Comparison Of *Glycine Max* and *Sida Acuta* in the Phytoremediation Of Waste Lubricating Oil Polluted Soil

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Abstract: *Glycine max* and *Sida acuta* were compared to evaluate their potential in phytoremediation of waste lubricating oil contaminated soil in a 56 day field experiment. The experimental methodology involved simulation of 15kg of soil with 2 litres of waste oil to achieve 13.3% (w/w) pollution level. The result of the analysis revealed that bacteria counts were higher in *G.max* treatment than *S. acuta* and the control (OPS). pH, Moisture, Electrical conductivity and Phosphorous levels were lower in the *S. acuta* treatment than the *G. max* treatment. Statistical analysis revealed that there were significant differences in pH, Electrical conductivity, Nitrogen, Iron, Nickel and Copper ($p<0.05$) whereas bacteria counts, Moisture, Organic matter content, Phosphorous, Lead and Zinc had no significant difference at 0.05% confidence level. The results indicate that *G.max* had a better potential than *S. acuta* in the remediation of waste lubricating oil contaminated soil**.**

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1. Introduction

Contamination of soils with petroleum hydrocarbons is a wide spread environmental problem and a growing concern in many countries, especially in Asia and African continents (Agamuthu *et al*., 2010). The indiscriminate disposal of spent lubricating oil by motor mechanics is a common source of spent lubricating oil contamination of soil in countries like Nigeria that do not enforce strict compliance to environmental laws (Ogbo *et al*., 2009). Contaminants present in soils can enter the food chain and seriously affect animal and human health (Khan, 2005). Waste lubricating oil creates unsatisfactory conditions for plant growth ranging from heavy metal toxicity to insufficiency in aeration of the soil (Stephen *et al*., 2010). Ogbo *et al*. (2009) reported that oil contamination causes slow rate of germination in plants. Adam and Duncan (2002) also reported that this effect could be due to the oil which acts as a physical barrier preventing or reducing access of the seeds to water and oxygen. Soil contamination is a problem of global scope, and yet no universal solution has been discovered to deal with it (Jankaite, 2009). Different methods have been employed in remediating contaminated soil with each having one form of disadvantage or the other. Phytoremediation, which entails the *in situ* use of plants and their associated microorganisms to degrade, contain or render harmless contaminants in the soil (Joner *et al*., 2004), is an innovative, economical and environmental compatible solution for remediating some contaminated sites (Oyelola *et al*., 2009).

Different types of plants have been found useful for phytoremediation of soil contaminated by hydrocarbons. Karthikeyin *et al*. (1999) reported that Alfalfa and Horse radish reduce concentration of kerosene-based jet fuel by 57-90% in five months. Ayotamuno *et al*. (2006) reported the use of *Zea mays* (corn) and *Pennisetum purpureum* (Elephant grass) in the remediation of petroleum- hydrocarbon contaminated agricultural soil in port-Harcourt, Nigeria. Njoku *et al*. (2009) reported the effect of growth of Glycine max on the physicochemical properties of crude oil contaminated soil.

The choice of *Sida acuta* and *Glycine max* for this study was because (1) *S. acuta* is a non edible plant and thrives in disturbed habitat (2) *S. acuta* is a weed found virtually in all localities in Nigeria (3). *G. max* is successful in climates with optimum temperatures of 20^oC to 30^oC, performs nitrogen fixation and is grown widely in Nigeria. The objective of this study was to determine the suitability of *S. acuta* and *G. max* in the mineralization of waste lubricating oil from contaminated soil.

2. Materials and Methods

Study area description-The experiment was conducted at the botanical garden of the Kogi State Polytechnic main Campus Lokoja, Nigeria. Lokoja is a confluence town (where Rivers Niger and Benue meets) and lies between latitudes 7^0 48^1 North and longitude 6^0 44^1 East and falls within the rich agricultural zone of the Guinea Savannah vegetation belt of the country and receives an annual rainfall of about 900-1700mm. The average temperature of the experimental area is 30^{0}C.

Field sites and experimental procedure- The experimental design consisted of perforated plastic pots containing 15kg of soil each simulated with 2 litres of waste lubricating oil obtained from Felele mechanic Village to achieve 13.3% (w/w) pollution level. The pots were perforated to increase aeration and to avoid water logging. Pots A_1 and A_2 served as the control (No plant treatment), B_1 and B_2 received *S. acuta* treatments and pots C_1 and C_2 received *G. max* treatment. The waste oil was thoroughly mixed with the soil in the pots and left undisturbed for one week (7 days). Young growing *S. acuta* were transplanted from the Botanical garden into bowls B_1 and B_2 and viable seeds of *G. Max* were planted in bowls C_1 and C_2 on the 8th day. The plants were monitored for 56 days in the rainy months of July and August.

Laboratory / Statistical methods: pH and Electrical conductivity of the soil was determined at ambient temperature using glass electrode pH and conductivity meter (Hannia, Italy). Nitrogen was determined by the micro Kjedahl method (Ibitoye, 2006). Phosphorous was determined by the Murphy and Riley (1962) method. The ignition method of Akinsanmi (1975) was used to determine the organic matter content while the dry weight method (Tropical development Institute, 1984) was used to determine the moisture content. Trace metal was determined using the Atomic absorption Flame spectrophotometer (Buck, Model VGP210, U.S.A). Microbiological analysis was carried out following the procedure described by Harrigan and McCane (1990). Analysis of variance (ANOVA) was performed using procedure of MINITAB software Release 13 (2000). Experimental precision achieved was reported at $p<0.05$ level.

3. Results

Figure 1 shows the total heterotrophic bacterial counts. It ranged from 6.0×10^5 to 1.6×10^6Cfu/ml for control (OPS), 6.0×10^5 to 1.9×10^6 for *Glycine max* treated pot (GCM) and 6.0×10^5 to 1.5×10^6 for *Sida acuta* treated soil (SAT). The results showed that the counts were higher at days 28 for OPS and 56 for GCM and SAT. Microbiological analysis of the soil samples showed that the bacteria associated with the plants include *Pseudomonas, Bacillus, Micrococcus, Flavobacterium, and Alcaligenes.* There was no statistical difference ($p<0.05$) in the counts between the treatments.

Table 1 shows the physicochemical properties of the soil samples. pH of the three treatments : Control (OPS), *G. max* (GCM) and *S. acuta* (SAT) ranged from 7.63 to 8.27, 7.58 to 8.17 and 6.97 to 8.17. The least pH was observed in SAT at day 56. Statistical analysis indicated that There was significant difference ($P<0.05$) in the pH between the treatments and the control (OPS). Treatment GCM had the highest electrical conductivity compared to the control (OPS) and SAT. There was a significant difference in the electrical conductivity between the treatments at 0.05% confidence level. Table 1 also revealed the Nitrogen and available Phosphorous in the soil. The highest concentration of Nitrogen was observed in OPS while the least concentration was observed in GCM. There was a significant difference in the treatments ($P<0.05$). There was an observed increase in phosphorous from day 0 to day 56 in the OPS. However, there was a sudden dip in the concentration at day 28 while there was a general decline in GCM and SAT at day 7 and gradual increase from day 28 to day 56. There was no significant difference in the phosphorous concentration between the treatments ($p<0.05$). The Organic matter content ranged from 5.37% to 5.80% in the OPS, 4.00% to 5.47% in GCM and 4.82% to 5.85% in SAT. The least concentration was observed in GCM at day 28 while the highest concentration was observed in SAT at day 7. No significant difference exists in the organic matter content of the soil between the treatments ($p< 0.05$). Moisture content of OPS ranged from 0.73-9.33%, GCM from 1.81-9.19% and SAT from 0.50- 6.96%. The lowest moisture was observed at day 56 in SAT while the highest moisture level was observed at day 7 in OPS. There was no significant difference in the moisture content between the treatments and OPS statistically.

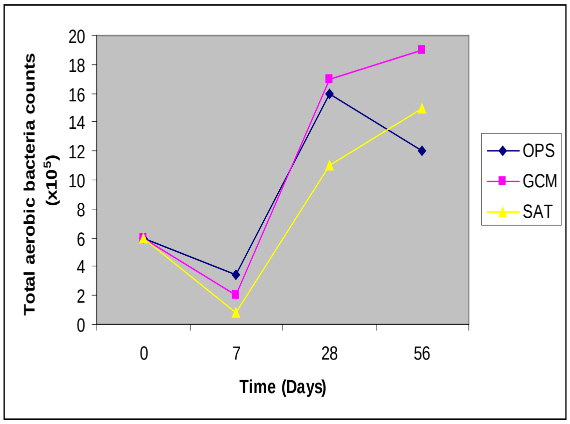

Fig 1. Total aerobic heterotrophic bacteria count
OPS:Control; GCM: *G. max* treatment;
SAT: *S. acuta* treatment

Table 1. Physicochemical characteristics of soil sample analysed

	pH				Ec (us/cm)				Moisture (%)				O.M C (%)				Nitrogen (%)				Phosphorous (ppm)			
Treatments	0	7	28	56	0	7	28	56	0	7	28	56	0	7	28	56	0	7	28	56	0	7	28	56
OPS	8.17	8.01	8.27	7.63	191	126	163	102	1.81	9.33	5.97	0.73	5.47	5.37	5.60	5.80	0.16	0.17	0.16	0.17	42.00	46.20	10.00	53.30
GCM	8.17	8.13	7.79	7.58	191	128	146	138	1.81	9.19	1.70	2.02	5.47	5.00	4.00	5.23	0.16	0.14	0.12	0.15	42.00	27.30	25.90	79.10
SAT	8.17	7.93	7.73	6.97	191	124	125	119	1.81	6.96	2.07	0.50	5.47	5.85	4.82	5.12	0.16	0.17	0.14	0.15	42.00	10.50	12.60	18.40

OPS: control; GCM: *Glycine max;* SAT*: Sida acuta, Ec:* Electrical conductivity; O.M.C: Organic matter content

Table 2.Trace metal analysed in soil sample

	Fe (ppm)				Pb (ppm)				Zn (ppm)				Ni (ppm)				Cu (ppm)			
Treatments	0	7	28	56	0	7	28	56	0	7	28	56	0	7	28	56	0	7	28	56
OPS	1.73	1.49	1.79	1.58	0.32	0.50	0.27	0.52	3.63	3.50	1.22	1.45	1.85	1.11	1.09	1.03	0.04	0.03	0.05	0.06
GCM	1.73	1.49	2.34	1.25	0.32	0.43	0.57	0.43	3.63	2.90	1.81	1.85	1.85	1.36	1.12	1.28	0.04	0.01	0.03	0.04
SAT	1.73	2.69	2.10	1.98	0.32	0.48	0.62	0.49	3.63	2.11	2.33	1.35	1.85	0.57	0.84	1.01	0.04	0.02	0.01	ND

OPS: control; GCM *Glycine max;* SAT*: Sida acuta;* ND: not detected

Table 2 shows the level of trace metals in the soil treatments analysed. The result showed that Zinc had a higher concentration than Iron, Lead, Nickel, and Copper in the treatments and OPS. A general decline was observed in the level of the trace metal from Day 0 to Day 56 in both treatments and OPS. There were significant differences in the levels of Iron, Copper, and Nickel ($P<0.05$) between the treatments and OPS. However, no significant different exist in the Lead and Zinc concentration ($P>0.05$) between the treatments and OPS.

4. Discussion

Soil pH in GCM and SAT were lower than the control-OPS. This may be due to increase in metabolic activities in the soil as a result of plant growth and associated microbial activities. This finding agrees with the findings of Ijah and Abioye (2003) that observed decrease pH in kerosene polluted soil, 30 months after spill and attributed the decrease to microbial activities. Both Nitrogen and Phosphorous were lower in GCM and SAT than OPS. This may be due to the fact that Nitrogen and Phosphorous are essential for plant growth and must have been utilized by the plant. The higher concentration of Phosphorous in OPS agrees with the findings of Ijah and Abioye (2003) and Stephen *et al.* (2010) who reported increase in Nitrogen and Phosphorous contents of the soil polluted by hydrocarbon products. Increase in Phosphorous content in OPS could be caused by the existence of reduced condition in the soil that made Iron Phosphorous soluble and brought some Phosphorous into solution (Ayotamuno *et al*., 2006). The decrease in trace metal concentration in the treatments relative to OPS could be attributed to containment or bioaccumulation of the metals by the plant, natural degradation by soil micro flora enhanced by favourable pH, volatilization and other abiotic factors such as Temperature (Oyelola *et al*., 2009, Stephen *et al*., 2010).

The increase in microbial counts of GCM and SAT relative to OPS substantiated the hypothesis that an increase in microbial activity was the mechanism responsible for phytoremediation. This highlights the view that the enormous increase in microbial counts in the treatment bowls (GCM and SAT) was linked with the treatment applied. The trend was different for OPS. Similarly, the view that phytovolatilization is a likely mechanism of phytoremediation remains attractive. An evidence of this was leaf chlorosis observed in the plants during the first few weeks of remediation. Such a situation suggests that volatile organic compounds were taken up by the roots of the plants, translocated within the plants and transpired through stems and leaves. The leaf chlorosis gradually disappeared before the 35^{th} day indicating that many of the organic compounds in the waste lubricating oil have been transferred to the atmosphere. This observation is in line with that of Ayotamuno *et al.* (2006) who observed similar disappearance of the chlorosis with time.

5. Conclusion

The result of this study demonstrates the potential of *G.max* and *S. acuta* in the remediation of waste lubricating oil contaminated soil. Given the short period of this study (56) days, it can be concluded that *G.max* and *S. acuta* are viable plants for phytoremediation and under field condition, *G.max* is a better alternative to *S. acuta*, and should be encouraged in the remediation of waste oil contaminated soil.

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