CHAPTER FIVE

5.1 CONCLUSION

Biodegradation of used lubricating oil was positively enhanced by organic wastes (BSG, BS and SMC) amendments. Supplementation of organic wastes with used lubricating oil contaminated soil recorded about 30 to 45% net biodegradation compared to control soil without organic wastes. However, out of the three organic wastes (BSG, BS and SMC), BSG showed the highest enhancement in the biodegradation of used lubricating oil at 5%, 10% and 15% oil pollution. Kinetic model of biodegradation rate showed the highest biodegradation rate of 0.4361 day^{-1} and least half life of 1.59 days in oil contaminated soil treated with BSG. This clearly point out the inherent potential of BSG in enhancing the activities of the indigenous microorganisms to degrade hydrocarbon source in contaminated soil, hence BSG can be recommended as a good organic wastes for enhancing hydrocarbon biodegradation in oil contaminated soil.

The toxicity of hydrocarbon in used oil contaminated soil to lettuce (*Lactuca sativa*) after soil remediation was low (60 – 100 % seed germination) in soil contaminated with 5% and 10% oil and amended with organic wastes. However, high toxicity (10 – 40 % seed germination) to lettuce was recorded in 15% oil pollution after the bioremediation of the soil. This observation pointed out that bioremediation is suitable for remediating soil contaminated with low to medium concentration (5 – 10% w/w) of hydrocarbon within short period of time (84 days). Remediation of high concentration (15% w/w and above) of hydrocarbon to completely innocuous substances may therefore require longer period of time.

Phytoremediation with *Jatropha curcas* and *Hibiscus cannabinus* showed positive response to enhance the removal of used lubricating oil compared to unplanted contaminated soil. The two plants showed a good potential to withstand minimum concentration (1% & 2.5%) of used lubricating oil. However, no accumulation of hydrocarbon was detected in the plant tissue, but the rhizosphere of *Jatropha* and *Hibiscus* harbours metabolically diverse bacteria measured as aerobic heterotrophic bacteria and hydrocarbon utilizing bacteria. Thus, suggesting that oil loss from the soil might be through rhizodegradation mechanism. Addition of 5% organic waste, especially BSG to the contaminated soil further enhances the growth of the plants and proliferation of bacteria in the soil, thus accounting for the additional removal of oil by about 33% and 29% in soil contaminated with 2.5% and 1% oil, respectively compared to the treatment with plants alone.

Both plant recorded substantial bioaccumulation of heavy metals (Fe and Zn) present in the used lubricating oil and soil used for the studies in their tissues (root, stem and leaves). First order kinetic rates of metal uptake by *J. curcas* and *H. cannabinus,* revealed higher uptake rate per month (0.014 – 0.109) of Fe and Zn uptake recorded by *H. cannabinus.*

The study therefore proves the viability of using *J. curcas* and *H. cannabinus* with BSG and BS amendment in remediating hydrocarbon and heavy metals (Fe and Zn) contaminated soil. This will afford an alternative method in removing oil and metal contaminants from soil while promoting growth of economically viable plants like Jatropha and Hibiscus whose seeds and fibre can be used for production of biodiesel and in paper manufacturing, respectively.

The results of used oil biodegradation by four microbial isolate (*Pseudomonas aeruginosa, Micrococcus luteus Candida tropicalis* and *Trichosporon mucoides)* from oil contaminated soil, showed *C. tropicalis* and *T. mucoides* ability to degrade used lubricating oil better (4 –

7%) than their bacterial counterpart used for the study within the period of 28 days. This result pointed out clearly the potential of *C. tropicalis* and *T. mucoides* to degrade hydrocarbons in oil contaminated soil within the shortest possible time (28 days) in broth culture. Thus, these yeast isolates can be used either as individual or as a consortium in seeding oil contaminated soil.

Based on the results of these findings, it is evident that supplementation of oil contaminated soil with organic wastes enhanced the degradation of used lubricating oil in contaminated soil. Phytoremediation further accelerated the remediation through rhizodegradation mechanisms and activities of rhizospheric bacteria. Hence, it is concluded that phytoremediation with supplementation of organic wastes is a viable option for soil remediation.