COW DUNG AND WATER HYACINTH NUTRIENT POWDER: GOOD SOURCES OF LIMITING NUTRIENTS FOR BIOREMEDIATION OF HYDROCARBON POLLUTED MANGROVE SWAMPS IN THE NIGER DELTA, NIGERIA


ABSTRACT

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The effects of organic fertilizers (Cow dung and Water hyacinth nutrient Recipe) on the bioremediation of hydrocarbon contaminated mangrove swamp soil were investigated on a 40 days study period. The Hydrocarbon polluted mangrove swamp soils were amended with different grams of cow dung or water hyacinth (Eichornia crassipes) nutrient/recipe. Biostimulation of the heterotrophic bacterial organisms and petroleum hydrocarbon utilising bacterial organisms were studied for 40 days. Proximate studies on the agro-based wastes indicated that the pH of the cow dung and water hyacinth recipe were alkaline. Conductivity of 60.00 µs/cm ± 0.001 and 89.47 µs/cm ± 5.100 for cow dung and water hyacinth recipe respectively were observed. The nitrate and phosphate concentrations were 25.06 mg/kg, 19.32mg/kg for cow dung; 38.48mg/kg and 27.89mg/kg for water hyacinth respectively. In the cow dung treated polluted soil, total culturable heterotrophic bacteria count and hydrocarbon utilising bacteria increased significantly in numbers as the polluted soil was amended with 40-50grams of Cow dung. Similarly, in the polluted soil group amended with organic fertilizer produced from Water hyacinth, the total culturable heterotrophic bacteria and hydrocarbon utilising bacteria increased in population significantly on application of 40-50grams of the Water hyacinth fertilizer. The under-utilised Cow dung and problematic plant (Water hyacinth) are useful sources of limiting nutrients required for bioremediation of crude oil polluted mangrove swamps in the Niger Delta.

Keywords: Bioremediation, Cow dung, Water hyacinth, Mangrove Swamps, Niger Delta.

INTRODUCTION

Nigeria is rich in natural resources, including Natural gas, Petroleum, Tin, Iron ore, Coal, Limestone, lead, Zinc, timber and extensive arable land. Prior to the discovery of oil in the 1950s, agriculture was the mainstay of the economy, with agricultural produce exported to the more industrialized regions of the world. By 1971 there had been a shift from agriculture to petroleum production, such that between 1973 and 1981 the value of agricultural exports fell from more than 1.5 billion USD to about 0.3 billion USD (World Bank, 1982). Currently, oil provides 80 per cent of budget revenues and 95 per cent of foreign exchange earnings. Hydrocarbon pollution of soil can occur in several ways, from natural seepage of hydrocarbons in areas where petroleum is found in shallow reservoirs, to accidental spillage of crude oil on the ground. Regardless of the source of contamination, once hydrocarbons come into contact with the soil, they alter its physical and chemical properties. The degree of alteration depends on the soil type, the specific composition of the hydrocarbon spilled and the quantity spilled (IPIECA, 1991).

Bioremediation is the use of naturally-occurring microorganisms or genetically-engineered microorganisms (bacteria and fungi) by man, to detoxify man-made/anthropogenic pollutants in an environment (Odgen and Adams, 1989). Since bioremediation is a microbial process, it requires the provision of nutrients among other factors or requirements. Nutrient is one factor that can hinder biodegradation if not handled properly and could limit the rate of hydrocarbon degradation in the terrestrial environment (McGill and Nyborg, 1975). According to Obire et al. (2008), the addition of nutrients that can limit biodegradation to the spill site is necessary and those nutrients are not different from fertilizer. The Bioremediation cost method is a widely used surrogate remediation approach that relies on some biological materials needed to derive a demand curve for a polluted site. This curve is in turn used to estimate the consumer’s (community) surplus or value of the polluted site to all users. This approach is widely used to value the remediation benefits of polluted areas and other natural areas. This method seeks to determine the demand for bioremediation, as a function of variables like the cost of cow dung and water hyacinth nutrient powder, bonny light crude oil. The cost of all these materials usually sums up the cost of travel, entry fees to polluted sites, and the opportunity cost of time spent. The most common forecasting technique for a specific site is the Clawson-Knetseh-Hotelling Method (Jhingan and Sharma, 2009). It is a technique commonly associated with benefit estimation in recreation cost-benefit analysis.
In response to the problem of Crude-oil spill in the Environment, the objectives of this research are to develop organic fertilizer from Water Hyacinth (*Eichhornia crassipes*) a plant species which nuisance to the Niger Delta, and also to study the economic effects of two organic nutrients namely Water hyacinth recipe and Cow dung on the biodegradation of Crude Oil and bioremediation of Petroleum hydrocarbon polluted Mangrove Swamps in the Niger Delta. This study reports the economic implications and sustainable development of applying Cow dung and nutrient powder produced from the problematic plant species (Water hyacinth- *Eichhornia crassipes*) for bioremediation of Crude oil polluted Mangrove Swamps in the Niger Delta, Nigeria.

**MATERIALS AND METHODS**

**Study area**
The mangrove swamp links Emuoha and Kalabari. This site was selected due to high level of pollution as a result of aged/old oil spillage from a flowstation pipeline. The predominant mangrove in this area was *Rhizophora racemosa* as identified by Dr. Godfrey C. Akani of the Department of Applied and Environmental Biology, Rivers State University of Science and Technology, Port Harcourt, Nigeria. Co-ordinates of the sampling points were determined using Global Positioning System (GPS). The co-ordinates of the sampling points were: 453/53.990°N; 650/43.745°E. The major occupation of Elibrada people is fishing in the mangrove and Agricultural/Land farming.

**Sample collection**
The soil sample was collected with a spade into a plastic pail which has already been cleaned (Eziuzor and Okpokwasili, 2010). The excavated soil was transported to the Environmental Microbiology Laboratory of the University of Port Harcourt for bioremediation studies.

**Soil contamination**
Bonny light crude oil (30mls) was poured in each treatment option containing 500grams of the mangrove soil (including the controls). The aim of this further contamination was to simulate condition of a major spill. The polluted soil was allowed to stand for seven days before amendment for acclimatization of the biota present. The soil samples were amended with different grams of organic nutrients. Samples collected for analyses immediately after amendment were referred to as zero hour or day.

**Preparation of organic fertilizer**
Limiting nutrients were supplied to stimulate the crude oil degrading microorganisms using indigenous waste/materials. These included Cow dung and Water hyacinth recipe. The Cow dung was sun dried for 5 days until moisture was driven off completely and subsequently, the Cow dung was stored for usage. The limiting nutrients (Phosphates) present in these organic nutrient recipes were analysed and reported.

**Preparation of the water hyacinth recipe**
The Water hyacinth (*Eichhornia crassipes*) used for this study was obtained from Choba River, accessible through Choba cattle Market, Port Harcourt. They were identified as Water hyacinth by Dr. Godfrey Akani of the Department of Applied and Environmental Biology, Rivers State University of Science and Technology, Port Harcourt. The Water hyacinth recipe was chopped into pieces, and air-dried. The dried Water hyacinth was grinded with local mortar and pestle, and the organic fertilizer was stored for use during the bioremediation experiment.

**Experimental design**
This is a laboratory scale experiment carried out in plastics pots. The split block design was used for the study. Preliminary range finding experiment
This was carried out to determine the amount of nutrients that will be used to amend a specific amount of crude oil polluted soil.
Each 500grams of soil was polluted further with 30mls of bonny light crude oil

**Bioremediation/Biodegradation Studies**
The bioremediation of petroleum hydrocarbons in the different experimental designs/set-up was studied/monitored by withdrawing samples for analyses at the zero day (immediately after amendment with organic fertilizers) and 40th day of the experiment for the following analyses.

**Microbiological analyses**
These included the determination of total culturable heterotrophic bacterial count (TCHBC), and total culturable hydrocarbon utilizing bacteria count (THUBC).

**Enumeration of total culturable heterotrophic bacteria (TCHB)**
The spread plate method on nutrient agar (Antech Laboratories) was used. Swamp soil suspensions were prepared by 10 fold serial dilutions with 1gram of soil, using peptone water as diluents. Aliquots (0.1ml) of appropriate dilutions were spread on triplicates of sterile nutrient agar. The plates were incubated for period of 18-24 hours in the incubator at 25°C. Colonies that formed during this incubation period were counted using this formula;
RESULT AND DISCUSSIONS

These studies were carried out to determine the amount of each of the organic nutrients that will significantly establish biostimulation and also sustain bioremediation. However, the application of 40 grams, and 50 grams each to 500 grams of water hyacinth nutrient solution to the polluted soil increased the bioload of the hydrocarbon utilising bacteria from 6.21 x 10^5 to 1.06 x 10^6 Cfu g^{-1}m, and 6.06 x 10^5 to 1.39 x 10^6 Cfu/gram respectively (p=0.53) (Table 2). In the Cow dung treated experimental groups, the insignificant increases in the total culturable heterotrophic bacteria count from zero day to the 40th day were 3.11 x 10^4 to 3.36 x 10^4 Cfu/gram, on amendment using 20 grams of Cow dung. The use of 30 grams of Cow dung could not also establish biostimulation as the increase was not significant (p= 0.04) (Table 3). However, the use of 50 grams of Cow dung increased the counts of the hydrocarbon utilising bacteria from 3.19 x 10^4 to 1.29 x 10^5 Cfu g^{-1} (p=0.05) (zero day to 40th day). The control experiment which was not amended had no significant increase in the bioload of the total culturable hydrocarbon utilising bacteria (Table 3).
The total culturable heterotrophic bacterial count did not significantly increase in biomass on application of 20 grams, and 30 grams of Cow dung was applied (Table 4). In addition, the commencement of polluted soil with 40 grams, and 50 grams of sterile Cow dung significantly increased the total culturable heterotrophic bacterial count from $3.12 \times 10^{9}$ to $1.4 \times 10^{10} \text{CFU g}^{-1}$ and $3.1 \times 10^{6}$ to $1.59 \times 10^{7} \text{CFU g}^{-1}$ respectively (Table 4). The control experiment did not show biostimulation as it was not amended with organic fertilizer. The use of 20 grams, and 30 grams of Water hyacinth recipe/Powder to stimulate heterotrophic species can achieve good results in a field scale since the increase in heterotrophic bacterial population was significant ($p_{0.01}$). 50 grams of Sterile Water hyacinth recipe/powder showed significant increase from $6.09 \times 10^{6}$ to $1.02 \times 10^{7} \text{CFU g}^{-1}$ and $6.22 \times 10^{3}$ to $1.49 \times 10^{4} \text{CFU g}^{-1}$ respectively ($p = 0.53 - 0.59$) (Table 5).

**Loss of total hydrocarbon (THC)**

On the option treated with 20 grams, 30 grams of Cow dung within zero hour to 40th day of the study ranged from 14241.10mg kg$^{-1}$ to 14006.21mg kg$^{-1}$ and 14162.28mg kg$^{-1}$ to 13926.80mg kg$^{-1}$ respectively. The loss of total hydrocarbon was not significant when 20 grams of Cow dung and 30 grams of Cow dung were used ($P = 0.27 - 0.29$) (Table 6). The experimental plots amended with 40 grams and 50 grams of Cow dung had a decrease in Total hydrocarbon Content from 14289.05 to 12617.50mg kg$^{-1}$, and 14229.67 to 9871.16 Mg kg$^{-1}$ (Table 6). The two experimental options amended with 40 and 50 grams of Water hyacinth Powder showed statistical significance when compared with the control and other options amended with 20 and 30 grams each of Water hyacinth nutrient powder. The application of 30grams, 40grams, and 50grams of Water hyacinth nutrient Powder was able to stimulate the hydrocarbon utilizers, and this led to a decrease of the THC from 14129.0 to 12926.78Mg Kg$^{-1}$, 14133.61Mg Kg$^{-1}$ to 12627.24Mg Kg$^{-1}$ and 14167.88 to 9610.32Mg Kg$^{-1}$ respectively (Table 7).

Proximate studies on the Cow dung, and Water hyacinth nutrient Powder showed the presence of different levels of Nitrate and Phosphate, Nitrate concentrations were 25.06Mg/Kg, and 38.48Mg Kg$^{-1}$ g for Cow dung and Water hyacinth respectively (Table 8). Statistical analyses using ANOVA indicated significant difference between the nitrate levels in Water hyacinth Powder and Cow dung (Table 8). Phosphate concentrations were observed to be 19.32Mg Kg$^{-1}$ and 27.89Mg Kg$^{-1}$ for Cow dung and Water hyacinth nutrient Powder (Table 8). The pH of these two organic nutrients was observed to be alkaline while conductivity values of the Cow dung and Water hyacinth Nutrient Powder were 60$\mu$S/cm and 89.47$\mu$S/cm (Table 8). The use of organic nutrient in bioremediation of polluted Marine Environment is of great advantages over use of inorganic fertilizers. The organic nutrients are environmentally friendly to the marine Ecosystem, and reduce the chance of algal bloom/eutrophication often associated with inorganic nutrients due to fast release of limiting nutrients (Phosphates and Nitrates). The use of agro-based wastes which are either not used or underutilised for bioremediation makes the process relatively cost-effective. Therefore, with the use of Clawson-Knetseh-Hotelling Method (Jhingan and Sharma, 2009), the benefit of the study is illustrated in figure 1 below by explaining the bioremediation cost method. Given this study, the economic valuation of the mangrove swamp before and after bioremediation is explained.

Figure 1 is used to show the level of restoration of the polluted area, the entry fee is OP which is fixed per visit. The initial demand to bioremediation mangrove swamp is shown by the demand curve BDo and the environmental quality level is Eo. The improvement in environmental quality of the mangrove swamp after the bioremediation exercises is shown by the outward shift from BD1 (E1) to AD1 (E1) which indicated an increase in the level of restoration of mangrove swamp area from EB1 to EB2 With this effect, an increase in bioremediation cost guarantees increase in the level of restoration. This implies that as the cost of remediation increases, the level of contamination decreases. Therefore, the importance or the benefits which the community derive from the exercise (bioremediation activities using cow dung or water hyacinth nutrient powder) are equal to the area APK. The net gain in consumers’ (community) surplus after the bioremediation of the polluted mangrove swamp which apparently led to improvement in environmental quality of the place is shown as: PAK-PBC = ABCK.

Based on the surplus, the positive impact of bioremediation is shown on the restoration of: agriculture (dryland loss, coastal protection and wetland loss); Forestry (water surplus, hurricane damage and droughts and water pollution, ecosystem and catastrophe. In addition, by induction, the two organic nutrients with respect cost benefits are of good biotechnological applications. In Nigeria, this is a pioneer and frontier laboratory-scale study which used agro-based wastes for bioremediation of petroleum polluted Mangrove Swamps at the laboratory scale. However, there are quite a number of studies on the use of agro-based wastes for bioremediation of polluted terrestrial environments including Farmlands. Obire et al, (2008) reported the significant ability of Poultry droppings and Cow dung to biostimulate the saprophytic and Petroleum utilising fungi in a polluted soil. The saprophytic fungal species reported by Obire et al., (2008) were Alternaria sp., Aspergillus sp., Cladosporium sp., Fusarium sp., Geotrichum sp., Mucor sp., Penicillium sp. and Trichoderma sp., Candida sp., Rhodotorula sp., Torulopsis sp. and Trichosporon sp. The petroleum-utilizing fungi isolated from Cow dung were Aspergillus sp.,
Cephalosporium sp., Cladosporium sp., Geotrichum sp., Mucor sp. Penicillium sp., and Candida sp. While the petroleum-utilizing fungi isolated from poultry droppings were Aspergillus sp., Cladosporium sp., Fusarium sp., Geotrichum sp., Mucor sp., Penicillium sp., Trichoderma sp., Candida sp. and Rhodotorula sp. The use of inorganic fertilizers for bioremediation is an old practice by Oil and Gas companies in Nigeria, and companies all over the world. Scholars in the field of Environmental Microbiology, Bioremediation, and Biotechnology etc have continued to design research studies on bioremediation using inorganic nutrients. In line with this, Ezuzor and Okpokwasili (2009) studied bioremediation of crude oil polluted mangrove soil in Port Harcourt. Ezuzor and Okpokwasili (2009) used NPK (Nitrogen Phosphorus Potassium) inorganic fertilizer as source of limiting nutrient and the hydrocarbon utilizing bacteria isolated included: Acinetobacter, Arthrobacter, Bacillus, Citrobacter, Alcaligenes, Flavobacteria, Pseudomonas, Vibrio and Corynebacterium.

Similarly, Odokuma and Dickson (2003) in a bioremediation study in a polluted (simulation using Bonny light) mangrove swamp in new Calabar River, Rivers State, Nigeria, was able to scale-up the hydrocarbon-utilizing bacteria using NPK fertilizer. The NPK fertilizer increased the bioload of the polluted mangrove soil from 1.5 x 10^3 to 1.5 x 10^9 Cfu g^-1. The use of inorganic oleophilic nutrients/fertilizers also achieves good result but it leaves the polluted sites with the problem of algal bloom, and the entire process is quite expensive. In comparison with inorganic nutrients, the use of organic fertilizers adds more values to the bioremediation process because its cost effectiveness, Environmental friendliness and ability to utilise waste materials previously labelled to be either valueless or ecologically problematic.

CONCLUSION

The recipe or nutrient from two agro-based wastes which are usually not utilised or underutilised in Nigeria demonstrated effective ability to degrade hydrocarbons and thereby restoring a polluted medium. This study was done in a laboratory Scales. However, further research attentions are needed on the use of the two nutrient sources for the bioremediation of Petroleum hydrocarbon polluted Mangrove soil. The further research work is expected to cover a larger scope including the degradation of Total Petroleum Hydrocarbon (TPH), Polycyclic Aromatic Hydrocarbons (PAH), Enzyme profiles and Microbial succession studies. Funds are still needed to expand the study.

ACKNOWLEDGEMENT

The authors wish to thank the Shell Petroleum Development Company of Nigeria (SPDC) for providing Research Fund for the study in the form of one year Research Internship in her Environment Unit which was granted to the lead author.
Table 2: Responses of total culturable hydrocarbon utilising bacteria count using water hyacinth recipe as limiting nutrients

<table>
<thead>
<tr>
<th>Experimental groups</th>
<th>TCHBC (Cfu/g)</th>
<th>Day 0</th>
<th>40th day</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.92 x 10^5</td>
<td>5.88 x 10^5</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>5.81 x 10^5</td>
<td>5.96 x 10^5</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>6.21 x 10^5</td>
<td>1.06 x 10^6</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>6.06 x 10^5</td>
<td>1.39 x 10^6</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>E (Control)</td>
<td>6.07 x 10^6</td>
<td>5.90 x 10^6</td>
<td>0.04</td>
<td></td>
</tr>
</tbody>
</table>

TCHBC: Total Culturable Heterotrophic Bacterial Count (Cfu/g: colony forming unit per gram). P – Values ≥ is considered significant. Real values are average of three (3) different readings.

Table 3: Changes in growth of total culturable hydrocarbon utilizing bacterial organisms using cow dung recipe as limiting nutrient source

<table>
<thead>
<tr>
<th>Test experiment</th>
<th>TCHBC (Cfu/g)</th>
<th>Day 0</th>
<th>40th day</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>3.11 x 10^4</td>
<td>3.36 x 10^4</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>3.41 x 10^4</td>
<td>3.61 x 10^4</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>3.27 x 10^4</td>
<td>3.79 x 10^4</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>3.19 x 10^4</td>
<td>1.29 x 10^5</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>J (Control)</td>
<td>3.47 x 10^4</td>
<td>3.29 x 10^4</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

TCHBC: Total culturable heterotrophic bacterial count Cfu/g: colony forming unit per gram. P – Values ≥ is considered significant. Real values are average of three (3) different readings.

Table 4: Changes in total culturable heterotrophic bacterial count using cow dung as source of nutrient

<table>
<thead>
<tr>
<th>Test experiment</th>
<th>TCHUB (CFU/gram)</th>
<th>Day 0</th>
<th>40th day</th>
<th>P – Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>3.15 x 10^6</td>
<td>3.29 x 10^6</td>
<td>&lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>3.09 x 10^6</td>
<td>3.26 x 10^6</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>3.12 x 10^6</td>
<td>1.4 x 10^7</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>3.16 x 10^6</td>
<td>1.59 x 10^7</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>J (Control)</td>
<td>3.06 x 10^6</td>
<td>3.27 x 10^6</td>
<td>&lt; 0.01</td>
<td></td>
</tr>
</tbody>
</table>

TCHUB: Total Culturable Hydrocarbon Utilizing Bacterial Count, CFU/gram: colony forming units per gram. P = values ≥ 0.50 is significant. Real values are average of three different readings.

Table 5: Changes in total culturable heterotrophic bacterial counts using water hyacinth as source of limiting nutrients

<table>
<thead>
<tr>
<th>Test experiment</th>
<th>TCHUB (Cfu/gram)</th>
<th>Day 0</th>
<th>40th day</th>
<th>P – Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6.18 x 10^6</td>
<td>6.37 x 10^6</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>5.92 x 10^6</td>
<td>6.22 x 10^6</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>6.09 x 10^6</td>
<td>1.02 x 10^7</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>6.22 x 10^6</td>
<td>1.49 x 10^7</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>E (Control)</td>
<td>6.20 x 10^6</td>
<td>6.09 x 10^6</td>
<td>&lt; 0.01</td>
<td></td>
</tr>
</tbody>
</table>

TCHUB: Total culturable heterotrophic bacterial count Cfu/gram: colony forming units per gram. P = values ≥ 0.50 is significant. Real values are average of three different readings.

Table 6: Loss of total hydrocarbon content using cow dung as nutrient source

<table>
<thead>
<tr>
<th>Test experiment</th>
<th>THC (mg/kg)</th>
<th>Day 0</th>
<th>40th day</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>14241.10</td>
<td>14206.21</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>14162.28</td>
<td>13926.80</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>14228.05</td>
<td>12617.50</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>14229.67</td>
<td>9871.66</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>J (Control)</td>
<td>14246</td>
<td>14201.49</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

THC: Total hydrocarbon values are average of three different values.
Table 7: Loss of hydrocarbon using Water hyacinth recipe as nutrient source

<table>
<thead>
<tr>
<th>Test experiment</th>
<th>THC (mg/kg)</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 0</td>
<td>40th day</td>
</tr>
<tr>
<td>A</td>
<td>14210.00</td>
<td>13380.00</td>
</tr>
<tr>
<td>B</td>
<td>14129.0</td>
<td>12926.78</td>
</tr>
<tr>
<td>C</td>
<td>14133.61</td>
<td>12627.24</td>
</tr>
<tr>
<td>D</td>
<td>14167.88</td>
<td>9610.32</td>
</tr>
<tr>
<td>E (Control)</td>
<td>14228.29</td>
<td>13646.71</td>
</tr>
</tbody>
</table>

THC: Total hydrocarbon (mg/kg), P – Values ≥ is significant

Table 8: Chemical composition of Cow dung and Water hyacinth recipe organic fertilizers used in the study

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Cow dung</th>
<th>Water hyacinth recipe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>± S.D.</td>
<td>± S.D.</td>
</tr>
<tr>
<td>pH</td>
<td>8.20 ± 0.820</td>
<td>9.91 ± 0.027</td>
</tr>
<tr>
<td>Conductivity (µs/cm)</td>
<td>60.00 ± 0.001</td>
<td>89.47 ± 5.100</td>
</tr>
<tr>
<td>Nitrate (Mg/kg)</td>
<td>25.06 ± 0.052</td>
<td>38.48 ± 0.050</td>
</tr>
<tr>
<td>Phosphate (Mg/kg)</td>
<td>19.32 ± 0.056</td>
<td>27.89 ± 0.018</td>
</tr>
</tbody>
</table>

Values are mean of three (3) replicate values

REFERENCES


