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The Environmental effects of dumped sachet (Polyethene) water on soil

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ABSTRACT

This research aimed at assessment of effects of water sachets on the environment and isolation and identification possible of bacteria that are presumably associated with biodegradation of the sachet from dumped soil as well to achieve, samples of three pure water sachets from the same company were collected and labeled A, B and C, cultured and transported to the laboratory for microbial isolation and identification. The packaging of sachet water is made of non-biodegradable synthetic polyethylene (polyethene), which does not decay, decompose or corrode, and which when burnt, produces oxides of carbon, nitrogen and Sulphur. However, the use of sachet water has become a menace, for its negative long-term environmental consequences, namely the vast increase in polythene waste that needs to be degraded. When one walks around large metropolitan areas in Nigeria, the polythene wastes that constitute the majority of litter is unavoidable and also the used sachet water bags constitute an alarming portion. Nigeria's total landmass is 923,768 Km^2 and from these calculations, it is obvious that the country generates approximately about 990,344 Km^2 (area) of sachet water waste daily which is larger than the total landmass of the country (Tiwary, 2015). The problem of solid waste disposal is alarming in urban centers of the country and is a major concern to the government.

Introduction

Wastes generally render our environment unfriendly and the worst of them all are those wastes that are non-biodegradable and as such, wastes of these forms pose a serious threat to our environment. One of these categories of non-biodegradable wastes is pure water sachets. They are found in virtually every part of Nigeria and various attempts have been made to biodegrade these pure water sachets. One of these attempts was carried out by (Nwachukwu, *et al*, 2010) in their research paper titled "Occurrence and recalcitrance of polythene bag wastes in Nigerian soils" where they attempted to biodegrade pure water sachets by burying them in the soil and subjecting them to acid and alkaline treatments with strains of Pseudomonas Spp. All these attempts proved abortive as the pure water sachets could not undergo the process of biodegradation.

Sustainability of the environment is an important factor influencing sustainable socioeconomic development of any community. However, anthropogenic practices have contaminated the environment to such an extent that managing and maintaining healthy environmental conditions has become a worldwide problem. Rapid urbanization and population growth in the last half century have outpaced government efforts to maintain and expand potable water infrastructure in Nigeria, and the private sector has responded with an easy – but environmentally threatening – solution. Stoler, *et al*. (2015) in their study asserted that, Sachet water, known colloquially as *"pure water"* has out competed nearly all alternatives to the unreliable government water infrastructure to become the country's cheap, mobile, and omnipresent answer to the country's urban water crisis. He further stresses the "pros" of sachet water – it is reliable, portable, potable, inexpensive, and available where pipe water is not, outweigh the "cons", the fluctuations in industry hygienic quality and locally generated waste.

The packaging of this sachet water is made of non-biodegradable synthetic polyethylene (polythene), which does not decay, decompose or corrode, and which when burnt, produces oxides of carbon, nitrogen and sulphur. However, the use of sachet water has become a menace, for its negative long-term environmental consequences, namely the vast increase in polythene waste that needs to be degraded. When one walks around large metropolitan areas in Nigeria, the polythene wastes that constitute the majority of litter is unavoidable and also the used sachet water bags constitute an alarming portion. Nigeria's total landmass is 923,768 Km^2 and from these calculations, it is obvious that the country generates approximately about 990,344 Km^2 (area) of sachet water waste daily which is larger than the total landmass of the country (Tiwary, 2015).

The problem of solid waste disposal is alarming in urban centers of the country and is a major concern to the government. This problem of waste generation and disposal is worrisome in Borno state, where it is always on the increase because of increasing population pressure and socioeconomic factors. Several environmental impacts including blockage of waterways and choking of animals, soils and mosaic litters of pure water sachet in the landscape requires urgent attention. The effects include, Increase disease transmission, contamination of ground and surface water, generation of Greenhouse gas emissions and other air pollutants, damage to ecosystems, injury to people and properties (Idiata & Iyasele, 2014)**.** Rapid urbanization, rural-urban migration, little or no town planning efforts coupled with attitudinal irresponsibility, lack of political will, ineptitude and graft have independently and collectively created environmental challenge in Nigeria resulting to human or solid waste decorating streets and public space everywhere in the country (Oyeniyi, 2011). Sachet water waste disposal is a vast problem that needs to be tackled because of the implications it has on biophysical environment such as soil, vegetation, air, water and on health. Mojekeh and Eze (2011), were of the view that nylon/plastic waste constitute serious environmental problem in Onitsha, unavailability/inaccessibility of waste recycling facilities, indiscriminate disposal of empty sacs of sachet water on roads/streets and gutters/drainages; pollution rate in Onitsha is environmentally non conducive for living especially in Okpoko (New Haven), Fegge and Odakpa areas of Onitsha; generally, consumers, producers and government are jointly and severally blamed for environmental pollution of littering streets with empty sacs of sachet water.

Ezeokpube and Obiora, (2014), in a study investigated the level of consumption of sachet water in Nsukka Urban, and find out high level consumption of sachet water in all the wards with University ward ranking highest (72%). It further shows that students were the highest consumers of sachet water (61%). High level consumption of sachet water in the study area invariably will lead to the high generation of sachet water wastes. In Uganda, (Mutagamba, 2007) noted that the effects of poor sachet water wastes disposal on the environment lead to loss of soil fertility because they cannot rot and decompose. He was of the view that polythene sachet water has an acidic combination of sulphur-oxide which with time disturbs the chemical formulae of the soils. He suggested that recollection of these sachet water wastes for recycling, by the producing companies will go a long way in solving these problems.

Babatunde and Biala (2010), noted that the oxides of carbon, sulphur and nitrogen produced from disposed water sachets cause various health problems such as cancer, carboxyl-haemoglobin, brain damage, dizziness, headache, fatigue, lethargy, respiratory problem and eye irritation. The resulting environmental ills from burning the sachet waste pose extreme health hazards to people (both consumers and non-consumers) exposed to them, such conditions according to (Adenuga *et al*, 2006) can precipitate epidemics and national health crises. In Nigeria, (Akunyili, 2003) noted that the disposal of waste generated from the production and consumption of packaged water including sachet water, constitutes an aspect of health and environmental hazards. She stressed that generally pollution affects not only the polluters but also the non-polluters, that is, it has external effects (externality) on those who are not responsible for the pollution especially during burning.

CONSUMPTION OF SACHET WATER

Health authorities have suggested that people drink at least eight (1.89 liters) glasses of water per day (USEPA, 2016) and the British Dietetic Association recommends 1.8 liters (Greenhalg, 2001). Howard and Bartram (2003), in a World Health Organization report, "Domestic Water Quantity, Service Level and Health" estimated requirements based on a 70 kg adult male, and a 58 kg adult female, under average conditions, estimated that adult females needed 2.2L/day and males 2.5L/day.

According to (Edoga et al, 2008) over 70 percent of Nigerian adults' drink at least a sachet of water per day resulting in about 50 to 60 million sachet water waste disposed daily across the country. If such quantities of sachet water waste are generated daily, there is need for their proper disposal. Improper disposal of the sachet waste will expose the country to environmental problems on soil, vegetation, air, water and on health. Tiwary (2015) in his study estimated the daily average need of water for man is between 2-3 litres for drinking alone. The average consumption is 2.5litres per day i.e. approximately 4.5 packs (60cl) consumed per day, which translates to generating 4.5 empty sachets of waste per person per day. The average area of a sachet water pack is approximately 0.0211m. The empty water sachets are not segregated before disposal. Rather they are thrown outside the house premise or any common area of garbage dump within a locality, mixed with other decomposable and non-decomposable waste items.

From the figures above, about 30-50% of the waste generated find their way to the nearest surface water body were all the drains are connected to, thereby polluting these water source(s), while the organic waste pose a lesser danger to the environment as it can easily decompose, waste nylons and plastics pose serious environmental issues and nuisance to the environment (Idiata and Iyasele, 2014). They are non-biodegradable. It is estimated that it takes between 30 to 40 years for a nylon fabric to decompose. This reduces water infiltration into the soil, land degradation, and can also make landfill site to fill up quickly. Burning of waste nylon and plastic bottles can cause air pollution. Poisonous gases such as carbon monoxide, furans and dioxins are released to the air. They can endanger public health, destroy the ozone layer and contribute to global warming.

A creative potable water solution barely two decades old, the fact that sachet waste can be found in even the most remote villages could lead an outside observer to believe the sachets have been around since the dawn of plastics (Stoler, 2013).

SACHET WATER PACKAGE (WASTE)

Narrowing down to Borno state, with population of 4,151,193 National Population Commission census, (2006) is not an exception to the menace of pure water sachet pack disposal. Different authors like (Fox, 1996; WHO, 2004; Tiwary, 2015), had estimated the daily water need for man as between 2-3 litres for drinking alone. The average consumption is 2.5litres per day i.e. approximately 4 to 6 packs (50cl) consumed per day, which translates to generating 4 to 6 empty sachets of waste per person per day. The average area of a sachet water pack is approximately $0.0211m^2$. Edoga, *et al*; (2008), was of the view that 70% of the population defend on pure water for their daily drinking water needs.

The average daily waste generated from pure water sachets and area covered by the waste in Borno state may be estimated on the table below;

Table 1. Sachet waste generated in Borno state per day and area covered

Borno State population	Sachet water waste generated (population x sachet consumed per day)	Area covered by waste Km^2 (sachet area x waste generated)	70% of the people drink pure water for their daily drinking needs (sachets consumed\day)

4,151,193	20,755,965	437,950.8	14,529,370.5

These wastes generated from pure water sachet alone would in no distant future affect the ecological footprint of the state. Ecological foot print can be defined as the impact of human activities measured in terms of the areas of biologically productive land and water required to produce the good consumed and to assimilate the waste generated.

The problems of waste disposal and generation in Borno state especially that of pure water sachet pack is alarming and would continue to be a problem as thousands of pure waters are produce daily to meet high demand. All polythene including pure water sachets are known to be non-biodegradable i.e. they cannot decompose like other organic waste, it is therefore not advisable for them to be land filled or buried as they affect the soil structure, composition and the level of microbial activities in the soil. Scientifically, it is not advisable to incinerate (burn) polythene products, as this is known to generate air-borne poisonous gases such as carbon monoxide, Sulphur, nitrogen and a range of other dangerous air pollutants which causes variety of human health problems like; respiratory diseases. The burning of plastics and other waste materials is also known to cause damage to the ozone layer, which equally causes so many ill health and environmental degradation.

Since pure water sachet cannot be buried or incinerated, the only means of adequately taking care of several millions of tonnages of sachets being produced in the course of drinking pure water is through the process of biodegradation and recycling.

Biodegradation of Polyethene

In biodegradation, microorganisms are used to break the strong carbon bonds through microbial actions that reduce the strength of polythene (as molecular weight decreases) and hence polythene gets degraded. Polyethylene can be degraded through two ways aerobic as well as anaerobic. In aerobic degradation oxygen acts as an electron acceptor and final products are carbon dioxide and water (Seymour, 1989). Anaerobic biodegradation occurs in absence of oxygen and therefore microorganisms use nitrate, sulphate and iron as electron acceptor (Datta, *et al*., 1998). Biodegradability may be evaluated by weight loss, tensile strength loss, changes in percentage elongation and changes in polyethylene molecular weight distribution.

Recycling of Polythene

Green recycling is defined by Environmental Protection Agency (EPA) as "the separation and collection of materials that otherwise would be considered waste, the processing and re-manufacturing of these items into new products, and the use of the recycled products to complete the cycle. Sachet water pack is made from thermoplastics. Thermoplastics, which accounts for 87 percent of plastics sold (Idiata and Iyasele, 2015), are the most recyclable form of plastics because they can be re-melted and reprocessed, usually with only minor changes in their properties.

Nylon or cellophane is non-biodegradable but its strength while in water or soil deteriorates with time. During the deterioration period, the chemicals with which, the cellophane is composed are gradually released and thus polluting the soil or water for upward of 40 years. Therefore, the amount of sachet waste generated influences the level of environmental threat (Tiwary, 2015).

The objectives of the study are; assess the effect of pure water sachet on the environment, Isolation of bacteria that are associated with biodegradation of the pure water sachet from dumped soil, Compare the initial weight of the pure water sachet with the final weight of pure water sachet and Suggest ways of riding the environment of pure water sachet waste

Methodology

Experimental sites

Three sites were selected for the study, they were an old refuse dump (site A), near a refuse dump (site B) and a plain ground near the Biology lab (site C) all within Ramat Polytechnic Maiduguri. The three sites were pegged for ease of identification. The holes were dug to a length of about 1 ft. to bury the pure water sachets.

Sample Collection

Three pure water sachets from the same company were collected and labeled A, B and C. The initial weight of the sachets was taken. After 2 weeks, they were removed carefully and weight taken again according to the site they were removed. The pure water sachets were taken to the laboratory for microbial identification. After taking the soil sample for culturing, the sachets were washed, room dried and weight using weighing balance in grams. These processes were repeated twice, at 2 and 4 weeks. The identification of microorganisms by gram staining technic was carried out in Biology lab, department of SLT, Ramat Polytechnic Maiduguri.

Data analysis

Simple percentage was used to determine the difference between the initial weight and the final weight of the pure water sachet.

Table 2. Presents the result of the weight of the three pure water sachets buried at three different locations

site	Initial wt(g)	wt at 2wks(g)	wt loss(%)	wt at 4wks(g)	wt loss(%)
A	1.7	1.5	20	1.3	40
B	1.7	1.4	30	1.3	40
C	1.7	1.6	10	1.4	30

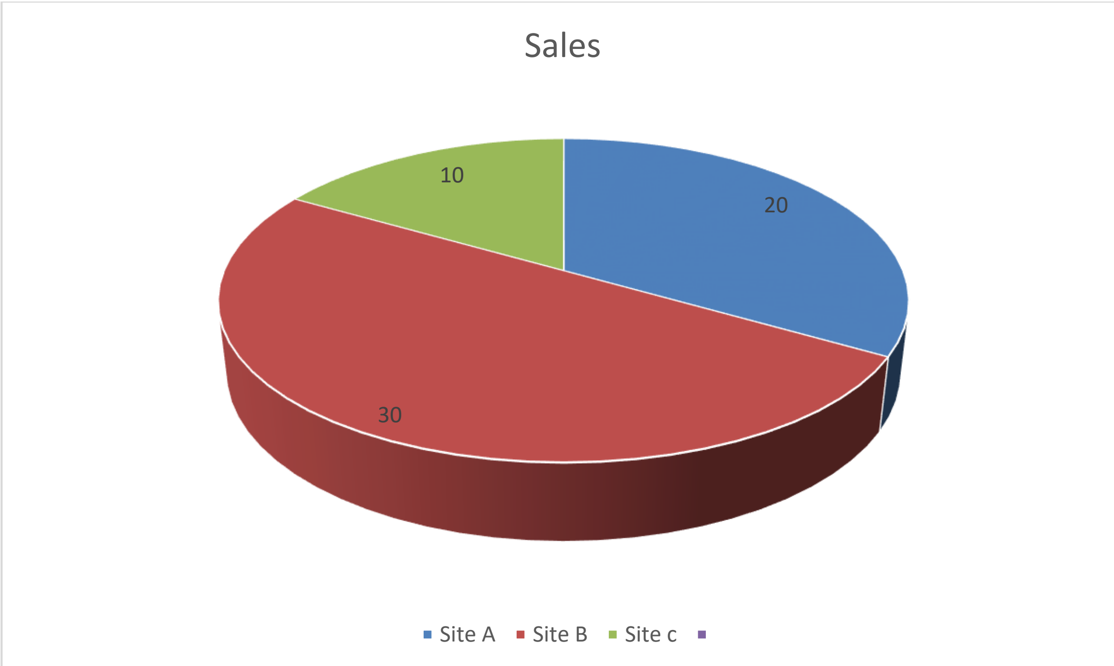

Fig. 1 Showing the percentage of pure water sachet buried at 2 weeks

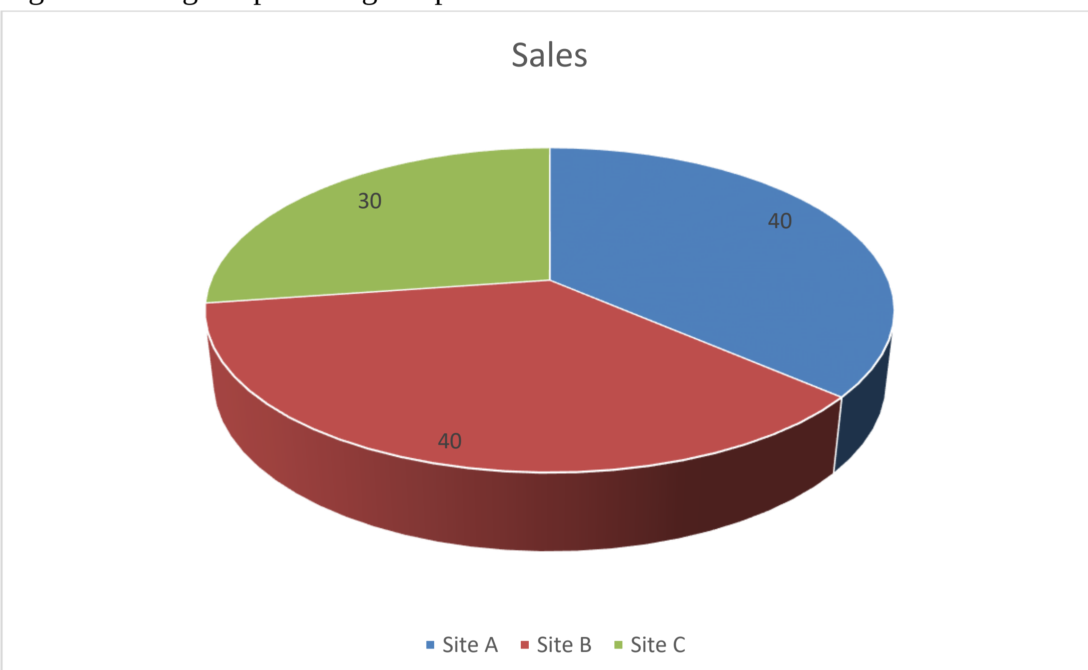

Fig 2. Showing the percentage of pure water sachet buried at 4 weeks

The weight of the pure water sachet in site A was found to be 1.5g which translate to 20% lose from the initial weight of 1.7g. After 4 weeks, the weight further reduces to 1.3g which was 40% of weight loss from the initial weight. At site B, the weight was 1.4g at 2 weeks while it reduces to 1.3g at 4 weeks which is 30% and 40% of the initial weight respectively. Weight loss of site C was 1.6g at 2 weeks which is 10% of the initial weight and it reduce to 1.4g at 4weeks which is 30% of the initial weight.

The mechanism of degradation of polythene may be due to environmental factors which may include microbes, moisture, heat, etc. Microorganism secrete compounds extracellularly that may break the complex molecular structure of polythene. Biodegradation is governed by different factors that include characteristics of polymer, type of organism, and nature of pretreatment. The characteristics of polymer such as mobility, crystallinity, molecular weight, functional groups and substituents present in its structure, and plasticizers or additives when added to the polymer all play a significant role in its degradation (Artham and Doble, 2008)

Gram staining

Gram staining was done to examine cell shape and gram reaction using the method of ((Buchanan and Gibbons, 1974).

Figure 1. The isolates in the lab

Results

Table 2. Presents the result of the gram staining on three different pure water sachets buried in three different location

Site	Colour	Shape observed	Characteristics
A	Purple	Cocci	Gram +
B	Pink	Cocci	Gram -
C	Purple	Cocci	Gram +

The result of the isolation of microorganism by gram staining on specimen A and C were observed to be purple in colour, cocci in shape and characteristics were gram positive, the suspected organism was staphylococcus. Specimen B was cocci in shape, pink in colour, characteristics was gram negative and the suspected organism was bacillus. On physical observation of the specimen, the surface of the polythene was rough to the touch and when pulled from the edges it comes apart, which suggest that it has lost it tensile strength.

Microorganisms degrade natural polymers and synthetic polymers by the process called biodegradation. Polymers like polyethylene are used as substrate for microorganisms' growth when they are being degraded. Degradation of polymers can be indicated by cracking, erosion, discoloration, and phase separation. Though, biochemical test was not performed to confirm the species isolated from the sachets but the study was similar to the works of (Divyalakshmi and Subhashini, 2015) in the biodegradation efficacy of *Desulfotomaculum nigrificans* and *Pseudomonas alcaligenes* on polythene bags. The *Pseudomonas alcaligenes* was found to be more effective than *Desulfotomaculum nigrificans* in degradation of polythene bag at 30 days, as the incubation period increased, there is a dramatic increase in weight loss of polythene bag.

In this study the weight loss of pure water sachet after the 4th week at site A and B were found to be 40%, while that of site B was 30%. This may be because of different organism were found on the sachet and the location of the site where they were buried may have different environmental condition. The presence of other genera apart from the dominating ones shows that more than one bacteria could be responsible for the degradation of a particular type of polythene. The field tests such as burying plastic samples in soil have been widely conducted for their biodegradation because of the similarity to actual conditions of use or disposal. The biodegradation of plastics proceeds actively under different soil conditions according to their properties, because the microorganisms responsible for the degradation differ from each other and they have their own optimal growth conditions in the soil (Orhan et al. 2004).

Staphylococcus and Bacillus were also studied by (Kumar et al. 2007) on class 3 (HDPE) and class I (LDPE) polythene where Bacillus was found as the dominant genera, class 2 polythene had Staphylococcus as the dominant genera. There might be a possibility that these different genera could be responsible for the biodegradation of different types of polythene. For example, Staphylococcus must be contributing more towards the degradation of class 2 polythyene while Bacillus towards class 1 and class 3 polyethylene. Other studies reported that Bacillus sp. showed more degradation in different blends of poly (ε-caprolactone) and poly (vinyl butyral) (Rohindra et al. 2003).

The result of the study by (Vatseldutt, 2014) where Staphylococcus sp. was found to degrade plastic effectively on the basis of weight loss of up to 52%. Studies were also conducted to isolate fungi with ability to degrade polyethylene. Study by (Singh and Gupta, 2014) showed common soil fungi like Aspergillus, Mucor, Penicillium, Fusaarium etc has the ability to degrade LDPE up to 36%. *Staphylococcus arlettae* was also found to degrade azo dyes where the strain was isolated from textile effluent from an activated sludge process. The study showed that using this organism the sequential micro-aerophilic/aerobic stages were able to form aromatic amines by reductive break-down of the azo bond and to oxidize them into non-toxic metabolites. Kathiresan, (2003), in his study, demonstrated that microbes from mangrove soil (bacteria as well as fungi) are able to degrade plastics but at a slower rate. These microbes comprised of gram negative and gram-positive bacteria and eight species of fungi. Dominant species included Streptococcus, Staphylococcus, Micrococcus (Gram-positive), Moraxella, and Pseudomonas (Gram-negative) and two species of fungi (*Aspergillus glaucus* and *A. niger*). Thus, the work revealed that many plastic degrading microbes can be isolated from mangrove soil.

Moreover, mangrove soil from Niger delta was also studied for plastic degrading microbe population. Two Aspergillus species were isolated which were studied for degradation of Low-density polyethylene (LDPE) and high-density polyethylene (HDPE) films. The results obtained showed that the carbon source for the two Aspergillus species (*Aspergillus japonicus* and *Aspergillus terreus*) was polyethylene films. Thus, the results proved that fungi isolated form mangrove soil of Niger delta can be used for biodegradation of PE films. LDPE is the most common solid waste and accounts for 60% of total plastic production.

Sivan *et al.* (2006), isolated a biofilm producing strain of *Rhodococcus ruber* (C208) that degraded polyethylene at a rate of 0.86% per week. The ability of *Bacillus* species to utilize polyethylene, with and without pro-oxidant additives, was also evaluated by (Abrusci *et al.,* 2011).

Recently, Deepika and Madhuri (2015) reported that *Pseudomonas* specie have significant plastic degradation capacity and it degrades up to 24.22% for the period of 6 months. Similarly, (Kyaw et al, 2012) studied biodegradation of low-density polythene (LDPE) by *Pseudomonas* species. They reported that after 120 days of incubation period, the percentage of weight reduction was 20% in *Pseudomonas aeruginosa* (PAO1), 11% in *Pseudomonas aeruginosa* (ATCC) strain, 9% in *Pseudomonas putida* and 11.3% in *Pseudomonas syringae* strain. Nanda et al. (2010), compared the biodegradation of natural and synthetic polythene by three different species of pseudomonas. Pseudomonas spp from sewage dump was found to degrade polythene efficiently with 46.2% for natural and 26.1% for synthetic polythene while house hold garbage dump gives lowest biodegrability of 31.4% and 16.3% for natural and synthetic polythene respectively.

Microbial population is now being extensively studied for biodegradation of polythene. Microbial biodegradation uses enzymes to degrade the plastics. Some microbes also use these polymers as their sole carbon source thus degrading the polymer. The biodegradable pathways of these microbes should be studied to gain insight in the degradation mechanism

Conclusion

In conclusion, if polythene can be degraded by microbes, it will reduce solid waste which causes environmental issues. Since microbes are catabolically versatile, Borno state should use it to its advantage and identify microbes which can degrade polythene. Genome based studies should be done and degradation pathways should be studied to develop strategies using microbes to degrade polythene. Apart from biodegradation, the recycling of these polythene sachets would go a long way in ensuring cleaner and sustainable environment. It would provide job opportunities to youths who collect the discarded sachet and sell it to the recycling plant for a fee. The recycled polythene may be processed into pallets, threads or polythene sheets to be used as raw material by small scale industries, cooperative associations and interested individual to produce items such as polythene shopping bags, mats, hand fans and basket woven by women. Polythene waste that is non-biodegradable can be used for other purposes like preparation of bitumen after mixing with asphalt that can be used for road construction (Akinpelu et al., 2013; Gürü et al., 2014).

Temitope et al (2015), in their study, produce composite tiles from pure water sachet and water bottles. Furthermore, the recycling and biodegradation of these sachets would reduce the incidence of blocked drainage, animal choking to death and release of poisonous gases when burnt.

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