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THE EFFECTS OF CRUDE OIL POLLUTION AND CHEMICAL REMEDIATION ON WETLAND USING GRANULAR ACTIVATED CARBON IN NIGER DELTA REGION

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ABSTRACT

This paper investigated the potency of granular activated carbon in the degradation of crude oil polluted wetland for a period of 60 days. The crude oil polluted wetland was supplemented with different concentration of Granular Activated Carbon such as: 800g, 700g, and 600g, throughout the period of study. The physicochemical properties of the wetland before and after pollution were analyzed in every 14days for a total period of 60 days. Microbiological and physicochemical parameters including total petroleum hydrocarbon (TPH) content were monitored from the baseline of 60 days. The results obtained showed that there was a PH of the wetland after pollution, while there were decreases in soil moisture content, and phosphorus content, which differ remarkably from the control samples. The percentage loss of (TPH) at the end of the investigation was 91.20%. Therefore, this study showed that Granular Activated Carbon is an effective nutrient source for biodegradation.

Keyboards: *Bioremediation, Crude oil, Granular Activated Carbon, Wetland.*

INTRODUCTION

Crude oil spillage is also a very common problem in the country Nigeria. Following the discovery of crude oil, oil activities and pipeline vandalization have given a concern in the Niger Delta area of Nigeria where the bulk of oil is produced. There is therefore a need for continuous research on the problems associated with pollution from spillage and its effects on the soil environment which has a negative impact on crop growth on it. Plants germinate, develop and grow in soil medium where water, air and nutrient resources supply plants for healthy growth for productive and profitable agriculture. Frequent crude oil spillage on agricultural soil and the consequence following effect on all forums of life, render the soil (especially the biologically active surface layer) toxic and unproductive. The oil reduces the soil's fertility such that most of the essential nutrients are no longer available for plant and crop utilization (Abil and Nwosu, 2009). The enormity of toxicity by oil spillage on crop performance is exemplified in mangrove vegetation, which has been dying off in recent times (Henry and Henke, 2005). Spilled crude-oil which is denser than water, reduces and restricts permeability: organic hydrocarbons which fill the soil pores expel water and air, thus, depriving the plant roots the much needed water and air (Brian, 1977). Soil properties involved in soil-plant-water relationship are degradable and include texture, moisture content, hydraulic conductivity, infiltration, pH and density, which effect plant growth and yield development (Michael, 1978: ICGR, 1999, Michael and Ojha, 2006). Odu and Onianwa (1987) demonstrated the effect of pollution on germination growth and nutrient uptake using pawpaw, and Aluadi*et al* (1996) demonstrated chronic effect on soil properties and microflora in a rainforest system. Daniel Kalio and Braide (2004) showed its effect on cultivated wetland areas of the Niger Delta. Other researchers employed maize, capsicum and dayflower for observation of pollution effect (Anoliefo and Nwosu, 1994; Daniel Kalio and people, 2006). Also Ebenezer *et al* (2010) showed the negative impact of oil spill on agricultural production. Source of these negative imparts include reduction in crop yield, pollution of rivers for fishing, land productivity and reduced farm income and standard of living of the people. Achuba (2010) studied the effect of crude oil contaminated soil at various sub lethal concentrations of the growth and metabolism of cowpea (vigna unguiculata) seedlings showing that crude oil induced environmental stress in the seedlings, thereby hindering the productivity of the plant. Similar effect was also observed in soil contaminated with Bonny light whole crude or its fractions on the germination of beans (phaseoluz vulgaris L.) and maize (zea mays L.). Overall, oil spillage affected crop yield and forum income, and by extension, the social and economic livelihoods of farming communities (Odjuvwuederhie *et al*, 2006; Chind and Breide, 2000; Afubi and Onokala, 2000).

Crude oil spillage has frequented the Alluvial River of Igbedi Wetlands in Bayelsa state, Nigeria, and has deprived these communities of their socioeconomic livelihood. This in turn has fostered hostility towards the oil companies when neither the government nor the oil companies acted quickly to accommodate or alleviate effect of the degradation (Agholino, 2000). Consequently, remedial action (apart from the occasional financial compensation) should have been undertaken to solve the ecological degradation that created economic distress on their agricultural livelihood (Essien and John, 2010). Mariana and Toti, (2011), showed that pollution by crude oil changes the properties of natural vegetation. In another study, it was reported that hydraulic conductivity, porosity, and bulk density of soil were affected by oil pollution.

Beside the changes in soil properties, crude oil with toxic compounds, radioactive materials, or disease-causing agents may have adverse effects on plant growth and animal health (Ere.

W and Amagbo, 2019). The destruction or alternation of nutrient source in soil affects the overall growth of plant. This effect of oil spillage on plant's nutrient source such as manganese and ferrous elements has been reported by Ere. W and Amagbo (2019).

The hydrocarbons found in crude oil spillage are large and complex molecules, and persistent in nature and may require a strong reagent to counteract their effects on agricultural soil.

Activated carbon from Agbo wastes such as barks of trees, saw dust, bran (Wheat, rice), husk (Wheat, rice, black gram), shells (groundnut, coconut, hazelnut, walnut, cotton seed), waste leaves (tea, cassia fistula), stalk (cotton, grape sunflower), peels (apple, banana, orange), and others (coffin beans, biochair, water hyacinth, soybean hulls, sugar cane bagasse, jatropha decoiled cakes, maize corn cob, sugar beet pulp, etc) can be used as sorbents to remove the contaminants especially heavy metals (Yeneneh and Maitra, 2011).

The common natural precursors for activated carbon synthesis include coals, petroleum coke, pitch, wood, nutshells peat, lignite, and more exotic ones include starch, sucrose, corn grain, leaves coffee grounds and straw. More advanced activated carbons (ACS) with better developed Porosity, reproducible properties and more uniform microstructure and pores are produced from synthetic polymers, such as polyacrylonitrile (PAN), polyvinylidene chloride (PVDC), polypyrrile (PPY), polyaniline (PANI), polydivinylbenzene (PDVB), to mention a few (Wentian and Gleb2013).

The objective of this study is to investigate the potency of granular activated carbon in the remediation of crude oil polluted wetland.

MATERIALS AND METHODS

Sample Collection

Loamy sand of the coastal plain wetland of the Igbedi River in Kolokoma/Opokumma Local Government Area of Bayelsa State was used for field experiment. This area has oil production and pipelines operations going on. The trial crop used was maize and beans plant, while the polluted soil was contaminated with crude oil, and the crude oil for this experiment were obtained from Nigeria National Petroleum Company (NNPC) in Port Harcourt, Rivers State. The granular activated carbon used for the experiment was brought from Swali Market Yenagoa, Bayelsa State.

The Soil and Coconut Shell Analysis

Physicochemical analysis of both soil and coconut shell was carried out in Institute of Pollution Study (IPS) Port Harcourt before the experimental set up to determine the quintiles of the elements present in both the soil and coconut shell samples and also to determine whether or not the project area (soil) is pristine. The low concentration of elements present in the soil was an indication that the environment is pristine and has not received any significant hydrocarbon pollution in the past.

Experimental Design

Three treatment options with varying concentration of granular activated carbon in polluted soil and a control were set up. The different treatment options were coded as WP-Oto WP3. Cell WP-O was the control volume, i.e did not receive any treatment, whereas cells WP-1, WP-2 and WP-3 were marked to receive 800g, 700g and 600g of granular activated carbon respectively during the remediation period.

Biodegradation under a controlled environmental condition was monitored for 60 days of study. The experimental design is shown in table 1.

Physicochemical Analysis of Soil

The pH of the soil samples was measured in 1:1 (soil: water) ratio using winlab digital pH water. Moisture content and total organic carbon contents were determined following the methods of Walkey and Black (2013).

Soil nitrogen and phosphate were determined quantitatively following the methods of America Public Association (1985).

In determining the Total Petroleum Hydrocarbon (TPH) of the soil, 5g of polluted soil was weighed in a trip beam balance and put in a conical flask and 10ml of toluene (hydrocarbon solvent) was added to the 5g contaminated soil and then stirred vigorously. The solution was filtered using a filter paper via funnel into test tube and the residue was thrown away.

The filter paper was then tested using a spectonic ZID spectrophotometer at 420m in wavelength. This wavelength guaranteed the maximum absorption of hydrocarbon. These filtrates are then transferred in different test tube one after the other and absorbent reading was taken in the process. A blank sample (toluene alone) was first tested for its absorbent and then the machine was adjusted to the zero mark before other readings were taken. A chart of absorbent again TPH (mg/kg) was then used to read the total. The total petroleum hydrocarbon was calculated with reference to Odu *et al* (1985) using the standard curve, and multiplication by the appropriate division factor.

Table 1: Experimental Design

CELLS	DESCRIPTION
WP-0	3kg of polluted soil
WP-1	3kg of polluted soil + 800g of activated carbon
WP-2	3kg of polluted soil + 700g of activated carbon
WP-3	3kg of polluted oil + 600g of activated carbon

Microbial Samples

The soil samples were later transported to the Department of Microbiology in Niger Delta University Wilberforce Island Amassoma, Bayelsa State for the purpose of isolation, identification and characterization of a possible microorganism presence in this soil.

Enumeration of Total Hydrocarbon Utilizing Bacteria and Fungi

Vapour – phase method was adopted to estimate the population of Total Hydrocarbon Utilizing Bacteria (THUB) on a modified mineral Salt Agar (MSA) with the following composition. Nacl = 10g, $MgSo_4$ = 0.42g, KH_2PO_4 = 1.32C1, Agar = 15.0g in one litre of distilled water as described by Chikere and Okpowasili (2011). A sterile filter paper was saturated with crude oil and placed inside the cover of each petri dish, kept in an inverted position the plates containing 0.1ml… of aliquots of serially diluted soil samples were incubated at 35-37^{0}cfor 5-7 days. The crude oil served as the only source of carbon and energy for the growing culture. After incubation, the colonies were counted and the mean counts were recorded. The same procedure used for the enumeration of hydrocarbon utilizing fungi with addition of 0.1m lactic acid for the inhibition of the growth of hydrocarbon utilizing bacteria.

RESULTS

Baseline microbiological and physiochemical properties of the crude oil contaminated soil and properties of granular activated carbon are shown in table 2. The baseline microbiological parameters were higher in the crude oil contaminated soil than in granular activated carbon, except for hydrocarbon utilizing fungi. The baseline physiochemical parameters were higher in activated carbon than in the contaminated soil except for TPH which was only present in the contaminated soil and total organic carbon.

DISCUSSION

The amount of hydrocarbon utilizers in the activated carbon and the contaminated soil were considerably high and adequate for bioremediation. The pH of activated carbon has been documented by other researchers to fall within the range of 5.0-8.0 (Fig. 1).

Table 2: baseline properties of contaminated soil and granular activated carbon compost

Parameters	Contaminated soil	Activated carbon
Total Heterotrophic bacteria (CFU/g)	1.92 x 102	1.32 x 104
Total Heterotrophic fungal (CFU/g)	1.22 x 105	6.7 x103
Hydrocarbon utilizing bacteria	8.2 x 104	6.4 x 104
Hydrocarbon utilizing fungi	5.3 x 102	9.4 x102
Total petroleum hydrocarbon (mg/kg)	143276.2	
pH	5.7	6.5
Moisture (%)	11.2	51.7
Total nitrogen (%)	4.2	20.8
Total phosphorus (%)	0.16	4.34
Total organic carbon (%)	11.6	7.46

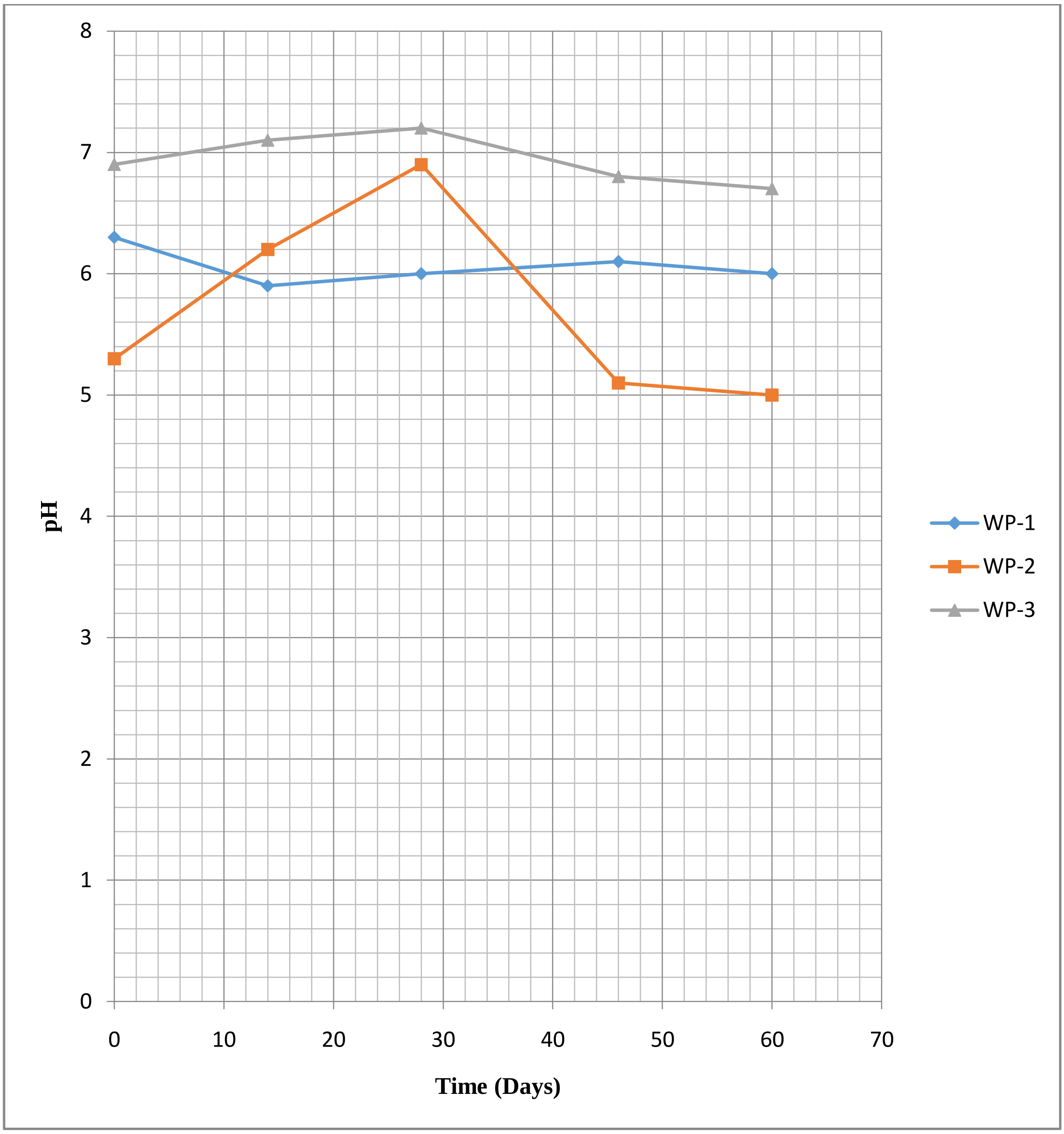

Fig. 1: Change in pH values of the treatment options during remediation study

The pH value of the various treatment set up were slightly acidic and alkaline. This may be attributed to the enhancement or enrichment of the nutrient levels (by supplementing growth various amounts of activated carbon of the soil). The total organic carbon (Toc) content of the contaminated soil prior to amendment was 11.60% at the end of 60 days, the TOC present in the sample was 7.30% for WP-1, 7.40% for WP-2, 8.30% for WP-3, experiments respectively, as shown in fig 2.

There were slight decreases in Total Organic Carbon (TOC) concentration in the various codes. The loss in TOC has been correlated with biomass increase in microbial systems. Ibiene et al. (2011) and Adenipakun and Ogunjobi (2011), however reported slight increases in TOC in their bioremediation studies. The total nitrogen content of the contaminated soil prior to after amendment of the experimental soil samples with various concentration of activated carbons, the total available soil nitrogen at day 60 of study period was 7.56% for WP-1, 9.67% for WP-2, 11.67% for WP-3, experiments respectively, as shown in fig 3.

Also, the total phosphorus content of the contaminated soil after amendment with various concentration of activated carbon for WP-1, WP-2, WP-3, after 60 days of the study increased to 3.96mg/kg, 6.21mg/kg and 9.16mg/kg respectively (fig.4) compared with the baseline of 0.61mg/kg.

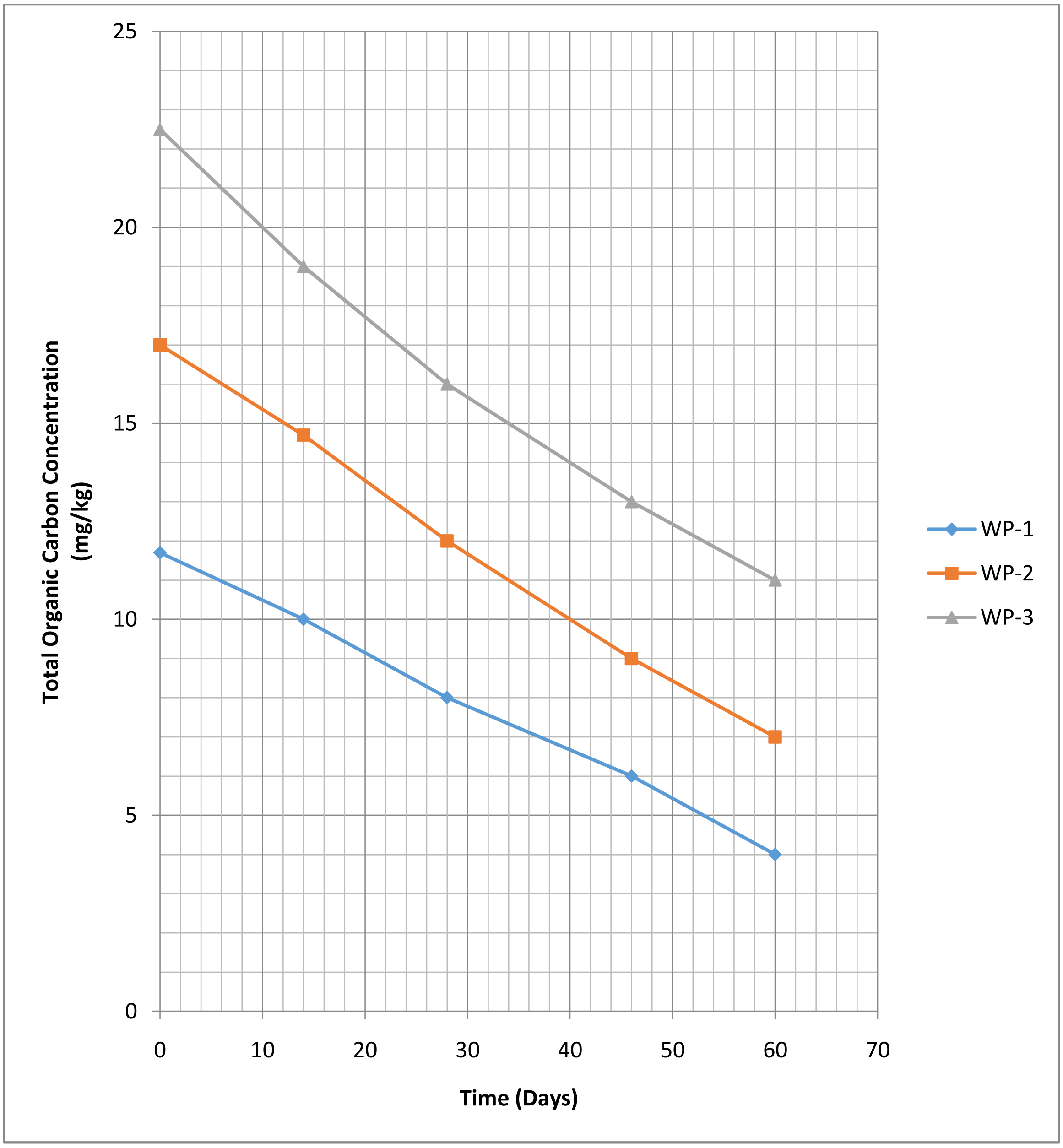

Fig. 2: Changes in Total Organic Carbon (TOC) Concentration of the Treatments Options during Remediation Study

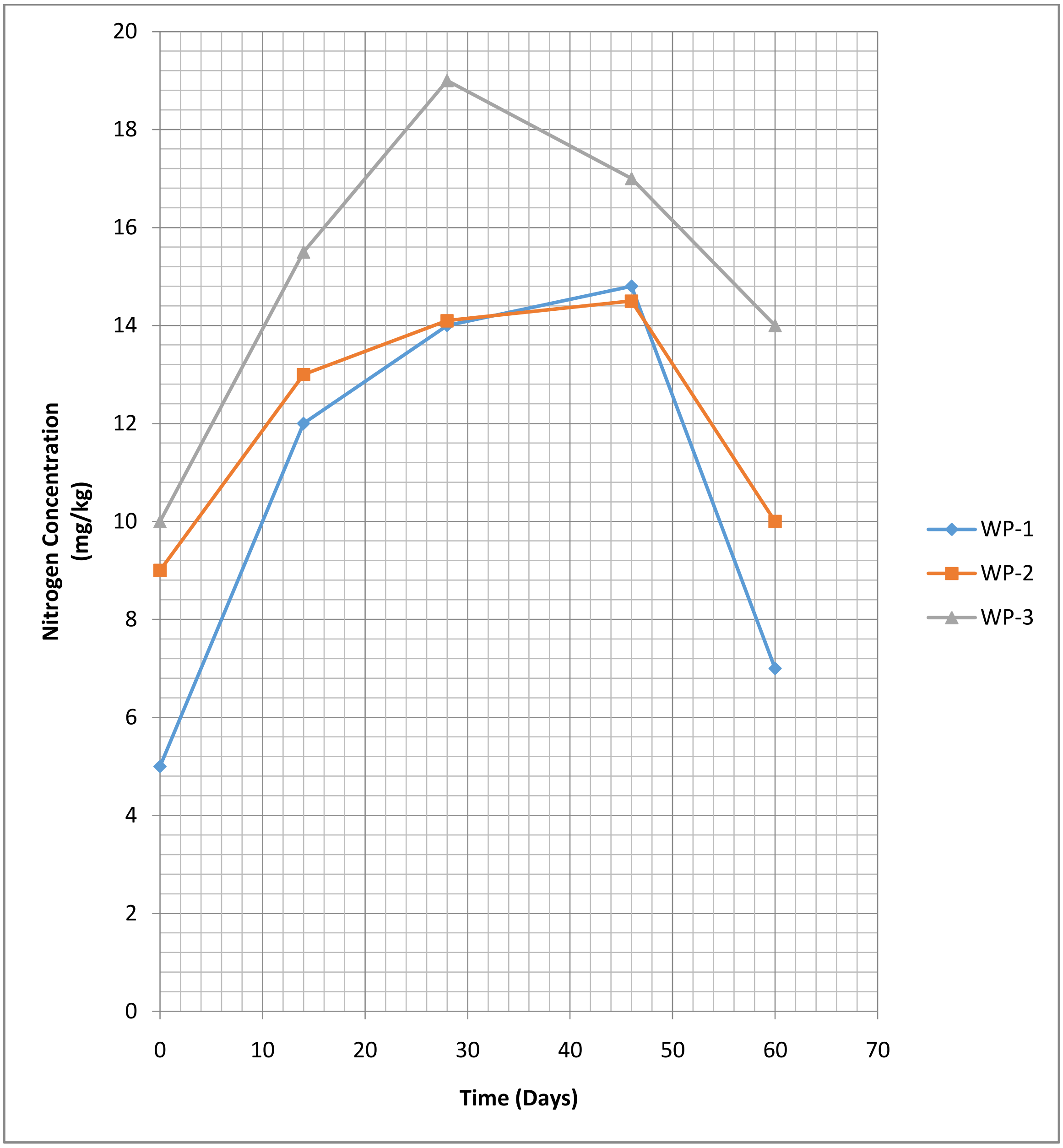

Fig. 3: Change in Nitrogen Concentration of the treatment options remediation study

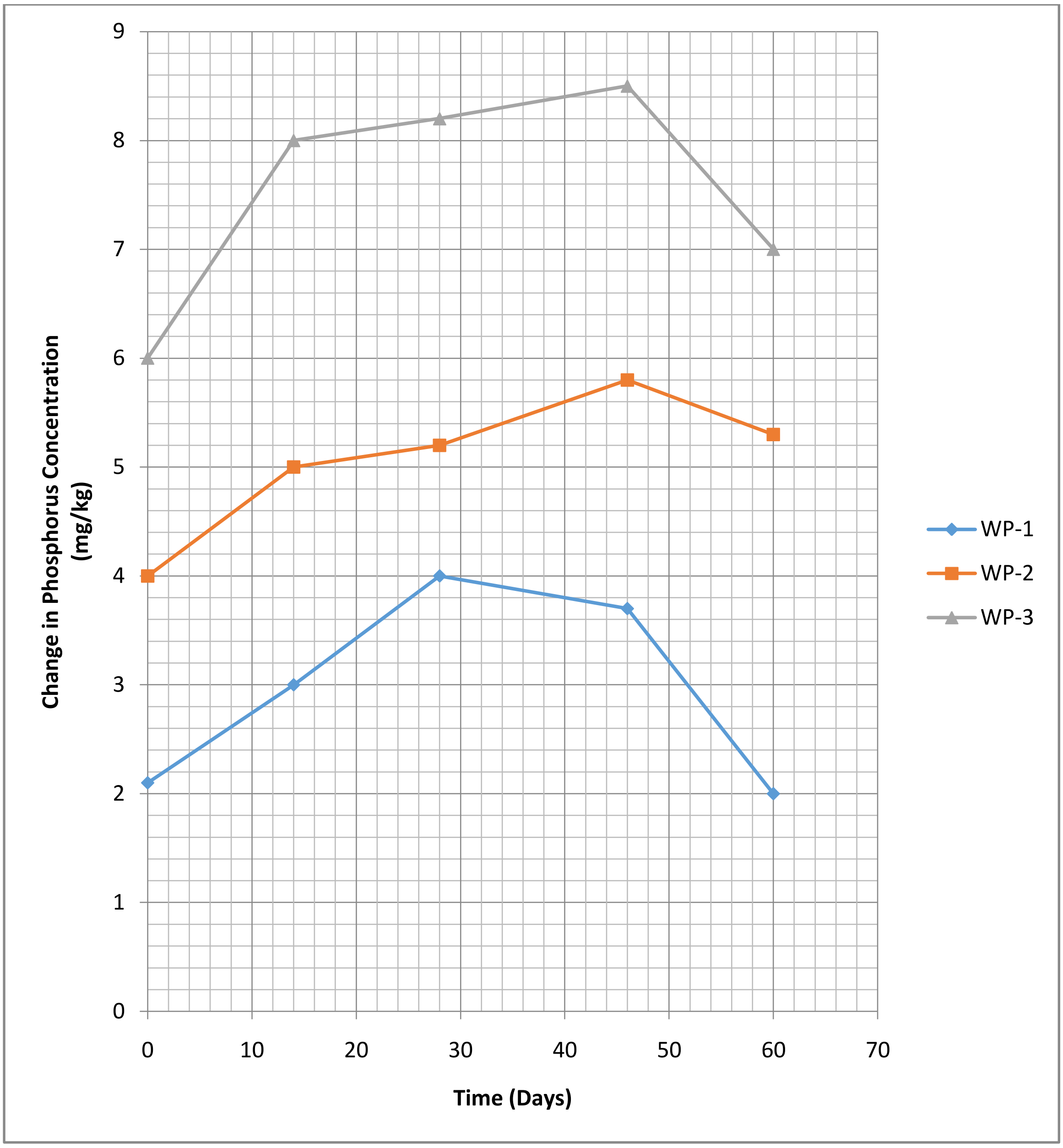

Fig. 4: Change in Phosphorus Concentration of the Treatment Options during Remediation Study

The result for Total Petroleum Hydrocarbon (TPH) shown in fig. 5 revealed a total percentage loss of 90.10% WP-3 after 60 days of study, a significance decrease with respect to time when compared to the baseline concentration.

Decrease in TPH indicates the effectiveness of granular activated carbon as a very useful bio-remediating organic substance. Stanley *et al.* (2017) and Adenipekum and Ogwijobi (2011) in their study also report a very high percentage loss of about 90% of TPH. The hydrocarbon utilizing bacteria isolated were both positive and negative bacteria. Okerntugba *et al*. (2015) reported that gram negative bacteria have a dominant population in crude oil contaminated soil. Bioremediation of crude oil by activated carbon yield favorable results when compared with myco-remediation. Granular activated carbon provides great capacity to remediate polluted soil when compared to other number of pleuritic family previously and commonly used in bio-remediation.

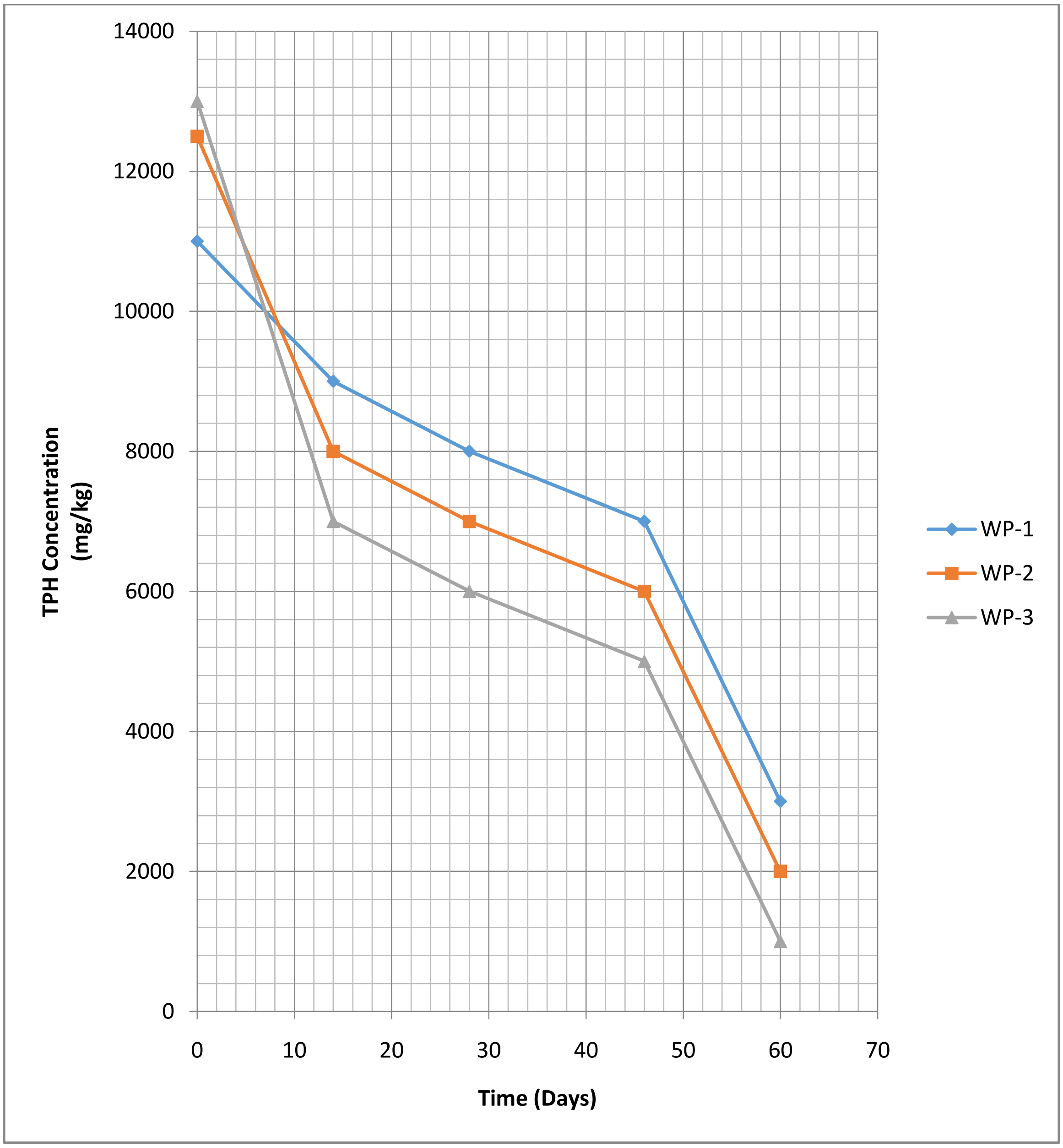

Fig. 5: Change in Total Petroleum Hydrocarbon (TPH) concentration of the treatment option during study

CONCLUSION

This research has shown the effectiveness of granular activated carbon in bioremediation. The result of the total petroleum hydrocarbon of 1012mg/kg and a percentage loss of 93.20% after 60 days of study shows a significant decrease with time when compared with the initial TPH Concentration of the contaminated soil of 13376.2mg/kg therefore future work should focus on how bioremediation of crude oil contaminated sites with optimum combination of granular activated carbon and other organic wastes.

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