Toxic Effects of Water Soluble Fractions of Crude Oil, Diesel and Gasoline on Ceratophyllum Demersum

Eshagberi G.O.
Dept. of Science Lab. Tech.,
Delta State Polytechnic,
Otefe – Oghara
godwineshagberi@gmail.com

***Abstract*- Oil exploration and exploitation has resulted in oil pollution in the Niger Delta. This study investigated the toxicity of water soluble fractions (WSFs) of crude oil, diesel fuel and gasoline on *Ceratophyllum demersum (L)*. The parameters measured include fresh weight, biomass production and relative growth rate. The water soluble fractions concentrations used were 25%, 50% 100% for crude oil and diesel and 5%, 10%, 20% were used for gasoline. Results from the study showed that at 25% WSF of crude oil and diesel fuel and 5% WSF of gasoline, there was significant increase ($P < 0.05$) in fresh weight, biomass production and relative growth rate of *Ceratophyllum demersum*. While increase in concentration resulted in decrease in the growth parameters. High concentrations of Water Soluble Fractions of gasoline were the most toxic followed by diesel fuel. This study showed that low concentration of water soluble fractions of petroleum hydrocarbons enhanced growth while high concentration was toxic to the aquatic macrophyte.**

Keywords: **Crude oil, diesel, gasoline, *Ceratophyllum demersum*.**

I. INTRODUCTION

The most serious oil spillage affects marine and coastal areas including the creeks and water distributaries. The overall effects of oil on ecosystem health and biota are numerous. Oil interferes with the functioning of various organs and systems of plants and animals. It creates environmental conditions unfavorable for life. For example, oil in water surface forms a layer which prevents oxygen from dissolving in water. Crude oil also contains toxic components which causes outright mortality of plants and animals as well as other sub lethal impacts [1], [2].

The major sources of oil pollution include drilling accidents, transportation accidents affecting tankers, leakages from refineries and storage tanks and leakages from pipelines. Between 1976 and 1997 about 2.8million barrels of oil have been released into the land, swamp, estuaries and coastal waters of Nigeria [3], [4].

All types of fresh water organisms are susceptible to the deadly effects of spilled oil. This includes mammals, aquatic birds, fishes, insects, microbes, invertebrates and algae, it tends to spread up to the food chain and eventually affects other species that depends on each other for sustenance [5].

Water soluble fraction (WSF) of petroleum is that small fraction of oil containing components which are fully or sparingly soluble in water. It was observed that water soluble fraction is produced during a long period of oil water contact [6]. When there is delay in cleaning operation after oil spillage has occurred, the water soluble components of the oil seep into the aquatic ecosystem [7].

The uptake of water-soluble hydrocarbons by plants is possible through the root system and the foliage [8]. The water soluble fraction of crude oil reduced the growth rate, biomass turnover and population of some aquatic macrophytes studied [1] [2] [7].

The objective of this study is to determine the effects of water soluble fractions (WSFs) of crude oil, diesel fuel and gasoline on *Ceratophyllum demersum (L)*.

II. MATERIALS AND METHODS

2.1 Plant Collection.

Ceratophyllum demersum was collected from pond near river Ethiope in Delta State, Nigeria.

2.2 Study Site

The study site was carried out in the Botany screen house of the department of plant Biology and Biotechnology, university of Benin, Benin City, Edo state.

2.3 Source of Crude Oil

The crude oil used in this study was collected from Forcados Tank Farm owned by Shell Petroleum Development Company (SPDC) of Nigeria.

2.4 Source of Diesel Fuel and Gasoline.

Diesel fuel and gasoline were obtained from Nigerian Nation Petroleum Corporation (NNPC) filling station along Sapele/Warri Road, Amukpe Sapele.

2.5 Preparation of Water Soluble Fractions (Wsfs) Of Crude Oil, Diesel Fuel and Gasoline.

Water soluble fractions of crude oil, diesel fuel and gasoline were prepared following the procedures of [5]. 500cm^3 of crude oil was mixed with 1500cm^3 of borehole water and the mixture was stirred using hallenkamp orbital magnetic stirrer for 24 hours at room temp. After 24 hours of shaking, the mixture was allowed to stand for a minimum of 3hours to obtain clear interphase between oil and water. The

IJHM

oil was decanted and the mixture was then poured into a glass stopper separating funnel and allowed to stand overnight. Pure and clear WSF obtained at the lower part of the funnel was siphoned into capped bottles to make the stock (100% WSF).

The procedure was repeated using diesel fuel and gasoline respectively until sufficient quantities of WSFs of crude oil, diesel fuel and gasoline were obtained each stock was diluted with pond water to give 50% and 25% strength WSF.

The experiment was designed with four treatments (0% - control, 25%, 50% and 100% WSFs). 200cm3 of each diluted WSF including the 100% WSF and the 0% (pond water) were poured into containers into which the macrophytes were introduced. There were 4 replicates per treatment. The set up was observed for 4 weeks and solutions continuously replenished.

2.6.1. Fresh Weight Measurement

The fresh weights of *Ceratophyllum demersum* was obtained before the experiment and weekly thereafter.

2.6.2. Dry Weight Measurement

The test plants for biomass production were harvested after 28 days and oven dried at 65℃ to constant weight.

2.6.3. Growth Measurements

The relative growth rate was calculated using the equation described by [9]

$$RGR = \frac{Inm_2 - Inm_1}{T_2 - T_1}$$

Where RGR = relative growth rate
In =natural log
T =time (days)
M_1 = dry mass of shoot at time T_1
M_2 = dry mass of shoot at time T_2

2.6.4. Statistical Analyses

The data was statistically analysed using the method described by Ogbeibu (2005).

III. RESULTS AND DISCUSSION

The effects of water soluble fractions (WSFs) of crude oil, diesel fuel and gasoline on the fresh water of *Ceratophylum demersum* are presented in figures 1, 2 and 3. The water soluble fraction (WSF) of gasoline was used at 5, 10 and 20% concentration. There were increases in fresh weight of *C.demersum* in the control treatment and in the 5% WSF gasoline. Initial increase in fresh weight of *C.demersum* occurred in 10% WSF of gasoline by a decrease after the week. Plants in 20% WSF gasoline showed a progressive decline in fresh weight from the beginning of the experiment (fig.1)

The effects of water soluble fraction (WSF) of crude oil is shown in fig.2. The highest increase in fresh weight in *C.demersum* took place in 25% concentration followed by control plants. There was a slight increase in 50% WSF and a decrease in fresh weight in 100% WSF of crude oil.

The effect of WSF of diesel fuel on *C.demersum* is shown in fig.3. The highest increase in fresh weight occurred in 25% concentration followed by the control plants. There were progressive decrease in fresh weight of *C.demersum* at 50% and 100% WSF of diesel fuel.

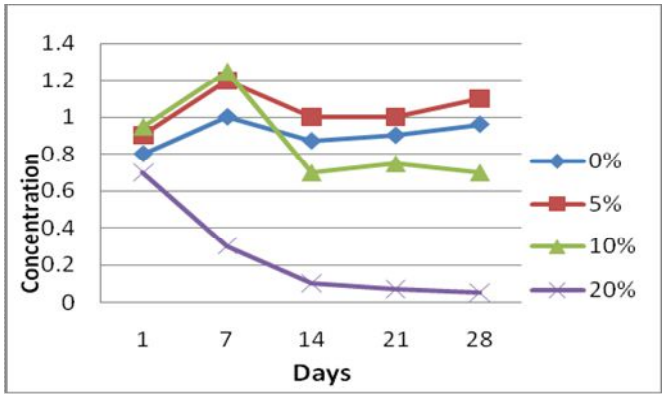


Fig. 1: Effect of Water Soluble Fraction (WSF) of gasoline on the fresh weight (g) of *Ceratophyllum demersum*.

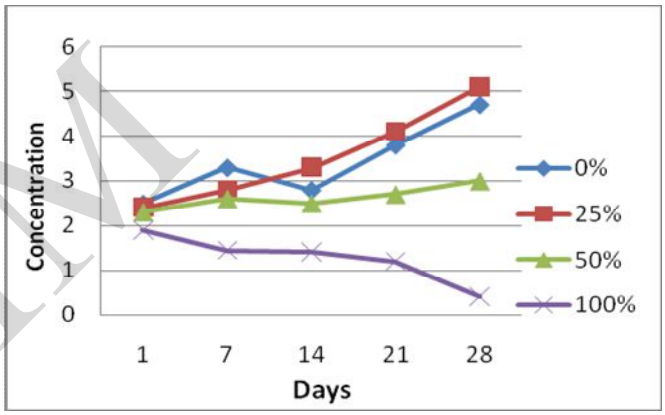


Fig. 2: *Effect of Water Soluble Fraction (WSF) of crude on the fresh weight (g) of Ceratophyllum demersum.*

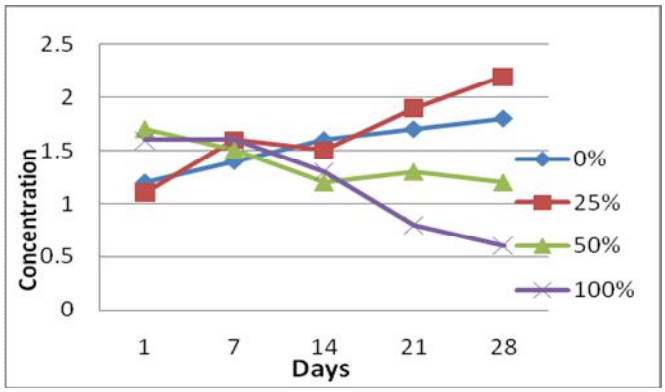


Fig. 3: *Effect of Water Soluble Fraction (WSF) of diesel fuel on the fresh weight (g) of Ceratophyllum demersum.*

The effect of WSF of crude oil, diesel fuel and gasoline on relative growth of *C.demersum* are shown in the tables 17, 18 and 19. When exposed to WSF of crude oil, the 25% WSF

IJHM

plants showed the highest relative growth rate followed by the control and 50% concentration. At 100%, the relative growth rate was negative, an indication that the plants were dying of high toxicity (tab.17). On exposed to water soluble fraction (WSF) of diesel oil, *C.demersum* showed the highest relative growth rate at 25% WSF, followed by the control plants. At 50% and 100% WSF concentration there was negative growth rate indicating high toxicity (tab.18). Table 19 shows the effects WSF of gasoline on *C.demersum*. The highest relative growth rate and lowest doubling time occurred in 5% WSF of gasoline followed by control plants. At 10 and 20% WSF of gasoline *C.demersum* showed negative growth rate indicating high toxic effect. The increases in relative growth rate at low concentration of WSFs of crude oil, diesel fuel and gasoline were all significant when compared with control.

Table I: Effect of Water Soluble Fraction (WSF) of crude oil on the Relative Growth Rate of *Ceratophyllum demersum.* Results are mean of 4 replicates ± SE.

CONCENTRATION (%) OF WATER SOLUBLE FRACTION	RELATIVE GROWTH RATE (RGR) (gg^{-1} day)
(control) 0	0.0127±0.0004
25	0.0169±0.0004
50	0.0045±0.0001
100	-0.01310±0.0000

Key **p<0.01 significant compared to control.

Table II: Effect of WSF of diesel oil on the Relative Growth Rate of Ceratophyllum demersum. Results are mean of 4 replicates ± SE.

CONCENTRATION (%) OF WATER SOLUBLE FRACTION	RELATIVE GROWTH RATE (RGR) (gg^{-1} day)
(control) 0	0.0122±0.0002
25	0.0176±0.0003**
50	-0.0112±0.0004
100	-0.0202±0.0003

Key **p<0.01 significant compared to control.

Table III: Effect of water soluble fraction (WSF) of gasoline on the Relative Growth Rate of Ceratophyllum demersum. Results are mean of 4 replicates ± SE.

CONCENTRATION(%) OF WATER SOLUBLE FRACTION	RELATIVE GROWTH RATE (RGR) (gg^{-1} day)
(control) 0	0.0105±0.0003
25	0.0150±0.0005**
50	-0.0112±0.000
100	-0.0803±0.0008

Key **p<0.01 significant compared to control.

When exposed to WSFs of crude oil, diesel fuel and gasoline *Ceratophyllum demersum* showed varied responses. Biomass production at low concentrations of WSFs of crude oil (25%), diesel fuel (25%) and gasoline (5%) was significantly of higher than the control plants. There was a significant decrease in biomass at 10% and 20% WSF of gasoline. There was a slight increase in biomass at 50% of WSF of crude oil and a decrease at 100%. At 50 and 100% WSF of diesel fuel there was decrease in biomass (tabs. 23, 24 and 25)

Table IV: Effect of WSF of crude oil on the biomass of Ceratophyllum demersum. Results are mean of 4 replicates ± SE.

CONCENTRATION OF WATER SOLUBLE FRACTION(%)	DRY WEIGHT(g)
(control)0	0.189±0.005
25	0.207±0.004**
50	0.150±0.004**
100	0.042±0.001**

Key **p<0.01 significant compared to control.

Table V: Effect of water soluble fraction(WSF) of diesel fuel on the biomass of Ceratophyllum demersum. Results are mean of 4 replicates ± SE.

CONCENTRATION OF WATER SOLUBLE FRACTION (%)	DRY WEIGHT(g)
(control)0	0.079±0.003
25	0.089±0.003*
50	0.047±0.002**
100	0.022±0.001**

Key **p<0.01 significant compared to control.

Table VI: Effect of water soluble fraction (WSF) of gasoline on the biomass of Ceratophyllum demersum. Results are mean of 4 replicates ±SE

CONCENTRATION OF WATER SOLUBLE FRACTION (%)	DRY WEIGHT(g)
(control)0	0.039±0.002
25	0.044±0.001*
50	0.028±0.002**
100	0.001±0.000**

Key **p<0.01 significant compared to control.

Water soluble fraction (WSF) of petroleum are the components that are soluble in water and consequently dissolve into water during an oil spill. [7], WSF of crude contain the cations Ca^{++} , mg^{++} , K+, Fe=, NH_4 , P+ and the anions Cl-,SO_4^{2-} NO_3^-. Also presentative. The heavy metals Cr, Pb, Cu, Zu, Mn and V. Constituents of water soluble fraction of petroleum include dispersed particulate oil, dissolve hydrocarbons, metallic and non-metallic ions [10]. It is the dissolved rather than the emulsified or the adsorbed fraction of spilled oil that is toxic to aquatic flora and fauna [11].

The result of this study show that low concentrations of WSFs of crude oil, diesel and gasoline stimulated increase in fresh weight of *C. demersum* while higher concentration resulted in decrease in fresh weight (Figs. 1, 2, 3). Other studies have shown that low concentrations of WSF enhance growth of phytoplankton [12] [13]. Similarly, when exposed

to WSFs of crude oil, diesel and gasoline, the relative growth rate of *C. demersum* was higher in low concentrations than high concentrations. The decrease at high and increase at low concentration were significant when compared to the control (Tables 1, 2, 3).

When exposed to the WSFs biomass production was enhanced at low concentration of 25% WSF of crude oil and diesel and at 5% WSF gasoline. The increase in biomass was significant ($P < 0.01$) when compared with the control. There was a significant decline in biomass as the concentration of WSFs increased. Several studies reported significant reduction in biomass production in *Pistia stratiotes, Spartina patens, Spartina alterniflora* and *Eichhornia crassipes* when exposed to various concentrations of crude oil [14]. Other studies show that the toxicity of WSF of crude oil on aquatic macrophytes is concentration dependent [1] [2] [7]..

IV. CONCLUSION

Oil pollution changes the physic-chemical properties of aquatic ecosystem which significantly affect the survival and distribution of aquatic macrophytes. Since aquatic macrophyte play important roles in the ecosystem incidences of oil spills should be promptly dealt with.

REFERENCES

[1] M.O. Agbogidi, and N.E. Edema. Effects of Crude oil and its water soluble fraction on the growth parameter of Panicum repens. Nigerian Journal of Ecology. Vol. 6: pp1 – 4. 2003.

[2] J.F. Bamidele and O.M. Agbogidi. Toxicity of Odidi Petroleum Oil and its water soluble fraction on three aquatic macrophytes. Nigerian Journal of Science and Environment. Vol. 2:113-121. 2000..

[3] J.A. Adeyanju. Government and the oil pollution crisis in Nigeria. International Journal of Environmental Issues. Vol. 2 No. 2, pp. 217-227. 2004.

[4] N. Zabby. Impacts of oil pollution on livelihoods in Nigeria. paper presented at the conference on Petroleum and pollution – how does that impact human rights? Co-organised by Amnesty International Forum and Friends of the Earth, Sweden at Kulturhuset, Stockholm, Sweden, 27th April 9p. 2009.

[5] O.A. Afolabi, S.A. Adeyemi, and M.A. Imebore. Studies on toxicity of some Nigerian crude oils on some aquatic organism. In: Proceedings of 1985 International Seminar on Petroleum Industry and the Nigerian environment, Lagos. pp 269 – 273. 1985.

[6] J.M. Baker. The effect of oil on plants. Environmental Pollution. Vol. 1: pp. 27-34. 1970.

[7] N.E. Edema, G.E. Okoloko, and M.O. Agbogidi. Physico-chemical characteristics of the water-soluble fractions of Ogini wellhead crude oil and the effects on Pistia stratiotes. American-Eurasian Journal of Agricultural and Environmental Science. Vol. 2 No. 6, pp. 633-638. 2007.

[8] T. Youssef. Physiological Response of Avicenna marina seedlings to phytotoxic effect of water soluble fraction of light Aratian crude oil. The environmentalist. Vol. 12 No.4. pp 149-159. 2002

[9] G.A Jackson. Marine biomass production through seasoned aquaculture. In: San Petro, A. (Ed). Biochemical and Photosynthetic Aspect of Energy Production. Academic, New York pp. 31-58. 1980.

[10] R.B. Kauss and T.C. Hutchinson. The effects of water soluble oil components on the growth of Chlorella Vulgaris. Environmental pollution. Vol.9, pp. 157-174. 1975

[11] R.l. Ziolli and W.F. Jardim. Operational problems related to the preparation of the seawater soluble fraction of crude oil. Journal of Environmental Monitoring. Vol. 4: pp. 1 – 5. 2001.

[12] R.S. Parah, R.A. Pandit, A.N. Kadan and M.M. Indap. Effects of Bombay high crude oil and its water soluble fractions on growth and metabolism of diatom Thalasscoscra sp. Indian Journal of marine Services. Vol. 37, No.3, pp 251-255. 2008.

[13] S. Nayer and B.P. Goh Environmental impacts of diesel fuel on bacteria and phytoplankton in tropical estuary assessed using in site mesocosm. Ecotoxicology. Vol. 2, pp 397-412. 2005

[14] R.S. Silva and A.F.M. Camargo. Effect of Urucu crude oil on the aquatic macrophyte Pistia stratiotes. Acta Limnologia Brasilia. Vol. 19, No.2, pp 155-161.

IJHM