Environmental impacts of the oil spill at Ikot Ada Udo in Akwa Ibom State, Nigeria

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May, 2008.

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EXECUTIVE SUMMARY

In May 2008, a study was carried out to assess the environmental damage caused by the crude oil spillage from the Corked Well, Ibibio 1, located at Ikot Ada Udo in Ikot Abasi LGA of Akwa Ibom State of Nigeria. The well belongs to the Shell Petroleum Development Company (SPDC) of Nigeria.

Between August and November 2007, a large volume of oil has been spilled from the corked well. The survey of the area showed that the crude oil had flowed from the corked well down the gentle slope to the streams, fish ponds and the main water stream of the area.

It was observed that the whole farmland in which the corked well is located has been highly polluted. The crops, weeds and other plants in the farm area were destroyed.

The physico-chemical characteristics of the soils and water in the area were also found to be affected by the pollution. The total hydrocarbon content (THC) was very high, particularly near the well head with values decreasing towards the fish pond area. The organic carbon content, pH values and total nitrogen were high in content while the available phosphorus decreased in value compared to a situation in unpolluted soil. The total contents of heavy metals Lead (Pb), Mercury (Hg) and Cadmium (Cd) were found to be much higher than what is found in unpolluted soils. The levels of Pb and Hg were above the Nigerian standards that require immediate cleaning operations.

The water in the fish ponds was found to be highly polluted with heavy metals. Levels of Lead (Pb), Cadmium (Cd), Mercury (Hg), Manganese (Mn) and Nickel (Ni) were found to be exceeding the levels in the drinking water guidelines of the World Health Organization many times. To a lesser extent, the main stream was found to be polluted with heavy metals.

The fish and plant contained very high levels of heavy metals, indicating pollution of fish with Lead (Pb), Cadmium (Cd), Vanadium (V), Chromium (Cr) and Mercury (Hg), and plant tissues with Lead (Pb), Iron (Fe), Copper (Cu), Nickel (Ni), Cadmium (Cd) and Chromium (Cr).

The study shows that the environment has been seriously damaged. This has adversely affected agricultural production, food security, wealth and health of the people. The immediate cleaning up of the environment of the area will be needed to save the situation. The question of payment of compensation may also have to be considered.

INTRODUCTION

Ikot Ada Udo is a village located in Ikot Abasi Local Government Area of Akwa Ibom State of Nigeria. The area is in the south-eastern part of Nigerian, now politically known as the South – South Zone in the Niger Delta Region along the eastern coastline of Nigeria.(Fig. 1,2)

The climate of the area is humid tropical. The rainfall is heavy, having a mean value close to 400mm. The rainy season is from April to November and the dry season begins in November and ends in March. Harmattan occurs in the months of December and January.

The soils in the area are formed on Tertiary Coastal Plain sands. The soils are deep with loamy sand to sandy loam surface over clay loam to sandy clay subsoil. Because of their sandy nature, they are fragile and highly susceptible to erosion. They are also acidic and are generally referred to ‘Acid Sands’ since they are both acidic and sandy.

The vegetation in the area is Tropical Rain Forest. However, in most of the areas the original rain forest has virtually disappeared because of clearing the forest for farming. What we have now is farmland with crops or land under fallow. The most important tree now is oil palm which is generally not destroyed when the land is cleared for farming. It is the most important economic crop for the people. The important arable crops grown in the area include maize, cassava, yams, coco yam, fluted pumpkin, plantain and banana.

Fig. 1: The Physiography and Geomorphological Units of Akwa Ibom State

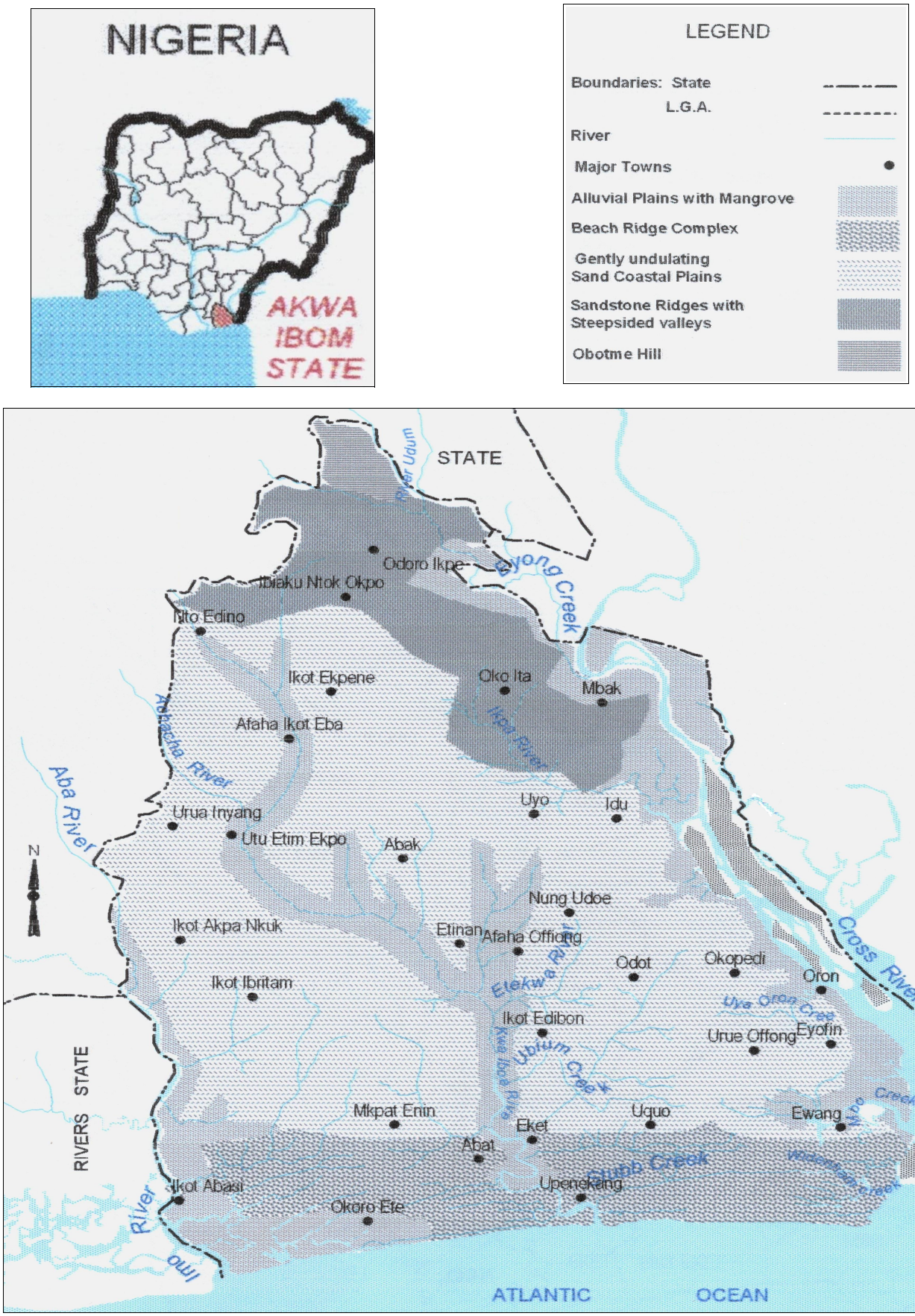


Fig. 2: Akwa Ibom State showing Ikot Abasi Local Government Area

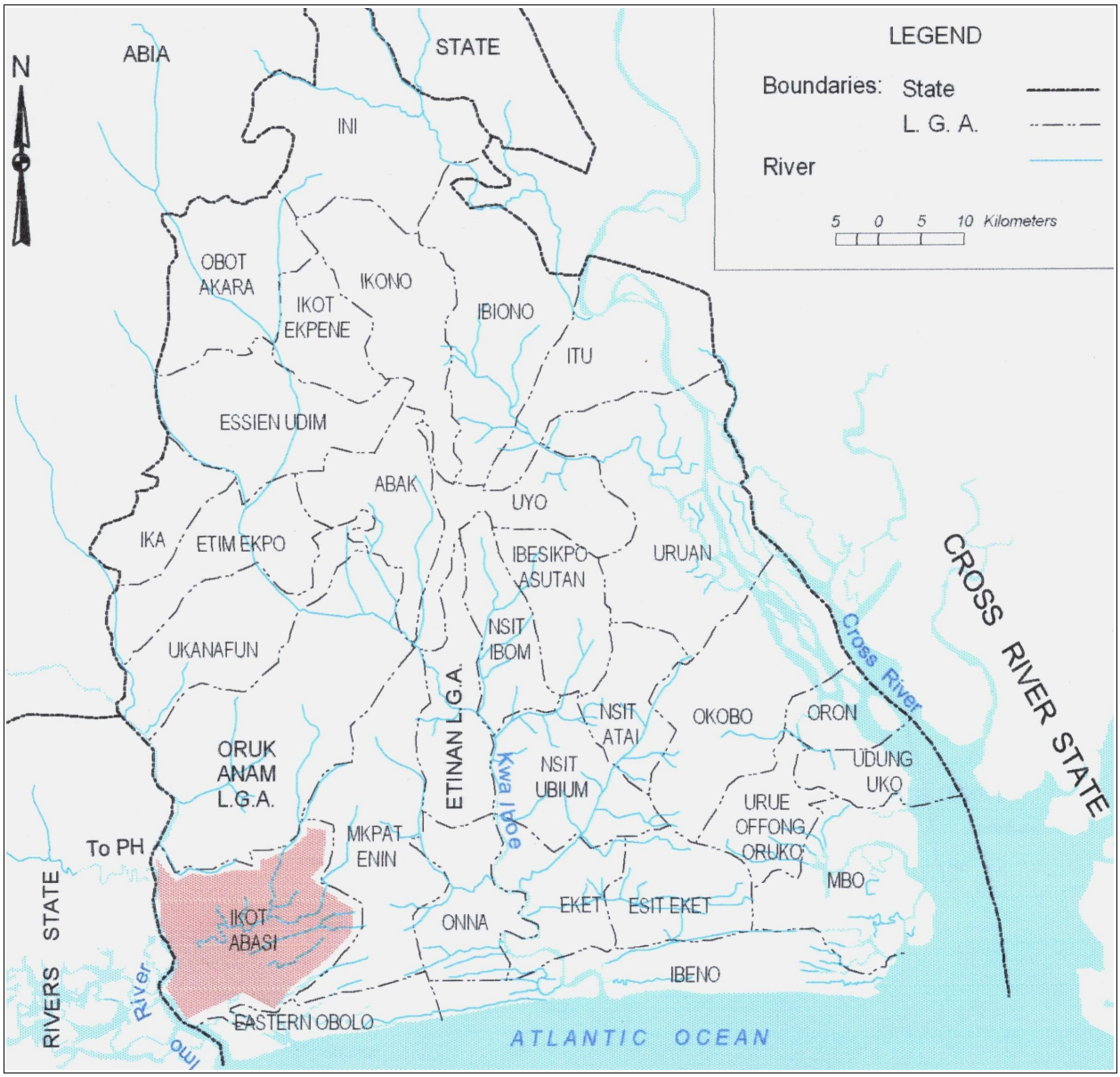
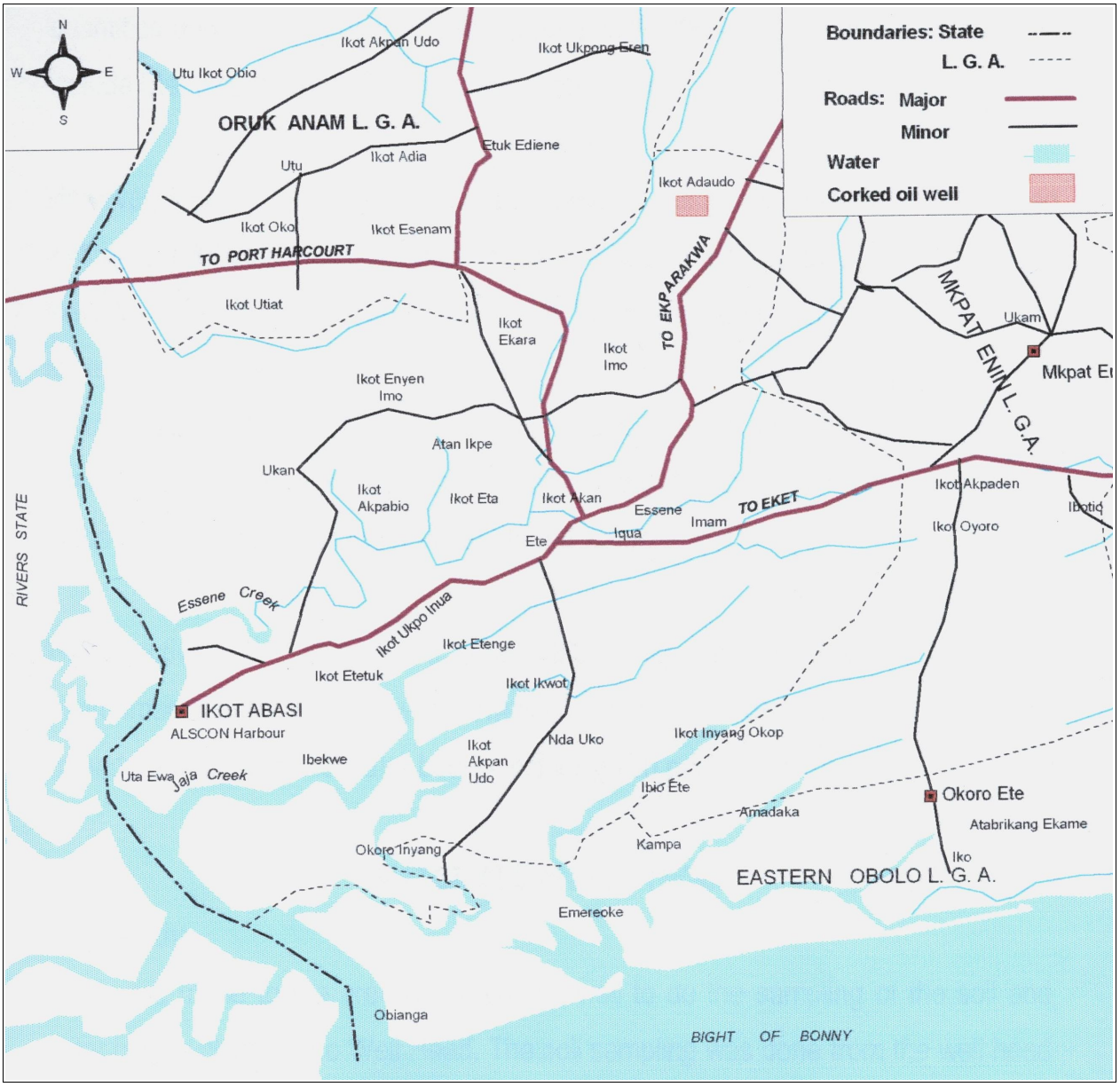


Fig. 3: Ikot Abasi Local Government Area showing the location of the corked oil well (Ibibio 1) at Ikot Ada Udo



Crude oil discovery at Ikot Ada Udo

Oil exploration in Ikot Abasi Local Government area by the Shell Petroleum Development Company (SPDC) started in the nineteen forties in the area. Ikot Ada Udo was one of the on-shore areas where oil was discovered in commercial quantities and the oil was preserved with corked wells. Other places in Ikot Abasi LGA include Ete, Ikot Okwo, Ikot Akpan Udo, Ikot Akan and Ikot Obioko. (Fig. 3)

However, for over 50 years the oil has not been tapped. The corked well at Ikot Ada Udo, designated as Ibibio 1, is one of the oil wells in the area from which oil has been leaking to pollute the environment. During the years, oil and gas have spilled from the corked well several times. This time, the situation has become very serious. Between August and November 2007, a large volume of oil has spread over an extensive piece of land and also into water bodies and fish ponds. The spill destroyed vegetation, crops and aquatic life, and caused health problems to the people because of the polluted air and water. The spill was stopped on November 7, 2007.

The objective of this study was to assess the damage done by the spilled oil on the environment of the area. The study was however limited to the damage done to the soil around the wellhead and water bodies including fish ponds in the area.

MATERIALS AND METHOD

Field Study

In May 2008, trips were made to the area of the corked well to do the sampling of the soil and water bodies close to the Well Head. Four points from the Well Head down the gentle slope were selected for soil sampling and at each point two soil samples were taken. The GPS at each point was noted. Two sediment samples were also taken from the fish pond. The sampling was done with the auger going down to the depth of about 15cm.

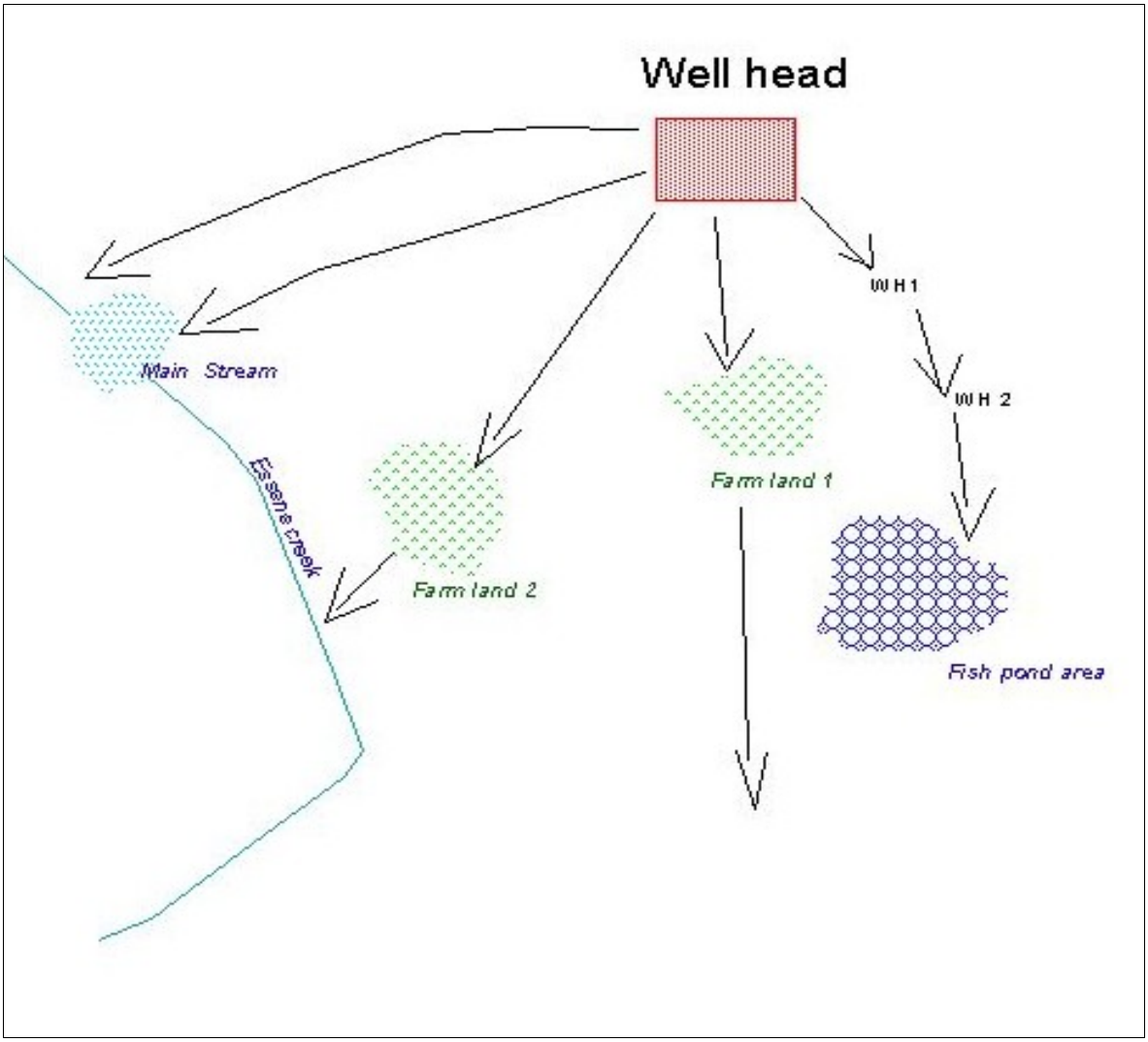
Water samples were taken from the two existing fish ponds and also from the main stream in the area. The soil and water samples were sent for laboratory analysis. One fish (caught in the pond) and plant materials affected by oil spill were also sent for laboratory analysis.

The sampling points and the respective GPS coordinates are given in Table 1 and the way the oil moved to the Fish Pond is shown in Fig. 4. The sampling points WH1 and WH2 were quite close to the corked Well Head. The sampling point of the main stream was up to 1.11km from WH1, while the distances of the farmland 2 and the fish pond area from WH1 were 174 and 97 meters respectively.

Table 1: Sampling points and GPS coordinates

No	Sampling point	GPS	soil samples	sediment samples	water samples
1	WH 1	$04^0$41’52N $07^0$41’07E 38M	2	-	-
2	WH 2	$04^0$41’51N $07^0$41’08E 31M	2	-	-
3	Farmland	$04^0$41’50N $07^0$41’06E 30M	2	-	-
4	Farmland	$04^0$41’48N $07^0$41’03E 29M	2	-	-
5	Fish Pond Area	$04^0$41’49N $07^0$41’08E 23M	-	2	2
6	Main Stream	$04^0$42’09N $07^0$40’34E 30M	-	-	1

Fig. 4: Diagram showing the Well Head, sampling points and the direction of flow of the spilled oil



Laboratory Analysis of the Samples Collected

(a) The soil samples were analysed for the following parameters:

- Particle size (textures) % sand, silt and clay
- pH
- Organic carbon
- Total Nitrogen
- Available phosphorus (using Bray P -1 method)
- Exchangeable Ca, Mg, K and Na

- Exchange acidity, EA
- Effective cation-exchange capacity (ECEC)
- Base saturation
- Electrical conductivity
- Total hydrocarbon (THC) (using Concawe 1962 Method)
- Heavy metals

(b) Water samples were analysed for the following parameters

- pH values
- Electrical conductivity (EC)
- Soluble solids (SS)
- Dissolved solids (DS)
- Dissolved oxygen (DO)
- Biological oxygen demand (BOD)
- Hardness
- Acidity
- Alkalinity
- Chloride (Cl-)
- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Sodium (Na^{+})
- Potassium (K^{+})
- Total hydrocarbon (THC)
- Heavy metals

RESULTS AND DISCUSSION

The physical environment of the area

The corked oil well is located on a farmland. At the time of the study, oil had leaked from the corked well and spread to a large area of the farmland destroying all the crops, weeds and other plants on the land. It is only the oil palm trees that are left in the area (Plates 1, 2 and 3)

Plate 1: Ibibio 1 corked well at Ikot Ada Udo.

Plate 2: destroyed cassava plants, plot 1

Plate 3: destroyed cassava plants, plot 2

The physico-chemical characteristics of the environmental components

(a) Soils

The physico-chemical characteristics of the soils are given in Table 2. The total hydrocarbon contents were very high with values ranging from 800 to 4.800 mg/kg. This shows that the soils were highly polluted with crude oil. The pollution decreased with the increase in distance from the wellhead.

The pH values of the soils are quite higher than what would be expected from the unpolluted soils. The values, which range from 6.0 to 7.0 with a mean value of 6.8, are higher than 7.0 in the samples collected from the highly polluted area near the wellhead. Since the soil derived from the coastal plain sands are known to be strongly acidic, the results show that the pollution has increased the pH values of the soils. The increase in the pH values may be attributed to the high pH values of the crude oil.

The organic carbon contents are also found to be very high with values getting over 20% in the area near the well head where the pollution is very high. Total nitrogen content also appears quite high in the highly polluted area near the well head, but decreases towards the less polluted area near the fish pond. The level of available phosphorus with a range of 4.0 – 14.0 mg/kg is on the other hand found to be low in the highly polluted area but high in the less polluted area near the fish pond. The high increase in organic carbon and total nitrogen is attributed to the organic and nitrogen compounds present in the spilled oil. The reduction in available phosphorus is due to the formation of insoluble phosphorus compounds arising from the reaction of the heavy metals present in the spilled oil with soluble phosphorus compounds in the soil solution.

From the results shown, the soil is highly polluted by the oil from the spillage leading to the increase in organic carbon, total nitrogen and pH values of the soil, and a decrease in available phosphorus.

Table 2: physico-chemical characteristics of soils and sediments

Sam-pling pnts	pH	EC	Org.C	N	AV.P	Ca	Mg	Na	K	EA	ECEC	B.S.	Sand	Silt	Clay	THC
Soils		dS/m	(%)	(%)	mg/ kg	◄——— Cmol/kg ———►						%	%	%	%	mg/ kg
1 a	7.0	0.194	21.24	0.63	7.00	2.52	1.20	0.04	0.10	2.08	5.94	64.98	84.2	5.8	10.0	4611
1 b	7.10	0.124	20.06	0.66	5.00	2.00	1.00	0.03	0.09	1.28	4.4	70.91	86.2	4.8	9.0	4743
2 a	7.00	0.100	19.12	0.60	5.00	2.52	1.20	0.04	0.10	1.44	5.30	72.82	80.2	7.8	12.0	4479
2 b	7.00	0.098	18.88	0.52	4.00	2.24	1.00	0.05	0.08	1.12	4.46	74.89	83.2	6.8	10.0	4800
3 a	7.10	0.090	18.17	0.50	8.00	2.24	1.00	0.04	0.06	1.16	4.50	69.58	80.2	8.8	11.0	2486
3 b	7.10	0.082	17.70	0.61	5.00	2.00	1.00	0.05	0.07	1.23	4.35	71.72	81.2	6.8	12.0	2286
4 a	6.70	0.061	16.52	0.50	7.00	2.10	1.10	0.05	0.08	2.00	5.33	62.48	79.2	8.8	12.0	1582
4 b	6.8	0.0668	16.99	0.50	13.00	2.10	1.00	0.04	0.09	2.10	5.33	60.6	78.2	7.8	14.0	1372
SS 1	6.10	0.063	3.96	0.17	13.00	2.30	1.20	0.05	0.09	2.40	6.04	60.26	75.2	9.8	15.0	1200
SS 2	6.00	0.0609	4.29	0.20	14.00	2.40	1.30	0.05	0.07	2.6	6.42	59.50	76.2	7.8	16.0	800

SS = Sediment Sample

(b) Water

The physico-chemical characteristics of the water samples, collected from two points in the fish pond and from the main stream, are given in Table 3. The results show that the samples collected from the fish pond have high contents of total hydrocarbon, while there is no indication of the presence of total hydrocarbon in the sample from the main stream. It is likely that any crude oil that entered the main stream must have been carried away by the water.

Table 3: physico-chemical characteristics of water

Parameters	Fish Pond 1	Fish Pond 2	Main Stream
Temperature 0^0C	29.66	30.00	27.00
pH	5.20	5.50	6.60
EC (dS/m)	0.063	0.075	0.020
SS (mg/l)	507.50	22.0	0.75
DS (mg/L)	702.5	35.0	2.00
DO (mg/l)	5.71	3.27	3.00
BOD (mgL)	2.45	2.20	2.10
Hardness (mg/L)	120.0	80.0	30.0
Acidity (mg/L) $CaC0_3$	215.0	115.0	40.0
Alkalinity (mg/L) $CaC0_3$	213.33	80.00	66.66
Cl (mg/L)	469.71	248.15	68.39
Ca (mg/L)	23.44	21.52	7.98
Mg (mg/L)	3.364	1.948	5.24
Na (mg/L)	47.16	34.44	27.68
K (mg/L)	38.90	25.64	6.86
THC (mg/L)	3200	1760	ND

ND = Not Detectable

(c) Heavy metal contents

(i) Soils

The contents of heavy metals in soils, sediments and in fish, plant and water samples are given in Table 4. The content of heavy metals in the soils and sediments are within the limits found in unpolluted soils and sediments, except for the elements Lead (Pb) and Mercury (Hg). The content of Pb in the soils and sediments ranged from 493 to 6.659 mg/kg, while the range in normal unpolluted soils globally is from 2 to 300 mg/kg. The range for Hg in the polluted soil was 1.0 to 25.6 mg/kg, but in the normal soils and sediments the range is from 0.02 to 2.0 mg/kg. This shows that the pollution of the soil with spilled oil has resulted in accumulation of Pb and Hg in soils and sediments. The intervention values for Pb, Hg and Cadmium (Cd) for the soil/sediment at the sampling points are given in Table 5. These intervention values for soils are stricter than the ones for a normal soil.

(ii) Water

Some of the heavy metal contents appear higher in concentration than what is accepted in quality criteria for public surface water or drinking water. These elements include Lead (Pb), Manganese (Mn), Cadmium (Cd) and Nickel (Ni). The concentration of these heavy metals, compared to the values accepted as the guidelines for drinking water by the World Health Organization (WHO, 2006), are summarized in Table 6.

It should be noted that the main stream, which is the Essene Creek, also contains high levels of heavy metals although no spilled oil was detected in the stream at the time of sampling. Initially, the stream was highly polluted by the spilled oil, but water did carry the oil to Imo River and then further to the Atlantic Ocean. The heavy metals present in the oil must have been retained in the water, while the oil which flows in the water was carried away by the current.

Table 4:
Heavy metals contents in soils, water, sediments and plant samples (mg/kg)

Sam-pling pnts	Pb	Fe	Mn	Zn	Cu	Ni	Cd	V	Cr	Hg
SOILS										
1 a	6659	18662	41	31	9	34	2.60	7	7	1.50
1 b	4645	21850	63	20	16	37	5.25	13	8	3.8
2 a	1445	23850	162	34	25	32	4.50	9	9	2.00
2 b	1178	24080	204	35	27	33	5.38	8	73	25.63
3 a	1271	23588	178	24	32	34	4.00	18	8	3.50
3 b	1058	24538	177	27	54	28	4.38	22	11	4.50
4 a	614	23963	444	46	35	24	4.63	17	15	1.75
4 b	1660	24163	246	33	35	45	3.00	27	16	5.25
SS 1	801	22735	58	28	74	24	3.63	40	9	1.00
SS 2	493	18950	20	16	28	12	3.13	15	8	2.25
FISH										
	747.50	16225	39.50	34.87	35	14.62	2.881	12	4.00	5.38
PLANT										
	521.25	11851	68.62	21.50	32	22.75	2.631	6	9.00	21.12
WATER SAMPLES										
FP 1	5.70	62.6	0.57	0.016	0.2	0.4	0.03	0.058	0.05	0.008
FP 2	0.34	26.0	0.95	0.01	0.2	0.4	0.03	0.034	0.04	0.032
MS	0.15	20.8	0.39	0.002	0.3	0.03	0.24	0.184	0.03	0.034

FP 1 = Fish Pond 1
FP 2 = Fish Pond 2
MS = Main Stream

Table 5:
Contents of excess levels of heavy metals in soil/sediment (mg/kg)

Heavy metal	Normal unpolluted soils	Intervention value (DPR 2002)	Polluted soil samples	Polluted sediment samples
Lead, Pb	10-30	312	614-6659	493-801
Mercury, Hg	0.02-0.625	7	1.50-25.63	1.00-2.25
Cadmium, Cd	0.03-0.80	6	2.60-5.38	3.13-3.63

Table 6:
Contents of excess levels of heavy metals in water bodies (mg/l)

Heavy Metals	Contents in fish ponds	Contents in main stream	WHO-guideline drinking water (2006)
Lead, Pb	0.34-5.70	0.15	0.01
Cadmium, Cd	0.03	0.24	0.003
Mercury, Hg	0.008-0.032	0.034	0.006
Manganese, Mn	0.57-0.95	0.39	0.4
Nickel, Ni	0.4	0.03	0.070

(iii) Fish

As shown in Table 7 below, the fish tissue has contents of heavy metals, Pb, Cd, V, Cr and Hg, higher than what is found in uncontaminated fish tissues. These high values must have come from the oil pollution.

Table 7:
Content of excess levels of heavy metals in fish tissues (mg/kg)

Metal	Concentration in tissue	Normal range
Lead (Pb)	747	0.50 – 2.00
Cadmium (Cd)	14.6	0.40 – 26.00
Vanadium (V)	12.0	0.14 – 2.30
Chromium (Cr)	4.0	0.20 – 2.00
Mercury (Hg)	5.4	0.30 – 1.00

(iv) Plants Tissues

The plant tissue is also found to have high concentrations of a good number of heavy metals namely, Pb, Fe, Cu, Ni, Cd and Cr, compared to the contents usually found in normal plant tissues (Table 8).

Table 8:
Content of excess levels of heavy metals in plant tissues (mg/kg)

Metal	Content in tissue	Normal range
Lead (Pb)	521.3	0.10 – 1.00
Iron (Fe)	11851	51.0 – 350.0
Copper (Cu)	32.0	1.0 – 15.0
Nickel (Ni)	22.8	< 1.30
Cadmium (Cd)	2.9	0.2 – 0.8
Chromium (Cr)	9.0	0.40 – 1.00

Leakage of oil into the groundwater

One serious environmental problem the spillage may cause is the leakage of oil into the ground water. The soils/sediments of the area are coarse in texture in the upper layer, so together with rain water the oil can easily leak into the subsoil. However, the subsoil is finer in texture having a higher percentage of clay fraction. This can prevent the rain water and oil getting easily through the soil, down to the ground water. In the upland soil of the area, the underground water is always found very deep in the soils but because of porous nature of the surface layer the spilled oil with the rain water may still get through the subsoil. It will be therefore necessary to monitor the ground water by sinking boreholes to collect the ground water for testing for oil and heavy metal contents especially for heavy metals like Mercury and Lead which can cause health problems.

CONCLUSION

The investigation has clearly revealed that environmental components of the area have been seriously polluted by the oil spill. High concentrations of Total Hydrocarbon (THC) are found in the soils and the Fish Ponds located in the area. The crude oil from the Well Head, which had moved from the corked well towards the Fish Ponds and the main stream, has completely destroyed the crops grown in the farmland and also the fish in the Fish ponds. High contents of some heavy metals above the normal levels are also detected in the soils and water bodies, and also in the tissues of fish and plant samples. This would clearly affect the qualities of crops and aquatic animals. Heavy metals are known to accumulate in the food-chain and could get into the drinking water. Staying in the polluted area would be harmful. The pollution must have created severe health risks to the people of Ikot Ada Udo.

It is strongly recommended that the Well Head will be adequately monitored to ensure that no further spillage occurs in future.

Meanwhile, the cleaning up of the area should be carried out as soon as possible and some compensation should be paid to the people who have suffered for a long time from the damaging spill.

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