The human health implications of crude oil spills in the Niger delta, Nigeria: An interpretation of published studies

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ABSTRACT

Background: The health hazards created by oil exploration and exploitation are covert and slow in action. They are not given the deserved attention in official documents in Nigeria, even as they can be major contributors to the disease burden in oil-bearing communities. This study is an interpretation of the data reported in several published studies on crude oil spills in the Niger delta region, Nigeria. **Materials and Methods:** A manual and Internet search was conducted to extract quantitative data on the quantity of crude oil spilled; the concentrations of the pollutants in surface water, ground water, ambient air and plant and animal tissue; and the direct impact on human health and household food security. **Results:** An average of 240,000 barrels of crude oil are spilled in the Niger delta every year, mainly due to unknown causes (31.85%), third party activity (20.74%), and mechanical failure (17.04%). The spills contaminated the surface water, ground water, ambient air, and crops with hydrocarbons, including known carcinogens like polycyclic aromatic hydrocarbon and benxo (a) pyrene, naturally occurring radioactive materials, and trace metals that were further bioaccumulated in some food crops. The oil spills could lead to a 60% reduction in household food security and were capable of reducing the ascorbic acid content of vegetables by as much as 36% and the crude protein content of cassava by 40%. These could result in a 24% increase in the prevalence of childhood malnutrition. Animal studies indicate that contact with Nigerian crude oil could be hemotoxic and hepatotoxic, and could cause infertility and cancer. **Conclusions:** The oil spills in the Niger delta region have acute and long-term effects on human health. Material relief and immediate and long-term medical care are recommended, irrespective of the cause of the spill, to ensure that the potential health effects of exposures to the spills are properly addressed.

Key words: Crude oil spill, health impact, Niger delta, Nigeria, oil-bearing communities, post-impact assessment

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INTRODUCTION

Oil exploration and exploitation is very lucrative, and a major revenue earner in Nigeria. But, like most industrial activities, it produces environmental hazards that are "slow poisons," in that they often take months and years to cause disease and death.[1] This is unlike the contamination of water, food, and the environment with micro-organisms, which immediately results in ill health.[1]

The covert and slow action of the hazards created by oil exploration and exploitation make it difficult to fully appreciate their contribution to the disease burden in Nigeria, especially in the oil-bearing communities, even with the emergence of non-communicable diseases as major causes of ill health in Nigeria.[2]

Each year, 100 s of post-impact assessment (PIA) studies are conducted to assess the impact of the hazards generated by the oil industry on the physical and social environment and on human health. But, most of these studies are conducted without any significant contributions from health professionals and are reported without highlighting the immediate and long-term implications of the identified hazards on the health of members of the impacted communities. This was sadly commented upon in the United Nations Environment Programme (UNEP) Ogoni environmental assessment report;[3] and is likely to

continue because even the technical review of the impact assessment reports, carried out by the Federal Ministry of Environment, often do not include a health professional.

This study is an interpretation of the human health implications of the data reported in several published studies on the impact of oil spills in the oil-bearing communities of the Niger delta region, Nigeria. It was designed to highlight the human health implications of the oil spills in the face of a total lack of such information in the official PIA reports.

MATERIALS AND METHODS

The Niger Delta is the fan-shaped area of about 70,000 square kilometers in the southern part of Nigeria, through which river Niger and river Benue empty into the Atlantic Ocean. It is basically a huge floodplain, formed primarily by centuries of silt washed down by the rivers Niger and Benue and crisscrossed by a web of creeks that link together the main rivers of Benin, Bonny, Brass, Cross, Forcados, Kwa-Ibo, Nun and other rivulets and streams.[4]

The Niger delta region is a region of dense cultural diversity; although it forms 7.5% of Nigeria's total land mass, it is inhabited by at least 25 million people in nine States and 186 Local Government Areas. The indigenous people are from roughly 40 ethnic groups and speak an estimated 250 dialects.[4]

Oil was first discovered in commercial quantities in the Niger delta region in 1956 at Oloibiri, in the present day Bayelsa State. Other discoveries soon followed and exports began in 1958, although significant quantities only began to flow from 1965, with the completion of a terminal on Bonny Island, in Rivers State, and pipelines to feed the terminal. In 2004, Nigeria exported an average of 2.5 million barrels of crude oil every day and with an oil reserve conservatively put at 35 billion barrels, this would continue for at least the next 40 years.[5]

Oil spill is a common fallout of oil exploitation and exploitation in the Niger delta region, with an estimated total of over 7000 oil spill incidents reported over a 50-year period.[6] This study used the quantitative data contained in published, peer-reviewed studies, carried out on some of these crude oil spills, following the futile attempts to gain access to the official PIA studies of the oil spills.

An Internet search was conducted on 17 August 2012 to extract quantitative data on the quantity of crude oil spilled into the Niger delta environment; the concentrations of the pollutants in surface water, ground water, ambient air, and the tissues of plants and fish in the polluted environment; the impact of the oil spill on household food security; and the direct impact of the oil spill on human health. The Internet search was complemented by manual search in the

library of the University of Port Harcourt and by contacting researchers known to be active in the field.

Summary data were calculated for the extracted data, particularly the range and mean concentration of the pollutants. These summary data were then compared with the WHO guideline values before determining the health implications. The recommended daily allowance (RDA) was used to determine the health implications of the trace metals contained in the water and plant and fish tissue samples that can be ingested. The RDA is determined by the Institute of Medicine of the U.S. National Academy of Science, which took into consideration the bio-availability of the various pollutants.[7]

RESULTS

There are no consistent figures of the quantity of crude oil spilled in the Niger delta, but it is widely believed that an estimated 13 million barrels (1.5 million tons) of crude oil have been spilled since 1958 from over 7000 oil spill incidents; a yearly average of about 240,000 barrels.[6] Inconsistency in the quantity of crude oil spilled has been attributed to a number of reasons, including the difficulty in accessing some spill sites (due to swamp conditions and remoteness); security concerns limiting access; some spills occurring away from community locations; a long time-lag between the initiation of a spill and its detection; the high volatility of the Nigerian crude oil, causing an estimated 50% to evaporate within 24-48 h; intentional company and government under-reporting; and inadequate government oversight.[8]

The oil spills affected at least 1500 communities in the eight crude oil-producing states in Nigeria, and were mainly from the 5284 oil wells that were drilled (as at 2006) and the 7000 km of crude oil pipeline that crisscrosses the Niger delta region.[6] Table 1 shows the causes of the crude oil spill. More than 30% of the spills were due to unknown causes, while 20.74% were attributed to third party activity.[9]

The oil spills often resulted in contamination of surface water with hydrocarbons and trace metals, as measured using atomic spectrometry. A study carried out in the mangrove wetland of the region recorded a mean Total Hydrocarbon THC concentration of 23.6 + 4.3 mg/l in the water, a mean concentration of 449.30 ± 55.42 µg/g in *Tympanotonus fuscatus* (Periwinkle) and 278.57 ± 34.57 µg/g in

Table 1: The causes of oil pipeline failures between 1999 and 2005[9]

Cause	Number (*N*=135)	Percentage
Mechanical failure	23	17.04
Corrosion	21	15.56
Operational error	17	12.59
Third party activity	28	20.74
Natural hazard	3	2.22
Unknown	43	31.85

*Periophthalmus papillio (*Mudskipper).[10] Another study recorded concentrations of benxo (a) pyrene that ranged from 0 to 2.32 ug/l.[11] The trace metal contamination as recorded in a study carried out in the Ughoton stream, in Edo State,[12] is shown in Table 2.

The water table in the region is high, varying from the ground surface at the Atlantic coast to 15 m toward the apex of the region. The water table fluctuates in response to daily tidal cycles in the coastal area and to seasonal rainfall in the coastal plain sands and upstream recharge areas.[13] Although most communities in the Niger delta region have soils that are high in clay and low in sand, which offers some protection to the groundwater aquifer, this is often not enough during an oil spill.[14] Groundwater at the site of an artisanal refining site in Bolo, Rivers State, contained up to 986.07 ppm of THC.[15]

No study was found on the air quality of the oil spill sites, but the concentrations of the volatile components of the crude oil are often very high, as shown by the values recorded 2 months after the spill was stopped [Table 3].[16]

The crude oil of the region contains some naturally occurring radioactive materials (NORM); the decay series of naturally occurring radionuclides headed by (238) U and (232) Th have mean activity concentrations of 0.80 ± 0.37 Bq kg (−1) and 0.17 ± 0.09 Bq kg (−1), respectively, in the crude oil blends, while the mean concentration of the non-decay series radionuclide, (40) K is 10.52 ± 0.03 Bq kg (−1).[17] The radiation level within oil spill sites is often up to 0.016 mRh-1, about 45% higher than the normal background level of 0.011 mRh-1 in the Niger delta communities,[18] and the concentrations of the NORM in surface water are often higher than the WHO recommended maximum permissible limit for drinking water. A study of the Imirigin oil field in Bayelsa State recorded an alpha activity of up to 16.95 Bg/l and a beta activity of up to 135.88 Bg/l.[19]

The crude oil spills reduced soil fertility.[20] They also smothered economic trees and food crops, outrightly killing them or reducing their yield,[21] causing a 60% reduction in household food security[22] as assessed using the Cornell-Radimer scale and shown in Table 4. The oil spills also reduced the quality of food crops; the ascorbic acid content of waterleaf was reduced by 36% [Table 5][23] while the crude protein content of cassava was reduced by 40% [Table 6].[24] The food insecurity and deterioration

Table 4: Prevalence of household food insecurity[22]

Food security status	Oil spill community (%) (N=301)	Reference community (%) (N=291)
Food secure	9 (2.99)	194 (66.67)
Food uncertainty	22 (7.31)	67 (23.02)
Food insecurity without hunger	76 (25.25)	23 (7.90)
Food insecurity with moderate hunger	105 (34.88)	7 (2.41)
Food insecurity with severe hunger	89 (29.57)	0 (0.00)

Table 5: The ascorbic acid content in some common vegetables grown in crude oil polluted soil[23]

Vegetable	Unpolluted soil (mg/100 g)	Polluted soil (mg/100 g)
Spinach oleraceae (spinach)	1057	635
Solanum melongena (garden egg)	880	712
Talinum triangulare (water leaf)	550	352

Table 2: The concentrations of trace metals in Ughoton stream during an oil spill[12]

Trace mineral	Range (mg/l)	Average conc (mg/l)	Who desirable limit (mg/l)
Iron	0.25-0.36	0.31	*0.3
Zinc	0.02-0.04	0.03	*3
Copper	0.04-0.05	0.14	2
Chromium	ND-0.08	0.053	0.05
Manganese	0.12-0.17	0.14	*0.4
Nickel	ND-0.08	0.023	0.07
Lead	ND-0.01	0.005	0.01
Cadmium	ND-0.08	0.023	0.003
THC	3.40-6.20	4.93	–

*Levels likely to give rise to consumer complaint; ND – Not detectable; THC – Total Hydrocarbon content

Table 3: The concentrations of aromatic in an oil spill site, 2 months after the spillage[16]

	Average conc. (mg/kg)
Benzene	73.21
Chlorobenzene	9.79
1, 2 Dichlorobenzene	20.50
1, 3 Dichlorobenzene	37.73
1, 4 Dichlorobenzene	4.86
Ethylbenzene	7.04
Toluene	19.2
M, p-xylene	19.69
o-xylene	2.04

Table 6: Percentage proximate composition and calorific value of cassava tuber harvested from oil spill and non-oil spoil soils[24]

Constituents	Tuber from unpolluted soil (%)	Tuber from polluted soil (%)
Moisture	60.81	63.95
Ash	0.50	0.58
Crude protein	0.74	0.44
Crude lipid	0.31	1.20
Crude fiber	1.41	1.56
Total carbohydrate	36.23	32.27
Calorific value (Kcal/100 g)	150.67	141.64

of the quality of the staple food led to a 24% increase in the prevalence of childhood malnutrition in the affected communities [Table 7].[22] The crude oil spills also resulted in the bio-accumulation of heavy metals in the surviving food crops like cassava and pumpkin [Table 8].[25] The concentration of lead and cadmium increased in the leaves of pumpkin by 90% and 94.29%, respectively.

Table 9 shows that exposures to the spilled crude oil were associated with significant increases in the period prevalence for diarrhoea, sore eyes, itchy skin and occupational injuries.[26] Shock, acute renal failure, extensive epidermolysis, conjunctivitis, mucositis, esophagitis, and chemical pneumonitis were reported in a 2 year old treated for febrile convulsion with a Nigerian crude oil.[27] Animal studies, conducted by feeding rats and other experimental animals with foods contaminated with crude oil, indicate that exposures to Nigerian crude oil could result in infertility [Table 10],[28] hemotoxicity,[29] hepatotoxicity,[30] and carcinogenesis (through its effects on chromatin DNA).[31]

DISCUSSION

A review of the studies showed the widespread presence of constituents of crude oil in the bio-physical environment of the impacted communities. The presence and quantity of these constituents are known to be capable of exerting some acute and long-term adverse health effects. Known carcinogens like bezo (a) pyrene and polycyclic aromatic hydrocarbon (PAH) were, respectively, found in the surface water and soil of the impacted communities. Like other known carcinogens, they do not have any safe levels, as even a few molecules of these can be genotoxic.[32] The activity of these known carcinogens probably explains the carcinogenicity reported in the animal study.[31] The difference in the concentration of PAH in the ambient air was also given as a reason for the higher prevalence of certain types of cancers seen in Port Harcourt compared with Ibadan.[33]

The review also showed that crude oil spill could cause a 45% increase in the normal background radiation level. This is another carcinogenic danger that could manifest as increased prevalence of certain cancers years after the oil spill. The radiation contamination caused by crude oil spill in the Niger delta region is often so widespread that the surface water[19] and crops grown in the impacted environment[34] are also contaminated beyond the maximum permissible limit.

The ingestion, dermal contact, and inhalation of the other constituents of spilled crude oil also have some acute and long-term health implications. Although the acute manifestations of the exposures were often mild and transient, as shown in Table 9, severe exposures as reported in the 2-year-old child could result in acute renal failure,[27] or even hepatotoxicity[29] and hemotoxicity,[30]

Table 7: Prevalence of childhood malnutrition[22]

Characteristics	Oil spill community (N=521) (%)	Reference community (N=435) (%)
Prevalence of underweight	246 (47.22)	101 (23.22)
Prevalence of stunting	149 (28.6)	113 (25.98)
Prevalence of wasting	109 (20.92)	58 (13.33)

Table 8: The average concentrations of heavy metals (mg/kg) in the leaves of food crops[25]

Trace mineral	Unpolluted site (cassava)	Polluted site (cassava)	Unpolluted site (pumpkin)	Polluted site (pumpkin)
Chromium	0.25	0.48	0.00	0.87
Nickel	0.025	0.035	0.025	0.04
Lead	0.08	0.14	0.11	0.21
Cadmium	0.08	0.16	0.035	0.068

Table 9: Symptoms reported by respondents by exposure categories and associations[26]

Variable	Exposed (%) (N=210)	Unexposed (%) (N=210)	O/R	P value
Malaise	49 (23.33)	33 (15.77)	1.63	<0.05
Headache	76 (36.19)	27 (12.86)	3.84	<0.001
Nausea	48 (22.86)	11 (5.24)	5.36	<0.001
Diarrhoea	87 (41.43)	28 (13.33)	4.6	<0.001
Sore eyes	69 (32.86)	9 (4.29)	10.93	<0.001
Sore throat	63 (30)	13 (6.19)	6.49	<0.001
Cough	56 (26.67)	17 (8.1)	4.13	<0.001
Itchy skin	103 (49.05)	14 (6.67)	13.48	<0.001
Rashes	90 (42.86)	13 (6.19)	11.37	<0.001
Occupational injuries	51 (24. 29)	12 (5.71)	5.29	<0.001

Table 10: Semen parameters of study animals[28]

Parameter	Rats exposed to crude oil (n=7)	Unexposed rats (n=8)
Relative weight of testis (g/100 g bwt)	0.20±0.03	0.28±0.04
Sperm density (epididymal sperm reserves (×10^6/ml)	20.0±1.3	14.5±2.7
Sperm motility (%)	70±8.2	40±6.6

as reported in the animal studies. The period prevalence of the symptoms reported in the Niger delta region were noted to be higher than the prevalence reported in the grounded oil tankers,[35,36] indicating greater levels of exposure in the Niger delta region. For instance, the period prevalence of sore eyes in the Niger delta study was 32.86% compared with 28% recorded during the grounding of the tanker *braer* in Shetland, Scotland[35] and 19.7% recorded during the *Sea Empress* oil spill in south west Wales.[36] This difference was attributed to the fact that members of the impacted communities in the Niger delta region, being sustenance farmers and fisher-folks, continued to ply their trade in the polluted environment, without any protective

gadgets.[37] The prevalence of diarrhoea was also noted to be significantly higher in the Niger delta study because the fish and animals killed by the spill were eaten.

The crude oil spills also resulted in the massive contamination of water, air, and food crops with hydrocarbon and trace metals, as shown in Tables 2, 3, and 7. These could have severe effects in humans in a manner that is often not acknowledged.[38] The surface water and food crops contained detectable concentrations of iron, zinc, copper, chromium, manganese, lead, nickel, cadmium, and hydrocarbons. The presence of iron, zinc, copper, chromium, and manganese in water and food items can be considered innocuous, as they are essential in body metabolism, and could therefore play a part in meeting the recommended daily requirement while lead, nickel, cadmium, and hydrocarbons are potentially toxic to human health.[38]

The surface water had a mean iron concentration of 0.31 mg/l, which is marginally above the level known to attract consumer complaint,[39] but much lower than the 6.2 mg/l reported in parts of the region.[40] This level of iron is only able to provide just 3.4% of the daily adult female iron requirement of 18 mg/day and 7.75% of the adult male requirement of 8 mg/l.[7] The presence of zinc in the surface water could have been a health boost in a region with a high prevalence of diarrhoeal diseases,[41] but the concentration is only able to provide 0.5% of the daily dietary requirement of 6 mg/day for children. The same can be said for the other nutrient trace metals.[42]

The concentrations of the potentially toxic lead, nickel, and cadmium were low in the surface water [Table 2] but showed some level of bioaccumulation in the food crops [Table 8]. The concentrations of lead in the surface water and food crops exposed the children in the impacted communities to 0.2 mg of lead daily, assuming a daily consumption of 2 l of water, 1 kg of cassava and 250 mg of pumpkin vegetable. This is up to the 5 μg/kg body weight per day known to cause cumulative damage in children,[43] a possibility further enhanced by the high prevalence of iron deficiency anemia in the communities[44] that can increase the rate of uptake of lead into the body.[45] Based on dose–response analyses, it is estimated that an accumulation of 25 μg/kg body weight of lead in the body results in a decrease of at least three Intelligent Quotient IQ points in children and an increase in systolic blood pressure of approximately 3 mmHg (0.4 kPa) in adults.[46]

The concentrations of cadmium in the surface water and food crops exposed members of the impacted communities to 0.2 mg of cadmium daily, which is more than the 0.03 mg/day reference dose for a 60 kg adult.[7] Cadmium is regarded as a cumulative toxin because of the human body's ability to excrete just 0.001% of the amount ingested in a day. Although it is considered probably carcinogenic,[39] most

chronic toxicity affects the kidneys, bones, and liver, and presents mainly in post-menopausal women as "Itai-Itai" disease with severe osteoporosis and osteomalacia, renal dysfunction, and normochromic anemia.[47]

The crude oil spill also resulted in the reduction of the quantity and quality of food available to households in the impacted communities, as shown in Tables 4-6. This could result in an up to 24% increase in the prevalence of childhood malnutrition [Table 5] and several hours of hunger pangs. These situations were said to be exacerbated in the Niger delta region by the near total absence of outside relief effort, such that members of the impacted communities were often left unassisted by the government and the oil company.[22] The health implications of childhood malnutrition and hunger are obvious,[48] but what is not well recognized is the implication of the exchange of sex for financial and other gratifications that is common in Niger delta communities, especially in a period of lack.[49] This exchange has been linked to the high prevalence of teenage pregnancy, criminal abortion,[50] sexually transmitted infections,[51] and HIV/AIDS in the region.[52]

About one-fifth of the oil spills were attributed to third party activity and therefore, did not attract any form of compensation to the impacted communities according to a clause in the Nigeria's Oil Pipeline Act that was designed to discourage sabotage. It is surprising that material relief and medical care were seen as "compensation" and therefore denied to members of the impacted communities. Desperate members of the communities were often forced to eat the fish killed by the spill and made to bear the full cost of any resultant health problem. Considering the possible acute and long-term effects of exposure to the oil spill, it is not fair to allow innocent members of the communities to face the situation alone; the least they should get are material relief and immediate and long-term medical treatment, the world standard for persons exposed to potentially carcinogenic environmental hazards. This formed the basis of the public health recommendations in the Ogoni UNEP report,[3] and should be the standard practice throughout Nigeria.

CONCLUSIONS

The review of these studies shows that oil spills in the Niger delta have acute and long-term effects on human health. Material relief and immediate and long-term medical care are recommended, irrespective of the cause of the spill, to ensure that the potential health effects of the exposures to the spills are properly addressed.

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