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Full Length Research Paper

Decreased biomass concentration on crude oil impacted soil; measurable indices in climate change

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Abstract

Climate change is a multifactor event that requires proper evaluation, monitoring and management. In this study, biomass content of *Zea mays* and *Arachis hypogea* were measured to evaluate their contribution to climate change. Different concentration (80g, 160g, 400g, 800g and 1200g) of crude oil were impacted in sterile soil and viable seeds of *Zea mays* and *Arachis hypogea* were planted in the soil samples. The result showed that A. hypogeal germinated better than *Z. mays*. Germination potential of the seedlings of *A. hypogeal* decreased by 10%, 30% and 70% for 80g 160g and 400g impacted soil, while *Z. mays* deceased by 10% and 40% for 80g and 160g impacted soil respectively. Biomass result decreased significantly (p<0.05) for *A. hypgea* (30 and 39.9%) and *Z. mays* (10% and 100%) at 80g and 160g. Total biomass for 80g impacted soil showed that *A. hypogea* had the highest (4.58 and 1.37) for wet and dry respectively while *Z. mays* had 3.60 and 0.89 biomass content. Root length, shoot length and total number of leaves decreased significantly (p<0.05) when compared with the un-impacted soil (control). Our observation showed that decreased plant biomass could lead to low productivity as well as increased atmospheric carbon dioxide therefore a measurable indicator in predicting the impact of climate change on soil productivity.

Keywords: Biomass, climate change, impacted soil, productivity

INTRODUCTION

Plant biomass plays major roles in fixing atmospheric CO_2 and as such an important factor in climatic dynamics. Plant leaves and some stems contain chlorophyll or other pigments capable of utilizing energy from the sun, water and CO_2 to produce carbohydrate. Increased atmospheric CO_2 has been implicated in causing increased temperature hence the concept of global warming (Urama and Ozor, 2011). An important consideration in relation to climate change is that carbon dioxide fertilization raises the optimum temperature for photosynthesis (Norby et al., 2002). Crude oil polluted soil is often characterized by increased water retention capacity, poor aeration and low nutrient bioavailability. This may not favour good plant development and may consequently lead to low/decreased plant biomass.

Climate change is a long-term shift in weather conditions which are identified by changes in temperature, precipitation, winds, and other indicators (CACC, 2012). Any factor that causes a sustained change to the amount of incoming energy or the amount of outgoing energy can lead to climate change. Factors that cause climate change can be divided into two categories - those related to natural processes and those related to human activity (Oberdorster and Cheek, 2000; Onwurah et al., 2007). Climate change also occur when there is a change in the amount of heat energy from the earth's surface and atmosphere that escapes into space over an extended period of time (Uguru et al., 2011). These changes, according to the report of the United Nations' intergovernmental panel on climate change can be caused by natural processes (IPCC, 2001). However, human activities are by far the major cause of climate change through the continuous release of greenhouse gases and aerosols into the atmosphere (Uguru et al., 2011).

Nigeria is Africa's largest oil producer, exporting about 2.5 million barrels of oil per day. Much attention is been given to the effect of crude oil pollution on man with less attention on its attended consequences on the environment and the climate at large. Oil spills in the delta's waterways killing and contaminating the soil, plants and animals in one of Africa's most bio-diverse regions. Increase crude oil pollution often leads to lots of degradation of plants and animals' environment (Onwurah et al., 2007). Biodegradative products include methane, carbon dioxide and some other gases that contributes to global warming also increase with increased crude oil exploration and utilization. However, when the rate at which CO_2 and other associated gases been generated exceeds the rate at which CO_2 is been fixed, the excess atmospheric CO_2 may give rise to CO_2 fertilization under normal condition or increased environmental temperation. Carbon dioxide (CO_2) is one of the main greenhouse gases that contribute to global warming, hence a major contributor to climate change (Lewis et al., 1999; Lewis et al., 2001). Most crude oil pollution of agricultural lands is due to human factors and a long effect on the plant biota. Unfavourable environmental conditions such as caused by crude oil pollution will create some level of vulnerability on affected plants. Good knowledge and understanding of the plant as a system and its responses to the environmental history in relation to climate change will be of immense help in the development of strategic options for reducing plant vulnerability (Kalu and Egbe 2011). In the Niger-Delta region of Nigeria, significant crop and aquatic food reductions with 2℃ warming are expected to have strong repercussions on food security, while rising temperatures could cause a major loss of tropical and swamp forest threatening fishermen and farmer's means of livelihoods. The aim of this research is to find out the link between biomass concentration, pollution rate and climate change.

MATERIALS AND METHODS

Sample collection and experiment design

Viable seeds of ground nut (*Arachis hypogea)* and maize (*Zea mays*) were obtained from the National seed council Umudike, Abia State Nigeria. The soil samples were collected from the Botanical Garden of University of Nigeria Nsukka. Equal quantity of soil (1 kg) was contaminated with 80g, 160g, 400g, 800g and 1200g of Bonny light crude oil. The mixtures were put into bowls of equal diameter (30cm) and were properly mixed.

The experiment was divided into two groups; for group A, the seeds were soaked in water for 8 hrs pre-planting while in group B, the seeds were not soaked in water. Each bowl was seeded with three grains of maize or groundnut respectively; they were watered with equal volume of water daily to favour proper germination. Germination time, number of leaves, root and shoot length were determined for a period of two weeks. Biomass content (g) was determined by differences in the wet and dry weights at the end of the experiment.

Statistical analysis

Means and standard deviations were calculated using the SPSS (statistical package for social sciences) software package (version 17).

RESULT

The result showed that A. *hypogea* germinated better than *Z. mays*. Germination potential of the seedlings of *A. hypogea* decreased by 10%, 30% and 70% for 80g 160g and 400g impacted soil, while *Z. mays* deceased by 10% and 40% for 80g and 160g impacted soil respectively. Biomass result decreased significantly ($p<0.05$) for *A. hypgea* (30 and 39.9%) and *Z. mays* (10% and 100%) at 80g and 160g. Total biomass for 80g impacted soil showed that *A. hypogea* had the Highest (4.58 and 1.37g) for wet and dry respectively while *Z. mays* had 3.60g and 0.89 biomass content. Root length, shoot length and total number of leaves decreased significantly ($p<0.05$) when compared with the un-impacted soil (control). Our observation showed that decreased plant biomass could lead to low productivity as well as increased atmospheric carbon dioxide therefore a measurable indicator in predicting the impact of climate change on soil productivity.

DISCUSSION

The impact of crude oil pollution on the environment may be much more than mere explanation of death or the outright physical observation of oil spill on the surface of soil or water bodies. Even though there could be a silent link between pollution rate and survival rate of exposed organisms, the impact of these pollutants on the climate change paradigm is often viewed with less emphasis. Plant tissue (including wood) is composed of about half carbon, all of which comes from carbon dioxide in the atmosphere. Fixing atmospheric CO_2 by plant has a direct effect on the biomass concentration. Photosynthesis rates tend to increase as carbon dioxide levels rise, leading to an increase in dry weight, or biomass, of plants grown under elevated carbon dioxide

Table 1. Germination potential of *Arachis hypogeal* and *Zea mays* soaked in water before planting in crude oil polluted soil.

Group	*A. hypogeal*	*Z. mays*
0g (Control)	10	10
80g	9	9
160g	7	6
400g	3 (Died after 7 days)	0
800g	3 (Died after 7 days)	0
1200g	0	0

Table 2. Germination potential of *Arachis hypogeal* and *Zea mays* not soaked in water before planting in crude oil polluted soil.

Group	*A. hypogeal*	*Z. mays*
0g (Control)	9	10
80g	3	6
160g	5	5
400g	0	0
800g	0	0
1200g	0	0

Table 3. Biomass content of *Arachis hypogeal* and *Zea mays* soaked in water before planting in crude oil polluted soil.

Group	Wet weight (g)		Dry weight (g)	
	G. nut	Maize	G. nut	maize
0g (Control)	6.54	4.00	1.95	0.99
80g	4.58(30.0%)	3.60(10.0%)	1.37(29.7%)	0.88(11.1%)
160g	3.93(39.9%)	0	1.17(40.0%)	0.59(40.4%)
400g	0	0	0	0
800g	0	0	0	0
1200g	0	0	0	0

levels. This is not so in polluted soil environment but rather a decrease in biomass concentration. The number of arable soil and plants being destroyed as a result of environmental pollution is increasing daily, thereby reducing the amount of carbon dioxide that is taken up by the plant community. Reduce CO_2 uptake will lead to

Table 4. Biomass content of *Arachis hypogeal* and *Zea mays* not soaked in water before planting in crude oil polluted soil.

Group	Wet weight (g)		Dry weight (g)	
	G. nut	Maize	G. nut	maize
0 g (Control)	5.50	2.68	1.18	1.23
80g	1.83 (66.7%	1.79 (33.2%)	0.39(67.0%)	0.82(33.3%)
160g	0	1.45(45.9%)	0	0.69(43.9%)
400g	0	0	0	0
800g	0	0	0	0
1200g	0	0	0	0

Table 5. Number of leaves, root and shoot length of *Arachis hypogeal* and *Zea mays* soaked in water before planting in crude oil polluted soil.

Group	*Ground nut*			*Maize*		
	No. of leaves	Root (cm)	shoot(cm)	No. of leaves	Root (cm)	shoot(cm)
0g (Control)	23	9.6	2.7	7	15.4	5.3
80g	18(21.7%)	7.5(21.9%)	1.7 (37.0%)	5(28.6%)	11.7(24.0%)	5.1((3.8%)
160g	12 (48.8%)	3.6(62.5%)	1.4 (48.2%)	3(57.1%)	8.1(47.4%)	4.0 (24.5%)
400g	0	0	0	0	0	0
800g	0	0	0	0	0	0
1200g	0	0	0	0	0	0

Table 6. Number of leaves, root and shoot length of *Arachis hypogeal* and *Zea mays* not soaked in water before planting in crude oil polluted soil.

Group	***Ground nut***			***Maize***		
	No. of leaves	Root (cm)	Shoot(cm)	No. of leaves	Root (cm)	shoot(cm)
0g (Control)	23	7.9	1.5	7	18.40	5.9
80g	16 (30.4%)	3.7 (53.2%	1.3(13.3%)	4 (42.9%)	10.50(42.9%)	4.3(27.1%)
160g	0	0	0	2(71.3%)	7.50(59.2%)	3.2(45.8%)
400g	0	0	0	0	0	0
800g	0	0	0	0	0	0
1200g	0	0	0	0	0	0

increased atmospheric CO_2 and consequently increased atmospheric temperature.

Energy balance in the ecosystem revolves around the biotic and abiotic components of the environment. Therefore, any alterations in the factors that affect this energy flow will ultimately affect the biomass concentration found in the environment.

Germination is panacea to the survival of any ecosystem. The decrease in the number of germinated seedlings has a direct relationship on the biomass quality and quantity harvested from that location. Plant biomass has been implicated in the energy balance of the ecosystem and hence a low biomass may lead to low energy balance.

Energy balance in an agricultural crude oil impacted soil is an interplay between gaseous exchange and photosynthetic process. When the atmospheric carbondioxide far exceeds the plant fixation capacity, excess carbon dioxide in the atmosphere tends to increase the atmospheric temperate and plant survival as well as productivity tends to be impeded. This was our observation in both *Arachis hypogea* and *Z. mays* planted soils. The impact on the economic crops was concentration dependent. At higher concentration (400 – 1,200g) germination process was reduced or totally stopped. This is a delicate occurrence for the biological energy flow (BEF) of the ecosystem. Onwurah et al., (1996) reported a reduction in the growth and nitrogen fixing potential of *Azotobacter vinlandii* on crude oil impacted soil. The quantity of chlorophyll per unit area is an indication of photosynthetic capacity and productivity of a plant. Therefore, the amount of chlorophyll in the leaf tissues may be influence by nutrient availability and environmental stresses such as drought, salinity, crude oil pollution of soil, heat etc. (Palta, 1990; Karacan, 2006 and Onwurah *et al*., 2007).

Germination is not outright dependence on photosynthetic apparatus of the plants, during this process; growth depends on the energy stored in the gymnosperm of the germinating seedling also. Ekpo et al., (2012) reported that these energy stored is useful for the germinating seedling until the photosynthetic apparatus of the plants switch in action to fix atmospheric carbon dioxide. This may be why most of the *A. hypogea* germinate more that the *Zea mays* even at 400 – 800g of impacted soil. This observation is also supported by the work of Mercks manual (2013) who reported that fat containing plants will store more energy than carbohydrate containing plants. Therefore, in managing climate change due to crude oil pollution, fat storing plants should only be used in the phytoremediation process since they may survive more than the carbohydrate producing plants.

In order to facilitate the growth potentials of these seedlings, the seeds were pre-soaked in water before planting in the impacted soil. We observed a general decrease in germination potential of pre-soaked seeds than in seeds not soaked in water. Although there was sufficient water in the soil; the water was not readily available to the seeds for growth due to partition coefficient of water, oil and the soil. Earlier work reported by other researchers also showed the same trend (Ekpo et al., 2012: Bhale, 2011). Oil spills generally, can cause various damages to the marsh vegetations. It was found to reduce growth, photosynthetic rate, stem height, density, and above ground biomass of *Spartina alterniflora* and *S. Patens* and may cause their death (Krebs and Tamer, 1981).

Biomass content measured as dry weight showed that pre-soaked *A. hypogea* had 30% reduction when compared with control group whereas *Z. mays* had 10% reduction with respect to control. This is in consonance with the work of Ekpo et al. 2012 who reported decrease in height at different concentration of the oil pollution as compared with the control plant.

Although the amount of carbon dioxide fixed was not estimated, we used an indirect method to determine this parameter based on the number of leaves, produced by the potted plants.

CONCLUSION

Our observation showed that decreased plant biomass could lead to low productivity as well as increased atmospheric carbon dioxide therefore a measurable indicator in predicting the impact of climate change on soil productivity.

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