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Evaluation of Bioaccumulation and Toxicity of Bisphenol-A and Phthalates on Earthworm and Nitrifying Bacteria from Soil Collected in Waste Management Landfill, Kaduna State, Nigeria

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ABSTRACT: Additives such as bisphenol-A (BPA) and phthalates are added to plastics during production processes in order to improve their properties. Since they are not covalently bound but simply mixed with the plastic polymer. They disperse easily in the environment, especially when plastic products are degraded into microplatics. Hence, the objective of this paper was to evaluate bioaccumulation and toxicity of bisphenol-A and phthalates on earthworm (*Apporrectoda ionga*) and nitrifying bacteria from soil collected in Waste management landfill, Kaduna Sate, Nigeria using standard techniques. Data obtained shows that Bisphenol A, Diethytlphalate, Dimethylphthalate and Diethylhexylphalate were detected in the plastic enriched compositing soil while only bisphenol A was detected in the control soil sample. The physico-chemical analysis of the composted soil and the control had electrical conductivity 254.00, 61.00us/cm, chloride 66.15, 16.00mg/kg, potassium 171.5, 4.25mg/kg, nickel 1.00, 0.25mg/kg, Iron 17.40, 3.11mg/kg, Zinc 2.90, 0.67mg/kg, moisture 5.32, 7.21% total organic carbon 5.26, 0.71% and total nitrogen 0.52, 0.07% respectively. The bacteriological analysis for composted soil and control soil growth ranging from 4.0 x $10^3 \pm 0.12$ to $3.5x10^3 \pm 10^4$cfu/g and $3.2x10^3 \pm 0.4$ to $2.8x10^3 \pm 0.10$ respectively. There was significant difference ($p<0.05$) in the bacteria counts from the control soil sample. The toxicity analysis revealed higher percentage utilization of nitrite with LC_{50} values of 25.04, 23.93, 15.9 and 13.39 and higher bacteria inhibition with EC_{50} values of 52.00, 81.72, 111.31 and 123.13. The results suggest that autotrophic transformation by nitrifying bacteria which enhances soil fertility may be hindered in an ecosystem polluted with these plasticizers as nitrification process will reduced. Percentage survival rate of earth worms decreased with increase in plastic concentration (75.47-20.93%).

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The dramatic increase in the use of plastic materials in the last decades has led to the dispersion of plasticizers in the environment. Plastic additives, such as phthalates and bisphenol (BPA) are added to plastics during production processes in order to improve their properties. Since they are not covalently bound but simply mixed with plastic polymer, they dispense easily in the environment, especially when plastic products are degraded into microplastics (Bansal *et al*., 2018). Uptake of chemicals by an organism can take place by breathing, absorbing through skin or swallowing. When the concentration of a chemical is higher within the organism compared to the surrounding (soil, air, water). It is referred to as bioaccumulation. Bioaccumulation occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost or eliminated by catabolism and excretion. Thus, the longer the

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biological half-life of a toxic substance, the greater the risk of chronic poisoning even if environmental levels of the toxin are not very high. (Bryan *et al.,* 1979). Toxicity on the other hand is the degree to which a chemical substance or a particular mixture of substance can damage an organism such as animal, bacterium or plant. Toxicity induced by toxic substance/metals is associated with bioaccumulation and biomagnification (Blowes *et al.,* 2003). Biological indicators, known as sentinels are used to evaluate various hazards within an ecosystem and the possible health effects on the populations. Sentinels may react to environmental toxicants before major problems occur in the environment and may be more vulnerable than humans to some types of environmental contaminants. A focus on sentinel species makes it practical to obtain an overview of trophic and ecosystem health which may reveal chronic and acute exposure patterns and to predict toxicological risks associated with the environment-plant-animal-human web of interaction and their trends (Zota *et al.,* 2016). Plastic accounts for 95% of the offshore waste on the seabed and on beaches of the sea and comes mainly from Turkey and Spain, followed by Italy, Egypt and France. Therefore, the dramatic increase in the use of plastic materials in the last decades has led to dispersion of platicizers in the environment. Recently, awareness is growing about how the smaller plastic fragments, the so-called microplatics (fragment less than 5mm), are harmful and dangerous to the environment and human health (Albert and Jegou, 2004). Their impact on the ecosystem is still under investigation, although some important implications are already known, such as the possibility to be injected by a wide variety of marine organisms and the consequent introduction into trophic cycle with deleterious effects on health of marine organisms (eg, abrasions, blockage of the digestic tract, absorption of harmful compounds). Single and combined effects of microplatics and other contaminants were studied in some marine organisms. These chemicals have the potential to accumulate in the tissues of marine organisms and cause specific and endocrine disruption (McParkland *et al*., 2014). The endocrine system performs fundamental task for the life of an organism and the hormones produced by the endocrine glands have the tasks of controlling delicate and complex phenomena such as reproduction, growth, development, as well as the metabolism. Endocrine disrupters (EDCs) are able to imitate, compete or stop the synthesis of endogenous hormones, this translates into alteration of glands function, alteration and reduction of reproduction with consequent low birth rates and potential loss of biodiversity. Compounds identified as EDS, such as phthalates, bisphenol A and heavy metals, are a major concern for marine organisms. Low-level exposure of these substances leads to both transient and permanent damages in the endoscrine system (Dodson *et al*, 2012). Phthalates and bisphenol A, sowed to have a role in development of obesity and glucose metabolism disorder.

Exposure to phthalates, particularly DEHP, causes a decrease in the reproduction of testicular testosterone in rodents and most of the reproductive toxic effects are suggested to be related to their antiandrogenic potential (Zamkowska *et al.,* 2018). Exposure to EDC, such as BPA, may led to detrimental human health effects, including interference with both male and female reproductive systems. This interference may cause a spectrum of disorders throughout life, including reproductive abnormalities and infertility, sexual precocity, hormone related cancers and may include effects on thyroid function, obesity and metabolism. BPA is the chemical more frequently reported in surface waters, among phenol compound (Barrett *et al.,* 2014). The primary industrial use of BPA is as a monomer for the production of epoxy resins, polyesters, food cans and lacquer coatings. In the environment, BPA is released through natural degradation of polycarbonate plastics, landfill leachates via hydrolysis of BPA from plastics and eliminated through sewage, via human-ingested BPA (Factor-litvak *et al*., 2014). Based on the above mention foregoing relating to bioaccumulation and toxicity of components of microplastics, the objective of this paper waste evaluates the bioaccumulation and toxicity of bisphol A and phthalates on earthworm (Apporrectoda tonga) and nitrifying bacteria from soil collected in Waste Management Landfill, Kaduna State, Nigeria using standard techniques.

MATERIALS AND METHODS

Collection of Soil Samples: Soil Samples were collected from Kaduna State Waste Management Landfill site located at Kakau in Chikun local Government Area of Kaduna State, Nigeria. Five soil samples (500g each) were collected from different locations within the waste management landfill site and one soil sample from a farmland at Akaka-Manda Community which will serve as the control.

In the laboratory, the five soil samples from the landfill site collected earlier were merged to form a composite sample (Ryan, 2000). The soil samples were homogenized and kept on the laboratory bench to air dry. The waste soil samples collected from landfill sites were used to isolate nitrifying bacteria, while a portion of the farmland soil was used to formulate specific concentrations for earthworm and plant toxicity analyses.

Collection of Earthworm (Aporrectoda ionga): The earthworms were collected from a farmland in Kawo, Kaduna State. The worms were collected according to method described by Spurgeon (2002). They were collected by digging and hand sorting from substance litres and were taken to the laboratory for identification. They were washed with water to remove soil particles and were left on moist filter paper for voiding. Earthworms were selected based on their maturity (shown by the presence of clitellum) and liveliness (active response when anterior segment is prodded).

Physicochemical Analysis of Soil Samples: The soil samples were analyzed for the following physiochemical parameters. pH, total organic carbon (TOC), moisture content and essential minerals such as nitrate, potassium, calcium-magnesium, sulphate, sodium and total hydrocarbon content according to methods of Atuanya *et al* (2016).

Phytochemical Analysis of Soil Samples: The quantitative phytochemical screening of collected soil samples was carried-out to determine the actual amount of plasticizers present in the soil samples. This was done using standardized methods according to Atuanya and Tudararo-Aherobo (2014).

Identification of Bisphnol-A (BPA), Phythalate and Other Plastic Components: Perkin-Elmer Gas Chromatograph model auto system XL with flame ionization detector was used for identification of BPA, phthalate and other plastic components by comparison between the retention times of BPA sample peaks and the standard compounds. The qualification was done by the internal normalization method. An Elite – 5 fused silica capillary column (30m x 0.25mm id. Crossbond 5% diphenyl-95% dimethyl polysiloxane, 0.25-m film thickness) was used for the GC separation using the following oven temperature programs 150^{o}c. (5min hold) heating to 250^{o}c at 30^{o}c/min and heating to 300^{o}c at 10^{o}c/min. The injector temperature was 250^{o}c. The injector volume was 1.0-L (n=3) in the split mode (1:50).

Preparation of plastic composted soil concentration for toxicity: For the determination of the median lethal concentration (LC_{50}), plastic concentrations of (100, 200, 300, 400 and 500g) in 1000ml of Winograsky medium respectively. For the median effective concentration, the following plastic concentration (20, 40, 60, 80 and 100mg/l) were formulated by adding (20, 40, 60, 80 and 100mg) in 1000ml of winograsky medium respectively. A control experiment consisting of Winograsky medium only (without the plastic composted soil) was setup according to Ibiene and Okpokwasili (2011).

Determination of Nitrifying Bacteria Acute Toxicity Test: Winograsky medium which was fortified by several grams of plastic granules (100, 200, 300, 400 and 500mg/l) and (20, 40, 60, 80 and 100mg/l) respectively was inoculated with 10ml of bacteria (*Nitrobacter* sp.) standard inoculum. They were allowed to stand for an hours for growth. One milliliter (1ml) of the suspension thereafter was plated from mineral salt media composted with different grams of plastic granules on a non-plastic composted Winograsky agar plates. This was done for all concentrations and repeated for 2, 3 and 4 hours intervals according to Okpokwasil and Odokuma (1996).

Determination of the Toxicity of Plastic Enriched Compositing Soil on the Growth and Survival of Earthworms: Four concentrations (50, 100, 150 and 200mg/4kg) of plastic enriched composting soil were prepared using plastic granules and 20g of cellulose was added to the soil as food for the earthworms. A blank (control) containing cellulose, water and non-plastic compound soil were also prepared. The distribution of individual earthworms among the chambers was randomized. Death, weight loss and behavioural symptoms were the criteria used in these test guidelines to evaluate the toxicity of bisphnol-A and phthales on the earthworms. Each test and control chamber was checked for dead or affected earthworms and observations recorded on 7, 14, 21 and 28 days after the beginning of the test according to Nonnard *et al* (2009).

Effects of Plastic Enriched soil on the Growth and Survival of Plants: Block design with three replicates were used to assess the impact of plastic enriched soil on the growth and survival of *Talinum triangulare.* Garden soil samples were collected from a farmland and were divided into four (A, B, C, D). 4kg each and three of them (B, C, D) were further fortified with different concentrations of (100, 150 and 200g/4kg) of plastic granules. The experiment consisted of four treatments amounting to an aggregate of 4 experimental buckets. Each bucket is of 4liters capacity and perforated at the base and set out on the field.

The treatments were:
A = Untreated 4kg composite soil sample (control)
B = (2.5% treated level) i.e 100g of plastics of composite soil sample.
C = (3.75% treatment level) i.e 150g of plastic granules to 4kg of composite soil sample.

D = (5% treatment level) i.e 200g of plastic granules to 4kg of composite soil sample.

Each treatment was thoroughly mixed in its allocated bucket at the beginning of the experiment. After fluted pumpkin seeds planted, percentage germination was observed, the height and stem girth of the plants were measured using a meter ruler for eight weeks.

Data Analysis: The data generated were analyzed by one-way ANOVA (analysis of variance) using Statistical Package for Social Science (SPSS) version 20.0. Differences in mean were compared by Duncan's multiple range test (Ogbeibu, 2015).

RESULTS AND DISCUSSION

The physicochemical parameters of the plastic enriched soil and the garden soil sample were analysed. The result revealed the presence of mineral and heavy metals in both soil samples at varying concentration. The increased release of metals into the test soil was as a result of plasticizer degradation which further affects the pH and other parameters of the test soil. (Table 1). BPA, DEHP, DMP and DEP were detected in the plastic enriched composting soil while only BPA was detected in the garden soil sample. (Table 2). The garden soil sample had higher counts compared to the test plastic enriched composting soil which was as result of the inhibition of bacteria by the plasticizers present in the test soil sample. (Table 3). Bacteria toxicity analysis showing the values for the median effective concentration (EC_{50}) and the median lethal concentration (LC_{50}) which was carried out with the plastic enriched composting soil sample at different time intervals. The EC_{50}, was used to determine the level of nitrite accumulation in the system while the LC50 was used to determine nitrifying bacterial inhibition by an increasing plastic concentration. (Table 4). A growth curve showing nitrifying bacteria inhibition from 1 to 4 hours for the LC_{50} analysis carried out with plastic contaminated soil sample. There was an increased inhibition with increase in plastic concentration in the system. (Table 5). A bacteria growth curve obtained from EC_{50} analysis showing nitrate accumulation by *Nitrosomonas* sp. grown on the plastic composted soil sample from 1 to 4hours. There was a continuous decrease in nitrite concentration with increased plastic concentration. (Table 6). There was a continuous decrease in the percentage survival rate of the worms with increase in plastic concentration. (Table 7). There was a continuous decrease in the percentage germination rate, height and stem girth of *Talinum triangulare* with increase in plastic concentrations. (Table 8). GCMS result for test plastic composted soil sample (fig1) and nitrifying bacteria inhibition from 1 to 4 hours is shown in fig. 2. While nitrite utilization of *Nitrosomonas* sp from 1 to 4 hours (fig.3).

Table 1: The physicochemical parameters of the plastic enriched composting soil and the garden soil sample.

Parameters	Plastic composted soil sample	Garden soil sample
pH	5.67	6.90
EC (µs/cm)	245.00	61.00
CT(mg/kg)	66.15	16.00
SO_4^{2}(mg/kh)	2.9	0.66
NO_3^{-}(mg/kg)	34.77	0.72
PO_5^{4} (mg/kg)	24.03	0.16
Na^{+} (mg/kg)	93.1	2.32
K^{+} (mg/kg)	171.5	4.25
Ca^{2+} (mg/kg)	19.85	1.87
Mg^{2+} (mg/kg)	24.25	4.93
Fe^{3+} (mg/kg)	17.40	3.11
Zn^{2+} (mg/kg)	2.90	0.67
Mn^{2+} (mg/kg)	1.48	0.39
Cu^{2+}(mg/kg)	2.21	0.12
Ni^{2+} (mg/kg)	1.00	0.25
Cd^{2+}(mg/kg)	0.76	0.19
V^{2+}(mg/kg)	0.96	0.23
Cr^{2+}(mg/kg)	1.3	0.32
Pb^{2+}(mg/kg)	0.44	0.11
Sand (%)	90	91
Silt (%)	6	4
Clay (%)	2	3
Total Carbon (%)	5.26	0.71
Total Nitrogen (%)	0.53	0.07
Moisture (%)	5.32	7.21

Table 2: Individual plasticizers detected in the soil samples and their concentrations.

Plasticizers	Plastic Composted Soil	Garden Soil Sample
BPA	45.02	2.01
DEHP	12.05	NR
DMP	28.25	NR
DEP	5.07	NR
DSP	<LOD	NR
BBIP	<LCD	NR
Total (ng/g)	90.39	2.01

Key: BBP – Butylbenzylphythatate; DEP: Diethylpithalate; DMP – Dimethylphthalate; DEHP – Diethylhexylphyalate; DPA – Bisphenol A; DBP – Di-n-butylphthalate; LCD: Limit of detection; NR: Not recovered

Table 3: Nitrifying bacterial count for the plastic enriched composting soil and the control garden soil.

Time (Days)	Garden Soil Sample	Plastic Composited Soil
1-3	4.0 x 103 ±0.12	No growth
4	$3.5 \times 10^3 \pm 0.10$	$23 \times 10^2 \pm 1.10$
5	$3.2 \times 10^3 \pm 0.40$	$1.0 \times 10^2 \pm 1.10$
6	$2.8 \times 10^3 \pm 0.80$	No growth
7	$2.0 \times 10^2 \pm 0.10$	No growth

Table 4: EC_{50}, and LC_{50} nitrifying bacterial toxicity test

Incubation time	EC_{50} for nitrite utilization	LC_{50} for percentage inhibitions
1h	52.00	25.04
2h	81.72	23.93
3h	111.31	15.93
4h	123.13	13.39

Table 5: Earthworm Growth and survival across various plastic enriched composting soil concentrations.

Concentration (g/kg)	Initial Weight (g)	Final Weight (g)	Weight change	Survival rate (%)
A	0.40 ± 0.05	0.53 ± 0.01	0.13	75.47
B	0.44 ± 0.10	0.12 ± 0.11	-0.32	22.27
C	0.43 ± 0.09	0.009 ± 0.10	-0.34	20.93
D	0.43 ± 0.11	0.00	0.00	0.00
E	0.41 ± 0.06	0.00	0.00	0.00

Key: *A = (control), untreated soil; B = 50g of plastic granules to 4kg of soil sample; C = 100g of plastic granules to 4kg of soil sample; D = 150g of plastic granules to 4kg of soil sample; E = 200g of plastic granules to 4kg of soil sample*

Table 6: Effect of plastic enriched soil on the growth and survival of *Talinum triangulare*

	Plant Height (cm)			Stem Height (cm)			Germination rate %		
Treatment	4 WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP
A	9.30	9.70	6.61	1.85	2.27	2.49	60.10	70.63	80.25
B	6.11	7.55	5.53	1.35	1.14	1.14	50.27	40.61	30.35
C	4.70	5.70	4.68	1.20	0.98	0.80	25.10	20.21	15.42
D	1.10	2.84	2.14	0.85	0.74	0.65	15.30	10.42	10.15

Key: *A = Untreated 4kg composite soil sample (control); B = (2.5% treatment level) bOg of plastic granules to 4kg of composite soil sample; C = (3.75% treatment level) 150g of plastic granules to 4kg of composite soil sample; D = (5% treatment level) 200g of plastic granules to 4kg of composite soil sample; WAP = weeks after planting*

The physicochemical analysis of both soil samples had electrical conductivity 245.00, 61.00us/ cm, Chloride 66.15, 16.00mg/ kg, Iron 17.40, 3.11mg/ kg, Copper 2.21, 0.12mg/ kg, Lead 0.44, 0.11mg/kg and percentage moisture 5.32, 7.21% for the plastic composted soil and the control soil sample respectively (Table 4). The high electrical conductivity recorded in the plastic composted soil sample could be as a result of the presence of lots of elements released into the soil samples from the degradation of plastic contaminants. The total organic carbon content recorded for the plastic composted soil was also high which is as a result of the release of carbon from carbon containing compounds from the plastic contaminants. The moisture content of the plastic composted soil sample recorded a low value, this is because soil water and oxygen are used up during combustion and degradation of these contaminants thereby leaving the soil with low percentage moisture content (Atuanya *et al*., 2014). It was observed that the plastic composted soil sample had a lower pH value than the control soil sample (Okpamen *et al*., 2013).

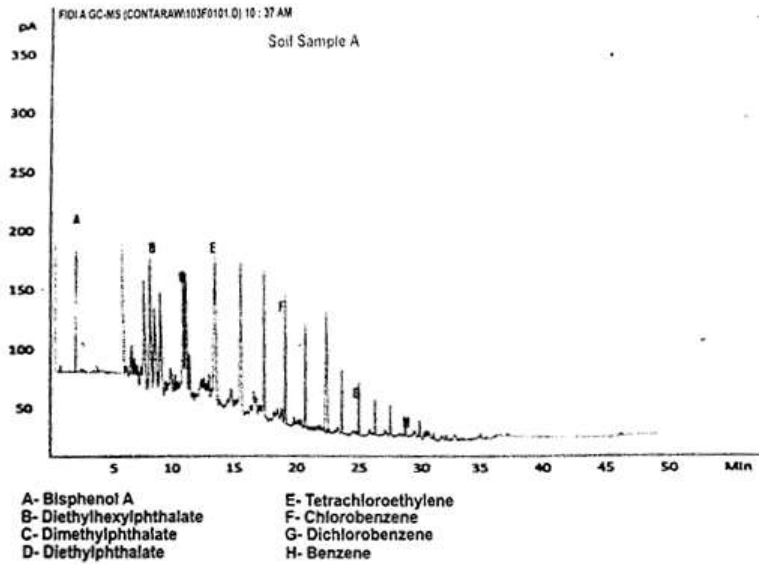

Fig. 1: Gas Chromatography result for the test plastic composted soil sample

Each of the soil sample inoculated into mineral salt broth were plated in nutrient agar plates for 7days. The bacteria count obtained from the control soil sample had higher counts compared to the test plastic composted soil which was as a result of the inhibition of bacteria by the plasticizers contaminants present in the test soil sample (Table 3). The concentration of the individual plasticizers was recorded and it showed that bisphenol A (BPA), Diethylphthalate (DEP), Dimethylphthalate (DMP), and Diethylhexyphthalate (DEHP) were detected in the plastic enriched composting soil while only bisphenol A (BPA) was

detected in the garden soil sample (Table 2). Most of these compounds are in the degradation pathway of lots of plastics components like bisphenol A, polyvinyl chloride, phthalates, organotins, alkyltins and alkylphenols as reported by Kolvenbach *et al*. (2007). Plastic contaminants have been shown to have acute effects on the biotic and abiotic components of the terrestrial environment (Alonso- Magdalena *et al*., 2012). The toxicity analysis of the soil showed that bacteria growth was inhibited with increase in plastic contaminant concentration and time. Fig.1 represents the bacteria growth inhibition by several concentrations of the plastic composted soil for 1, 2, 3 and 4 hours' time interval. Also, the bacteria ability to utilize nitrite from the test plastic composted soil was investigated at varying concentrations from 1 to 4 hours; the bacteria showed an increase in nitrite utilization and began to decrease in nitrite utilization across the increasing plastic contaminant concentrations with time (Fig. 2).

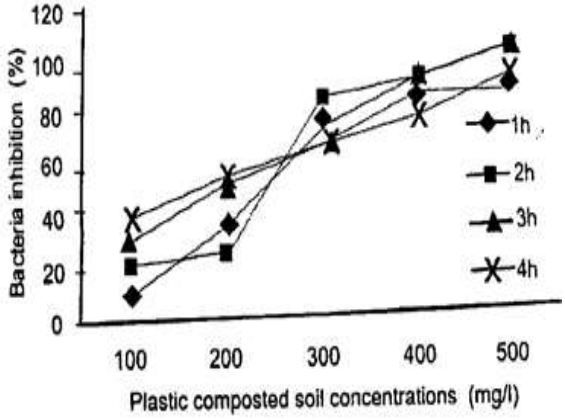

Fig 2: Nitrifying Bacteria inhibition from 1 to 4 hours.

The toxicity analysis revealed that there was higher percentage utilization of nitrite with EC_{50} values of 52.00, 81.72, 111.31 and 123.13 and LC_{50} values of 25.04, 23.93, 15.94 and 13.39 which decreased with increased exposure time and contaminant concentration showing a high inhibition of *Nitrobacter* growth. It was observed that through the process of plastic contaminant degradation. A lot of elements and harmful gases are released into the soil which adversely affect soil bacteria growth, soil properties and functions. The acute toxicity effect of soil composted with plastic was conducted since the nitrification process is a function of enzyme activities and its measurement has been used as an indicator of pollution (Williamson *et al*., 1981; Wang *et al*., 1983).

The decline in the *Nitrobacter* sp. counts as the concentration of the plastic composted soil increased could be due to the toxic effect of the plastic contaminants as earlier reported by Okpokwasili *et al*. (1996) who studied toxicity of different insecticides concentrations on *Nitrobacter* sp. The EC_{50} values increased with increased in exposure time while LC_{50} values decreased with increased exposure time (Table 4). This shows that at low plastic composted soil concentrations the bacteria was able to adapt and oxidize nitrite which increased with time (Fig 4) at higher plastic composted soil concentrations, the bacteria growth and metabolism was reduced (Fig 1) resulting to a decrease in the LC_{50} values. This is as a result of the inhibition of enzyme activities by the toxicant (Jujena *et al*., 1978). The comparison of the LC_{50} and EC_{50} values showed that the LC_{50} is a more sensitive criterion for the determination of the acute toxicity of plastic composted soil.

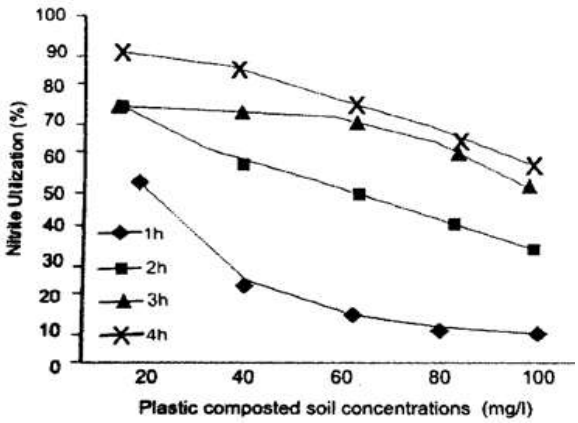

Fig 3: Nitrite Utilization by *Nitrosomonas* sp. From 1 to 4 hours.

Plastic contaminants in the soil has a negative effect on plant growth (Boots *et al*. 2019; de Souza Machado *et al*., 2019; Qi *et al*., 2020). It may be caused by the agglomeration of plastics after ageing and degradation in the soil system (Table 4). The agglomeration of plastics negatively affected plant roots or their symbionts, potentially inhibiting plant growth (Galloway *et al*., 2017). Meanwhile plastic contaminants could also affect soil biota such as earthworms (Table 4) and soil biophysical properties including bulk density, soil aggregation and water holding capacity (de Souza Machado *et al*., 2019; Lwanga *et al*., 2017) which indirectly impact nutrient cycling and plant productivity. The results obtained from this study suggests that autotrophic transformation by nitrifying bacteria may be hindered in an ecosystem polluted with these plasticizers as nitrification processes will be reduce.

Conclusion: From this study, it was observed that bisphenol A (BPA) and phthalates which are chemicals used for the production of plastics occupy space on landfill sites as contaminants making the land

unavailable for agricultural and other numerous purposes. It was also observed that this plasticizer and its degradation by-products are greatly available and toxic to soil and soil biological sentinel. Plasticizers pollution in agricultural and urban soils is widespread in Nigeria through the use of land application of agricultural chemicals, wastewater and biosolids, as well as the use of plastics in general modern-day living. The presence of phthalic acid esters in soils is affecting the soil quality because phthalic acid ester pollution affects microbial activity, microbial diversity, enzyme activity (e.g., urease, phosphatase, catalase), and soil invertebrates such as earthworms, as well as the yield and quality of agricultural crops. The current level of research is not sufficient to understand all mechanisms and implications of the wide spread phthalic acid ester distribution in soils. The results from this work indicates that uncontrolled plastic contaminants released into the soil environment will adversely affect soil nitrifying bacteria which will further alter the soil nitrification process and ultimately affect soil production. Further research into the production of biodegradable less toxic plastics, recycling and converting plastics waste into other useful areas will be a relief to the soil environment. From the above discussion, it is clear that Bisphenol A and phthalates in soil will not only have negative effects on soil properties but also accumulate in food, causing human exposure to these plasticizers. Therefore, Bisphenol A and phthalates may pose a major risk to ecosystems and human health. In order to avoid the threat, it will be important to reduce and eliminate plasticizers emission sources and remedy the plasticizers pollution that is already present in the environment. A range of remedial techniques including physical, chemical, and biological treatments will be introduced in detail in the following sections.

REFERENCES

Alonso-Magdalena, P. Ropero, A.B, Somano, S., Garcia-Arevalo, M., Ripoll, C. and Fuentes, E. (2012). Bisphenol A acts as a potent estrogen via classical estrogen triggered pathway. *Molecular Cell Endrocrinol.* 353: 201-207.

Atuanya E.I., Udochukwu, U. and Dave-Omoregie, A.O. (2016). Bioavailability and toxicity of plastic contaminants to soil and soil bacteria. *J. Microbiol. Res.* 13 (6) 1-8.

Atuanya, E.I and Tudamo-Aherobo, L. (2014). Ecotoxicological effects of discharge of Nigerian petroleum refinery oil sludge on the biological sentinels. *Afr. J. Environ. Sci. Technol.* 9 (2): 95-103.

Bansal, A., Henao-Mejia, J. and Simmons, R.A. (2018). Immune System: An Emerging Player in Mediating Effects of Endocrine Disruptions on Metabolic Health. *Endocrinol.* 159(1): 32 – 45

Boots, B, Russel, C.W. and Green, S. (2009). Effect of Microplastic in Soil Ecosystem. *Environ. Sci. Technol.* 53: 11496 – 11506.

Bornnard, M., Romeo, M. and Amiard-Triquet, C. (2009). Effects of copper on the burrowing behavior of estuarine and coastal invertebrates. The polychaeteneresis diversicolor and the bivalve scrobicularia plana. *Human. Ecol. Risk Assess.* 15(1): 11-26.

Canstedt, F., Jonsson, B.A and Bornehag, C.G (2013). PVC flooting is related to human uptake of phthalates in infants. *Indoor. Air.* 23(1): 32-39.

De-Souza Machado, A.A., Lou, C.W., Till, J., Kloas, W., Lechmann, A., Becker, R. and Rilling, M.C (2018). Impact of plastic contaminants on the soil biophysical environment. *Environ. Sci. Technol.* 52: 9659-9665.

Gaion, A., Santori, O., Scuderi, A. and Fattorini, D. (2014). Bioaccumulation and biotransformation of ansenic compounds in hediste divrsicolor after exposure to spiked sediments. *Environ. Sci. Pollut. Res.* 21(12): 14-17.

Galloway, T.S., Cole, M. and Lewis, C. (2017). Interactions of Microplastic debris throughout the marine ecosystem. *Nat. Ecol. Evolut.* 1:1-8

Lwanga, E.H., Gertsen, H., Peters, P., Sahnki, T.I., Van der Ploeg, M., Besseling, E., Koelmans, A.A. and Gerssen, V. (2017). Incorporation of plastic contaminant from litter into burrows of *Lumbricus terrestris Environ. Pollut.* 220*:* 523 - 531

Ogbeibu, A.E. (2015). *Biostatistics: A Practical Approach to Research and Data Handling* (2nd ed.). Minded Publishing Company, Lagos, Nigeria. 165pp.

Okpokwasili, G.C and Odokuma, L.O. (1996). Response of Nitrobacter sp. To toxicity of drilling chemicals. *J.of Petrol. Sci. and Engineer. 16:* 81-87.

Qi, R. Janes, D.L, Li, Z, Liu, Q and Yan, C (2020). Behaviour of microplastics and plastic film

residues in the soil environment. *Sci. Tot. Environ.* 793: 134-142.

Ryan, J. (2000). Soil and plant analysis in the Mediterranean region: limitation and potential. *Soil Sci. Plant Anal.* 31(11-14): 2147-2154.11.

Spurgeon, D.J. and Hopkin, S.P. (2000). The development of genetically inherited resistance to zinc in laboratory selected generations of earthworms. *Environ. Pollut.* 109(2): 193-201.

Vilaplana, F., Kamisson, P., Ribes-Greus, A., Ivaersson, P., and Karisson, S. (2008). Analysis of brominated flamed retardants in styrenic polymers. Comparison of the extraction efficiency of ultrasonication microwave assisted extraction. *J. Chromatog.* 1196-1197: 139-146.

Wang, W. and Reed, P. (1983). *Nitrobacter* as an indicator of toxicity in wastewater. *J. Energy and Nat. Resourc.* 4:6-12

Williamson, K.J and Johnson, D.C. (1981). A bacteria bioassay assessment of waste water toxicity. *Wat. Resour.* 15: 383-399.

Zota, A.R., Philips, C.A. and Mitro, S.D. (2016). Recent Fast Food Consumption and Bisphenol A and Phthalates Exposures among the U.S. Population in NHANES, 2003-2010. *Environ. Health Perspect.* 124(10): 1521-1528.