishes the important role play by Ondo State Integrated Wastes Recycling and Treatment Project (OSIWRTP) in solid waste management and in generation of wealth for the state. This initiative has not only made Akure environmentally friendly but has created employment for operators. The following aspects should be improved for better operation in the future:

(i) The public should be educated regarding waste minimization techniques at home. The success of waste minimization relies largely on education, increase of public awareness and people's willingness to change their wasteful habits. For this reason, waste education must be implemented first. In addition, source separation activities should be implemented at household level in other to minimize the cost of separation at the recycling plants and to enhance the quantity and quality of the recyclables.

(ii) The waste to wealth activities of Ondo state should include the production of plastic lumber. Plastic lumber is also one of the major products manufactured using commingled waste plastic collected. Plastic lumber is currently used in products such as marine piling, pier and dock surfaces, fences and park benches. Plastic lumber is widely marketed as an alternative to chromated copper arsenate (CCA) pressure treated lumber for marine

applications. Plastic lumber is designed to outlast conventional wood products and is claimed to possess beneficial properties such as high strength, durability and resistance to rot.

(iii) Scavenging should be properly coordinated for the purpose of deriving maximum economic benefits from such activities and also for the health and safety of those involved.

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