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Theoretical Application of Decision Support System in Petroleum Contaminated Ogoniland in South-Southern Nigeria

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Abstract

Land is an indispensable natural resource made up of soil and groundwater, both of which have many functions for which we depend on, support of agricultural activities, engineering structures, portable water for domestic and industrial use as well as sustenance of flora and fauna in order to maintain favorable ecosystem. Contaminants in land pose a number of threats to public health and the environment; other natural resources; and have detrimental effects on property such as buildings, crops and live stocks. The most effective method of dealing with these contaminants is to cleaning up and returning the sites to beneficial use. The cleanup process involves making a choice from amongst competing remediation methods, where the wrong choice may have disastrous social, economic and environmental impact. This work presents the development of a Decision Support System via thorough literature survey. The Developed DSS was applied to petroleum contaminated site in Ogoniland South-East Nigeria. Finally, Air sparging, phyto-remediation and soil vapour extraction methods were systematically recommended.

Keywords: Decision support system; Petroleum; Contaminated land; Remediation

Introduction

Land is a limited resource that is increasingly getting polluted as a result of land contamination. Land is made up of soil and groundwater both of which have numerous functions for which humanity depend on, including provision of food and water, supporting shelter, natural flood defence, waste containment, maintaining natural cycles etc. Contaminants in land pose a number of threats to public health and ecosystem and have detrimental effects on lives and properties [1,2].

Petroleum hydrocarbon contaminants are amongst the most commonly occurring at contaminated sites. According to the European Environmental Agency (EEA) approximately 14.1 percent of identified contaminated lands in its countries are cause by the oil industry, with heavy metals, mineral oils and hydrocarbon contaminants constituting approximately 90% percent of the total contaminants found on sites [3]. According to available statistics, in the last 30 years more than 400,000 tons of oil have spilled into the creeks and soils of southern Nigeria. About 70% of the oil has not been cleaned basically because of inefficient cleaning or remediation method, ERA 2010. Figure 1 shows some contaminated sites in Ogoniland South Nigeria. The clean-up process involves making a choice from amongst competing remediation methods, where the wrong choice may aggravate the problem resulting to disastrous social, economic and/or environmental negative impact [1-8].

Contaminated land management is therefore much complex than the selection and implementation of removal solutions, and requires extensive data collection and analysis at huge cost and effort [2]. The need for decision support in contaminated land management decision making has long been widely recognised [4], and in recent years a large number of Decision Support System (DSS) have been developed. Nigeria is ploughed by numerous oil spills. The United Nations Environmental Programme (UNEP) announced that oil firms contaminated a 1,000 sq km (386 sq miles) area of Ogoniland, in the Niger delta with disastrous consequences for human health and wild life. Ogoniland is just a representative of many southern part of Nigeria that are contaminated [5]. The three-year investigation of UNEP discovered that;

i. Heavy contamination of land and underground water causes, sometime more than 40 years after oil was spilled.

ii. Soil contamination is located more than five metres deep in many areas studied.

iii. Most of the spill site oil firms claimed to have cleaned are still highly contaminated.

iv. The UNEP report also cited lack of adequate remediation procedure or institutional framework and lack of trained manpower in government supervisory agencies as another

Figure 1a: The cumulative impact of artisanal refining puts significant environmental pressure on Ogoniland.

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Figure 1b: Aerial view of artisanal refining site (Bodo West, Bonny LGA).

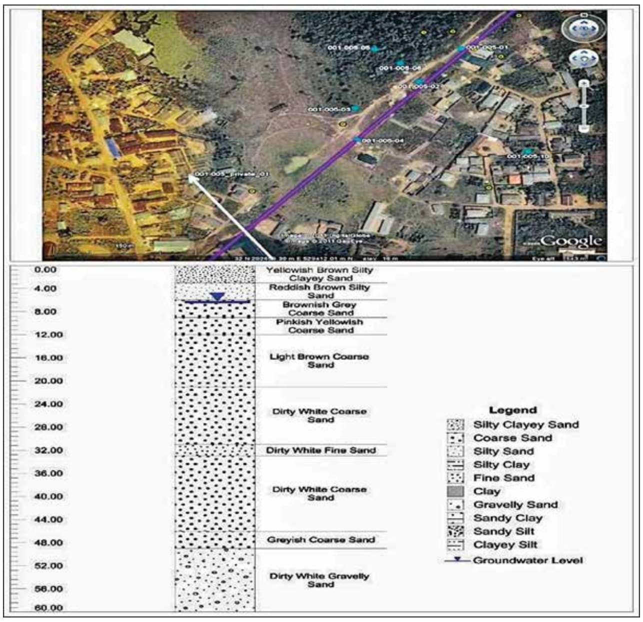

Figure 2: Soil logs from Nsioken Agbi Ogale, Eleme L.G.A.

reason why it is very difficult to embark on, and enforce appropriate remediation procedures.

The structure of Practise Guide for investigation and remediation of contaminated land (PG) follows the stages of the contamination assessment and remediation process as summarized inflow chart in Figure 2 [6-15].

Methodology (Decision Support System)

The Decision Support System is designed by ranking the contaminants, soil type, cost, efficiency and duration of operation as shown in Table 1 [16-23]. The comparative evaluation of soil remediation techniques using decision support system comprising of contaminant type, cost, soil type (Table 2).

Theoretical Application, Result and Discussion (A case study of Nsioken Agbi Ogale, Eleme L.G.A Ogoniland)

The result of soil logs from Nsioken Agbi Ogale, Eleme is shown in Figure 2; Considering that the oil spills took place between 1986 and 1990, natural attenuation, or biodegradation of contaminants has not proven effective in reducing contaminant concentrations to safe levels in the affected area [5,24-33]. Another reason why natural attenuation has failed is the presence of silty clay or pure clay soil in some areas. Natural attenuation does not work well in fine grained soils [34-40].

Critically analysing Table 2 in relation to the soil log result of Nsioken Agbi Ogale between 0-4 m, the most suitable method is the combination of phyto-remediation and soil vapour extraction. Phyto-remediation has to be applied first between 2 to 3 years. First, because of its effectiveness in all types of soil type, secondly, because of its cost effectiveness (Figure 2) [41-48].

After this period, the most effective, the relative cost effective method, that is soil vapour extraction should be used for at least one year to give the final recovery touch. SVE is emerging as the most frequently used technology. SVE not only promises good result in short time, but it is also cost effective [40,49-55].

Furthermore, between 4-6 m depth, methods effective in groundwater such as Air Sparging should be used in combination with SVE. SVE will take care of deficiencies evident in Air sparging such as inability to work where soil permeability is low and little lag in efficiency. Air sparging should be applied for six months before the application of SVE for one year [56-59].

Conclusion and Recommendations

The methods recommended in section 4 above should be applied in the study area. In summary, Air Sparging should be applied for six months between 4 to 6 metres whereas phyto-remediation should be applied for 2 years between 0-4 m. After this period soil vapour extraction should be used for at least one year over the entire length of six metres. After the remediation, TPH value should be checked to make sure it is within the acceptable limit, if not the SVE should continue for another one year. Finally, Nigeria government should put

Contamination		Soil Type		Cost		Efficiency		Duration	
Type	Representation	Type	Representation	Range	US/Tonnes	Range	Rank	Range	Rank
VOCS	A	Fine clay	A	>150	A	>90%	A	1-6 months	A
SVOCS	B	Medium clay	B	75-150	B	75-90%	B	6-12 months	B
Medium to heavy hydrocarbons	C	Silty clay	C	50-75	C	50-75%	C	1-2 years	C
		Clay silt	D	25-50	D	<50%	D	2-5 years	D
		Silty sand	E	25	E			>5 years	E
		Silt	F	<10	F				
		Sandy clay	G						
		Sandy Silt	H						
		Sand	i						

Table 1: Decision support system for petroleum containment land.

Technique	Contaminant	Soil type	Cost	Efficiency	Duration
Enhanced Bioremediation	B & C	A-I	C-D	B	D-E
Bioventing	B & C	D-F	C-E	A	A-B
Natural Attenuation	A & B	F-I	Variable	A-B	E
Phylo-remediation	A, B & C	Independent	D-E	C-D	D-E
Air Sparing	A & B	F-I	C	B	A
Soil Vapour Extraction	A & B	F-I	C	A	B-C
Thermal Treatment	A & B	A-I	E-F	B	A-B
Soil Washing	B & C	F-I	A-B	A	A
Incineration	A, B & C	A-I	E-F	B	A-B
Thermal Desorption	A & B	A-F except C	C-E	A	A-B
Excavation and Disposal	A, B & C	A-I	A-B	A	A-B

Table 2: Comparative evaluation of soil remediation techniques.

up a strong legal and institutional framework to enforce remediation of petroleum contaminated land. Government should train adequate manpower that will take charge of the aforementioned institutions as well as pay them what is obtainable in multinational oil companies in order not to lose their services.

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