

Recycling Technologies for Polyethylene Waste—A Mitigation Measure to Reduce Non-Biodegradable Pollutants in Nigeria’s Waterways (A Case-Study of Osun State, Nigeria)

¹**Adegoke, C. W. and ²Oginni Wale**

¹*Director, Centre for Alternative Energy Research & Rural Environmental Technologies (CAERRET), Osun State University, Osogbo Main Campus PMB 4494 Oke-Baale Osogbo, Osun State, Nigeria.*

²*Research Associate, Centre for Alternative Energy Research & Rural Environmental Technologies (CAERRET) Osun State University, Osogbo Main Campus, PMB 4494 Oke-Baale Osogbo, Osun State, Nigeria.*

Correspondence: +234-703-939-3221; pfsdallas@yahoo.com

Accepted on July 21, 2013

Abstract

*Most state governments in Nigeria are grappling with the challenge of sanitation through regular collection of solid waste being disposed by the citizens. The recent administration in Osun State has made efforts towards attainment of good sanitation and environmental sustainability through the activities of OYES and OCLEAN programmes respectively. In order to achieve greater strides and more efficiency in the current solid waste management efforts it is advocated in this paper that Government should adopt the 3 R’s concept of solid waste Best Management practice (BMP) viz: **Reduce, Reuse, Recycle** by converting polyethylene waste into alternative building material products such as **Polycrete™** recently innovated by the author at The Centre for Alternative Energy Research & Rural Environmental Technologies (CAERRET). The material is a new asbestos-free composite engineered Alternative Building Material product - **POLYCRETE™** using Polyethylene “pure-water” sachets waste and paper as major raw materials. (Nigerian Patent for Polycrete is pending at Abuja Patent Office under Application No. NG/P/2011/148). Polycrete is now being employed in the production of Decorative Ceiling Boards and fire-retardant, sound-proof Partition Wall Panels suitable for building of rapid mass housing delivery such as schools and halls in Osun State. Polyethylene, plastics and paper waste are a major component of the total volume of solid waste being generated in most urban centres. If this component of solid waste can be sorted/segregated from source through appropriate legislation and management plan of the Government, Uniosun and other SME’s/Recycling companies will be a ready receptor of these materials and will convert it through its newly invented technologies into alternative building materials for the benefit of the entire State. Osun State Government, through partnerships can also export this technology to other LGA’s of the state and other parts of the Federation. The entire citizenry of the state can be sensitized/mobilized to buy into the 3R’s of sustainable waste management through efforts of Osun State Ministry of Environment, NESREA, NOA, Justice Development & Peace Initiative NGO etc. It is posited in this paper that if recycling technologies are adopted and promoted by the state Government, the total volume of waste being handled by collection trucks and OYES crew will reduce by at least 40%, the processed recycled materials will be a source of income for the state (**Resource Recovery**) acting as raw material feedstock to downstream industries, pollution of waterways/associated seasonal flooding and environmental*

*degradation will be mitigated, environmental sustainability will be assured and a **win-win** situation will result for both the state and the various SME's who will be involved in Recycling/Waste-to-Wealth technologies.*

Key words: *non-biodegradable waste, water pollution, recycling, alternative building material technology.*

Introduction

Modern Integrated Waste Management strategies embrace the **3 R's** of waste management Best Management Practice (**BMP**) – i.e. **Reduce**, **Reuse** and **Recycle**. Hardly can the old concepts of incineration be talked about except in considerations of Waste-to-Energies (**WtEs**)/Biomass applications.

Thus modern practices in sustainable waste management involve:

Source Separation/Segregation of waste, followed by **Timely Collection, Reuse & Recycling** of the non-organic fraction (production of alternative materials); and **Energy & Compost/Fertilizer** production of the organic waste fraction via **anaerobic digestion**. Metallic materials are separated and **baled** to supply ingot production plants. In this process cycle, most of the non-metallic waste resources are not destroyed as with the practice of incineration but **REUSED or RECYCLED** to develop new alternative material products to satisfy a **future resource-depleted** society (**Resource Recovery** concept).

At Osun State University, a newly engineered asbestos-free alternative building material product, **POLYCRETE™** was recently invented by the author (1) – using i) Polyethylene Pure-water Sachet Waste (polyfibers), ii) Waste Paper (printers off-cuts) and iii) Portland Cement. The new engineering material is now being employed in local production of decorative ceiling boards and partition wall panels which can aid in accelerating mass housing delivery in Osun State and Nigeria in general. Polycrrete building materials are asbestos-free, cheaper and now compete with conventional imported POP & Nigerite products. Nigerian Patent on the invention is being processed by Osun State University with the Federal Ministry of Commerce & Industry, Abuja through National Office for Technology Acquisition and Promotion (NOTAP).

The Executive Governor of Osun State, Engr. Rauf Aregbesola at the inception of his administration, declared a 90-day Emergency on Environmental Sustainability in Osun State. At the World Environment Day Forum recently held on 8th June, 2011, he lamented the abject state of the environment as his new administration met it and resolved to correct the anomaly. We are sure His Excellency will see wisdom in embracing the **Best Management Practice (BMP's)** in modern sustainable waste management which will serve to minimize the current expenses and energies currently being dissipated on waste collection/dumping in the state.

If **recycling technologies** are adopted and promoted by the state Government as currently being practiced at Osun State University in the production of new alternative building materials, the total volume of waste being handled by collection trucks will reduce, the processed recycled materials will be a source of income for the state (**Resource Recovery**) acting as raw material feedstock to downstream industries, seasonal flooding/

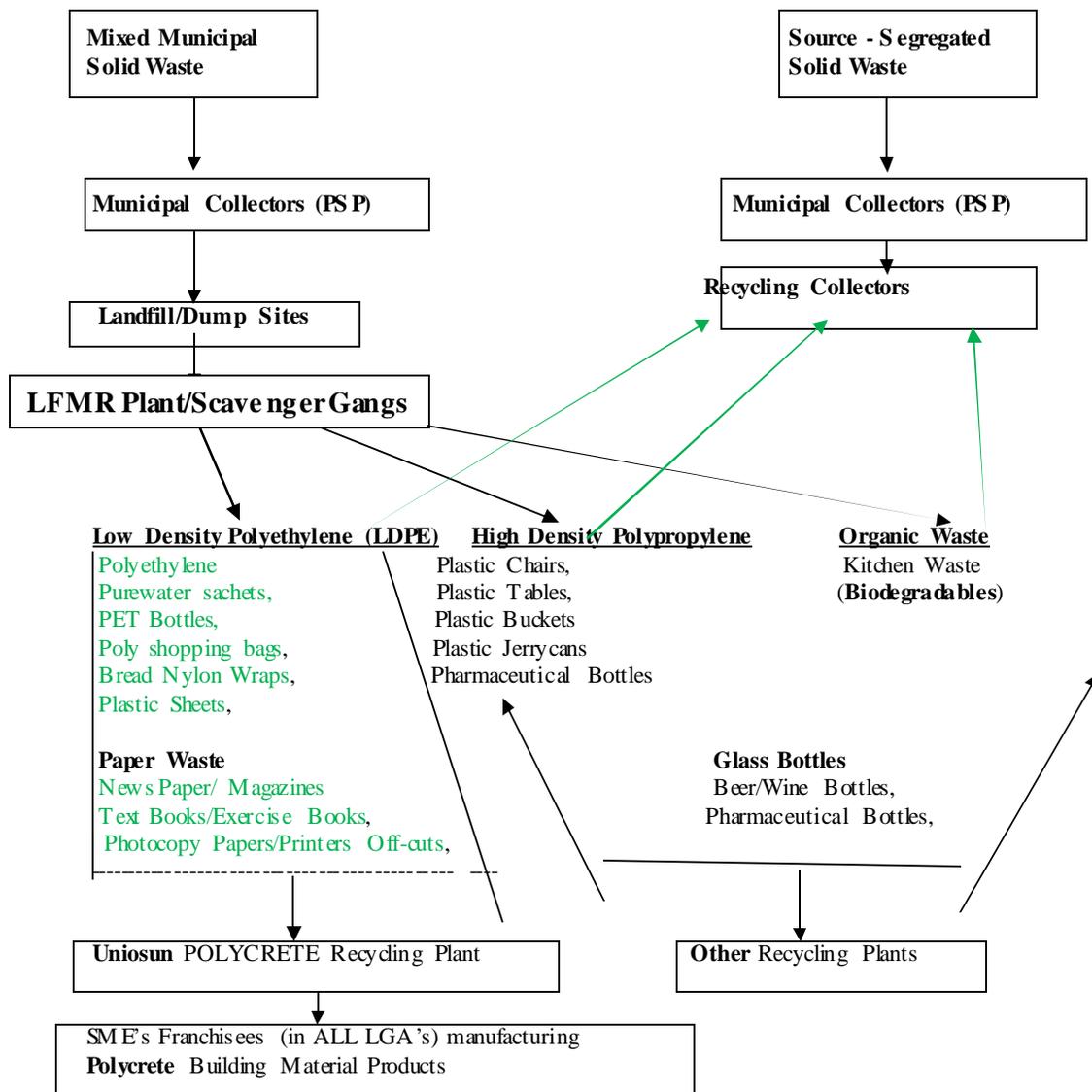
environmental degradation will be mitigated, environmental sustainability will be assured and a **win-win** situation will result for both the state and the various SME's who will be involved in **recycling/Waste-to-Wealth technologies**.

This paper addresses the **Waste-to-Wealth conversion of Polyethylene and PET materials to Alternative Building Materials products (POLYCRETE™)** as an effective way of mitigating plastic-based non-biodegradable pollutants in Nigeria's waterways.

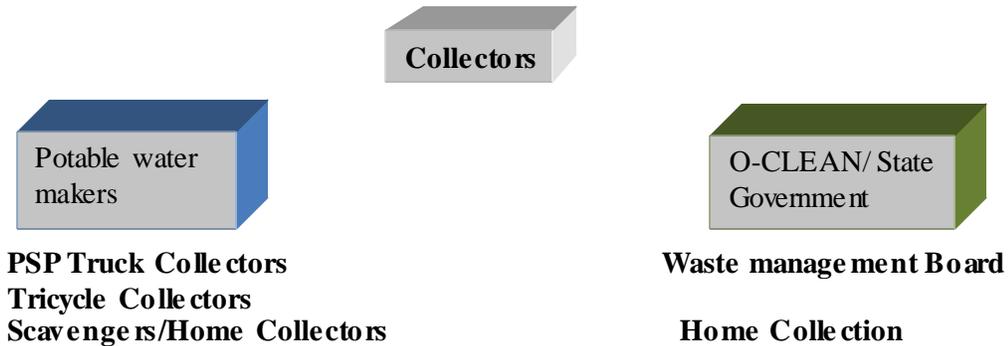
Proposed Integrated Waste Management Process Cycle

The overall Integrated Waste Management Process Cycle and sub-components are as shown in the Process Flow Chart as indicated below:

Integrated Waste Management Process Flow Chart
(Copy Right © Uniosun)



Recommendations for Effective/Sustainable Polyethylene/Plastic Waste Collection



- Due to the infrastructural requirements of mobile trucks and personnel, by the potable water manufacturers, it is paramount that the pure water manufacturers should be persuaded, and if necessary, mandated to flag-off SMEs, solely responsible for the collection of waste polyethylene materials in their marketing target environs/vicinity as a division of their potable water schemes. This will enable effective delivery of their products as well as adequate collection of polyethylene waste emanating from the use of their products. If they are not persuaded to do this, then the “Polluter Pay Principle Policy” may be applied as sanction in Osun State.
- The potable water manufacturers are also to employ scavengers to collect polyethylene waste, in abundance on the nooks and crannies of streets within an earmarked geographical location. The scavengers bearing trucks are to buy from householders at **₦5/kg**, while the scavengers sell the product at **₦15/kg**, to PSP Truck Collectors, who will in turn sell to Recycling companies like UNIOSUN – manufacturer of POLYCRETE at **₦20/kg**.

Government’s Enactment of Guidelines

1. The government should embark on vigorous Awareness/Enlightenment campaign for procedural waste segregation from home source via advert and TV programmes to educate the citizens of the state; and through agencies such as Ministry of Environment, NESREA, NOA etc.
2. The separation of “**ORGANIC WASTE**”, in one “Black” plastic bag container, while another “Blue” bag contains only “**RECYCLABLE WASTE**”; for proper recognition by the citizenry.
3. The waste management board/ O CLEAN Project should also see to the compliance of source-segregation of recyclables from organic waste.
4. Appropriate penalties/sanctions should be enforced on failure to comply.
 - Government should work out the modalities of sensitizing the citizenry (through NESREA, NOA and Min. of Environment) on how to segregate the total household waste into i) Recyclables and ii) Organic Waste
 - Govt. should dedicate two separate days of the week for separate collection of Recyclables and Organic wastes respectively.
 - Govt. or PSP Collectors shall buy Recyclables from householders at the rate of **₦5.0 per kg**

Recyclables can be subsequently sold to Recycling companies (e.g. Uniosun) at the rate of N20.00 per kg.

- If the above recommendations are followed, the total volume of solid waste being collected weekly by OCLEAN/OYES initiatives **will drastically reduce by at least a factor of 4.**

Sources of Polyfibre (Polyethylene, Recyclable Materials)

Low Density Polyethylene (Polyfibre)

- **(Main Stream)** Pure Water Sachets, Table 'Pure' water bags,
- Nylon gift/delivery bags,
- Milo, Bournvita (Beverage) sachets,
- Gift item wrappings, serviette wrappers,
- Dry cleaning 'nylon' wrappings,
- Poly bags
- Free wrapping bags
- Free dispense 'nylon' bags
- Used shower curtains, Tomato paste sachets (processed food sachets)
- Food stuff "sacs" (Rice, Garri, Beans), Polythene off-cuts from manufacturers, busted pure –water sachets from makers, shopping plastic bags
- Drug sachets (used)
- DVD/CD & Nylon packs
- Used recharge cards packs/wraps
- SIM card packs
- Take away nylon packs
- Detergent /soap wraps
- All nylon /polyethylene

High Density Polypropylene

- Cosmetic plastic containers (Hair cream, Relaxer/ pomade container)
- Broken plastic chairs
- Damage plastic Jerry cans/Kegs, used table water PET bottles /juice bottle /soft drink bottles e.g. Lacasera, Coke, Fanta, Viju etc.
- Veg. Oil containers
- Used wheel covers (plastic based materials)
- Take - away plastic plates, micro-wave plastic plates, Plate Plastic ware cabinet/Rack. Cosmetic perfume packs.
- All plastic polymerized materials and products.
- Cappuccino, Lattes etc cups.
- Ice-cream scoop cups, yoghurt bottles,
- Used Plastic spoons/plates

Waste Products Economics

Density/Unit Weight:

Our research findings show that Average density of GRANULATED polyethylene waste

= 280.0 kg/m³ (cf. water = 1000.0kg/m³)

Unit weight of UNGRANULATED polyethylene waste = 40.0kg/m³

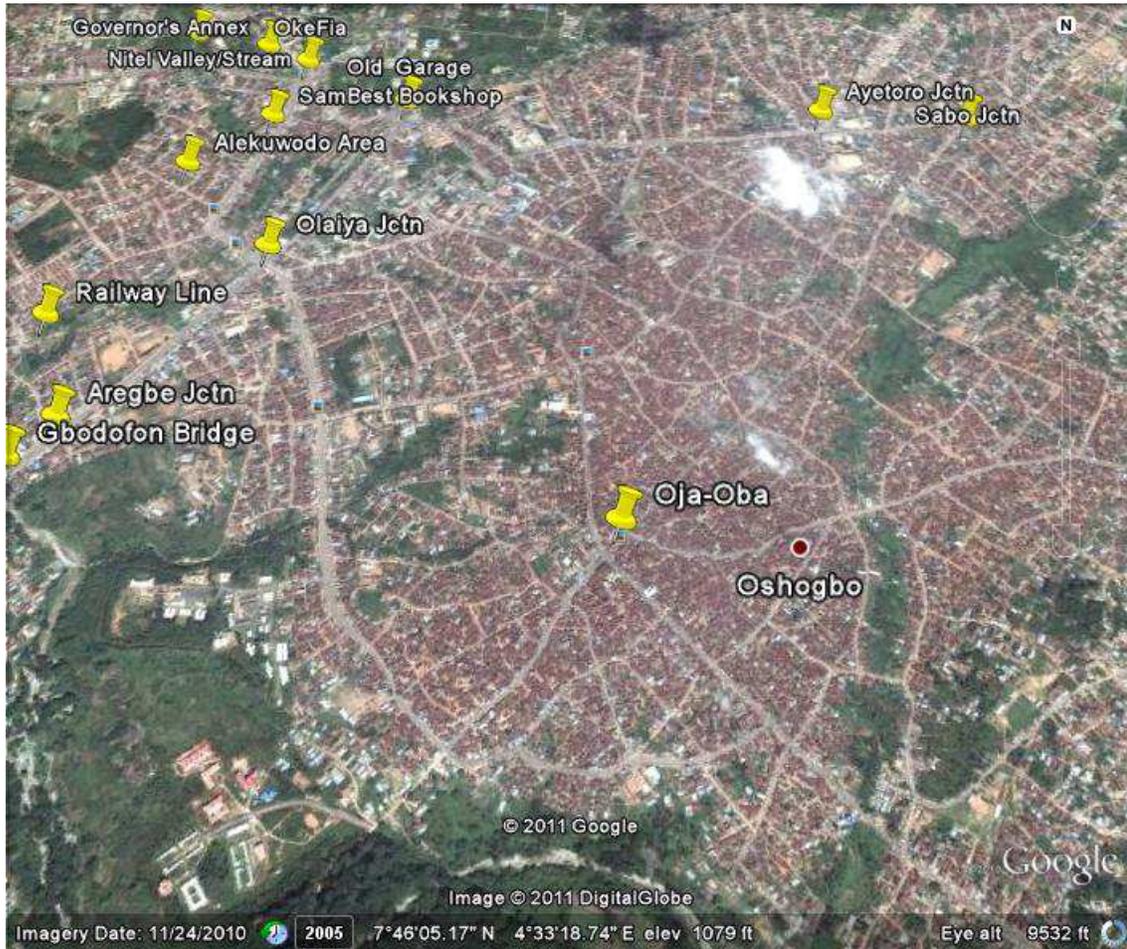
A bag of rice stuffed with purewater sachets should weigh about 10.0kg

Prevailing Market Price of Waste Products

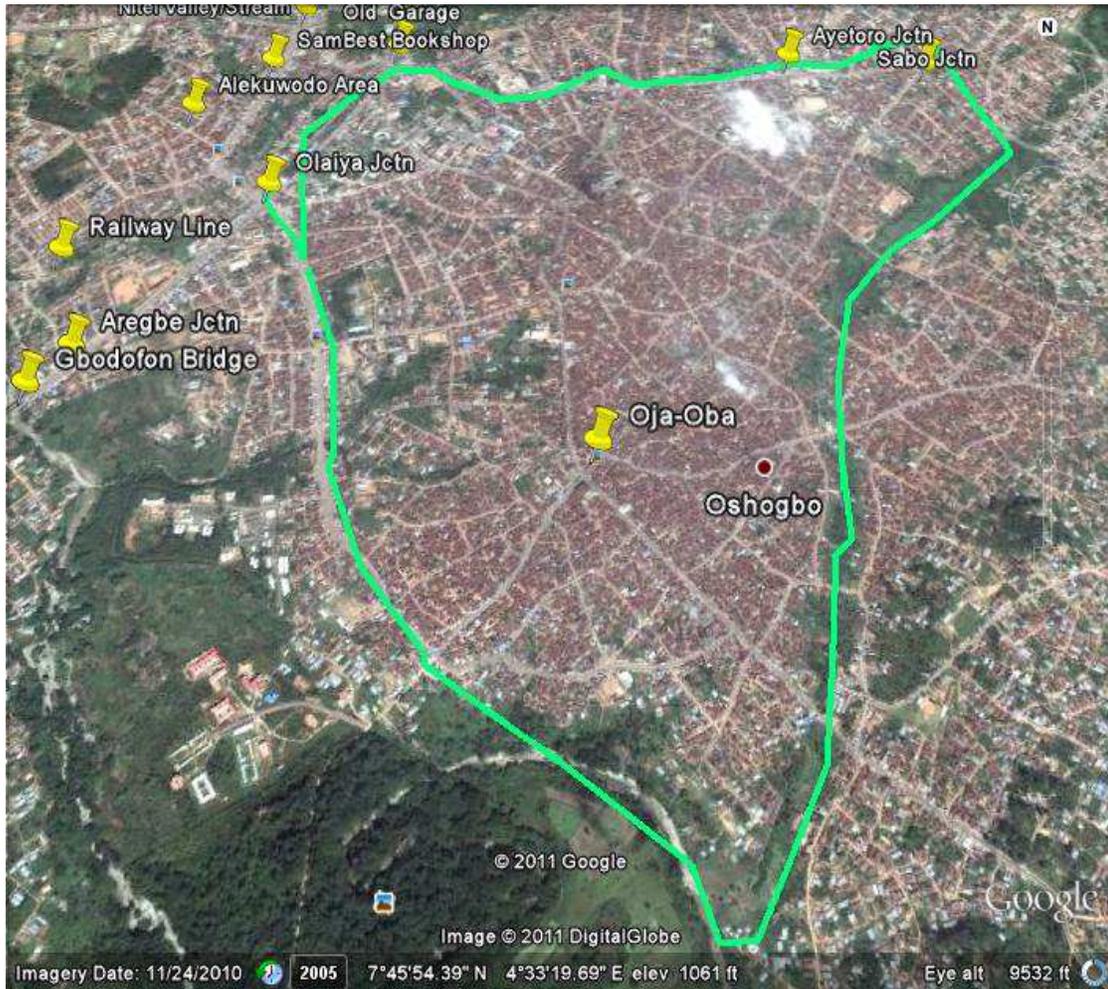
- Unprocessed Polyethylene waste (directly from household) should cost 5.0 per kg
- From Collectors – N10.0 per kg
- From Osun State Government = N20.0 per kg
- Processed Polyethylene waste (Granulated) = N70.0/kg

City Divisioning into Drop-Off Centres/Waste Collection Wards

For the purpose of an organized system of Drop-offs/Buy-backs of recyclables and collection of waste it is desirable to divide the cityscape into collection wards which fall within natural drainage basin sub-divisioning of the city. For example as shown in the fig. below: the area between Olaiya-Ayetoro-Sabo-Oja-Oba-Isale Osun has been designated as a natural Waste Collection Ward as it falls within a distinct section of the Okooko-Osun/Alekuwodo River Drainage Basin.



AERIAL VIEW OF OKOOKO-OSUN/ALEKUWODO DRAINAGE BASINS.



TYPICAL OKOOKO-OSUN/ALEKUWODO WASTE COLLECTION WARD AREA.

Waste-to-Wealth Activity Chart
Waste-to-Wealth Collection, Segregation and Management of Recyclable Waste
(Activity Chart)

	Stakeholders	Collection, Segregation and Management Activities
1	Osun State Ministry of Environment and Sanitation	<ol style="list-style-type: none"> 1. Adoption of legislation and management of components of solid waste such as Polyethylene and Paper waste which are recyclable materials 2. Coordination and liaison with relevant stakeholders in Osun State 3. Sensitisation to educate and enlighten the citizenry of Osun State in relation to the benefits of effective and sustainable polyethylene and paper wastes recycling 4. Organisation of trainings of the citizenry and private sector in relation to Osun State Government's general policies and guidelines in overall waste management strategies for the state
2	Osun State Local Government Authorities	<ol style="list-style-type: none"> 1. Sensitisation of each local government's citizenry 2. Organisation of trainings for each local government's citizenry 3. Collection and segregation of waste
3	Osun State University Centre for Alternative Energy Research & Rural Environmental Technologies (CAERRET)	<ol style="list-style-type: none"> 1. Organisation of trainings of the citizenry and private sector in relation to Osun State Government's general policies and guidelines in overall waste management strategies for the state 2. Organisation of Capacity Building Workshops 3. Organisation of continuous technical support to franchisees who are under licence from Osun State University 4. Centre for Alternative Energies & Rural Technologies (CAERRET) 5. Purchase of waste materials from Local Government Authorities, PSP Truck Collector, Scavengers and Home Collectors 6. Production of good quality Polycrete materials
4	Osun State Waste Management Authority (OWMA)	<ol style="list-style-type: none"> 1. Enforcement of the compliance of source-segregation of recyclables from organic waste 2. Enforcement of penalties/sanctions on failure to comply with segregation of recyclables from organic wastes 3. Collection and Segregation of waste materials
5	National Environmental Standards and Regulations Environmental Agency (NES REA)	<ol style="list-style-type: none"> 1. Coordination and liaison with relevant stakeholders in Osun State and enforcement of environmental standards, regulations, rules, laws, policies and guidelines. 2. Sensitization to educate and enlighten the citizenry of Osun State in relation to the benefits of effective and sustainable polyethylene and paper wastes recycling
6	National Orientation (NOA)	<ol style="list-style-type: none"> 1. Sensitization to educate and enlighten the citizenry of Osun State in relation to the benefits of effective and sustainable polyethylene and paper wastes recycling
7	Pure Water Producers Association/Association of Table-Water Producers (ATWP)	<ol style="list-style-type: none"> 1. Collection and segregation of recyclable waste materials directly from source at their factory sites 2. Direct Dropping of Polyethylene Waste from their factories with Osun State University (CAERRET)
8	Hotels/ Hospitality Association	<ol style="list-style-type: none"> 1. Collection and segregation of recyclable waste materials 2. Selling of recyclable materials to Osun State University Centre for Alternative Energies & Rural Technologies (CAERRET)
9	Scavengers/Tricycle Cart Pushers and Home Collectors	<ol style="list-style-type: none"> 1. Collection and segregation of waste materials 2. Purchase of recyclable materials from Home Collectors 3. Selling of recyclable materials to Osun State University Centre for Alternative Energies & Rural Technologies (CAERRET)
10	Osun State Citizenry	<ol style="list-style-type: none"> 1. Collection and segregation of recyclable waste materials 2. Selling of recyclable materials to Osun State University Centre for Alternative Energies & Rural Technologies (CAERRET)
11	National Youth Service Corps's (NYSC) Community Development Scheme	<ol style="list-style-type: none"> 1. Collection and segregation of recyclable waste materials 2. Selling of recyclable materials to Osun State University Centre for Alternative Energies & Rural Technologies (CAERRET)

**OSUN STATE TO ADOPT 3R's OF SUSTAINABLE SOLID WASTE MANAGEMENT (REDUCE, REUSE, RECYCLE!)
The RIGHT TIME is NOW!**



A TYPICAL STREET DUMP AREA WITH MORE THAN 50% RECYCLABLE POLYETHYLENE MATERIALS

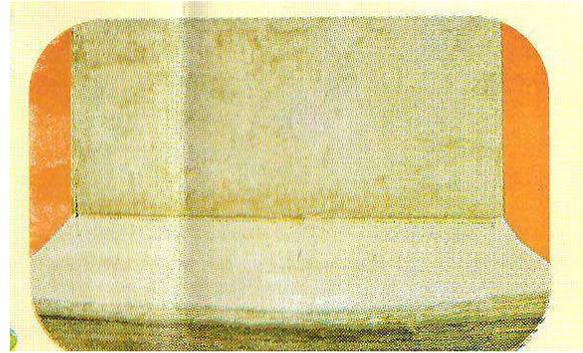
(Captured at Idi-se ke Area of Station Road, Osogbo, Monday 31st, October 2011)

Building Material Products =====> **CONVERSION to Useful Alternative**

LEAD TO =====>

Waste-to-Wealth Finished POLYCRETE Products (Green Products)

=====➔



Installed Polycrete Decorative Ceiling Boards

Polycrete Partitioning Wall Panels (Alternative to Plywood)

Conclusion

Recycling is one of the cardinal 3 R's of sustainable waste management best practices. The others are: **Reduce** & **Reuse** being first and second in hierarchy respectively.

The Centre for Alternative Energy Research & Rural Environmental Technologies (CAERRET) at Osun State University, Osogbo is presently engaged in recycling of Polyethylene and paper waste materials by converting the processed waste materials into alternative building material product - **Polycrete™**. The new engineering material is being employed in the production of Decorative Ceiling Boards and Partition Wall Panels now being employed in "Dry Construction" Technology. (Nigerian Patent for **Polycrete** is Pending at Abuja Patent Office under Application No. NG/P/2011/148).

Since the Polycrete technology is presently on ground at Osun State University, Uniosun can easily partner with Government in its vision to achieve environmental sustainability in Osun State. Polyethylene and Paper waste is a major component of the total volume of solid waste being generated in all urban centres. If this component of solid waste can be sorted/segregated from source through appropriate legislation and management plan of the Government, Uniosun will be a ready receptor of this material and will convert it through its newly invented technologies into alternative building materials for the benefit of the entire State. Osun State Government, through partnerships can also export this technology to other LGA's of the state and other parts of the Federation. The entire citizenry of the state can be sensitized/mobilized to buy into the 3R's of sustainable waste management through efforts of Osun State Ministry of Environment, NESREA, NOA, Justice Development & Peace Initiative NGO etc.

Waste management implementation in the state should be the responsibility of each Local Government area while the Osun State Government provides the necessary legislation, support and general policy/guidelines in overall Waste Management strategies for the state. Part of this responsibility includes timely collection of refuse from households and designation of a dedicated area of the LGA as a Landfill area where all the solid waste emanating from the LGA will be safely dumped.

When a recycling policy is adopted in the state, recyclables will be collected from households by Tricycle Cart Pushers or by PSP operators and Dropped-off in a Holding Bay in each LGA or taken to a cleared area of the main landfill where recycling companies can come to buy off the recyclables. The Government will have to encourage entrepreneurs to set up recycling companies who will use the various recyclables as raw materials input.

Since the state is yet to adopt a litter control ordinance and recycling policy, waste is presently being handled in a mixed form wherein organic waste and recyclables are being collected and dumped together in the landfill. For this situation, the LGA has to invest in some Landfill Mining & Reclamation Equipments (LFMR) in order to adequately manage operations and keep the landfill in an organized state wherein recyclables can be mined and moved to cleared areas of the landfill while the bio-degradable organic waste are pushed to another section of the landfill for possible future collection/production of compost manure/organic fertilizers.

However, source segregation of waste from each household and the adoption of 3 R's of sustainable waste management practice will be the desirable, sustainable and ultimate practice to be adopted in the state.

References

- Adegoke C.W., Gasu, M.B., and Abiona, S. "Waste-to-Wealth Technology in Conversion of Polyethylene "Pure Water" Sachets Waste to an Alternative Building Material Product" RETAV, November 2009 Conference, Obafemi Awolowo University, Ile-Ife, Nigeria.
- Adegoke C.W., Kayode O.M. and Abidoye L.K. 'Weight Reduction Study of Polycrrete™ –An Asbestos-Free Alternative Building Material Product' Paper presented at the 5th International Conference of Africa-Materials Research Society (A-MRS), Abuja 17th – 19th December, 2009.
- Adepitan Adegboyega "Waste Management Practice in Nigeria" 2010. Publisher JIMSIF Ltd. ISBN 978-978-909-929-0.
- Adewumi, I. (2004): "Municipal solid wastes Management": The need for a paradigm shift, *Ife Environmentalist*, NISEM, Ife, pp 1-2.
- Arnon, Bentur "Fiber Reinforced Cementitious Composites", London Elsevier Applied Sciences, 1990.

- Koya, O.A., Adegoke, C.W., and Kayode O.M. "Mathematical Modelling of Comminution Process of Some Selected Raw Materials by Hammer Mill"- A Technical Proposal submitted to Raw Materials Research and Development Centre and National Mathematical Centre, Abuja
- St. John D. A. "Concrete Petrography" - A Handbook of Investigative Techniques, London Arnold Publishers, 1998.
- Neville, A.M. "Properties of Concrete" Pitman Publishing Limited, 1977.