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RESEARCH PAPER

Physico-Chemical and Microbiological Assessment of Soils from Dumpsites for Plastic Degrading Microorganisms

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ABSTRACT
Plastic pollution is a threat to the environment because of its slow degradation rate and high usage. The aim of this study is to isolate plastic degrading microorganisms from soils. The soil samples used for this study were collected from dumpsites filled with plastic and plastic materials and the effectiveness of the degradation of plastic materials was studied over a period of six (6) weeks in broth and agar culture under laboratory conditions by weight determination method. Physicochemical and microbiological analysis was carried out on the various soil samples using standard protocols. The biodegradation of polyvinylchloride (PVC) was done in-vitro using the microorganisms isolated from the soil. Microorganisms that were able to degrade a higher percentage of the plastic materials were; *Staphylococcus aureus, Streptococcus sp, Bacillus sp, Escherichia coli Aspergillus niger, Aspergillus flavus* and *Trichoderma viridae.* The total viable count for bacteria and fungi were within the range of $11.8x10^5$ CFU/g to $2.0x10^{10}$ CFU/g and $3.3x10^5$ CFU/g to $0.1x10^{11}$ CFU/g respectively. *Staphylococcus aureus, Streptococcus sp, Bacillus sp, Micrococcus sp, Aspergillus niger, Aspergillus flavus,* and *Trichoderma viridae,* degraded plastic up to 25%, 31.2%, 25% 31.2%, 12%, 10% and 10% respectively. These isolates may be used to actively degrade plastics, thereby reducing the rate of plastic pollution in our ecosystem.
Keywords: Biodegradation, plastic, pollution, polyvinylchloride, wastes.

INTRODUCTION

Plastics are strong synthetic substances that consists of hydrocarbon based polymer and are non-biodegradable (Patil et al., 2018). They are polymeric material that is synthetic or semi-synthetic and can be moulded into any shape. Due to their versatility, durability and lightweight, they are used in the packaging and production of different materials needed to make life easy for man. They have become substitutes for glass, metal, ivory, horn, silk, cotton, and natural rubber (Phil, 2018). Basic materials used for the production of plastics are derived from coal, natural gas and oil (Afreen et al., 2020). They can be called “ubiquitous” because they can be found almost everywhere (construction companies, industries, corporate offices, our homes, schools, market, etc). Due to the daily production and use of plastics, the disposals of used plastics are not done efficiently thereby causing pollution in the environment. Therefore, in order to prevent plastic accumulation, adequate disposal system should be adopted (Hossain et al., 2019). Nonetheless, most synthetic plastics such as polyethylene, polypropylene, polystyrene, polyvinyl chloride and polyethylene terephthalate, are non-biodegradable, and their expanding collection in the climate has been a danger to the planet (Jambeck et al., 2015).

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Plastic pollution occurs as a result of the wide variety of plastic products produced and used by consumers. Plastic pollution is the build-up or accumulation of plastic and plastic products in our environment which is detrimental to the ecosystem (Laura, 2018). Thousands of tons of plastics are being discarded into our environment by natural events and human actions. This action cause adverse effect to the health and survival of a population (Hossain et al., 2019). Plastic accumulation can cause harm to the land, streams and seas. It is assessed that 1.1 to 8.8 million tons of plastic waste enters the sea from waterfront networks (coastal bodies and oceans) each year (Jambeck et al., 2015). It is assessed that there is accumulation of 86 million tons of plastic marine garbage in the overall sea as of 2013, with a presumption that 1.4% of worldwide plastics delivered from 1950 to 2013 has entered the sea and has amassed there (Jambeck et al., 2015). Biodegradation is a process whereby microorganisms break down organic substances into smaller compounds through metabolic or enzymatic processes (Phil, 2018). Plastic biodegradation is an environmental friendly method to degrade polyethylene and plastic products as it does not generate any harmful by products (Afreen et al., 2020). In microbiology, “biodegradation” means the decaying of all organic materials that is carried out by life forms comprising mainly bacteria, fungi, and protozoa. Through the process of degradation, hazardous toxic materials are made less toxic or non-toxic (Laura, 2018)). Microorganisms break down these materials into smaller form for them to be able to feed on. This serves as nutrients, carbon and energy source. When microorganisms degrade plastics through enzymatic actions, they cause a cleavage of the polymer chains into monomers and oligomers which are now further absorbed by the microbial cells to be metabolized (Patil, 2018).

The problem of plastic degradation has made plastic a major focus in solid waste management. The accumulation of these plastics in the environment is causing great damage to our ecosystem. Aquatic organisms are being suffocated due to excess plastic in the water bodies, and accumulation and disposal of these plastics in the environment could evoke a big ecological issue (Patil, 2018). There is an urgent need to find solution to this problem. The aim of this study is to isolate plastic degrading microorganisms from soils collected from several dump sites and landfills in Alimosho local government area of Lagos State.

MATERIALS AND METHODS

Alimosho is a Local Government Area in the Ikeja Division, Lagos State, Nigeria. It is the largest local government in Lagos, with 1,288,714 inhabitants. Alimosho is home to a good number of the working population in Lagos who lives on the Mainland and work on the Island. Soil samples were collected from different dump sites and landfills in Igando. Soluos community is situated at Ikotun/Igando Local Council Development Area of Alimosho Local Government in Lagos State, Nigeria. Three dumpsites are located in the Soluos community known as Soluos 1 (Closed), Soluos 2 and Soluos 3 (open). Soluos 1 covers about 7.8 hectares of land and located on (N06^{o} 34. 307’ , E003^{o} 15. 211’), Soluos 2 covers approximately 3.2 hectares and is located on (N06^{o} 34. 286’ , E003^{o} 15. 146) of land and Soluos 3 covers about 5 hectares and is located on (N06^{o} 33. 897’ , E003^{o} 15. 082’) of land (Salami & Susu, 2019). The Soluos landfills are located at the extreme east-west area of metropolitan Lagos in Alimosho Local Government. They are among the five active landfills currently operated by Lagos Waste Management Authority (LAWMA) (Adeolu & Tope, 2012). It is reported that Soluos 2 and 3 landfills receives 81,388 metric tonnes of MSW out of a total of 239,282 metric tonnes landfilled in December, 2011 (LAWMA, 2011). They receive waste from the entire Lagos metropolis and wastes are of different types, from domestic, commercial, and industrial sources.

A total of 16 samples were collected between June and August 2021, from three different dumpsites located at Igando, Alimosho LGA. The soil samples were specifically collected from areas populated with plastic bottles and nylon. The samples were collected using a soil auger at a depth of 10cm and transferred into a well labelled sample collection tube and transferred to Anchor University's microbiology laboratory for analysis.

All media (Nutrient agar, Potato dextrose agar, Mineral salt medium) were prepared according to the manufacturer's instruction;

The different physico-chemical analysis carried out on the soil samples are;

The pH was checked using pH meter (BANTE-510, China), the electrode of the pH meter was calibrated with standard buffer solutions with known pH values. 20g of the soil sample was diluted into 100ml of distilled water and stirred for some minutes. The pH value is recorded (Corwin & Yemoto, 2020)

Organic matter was assessed according to Oyeyiola & Agbaje, (2013). 16 crucibles were dried in the oven at 105°C for 24 h and cooled in the desiccators. After cooling, the weights of the crucible were taken separately and 1g of each soil sample was added into the different crucibles. The samples were heated on a Bunsen burner for 30 min with occasional stirring. They were transferred into desiccators to cool down and the weight was recorded.

Soil moisture content is the available water present in the soil that is necessary for plant growth and organism's survival. Sixteen (16) crucibles were dried in the oven at 105°C for 24 h, after which their weights was taken separately. 1g of each soil sample was weighed into each crucible. The samples were dried in an oven at 105°C for 24 h. The crucibles were made to cool down in the desiccators and the weight of each crucible was recorded (Oyeyiola & Agbaje, 2013).

100g of the soil sample was diluted into 200ml of distilled water and stirred for 30 sec and allowed to sit for 15 min, the solution is filtered into another clean beaker and measured using the conductivity meter (BANTE-510, China). The conductivity and total dissolved solids (TDS) value was recorded (Corwin & Yemoto, 2020).

Pour plate method was used to culture the organisms aseptically. Nutrient agar was used to culture bacteria and Potato Dextrose Agar (PDA) with antibiotics (Chloramphenicol to inhibit the growth of bacteria) was used to culture fungi. Mineral Salt Medium was used in screening the isolated organism, and determining the weight loss of the plastic material.

The isolates were characterized and identified based on their colony appearance, cellular morphology and biochemical reactions.

Lactophenol cotton blue stain was used in the identification of fungi isolates. A drop of lactophenol solution was placed onto a clean slide, the wire loop was sterilized using burner with blue flame. Using the wire loop, a small amount of the fungal culture was removed from the edge (younger colonies), the fungal culture was spread gently on the slide using the wire loop in order to tease out the fungal structures, and the cover slip was gently placed on the slide. The slide was examined under the microscope, the fungal elemental characteristic was detected, examined and recorded (Wanger et al., 2017).

The isolated microorganisms were screened to check their ability to degrade plastics and polyethene using Mineral Salt Medium (MSM) with the addition of agar-agar. Polyethylene and plastic powder were added to mineral salt medium at a final concentration of 0.1% respectively. The medium was placed in a shaker for 1h and autoclaved at 121°C for 20 min. The medium was poured into sterile plates and allowed to solidify. Wells were made in the agar using well borer and the isolated organisms were added into the well. The plates were then incubated at 30°C-37°C for 2-4 weeks and growth around the well was observed (Divyalakshmi & Subhashini, 2016). Media on Petri dish with the addition of polyethylene

terephthalate (PET) powder and without the introduction of microorganism were used as control.

Pour plate technique was carried out to test the plastic degrading ability of the isolates. The cell suspension of the culture was added to a sterile Petri dish, followed by the addition of warm nutrient agar media. The plate was swirled to ensure homogenization of the culture. The PVC strips were then aseptically placed on each plate containing the bacterial samples. The plates were placed in the incubator at 37° C for few weeks. The plates were periodically removed and the film was observed for any sign of microbial growth (Sharma et al., 2014).

RESULTS AND DISCUSSION

This study describes the isolation, identification and characterization of plastic degrading microorganisms from the soil. It is clear that microorganisms have the ability to degrade these synthetic plastics but takes a longer period of time due to the structure of the plastics. The total viable count for bacteria ranged from 11.8x 10^{5} to 0.2x 10^{11} CFU/g which shows that the soil is home to vast quantity of microorganisms. Some of the isolated bacteria are; *Staphylococcus sp, Streptococcus sp, Pseudomonas sp, Bacillus sp, Neisseria sp* and *Escherichia coli.* Table 1 shows that sample 4 had the highest total viable count and sample 3 had the lowest count.

Table 1: Mean bacteria count

Soil sample	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}
1	114.75±127.57	99.25±135.00	14.25±7.54	3.75±2.06	2.00±2.82	3.25±0.95	1.00±0.81
2	164.25±156.75	159.50±162.23	16.00±12.96	5.75±6.75	5.75±7.22	1.25±1.50	2.00±2.44
3	20.25±24.90	28.25±25.61	7.00±8.75	4.25±4.03	3.75±2.21	1.75±2.36	0.50±1.00
4	300.00±0.00	194.00±133.08	12.75±13.69	31.50±22.24	14.75±14.24	13.75±14.24	12.00±13.95

Table 2: Mean fungi count of the soil samples

Soil sample	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}
1	5.00±2.44	3.00±1.41	2.00±2.82	0.75±0.50	1.25±1.89	0.50±1.00	0.50±0.57
2	8.25±5.05	1.75±2.06	1.00±0.81	0.00±0.00	0.50±0.57	0.25±0.50	0.25±0.50
3	16.00±10.64	5.00±3.55	1.75±1.70	0.25±0.50	0.25±0.50	0.50±0.57	0.25±0.50
4	17.00±11.77	6.75±4.92	3.00±4.76	1.00±0.81	1.50±1.29	0.75±0.95	0.50±0.57

Table 2 shows that sample 4 had the highest viable count and sample 3 had the lowest viable count for fungi.

Table 3: Biochemical and microscopic test result

S/N	Ca	Ct	Ma	Coa	Oxi	Glu	Suc	Lac	Shape	Gram stain	Gas	H_2S	Pep	Probable organism
1	+	+	+	+	+	+	-	-	C	+	-	-	+	Staphylococcus aureus
2	-	+	+	-	-	+	+	+	C	+	-	-	-	Streptococcus pneumonia
3	-	-	+	-	-	+	-	-	C	+	+	-	+	Streptococcus faecium
4	-	+	+	+	+	+	-	-	C	+	-	-	+	Staphylococcus hyicus
5	+	-	-	+	+	+	-	-	C	+	-	-	+	Micrococcus radiodurans
6	-	-	+	+	+	+	-	-	C	+	-	-	+	Staphylococcus sp
7	+	+	-	+	-	-	-	-	R	+	-	-	+	Bacillus sp
8	+	-	-	-	+	+	-	-	C	-	+	-	+	Neisseria sp
9	-	-	-	-	+	+	-	-	C	-	-	+	+	Neisseria sp

S/N	Ca	Ct	Ma	Coa	Oxi	Glu	Suc	Lac	Shape	Gram stain	Gas	H_2S	Pep	Probable organism
10	-	+	-	+	+	+	+	+	C	+	-	-	-	Micrococcus luteus
11	+	+	-	-	+	+	-	-	C	+	-	-	+	Micrococcus radiodurans
12	+	+	-	-	+	+	-	-	C	-	-	-	+	Neisseria sp
13	-	-	-	+	-	+	-	-	C	+	-	-	+	Streptococcus equi
14	-	-	+	-	-	+	-	-	R	-	-	-	+	Escherichia coli
15	-	+	-	-	-	+	-	-	C	+	-	-	+	Streptococcus mitior
16	-	+	-	-	-	+	-	-	R	+	+	-	+	Lactobacillus sp
17	-	+	-	-	-	+	-	-	C	+	-	-	+	Streptococcus sp
18	-	-	-	+	-	+	-	-	C	+	-	-	+	Streptococcus agalactiae
19	+	-	-	-	-	+	-	-	R	+	-	-	+	Listeria sp
20	-	-	-	+	+	+	-	-	C	+	-	-	+	Streptococcus equi
21	-	-	-	-	+	+	-	-	C	-	-	-	+	Neisseria sp
22	-	-	-	-	+	+	-	-	C	-	-	-	+	Neisseria sp
23	-	-	+	-	+	+	-	-	C	+	-	-	+	Micrococcus mucilaginosus
24	-	-	+	+	-	+	-	-	R	+	-	-	+	Bacillus sp
25	+	-	+	+	+	-	-	-	C	+	-	-	+	Staphylococcus aureus
26	-	-	+			+	+	+	R	-	-	-	-	Pseudomonas sp
27	-	-	+	-	-	+	-	-	C	-	+	-	+	Streptococcus sp
28	-	-	+	-	+	+	+	+	C	+	-	-	-	Micrococcus mucilaginosus
29	-	+	+	+	+	+	-	-	C	+	-	-	+	Staphylococcus aureus
30	+	+	-	-	-	-	-	-	R	+	-	-	+	Proteus sp
31	+	-	+	+	+	+	-	-	C	+	-	-	+	Staphylococcus xylosus
32	+	+	+	-	+	+	-	-	C	+	-	-	+	Staphylococcus varians
33	-	-	-	-	-	+	-	-	C	+	-	-	+	Micrococcus sp
34	+	-	-	-	+	+	-	-	C	+	-	-	+	Cellobiosococcus sp
35	-	-	+	+	+	+	-	-	C	-	-	-	+	Streptococcus sp
36	+	-	-	-	-	+	+	+	C	-	-	-	-	Neisseria sp
37	-	+	-	-	+	+	-	-	C	+	-	-	+	Streptococcus sp
38	+	-	-	-	-	+	-	-	C	+	-	-	+	Micrococcus sp

KEY: + positive; - negative; C cocci, R rods; Ca catalase; Ct Citrate; Ma Mannitol; Coa Coagulase; Glu glucose, Oxi oxidase, Suc sucrose, Lac lactose; Pep peptones

Table 4: Morphological and microscopic characteristics of fungi isolates

S/N	Morphological characteristics	Microscopic characteristics	Probable organism
1	Black to grayish colour, and are hairy, suede-like to floccose	Conidiophores are branched and elongated. Conidia are produced on the conidiophores	*Alternaria sp*
2	Dark green with orange to yellow in areas. Exudate is usually present and may be brown to purplish.	Hyphae are septate and hyaline. Conidial heads are columnar. Conidiophores are short and smooth-walled. Vesicles are hemispherical, small, with metulae and phialides occurring on the upper portion.	*Aspergillus nidulans*
3	Colonies are moderately fast growing, flat, white in colour, often with a powdery or granular surface texture. Reverse pigment absent or pale brownish-yellow.	Conidia are numerous, hyaline, single-celled, clavate to pyriform, smooth, and have broad truncate bases and pronounced basal scars. The conidia are formed at the tips of the hyphae.	*Chrysosporium tropicum*

S/N	Morphological characteristics	Microscopic characteristics	Probable organism
4	Colonies are grey to dull green, velvety and tufted. The edges of the colony is grey to white, and feathery	Conidia are produced in branched acropetal chains, being smooth, verrucose or echinulate, one to four-celled, and have a distinct dark hilum. Conidia are shield shaped	*Cladosporium sp*
5	Colony is pink, smooth, soft and moist. They have a fast growth rate	Round, oval budding cells and have no pseudohyphae	*Rhodotorula mucilaginosa*
6	Colonies are usually flat, white to cream in colour with a powdery to suede-like surface and yellowish to pinkish brown reverse pigment	Microconidia are borne on the conidiophores	*Trichophyton sp*
7	Colonies are flat, Yellow-green and powdery	Spores are borne on the conidiophores. Conidiophores are long, with globose smooth conidia	*Aspergillus flavus*
8	Colonies are dark green with white edges and smooth surface.	Spores are borne in a sac on the conidiophores	*Aspergillus fumigates*
9	Colonies are brown with rough surface	Spores are borne on the hyphae filament	*Aspergillus niger*
10	Colonies are light- violet, with fluffy mycelia groth	Spores are borne in a sac on the hyphae	*Fusarium sp*
11	Colonies have blue-green colour with white edges and yellow pigment	Filamentous hyphae with conidia. Hyphae are slender and branched.	*Penicillium chrysogenum*
12	Dark green colonies with visible light yellow pigment	Conidia are borne on the conidiophores in branches	*Penicillium glandicola*
13	Yellow-green colonies that grows like grass	Conidia are directly borne on the conidiophores without a sac	*Trichoderma viridae*

Table 4 describes the morphological and microscopic characteristics of the fungi isolated from the soil

The isolates that grew around the well on the Mineral salt medium (MSM) media with polyethylene terephthalene powder are; *Staphylococcus aureus, Staphylococcus hyicus, Bacillus sp, Streptococcus mitior*, *Lactobacillus sp*, *Micrococcus sp*, *Proteus sp*, *Pseudomonas sp*, *Niesseria sp*, *Micrococcus mucilaginosus*.

The isolates that grew around the well on the potato dextrose agar (PDA) with terephthalene powder are; *Aspergillus niger*, *Aspergillus flavus*, *Penicillium glandicola*, *Aspergillus fumigatus*, *Penicillium chrysogenum*, *Trichoderma viridae*, *Fusarium sp*.

Table 5: Texture, colour and type of each soil sample

Soil sample	Texture	Type of soil	Colour
1	Coarse	Sandy	Dark brown
1a	Coarse	Clay	Reddish brown
1b	Fine	Sandy	Light brown
1c	Fine	Clay	Reddish brown
2	Fine	Loamy	Dark brown
2a	Coarse	Sandy	Brown
2b	Coarse	Loamy	Brown
2c	Fine	Loamy	Dark
3	Coarse	Loamy	Brown
3a	Fine	Loamy	Brown
3b	Fine	Loamy	Dark brown

Soil sample	Texture	Type of soil	Colour
3c	Coarse	Loamy	Dark brown
4	Fine	Loamy	Dark
4a	Coarse	Loamy	Dark
4b	Fine	Loamy	Light brown
4c	Coarse	Sandy	Brown

Table 5 shows the texture, colour and type of each sample of soil collected. The organic Matter and Moisture soil content for each soil sampled was obtained, the result is presented in table 6

Table 6: Organic matter and Moisture content percentage of each soil sample from each dumpsites

Soil sample	Organic Matter (%)	Moisture Content (%)
1	0.25	0.19
1a	0.40	0.43
1b	0.04	0.12
1c	0.42	0.48
2	0.37	0.53
2a	0.38	0.23
2b	0.57	0.52
2c	0.80	0.25
3	0.47	0.21
3a	0.17	0.07
3b	0.24	0.04
3c	0.88	1.81
4	0.13	0.26
4a	0.87	0.48
4b	0.13	0.09
4c	0.30	0.04

Table 6 shows the percentage of organic matter and moisture content available in each soil sample. Sample 3c has the highest percentage organic matter of 0.88% and moisture content of 1.81%. Sample 1b has the lowest percentage organic matter of 0.04%, sample 3b and 4c has the lowest percentage moisture content of 0.04%.

To determine if there was any significant difference in the organic matter and moisture content of the soil samples for the three locations, ANOVA test was conducted. The result is presented in Table 7.

Table 7: Mean difference of organic matter and moisture content

		Mean±SD	Df	F	P
Organic Matter	1	0.28± 0.15	3. 12	0.636	0.606
	2	0.53±0.20			
	3	0.44±0.32			
	4	0.36±0.35			
Moisture Content	1	0.31±0.18	3,12	0.350	0.790
	2	0.38±0.16			
	3	0.53±0.86			
	4	0.22±0.20			

The result in Table 7 shows that there was no significant difference in the organic matter of the various sampled soil, [$F(3, 12) = 0.636$; $\rho > 0.05$]. There was also no significant difference in the moisture content of the soils sampled [$F(3, 12) = 0.350$; $\rho > 0.05$].

Table 8: Statistics of physicochemical parameters

Soil sampled	pH	Conductivity	Temperature	TDS
1	7.51±0.24	357.75±145.27	26.13±0.37	178.70 ± 72.67
2	7.69±0.23	469.10±236.00	26.20±0.14	234.35 ±117.88
3	7.60±0.14	436.58 ± 373.01	26.05±0.29	225.90 ± 177.97
4	7.61±0.17	523.50±118.71	26.05±1.00	259.90 ±63.21

Table 8 shows the mean and standard deviation for pH, conductivity, temperature and total dissolved solids performed on the different soil samples at different locations on the dumpsites.

Table 9: ANOVA of the different physicochemical parameters

			Sum of Squares	Df	Mean Square	F	Sig.
pH	Between Groups	(Combined)	0.092	3	0.031	0.760	0.538
	Within Groups		0.484	12	0.040		
	Total		0.575	15			
conductivity	Between Groups	(Combined)	57658.457	3	19219.486	0.334	0.801
	Within Groups		690038.238	12	57503.186		
	Total		747696.694	15			
Temperature	Between Groups	(Combined)	0.062	3	0.021	0.067	0.977
	Within Groups		3.708	12	0.309		
	Total		3.769	15			
TDS	Between Groups	(Combined)	13798.407	3	4599.469	0.335	0.800
	Within Groups		164542.790	12	13711.899		
	Total		178341.197	15			

Table 9 shows the ANOVA test conducted to determine if a significant difference exists in the physical parameters obtained from the various soil sample. The result shows that there was no significant difference in the pH [F (3, 12] = 0.760, p = 0.538], Conductivity [F (3, 12] = 0.334, p = 0.801]; Temperature [F (3, 12] = 0.067, p = 0.977] and TDS [F (3, 12] = 0.335, p = 0.800].

Polyvinyl chloride (PVC) strips were degraded by the isolates; the weights at various times (4 and 6 weeks) were recorded. The result is presented in Table 10.

Table 10: Difference in weight of polyvinyl chloride film after 4 and 6 weeks

S/N	Probable organisms	Initial Weight (g)	4 weeks (g)	6 weeks (g)	Difference in 4 weeks Weight (g)	Difference in 6 weeks Weight (g)
1	*Staphylococcus sp*	0.16	0.14	0.13	0.02	0.03
4	*S. hyicus*	0.18	0.18	0.18	0.00	0.00
5	*M. radiodurans*	0.16	0.12	0.11	0.04	0.01
7	*Bacillus sp*	0.14	0.11	0.10	0.02	0.05
9	*Neisseria sp*	0.18	0.17	0.15	0.01	0.03
13	*Strep. Equi*	0.16	0.14	0.13	0.02	0.03
14	*E. coli*	0.16	0.14	0.14	0.02	0.04
15	*Strep.mitior*	0.16	0.15	0.15	0.01	0.01
16	*Lactobacillus sp*	0.14	0.14	0.13	0.00	0.01
17	*Streptococcus sp*	0.16	0.12	0.11	0.02	0.03
24	*Bacillus sp*	0.12	0.10	0.10	0.02	0.02
25	*Staphylococcus sp*	0.12	0.12	0.11	0.00	0.01
28	*M.mucilaginosus*	0.12	0.10	0.10	0.02	0.02

S/N	Probable organisms	Initial Weight (g)	4 weeks (g)	6 weeks (g)	Difference in 4 weeks Weight (g)	Difference in 6 weeks Weight (g)
29	*Staphylococcus aureus*	0.16	0.13	0.12	0.02	0.05
30	*Proteus sp*	0.18	0.18	0.17	0.00	0.01
35	*Streptococcus sp*	0.16	0.13	0.12	0.03	0.04
37	*Streptococcus sp*	0.18	0.16	0.16	0.02	0.02
38	*Micrococcus sp*	0.16	0.16	0.15	0.00	0.01
26	*Pseudomonas sp*	0.18	0.15	0.14	0.03	0.04
27	*Streptococcus sp*	0.14	0.13	0.13	0.01	0.01

Key: sp- specie, M- Micrococcus; S- Staphylococcus; Strep- Streptococcus; E- Escherichia

The result shows that the organisms degraded the polyvinyl chloride film within four weeks, and also further degraded them in six weeks. But it was observed that organisms 4 (*Staphylococcus hyicus*), 25 (*Staphylococcus sp*), 16 (*Lactobacillus sp*), and 30 (*Proteus sp)* had the lowest degradation value, while organism *Bacillus sp* (25%) and *Staphylococcus aureus* (25%) had the highest degradation value. The difference in weight for four and six weeks were further presented graphically in Figure 1.

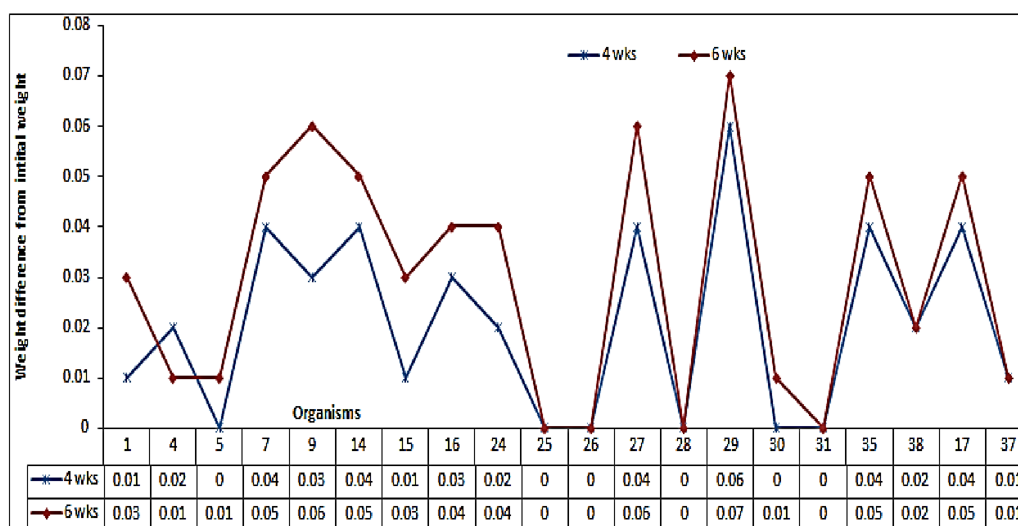

Fig 1: Difference in the initial and final weight of polyvinyl chloride (PVC) film

Table 11: Weight of polyvinyl chloride after 4 and 6 weeks

Possible organisms	PVC						
	Initial wt (g)	Final weight (g)		Difference in weight (g)		Weight loss %	
		After 4 weeks	After 6 weeks	After 4 weeks	After 6 weeks	After 4 weeks	After 6 weeks
Penicillium glandicola	0.50	0.49	0.47	0.1	0.3	2%	6%
Aspergillus flavus	0.50	0.46	0.44	0.4	0.76	8%	12%
Aspergillus fumigatus	0.50	0.48	0.47	0.2	0.3	4%	6%
Penicillium chrysogenum	0.50	0.49	0.49	0.1	0.1	2%	2%
Aspergillus niger	0.50	0.47	0.45	0.3	0.2	6%	10%
Fusarium sp	0.50	0.49	0.47	0.1	0.3	2%	6%
Trichoderma viridae	0.50	0.47	0.45	0.3	0.5	6%	10%

Table 11 shows the weight loss percentage, from the result, *Aspergillus flavus*, *Aspergillus niger*, and *Trichoderma viridae* degraded a higher percentage of the polyvinyl chloride film. The difference is shown in figure 2.

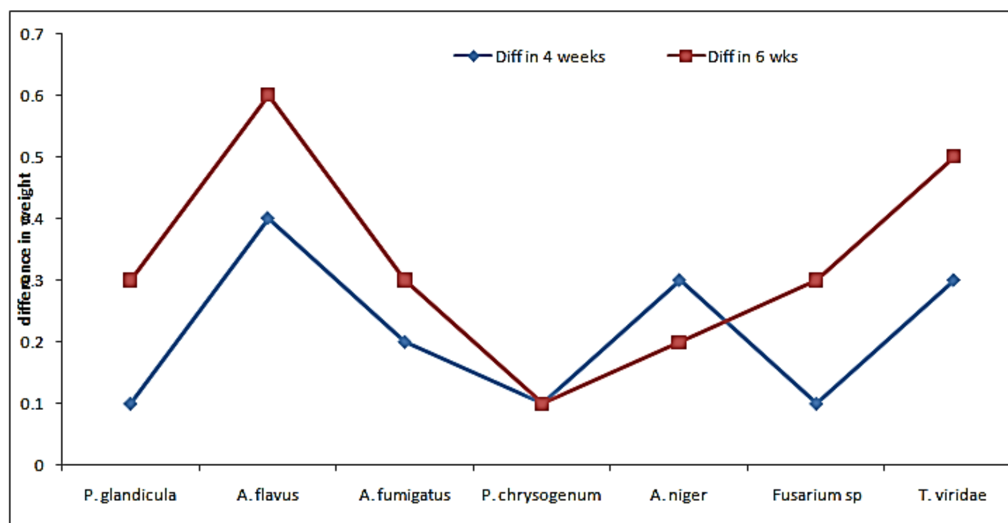

Fig 2: Difference in the weight of polyvinyl chloride films after 4 and 6 weeks

Figure 2 shows that *Penicillim chrysogenum* had the lowest percentage weight loss during the interval of 6 weeks, *Aspergillus flavus* had the highest percentage weight loss of 12%.

The findings in this report shows that Sample 3c had the highest percentage organic matter of 0.88% and moisture content of 1.81%. Sample 1b had the lowest percentage organic matter of 0.04%, sample 3b and 4c had the lowest percentage moisture content of 0.04%. Sample 2 had the highest mean conductivity of 469.10±236.00, the soil sample with the highest mean TDS was sample 4 of 259.90 ±63.21. Priyanka &Archana, (2011), tested the organic matter and moisture content of the various soil samples collected from different sites and discovered the biodegradability of plastic by the help of microorganism. The soil samples had a higher moisture content and organic matter percentage compared to the recorded moisture content and organic matter percentage in this study.

Bacillus sp and Staphylococcus aureus had the highest percentage weight loss in degrading Polyvinyl chloride (PVC) film. This result agrees with the report of Sharma et al., (2014) who researched on the isolation and characterization of plastic degrading bacteria from soil collected from the dumping grounds of an industrial Area in India which showed the degrading ability of *Bacillus sp* on polyvinyl chloride strips (PVC). This result is also in consonance with the report of Divyalakshmi & Subhashini, (2016) who performed a research on the screening and isolation of plastic degrading bacteria from various soil environments and isolated *Staphylococcus aureus*.

Bacillus sp is a Gram positive, aerobic, non-spore forming rods. *Bacillus sp* have been isolated from the soil in the Niger Delta with some related species, with the degradation of hydrocarbons related with raw petroleum (Akpan- Idiok & Solomon, 2012; Eziuzor & Okpokwasili, 2009). The result of this work agrees with the report of Arkatkar et al., (2009) who recorded proof of microorganisms that can degrade hydrocarbon, and suggested that they should also be able to degrade polyvinylchloride since their degradation is comparable. Both *Bacillus mycoides* and *Bacillus subtilis* displayed varying levels of capacity to degrade polyethylene. Also, it is expected that their separation from soil continually dirtied by oil slick may have conferred on them such degrading capacity.

The fungi isolated are *Aspergillus niger*, *A. flavus*, *A. fumigatus*, *Penicillium chrysogenum*, *P.glandicola*, *Trichoderma viridae*. The total viable count for fungi ranged from $0.1x10^{11}$ to $3.3x10^{5}$, which shows that the soil is home to vast quantity of microorganisms. *Aspergillus flavus, Aspergillus niger* and *Trichoderma viridae* degraded polyvinyl strips by 8%, 6% and 6% respectively. This results correlates with the research of Sakhalkar & Mishra, (2011), on the screening and identification of soil fungi with potential of plastic degrading ability. In their research, *Aspergillus niger* and *Aspergillus flavus* was able to degrade polyvinyl chloride film. Singh et al., (2012), in their research on the microbial degradation of polyethylene (low density) by *Aspergillus fumigatus* and *Penicillium sp* were able to test the action of *Trichoderma viridae* on polyvinyl chloride (PVC).

CONCLUSION

This research has shown that bacteria can degrade and utilize plastics for their metabolic activity, hence the use of plastic degrading microorganisms to reduce the rate of plastic pollution should be adopted. These specific strains of microorganisms (*Staphylococcus aureus, Pseudomonas sp, Bacillus sp Streptococcus sp, Micrococcus sp, Aspergillus flavus*, *Aspergillus niger* and *Trichoderma viridae*) can be cultured in large quantity and used in bioremediation. The following recommendations are suggested, that the production of plastics should be minimal and the production of natural, easily degradable plastics should be encouraged. Plastic degrading microorganisms should be used in bioremediation of plastic and the enzymes produced by plastic degrading microorganisms which enables them to degrade plastics, should be extracted and produced in large quantity for use in bioremediation. Public awareness about plastic pollution and its negative impact on terrestrial and aquatic ecosystem should be made through the media to all the masses, as most people are unaware of the harm synthetic plastic is causing in the ecosystem. Proper waste disposal system should be made available for people living in both urban and rural areas and those living close to aquatic environment.

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The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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