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Effects of Crude Oil Pollution on Horticultural Crops in Rivers State, Nigeria

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Keywords : Horticultural crops; crude oil pollution; oil and gas exploration; crude oil polluted farms; non polluted farms; Rivers State Nigeria.

I. Introduction

The Niger Delta region of Nigeria is one of the world's largest wetlands and includes by far the largest mangrove forest in Africa. Its biological diversity is of global significance. Within the extremely valuable ecosystem, oil activities are widespread (Niger Delta Development Commission, 2006). The emergence of oil as the world's leading fuel was partly due to its relative cleanliness but the enormous scale of the petroleum industry's operation has inevitably created a new set of difficult environmental problems as being experienced today in the Niger Delta region of Nigeria (Ekanem, Ejue, Amim and Adalikwu, 2010; Ugbomeh and Atubi, 2010; Onyenekenwa, 2011(a)). The Niger Delta region of Nigeria includes the following states: Rivers, Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo and Ondo States.

Presently, in Nigeria, oil spills regularly occur in the oil producing areas of the country, while gases are continually flared in these areas (Abii and Nwosu, 2009; Idodo – Umeh and Ogbeibu, 2010). With advanced technology in use in the oil industry, accidents should be less frequent but this certainly has not completely eliminated accidents and vandalisations (Iturbe, Castro, Perez, Flores and Torres, 2008; Ogbu, 2008).

Exploration of natural gas deposits of the Niger Delta region of Nigeria has not been economically viable until recently (NDDC, 2006). As a result much of it has been burnt off and is still being burnt off to allow access to underlying oil (Platform, 2006; Cohen 2008). The burning gas (flares) produce gases such as nitrogen oxide and sulphur dioxide which are released into the air. These air-borne pollutants are highly toxic (Mourad, Ghazi and Noureddine, 2009; Nkwocha and Pat – Mbano, 2010), and the growth of plants (especially horticultural and annual crops) are particularly inhibited by the hot, sooty emissions (Bello, Aladesanwa, Akinlabi and Mohammed, 1999; Dung, Bombom and Agusomu, 2008).

In effect, the Nigerian environment (especially Rivers State with its petrochemical industries, heavy oil and gas production and refining activities) is not safe judging from the effect of oil and other human activities on the environment and it will require much efforts to make it safe, which very few had paid attention to including the government, multinational oil companies and individuals (Ajibade and Awomuti, 2009; Ezeabasili, 2009; Onyenekenwa, 2011 (b)).

II. The Problem and Significance of Study

This environmental impact of the oil and gas industry essentially results from the activities and processes necessary for the successful operations of the oil and gas industry by the multinational oil companies. This had caused a lot of distortions in the soil, flora and fauna, traditional economies (such as farming, fishing, livestock and wildlife production), and social practices of the people of the area (Orta-Martinez and Finer, 2010; Huang, Jiang, Zeng, Chen, Zhao, Liao, Shou and Xu, 2011). It has also engendered poverty, food contamination and lack of security of human life (Onwuka, 2005; Enemugwem 2009; Ajibade and Awomuti, 2009).

With irregularities in the major primary sources of livelihood activities of the people of Rivers State, Nigeria due to oil and gas exploration and production, the question this article poses therefore is: to what extent is crude oil pollution a problem to horticultural crops in Rivers State of Nigeria?

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There is scarcity of researched data on the effects of crude oil pollution on horticultural crops in Rivers State, Nigeria (Dung et al., 2008). Many studies had examined the effects of crude oil exploration and production on Nigerian agriculture. The earlier studies include Odu (1983) and Bello et al. (1999). The more recent studies include Ekundayo, Emede and Osayande, (2001); Achuba (2006), Agbogidi, Eruotor and Akparobi, (2007), Eriyameru, Asagba, Onyeneke and Aguebor – Ogie, (2007); Abii and Nwosu (2009); Idodo – Umeh and Ogbeibu (2010). None of these studies had examined the effects of crude oil pollution on horticultural crops production and its economic implications on farmers in Rivers State in details.

Effects of crude oil pollution in this context will include the various degrees of oil spillages on farmland and areas of land formerly used for horticultural crops production but now occupied by flow stations, oil well sites, gas flaring sites, borrow pits excavated during construction and installations of equipment for crude oil production operations, laying of pipelines and other oil and gas activities.

III. The Objectives of The Study

The main objective of this study is to examine the effects of crude oil pollution on horticultural crops production in Rivers State, Nigeria.

The specific objectives are to:

(i) Examine and compare the areas of farmland used for horticultural crops production in crude oil polluted and non polluted farms in Rivers State.

(ii) Estimate and compare the output of horticultural crops produced in crude oil polluted and non-polluted farms in the study area.

(iii) Estimate and compare the farm income realized from horticultural crops in crude oil polluted and non polluted farms in Rivers State.

(iv) Suggest policies to ameliorate the negative effect of crude oil pollution on horticultural crops in Rivers State of Nigeria.

IV. Literature Review

Odu (1983) reported that plants are adversely affected by gas flares. This effect become progressively more serious as one gets nearer the flares. Vernalisation (i.e the requirement of low temperature for stimulation of flowering) fails, or slow photoperiod response (a reaction to the duration and timing of the light and dark conditions, i.e relative length of day and night), except in a few local horticultural crops like okra and some varieties of cowpea and maize, fail to occur. The study further reported that direct heat radiation, apart from consideration of comfort, standards and human performance near flares, result in dehydration and affect seed setting in some plants. The premature of defoliation and malformation of leaves of pawpaw, banana, plantain, coconuts and oil palm trees at proximal farming locations to the flares could also had been caused by sooty emissions.

Bello et al. (1999) experimentally examined the effects of gas flaring at the Ozombe oil flow station in Oguta Local Government Area (LGA) of Imo State, Nigeria, on the growth and yield of maize on farms located at distances of 200 metres, 600metres and 1000 metres respectively, east, west, south and north of the gas flaring point. Another farm located 10km away from the gas flaring point was included as control experiment. Experimental finding indicated that crops mean percentage of plant survival and grain yield were significantly reduced in all the locations compared with the control. The study observed that farms located 200metres away from the flaring point failed to produce any yield.

Ekundayo et al. (2001) studied the effect of crude oil spillage on growth, productivity and nutrient uptake of maize (Zea mays L.) The results showed that in crude oil polluted soils, germination was delayed and the germination percentage was significantly affected by oil pollution. Growth was poor in polluted soils using parameters such as plant height; stem girth, ear height, leaf area at four weeks after planting, leaf area at maturity and average length of primary roofs as growth indicators. Grain yield was significantly reduced at 95% level of probability when compared with the control. Leaf analysis of the maize plants grown in soils contaminated with crude oil a week before planting (preplant treatment) revealed mean levels of heavy metals which were higher than maximum permissible levels for maize in tropical soils.

Achuba (2006) studied the effect of crude oil contaminated soil at various sublethal concentrations on the growth and metabolism of cowpea (vigna unguiculata) seedlings. The results showed that crude oil induced environmental stress in the seedlings. Agbogidi et al. (2007) results showed that soil treatment with crude oil at four weeks after planting (4WAP), maize died within 24 hours while the plant without crude oil treatment remained intact. The study showed that the time of application of crude oil to soil has a significant effect on growth of the maize. Eriyameru et al. (2007) studied the effect of contaminating soil with Bonny light whole crude, or its fractions on germinating beans (phaseolus vulgaris L.) and maize (Zea mays L.). The results showed that there was dose dependent reduction in the number of bean or maize seeds that germinated in the contaminated soils compared with the control ($p < 0.05$), with the least number recorded in the 0.3% contaminated soil.

Dung et al. (2008) explored the spatial variability effects of gas flaring on the growth and development of cassava, water leaf and pepper, crops commonly cultivated in the Niger Delta. Results showed that retardation in crop development manifested in decreased dimensions of leaf lengths and width of

cassava and pepper crops closer to the gas flare point. Cassava yields were higher at location further away from flare points. Higher temperature around the gas flare appear to be the cause of the retardation in crops.

Abii and Nwosu (2009) studied two oil spill affected areas (Ogali and Agonchia) while an unaffected area (Aleto) all in Eleme LGA, Rivers State was used as control. The results showed that there was a significant decrease in the Ca, K, P, (CEC), as well as a significant increase in the sand fraction and Na content of the oil-spill affected soils when compared with the non affected soil. The results further showed that oil-spill had adversely affected the nutrient level and fertility states of Eleme soil.

Idodo-Umeh and Ogbeibu (2010) investigated the bioaccumulation of heavy metals in cassava tubers and plantain fruits grown in soils impacted with petroleum and non-petroleum activities in Olomoro in Isoko South LGA of Delta State, Nigeria. The results showed that all heavy metals revealed higher values in petroleum impacted soil than non – impacted soil. The values of heavy metals were higher both in epicarp and mesocarp of plantain fruits harvested from petroleum impacted soil than from non petroleum impacted soil. In cassava tubers, the values of heavy metals in the cortex were all higher in the petroleum impacted soil than in non impacted soil.

V. Methodology

This study was conducted in Rivers State of Nigeria, between August 2002 and April 2003. Rivers State is blessed with abundant natural resources including majority of Nigeria's oil and gas deposits (NDDC, 2006). As at today on shore and off shore oil fields in Rivers State involving crude oil exploration activities are scattered throughout the 23 LGAs of the state. The state is characterized by two distinct seasons; wet and dry, which favour the production of horticultural crops such as leafy vegetables, okra, melon, pepper, banana, and assorted types of fruits.

The primary data were collected through personal interviews, observations and structured questionnaires distributed among farmers in crude oil polluted and non-crude oil polluted areas of the state. A multistage stratified sampling procedure was used to obtain the data for this study. The first stage involved the selection of 17 LGAs out of the existing 23 LGAs in the state. These 17 LGAs were selected based on the fact that they were more crop farming inclined than the others. The second stage involved the stratification of farmers in a LGA into two sampling units namely crude oil polluted and non-crude oil polluted (non-polluted) farms. This was because information was required from both the crude oil polluted farms and non polluted farms. The third stage involved the random sampling of ten (10) farmers from crude oil polluted areas in a selected LGA and a corresponding number of ten (10) farmers from non-polluted farmlands in the same locality in a selected LGA.

A total of 340 questionnaires were distributed among horticultural crop farmers in the 17 LGAs selected in Rivers State. Out of the 340 questionnaires distributed, due to difficult terrain, uncompromising attitudes of the farmers, the politicking of crude oil pollution issues and persistent youth restiveness in the state (Ekanem et al., 2010; Ugbomeh and Atubi, 2010), 14 questionnaires were not retrieved. Furthermore, 30 questionnaires were found inconsistent with the objectives of the study. Hence, only 296 questionnaires were found suitable for the analysis. Data were analysed using descriptive statistics.

VI. Results and Discussion

The results and discussion were made under three sub headings according to set objectives namely: area of farmland used for horticultural crops production in crude oil polluted farms and non-polluted farms, horticultural crops output produced by farmers surveyed; and farm income realized from horticultural crops produced.

a) Area of farmland used for horticultural crops.

The average farm size cultivated per horticultural crop grown (ha) was obtained by dividing the total number of hectares cultivated by the number of farmers cultivating that horticultural crop as shown in Table 1. The coefficient of variation described the relationship between the standard deviation and average farm size, expressed in percentage. The ranking was done according to the total number of hectare cultivated per horticultural crop.

The total number of hectares of horticultural crops cultivated in the crude oil polluted farms was higher (454.61ha) than in the non-polluted farms (347.10ha); so also was the mean value in crude oil polluted farms (75.77ha) higher than the mean value in non-polluted farms (57.85ha). The number of farmers involved in cultivating horticultural crops in crude oil polluted farms was higher (454) than the number of farmers involved in non-polluted farms (316). Despite the higher number of respondents (farmers) cultivating horticultural crops in the crude oil polluted farms the average farm size cultivated (1.04ha) was lower than that of the non-polluted farms (1.17ha). The differences in the average farm sizes cultivated between the crude oil and gas polluted farms and non-polluted farms were clearly noticed in the following crops: fruits (1.06ha) in crude oil polluted farms, as against (1.54ha) in non-polluted farms; leafy vegetables (1.03ha) in crude oil polluted farms as against (1.15ha) in non-polluted farms; melon (1.03ha) in crude oil polluted farms, as against (1.13ha) in non-polluted farms. This is to say that because of crude oil spillages on the farmlands, acquisition of farmlands for installation and construction oil well sites, flow stations, gas flaring sites and laying of pipelines etc., the farm sizes had been reduced. Therefore, crude oil and gas exploration, exploitation

Table 1 : Distribution of horticultural crops grown and areas of farmland used in Rivers State.

Horticultural crops cultivated	Total number of hectares cultivated (ha)	Average farm size (ha)	Standard deviation (S.D) (ha)	Minimum value (ha)	Maximum value (ha)	Coefficient of variation (C.V.) (%)	Number of farmers involved	Ranking
Crude Oil polluted farms								
Pepper	74.38	0.88	0.62	0.20	2.50	70.45	85	3rd
Okra	84.70	0.89	0.69	0.10	3.00	77.53	95	2nd
Melon	67.65	1.03	0.89	0.20	10.00	86.41	66	4th
Vegetable (leafy)	134.53	1.03	0.81	0.10	5.00	78.64	130	1st
Fruits	41.15	1.06	0.79	0.30	5.00	74.53	39	6th
Banana	52.20	1.34	0.79	0.20	6.00	58.96	39	5th
Total	454.61	6.23	4.59	1.10	31.50	-	454	-
Mean value	75.77	1.04	0.77	0.18	5.25	74.42	76	-
Non – polluted farms								
Pepper	5.65	0.88	0.49	0.10	2.50	55.68	59	5th
Okra	61.85	0.90	0.53	0.10	2.00	58.89	69	3rd
Melon	64.65	1.13	0.92	0.20	7.00	81.42	57	2nd
Vegetable (leafy)	80.75	1.15	0.82	0.10	5.00	71.30	70	1st
Fruits	33.80	1.54	0.65	0.10	5.00	42.21	22	6th
Banana	54.40	1.39	0.84	0.45	5.00	60.43	39	4th
Total	347.10	6.99	4.25	1.05	26.50	-	316	-
Mean value	57.85	1.17	0.71	0.18	4.42	61.66	53	-

Source : Field Survey, 2003

and production in Rivers State of Nigeria had negative effects on areas of farmland cultivated with horticultural crops. These results go to support the fact that crude oil pollution and exploration activities have negative effects on farmland i.e reducing available areas for farming activities (Odu, 1983; Onwuka, 2005; Abii and Nwosu, 2009).

b) Horticultural crops output produced by farmers

The distribution of horticultural crops output in crude oil polluted and non – crude oil polluted farms were presented in Table 2. The results on Table 2 showed that total value of output from all cultivated horticultural crops by respondents in crude oil polluted farms was 15.98tons and 18.75 tons in non – polluted farms. The table further showed that values of output of fruits, banana, pepper, okra and leafy vegetables in the non-polluted farms were considerably higher than the values of their output in crude oil polluted farms. The average output per horticultural crop farm produced in crude oil polluted farms was 384.58kg and 550.94kg in non-polluted farms. Again, the values of average output produced per fruits, leafy vegetables, pepper, okra, banana and melon farms cultivated were significantly higher in non-polluted horticultural farms than in crude oil polluted farms. This means that output of horticultural crops both in total values and average per farm produced was higher in non-polluted farms than in crude oil polluted farms, which goes to say that crude oil pollution resulting from the oil and gas exploration, exploitation and production in Rivers State of Nigeria had a negative effect on the quantity of output produced, despite the fact that total areas cultivated in the crude oil polluted farms category were higher (454.61ha) than in the non-polluted farms category (347.10ha). These negative effects of crude oil pollution on crops had been earlier highlighted by Odu (1983), Bello et al. (1999), Ekundayo et al. (2001), Dung et al. (2008). Therefore, this study supported the findings of the above named authors and confirmed that the results were similar from the point of view of output reduction on crude oil polluted areas.

The grain equivalent figures were obtained after the actual produced weights were carefully converted into grains equivalent to uniformise the output into standard grain forms. The grain equivalent value in crude oil polluted farms was 3.64 tons which was lower than the 4.33 tons obtained in non-polluted farms. The average output per horticultural farm for the total grain equivalent in crude oil polluted farms (83.80kg) was lower than the 98.10kg obtained per cultivated horticultural farms in non-polluted farms. These results go to confirm that crude oil pollution had negative effects on the output of crop farms either in absolute values or grain equivalent forms.

Table 2 : Distribution of horticultural crops output in Rivers State

Horticultural crops produced	Total number of hectares cultivated (ha)	Number of farms cultivated	Output from all farms cultivated (tons)	Standard deviation (S.D.) (tons)	Average output per farm cultivated (kg)	Coefficient of variation (C.V..) (%)	Ranking
Crude Oil polluted farms							
Pepper	74.38	85	0.32	0.17	3.76	53.13	5th
Okra	84.70	95	0.38	0.25	4.00	65.79	4th
Melon	67.65	66	0.11	0.09	1.67	81.82	6th
Vegetables (leafy)	134.53	130	0.77	0.63	5.92	81.67	3rd
Fruits	41.15	39	3.00	2.65	76.92	81.82	2nd
Banana	52.20	39	11.40	9.91	292.31	86.93	1st
Total value	454.61	454	15.98	13.50	384.58	84.48	-
Mean value	75.77	76	2.66	2.25	64.10	84.59	-
Total Grain Equivalent value	-	-	3.64	2.26	83.80	62.09	-
Mean Grain Equivalent value	-	-	0.16	0.38	13.97	62.30	-
Non polluted farms							
Pepper	51.65	59	0.49	0.28	8.31	57.71	4th
Okra	61.85	69	0.48	0.27	6.96	58.25	5th
Melon	64.65	57	0.17	0.13	2.98	76.47	6th
Vegetables (leafy)	80.75	70	0.88	0.63	12.67	71.59	3rd
Fruits	33.80	22	4.60	3.17	209.09	68.91	2nd
Banana	54.40	39	12.13	7.81	311.03	64.39	1st
Total value	347.30	316	18.75	12.29	550.94	65.55	-
Mean value	57.88	53	3.13	2.05	91.82	65.50	-
Total Grain Equivalent Value	-	-	4.33	2.79	98.10	64.43	-
Mean Grain Equivalent Value	-	-	0.72	0.47	16.33	65.28	-

Source : Field Survey, 2003.

c) Farm income realized from horticultural crop sales

The average annual farm income realized from horticultural crops produced in Rivers State was presented in Table 3. The original monetary value of horticultural crops produced in Rivers State in 2003 was in local Nigerian currency, the Naira. The naira value were converted into United States of America dollars (US $) using the prevailing exchange rate of N120 for a US $1.00 as at the period of survey in 2003. The results in Table 3 showed that the total mean value of horticultural crops produced in crude oil polluted farms was $324.70 and $365.85 in non-polluted farms. These results obtained in Table 3 showed that the average values of crop produced per farm in non polluted farms were higher than in crude oil polluted farms. This was more evident in crops such as banana, leafy vegetables and pepper.

The total average farm income realized per ha of horticultural crops produced in crude oil polluted farms was $302.69 and $329.14 in non-polluted farms. These results also showed that values of horticultural crops in crude oil polluted farms were considerably lower in all crops than in non-polluted farms, as was evident in the value of pepper, leafy vegetables and banana respectively. These lower values of farm income in crude oil polluted farms had been caused by the negative effects of crude oil pollution on horticultural crops output. These results are similar to and support the findings of Odu (1983), Bello et al. (1999), Dung et al. (2008), Abii and Nwosu (2009), whereby oil and gas exploration, exploitation and production affected the value of crops produced through their effects on soil, directly on crops and/or atmospheric impacts. This study states categorically that farm incomes declined where crude oil pollution had occurred on horticultural crop in Rivers State, Nigeria as compared to non-polluted areas.

VII. Conclusion and Recommendation

a) Conclusion

In conclusion, the results of this study showed that the average hectares of horticultural crop farms cultivated during the period of survey was least in crude oil polluted farms (1.04ha) as compared to the non-polluted farms (1.17ha). Secondly, the findings of this study revealed that the output of horticultural crops in crude oil polluted farms

Table 3 : Average annual farm income realized from horticultural crops produced in Rivers State (US$)

Horticultural crops produced	Average produced per farm ($)	Standard deviation (S.D.) ($)	Average farm size (ha)	Average farm income produce per ha ($)	Coefficient of variation per ha ($)	Ranking
Crude Oil polluted farms						
Pepper	31.27	14.65	0.88	35.53	46.85	6th
Okra	31.47	23.56	0.89	35.38	74.86	5th
Melon	54.70	42.18	1.03	53.11	77.11	3rd
Vegetable (leafy)	64.97	53.15	1.04	62.47	81.81	2nd
Fruits	50.78	45.14	1.06	47.91	88.89	4th
Banana	91.51	75.13	1.34	68.29	82.10	1st
Total value	324.70	253.81	6.24	302.69	78.17	-
Mean value	54.12	42.30	1.04	50.45	78.16	-
Non-polluted farms						
Pepper	38.74	23.50	0.88	44.02	6-.66	5th
Okra	36.98	20.37	0.90	41.05	53.13	6th
Melon	60.36	55.19	1.13	53.42	91.43	3rd
Vegetable (leafy)	73.73	53.66	1.15	64.11	72.78	2nd
Fruits	53.24	43.93	1.54	54.57	82.51	4th
Banana	102.82	65.41	1.39	73.97	63.62	1st
Total value	365.84	262.06	6.99	329.14	71.63	-
Mean value	60.97	43.68	1.17	54.86	71.64	-

Source : Field Survey, 2003

(15.98tons) were significantly lower when compared with non-polluted farms (18.75tons). Lastly, this study also reported that farm income realized from horticultural crops produced per farm was significantly lower in crude oil polluted farms ($324.70) than in non polluted farms ($365.84). Therefore, this study states categorically that crude oil pollution had detrimental and negative effects on the area of farmland cultivated, horticultural crops output produced and hence farm income.

b) Recommendations

In order to ameliorate the observed negative and detrimental effects of crude oil pollution on horticultural crops produced in Rivers State, Nigeria, it is being recommended that crude oil pollution in the state in whatever form (acquisition of farmland for production, exploration and exploitation of oil and gas or crude oil spillages) should be minimized to acceptable minimum standard as it is practiced by the same multinational oil and gas companies in other parts of the world (Otton, Zielinski, Smith, Abbott and Keeland 2005). This could be done by all stakeholders in the Nigerian oil and gas industry to enact and enforce laws for effective control of rate of crude oil spillages (Eweje, 2006; Ezeabasili, 2009; Ajibade and Awomuti, 2009) and pipelines vandalisation on farmland, prevention of gas flaring (by re-injecting the gas back into the ground for a more adequate and better future use), and keeping to agreed dates of stopping the flaring of gases (Patform, 2006; Cohen, 2008; Ogbu, 2008) as these devastate crops planted, crops output produced and hence reduce farm income accruable to crop farmers, thereby causing heavy economic losses to crop farmers (Onwuka, 2005). Secondly, when oil spills and/or farmland is acquired for oil and gas production and exploration purposes by

multinational oil and gas companies adequate list of affected farmers should be compiled by authorities concerned and authenticated, and commensurate amount of compensation paid to them in line with the economic trends in the country. This will help relocate such affected farmers and/or to diversify their sources of income.

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