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Biostimulation of spent engine oil contaminated soil using *Ananas comosus* and *Solanum tuberosum* peels

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HIGHLIGHTS

- Biostimulation potential of *A. comosus* and *S. tuberosum* peels in soils contaminated with spent engine oil.
- The study established that *A. comosus* and *S. tuberosum* peels significantly caused a disappearance of spent engine oil contaminated soils.
- There was significant increase in the population densities for total bacteria count and total hydrocarbon degrading bacteria species.
- The individual bacteria possessed the ability to utilize hydrocarbons efficiently.

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ABSTRACT

This paper presents an assessment of biostimulation potential of *A. comosus* and *Solanum tuberosum* peels in soils contaminated with spent engine oil. Microcosms bioreactors containing the spent engine contaminated soil and the peels were set up and monitored for 49 days. The extents of disappearance of the spent engine oil were determined by analyzing the contaminated soils using gas chromatography (GC) coupled with mass spectrometry. Dominant bacteria species were isolated, characterized and tested for their biodegradation potential on different hydrocarbons. Increases in optical density (OD) fluxes and reduction in pH implied that the bacteria species utilized the hydrocarbons optimally. Microscopic examination, physiological tests and comparison to the standard reference organisms, identified the bacteria as members of *Arthrobacter*, *Bacillus* and *Pseudomonas* species. The results from GC-finger prints showed that the biostimulants (*A. comosus* and *S. tuberosum)* peels resulted in the disappearance of major aliphatic and aromatic hydrocarbons within the contaminated soil.

1. Introduction

Improper disposal/discharge of spent engine oil and other chemicals into the environment can result to extensive soil contamination. These often result to a long-lasting contamination of lands due to the recalcitrance nature of some hydrocarbons/poor substrate availability of these compounds to microbial enzymes (Falciglia et al., 2016).

Spent engine oil is derived after the use and drain out of lubrication oil from vehicle during servicing. According to some reported literature (Adesodun and Mbagwu, 2008; Nwinyi and Olutubo, 2014; Nwinyi et al., 2014), spent engine oil differs

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from the unused lubrication oil due to presence of metals and chemicals such as lead, tin, manganese, iron, and silicon. In some developing countries and Nigeria in particular, about 20 million gallons of spent-engine oil (SEO) are produced yearly from mechanic workshops and disposed casually into the environment (Faboya, 1997; Agarry and Ogunleye, 2012). Spent engine oil is a pollutant of great concern, with large volumes polluting the aquatic and terrestrial ecosystems (Yan et al., 2016). Spent motor oil is black to brown in color. It consists of 80%–90% huge quantities of long-chain saturated hydrocarbons. It also has a liquid combination of low to high molecular weight (C_{15}–C_{18}) aliphatic and aromatic hydrocarbon, chlorodibenzofurans, polychlorinated bi-phenyls, additives and disintegrated product (Koma et al., 2003; Bahadure et al., 2013). These compounds are toxic, carcinogenic and tetratogenic to human beings. However, owing to the rareness of knowledge about the severe environmental impact of the spent oil in the environment, artisans arbitrarily dispose-off the waste oil into sewers, water drains, open vacant plots and farmlands (Nwinyi et al., 2014). This constitutes an important cause of soil contamination in Nigeria. The chemical impurities in the spent engine oil contribute significantly to chronic hazards because they could get dissolved in soil surface and groundwater (Blodgette, 2001; Abdulsalam et al., 2012; Nwinyi et al., 2014). The health hazards associated with human when exposed to spent oil include but not limited to: anemia, tremor with consequent deaths (Nwinyi et al., 2014). Spent engine oil spill negatively impact on the environment by having wide-spread and long term effects on the coastal wetlands, reduction in photosynthesis in plants, transpiration and death of the biota depending on the volume of spill (Santas et al., 1999; Cappello et al., 2007; Kalantary and Badkoubi, 2006). Anozie and Onwurah (2001) reported of enlarged kidney, liver, spleen weights, protein oxidation and lipid perooxidation as side effects of exposure to spent engine oil in rats exposed or at spilled sites. The impact of spent engine-oil on soils range from depletion of nutrients especially nitrogen and phosphorus to degradation of soil physical properties and inhibition of microbial activities (Amadi and Debari, 1992; Osaigbovo et al., 2013).

Microbial transformation and degradation is now understood to be the foremost decomposition procedures used for effective elimination of hydrocarbons from the environment (Nwankwegu and Onwosi, 2017; Kastner and Mitner, 2016; Agarwal and Liu (2015).

Studies carried out both in microcosms and field experiments showed that organic amendments not only act by improving soil structure and serving as a source of nutrients, they can also strongly enhance the activities of microflora (Crecchio et al., 2001). Pollutant degradation rates can be improved through amendment with nutrients in contaminated systems. This leads to an increase in the population of indigenous microorganisms and the understanding of the growth fluxes can provide a clue about the effectiveness of the amendments (Yan et al., 2016).

African nations among other developing nations are faced with no adequate measures in the monitoring, control and regulation of the activities that leads to spent oil pollution of soil (Anoliefo and Vwioko, 1995). This is mainly as a result of no baseline data on spills and paucity of information on the impact of indiscriminate disposal of spent oil. Mishra et al. (2001) revealed that challenges posed by engine oil spills in developing countries far outweigh their uses. Thus, it is expedient that novel methods that could transform and remediate spent engine oil contaminated soil is a necessity. Based on the need to evolve ways for effective remediation of spent oil contaminated sites, the present study was set out to explore the use of *A. comosus* and *S. tuberosum* peels in stimulating microbial activities on spent oil contaminated soils, establish and document the valuable impacts of the biostimulation on the contaminated soils by screening for the disappearance of spent engine oil fingerprints before and after amendments and evaluation of microbial viability and dominance on the hydrocarbons.

2. Materials and methods

2.1. Chemicals and reagents

The chemicals/reagents used in this study were of analytical grades. The chemicals include: Ethanol (BDH chemicals Ltd), Hexane (BDH chemicals Ltd), sulfuric acid, Potassium sulfate and copper sulfate in combination (95%–98% - mixed catalyst digestion tablets) and sodium hydroxide. The $(NH_4)_2SO_4$, $MgSO_4.7H_2O$, Ca $(NO_3)_2.4H_2O$, K_2HPO_4, KH_2PO_4 were sourced from Merck Germany. The media used in this study include nutrient agar (Fluka), nutrient broth (Zayo Sigma), Sulfide, Indole, Motility (SIM) agar (Oxoid), Methyl Red Voges Proskaeur (MRVP) broth (Biomark) was provided by the Microbiology laboratory, Covenant University. The analytical standards for the spent oil (hydrocarbons) were obtained from Ultra Scientific, USA, RI 02852.

2.2. Sample collection

Spent engine-oil contaminated soil samples were collected from the New Estate generator plant (NEGP) and Female hostel generator site (FHGS). The soil samples collected from FHGS showed a sandy-texture appearance while that from NEGP were clayey. The soil samples were collected randomly at a depth of 5–10 cm and packed in sterile polyethylene bags. Soil samples from the NEGP was tagged A while FHGS was labeled B. The soil samples were transferred to the laboratory and stored at 4 °C (Alam and Rizvi, 2011). The *A. comosus* and *S. tuberosum* peels were sourced from the potato and pineapple waste from Covenant University cafeteria. The *A. comosus* and *S. tuberosum* peels were oven dried at 40 °C for 4 h respectively. The dried peels appeared milky brown and was pulverized into fine particles (using Emel blender) and sieved using 2 mm mesh. The samples were then stored in airtight containers for future use.