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EFFECTS OF AGRO-INDUSTRIAL WASTE ON THE PHYTOREMEDIATING POTENTIAL OF SUNFLOWER IN HYDROCARBON-CONTAMINATED SOIL

BY

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CERTIFICATION

This is to certify that this research work was carried out by AHMED Danfulani Habiba (SCP10/11/H/0272) in the Institute of Ecology and Environmental Studies, Obafemi Awolowo University Ile – Ife, Nigeria under my supervision.

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DEDICATION

This work is dedicated to Almighty Allah (SWT) and my lovely parents. May Allah's love and endless blessings continue to strengthen me in all my endeavours.

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ABSTRACT

This study investigated the growth performance and yield of sunflower (*Helianthus annuus* L.) under different concentrations of petroleum hydrocarbon contaminated soils. This was with a view to assessing the phytoremediating potentials of the test crop when different agro-industrial wastes were applied as soil enhancers.

The study was carried out at the screenhouse of the Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife. Poultry droppings were collected from the University Teaching and Research Farm and composted. Sawdust was collected from sawmills along Road Seven, Ile-Ife and ashed. The composted poultry manure and the ashed sawdust were mixed at different ratios [0:100 (PW_0SD_{100}), 25:75 ($PW_{25}SD_{75}$), 50:50 ($PW_{50}SD_{50}$), 75:25 ($PW_{75}SD_{25}$), 100:0 ($PW_{100}SD_0$)] to act as enhancers. Bulk surface soil sample from an exhaustively cropped land was collected, air-dried and sieved through a 2 mm mesh. One hundred and thirty five pots with perforations at the bottom, each with five kilograms of the air-dried soil was contaminated to different levels (0, 1, and 2%) of crude oil from Nigerian National Petroleum Corporation, Eleme, Rivers State. The manures were applied at the rates (0, 4, 8 t ha^{-1}) two weeks before planting of sunflower seeds and pots were watered to field moisture capacity with distilled water. Viable seeds of sunflower from Institute of Agricultural Research and Training, Ibadan were sown at four seeds per pot and the emerged seedlings were thinned to two stands per pot two weeks after sowing. The pots were maintained weed-free throughout the experimental period. Growth parameters (plant height, stem girth, number of leaves and leaf area) of sunflower were measured fortnightly. The root, shoot and grain yield of sunflower were harvested at full maturity and analysed for Pb, Cd and total petroleum hydrocarbon (TPH). Pre

and post cropping analyses of soils were carried out to determine the nutrients, Pb, Cd and TPH using standard methods. Data obtained were subjected to ANOVA and descriptive statistics.

Seedling emergence was recorded in all the pots and they all survived till the end of the growing period, except for 2% crude oil contaminated pots without 100% and 75% poultry wastes. Highest growth performance was recorded in pots with no contamination but with $PW_{100}SD_0$ (186 cm, 36, 3.8 cm, 141 cm^2 and 23.0 g /pot) while the control pots had the least growth performance of 117 cm, 12, 2.0 cm, 19 cm^2 and 16.8 g/pot) for the plant height, number of leaves, stem girth, leaf area and shoot yield respectively. The highest uptake values of Pb, Cd and THC in the shoot were: 0.99, 1.01 and 1.98 mg kg^{-1} while the roots: 1.78, 1.80 and 1.74 mg kg^{-1}respectively at 2% contamination when 8 t ha^{-1} of $PW_{100}SD_0$ was applied. The uptake of Pb 0.43, Cd 0.48 and TPH 0.83 mg kg^{-1} was obtained in the grains at 2% contamination when 8 t ha^{-1} of $PW_{100}SD_0$ was applied. Addition of composted poultry manure and ashed sawdust increased the soil acidity by 18% and this enhanced the bioavailability of other soil properties.

The study concluded that sunflower plant could be effectively used for the remediation of petroleum hydrocarbon-contaminated soils and poultry manure compost mixed with ashed sawdust enhanced the remediating ability.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The exploration and exploitation of the environment date back to the existence of man on earth (Ekundayo, 1988). Oil exploration and exploitation are two of the activities that started at different times in different parts of the world. Before the discovery of crude oil, Nigerian economy survived and flourished on agriculture. The history of oil exploration in Nigeria could be traced to the first decade of the last century (Charles *et al*., 2009). Olujimi *et al*. (2011) observed that exploration and exploitation has not only caused degradation to the environment and destroyed the traditional livelihood of the people but has also caused environmental pollution that has affected weather conditions, soil fertility, waterways aquatic habitats and wildlife. Processing and distribution of petroleum hydrocarbon as well as the use of petroleum products are the main cause of soil contamination (Ayotamuno *et al.,* 2006). Oil spill incidents have occurred in various parts and at different times along our coast, if these are not monitored or controlled, they could lead to general loss of our God given environment.

Soil is the collection of natural bodies on the earth surface supporting or capable of supporting crops and showing properties resulting from integrated effect of climate and living organisms on parent rock as conditioned by relief and time. Soil is very important to human existence for various reasons especially agriculture. However, soil has been subjected to several abuses including spillage of petroleum (crude oil) and petroleum by-products, dumping of wastes and other contaminating activities (Wellingia *et al*., 1999; Nwaugo *et al.,* 2007; Osam, 2011).

Environmental remediation is the removal of pollutants or contaminants from environmental media such as soil, groundwater, sediment, or surface water for the general protection of human health and the environment. Remediation is generally subject to an array of regulatory requirements, and also can be based on assessments of human health and ecological risks where no legislated standards exist or where standards are advisory.

There are several techniques of remediation. The selection of any soil remediating method depends on the penetration depth of the contaminant into the soil and on the nature of the soil if the contaminants in the subsoil are biodegradable. Some of these methods could have adverse effects on the environment, while some could be expensive to use. An environmentally sound technology that addresses the inadequacies of these remediation practices will therefore be pertinent in this era of global economic meltdown (Osam *et al.,* 2011). Phytoremediation technology is more favorable due to its potential for cleaning up environment and the overall aesthetic perfection of the contaminated sites (Chen and Cutright, 2002; Fayiaga *et al*., 2004).

Phytoremediation is the use of plants for the cleaning up of environments contaminated with hazardous wastes. Plants can be used in site remediation both through the mineralization of toxic organic compounds as well as through the bioaccumulation and concentration of heavy metals and other inorganic compounds (Nishi *et al.,* 2010). Plants act as solar-powered pump-and-treat systems as they take up water-soluble contaminants through their roots and transport/translocate them through various plant tissues where they can be metabolized, sequestered, or volatilized.

High biomass producing plant species such as sunflower have potential for extracting heavy metals in polluted soils. The importance of sunflower is enormous; one of these importances is an emerging technology known as phytoremediation, whereby, plants with high biomass have capability of removing large amounts of trace metals by harvesting the

aboveground biomass. Adewole *et al.,* (2008a) observed that cultivable sunflower has the ability to store heavy metals in their roots such as Cd, Zn and Pb

1.2 Effects of Organic Fertilizer in Hydrocarbon Contaminated Soils.

Organic fertilizer refers to soil amendment derived from natural sources that guarantees, at least, the minimum percentages of nitrogen, phosphate, and potassium. The nutrients in organic fertilizers are released much more slowly than synthetically produced ones. Fertilizer stimulates microbial growth and increases rate of hydrocarbon biodegradation. Organic fertilizers not only provide essential nutrients to plants, they also improve soil structure. Organic matter helps break up heavy clay soil, improve air circulation and drainage, and also increases the capacity for sandy soils to retain moisture. Good soil structure makes it easier for the roots of plants to reach moisture and to absorb the nutrients and also take along the contaminants from the contaminated soil.

1.3 Justification for the Study

One of the problems of environmental degradation in Nigeria till date is contamination from crude oil. Soils contaminated with crude oil are abandoned due to their inability to support agricultural activities. There is dearth of information on the use of sunflower for the phytoremediation of crude-oil-contaminated soil. This study therefore seeks to assess the ability of sunflower to phytoremediate crude-oil-contaminated soil under different organic fertilizers as enhancers.