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RECYCLING OF PLASTIC WASTE AND THE QUEST FOR SUSTAINABLE DEVELOPMENT IN MASVINGO, ZIMBABWE

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Abstract:
The industrial revolution which started in Europe during the 19th century has brought about major changes to human life. While humankind has realised major changes in terms of diet, nutrition, health and mobility, the resultant problems of waste disposal have worsened considerably owing to the emergence of products that are non-biodegradable. A good example is that of plastic waste whose proliferation has reached unprecedented levels during the last decades. Today plastic waste is posing a threat to livestock, fish and other aquatic creatures. Most urban centres in developing countries are littered with large volumes of plastic waste. Due to its non-biodegradable nature, it is posing a major problem to the natural environment. In some cases, livestock which consume the waste end up developing health problems which often lead to their death. On the other hand, the disposal of plastic waste into water bodies such as dams, lakes and seas have a negative impact on aquatic life. This paper examines the recycling of plastic waste in Masvingo by members of the informal sector in the city. The United Nations Environment Programme (UNEP) headquarters in Nairobi recently banned plastic waste in coastal areas due to their threat to aquatic life. It is noted that such efforts are geared towards the eradication of this waste thereby achieving sustainable development (SD). This study was conducted between January and May, 2018. It recommends the establishment of formal strategies of recycling waste which would create more jobs for unemployed citizens.

Keywords: plastic waste, recycling, employment, sustainable development, Masvingo

1. Introduction

Natural and synthetic polymers play very crucial roles in the lives of living organisms. The most commonly used synthetic polymers are plastics. There has been a rise in the demand for plastic as it has significantly replaced wood, metal and paper usage in our day to day lives. The increased use of plastics is largely due to their favourable properties namely high durability, light weight, low cost, versatility, good water, air, chemical barrier properties and good hygiene properties and they can take a range of colours (Luthra, 2014 and Pavani, 2014). Although plastics are polymers, not all polymers are plastics. Polymers are large macromolecules made from small molecules chemically joined together. The small molecules repeatedly joined together are called monomers. Polymers are classified by two major criteria, namely: polymerization mechanism and thermal behaviour. There are three different classes used to group polymers namely elastomers, plastics and fibres (Cwik, 2014).

Plastics are a group of natural or synthetic high molecular weight polymers that were invented by Alexander Parkes in 1862. The name was derived from the Greek word *plastikos* as they are capable of forming different moulds and shapes.

Plastics are divided into two groups namely thermoplastics and thermosetting plastics. Thermoplastics are mostly used for different applications as they soften when heated and harden when cooled. These types of plastics can also be repeatedly moulded, shaped and used a number of times. Most plastics have a carbon backbone, some contain elements like 0,N and S other than hydrogen. Most commonly used plastics are synthetic plastics namely polyethylene (low density LDPE), linear low density LLDPE and high density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (solid-PS, expandable-EPS), polyethylene terephthalate (PET) and polyutherane (PUR) These plastics have various important uses which include a few examples (Table 1). On different products, the type of polymer present is indicated by a specific Resin Identification Code (RIC) as shown in the figure 1 below.

Figure 1: The Resin Identification Code (RIC) for different polymers

Table 1: Different plastic types, their application and health status

Type of Plastic	Application	Health status
PET	plastic bottles, containers (water, juice, soft drinks and peanut butter)	Safe and recyclable
HDPE	Packages (shampoo, detergents and milk), plastic toys, plastic buckets and dishes	Safe than transparent plastic material and recyclable,
LDPE	CDs, bottles and grocery bags.	Safe, recyclable

PP	food containers (kids lunch boxes and juice bottles), plates, medicine bottles	One of the best and safest types of plastic Suitable for both hot and cold liquids Unharmful and highly recommend for food containers frequently used
PVC	plumping pipes, bathroom curtains, toys, and transparent plastic wraps Very cheap	Harmful and toxic if used for long time
PS	Packaging (food and important material)	Dangerous and unstable No longer used in Zimbabwe

Source: Rajaram, E.A, 1997

2. Research Methodology

This study was prompted by the discovery of some women who were selling home-made floor polish in the city of Masvingo. After observing a number of people who were engaged in the business, the researchers decided to embark on a study of their operations in the city. Initially a perusal of literature on the subject was conducted followed by a pilot study. This led to the mapping of areas where this business was conducted. This was also followed by interviews which targeted the participants of the activity. The researchers watched how the production of floor polish was done as well as the marketing procedures. The information which was collected was analyzed and it led to the views which are expressed in this paper.

3. Dangers of Plastic Materials on the Environment

The use and demand of plastic is fast growing as a result of rapid population growth and improvement of people's standards of living. Plastics have important uses in various places such as industries, educational institutions, medical institutions and domestic places. The consumption of plastics has increased from nearly 5 million tonnes in 1950s to about 100 million tonnes hence more plastic waste is being generated. The properties of plastics and the additives incorporated during processing to make it attractive to the industry and consumers are also responsible for the environmental and health problems they cause. The additives include chemicals like plasticizers, lubricants, pigments and stabilizers. Plastic waste causes a lot of environmental and social problems as it is chemically stable and does not easily degrade under natural conditions. The strong covalent bonds in plastics that make them durable are also responsible for their resistance to natural degradation processes.

The environmental and social problems caused by plastic waste include environmental pollution, filling of land spaces, loss of natural resources, blockage of sewage systems and negative impacts on health. Plastic waste in landfill generally requires a very long time to degrade. Municipalities and industries have plastic waste as significant components of their solid waste after food and paper. Being light weight, plastic waste is transported by flood, wind and human beings to flood water bodies. In marine environments plastic waste kills animals through entanglement and ingestion.

Ingestion of plastic waste also kills domestic animals in most rural areas of Zimbabwe. Plastic waste littering on land surfaces leads to its burial in soils which can interfere with the production of nutrients hence reducing soil fertility. This greatly affects agriculture which is a major economic drive in Zimbabwe hence poor plastic waste management also has a negative impact on the Zimbabwean economy too.

3.1 Dangers of burning Plastic Materials

In Zimbabwe, plastic waste littering is a common sight in both urban and rural areas. In developing countries like Zimbabwe, there is also an increase in plastic demand hence an increase in plastic waste. Some of the plastic waste is burnt in backyards or in open spaces near homes. Plastics burnt using uncontrolled fire at low temperatures produce black carbon smoke as a result of incomplete combustion of the carbon back bone in polymers. Toxic volatile substances are also released into the environment as well as greenhouse gas emissions. The burning of plastic waste such as polystyrene foam cups, food trays and many other styrene based containers releases styrene gas which can easily be absorbed by the skin or lungs. At high levels, styrene gas can damage different mucous membranes in the body and eyes whilst very long exposure can damage the central nervous system. Burning of polyvinyl chloride plastic (PVC) also referred to as the dangerous plastic releases organo-based chlorides as well as dioxins. Dioxins are carcinogenic and extremely poisonous chemicals even at low levels.

3.2 Municipality waste collection systems

The most commonly used methods of municipalities to manage plastic waste are landfilling, incineration and recycling at times. However, there is a lack of an integrated solid waste management system to minimize different environmental problems caused by plastic waste. The main causes of an inefficient solid waste management system are: poor financial support from the government, ignorance of waste management policies by the public, poor public and media awareness. Landfilling can occupy a significant portion of the land which can be used for other income generating projects such as housing schemes. The increasing cost of landfill disposal systems and resistance of citizens for this system is driving the need to come up with ways to convert plastic waste into useful products. Direct incineration leads to greenhouse gas emissions, pollutants in the form of particles and it also faces resistance from the public. Hence recycling can be a better option. An Integrated Solid Waste Management (ISWM) system based on 3Rs (reduce, reuse and recycle) principle has been introduced by UNEP in order to reduce plastic waste.

3.3 Recycling of Plastic Materials

Recycling minimizes some of the problems caused by plastic waste. There are three ways in which recycling is being carried out namely mechanical recycling, mixed waste recycling and feedstock recycling (chemical recycling). Plastic waste is being used to produce fuel through chemical recycling. During chemical recycling fuel is produced

from plastics through pyrolysis. Pyrolysis is also known as thermolysis and this process involves the breaking down of large molecules to produce smaller molecules in the presence of chemicals and heat. During pyrolysis, air is excluded in order to improve yield, safety and quality of yield to be obtained. During pyrolysis, plastic waste is turned into gasoline and diesel. The temperature required for the process usually ranges between 350^{Θ}C and 900^{Θ}C. The products from pyrolysis of a polymeric material like plastic waste consist of a solid residue in form of a carbonized char and a volatile fraction in form of a condensable hydrocarbon oil whose main components are olefins, naphthenes, paraffins, isoparaffins and high calorific gas. The nature of the plastic waste utilized during pyrolysis and the processing condition determine the composite nature and proportions of the products. The pyrolysis of plastic waste requires very high temperatures which lead to the production variety of products. However, in the presence of a catalyst lower temperatures can be used. There are three types of commercial methods used to produce fuel from plastic waste namely the Thermofuel process, SMUDA process and HITACHI process. The oil from pyrolysis can be mixed with kerosene or gasoline. Pyrolysis of plastic waste into fuel benefits both the environment and the economy of a country. However, this technique cannot easily be implemented in Zimbabwe as it is relatively expensive since the country is faced with economic challenges.

In Zimbabwe mechanical recycling is commonly used, recycling often requires unmixed plastic waste material in viable amounts. There are four stages involved in mechanical recycling namely: sorting, size reduction, washing and separation. During mechanical recycling plastic waste is converted into new raw materials without changing the basic structure of the polymeric material present. Looking at the current economic situation in Zimbabwe mechanical recycling suits the country best. Singh and Gupta (2017) carried out a comparative study of a concrete mix design where the fine aggregates were replaced with pellets from plastic waste. Varying ratios of plastic waste pellets replaced fine sand aggregates. In some samples, super plasticizer was added to improve the aggregation between the components of the concrete design mix. However, they noted that the concrete design mix with plastic waste was suitable where low degree workability is required after testing different parameters. Ghernouti (2014) investigated the valorization of plastic waste bags in the construction of a concrete design mix. Plastic waste bags were seen to improve the workability and reduce density of the concrete however; compressive strength was seen to decrease. Another important result was that only a certain ratio of plastic waste bags can be used in the concrete design mix. Plastic waste has also been used in the formulation of paver blocks. A maximum of 2% and 4% plastic waste component was required to retain the required compressive strength in paver blocks and solid bricks respectively. According to literature, plastic waste has been used in the production of concrete bricks. However, according to the author limited literature has been reported on the production of floor polish using waste plastics as one of the major components of the ingredients.

3.4 Using plastic waste to produce home-made Floor Polish

According to the Zimbabwe Television (ZTV, 29/03/18) plastic waste has been used to produce home-made floor polish, diesel, bricks and crayons. With the growing abundance of plastic waste, this has proven to be a viable business. Studies carried out in Masvingo city and Norton have shown that some people derive their livelihood from producing and marketing home-made floor polish which is derived from plastic waste. Since 2014, these women have been selling homemade floor polish in cities and towns on open spaces outside some shops. The business was started as a source of income. The raw materials used by the women for the production of floor polish include various forms of plastic waste excluding PVC and PET plastic waste bottles, waxes or candle waxes, paraffin, perfume and colorants such as black oxide black powder and redoxide powder. According to the women, the red floor polish has a high demand. The plastic waste used in the formulation is sourced from various shops in Masvingo such as N. Richards, Pick n Pay and at times from other waste collectors who sell them at $1 for 90kg packets. When making the floor polish plastic waste is melted then wax is added. The colorant is dissolved in paraffin for about 45 minutes then added to the mixture of plastic and wax. The women prepare floor polish with the aid of their husbands at home. They use an open space, a drum and fire wood. The quantities used in the formulation are estimated as a result of their vast experience in the business.

According to the women, their formulation is always perfect and their business has since established permanent customers who prefer to use the home made floor polish over the commercially available ones. Every formulation made produces a twenty litre bucket of floor polish which will produce roughly twenty 300ml tins. The tins can be sold on an average of four days if it is during busy times such as festive seasons, month-ends, public and school holidays. Red floor polish is reported to be in high demand. The sales are done through cash or Eco cash and when in town the product is not sold on credit except at homes in the low-income residential areas. Another young woman from Norton a small town in Zimbabwe was also interviewed. She also produced homemade floor polish. According to her response, the formulation of the floor polish was the same as the one described above. Plastic waste for the formulation is collected from local shops in Norton. The young woman was however fortunate sometimes as she got floor polish orders from some local schools.

The polymer is a major ingredient of floor polishes often referred to as the backbone of the formulation. In the projects described above plastic waste being, polymers were used during formulation of the floor polish. Floor polish offers a thin hard protective film on floor surfaces whilst beautifying the floor. Polymers play a significant role in determining the ultimate quality of the floor polish. Properties determined by the type of polymer in the floor polish include ultimate gloss quality, removability, toughness, hardness and ability to resist scratch, water, soil, detergent and slip. Quality floor polishes may contain as much as twenty five ingredients however; the main components of the formulation are polymer emulsions, film formers, modifiers, preservatives and water. However, some simple floor polishes may just

contain three classes of ingredients namely: polymer backbone, film formers and modifiers. Film formers are also known as solvents which are classified as coalescing agents and plasticizers. In the projects described above a coalescing agent which evaporates shortly whilst leaving behind a continuous film without flaws was used. Containers should be kept closed to prevent loss of the coalescent agent as this will lead to poor adherence, low gloss and poor durability. Modifiers such as wax will be used in order to make the film soft and the floor polish buffability. Waxes are low molecular weight polymers.

4. Other Methods of Reducing Plastic Waste In Zimbabwe

There are various methods which are employed in reducing plastic waste in Zimbabwe as this section seeks to show.

4.1 Construction of plastic vegetable and flower bed ridges

This study has shown that a few households collect empty 1 litre and 2litre PET plastic waste bottles which then are used for the construction of ridges that surround vegetable gardens or flower beds. The empty containers are filled with water or sand. When the empty PET containers are filled with water, they are placed with the bottle opening facing up. In the case where soil is used to fill the empty bottles, they are placed in an upside down manner, where the bottom is facing upwards. According to the owners of the gardens, these types of ridges are advantageous over the conventional soil ones in a number of ways. The advantages of using plastic waste incorporated ridges are

a) Durability- these ridges are not easily destroyed as they do not degrade like the conventional soil ones hence they often last longer
b) Promotion of a clean environment - Plastic waste that usually lies idle in drainage systems or to be collected by the municipality is used productively for a good purpose
c) Creativity – the use of these plastic waste containers as components of ridges promotes creativity, in most cases witnessed varying colors being used in an colorful manner which attracts the eyes
d) Reduction of soil loss- soil is not easily washed away from the vegetable and flower beds into the surroundings since the plastic waste ridges can be washed away by water

4.2 Use of plastic waste as packaging containers

The interviews conducted also revealed that in some homes especially in rural areas empty containers of PP plastic waste are reused for packaging peanut butter. Some school children use the PET plastic waste water and juice containers to refill with juice and this is a very common practice in both rural and urban areas. Empty clean PET plastic waste containers previously containing water or juice are also used to store water in a number of homes. According to a young man interviewed, he collects plastic

waste for packaging his home made detergents for sale to the local community. Empty HDPE buckets of paint or cooking oil are washed and sold to the community for various uses such as storing of water, mealier meal, fetching water and the like. Large empty plastic waste containers of food stuffs are often reused as food canisters and lunch boxes. However, these methods are on a very small scale, they do not contribute significantly to the reduction of plastic waste in towns, and these generate little income for entrepreneurs.

4.3 Plastic waste management in Zimbabwe

The discharge or disposal of any solid waste which causes pollution in the environment or ill-health to living organisms is prohibited in Zimbabwe (The Herald, 7 September, 2011)

4.4 Roles of the Environmental Management Agency (EMA) in controlling plastic waste

The Environmental Management Agency (EMA) has been serving as a watchdog for environmental sustainability at both local and national levels. (Mapira, 2011). According to the Environmental Management Act Chapter 20:27, Section 10 , *EMA is entitled to assist and participate in any matter pertaining to the management of the environments whilst regulating and monitoring the collection, disposal, treatment and recycling of waste*; (Environmental Management Act 20.27).

In order to control the use of plastic in Zimbabwe, Statutory Instrument 98 of 2010 was gazetted. This was followed by the ban of plastic packaging with a wall thickness of less than thirty micrometers. However, the packaging used on bread and clingy wraps was excluded from the ban together with biodegradable plastics (www.ema.co.zw plastic packaging and plastic bottles regulations statutory instrument 98 of 2010)

4.5 Roles of local authorities in controlling plastic waste

The Urban Councils Act (CAP 29:15) stipulates that local authorities are responsible for solid waste collection like plastic waste, cleansing inspection, street cleaning services, issuance of waste disposal permits as well as waste disposal services in the urban areas. (Urban Coucils Act: CAP 29:15). Hence, local government plays a vital role in managing solid waste in order to create and promote a sustainable environment. The municipal By-laws also play a pivotal role in promoting a clean environment.

5. Challenges of Plastic Waste Management

In general, there are several challenges of plastic waste management in Zimbabwe. These are listed below.

5.1 Public unawareness

From the interviews conducted, a significant number of the public was unaware of the dangers of littering plastic waste in open spaces as well as backyard incineration. Development committees and residents associations were not active in implementing a sustainable plastic waste management. The public needs to be educated on the fact that waste is their own disadvantage. (Bgwoni, 2015)

5.2 Poor communication between important stakeholders

The communication levels between important stakeholders such as communities, local civil society organizations, councilors and technical personnel in local authorities are poor. All these stakeholders play important roles in plastic waste management. The public interviewed was ignorant of the different acts that protect the environment together with the different organizations driving those acts (TARSC, 2010).

5.3 Poor implementation of the legal legislation governing plastic waste management

EMA and local government attributed their lack of effectiveness in implementing different legislations that govern the control of plastic waste to lack of financial resources. Financial resources drive different programmes such as public awareness campaigns, purchase service and maintain the refuse collection fleet (Bgwoni, 2015)

5.4 Shortage of resources and technical personnel

There is a shortage of resources to manage plastic waste. In Masvingo city there is no plastic recycling company that is locally available. There is reported to be a shortage of technical personnel and technology required for recycling plastic waste on a large scale. There is also lack of adequate equipment to use at household levels such as bins. In communities, there is a lack of recycling services, central collection points, good road networks and community bins (TARSC, 2010). Local authorities are also faced with serious shortages of refuse trucks, adequate personal and shortage of adequate protective clothing for employees who collect refuse.

5.5 Lack of compliance of the community to the existing legislations on management of plastic waste

From the questionnaires and group discussions conducted there is evidence of resistance of the community to comply with the different legislations governing the control of plastic waste. This is clearly evidenced by plastic waste litter found on almost every open space in and around Masvingo city. A significant portion of litter on open dumpsites is plastic waste.

5.6 Irregular waste collection schedules

Masvingo city often tries to meet their schedules of refuse collection however, at times, the schedule is not met and this contributes to the littering of plastic waste. According to the responses obtained from the questionnaires, no communication is made prior to

the disruption of the refuse collection schedule hence the public often litter on open dumpsites.

6. Implications for Sustainable Development in Zimbabwe

At the global level, there is a massive proliferation of plastic waste, which is a major threat to natural ecosystems (Miller, 1994). In grazing areas, cattle which consume plastic waste develop health problems which often lead to death due to the nature of the product. As mentioned previously, unlike other forms of waste, plastic is not easily biodegradable. Recently, the United Nations Environment Programme (UNEP) headquarters in Kenya has banned the disposal of plastic products on coastal areas (UNEP Report, Nairobi, 12/2/2018). Plastic waste in Kenya has been known to endanger aquatic creatures in coastal regions of the country. SD has been defined as a form of development which seeks to meet the needs of the present without preventing those of future generations to meet their own (WCED, 1991). There are at least three forms of SD, namely ecological, economic and social SD. While ecological SD seeks to protect the natural ecosystems against further damage, economic SD is geared toward the generation of profit in the exploitation of natural resources. Social SD, on the other hand addresses issues of social justice by championing the needs of the poor.

Obviously, these goals are contradictory and attempts should be made to reconcile them. The recycling of plastic waste can be viewed as a major stride towards safeguarding the natural environment against further damage. As mentioned previously, plastic waste has also been known to be useful in the production of diesel, bricks and crayons. An intensification of such recycling activities is necessary as it reduces the amount of plastic materials which are disposed on the environment. Zimbabwe and other African countries should follow the example of Kenya in banning the widespread disposal of plastic waste. In recent years, Zimbabwean plastic bags have been sold to shoppers as a deliberate strategy to discourage the consumption of this type of waste. However, the price of plastic bags has proved to be non-prohibitive.

7. Recommendations on Plastic Waste Management

Various recommendations can be adopted in an attempt to deal with challenges of plastic waste disposal in Zimbabwe.

7.1 Introducing community based waste management organizations

Community based organizations are defined as a group of whose interests are to meet the needs of their respective communities. Although they have been functional in Masvingo city, their performance has since declined and their significance has greatly reduced (Bgwoni, 2015). The community based waste management organizations play important social, economic and environmental roles in communities. The involvement of such groups creates an integrated approach to solid waste management. The

engagement of community based organizations improves knowledge and awareness of the public on dangers of plastic waste. These types of organizations also give the public a sense of ownership and responsibility of their environment.

7.2 Promotion of the 3Rs method

The 3Rs method involves reducing, re-using and recycling plastic waste thus reducing the amount of waste generated. (Bgwoni, 2015). Volumes of waste are reduced prior to disposal. Under this method, plastic waste is reused in its current form. Plastic waste can also be a direct or indirect raw material for a new product. (TARSC, 2010)

7.3 Waste segregation at the source

Waste segregation promotes recycling whilst limiting waste produced. Segregation is important for the management of waste. However, from the questionnaires the public was not supporting the idea of segregation as it cited the inconvenience of doing this and the fact that waste will now occupy more space. Hence, there was a need to increase public education on problems associated with plastic waste. In order to promote this practice incentives might be important to facilitate the practice (TARSC, 2010)

7.4 Intensifying education awareness campaigns

These awareness campaigns are important so as to enlighten the public on the dangers of plastic waste accumulation and importance of waste management. (Bgwoni, 2015). EMA should intensify campaigns on environmental laws and policies (solid waste). The public needs to be educated on the fact that waste is their own disadvantage. Zero litter training seminars could be conducted in urban centres and schools. Media can play a vital role in educating the public by broadcasting in Radios, Television and the press on how to manage plastic waste

7.5 Charging fines on illegal waste disposal and volume of waste generated

In America, a known as Pay As You Throw (PAYT) system has been introduced which has led to the decrease in waste generated by the community. A polluter pay fine can also be introduced where a fee is paid upon littering. In Zimbabwe Harare Institute of Technology (HIT) has been practicing a polluter pays fine which has seen the university having the cleanest campus in Zimbabwe.

7.6 Promoting an integrated approach to solid waste management

The government, relevant government ministries, Non-Governmental organizations (NGOs), Environmental Agencies and the general public need to fully participate in the management of solid waste including plastic waste. The relationship within the different stakeholders should improve where differences should be set aside and work together to solve the environmental problems caused by plastic waste.

8. Conclusions

This paper has examined the challenges of plastic waste in Masvingo (Zimbabwe). A product of modern industrialization, plastic waste poses a serious threat to the natural environment. This is mainly due to its failure to biodegrade once disposed into the natural environment. The paper has shown how some members of the informal sector have put plastic waste to use through the production of home-made floor polish which is eventually marketed in some public places. Plastic waste has also been used to produce diesel, bricks and crayons. Such products tend to reduce the amount of pollutants in the environment thereby promoting SD at the global level. Since plastic has proved to be very useful in our daily lives, it would not be wise to ban its production. However, recycling would be a more plausible approach. Bricks made out of plastic have proved to be quite durable in the construction industry.

On the other hand, the conversion of plastic waste into home-made floor polish reflects the ingenuity of ordinary people in the recycling of potential waste. It is recommended that municipal authorities should provide bins meant for different forms of waste so that those who need the waste for further processing find it easy to retrieve it. Another suggestion is to encourage industries to embark on the processing of some wastes into consumable products such as those mentioned above. Eventually, very little waste would have to be discarded as most would have been recycled to produce other goods. In this way, the problems of waste disposal would have been drastically reduced thereby promoting SD at both national and global levels. This would also generate employment for thousands of unemployed citizens in the city.

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References

1. Agnieszka Ćwik. 2014, Fuel from Waste - Catalytic degradation of plastic waste to liquid fuels. Techico Lisboa and the Looming Waste Crisis.
2. Atul Singh, Vaibhav Gupta 2017 Experimental Study on Plastic Waste Material in Concrete and their applications. *International Journal of Enhanced Research in Science, Technology & Engineering.*
3. Balamurugan, U. V. Goutham 2017 Effective Utilization of PET Bottles in Self-Compacting Concrete International Conference on Emerging trends in Engineering, Science and Sustainable Technology.

4. Bgwoni, T. T. 2015 'The Role of Community Based Organizations in Solid Waste Management. A Case of Masvingo Urban, Zimbabwe', Department of Geography & Environmental Studies, Midlands State University, Gweru
5. Hansen, Erik et al. 2013 Hazardous substances in plastic
6. European Bioplastics 2015 Mechanical Recycling. www.european-bioplastics.org
7. Girish, Luthra CMDC. Business Models for conversion of waste plastic to fuel. GEPIL Group of Companies. www.hazwasteindia.com, www.gepil.in Ilda T. Hershey, MS and Nicole L Wolf. *Journal of Chemical and Pharmaceutical Sciences.*
8. Mapira, J. 2011 Challenges of Solid Waste Disposal and Management in the City of Masvingo, Zimbabwe, *Journal of Social Development in Africa Vol 26 No 2*: 67-91
9. Michael Belliveau, Stephen Lester 2014 The Poison Plastic, Health Hazards
10. Miller, G. T. 1994. *Living in the Environment: Principles, Connections and Solutions*, Wadsworth Publishing Company, Belmont
11. Mohamed M. Garib Alla, Ahmed Ahmed, Babiker K. Abdalla 2014 Conversion of Plastic Waste to Liquid Fuel. *International Journal of Technical Research and Applications*.
12. Moinuddin Sarker, Mohammad Mamunor Rashid 2012 First Simple and Easy Process of Thermal Degrading Municipal Waste Plastics into Fuel Resource. *IOSR Journal of Engineering (IOSRJEN)*
13. Oumaya Yazoghli, R. M. Dheilly, Michèle Quéneudec 2005 The valorisation of plastic waste: thermal conductivity of concrete formulated with PET.: https://www.researchgate.net/publication/263392405.
14. Pavani, P. T. Raja Rajeswari, 2014 Impact of Plastics on Environmental Pollution.
15. Rajaram, E. S, 1997 Plastic recycling in Bangalore, India, UWEP, Bangalore
16. Science for Environment Policy Report 2011 Ecological and Human Health Impacts.
17. Sharjah Municipality. Harmful Effects of Plastic.
18. The Dangers of Backyard Trash Burning. http://osufacts.okstate.edu into a Resource. URL IETC: http://www.unep.or.jp/
19. Training and Research Support Centre (TARSC) Civic Forum on Housing (CFH). 2010 'Assessment of Solid Waste Management in three local authority areas of Zimbabwe, Report of a Community Based Assessment: Discussion Paper, TARSC, Harare
20. United Nations Environment Programme (UNEP) 2009 Converting Waste Plastics
21. United Nations Environment Prorogramme (UNEP) 2018, UNEP Headquarters, Nairobi
22. Urban Waste Expertise Program 1997 Plastic Recycling in Bangalore, India
23. Vanitha, S. V. Natrajan and M. Praba 2015 Utilisation of Waste Plastics as a Partial Replacement of Coarse Aggregate in Concrete Blocks. *Indian Journal of Science and Technology*.

24. Vijaykumar B. Chanashetty and B.M. Patil 2015 Fuel from Plastic Waste. *International Journal on Emerging Technologies*
25. Women in Europe for a Common Future. Dangerous Health Effects of Home Burning of Plastics and Waste. http://www.arb.ca.gov/smp/resburn/resburn.Htm
26. WCED, 1991 *Our Common Future: World Commission on Environment and Development*, Oxford University Press, Oxford
27. Zimbabwe Television (ZTV) Morning News 29/ 03.2018