

ENVIRONMENTAL IMPACT OF END OF LIFE TYRE (ELT) OR SCRAP TYRE WASTE POLLUTION AND THE NEED FOR SUSTAINABLE WASTE TYRE DISPOSAL AND TRANSFORMATION MECHANISM IN NIGERIA¹

Abstract

End of Life tyre (ELTs) or scrap tyres are a form of solid wastes emanating from the use and disposal of tyres. ELTs have become the latest menace to the environment the world over, Nigeria inclusive. Heaps of scrap tyres stockpiled or disposed of in landfills and in open dumpsites are common views in Nigeria. ELT wastes causes grave environmental pollution as well as many health problems. Open burning or landfilling is the primary mode of disposal of ELT waste in Nigeria. These methods of scrap tyre disposal have negative environmental and socio-economic impacts. The aim of this research is to examine the various green options available for waste tyre transformation and disposal adopted by foreign jurisdictions with a view to reconciling Nigerians needs (automobiles and other vehicle consumption) with the capacity of the Nigerian environment as well as the peoples to cope with the consequences of socio-economic development. This paper strongly recommends that Nigeria adopt one or more of the green options and technologies examined in the work for managing ELT waste for sustainable development.

Keywords: *Environment, End of Life Tyre, Waste Management, Scrap Tyres, Pollution, Sustainable Development.*

1. Introduction

End-of life tyre (ELT) or scrap tyre refers to tyre that has ceased to perform its original function having exhausted all its re-use options. It is a non-reusable tyre in its original form. ELTs are not re-usable as a second hand purchase.² ELTs are a special kind of waste. There are municipal solid wastes rather than hazardous wastes.³ When it is decided that the used tyre is neither reusable nor reconstructable, it is discarded and the recycling or recovery process begins. Since the 1972 Stockholm Conference on the environment, environmental sustainability has been a recurrent theme in the face of increasing environmental pollution. Pollution is the introduction of substances into the environment whose by-products in time have harmful or negative effects on the environment. Environmental pollution arises because of man's activity that directly and indirectly affects the environment. When a foreign substance is introduced into the environment in a high and unmonitored concentration, it becomes a pollutant and a threat to the environment. According to the European Environment Agency, pollution is the introduction of substances or energy into the environment, resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems, and impair or interfere with amenities and other legitimate uses of the environment.⁴

To understand why scrap tyres are environmental hazards, it is important to understand the properties of tyres. A tyre is a rubber covering, pneumatically inflated and placed round a wheel to provide a flexible

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² Used or scrap tyres could be part-worn or end of life tyres (ELTs). It is only 'part-worn tyres' that can be retreaded or re-used for its original purpose so long as the residual thread depth remains but an ELT can no longer be re-used in its original form or retreaded and thus needs to be transformed through an elected process of recycling or recovery before a final disposal in landfills or incinerators. See 'End of Life Tyres', European Tyre and Rubber manufacturers Association, < www.etrma.org/tyres/ELTs> accessed 10 July 2018

³ Chris Dinesen Rogers, 'What are the Environmental Impacts of Throwing Away Tires?', <https://homeguides.sfgate.com/environmental-impacts-of-throwing-away-tires-79649.html>> accessed 14 July 2018

⁴ 'Pollution, European Environment Agency', <www.eea.europa/themes/water/wise-help-centre/glossary-definitions/pollution> accessed 10 July 2018

cushion and form a soft contact with the road.⁵ Tyres are manufactured for use in almost all forms of mechanical vehicles such as passenger cars, bicycles, tricycles, vans, trucks, airplanes, etc. The materials of modern pneumatic tyres are synthetic rubber, natural rubber, fabric, wire, carbon black and other chemical compounds. Most times, when tyres have served their original purpose, there are usually discarded in landfills or stockpiled or burned in open field. In many jurisdictions of the world, ELTs are not usually recovered or recycled but stockpiled or burned. ELTs are very problematic because they are non-biodegradable. They do not decay and may take decades to disintegrate naturally. The consequence is resort to green or eco-friendly technologies for sustainable scrap tyre waste disposal and management. The development or adoption of a green tyre waste management and recycling technology depends on the economic and industrial conditions of a country.⁶

2. Traditional Methods of Scrap Tyre Disposal

The increasing pollution caused by the increased use of automobiles and other vehicles has become a cause for alarm around the world. However beneficial tyres may be to mobility, scrap tyres negatively affect the environment when improperly disposed of. Below are examples of methods of scrap tyre disposal that negatively affects the environment.

Landfilling/ Stockpiling

Landfilling is one of the most common methods of scrap tyre waste disposal in the world. Yearly, millions of tons of tyre waste go into already overcrowded landfills. Tyres occupy so much land space in landfills due to their large mass. Tyres are basically non-biodegradable because of their complex chemical and physical composition. Thus, they could take decades to decay and are extremely difficult to compact in landfills because of their buoyancy. When tyre wastes are stockpiled, they tend to collect water and thereby provide suitable breeding ground for malaria causing mosquitoes.⁷ The negative environmental impact of landfilling or stockpiling of tyre wastes is huge. Although, landfilling is generally the cheapest and most convenient method of disposing of solid wastes such as ELTs, landfilling of whole or shredded tyres is entirely prohibited in some countries for reasons stated above.⁸ In the EU, landfilling of whole and shredded tyre is banned while in South Australia, whole tyres are banned.⁹ Landfill bans or restrictions when well planned and implemented with sufficient time for adjustments, can produce significant reductions in disposal of tyre wastes and increase resource recovery.¹⁰

Burning

Scrap tyre burning offers ephemeral relief from scrap tyre menace and long term negative environmental impacts. Open burning of scrap tyres in dumpsites and landfills is a major occurrence in underdeveloped countries as Nigeria. Open burning of scrap tyres generates a thick black toxic smoke and large quantities of hazardous gaseous emissions. The thick black smoke and toxic residues emitted from burning tyres may

⁵ English Oxford Living Dictionaries, <<https://en.oxforddictionaries.com/definition/tyre>> accessed 15 July 2018

⁶ Margaret Matthews, 'Review of Management of Used Tyres at Landfill Sites, Sustainable Strategic Solutions', WA, (2006), p 27 <www.wasteauthority.wa.gov.au/media/files/documents/tyres_at_land_fill_review.pdf> accessed 13 June 2018

⁷ 'Environmental Problem Associated with Waste Tire', <infohouse.p2ric.org/ref/11/10504/html/intro/problems.html> accessed 13 July, 2018

⁸ In the United Kingdom and EU generally, landfilling of whole tyres and shredded tyre have been banned. See 'UK Waste Tyre Management Best Practice: Handling of Post-Consumer Tyres – Collection & Storage: The Waste & Resources Action Programme', 2006, p 1 <<http://www.wrap.org.uk/sites/files/wrap.pdf>> accessed 19 July 2018

⁹ Ben Messenger, 'Tackling Tyre Waste', (2013), <<https://waste-management-world.com/a/tackling-tyre-waste>> accessed 13 July 2018. See also 'EPA Guideline: Waste Tyres' <https://www.epa.sa.gov.au/files/4771416_guide_tyres.pdf> accessed 13 July 2018

¹⁰ 'Landfill Ban Investigation- Final Report', (2011), Australian Government Department of the Environment and Energy, <www.environment.gov.au/protection/national-waste-policy/publications/landfill-ban-investigation-final-report> accessed 12 July 2018

cause environmental harm, nuisance and pose direct threats to the economy¹¹, public health and safety.¹² More so, the toxins released from the smoke can contaminate soil quality, groundwater and surface water. Airborne emissions from the open burning of scrap tyres are a common occurrence in Nigeria.¹³

3. End of Life Tyre Waste Situation in Nigeria

The rapid increase in Nigeria's population growth and income growth has resulted in a corresponding increase in the importation and purchase of all forms of motor vehicles. This change in consumption pattern has caused an increase in the amount of scrap tyres generated periodically. The number of scrap tyres in Nigeria increases monthly thereby amounting to high concentration of this solid waste in environmentally harmful quantity. It is estimated that thousands of tons of scrap tyres are abandoned in various parts of the country.¹⁴ Many ELTs in Nigeria also end up in the waterways and on the streets. Many are also burned during festivities; as roasting material in abattoirs¹⁵ and in extrajudicial killings of suspected criminals.¹⁶ Tyres have been stock piled around the country for years both legally and illegally in landfills and open dumpsites.¹⁷ These open dumpsites, which are usually indiscriminately located near residential settlements, causes leachate to contaminate nearby soil, surface and underground water bodies that are relevant to the residents who completely depend on those resources. This situation is aggravated by the absence of a scrap tyre waste collecting system as well as designated specially constructed landfill sites in the country for tyre wastes. This further highlights the need for a comprehensive national solid waste management policy that would incorporate this present scrap tyre menace.¹⁸ Recycling is still a nascent concept in Nigeria and as such has not received much attention from the government. Material recovery or recycling operations are carried out mostly by the private sector that employ scavengers to sort refuse for a fee and salvage any recyclable waste material prior to the ultimate disposal of the waste. Presently there is

¹¹ The destruction of soil quality in turn affects the quality of food and causes huge socio-economic losses to the country. See 'How do Old, Discarded Tires Affect the Environment?' (2014), Eco Green Equipment, <ecogreenequipment.com/how-do-old-discarded-tires-affect-the-environment/> accessed 10 July 2018

¹² 'Health Impacts of Open Burning of Used (Scrap) Tires and Potential Solutions', (2015), Environmental Law Alliance, <www.elaw.org/content/health-impacts-open-burning-used-scrap-tires-and-potential-solutions-science-memo> accessed 15 July 2018

¹³ Just recently in Port Harcourt, Nigeria, on the 3rd of June 2018, some unscrupulous men set fire to the scrap tyre dump site at Mile One, Diobu, by Silver bird Cinemas, Port Harcourt, Rivers State. The over 100,000 tyres burned for four days plunging the vicinity in a thick blanket of black smoke. This incidence caused not only destruction of property, but huge air pollution from hazardous chemicals emitted into the air. There was also incidence of poor visibility in the area as well as health effects. This further worsened the black soot environmental pollution the State has been battling for two years now.

¹⁴ 'Scrap Tyre Recycling In Nigeria; The Pre-Feasibility Report', <forumfera.com/marketresearchreports/manufacturing-market-research-reports/scrap-tyre-recycling-in-nigeria-the-pre-feasibility-report-2/> accessed 13 July, 2018

¹⁵ AC Friday & JN Nwite, 'Implications of Roasting Goats with Tyre on Human Health and the Environment in Abakaliki, Ebonyi State Nigeria', (2016), Journal of Pollution Effects and Control', <https://www.omicsonline.org/open_access/> accessed 9 July 2018. See also, 'At Bwari Abattoir, Cows are Roasted with Used Tyres' <Daily Trust, Friday July 20 2018, www.dailytrust.com.ng/daily/city-news/23387> accessed 9 July 2018.

¹⁶ 'Necklace' Lynching's that Shocked Africa: Agonising Deaths of Four Students Who were Burned Alive is Posted Online', (2012), <www.dailymail.co.uk/news/article-2239201/Necklace-lynchings-shocked-Africa-Agonising-deaths-students-mistaken-theives-burned-alive-posted-online.html> accessed 9 July 2018. See also 'Sick Mob Beat and Burn Boy to Death as Punishment for Stealing Food in Nigeria', (2016), <www.irishmirror.ie/news/world-news/sick-mob-beat-burn-boy-9282370> accessed 9 July 2018.

¹⁷ A landfill is differentiated from an open dump in that the landfill is an engineered design, consisting of a variety of systems for controlling the impact of land disposal on human health and safety and on the environment. An Open dump is an uncontrolled system and has not been the subject of engineering design.

¹⁸ Benefit Onu, et al, 'Solid Waste Management: A Critique of Nigeria's Waste Management Policy', *The International Journal of Knowledge, Culture and Change Management*, (2012), 11, pp 10 & 18.

no tyre recycling or resource recovery facility in the country.¹⁹ Thus, legislations, policies as well as technologies championing tyre recycling; resource recovery and addressing issues of tyre manufacturing, haulage, disposal, storage, processing, etc. are practically non-existent. Every now and then, the heap is set ablaze in a bid to dispose of them and free up land space. The unregulated landfilling, stockpiling or open burning of tyres in Nigeria for whatever reason negatively affects the Nigerian environment in ways expressed above.

4. Framework for ELT Waste Management in Nigeria

Constitution of the Federal Republic of Nigeria 1999 (as amended)

The Nigerian constitution recognizes the importance of environmental protection and resource conservation when it provided in section 20 that it is an objective of the Nigerian State to improve and protect the air, land, water, forest and wildlife of Nigeria. The Constitution intended that this objective be achieved through promulgation and adoption of necessary laws, policies, regulations and international Conventions on environmental protection and resource conservation for sustainable development.²⁰ The constitution also grants powers to the Local Government to oversee among other things, refuse disposal.²¹

National Environmental Standards and Regulation Enforcement Agency (NESREA) Act 2007

The NESREA Act is the major federal Law guiding environmental matters in Nigeria. It makes provision for solid waste management in Nigeria and prescribes penal sanctions for acts that run contrary to proper and adequate waste disposal procedures and practices. The Federal Ministry of Environment, Housing and Urban Development (FMEHUD) administers the Act, alongside the National Environmental Standards and Regulation Enforcement Agency established under the NESREA Act of 2007.

In order to effectively enforce the statutory functions of NESREA, the Minister of Environment empowered by the NESREA Act made Regulations. These Regulations are to be implemented at all levels of government. Some of the Regulations vital to this research are National Environmental (Surface and Groundwater Quality Control) Regulations 2010; National Environmental (Sanitation and Wastes Control) Regulations, 2009²² The National Environmental (Ozone Layer Protection) Regulations 2009;²³ National Environmental (Control of Bush/ Forest Fire and Open Burning) Regulations 2010; National Environmental (Domestic and Industrial Plastic, Rubber and Foam Sector) Regulations 2010; National Environmental (Permitting and Licensing System) Regulations 2009

In order for industrial facilities and businesses whose operations may have an impact on the Nigerian environment to be environmentally friendly as well as being compliant with existing environmental laws and Regulations, NESREA issues several kinds of permits.²⁴ The permits of importance to this research are the Air quality Permit,²⁵ the Eco-Guard Certification²⁶ and the Wastes and Toxic Substances Permit.²⁷

¹⁹ Ibid

²⁰ CFRN 1999 (As Amended) ss12 & 19 (d). More so, ss 33 and 34, which guarantee fundamental human rights to life and human dignity respectively, have also, being argued to be linked to the need for a healthy and safe environment to give these rights effect.

²¹ CFRN 1999 (As Amended) para (h), fourth schedule gives the function of disposal of waste to the local governments. However, some state governments have enacted laws divesting the local governments of this power thereby causing a confusion and draw back in waste management in Nigeria.

²² Regulations No. 28 of 2009, Vol. 96, No. 60

²³ Federal Republic of Nigeria, Abuja, Regulations No. 32 of 2009, Official Gazette, Vol. 96, No. 64 dated 13th October, 2009.

²⁴ See <www.nesrea.gov.ng/publications-downloads/permits> ibid

²⁵ This is geared towards regulating operations causing atmospheric emissions, open burning, etc.

²⁶ Eco-guard Certification is issued to facilities that are in the pre-construction and construction stages of their projects. The Eco-Guard Certification looks at the impacts of pre-construction and construction activities of facilities on the Ecosystem. Some of these impacts may include: Surface and Ground water disturbances (siltation), soil excavation/erosion, release or spill of oil/lubricants from construction equipment, fugitive dust

Environmental Impact Assessment (EIA) Act 1992 Now Cap E12, LFN 2004

The purpose of the EIA Act is established to among other things evaluate the impact of any public or private project likely to have significant impact on the environment.²⁸ This Act will come in handy in the assessment of proposed plans for landfills, tyre manufacturing, reprocessing, storage, recycling, etc. facilities.

Land Use Act 1978.

This Act grants control over land to State governments for proper allocation towards beneficial purposes to the state.²⁹ This Act could come in handy in the selection of lands to be used as landfill sites for the final disposal of ELTs in all the states of the Federation and also for the establishment of tyre recycling and reprocessing facilities.

National Policy on Environment, (Revised 2016)³⁰

The Nigerian Government originally launched this National Environmental Policy on 27th November 1989. The purpose of this National Policy on the Environment is to define a new holistic framework to guide the management of the environment and natural resources of the country for sustainable development. This environmental Policy hopes to achieve a balance between the resource needs of the nation against the carrying capacity of the environment. This Policy hopes to secure a quality of environment adequate for good health and wellbeing as well as promote sustainable use of natural resources and promote an understanding of the essential linkages between the environment, social and economic development issues. The Policy encourages individual and community participation in environmental improvement initiatives; raises public awareness and engendering a national culture of environmental preservation. The Policy seeks to build partnership among all communities, stakeholders, including government at all levels, international institutions and non-governmental agencies on environmental matters. The Policy employs economic instruments in the management of natural resources. Environmentally friendly technologies are encouraged as well as Environmental Impact Assessment of all major development projects.

The National Policy also seeks to promote consumption patterns that have minimal environmental footprints. The Policy seeks to internalize environmental costs into economic transactions to cater for environmental restoration and compensation to local communities for harms suffered. The Policy aims to reduce wastes and ensure recycling and re-use of materials and products as well as promote public awareness on economic and environmental impacts of wasteful production and consumption patterns and encourage efficiency in resource utilization including promoting the production of durable goods.³¹ All these objectives stated above are very vital in achieving sustainable scrap tyre recycling and waste management system.

5. Green Tyre Recycling Options towards Sustainable Waste Tyre Disposal

from surface-soil disturbances and ground excavation activities, use of heavy equipment and machines, increase in vehicle movement and access to the site, displacement of endangered, threatened or rare species of flora and fauna, local vegetation and wildlife, generation of solid and domestic wastes, among others. See <<http://www.nesrea.gov.ng/eco-guard-certification/>> ibid

²⁷ This is geared towards issues of waste generation, restricted chemicals, sludge disposal, etc.

²⁸ Environmental Impact Assessment Act, s 2

²⁹ Land Use Act 1978, s 1

³⁰ Formerly, 1989. See 'Federal Ministry of Environment', <Environment.gov.ng> accessed 14 July 2018

³¹ Ibid pp pp 31-48

Tyre recycling is the process of repurposing vehicle tyres that are no longer suitable for use on vehicles due to wear and tear or irreparable damage.³² The process of tyre recycling involves the collection and separation of tyre waste materials, the preparation of scrap tyres for re-use, processing, and re-manufacture; and the re-processing, re-manufacture and re-use of these materials. Since ELTs are difficult to dispose of, they could be converted into potential economically viable and sustainable products instead of being left to constitute environmental menace. This has spurred research into ways to successfully dispose of or recycle tyres into economically viable and sustainable products. Scrap tyres are indeed not only an environmental issue, but also as an economic benefit.³³ The tyre and rubber waste recycling business is a very thriving industry. It is the major sector of the economy of the United States and it generates a whopping annual sum of 959.2 million dollars from registered and licensed Tyre and Rubber Waste Recycling companies in the country.³⁴ The industry also employs several thousands of people. Despite the huge capital outlay, the market for recycled tyres is huge and can accommodate loads of investors. Tyre recycling is a very profitable venture.³⁵ To convert the waste tyre into a valuable product, it must first be reduced in size and then recycled. Tyre recycling reduces the negative environmental impacts of tyre stockpiling, burning and landfilling. It has become a resource-efficient approach to tyre waste management and pollution control. It makes for sustainable development as it not only protects the environment; it is both economically and socially beneficial. Popular tyre recycling methods practiced around the world are examined below:

Retreading

Retreading used tyres is a form of tyre recycling. When a tyre's lifecycle comes to an end, the tyre tread depth reduces. At this point, the best course is to repair or retread the used tyre and then re-use it for the same original purpose for which it was designed.³⁶ One of the best uses of ELTs is to retread them, but this process is quite expensive and very few countries resort to it. Retreading gives used, worn out tyres an extended useful life because during the process, about 80% of the original material value of a tyre is available for re-use.³⁷ The U.K. has benefited from reusing and exporting retreaded tyre casings.³⁸ The U.S. has taken advantage of the growing market in retreaded tyres because it is highly sustainable. According to the American Remanufacturing Industries Council and Future Marketing Insights, the cost of retreaded tyres is 30-5- per cent lower than that of a new tyre and generates huge income for the American economy.³⁹ Retreads are definitely greener than new tyres and the retreading process produces less carbon emissions and uses far less oil than the production of a new tyre.⁴⁰

Waste Transformation

Waste transformation is the process of altering the physical, chemical, and biological components of wastes to become a new valuable product. The practice of waste transformation or resource recovery, which is a form of recycling, improves the effectiveness and efficiency of already existing solid waste management operations and systems. In relation to tyres, waste transformation involves recovering the reusable and recyclable components of rubber tyre thereby reducing the disposal of whole tyres in landfills;

³² Salman Zafar, 'Disposal of Waste Tires', op cit

³³ Salman Zafar, 'Disposal of Waste Tires', ibid

³⁴ 'Starting a Tire Recycling Business-A Complete Guide', <www.profitableventure.com/starting-a-tire-recycling-business/> accessed 18 July, 2018.

³⁵ Ibid.

³⁶ 'What is Retreading?- Advantages and Disadvantages', (2015), <<https://tyres.cardekho.com/news/what-is-retreading-advantages-and-disadvantages/>> accessed 19 July 2018.

³⁷ Freddy Rader, 'Tire Recappers', (2017), <www.tirerecappers.com/tire-recappers-news/made-usa-retreads-better-new-imported-tires/> accessed 8 July 2018

³⁸ 'UK Waste Tyre Management Best Practice: Handling of Post-Consumer Tyres – Collection & Storage: The Waste & Resources Action Programme', 2006,

³⁹ Freddy Rader, op cit

⁴⁰ Ibid

saving land space for only final waste material that cannot be transformed any further or reduced. At the end of the resource recovery process, there is a considerable reduction of the original tyre waste material during waste transformation. The traditional method of stockpiling tyres or dumping in landfills is fastly becoming out of tune with modern and sustainable environmental practices. Efforts are now geared towards reducing the amount of tyre waste generated; thus, the emphasis on waste tyre transformation, resource recovery and recycling. In practicing waste transformation or resource recovery, regards must be had to the economic factors as the process could be cost intensive albeit truly sustainable. Several technologies are developed and practiced to encourage scrap tyre waste transformation. Such technologies are cryogenic/material recovery (Crumbed Rubber) and pyrolysis (Tyre Derived Fuel). Statistics of the European Tyre and Rubber Manufacturers Association (ETRMA) shows that about 95% of Europe's ELTs were successfully recovered through energy and material recovery processes.⁴¹ The UK has derived great environmental benefits in recycling and processing whole tyres, tyre shreds, rubber granulates and rubber powders.⁴² In the U.S., 4.39 million tonnes of waste tyres were recovered through energy and material recovery process.⁴³

Tyre shredding or Rubber Crumbing

Tyre shredding or rubber crumbing is usually the first procedure in the tyre recycling process. The process involves the reduction of used tyres into small manageable chips separated into major components of rubber and steel called crumb rubber.⁴⁴ This form of recycling is environmentally friendly, and allows used tyres to be used repeatedly. Tyre shredding or crumbing is done to provide a raw material in a form of rubber crumbs or to reduce the volume of tyres before landfilling.

Shredded tyres and Crumbed Rubber are also known as Tyre Derived Aggregate (TDA). They have many civil engineering applications such as barriers for collision reduction,⁴⁵ for sound and impact absorption properties; as insulation in building foundations and road base material; highway crash barriers, sound absorbing walls, boat fenders on harbour walls. Also, entire homes 'green buildings' can be built with whole tyres.⁴⁶ It is also used in erosion control and rainwater runoff and to protect piers and marshland from wave action. It is used as light rail vibration and embankments, sub-grade insulation for roads and septic system drain fields, erosion control on steep slopes or roadsides, and sound barriers between roadways and residences.⁴⁷ They are used in landfills for leachate lines; as a back-fill for retaining walls; as fill for landfill gas trench collection wells; as back-fill for roadway landslide repair projects as well as a vibration damping material for railway lines. Shredded tyres can also be used in landscaping as artificial turf or synthetic carpet grass in homes, offices and recreational areas like stadiums,⁴⁸ in airports for the

⁴¹ Ben Messenger, 'Tackling Tyre Waste'

⁴² 'UK Waste Tyre Management Best Practice: Handling of Post-Consumer Tyres – Collection & Storage: The Waste & Resources Action Programme', 2006.

⁴³ Ibid

⁴⁴ Crumb rubber and rubberized asphalt is one of the three largest markets for scrap tyres. Crumb rubber is the product obtained from cryogenic grinding of scrap tyres. See Rick Leblanc, 'The Importance of Tire Recycling', (2018), Small Business Resources, <www.thebalancesmb.com/the-importance-of-tire-recycling-2878127> accessed 13 July 2018. See also Salman Zafar, 'Recycling of Waste Tyres', Cleantech Solutions, <www.cleantechloops.com/recycling-wastes-tyres/> accessed 20 July 2018.

⁴⁵ Olli Honkamaika, 'Shredding Tires is a prosperous Business', (2012), Tana, <www.tana.fi/blog/shredding-tires-is-a-prosperous-business> accessed 13 July 2018

⁴⁶ Civil engineering applications is one of the greatest markets for scarp tyres. See Rick Leblanc, op cit (n 97)

⁴⁷ 'An American Success Story: Tackling Scrap Tyre Stockpiles', Waste Management Review, 2016, <wastemanagementreview.com.au/us-scrap-tyre-stockpiles-program/> accessed 13 July, 2018.

⁴⁸ Artificial turf is a surface of synthetic fibers made to look like natural grass. It is most often used in arenas for sports that were originally or are normally played on grass. However, it is now being used on residential lawns and commercial applications as well. See Hefa Cheng et al, 'Environmental and Health Impacts of Artificial Turf: A Review', (2014), Environmental Science and Technology, 48 (4), American Chemical Society,

embedding of runway lighting in landing surfaces for aircraft.⁴⁹ In the U.S.A and EU⁵⁰, shredded rubber crumbs are mixed into hot melt asphalt typically a crumb rubber modifier-recycled asphalt pavement CRM-RAP⁵¹ and as an aggregate in cement manufacturing for making ‘green buildings and structures’.⁵² Shredded rubber tyres can be utilised in garden beds as bark mulch or rubber mulch⁵³ to hold in the water and to prevent weeds from growing. It is also used as material to be cut up into shoe soles or other simple rubber goods like mats, floor tiles, muffler hangers, walk pads, carpet padding, well chocks, brake pads, traffic calming devices, clothing accessories such as belts, handbags and buttons. It is used as raw material in the rubber and steel⁵⁴ industry; for making new tyres, dock bumpers, patio decks, railroad crossing blocks, rubber tiles and bricks, animal bedding, movable speed bumps, etc.

Pyrolysis Process or Energy Recovery

Tyre Derived Fuel (TDF) popularly referred to as waste to energy process, is amongst the first market for scrap tyres on the global scale and remains the most beneficial and highly sustainable⁵⁵ end use as supplemental fuel in Europe,⁵⁶ Asia-Pacific and the United States. Pyrolysis is a thermal decomposition process in which scrap tyre is decomposed at high temperature usually from 450-550 degree Celsius in either an oxygen-free or low-oxygen atmosphere.⁵⁷ The purpose of pyrolysis is to break the tyre into its original components of oil, gas, solid residue (char), and low-grade carbon black, which cannot be used in tyre manufacture. Pyrolysis of scrap tyres offers an environmentally and economically feasible method for transforming waste tyres into heat and electrical energy.⁵⁸ Pyrolysis of scrap is an attractive alternative to

<<https://pubs.acs.org/doi/abs/10.1021/es4044193>> accessed 14 June 2018. See also Luz Claudio, ‘Synthetic Turf: Health Debate Takes Root’, (2008), *Environmental Health Perspective*, 116, <www.academia.edu/31488016/Synthetic_Turf_Health_DebateTakes_Root> accessed 19 July 2018. See also Salman Zafar, ‘Pyrolysis of Tire’, (2008), 116(3), <www.ncbi.nlm.nih.gov/pmc/articles/PMC2265067/> accessed 19 June 2018

⁴⁹ Playground surfaces are paved with the shock absorbing rubber-moulded material. like in the U.S.A.

⁵⁰ This is the case in Italy and Romania. See Vincenzo Torretta et al, ‘Treatment and disposal of tyres: Two EU approaches. A review’, (2015) *Waste Management*, 45, pp 152-160.

⁵¹ This rubberised asphalt cuts traffic noise and vibration by 25%, creates more flexibility, and even last longer than normal roads. See ‘Quieter Traffic’, (2012), *The Economist*, <www.economist.com/science-and-technology/2012/06/30/when-the-rubber-hits-the-road> accessed 15 July 2018. See also ‘Scrap Tires: U.S. EPA Region VII Scrap Tire Disposition, (2005), <www.vaasphalt.org/pavement-guide-recycling/scrap-tires-tech-brief> accessed 13 July 2018. See also Vincenzo Torretta et al, *ibid*

⁵² This is the practice in the U.S and the EU. See Vincenzo Torretta et al, *ibid*, p 154.

⁵³ Rubber mulch is a type of mulch used in gardens and sustainable landscaping that is made from recycled rubber. Rubber mulch generally consists of either waste tyre buffing’s or nuggets of synthetic rubber from tires that are ground up whole, after having their steel bands removed. Almost any tire can be used to make rubber mulch, including passenger vehicle tires and large truck and trailer tires.

⁵⁴ Steel industries use it as carbon source by replacing the coal or coke during manufacturing. See Olli Honkamaika, *op cit*.

⁵⁵ During the Pyrolysis process, no exhaust gas is let out to pollute the air. The rubber tyres are fully combusted in water seal and gas burner with safety devices. This eliminates the release of polluting exhaust gas and large amount of fuel is saved. The gases is then stored for further use in the process or it is burnt in an incinerator cum scrubber, pre-treated in wet scrubber before discharging to the atmosphere. The Pyrolysis process will also protect ground water and soil quality as no waste liquid effluent is let out to pollute the water or soil. During the process, faint acidic wastewater will be produced in the course of treatment of oil products. This water is neutralized by passing the rough a wet scrubber and evaporated in a specially designed evaporator cum gas burner system. The Pyrolysis process also saves land space as no solid wastes in the form of scrap tyres are dumped in landfills or dumpsites. See Salman Zafar, ‘Pyrolysis of Tire’, *BioEnergy Consult*, 2018, *op cit*.

⁵⁶ ‘UK Waste Tyre Management Best Practice: Handling of Post-Consumer Tyres – Collection & Storage: The Waste & Resources Action Programme’, 2006, (n95). See also Salman Zafar, ‘Pyrolysis of Tire’, *ibid*

⁵⁷ ‘Wide Applications of the End Products from Tire Pyrolysis Process’ <<http://bestonpyrolysisplant.com/wide-applications-end-products-tire-pyrolysis-process/>> accessed 14 July 2018. See also Salman Zafar, ‘Recycling of Waste Tyres’, *op cit*.

⁵⁸ David Mills, ‘Tire Pyrolysis is being Rolled Out in the USA’, *Bridging the Gulf for a Greener Tomorrow*, (2017), <<https://enviro-resourcestc.com/tire-pyrolysis/>> accessed 14 July 2018

disposal in landfills as it saves land space and allows the high energy content of the tyre to be recovered as fuel.⁵⁹ Using tyres as fuel produces equal energy as burning oil and 25% more energy than burning coal. Tyre pyrolysis plants are in use in several countries now, including the USA,⁶⁰ Japan, India, and France. The carbon black produced by pyrolysis application (CBP) or rubber char is more economical compared to carbon black produced primarily from petroleum and is more price-efficient. It is to be used as a raw material in the following industries such as the electric cable jacketing, the conveyor bands; carrier bands; home and doormats; black nylon bags; hoses, rubber additives; automotive spare parts; heat isolation; plastic pipes; black colourant in industrial rubber products, etc.

The pyro process converts scrap tyres into Pyro Diesel Oil (PDO); high grade Light Speed Diesel Oil (LDO) and Industrial Furnace Oil (IFO). Recovered PDO, LDO and IFO can be used to generate electricity and help mitigate country's power shortages. PDO, LDO and IFO are suitable fuel oils for rural pump sets and gen sets. The U.S. EPA acknowledges tyre-derived fuels as a viable alternative to the use of fossil fuels so long as proper regulatory controls are in place. The use of ELTs (whole tyres, half tyres, shredded rubber chips) is increasingly regarded as a valid alternative fuel in the cement industry,⁶¹ and in paper mills⁶² and power plants.⁶³ Since tyres are largely composed of hydrocarbons, they may provide an alternative non-fossil fuel resource when they are burned in special incinerators or kilns. Tyres may also be burnt to provide energy for the production of steam for vulcanization, lime paper, steel wires, zinc oxide and sodium sulphate.⁶⁴ Tyre Derived Fuel (TDF) is one of the largest applications of scrap tyres in U.S.A and the U.K⁶⁵. However, it is currently being challenged due to the steep fall in oil prices in recent years.⁶⁶

Other ELT Repurposing Options

Scrap tyres can be vulcanized⁶⁷ when they have reached a point whereby their re-use option is exhausted. Then, the physical properties of the ELTs or scrap tyres can be exploited beyond the original purpose mainly for aesthetic purposes.⁶⁸ In addition to agricultural applications, rubber mulch is also good in

⁵⁹ An average car tire is made up of 50–60% hydrocarbons, resulting in a yield of 38–56% oil, 10–30% gas and 14–56% char. The oil produced is largely composed of benzene, diesel, kerosene, fuel oil and heavy fuel oil, while the produced gas has a similar composition to natural gas.

⁶⁰ TDF is the oldest and most developed market for scrap tires in the U.S. Industrial facilities across the country, including cement kilns, pulp and paper mills and electric utilities use tdf as a supplemental fuel to increase boiler efficiency, lower fuel costs; lower emissions, including lower greenhouse gas emissions, high heat value compared to traditional fuels; each tire has energy potential. See 'Tire Derived Fuel (TDF) – Overview', <<http://www.scraptirenews.com/tdf.php>> 21 July 2018

⁶¹ Cement manufacturing companies use whole tires and TDF to supplement their primary fuel for firing cement kilns. The very high temperatures and long fuel residence time in the kiln allow complete combustion of the tires. There is no smoke, odor or visible emissions from the tires. The ash is incorporated into the final product, thereby eliminating waste. See 'Tire Derived Fuel (TDF) – Overview', *ibid*

⁶² Electric power utilities use TDF as a supplemental fuel to produce power in boiler operations. See 'Tire Derived Fuel (TDF) – Overview', *ibid*

⁶³ Salman Zafar, 'Recycling of Waste Tyres', *op cit*.

⁶⁴ Vincenzo Torretta et al, *op cit*, (n 105) 155-158

⁶⁵ Blue Circle, Britain's largest cement maker, uses scrap tyres as a replacement fuel at its plant at Westbury, Wiltshire.

⁶⁶ David Mills, *op cit*

⁶⁷ Itziar Iraola Arregui, 'A Fresh Focus on New Approaches to Recycling Tyres is Needed', *The Conversation*, (2016), <theconversation.com/a-fresh-focus-on-new-approaches-to-recycling-is-needed-63214> accessed 16 July 2018.

⁶⁸ For several uses of scrap tyre see 'Charming DIY Ideas How to Reuse Old Tires', *Architecture Art Design*, <www.architectureartdesigns.com/charming-diy-ideas-how-to-reuse-old-tires/> accessed 13 July 2018. See also '20 Ways to Reuse Old Tires from the Practical to the... Pretty Weird', (2017), <<https://m.huffpost.com/us/entry/7588906>> accessed 13 July 2018.

playgrounds as it has elasticity⁶⁹ which gives it a springy quality when used in a thick layer. This makes it a natural choice for playgrounds, where the extra springiness provides additional safety for children when they fall off playground equipment. In Indonesia and Ethiopia, waste tyres are recycled into shoes.⁷⁰ Old whole tyres may be converted into a swing for play and as flowerpots. Whole tyres are also employed as exercise equipment for athletic programs and Man-O-War activities. Many cattle farmers re-purpose old tractor tyres as water troughs for their cattle by placing them over natural springs or by piping stream water into them. Scrap tyres can also be re-purposed to serve as artificial reefs to provide shelter for sea life. This innovation helps the reef to thrive with new species of aquatic organisms. The substances that come out of the tyre do not affect the marine life on the reef.⁷¹

6. Conclusion and Recommendations

This research seeks to reconcile the needs of Nigerians (automobile/vehicle consumption) with the capacity of the environment to cope with the consequences of economic development in Nigeria. There can be socio-economic development without environmental destruction. Nigerians and the world at large can enjoy the benefits of tyres without having to destroy the environment for the present and future generations. There must be a balance between tyre consumption and environmental, social and economic development. This is the concept of sustainable development. The researcher therefore recommends that in the light of the increasing problems associated with ELTs or scrap tyres in Nigeria, any or all of the green or eco-friendly measures examined in the work should be locally developed, adopted and implemented for environmental protection, resource conservation and sustainable development. The Nigerian government should encourage the establishment of facilities for retreading of tyres since making use of retreads will help to reduce the rate at which used tyres are generated. Poor quality tyres that are usually imported at a low rate have a short life span and therefore exacerbate the problem of waste tyre generation and accumulation. Energy recovery process should be practiced to tackle energy and power shortages in the country. Incineration of tyres in cement kilns, paper industries should be practiced in Nigeria as this consumes large quantities of used tyres and produces no residue for further disposal.

At the rate at which scrap tyres are accumulating in Nigeria, there is need for the enactment of a waste tyre manufacturing and disposal law or regulation that would among other things, fix a legal minimum tyre tread thickness; regulate waste tyre manufacturing, car and tyre sales, tyre importation, storage, processing, disposal, etc. In addition, integrated policies on tyre waste minimization reuse, recycling, and disposal should be developed at all levels of government just like the USA and Australia.⁷² This would reduce waste tyre generation and save landfill space. Wastes segregation from the point of generation should be practiced in relation to tyres in Nigeria and efforts should be directed towards increasing the collection efficiency of scrap tyres. In addition to the Policy Statement on wastes contained in the Revised National Policy on the Environment, which makes it an objective of government to secure and enforce a legislative ban on plastic bags should also be expanded to secure and enforce a legislative ban on the open burning, and illegal or legal landfilling and stockpiling of whole tyres as conditions would permit. Should the government seek to dispose final tyre wastes in landfills or monofills, it should be a landfill in a designated location, faraway from residential areas. The landfill or monofill should be built in line with modern engineering specifications.⁷³

⁶⁹ The State of Maryland has nine playgrounds that use rubber tyres as a building material. See Jim Motavalli, *op cit*.

⁷⁰ Itziar Iraola Arregui, *op cit*.

⁷¹ See <<https://www.theguardian.com/society/2002/may/15/environment.waste>> accessed 15 July 2018

⁷² See 'Product Stewardship for End of Life Tyres-Fact Sheet', Australian Government Department of the Environment and Energy, (2014), <www.environment.gov.au/protection/national-waste-policy/publications/factsheet-product-stewardship-end-life-tyres> accessed 12 July 2018

⁷³ On building considerations for landfills see Adewole, A. Taiwo, 'Waste management towards sustainable development in Nigeria: A case study of Lagos state', (2009), *International NGO Journal*, 4 (4), pp 173-179

Nigeria should in addition to penal sanctions, also rely on market based and incentive based mechanisms like tyre fees/taxes, landfill taxes, tax credits, subsidies and incentives, deposit refund systems,⁷⁴ etc. to regulate waste tyre pollution and disposal and to promote the usage of recycled tyres. These economic devices will also be a source of sustainable funding for scrap tyre waste management recycling programmes throughout the Federation. Recycling and resource recovery operations will also create jobs for Nigerians. Incentives should be given to encourage Nigerians to collect waste tyres and appropriately dispose of them in authorized sites for further action. More so, there is need for public environmental awareness and participation towards scrap tyre pollution and proper usage and disposal. This can be achieved through development of programmes to increase community participation and develop positive attitude and knowledge on the collection, storage, disposal and recycling of tyre wastes. Governments at all levels should build good quality roads throughout the country for optimum satisfaction from the use of recycled or retreaded tyres. Transportation infrastructures should be developed to encourage all Nigerians to patronise public transport and reduce the rate of automobile importation.

There is need for international cooperation with foreign waste management and recycling companies as well as international organizations like UNEP and the World Bank; local and international stakeholders, NGOs, CSOs, etc. There is also need for the government to partner with the private sector, future tyre manufacturing industries in the country, tyre haulers and rubber industries on tyre waste disposal management. This will change the current situation of government being the sole financier of waste management operations in the country and help generate funds for research, establishment of tyre recycling plants and technologies, equipment, training of tyre vulcanization, recycling and resource recovery experts, etc.

Environmental agencies should be properly funded for effective and efficient service delivery. Poor funding has also made it impossible to finance the establishment of modern tyre recycling or resource recovery technology, facilities and expert personnel. It has also prevented research into local friendly recycling methods and technologies for waste tyre disposal. There is need for government to make reasonable budgetary allocation to environmental agencies. Relevant enforcement agencies at all levels of government should keep accurate records of all activities relating to tyre in the state such as number of tyres imported, manufactured, disposed, recycled, etc. within a given period. This will aid in accessing the scale of environmental risk and planning for appropriate method of disposal. Record keeping will also help to provide vital statistics for the evaluation of progress made as well as provide investment information for those seeking to invest in the scrap tyre waste transformation initiatives.

To curb the negative environmental impacts of scrap tyre wastes, the problem must be reduced from the source. Manufacturers, processors, transporters, dealers in tyres within the country must adopt green methods of tyre disposal. Since the life cycle or life span of a tyre has a huge role to play in a bid to conserve the environment, manufacturers must improve the overall quality of their tyres in terms of its grip, tread wear, rolling resistance and stability. This is because tyres with a longer life span will not be disposed of as waste quickly. This will also have some market implications because consumers will generally buy tyres with the highest possible mileage and this makes manufacturers zealous to improve the life span of their tyres. This will in turn help to reduce the frequency and number of used tyres generated. More so, the various agencies like customs, SON, NAFDAC, etc. in Nigeria in charge of quality check and control of imported goods must beef up their work to ensure that Nigeria is no longer a dumping ground for poor quality tyres.

⁷⁴ In relation to tires, this will require a monetary deposit at the time of every car sale or tire sale. This money will be refunded when the car or tire is no longer useful to the purchaser. Although, this system may have cost implications, it would effectively and sustainably manage tire wastes by preventing illegal dumping and burning and taking used tires to designated sites for recycling.