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Full Length Research Paper

A Study on the impacts of waste lubricating oil on properties of soil and the conceivable cures

Owumi E. Great

Department of Chemical and Polymer Engineering, Faculty of Engineering, University of Ibadan, Ibadan, Nigeria. Email: great.owumi@ymail.com

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Waste oil management in Nigeria is not well supervised, hence the indiscriminate disposition into the soil drains and sometimes open water. This has attendant implications on soil and water quality. Need has arisen to evaluate the consequence of such mismanagement on the environment. This study was designed to evaluate the effects of waste oil on the physical and chemical properties of soil in Lagos, and the possible remedies. The soil analysis showed that waste lubricating oil adversely altered the physical and chemical properties of the soil. It resulted in increase in bulk density from 1.10 to 1.15 g/cm^3, organic carbon (2.15 to 3.05), moisture content and reduction in pH (6.5 to 6.0), porosity, capillarity (8.10 to 0.04 cm/h), water holding capacity, phosphorus and potassium contents. However, application of remediation agents such as water hyacinth, organic waste (ground corn cobs) and Polyurethane foam to the contaminated soil sample reduced the waste oil concentration and this resulted in improvements in the physical and chemical properties of the soil.

Key words: Waste oil, pollution, remediation, water hyacinth, reduce wear, environment.

INTRODUCTION

Lubricating oils are viscous liquids product of petroleum composed of long-chain saturated hydrocarbons (base oil) and additives that are used for lubricating moving parts of engines and machines. It is usually produced by vacuum distillation of crude oil (Kalichevsky and Peter, 1960). It aids the reduction of frictional forces between contacting metal surfaces of the engines by creating a separating film between the metal surfaces of adjacent moving parts. This minimizes direct contact between them, thereby decreasing the heat caused by friction and reducing wear, thus protecting the engine. There are three major classes of lubricating oils, namely: lubricating greases, automotive oils and industrial lubricating oil. Waste oils are usually generated during servicing of engines (Anoliefo and Vwioko, 2001; Ogbo et al., 2006). Waste lubricating oil having been contaminated with impurities in the course of usage and handling; contain Toxic and harmful substances such as benzene, lead, cadmium, polycyclic aromatic hydrocarbons (PAHs), zinc, arsenic, polychlorinated biphenyls (PCBs) etc. which are hazardous and detrimental to the soil and the surrounding environment.

Increase in demand for cars, heavy duty automobiles, generators etc. throughout the years, led to increase in demand for lubricating oils, and this eventually resulted in the generation of large volumes of waste oils worldwide. In Nigeria, waste oil irrespective of the type and source of collection, is sometimes dumped on vacant plots, farm lands etc., causing harmful or toxic materials to percolate through the soil thus contaminating the soil and thereby changing the physical and chemical properties. Used oil is also sometimes dumped down drain, sewers, disrupting the operations at waste water treatment plants (Odegba and Sadiqi, 2002). Research has shown that the increased pollution incidents in the environment are more widespread than pollution with crude oil (Atuanya, 1980). In recognition of the danger of environmental pollution caused by the indiscriminate disposal of waste oils to individuals and nations, management of waste oil then became a critical course of concern to nations of the world.

METHODOLOGY

Sample preparation

Soil sample contaminated with waste oil were collected at depth of (0 to 5 cm) from two different spots: in an auto-mechanic workshop in Lagos while the uncontaminated soil sample of the same quantity was collected at the same depth of (0-5cm) at about 5 meters away from the contaminated spot.

The two soil samples were put into two medium sized (15 cm^3) plastic containers and labeled 'A' for the uncontaminated soil sample and 'B' for the contaminated soil sample. Both samples were sieved and taken to "Lagos State Material Testing Laboratory, Ojodu-Berger, Lagos for evaluation and analysis of the soil properties in the laboratory. The physical and chemical properties of both soil samples were then analyzed accordingly and various results obtained for the tested parameters.

The physical properties determined were: bulk density, soil capillarity, soil porosity, water holding capacity. The chemical properties determined were: soil pH, phosphorus content, potassium content and moisture content.

Methods of soil analysis

The soil samples were analyzed for both physical and chemical properties using various methods of analysis as discussed below.

The bulk density was determined according to ASTM 29. The soil porosity, soil capillarity and water holding capacity (WHC) were determined according to Akinsanmi (1975); soil pH was tested by means of a glass electrode pH meter by dipping the glass electrode into 1:1 soil-water suspension; Exchangeable cations, Potassium ($K+$), was determined by using methods of "Udo and Ogunwale (1986)," whereby the ammonium acetate extract topsoil samples were subjected to flame photometry and atomic absorption spectrometer; available phosphorus was extracted by Bray 1 method (Bray and Kurtz, 1945) and analyzed colometrically; Organic carbon (c) was determined using the adapted (Walkley and Black, 1934) method.

Bulk density

The bulk densities of the soil samples were determined according to ASTM C29. Apparatus used were: metal cylindrical container, weighing balance, vernier caliper.

Soil capillarity

The soil capillarity was determined using Akinsanmi (1975) method. Apparatus used were 2 long and wide glass tubes, cotton wool, dry soil samples, clock and ruler.

Procedure: The lower end of each tube was closed with a plug of cotton wool. One tube was filled with dry uncontaminated soil and the other with dry contaminated soil sample. The ends of the tubes were tapped gently on the bench to tightly pack the soils in both tubes such that the soil was not more tightly compressed in one tube than the other. The tubes were set in a trough containing water up to a depth of 5 cm. Each tube was supported with a clamp when necessary. After intervals of ten minutes, the rise of water in each tube above the level of water in the trough was then measured. The experiment was left for about 24 h and then examined for the rise of water level in both soil samples.

Soil porosity and water holding capacity (WHC)

These were also determined according to Akinsanmi (1975). The various results were as shown in Table 1. Apparatus used were oven, two 100 cm^3 measuring cylinders, two funnels, cotton wool, dry soil samples and stop clock.

Procedure: Equal volumes of both soil samples were completely dried in an oven and placed in separate funnels plugged with cotton wool. The funnels were carefully tapped persistently on the bench until all visible air spaces were filled, and each funnel placed in the open end of each 100 cm^3 measuring cylinder. 50 cm^3 of water was quickly poured into the funnel containing each soil sample. Using the stop clock, the time taken for the first drop of water to drip through into the measuring cylinder was noted in each case. Water was allowed to drain through the soil samples until no water dripped into the measuring jars any longer. The volume of water which passed through was measured in each case. By subtraction, the volume of water retained was determined in each case.

Soil pH

The soil pH was determined with the use of pH indicator (meter). Apparatus used were test tube, pH indicator, weighing balance, spatula, beaker.

Procedure: 5 g of the soil sample was weighed into 5 g of distilled water in a test tube and vigorously stirred. The pH was obtained using a pH indicator and read after 3 s. It was cross-matched with the color scale. pH of 6.5 was obtained for the soil sample without oil while pH of 6.0 was obtained for the waste or used oil contaminated soil.

Phosphorus content

This was determined by the Bray and Kutz method with the use of absorption spectrophotometer. Apparatus used were test tube, beaker, and absorption spectrophotometer. Reagents used were: Bray extractant consisting of 0.025 normal HCl and 0.03 normal NH_4F.

Procedure: 1 g scoop of soil and 10 ml of extractant were mixed together for 5 min. This was further shaken to give a blue color. The intensity of the blue color filtrate developed was treated with ammonium molybdate – hydrochloric acid solution and aminonaphthol – sulfonic acid solution. The color was measured using an absorption spectrophotometer at 640 nm. The result was calculated in ppm as shown in Table 2.

Potassium content

Apparatus used were: test tube, color scale, beaker, and spatula.

Table 1. Results of soil analysis showing effects of waste lubricating oil on the physical properties of soil.

Parameters	Uncontaminated soil sample 'A'	Contaminated soil sample 'B'
Bulk density (g/cm^3)	1.10	1.15
Soil capilarity (cm/h)	8.10	0.04
Soil porosity (ml)	110	80
Water holding capacity (WHC) (ml)	55.0	15.0

Table 2. Results of soil analysis showing the effects of waste lubricating oil on the chemical properties of soil.

Parameters	Uncontaminated Soil Sample 'A'	Contaminated Soil Sample 'B'
Soil pH	6.5	6.0
Phosphorus content (ppm)	80	40
Potassium content (ppm)	98	60
Organic carbon	2.15	3.05
Moisture content (%)	3.5	9.9

Procedure: A test tube was placed into cavity of the thermoformed lining and filled with 0.7% nitric acid. Potassium test sticks were removed as required and then the container was resealed immediately. A test stick was dipped into the solution to be tested so that the reaction zone was completely moist. Excess liquid was shaken off. A test stick was placed into the test tube which was filled with 0.7% nitric acid and then left for one minute. The test tube was removed and compared with the color scale. In the presence of potassium, the test paper turned yellow to orange red.

Moisture content

Apparatus used were: sampling can with lid, weighing balance, oven, and spatula.

Procedure: The sampling cans were weighed with weighing balance based on different samples to be tested. Each sampling can was filled with the soil sample and weighed. They were dried in oven for six (6) hours and weighed. Results obtained were as recorded in Table 2.

RESULTS AND DISCUSSION

Results of the soil analysis on both soil samples indicate that the presence of waste lubricating oil in the soil altered the soil chemistry, and thus led to adverse effects on the physical and chemical properties of the soil.

The presence of waste or used lubricating oil in the soil altered the physical properties as explained below and shown in Table 1. The bulk density slightly increased with the presence of waste oil. While the bulk density in the control or uncontaminated soil sample was 1.10 g/cm^2, that of waste oil contaminated soil was 1.15 g/cm^3.

The rate of soil capillarity in the control or uncontaminated soil sample was 8.10 cm/h while that of contaminated soil sample was 0.04 cm/h (Table 1). The drastic drop in capillary rise in the waste oil contaminated soil sample was due to reduction in the pore spaces of the soil. The soil porosity decreased with the presence of waste lubricating oil. The value reduced from 110 ml for the control (uncontaminated) soil sample to 80 ml for the treatment or contaminated soil sample. Presence of waste lubricating oil drastically reduced the water holding capacity of the soil as shown in Figure 1 due to the presence of pollutants from the waste oil. Hence, the water holding capacity in the control experiment was 55.0 ml while that of treatment or contaminated sample was 15.0 ml.

The presence of waste lubricating oil also had some significant adverse effects on the chemical properties of the soil. As shown in Table 2, the chemical properties of the soil were altered by pollution of the waste lubricating oil. The result of the soil analysis showed that waste lubricating oil reduced the pH value from 6.5 to 6.0 thereby making the soil more acidic. The reduction in pH value which resulted in increase in the acid level of the soil was probably due to the addition of carbon present in the waste lubricating oil to the carbon already present in the soil. A drastic reduction from 80 ppm in the control or uncontaminated sample to 40 ppm in the treatment or contaminated soil sample was observed. There was a considerable reduction in the potassium content in the waste oil contaminated soil. The value dropped from 98 ppm in the uncontaminated soil sample to 60 ppm in the contaminated sample. It was observed that there was increase in the carbon contents in the waste oil contaminated soil more than the value recorded in the control or uncontaminated soil sample. It increased from 2.15 in the control sample to 3.05 in the treatment sample.

However, the increase in carbon content can also be attributed to the addition of carbon present in the waste lubricating oil to the carbon already present in the soil. The moisture content increased from 3.50% in the control sample to 9.9% in the treatment sample as shown in Figure 2. This is due to the additional weight obtained from the moisture of the waste oil to that of the soil sample.

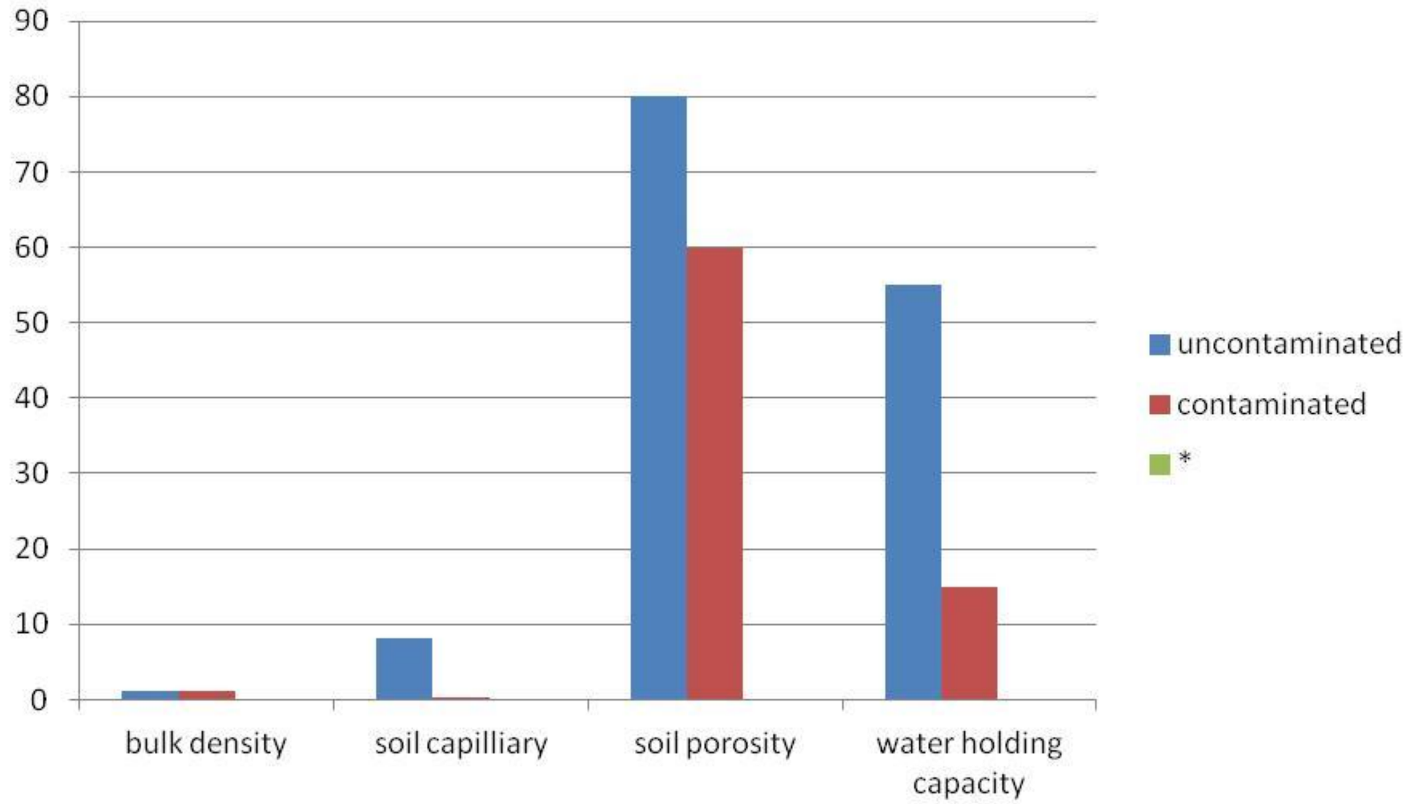

Figure 1. Effects of waste oil on the physical properties of soil.

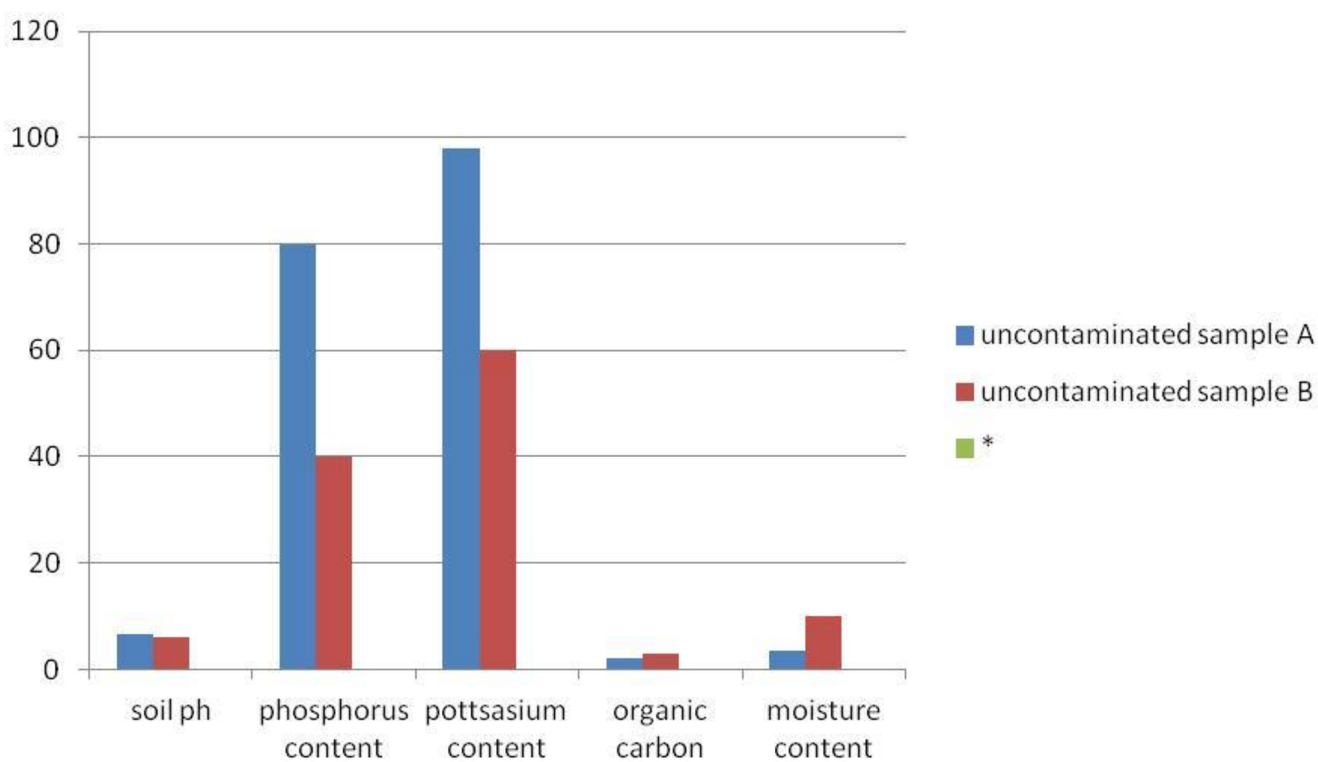

Figure 2. Effects of waste oil on the chemical properties of soil.

Table 3. Results of soil analysis showing the effects of Remediation Agents on the physical properties of waste lubricating oil contaminated soil.

Parameters	Test values obtained		
	Contaminated soil sample + Water hyacinth "B1"	**Contaminated Soil Sample + Organic waste (Ground corn cobs), "B2"**	**Contaminated soil sample + Polyurethane foam, "B3"**
Bulk density (g/cm^3)	1.14	1.13	1.11
Soil capillarity (cm/h).	0.08	0.10	0.20
Soil porosity (ml)	65	70	75
Water holding capacity (WHC) (ml)	20.0	25.0	33.0

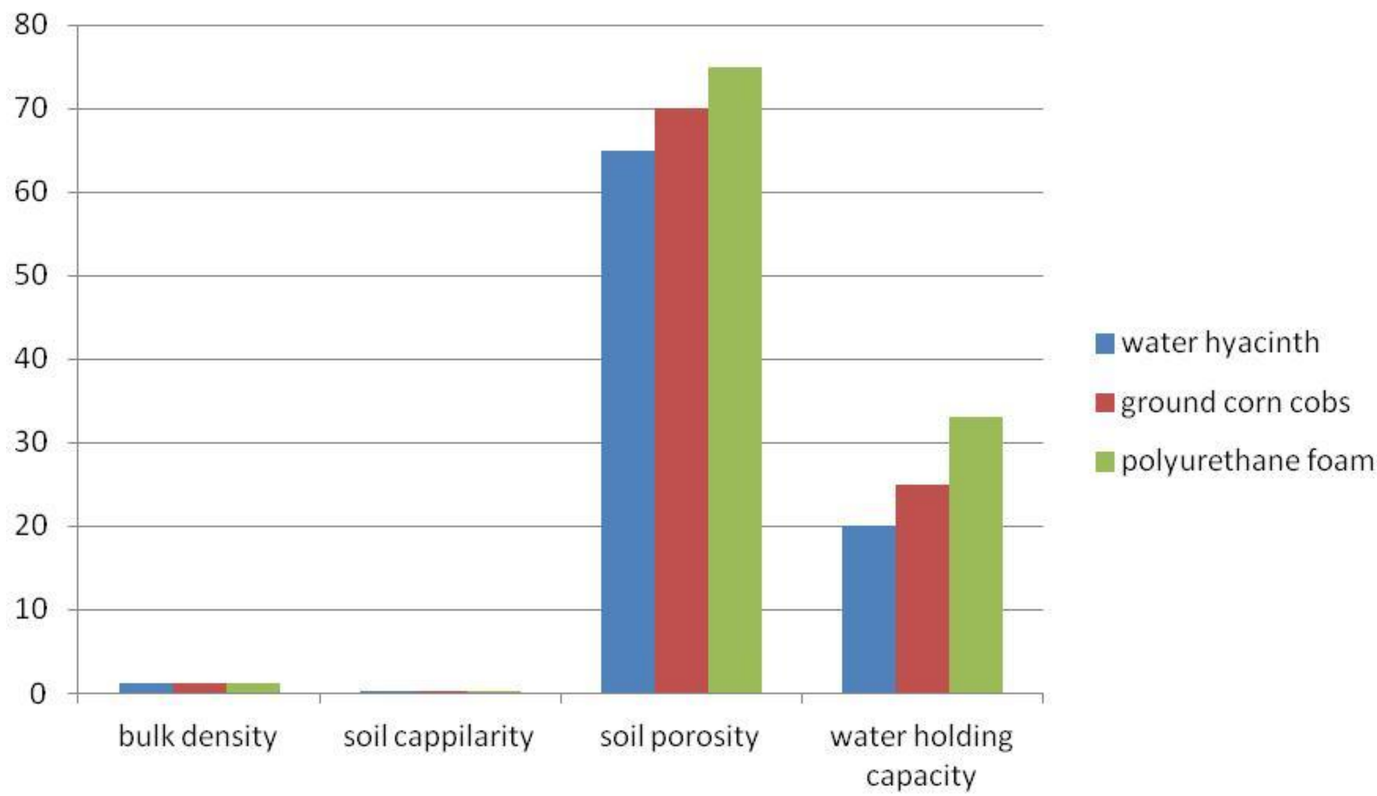

Figure 3. Effects of remediation agents on the physical properties of contaminated soil.

The application of the remediation agents resulted in increase in the soil capillarity, water holding capacity (WHC), soil porosity and reduction in the bulk density as shown in Tables 3 and Figure 3 respectively.

Results of analysis of the soil samples after addition of the remediation agents also showed that there were significant improvements/changes on the chemical properties of the waste oil contaminated soil. Addition of the remediation agents resulted in a considerable increase in the "initially reduced values" of some chemical properties of the waste oil contaminated soil sample namely: Soil pH, phosphorus and potassium contents; while the carbon content and moisture content experienced a drop in values with the presence of remediation agents as shown in Table 4. However, the remediation effect was observed to be fastest and greatest with the polyurethane foam, followed by the organic waste (ground corn cobs) and water hyacinth in that order as shown in Figure 4.

Conclusion

This research study revealed that waste lubricating oil significantly and adversely affected both the physical and chemical properties of the soil. It also revealed that waste lubricating oil contains so many toxic and hazardous or harmful substances such as PCBs, PAHs, benzene, lead, arsenic, zinc etc., which aid contamination of soil

Table 4. Effects of remediation agents on the chemical properties of waste lubricating oil contaminated soil.

Parameters	Test values obtained		
	Contaminated soil sample + Water hyacinth, "B4"	Contaminated soil sample + (Ground corn cobs), "B5"	Contaminated soil sample + Polyurethane foam, "B6"
Soil pH	6.02	6.05	6.20
Phosphorus content (ppm)	45.0	48.5	52.0
Potassium content (ppm)	65.0	68.0	72.0
Organic carbon	2.80	2.50	2.35
Moisture content (%)	6.50	6.20	4.15

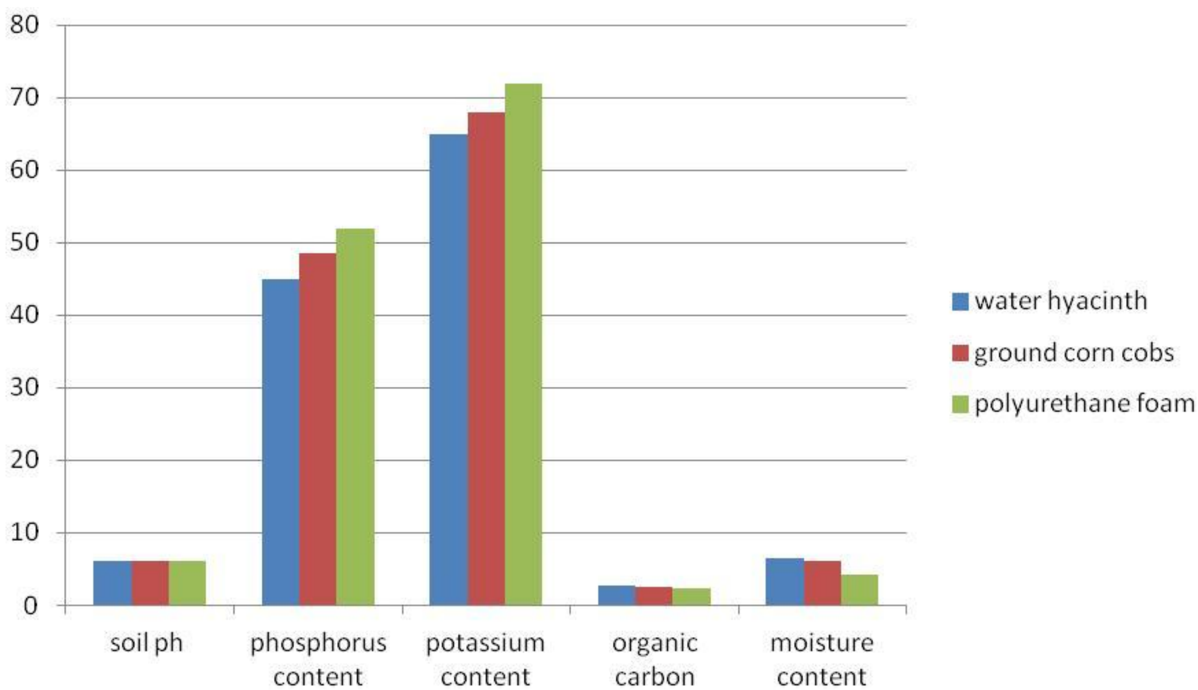

Figure 4. Effects of remediation agents on the chemical properties of waste oil contaminated soil.

properties unlike the virgin oil. However, remediation using ground corn cobs, water hyacinth and polyurethane foam reduce the effect of the contaminants to varying degrees.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Anoliefo GO, Vwioko DE (2001). Effects of Spent Lubricating Oil on the Growth of Caposicum annum L. and Lycopersicom esculenta Miker. Environ. Poll. 88:361-364. http://dx.doi.org/10.1016/0269-7491(95)93451-5

Akinsanmi O (1975). Certificate Agricultural Science. Longman 196 pp.

Atuanya EI (1980). "Effects of Waste Engine Oil Pollution on Physical and Chemical Properties of Soil. A Case Study of Waste Oil Contaminated Delta Soil in Bendel State. Nig J. Appl. Sci. 5:155-176.

Atuanya EI (1980). Effects of Waste Engine Oil Pollution on Physical and Chemical Properties of Soil. Nig. J. Appl. Sci. 5:55-176.

Odjegba VI, Sadiqi AO (2002). Effects of Spent Engine oil on the Growth Parameters, Chlorophyll and Protein Levels of Amaranthus hybridus L. The Environmentalist 22:23-28. http://dx.doi.org/10.1023/A:1014515924037

Udom BE, Mbagwu JSC, Willie ES (2008). A journal on "Physical Properties and Maize production in a Spent oil Contaminated Soil Bioremediated with Legumes and Organic Nutrients 7(1):33-40.