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Management of petroleum hydrocarbon contaminated sites in Nigeria: Current challenges and future direction

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Abstract

Sites affected by petroleum hydrocarbons from oil exploitation activities have been identified as a major environmental and socio-economic problem in the Niger Delta region of Nigeria. The current Nigerian regulatory instruments to manage these contaminated sites are fragmented and the roles and responsibilities of government agencies, such as the Department for Petroleum Resources (DPR), and the National Oil Spill Detection and Response Agency (NOSDRA), are not well defined. This lack of coordination has led to ineffective land contamination policy and poor enforcement more generally. Appropriate, risk-based policy instruments are needed to improve regulatory capacity, and to enhance the regulator's ability to manage new and existing petroleum hydrocarbons contaminated sites. Lessons can be learned from countries like the United Kingdom (UK) and the United States America (USA) that have experience with the management and clean up of historically contaminated land. In this paper, we review the status of petroleum hydrocarbon contaminated sites management in Nigeria and identify the gaps in existing policy and regulation. We review the contaminated land policies and regulation from the UK and the USA, and identify lessons that could be transferred to the Nigerian system. Finally, we provide a series of recommendations (e.g. source – pathway-receptor approach, soil screening criteria, clean-up funding, liability) that could enhance contaminated land legislation in Nigeria.

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1 Keywords: Contaminated-land, risk management, Niger Delta, environmental policy,
2 oil spill
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1 Introduction

The Federal Republic of Nigeria, commonly referred to as Nigeria, is located in West Africa, covering an area of 923,773km^2 (Nwilo and Badejo, 2006), and is comprised of 4 regions, 36 states, and 774 Local Government areas (Adeyemi, 2013). Nigeria has a diversity of natural resources, such as bitumen, coal, iron ore and crude oil. Nigeria is the 12th largest producer of petroleum hydrocarbons in the world and its main oil producing region is the Niger Delta. The Niger Delta is located at the apex of the Gulf of Guinea on the west coast of Africa and within Nigeria's southern geopolitical zone (Figure 1). Approximately 31 million people live within the Niger Delta (NDDC, 2014). Geographically, the Niger Delta (Figure 2) covers an area of 112,000 km^2 and encompasses one of the most bio-diverse ecosystems on the planet (Ugochukwu and Ertel, 2008). Ecologically sensitive regions include, for example, coastal barrier islands, mangrove swamps, and freshwater swamps (NDDC, 2014).

In the late 1950s, Britain (British Petroleum) discovered crude oil in the region and in 1958 the country started commercial production at Oloibiri – a village in the Niger Delta – producing 6000 barrels per day (Kadafa et al., 2012). Today, about 606 oil fields (355 situated onshore and 251 offshore), 5,284 oil wells, and 7,000 km of oil and gas pipelines are operated by 13 multi-national companies in the region (Nwilo and Badejo 2006; Kadafa 2012). The region prides itself as the hub of oil exploration and production infrastructure in Nigeria (Eke, 2016), and currently produces on average 1.7 million barrels per day as of 2015 (OPEC, 2015).

The oil sector has become vital to the Nigerian economy. Reports estimate the export value of oil from the region to be $89b USD per annum (OPEC, 2015), or in excess of

$600b USD since 1960 (Ite et al., 2013). This translates into a contribution of up to 35% of Nigeria's gross domestic product (GDP), and over 90% of its foreign exchange wealth (Akpabio and Akpan, 2010; OPEC, 2015). Despite the country's oil wealth, the majority of the population, including the oil producing communities in the Niger Delta, remain relatively poor (Eke, 2016). The common employment is agriculture, food production, and fisheries (NDDC, 2014).

The Niger Delta has been reported as one of the most heavily oil-impacted regions in the world due to over five decades of oil exploitation activities (Zabbey and Uyi, 2014), coupled with poor management practices that have led to the contamination of soil and groundwater resources. Since the inception of the Nigerian oil sector, 13 million tonnes of hydrocarbons have been reported as spilled in the Niger Delta (Nwilo and Badejo, 2006; Kadafa, 2012) as a result of sabotage, pipeline vandalism (individuals that break pipeline during oil theft), well blowout, and engineering failure (e.g. pipeline rupture) (Nwilo and Badejo, 2006; Ambituuni et al., 2014; Könnet, 2014). Considerable oil contamination of the land has been reported (Ite et al., 2013; Linden and Palsson, 2013) and recent estimates suggest that over 2000 land-based oil-contaminated sites exist(Ite et al., 2013).

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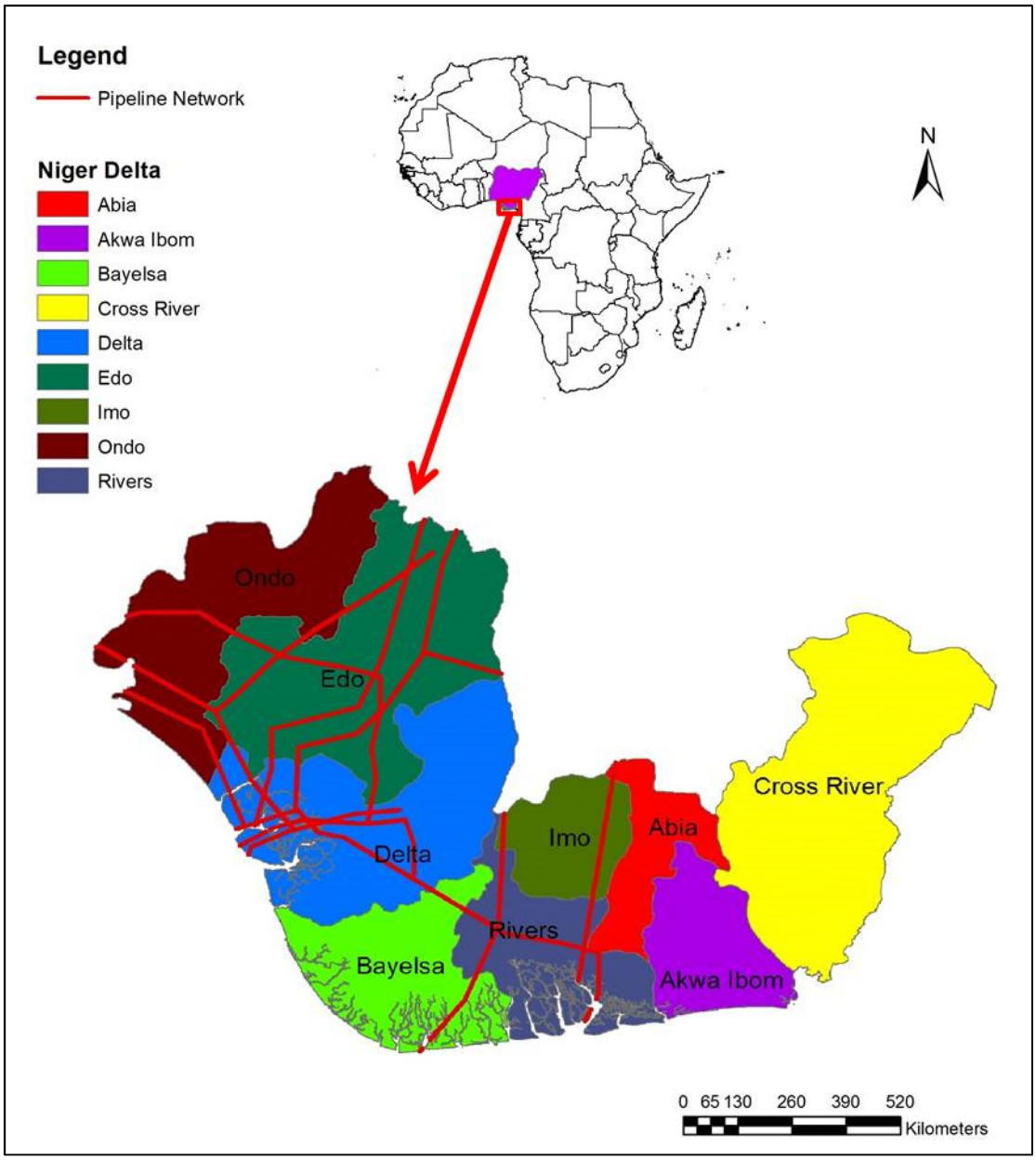

Figure 1: Map of Africa showing the Niger Delta region (red box) and oil pipeline network (red lines).

Nigeria has made few attempts to clean-up oil-related contaminated land and the most common approach used is remediation by enhanced natural attenuation (RENA)

(UNEP, 2011; Orji et al., 2012). RENA is a farming treatment bioremediation method whereby contaminated media (e.g. soil and sediments) are periodically tilled to provide aeration (Ebuehi et al., 2005). This approach differs from monitored natural attenuation (MNA) that relies on natural processes for remediation without human intervention (Jørgensen et al., 2010). RENA is often used in Nigeria and has been reported as ineffective as concentrations of contaminants in soil remain significantly high, even after sites have been certified remediated (UNEP, 2011). RENA is an inappropriate approach because of the extent and scale of the spills with oil penetrating soil to depths of over 5 m and leaching into groundwater aquifers (Ebuehi et al., 2005; Orji et al., 2012). In addition, RENA is ineffective for the treatment of contaminated aquifers, as this preferred approach to remediation has led to some communities no longer having access to safe drinking water (UNEP, 2011), due to hydrocarbon contamination of aquifers that are sources of potable and non-potable water in communities. Of the few attempts made to remediate contaminated land, none have involved stakeholder inputs (Rim-rukeh, 2015), and this has led to conflict and protest against the government and industry operators (UNEP, 2011).

The United Nations Environment Program (UNEP) report (Environmental Assessment of Ogoniland) is the most influential account to document the scale of pollution in the region (UNEP, 2011). A major recommendation from this report highlighted the need for development and adoption of oil pollution mitigation strategies. In general, Nigeria lacks the policies necessary to manage pollution, and this has been attributed to a number of different factors, e.g. a fragmented governance structure, a lack of decision transparency, and poor implementation (Ajayi and Ikporukpo, 2005; Ite et al., 2013).

Examples of countries with effective policies to manage pollution and contaminated land exist. Two such examples include the United States of America (USA) and the United Kingdom (UK). These countries have spent considerable time and effort to develop governance structures and strategies that provide effective management of contaminated land (Hird, 1993; Luo et al., 2009; Rodrigues et al., 2009; Swartjes et al., 2012; Kiel, 2013). Though the drivers (or conditions) that led to these developments will differ from that of Nigeria, the overarching principles should remain the same, i.e. environmental mitigation and reduction of human health impacts (Ferguson, 1999; Rodrigues et al., 2009a; Swartjes, 2011).

Therefore, Nigeria could benefit from the lessons learned in the USA and UK as they seek to improve their contaminated land management policy. In this study, we focus on petroleum hydrocarbon contaminated sites in the Niger Delta region. Using this region as a case study, we review the current contaminated land management situation in Nigeria to identify the gaps in policy and regulation. We also review the UK and USA experiences to identify the elements of those policies that could support progress in Nigeria. Finally, we propose recommendations for Nigeria that could support further development and implementation of a more effective contaminated land management regime.

2 Contaminated land management in Nigeria

2.1 Regulatory history of contaminated land in Nigeria

Contaminated land management regulation in Nigeria can be classified as three distinct periods (Figure 2), which include:

1) no legislation;

2) non-specific legislation; and

3) specific legislation.

Between 1956 – 1968 (during the period of no legislation) oil exploration and production was in its infancy, with oil exploitation initiated in 1956 and commercial production at Oloibiri stating in 1958. During the period between 1956-1960 (Nigeria achieved independence in 1960) regional management policies for oil exploitation and production were being developed. No specific regulations to manage contaminated land were in place at this time, nor were there any legal instruments available to discourage contamination (Ite et al., 2013). However, it is worth mentioning that pieces of regulation related to granting of licenses for the establishment of pipelines (i.e. the Oil and Pipeline Act 1956), safety of oil drilling operations (the Mineral oils (safety) regulation 1963), importation, exportation, loading and landing of petroleum (i.e. the Petroleum regulations 1967), and the Oil in navigable waters Decree 1968 which led to the Petroleum Act 1969 were enacted (DPR, 2002).

At the end of this period (1956—1968) oil contamination incidents were on the rise and this elicited a response from the Nigerian authorities and marked the beginning of the

period of non-specific legislation (1969-2001) (Anago, 2002; Ogbodo, 2009). During this period the Petroleum Act (1969) was developed to provide an overarching legislation for the prevention of environmental pollution in different environmental media, e.g. water, air and soil. Other notable legislations, such as the Harmful Waste Act 1988 and the Environmental Impact Assessment Act 1992, were established but were not designed specifically to address contaminated land management (Ajayi and Ikporukpo, 2005; UNEP, 2011).

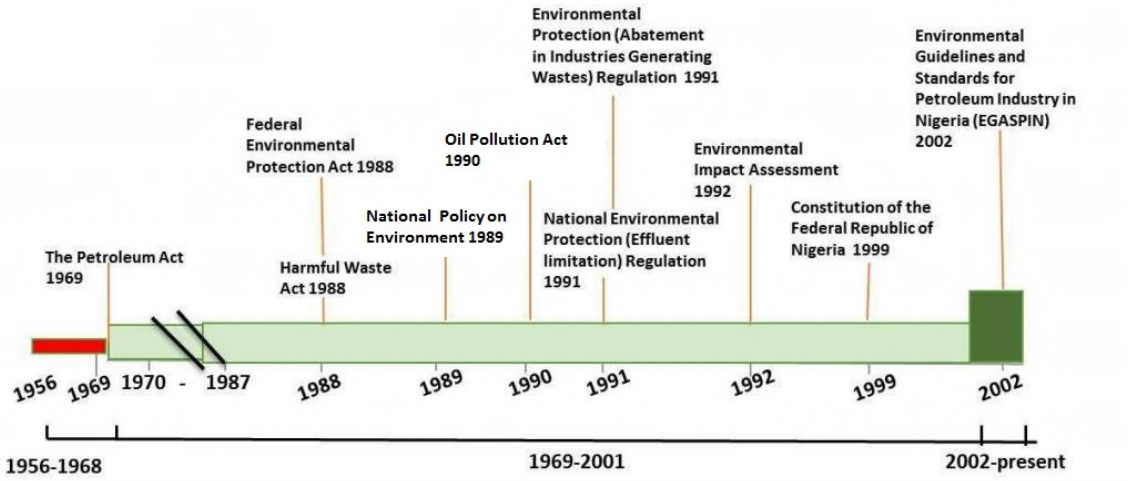

Figure 2: Timeline presenting the development of contaminated land management policy in Nigeria from 1956 to present. Red – period of no legislation; Light green - period of non-specific legislation; Green – period of specific legislation.

Increases in oil production, incidents of oil pollution (Badejo and Nwilo, 2004; Nwilo and Badejo, 2005), and community protests specifically in Ogoniland (Osaghae, 1995), led to a response from Government in the form of the Environmental Guidelines and

Standards for the Petroleum Industry (EGASPIN), which was published in 1991 and enacted in 2002. The EGASPIN 2002 regulations represented the first time in Nigeria where regulations specifically related to the management of contaminated land were enacted. To date, EGASPIN 2002 forms the regulatory basis of the current environmental mandate related to oil contamination in Nigeria. Since 2002, no other regulations related to contaminated land management have been enacted.

Many of the guidelines for environmental quality standards described within the EGASPIN have been adopted from other countries (mainly from the USA). This has been attributed to Nigeria's lack of technical capabilities and expertise to develop such guidelines (Ajayi and Ikporukpo, 2005). There are concerns that the guidance within EGASPIN 2002 lacks contextualisation; particularly that the conditions in the USA for land use, soil type, and soil total organic carbon differ from those in Nigeria. This difference could have an impact on the appropriateness and efficacy of the guidelines to assess and thus risk management (Ajayi and Ikporukpo, 2005, UNEP, 2011).

2.2 EGAPSIN - Current approach to contaminated land management

The EGASPIN describes environmental quality control guidelines that cover oil exploration, production operations, hydrocarbon processing, transportation, permits, sanctions, and pollution abatement technologies (DPR, 2002). Specific to contaminated land, the EGASPIN provides a set of guidance to mitigate the risks of contaminated land to human health and ecological systems. This is a risk-based framework that uses a multi-tiered contaminated land risk management approach In the event of a new spill, the EGASPIN requires the operator to report it to the Department of Petroleum Resources (DPR), however, in practice operators report to both the National Oil Spill

Detection and Response Agency (NOSDRA) and DPR. Next, a risk assessment is conducted at the discretion of the operator and the director of DPR. The risk assessment process requires the development of a conceptual site model (CSM) to identify all potential pollution linkages. Finally, a risk ranking exercise is performed (DPR, 2002) to identify priority sites requiring attention.

In Nigeria, risks are assessed using soil screening values (SSVs) that are predicated on contaminant concentrations for which soil functionality, plant life, animal, and human health are deemed to be threatened or could be seriously impaired. Management actions are triggered when certain contaminant threshold levels are exceeded (DPR, 2002). These values were directly adopted from the American Society for Testing and Materials (ASTM), a standards organisation that develops and publishes voluntary technical standards for materials and products testing(ASTM, 1995), as developed by the ASTM Committee E-50 on Environmental Assessment as part of Data Series 64 on Clean up Criteria for Contaminated Soil and Groundwater. Developed for specific conditions in the USA, it is unclear how appropriate these are for assessing risk under Nigerian conditions.

2.3 Governance and regulatory organisational structure

Environmental management falls under the responsibility of numerous governmental departments and agencies at the federal, state, and local levels (Figure 3). Only two agencies have the responsibility to manage contaminated land, and these are the DPR and the National Oil Spill Detection and Response Agency (NOSDRA). DPR is responsible for managing legacy sites (i.e. spill sites that have existed over a long period

of time and no polluter has taken responsibility) and NOSDRA is responsible for the detection and management of emergency oil spills (Oyefusi, 2007; Ambituuni et al., 2014; Rim-rukeh, 2015).

Despite this difference, agency (NOSDRA and DPR) roles often conflict. For example, when an oil spill occurs the operator must notify both agencies, each of which will then initiate an independent risk assessment of the site. Conflict might thus arise from different assessments (e.g. the assessment of the Bonga oil spill in 2011), which could impact the legitimacy of the management recommendations provided by NOSDRA who has the mandate to address new spills. Duplication of responsibility exists elsewhere, for example, pollution prevention and management of the oil sector falls under jurisdiction of two different federal agencies sitting across two different ministries (Figure 3) (Eneh, 2011). Overlap will ultimately lead to inefficiencies in the governance process, such as the double budgeting for management of contaminated sites, and conflicting recommendations from regulators (Ajai, 2010; Eneh, 2011; Ambituuni et al., 2014).

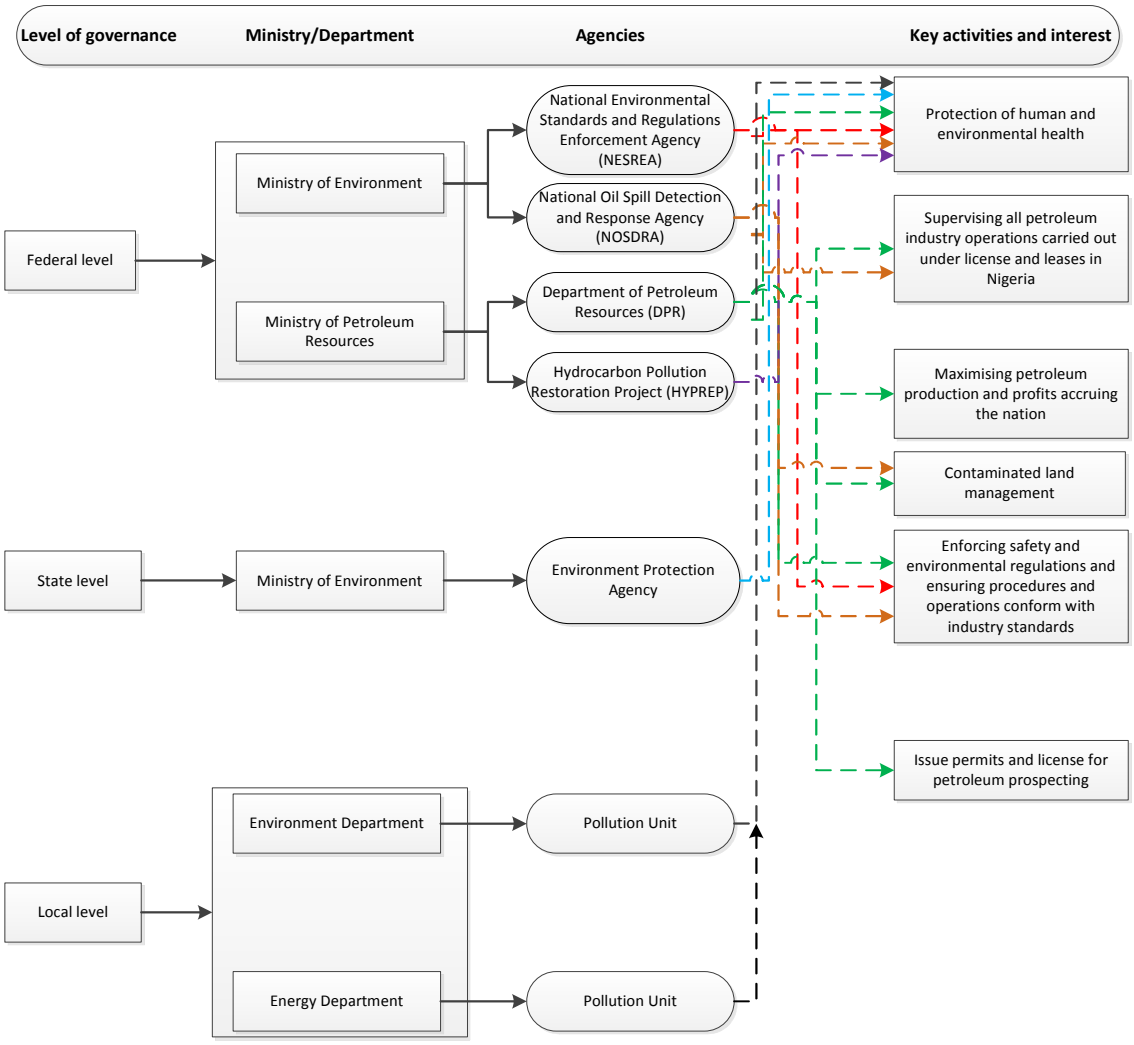

Figure 3: Map of the Government departments and agencies that are responsible for environmental management in Nigeria. This map shows the overlap of activities between different departments and agencies. Functions performed by each agency are represented in colour: NESREA (red), DPR (green), NOSDRA (orange), HYPREP (purple), Environment Protection Agency (blue), Pollution Unit (black).

Concerns about conflict of interest exist in DPR's dual role for contaminated land management (limited legacy sites) and responsibility to maximise oil production and

collect oil related revenues (Okotoni, 2004). This arrangement has led to reports of unethical behaviour, i.e. corruption (Eneh, 2011; UNEP, 2011). Countries such as the USA and UK specifically separate these two roles to avoid such occurrences (Ramseur and Hagerty, 2013).

2.3.1 Shortcoming in governance

Nigeria suffers from a number of operational shortcomings that have an impact on the development of effective governance. One shortcoming is a lack of adequately trained and experienced personnel who understand the technical aspects of contaminated land risk assessment and management (Ajayi and Ikporukpo, 2005; Eneh, 2011; UNEP, 2011). Another shortcoming is a weak and ambiguous definition for contaminated land (Table 1), which is crucial for identifying contaminated land and subsequently developing and implementing suitable risk management measures (Walton, 1997).

Table 1: Statutory definitions for contaminated land in the UK, USA and Nigeria

Country	Definition	Reference
UK	"any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that – (a) significant harm is being caused or there is a significant possibility of such harm being caused; or (b) significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused"	(DEFRA, 2012)
United States	"a real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant. The term "pollutant or contaminant" shall include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations..."	(CERCLA, 2002)
Nigeria	"The presence in the environment of an alien substance or agent or energy, with a potential to cause harm"	(DPR, 2002)

Other shortcomings include insufficient funding to support the assessment and management of contamination, as well as enforcement of regulations. For example, the national government has started the implementation of the UNEP recommendations on oil contaminated sites in Ogoniland (UNEP, 2016). However, the project is experiencing funding challenges due to lack of a funding structure. Lack of funding manifests in areas such as training, logistics, and facilities (Eneh, 2011), and it has been observed that operators, with sufficient resources, are often willing to assist regulators

during their assessments and investigations (Oyefusi, 2007). For example, most spills in the Niger Delta occur in remote locations where transportation is limited (e.g. helicopters and boats used to access spill sites). Under these circumstances, regulators will depend on operators to provide access to spill sites. Experts suggest that this type of engagement might interfere with the completion of a risk assessment leading to biased reporting of the cause, volume, and extent of an oil spill (Eneh, 2011; UNEP, 2011; Könnet, 2014). At a higher level, this type of engagement could potentially present opportunities for corruption or abuse of the regulatory process.

Fragmented legislation, insufficient funding, and a lack of expertise pose a significant challenge to contaminated land management in Nigeria. In addition, the regulation does not effectively assign liability. Rather than outlining a process to identify and apportion liability, the EGASPIN states that the operator is liable for all oil spills (DPR, 2002). While this ensures the operators take responsibility for security and integrity of oil extraction and exploration infrastructures such as pipelines, it does not achieve the principle of polluter pays because there is no action or mechanism in place to identify and ensure that the operator pays for land contamination (Könnet, 2014). To understand how Nigeria might address these challenges, we review the UK and the USA contaminated land management regimes to identify lessons that could be learned and transferred to a Nigerian context.

3 Contaminated land management in the UK

In the UK, contaminated land is defined as outlined in Table 1. The UK definition is specific and reflects the source-pathway-receptor model, which makes it easier for a regulator to identify contaminated land and determine the level of contamination.

The onset of urban land contamination in the UK can be traced back to over 200 years (Kossoff et al., 2016; Pizzol et al., 2016; Swartjes, 2011). There had been concerted efforts from the Government, regulators, the regulated and policy makers to ensure that the legacy of contaminated land and associated risks is addressed (Forton et al., 2012). Today, the UK contaminated land management regime is a reference point for many countries such as China (Brombal et al., 2015), Cameroon (Forton et al., 2012) and European countries (Rodrigues et al., 2009b). Different approaches for decision making on contaminated land have been developed and evolved over the past few decades through extensive scientific investigation from being cost-centric in the 1970s, techno-centric in the 1980s and risk-based in the 1990s (Pollard et al., 2004a) to a much more integrated and sustainable technique (Bardos et al., 2016).

Initial attempts to regulate land contamination in the UK were introduced in the Town and Country Planning Act of 1947. In 1974, the Control of Pollution Act was introduced, and this Act specified the different types of pollutions (e.g. waste on land, pollution of water, noise, and air pollution) that might be encountered in the planning process. A contaminated land management strategy was initiated in the UK in 1976 with the development of the Inter-departmental Committee on the Redevelopment of Contaminated Land (ICRCL) (Rodrigues et al., 2009a). The mandate of the ICRCL was to provide experts with the necessary tools to assess and manage the risks associated

with contaminated land. In particular, the ICRCL published a set of guidance for the management of human health hazards that might result from exposure to contaminated land (Guidance Note 59/83, 1987). The ICRCL also developed trigger values for three groups of pollutants (i.e. toxic metals, aggressive substances, and phenols) and assigned land use categories to support risk assessment and management decisions (Rodrigues et al., 2009a).

As time passed, concerned stakeholders like landowners and developers, regulators, and local authorities, demanded more specific contaminated land regulation. As a response, the UK Government developed two principal regulations: the Town and Country Planning Act 1990 and Part 2A of the Environmental Protection Act 1990 (Catney et al., 2006). The main purpose of these regulations was to improve the identification of contaminated land that posed an unacceptable risk to human health and environmental receptors (EA, 2002). Additionally, Part 2A was intended to prevent new contamination, promote remediation and redevelopment of legacy sites, and to intervene where development might not be feasible because a site could pose risks to receptors (Brombal et al., 2015; Luo et al., 2009). Founded on risk-based principles, Part 2A was intended to promote voluntary clean-up on about 10% of sites in the UK, while the majority of sites were remediated as part of normal land development processes under the Town the Country Planning Act 1990 (Luo et al., 2009). Stakeholder consultations are a central tenet of the redevelopment process, and are used to create awareness, harness contributions to new policies, and educate the public about changes or updates to contaminated land management policy. The precautionary and polluter pays principles are also significant components of UK contaminated land management. The

precautionary principle promotes discretion in the presence of uncertainty, seeking to protect the public from exposure to harm (Reinikainen and Sorvari, 2016), while the polluter pays principles assigns liability for clean-up on the person or persons responsible for the release of a polluting substance (Catney et al., 2006; EA, 2009a). Appropriate persons are classified further: Class A persons are those who knowingly, or unknowingly, permitted polluting substances in, on, or under land while Class B persons are the owners or occupiers of a site who may be liable if the actual polluter is not found (DEFRA, 2012). If neither a Class A nor B person is found, the site is classified as an 'orphan site' and becomes the responsibility of the local council (DEFRA, 2012). The UK's polluter pays principle has been adapted by other countries, including the Netherlands, and Finland (Rodrigues et al., 2009a; Sorvari et al., 2009).

Pragmatically, Part 2A provides practitioners with a series of steps to assess the risk associated with contaminated land. These steps include: identification, determination, liability, appeals against remediation notice, and offences of non-compliance, among others (UK Government, 1990). Statutory Guidance (SG) to aid implementation has also been refined over the years to clarify the objectives of legislation and thus support its implementation. Also, as new scientific knowledge becomes available it is integrated into the SG documents, thus providing a routine update that demonstrates a desire for continuous improvement of legislation. For example, to achieve a more targeted approach to identifying and managing contaminated land in relation to the risk (or possibility) of harm to human health, the revised SG presented in 2012 established a new four category system for considering land under Part 2A. Categories range from Category 4, where the likelihood that land poses a significant possibility of significant

harm is low, to Category 1, where the likelihood that land poses a significant possibility of significant harm is unacceptably high (CL:AIRE, 2014). The Impact Assessment (IA) that accompanies the revised SG explains this system in more detail and identifies a potential role for Category 4 Screening Levels (C4SLs) to provide a simple test for deciding whether land is suitable for use and thus not contaminated.

Overall, the UK's contaminated land legislation uses a risk-based, tiered approach to support decision making as outlined in CLR 11 (DEFRA, 2012; DEFRA and EA, 2004). Tier 1 requires that a potential connection be identified between a hazard and a receptor, and this is done using the source, pathway and receptor S-P-R model (EA, 2004). The S-P-R model is a critical component for determining a potential pollutant linkage, which indicates the potential presence of risk (EA, 2004; Rodrigues et al., 2009; Nathanail et al., 2013). If a pollutant linkage is established, the process moves to Tier 2, which requires the completion of a generic quantitative risk assessment. This assessment is supported by soil guideline values (SGVs). SGVs are scientifically derived contaminant thresholds designed to protect human health from exposure to long-term contamination in soil (EA, 2009b). SGVs are based on specific land use, assumptions about contaminant behaviour, and the sources, pathways, and receptors (Cheng and Nathanail, 2009). If guidance values are unavailable, professional bodies (e.g. Land Quality Management) might provide generic assessment criteria (GACs) to simplify the risk assessment process and provide a benchmark for decision-making (DEFRA and EA, 2004; Forton et al., 2012). At a high level, SGVs serve as screening tools to determine whether or not a site requires further assessment, based on the effects to human health. If SGVs are exceeded, the process moves to Tier 3, which requires the

completion of a detailed quantitative risk assessment (Carlon et al., 2007). In such instances, there is need to develop and use site specific information to inform the risk assessment process. This will necessarily require the development of Site Specific Assessment Criteria to enable informed decision-making in the risk assessment process. Overarching this process is the consideration of sustainability, whereby risk assessors and policy makers ensure that the decision-making process integrates stakeholders, and that the final decision returns environmental, economic, and societal benefit to the public (Bardos et al., 2016; Hou et al., 2014).

Funding to manage contaminated land is provided through the land capital grant scheme. Local authorities can use the fund to clean-up historic sites, however this funding has been reduced over time and is expected to end in April 2017 (Mills and Reeve, 2015).

Responsibilities within government to manage contaminated land are divided between departments. Local Authorities are responsible for delivery, and focus on the protection of human health, inspection, identification, and maintenance of a contaminated site registry. They also play a role in the management and monitoring of clean-up actions, and the facilitation of public consultations. The Environment Agency (EA) provides support to Local Authorities and is responsible for managing Special Sites, which are those where soil is contaminated by explosives or radioactive substances, are owned by the Ministry of Defence, or directly impacts on controlled waters (EA, 2009a, Catney et al., 2006; Defra, 2012). The EA, together with Defra develop policies and supervise implementation.

4 Contaminated land management in the US

The statutory definition for contaminated land in the USA is outlined in Table 1. Similar to the UK definition, it identifies what constitutes a hazard, and specifies the need to protect human and environmental receptors. This provides regulators with direction to identify and quantify contaminated land.

Contaminated land regulation in the USA originated from concerns about the effects of contaminated soil and water on human health and the environment (Bearden, 2012). The first legislation for contaminated land management was part of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), which was developed in response to the *SS Torrey Canyon* oil tanker spill off the South West coast of the UK in 1968 (USEPA, 2016). This strategy was developed to help officials cope with similar types of spills in the USA, and served as a blueprint for response to land contamination from oil spills and hazardous substances in the USA. In 1976, the Resource Conservation and Recovery Act (RCRA) was developed to manage contaminated land. Briefly, the RCRA addressed the management and disposal of hazardous wastes and was the basis of contaminated land management up until 1980 (CERCLA, 2002; Nathanail et al., 2013). Incidents such as the Santa Barbara oil spill of 1969 (Hendy et al., 2015), and the hazardous waste deposited at the Love Canal, NY in 1978 (Austin et al., 2011)further raised the profile of contaminated land in the USA, and in 1980 the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) was developed. Commonly referred to as the Superfund programme, this act was used to designate funding (generated from taxation of the chemical and petroleum industries) to the remediation of historically contaminated sites (Rodrigues et al., 2009a). In 1986

the Superfund programme was updated (i.e. Superfund Amendments and Reauthorisation Act) (Nathanail et al., 2013) to include the introduction of community awareness initiatives, and to broadened the public's access to information about the potential threats posed by contaminants. The Superfund program has been very effective with remediation action taken on 2436 sites, of which 428 sites have been completely remediated (USEPA, 2012). In addition, 1,361 sites have been listed on the National Priority List (NPL), which is a list of national priority sites based on the type of contamination and the threat it poses to public health.

Similar to the processes of the UK, the Superfund process comprises a series of steps that support the decisions that lead to the remediation of contaminated lands. These steps include definition of contaminated land, prescription on how to issue abatement notice, financial liability, clean up (including removal and remedial measures), and litigation procedures, among others. Risk Assessment Guidance for Superfund (RAGS) was developed to clarify the procedures and aid practitioners' implementation of the CERCLA (USEPA, 1997; Kowalski et al., 2002).

The USA approach is risk-based, similar to the UK, but the two systems differ in how they score and assess priorities to human health and ecological receptors. To assess the risk to public health and the environment the USA uses a Hazard Ranking System (HRS) that comprises a score based on the assessment of likelihood to cause harm, the behaviour of a substance, and the proximity of receptors in the area. These scores are used to determine the status of a site and if a site scores sufficiently high, it is listed on the USEPA's NPL, thus classifying it as requiring long-term clean-up (DeLong, 1995; Rahm, 1998). The USA also enforces the polluter pays principle once a potential

responsible party (PRP) has been identified. Where no PRP is identified, the regulator takes up remedial action and 'apportions liability' to a PRP when one is identified (CERCLA, 2002). Regarding sustainably, the USA also ensures that final decisions on contaminated land management will provide benefits to society, will reduce environmental footprints, and will lessen economic impacts (Hou and Al-Tabbaa, 2014; Hou et al., 2014).

Guidance documents are available to support practitioners and these include ASTM International's health-based site clean-up criteria (Rodrigues et al., 2009a), the Regional Screening Levels (RSLs) for human health and different land use (USEPA, 2015), and the contaminated sediment remediation guidance for hazardous waste sites (USEPA, 2005). Programmes have also been initiated to support remediation work on superfund sites and these include the site-specific risk based corrective action programme, and voluntary clean-up programmes (De Sousa, 2001; Rodrigues et al., 2009).

Responsibility to regulate contaminated sites falls within the jurisdiction of the USEPA. Oversight of risk assessments and remediation activities is the responsibility of the State, except in the instances of contaminated land emergencies (e.g. spills) and hotspots (sites that require urgent attention) where regional teams take the lead and report to the USEPA (CERCLA, 2002).

5 Lessons learned: recommendations that could benefit contaminated land management in Nigeria

The Nigerian contaminated land management system lags behind those in the UK and the USA in terms of its effectiveness to identify relevant sites, conduct appropriate detailed risk assessments, and to initiate remediation activities. Nigeria lacks a comprehensive regulatory framework for contaminated land management that integrates sustainability appraisal. More specifically, Nigeria requires a more effective statutory definition for contaminated land, better regulatory coordination, mechanisms to apportion liability, soil screening values, training, proportionate fund, and technical expertise. In the following section we will discuss how lessons from the UK and the USA might be used to address these gaps (Table 2).

Table 2: Lessons based on the UK and USA experiences that might benefit contaminated land management in Nigeria

	UK	USA	Current practice in Nigeria	Recommendations for Nigeria
Statutory definition	Clear statutory definition for contaminated land that makes reference to the S-P-R and pollutant linkage methodology.	Clear definition for contaminated land that makes, and identifies the significance of the S-P-R relationship.	The current definition is ambiguous and does not make reference to source of hazard, pathways and receptor	Revise existing guidance to provide a statutory definition for contaminated land that refers to the S-P-R model.
Regulator structure and capacity	The local authorities and the EA are well coordinated with clarity of roles and standards. Both authorities are equipped with technical personnel.	The USEPA is well coordinated and understands its roles. It is adequately equipped with appropriate training, technical, and human resources.	Multiple and overlapping regulatory agencies exist. Lack of periodic training and capacity building and development platforms.	Revise existing guidance to clearly define roles and responsibilities of agencies. Provide regular training to improve capacity for contaminated land identification and remediation techniques.
Funding contaminated land	Government funding has been reduced. Policy encourages voluntary remediation by private land owners.	Government funds contaminated land clean-up via the Trust Fund. Voluntary remediation is encouraged.	There is no funding mechanism or structure for oil contaminated land management.	Adequate legislation including the polluter pays principle should be enforced for pollution events and approaches to deal with 'orphan sites' outlined. In the short term, a Trust Fund should be established with contributions from crude oil sales to fund contaminated land clean up. This has started in Ogoniland although the

				source of funding is not sustainable.
Technical approach	Land use is considered in the assessment. Scientifically derived values such as GACs and SSTLs are used for screening contaminants.	Land use is considered in the assessment. Scientifically derived endpoints and the HRS method are used to screen sites (CERCLA, 2002)	Generic soil screening values which might be inappropriate for the Nigerian environment are used for contaminant screening.	Produce nationally consistent methods for deriving human health and ecologically appropriate screening values that consider land use (i.e. fit for purpose).
Liability	Appropriate Person (AP) is identified through a structured process. AP could be Class A or B (EA, 2009a).	Potential Responsible Party (PRP) is identified through a structured process. The regime practice both strict and joint liability (CERCLA, 2002).	There is no structure for identifying or allocating liability to a polluter.	Stringently implement the polluter pays principle. Implement means to identify a polluter and apportion liability
Sustainability appraisal	Contaminated land management decisions are based on maximising societal benefits, while reducing costs, and environmental damage.	Sustainability is geared towards reducing the environmental footprint of contaminated land management decisions.	The current approach to contaminated land management does not integrate sustainability principles and thus maximising societal benefits is challenging.	Develop a policy to integrate sustainability indicators that maximise societal benefits, reduce cost, and environmental footprint into management decisions.
Public awareness	Extensive consultations are held to educate the public and create awareness of new policies and changes to contaminated land management policies.	Public awareness programmes are undertaken to educate stakeholders and members of the public of changes to policy and identified contaminated sites	Low public awareness and participation in contaminated land management.	Increase public awareness via different media such as symposia and workshops in rural and urban areas to inform the public about contaminated land policies and impacts.

5.1 Statutory definition for contaminated land

To distinguish between lands that are deemed contaminated and those that are not requires a clear statutory definition (Catney et al., 2006). The provision of a definition sets the basis for quantifying the extent and scale of contamination (Walton, 1997), and informs the risk management approach used to contain and treat contamination. For example, the UK statutory definition (Table 1) identifies receptors (i.e. human health, land and controlled waters) that must be protected (Luo et al., 2009), as well as the authority responsible for management. Definitions from the USA provide details about what constitutes a release, or a hazard, which can guide management activities. Elements of the source—pathway—receptor model are present in both definitions. The statutory definitions in the UK and USA reflect the risk-based model, reduce ambiguity, and identify receptors that could be impacted.

Definitions for contaminated land management in the EGASPIN are broad and generic (see DPR, 2002), which could lead to ambiguity about the risks presented by contaminated land (e.g. hazards, receptors, exposure). The current definition (see Table 1) might benefit from more information about the environment (e.g. land and water), the hazard, and the harm. For example, the UK the definition includes harm to ecological as well as human receptors. Subtle changes in language are needed to improve the specificity of the definition, to differentiate land use and to reduce ambiguity.

5.2 Regulatory coordination

Effective implementation of regulation requires a coordinated regulatory system across government. Nigerian regulatory coordination for contaminated land management is flawed, evidenced by fragmented responsibility across Government (e.g. federal, state, and local) and between agencies (e.g. DPR and NOSDRA) (Figure 3). Poor coordination could lead to a duplication of efforts, discordant environmental governance, and unethical behaviour, such as corruption (Ajayi and Ikporukpo, 2005; Ajai, 2010; Eneh, 2011; Ambituuni, Amezaga and Emeseh, 2014).

Both the UK and USA contaminated land regulatory regimes are decentralised, and their functions are facilitated by clear roles and responsibilities spread across different stakeholders so as to avoid duplication of effort (Catney et al., 2006). For example, UK responsibilities are shared between the Environment Agency and local authorities, with each actor responsible for a specific activity so as to minimise duplication and the chance of conflicting reports (DEFRA, 2012). Similar structures are present in the USA where the roles of the USEPA and the Regional Decision Teams are clearly defined and separated (CERCLA, 2002). Learning from the UK and USA, the roles and responsibilities between DPR and NOSDRA need to be redefined and where possible, a system should be developed to coordinate actions for human health, water, environmental management, as well as emergency response (EA, 2009; Luo et al., 2009).

When redefining roles and responsibilities, Nigeria must separate responsibility for environmental enforcement and revenue collection to avoid opportunities for corruption. Lessons can be learned from the USA where the potential for conflict of interest within

the USA Department of Interior (responsible for the collection of oil royalties and environmental pollution management) became apparent during the Deep Water Horizon oil spill in 2010. In response, the USA divided responsibility between the USA Bureau of Safety and Environmental Enforcement (inspection and environmental management) and the Office of Natural Resources Revenue (revenue collection) (Ramseur and Hagerty, 2013). Similar examples for redefining roles exist elsewhere that relate more closely to developing economies (e.g. Thailand) (Singkran, 2014).

Coordination can also be used to improve the promptness of reporting and response time by locating teams near to communities that are prone to contamination (e.g. oil spills), or home to legacy sites (i.e. past spill sites). The USEPA uses this approach to locate regional teams across the county; a process that expedites the identification and reporting of spills and contamiantion. In Nigeria, this mechanism could be used to involve local committees to monitor pipelines and report spill incidences to the central regulator. This small-scale approach might also address issues about pipeline vandals or spontaneous pipeline cracks (Orubu et al., 2004).

5.3 Risk-based decisions

Governments must prioritise the allocation of limited resources to clean-up contaminated sites. Decisions to prioritise sites are often risk-based, and frameworks to assess risk adopt the source-pathway-receptor (SPR) model (Luo et al., 2009; Reinikainen and Sorvari, 2016). The SPR model determines whether there is a linkage between pollutant and receptor (Rodrigues et al., 2009b; Swartjes, 2011; Defra, 2012). If no pollutant linkage is identified then there is no risk, but if risk exists, an assessment of severity can be used to identify those sites that pose a significant risk to receptors (Nathanail et al., 2013). Importantly, this process promotes the use of evidence to justify decisions (Reinikainen and Sorvari, 2016).

Both the UK and USA use risk-based models to identify and manage contaminated sites (CERCLA, 2002; Defra, 2012; Kiel, 2013). Nigeria, on the other hand, lacks a comparable risk-based framework despite reference to the establishment of pollutant linkages in the EGASPIN (DPR, 2002). Opportunity exists for Nigeria to directly adopt risk-based best practices from either the UK or USA. By adopting these practices, Nigeria can avoid unnecessary assessments and the associated economic burden. For example, in the absence of risk (where no pollutant linkage exist), the requirement for a detailed site assessment should be negated (see DPR, 2002). The most profound benefits that Nigeria could realise by adopting a risk-based approach would be the increased transparency, logic, and evidence-base for decision-making about contaminated land.

5.4 Soil screening values

Soil screening values (SSVs) are pre-determined contaminant concentrations found in soil or groundwater that represent a threshold concentration, above which further risk assessment might be necessary (EA, 2004b; Cheng and Nathanail, 2009). SSVs focus on harm to human health and ecological receptors (MfE, 2006). The UK has developed soil guideline values (SGVs) that are specific to human health protection (CL:AIRE, 2010), but exceedance of SGVs does not expressly indicate the existence of risk, because other factors like pollutant linkages must also be considered (DEFRA, 2012). The USA has developed soil-screening levels (SSL) that protect both human and ecological receptors from exposure to harm and are also used as target levels for clean up. These values are dependent upon soil type and land use classifications, so they will vary from site to site and might not be transferable to different countries (Rodrigues et al., 2009; Defra, 2012).

Nigeria uses generic SSVs to assess contaminants in soil. These values were taken from different international guidelines, which has led to conflicts in terminology (e.g. acceptance criteria, trigger values, maximum acceptable values, environmental quality guidelines, intervention levels), receptors, and methodologies and assumptions. Concerns about the appropriateness of SSVs used in Nigeria (derived from ASTM for the USA) have been raised, along with their presumed fitness for purpose (Cheng and Nathanail, 2009), which has contributed to the uncertainty experienced by practitioners and regulators when investigating contaminated sites (UNEP, 2011; Ambituuni, Amezaga and Emeseh, 2014). Nigeria needs an overarching national guideline that sets

out a method to derive contextually relevant SSVs that protect human and ecological receptors.

5.5 Liability and funding

Clean-up of contaminated sites can be prohibitively expensive and funding is arguably the most important challenge facing contaminated land management. Funding availability is an on-going concern in Nigeria, despite the one-off investment of 1 billion USD provided by the Nigerian Government and liable operators to clean-up contamination in Ogoniland (Orubu, Odusola and Ehwarieme, 2004; Steiner, 2010; Anyanwu, 2012). The effectiveness and sustainability of this type of fund is unknown (Könnet, 2014). The USA addresses funding challenges through their Superfund mechanism, which transfers funds from the chemical and petroleum industries (as a tax) to clean-up activities. UNEP (2011) suggested a similar approach for Nigeria whereby a percentage of the Excess Crude Account (petroleum royalty scheme) could be assigned to a contaminated land management fund.

In the UK and USA, funding is a function of liability (the process of identifying the person or group of persons that have unknowingly or deliberately contaminated land) (Alberini et al., 2005; Catney et al., 2006; Larson, 2005; Luo et al., 2009; Zhao, 2013). In the UK, the polluter pays principle ensures that the liable parties pay for the damage done to the natural environment, (Luppi et al., 2012; Zhu and Zhao, 2015). Nigeria could adopt the polluter pays principle, or assign responsibility to the operator, or the owner of an exploratory license (EA, 2009a). Regardless, Nigeria could benefit from the adoption of structured approaches for assigning legal responsibilities similar to those used in the UK and USA (Nathanail et al., 2013). These responsibilities, used in

conjunction with insurance mechanisms, could be used to manage contamination due to pipeline sabotage or vandalism. While we recommend an effective policy detailing the different elements of a contaminated land policy, Nigeria's structure should also include a protocol for polluter identification, evidence to determine liability, site investigation, nature of polluter's involvement and polluter's potential defence.

5.6 Training and expertise

The practice of contaminated land management continues to evolve (Brombal et al., 2015) and in order to remain current, practitioners must receive regular training and retraining (Bardos et al., 2016). Skills acquisition is a means to build and maintain expertise and many countries integrate regular training into their contaminated land management policy frameworks (Luo et al., 2009; Brombal et al., 2015).

Agencies for managing contaminated land in the UK and USA continually train and educate their personnel to keep up with innovation and change (Luo et al., 2009). In the UK, practitioners have access to numerous training platforms e.g. Sustainable Remediation Forum (SuRF) UK (Bardos et al., 2016), Network for Industrially Contaminated Land in Europe (NICOLE) (Bardos, 2010), and the Contaminated Land Rehabilitation Network For Environmental Technologies in Europe (CLARINET) (Vegter, Lowe and Kasamas, 2002).

The level of contaminated land management expertise in Nigeria is low, and training networks like those in the UK are not readily available. In the absence of technical expertise, agencies like DPR and NOSDRA depend on the knowledge of operators to conduct site investigation (Ambituuni et al., 2014), which might influence the assessment about the volume of a spill or its perceived level of impact (Eneh, 2011). We believe that

Nigeria has two options to improve the technical expertise levels. The first is to develop training platforms like those in the UK, to provide a mechanism for regulators and other practitioners to exchange knowledge and develop skills. Development of such networks requires time and effort, and therefore a more immediate solution might see Nigeria develop strategic partnerships with organisations like SuRF and NICOLE to provide training. Advantages of this approach would include a rapid up-skilling of the workforce and an immediate introduction of global best practice into Nigeria.

5.7 Public awareness

Public awareness comprises elements of education, communication, and understanding, and the facilitation of awareness requires mechanisms that enable the public to actively participate in the management of contaminated land (Sorvari et al., 2009; Erdem and Nassauer, 2013). These mechanisms include seminars, workshops, exhibitions, conferences, or websites, which are used to initiate open dialogues between different contaminated land stakeholder groups.

Public awareness about contaminated land, spills, and regulations in Nigeria is low (Ugochukwu and Ertel, 2008) and one might argue that this has led to the deliberate release of crude oil into the environment (e.g. pipeline vandalism) or restrained urgency in dealing with contamination (Nwilo and Badejo, 2005). By contrast, public awareness in the UK is high, due to media coverage and the use of public consultations. This is usually done in to form of extensive stakeholder consultation and is used to raise awareness, and educate residents, land developers, and the public about the issues associated with land contamination. Prior to publishing Statutory Guidance in the UK, stakeholder consultations were held to ensure that the public and interested parties could

contribute to the guidance and be made aware of the issues (DEFRA, 2012). The use of public consultation is ingrained in UK governance, whereas it would be a new concept for Nigeria. To initiate public awareness Nigeria could use local mechanisms (e.g. town-crier) to reach out to the local population to make them aware of the impact of spills on, for example, soil fertility or fishing waters. Education might discourage acts of deliberate contamination (Ukeje, 2001; Ugochukwu and Ertel, 2008), and would improve awareness of environmental issues and their governance.

5.8 Sustainability appraisal

The trend in contaminated land management is towards sustainability, whereby decisions about contaminated land management integrate socio-economic and environmental concerns (Bardos et al., 2016; Sam et al., 2016). Sustainable approaches are intended to ensure long-term benefits and to avoid unsustainable clean-up decisions (Kiel, 2013; Kapp, 2014). Both UK and USA regimes have developed initiatives that integrate sustainability principles into their contaminated land management decision-making processes (Bardos, 2009; P. Bardos et al., 2011; R. P. Bardos et al., 2011; CL:AIRE, 2015). For example, the USA encourages operators to reduce the environmental footprint of remediation strategies (Hou et al., 2014; Hou and Al-Tabbaa, 2014).

With the benefit of time, the UK and USA have been able to incrementally improve their contaminated land management programs, but Nigeria has the opportunity to rapidly advance their program by integrating sustainability principles from the beginning. Introducing frameworks like the UK's protocol for sustainability appraisal, or the USA's approach for minimising the environmental footprint of remediation

practice (Bardos et al., 2012; Hou et al., 2014), would provide a step-change advancement that would benefit Nigeria by ensuring that solutions consider social, economic, and environmental factors fairly (UNEP, 2011). Implementation will require education, for example, communication amongst stakeholder groups affected by contaminated land (Booth, 2015). Sustainability forums that encourage the exchange of innovative ideas might also be considered, for example, the Sustainable Remediation Forum US (SuRF US), SuRF UK, and SuRF Australia (Bardos et al., 2016).

6 Conclusions

Contaminated land management in Nigeria suffers from a number of gaps, or limitations: lack of a clear statutory definition for contaminated land, poor coordination of governance, lack of a risk-based approach, inexperience, weak policy frameworks, and limited funding, yet there is opportunity for Nigeria to learn lessons from other countries (e.g. UK, and USA) to improve their system. In this paper, we reported on a number of recommendations that Nigeria could adopt from the UK and the USA regimes. Specifically, Nigeria could benefit from an improved definition of contaminated land, better regulatory coordination, adoption of risk-based decision tools, development of soil screening values, improved determination of liability, a means to generate additional funding, and the integration of a sustainability assessment. Progress to develop and implement contaminated land management regulation in Nigeria has been slow, yet despite Nigeria's urgent need for clear regulatory policy we do not believe it should rush into the transfer of policy from elsewhere. This is because success will depend on how well Nigeria is able to contextualise policy to meet their unique

environmental, economic, cultural, and political needs. We suggest that further research is needed to understand these contextual needs, how they might affect policy transfer, and how knowledge about these needs can be used to improve contaminated land management in Nigeria.

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