

# Management of Groundwater Contamination in Ogoniland, Niger Delta



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FEDERAL CONTAMINATED SITES  
SITES CONTAMINÉS FÉDÉRAUX



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# Contaminated land: the issue

Management of contaminated land and water: major issue globally.

Recent (and historical) industrial, urban and commercial activities have led to the presence of elevated concentrations of a wide range of contaminants in soils, sediments and surface- and ground-waters, affecting the health of millions of people worldwide.

In EEA alone:

250,000 sites requiring remediation.

Potentially polluting activities at 3 million sites.

The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

Source: FOREGS Geochemical Atlas,  
[http://www.gtk.fi/publ/foregsatlas/  
index.php](http://www.gtk.fi/publ/foregsatlas/index.php)

# Contaminated land: the issue

A range of national and regional legislation has consequently been implemented to enforce the clean-up or remediation of contaminated land, the clean-up or protection of surface and groundwater resources, and the effective management of drinking water, and waste effluents.



<http://ferreiraconstructionsouthern.com/services/environmental-remediation/>

# Ogoniland, Niger Delta, Nigeria



[Shell, 2011](#)

<http://www.nddoe.org>

## Niger Delta state and Ogoniland

Oil infrastructure established since 1960s

Extensive operational and dormant oil field facilities

# Study area

- Ogoniland consists of 4 Local Government Areas In Rivers State
- Was a Producing Oil Field between 1960-1993
- Pipelines carrying oil still pass through Ogoniland
- An extensive wetland exists, surrounding the 4 LGA
- Pollution, through air and water, migrates into and out of Ogoniland (112,000 Km<sup>2</sup> Of Land Area Is Oil Affected; Core Delta Is 75,000 Km<sup>2</sup>)
- 32 Million (22% Of Total Nigerian Population), 2/3 under 30 years Of Age
- Ecological areas are sandy coastal barriers, mangrove swamps, freshwater and saltwater wetlands, lowland rainforest
- 76 to 80% of population In rural areas and 50 to 55% in urban areas do not have access to safe drinking water

# Contamination in Ogoniland

- 1958–2010: est. 546 million gallons crude oil spilled; av. 300 spills or nearly 10.8 million gallons/year 1986—2003: 50,000 acres of mangrove forest affected
- Oil industry operations ongoing since 1960s
- Currently air, water, soil and wetlands are heavily polluted
- Estimated that it will take decades to restore the system, even if appropriate actions are taken



Hamadina and Anyanwu, 2012



<http://www.unep.org/annualreport/2014/en/disaster-conflict.html>

# Environmental assessment of Ogoniland: key observations from UNEP (2011) report

- 67 contaminated locations next to oil industry installations were investigated
- 41 of these sites have pollution levels exceeding Nigerian intervention values
- In 38 of these sites, pollution has migrated >1 meter below ground
- Pollution has migrated to or more than 5 meters below ground in 13 locations
- In no-spill sites the target value has been achieved
- 366,000 cubic meter of soil exceeds intervention values
- 2.5 million cubic meters of soil exceeds target values



<http://ngm.nationalgeographic.com/2007/02/nigerian-oil/oneill-text>



# Environmental assessment of Ogoniland: key observations from UNEP (2011) report

- Local communities exposed to hydrocarbons from air, drinking water, bathing, swimming and walking
- Presence of benzene in air at concentrations higher than WHO indoor air standards
- Hydrocarbons detected in drinking water in 28 community drinking water samples
- Hydrocarbons were observed in 6 rain water samples
- These are “on sampling basis only”
- Indicative of major public health concern



<http://freshnewsng.com/blog/buhari-moves-to-clean-up-oil-spillage-in-ogoniland/>



# Knowledge gaps

- There is an emerging international body of research and practical applications on extensive (i.e. large area), less invasive remediation approaches focusing on *in-situ* biological techniques (bioremediation and phytoremediation) and natural attenuation processes. These are relatively low cost options but their detailed site specific applicability in Ogoniland (and in surrounding areas of the Niger Delta) is yet to be assessed.
- In addition, previous surveys have examined total petroleum hydrocarbons around key oil-producing sites in Ogoniland. To effectively manage contamination, however, and assess groundwater transport processes (and risk to drinking water, and airborne exposure routes), an understanding is needed of the concentrations, distribution and migration mechanisms of different hydrocarbon components (e.g. LNAPL, DNAPL) and their relative risk.

# Aims and Objectives of this study

- **To investigate the extent of, and processes controlling, environmental contamination at hydrocarbon industry-impacted sites in Ogoniland, Nigeria, and to evaluate practical methods of managing this contamination.**
- To investigate the distribution and concentrations of key hydrocarbon contaminants in groundwater and surface water, and the processes controlling this.
- To examine the impacts of this contamination on drinking water sources.
- To assess the application of practical groundwater remediation methods, with particular emphasis on enhanced bioremediation, phytoremediation and natural attenuation approaches.
- Based on the above, to recommend systems of improved environmental management for hydrocarbon contamination in Ogoniland and the wider Niger Delta

# Data collection

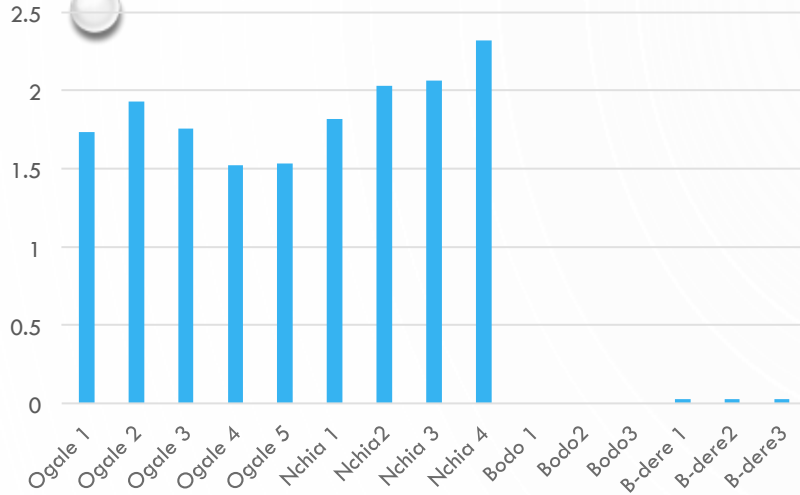
- Data collected through a qualified environmental consulting firm and transported through DHL service to UK.
- Groundwater and surface water samples collected using bailers
- Field observations/site details were recorded



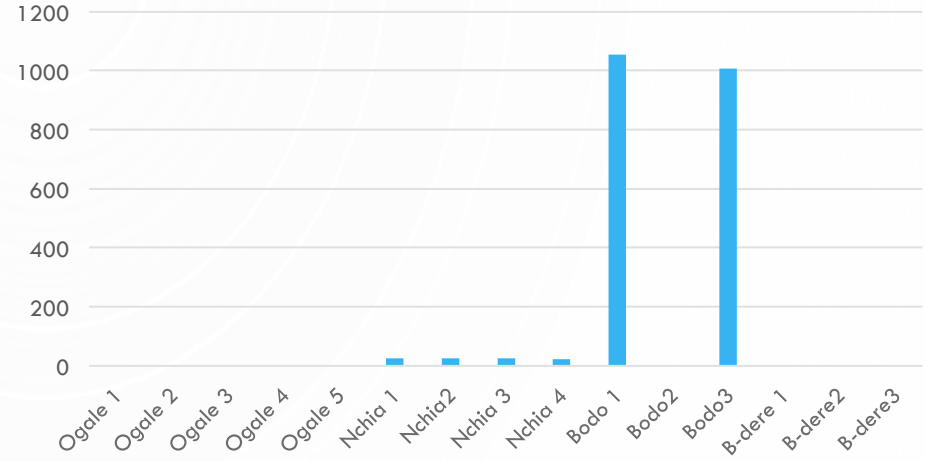
<http://www.theatlantic.com/photo/2011/06/nigeria-the-cost-of-oil/100082/>

# Illustrative groundwater and surface water data

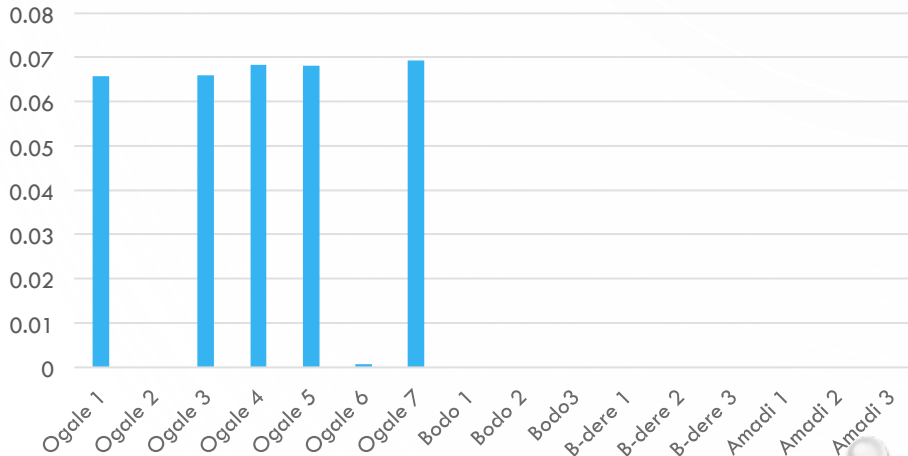
### Fe (ppm) in surface water samples



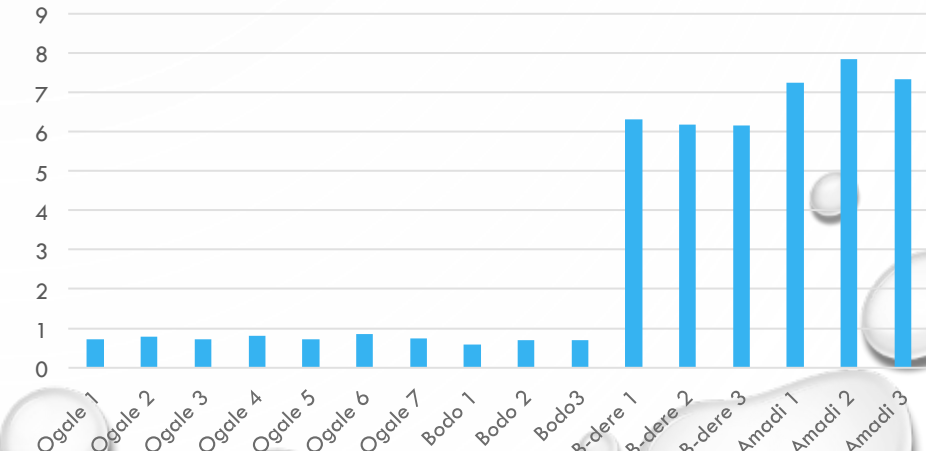
### Sulfate (ppm) in Surface water samples



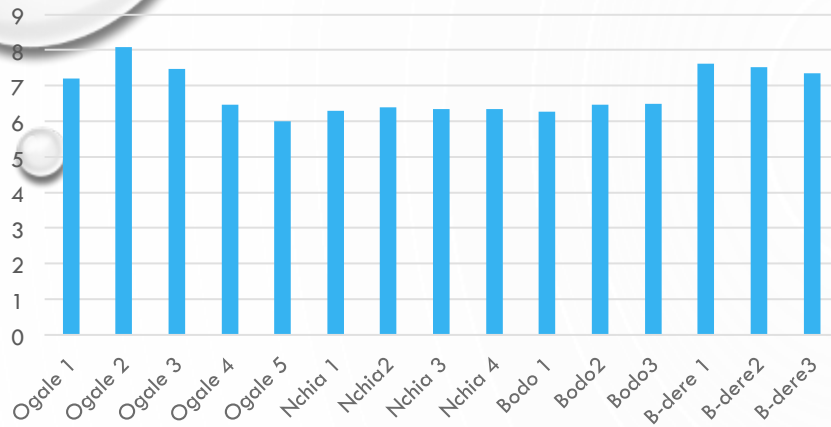
### Fe (ppm) in Groundwater samples



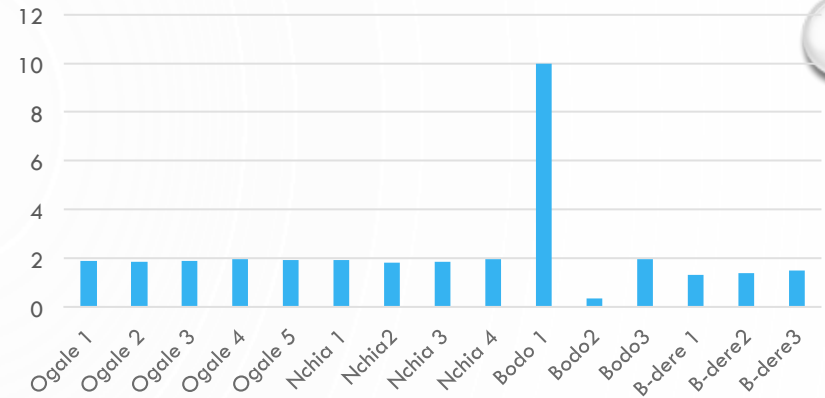
### Sulfate (ppm) in Groundwater samples



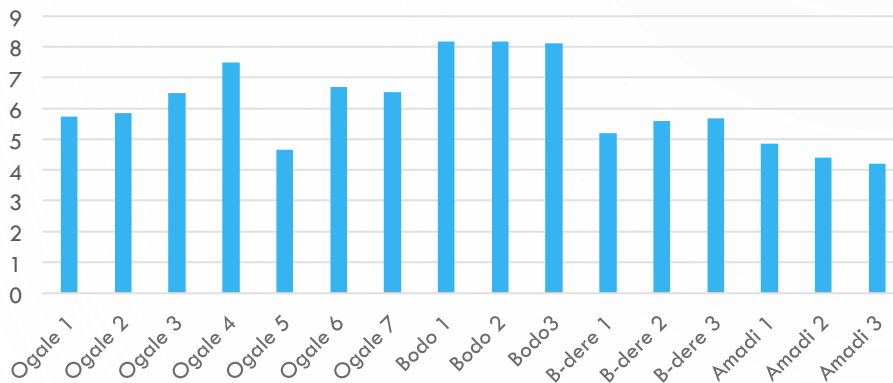
pH in Surface water samples



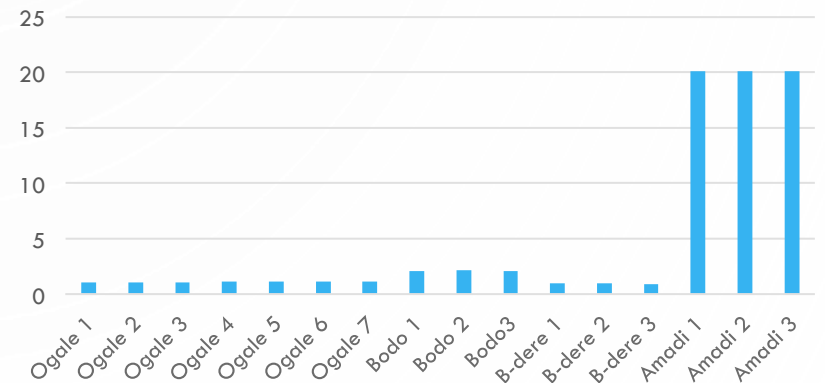
Chloride (ppm) in Surface water samples



pH in Groundwater samples



Chloride (ppm) in Groundwater samples



- ❖ Parameters exceeding WHO standards in groundwater are Mn, Mg, Nitrate, EC and Turbidity
- ❖ Parameters exceeding WHO standards in surface water are K, Mg, EC, Turbidity, and Bromide.

# TPH and Phenol data

## TPH Sample Results

Toluene	Ethyl-benzene	Xylenes	Benzene
<1.5ppm	<0.5ppm	<1ppm	<2ppm

## UNEP (2011) Ranges for TPH

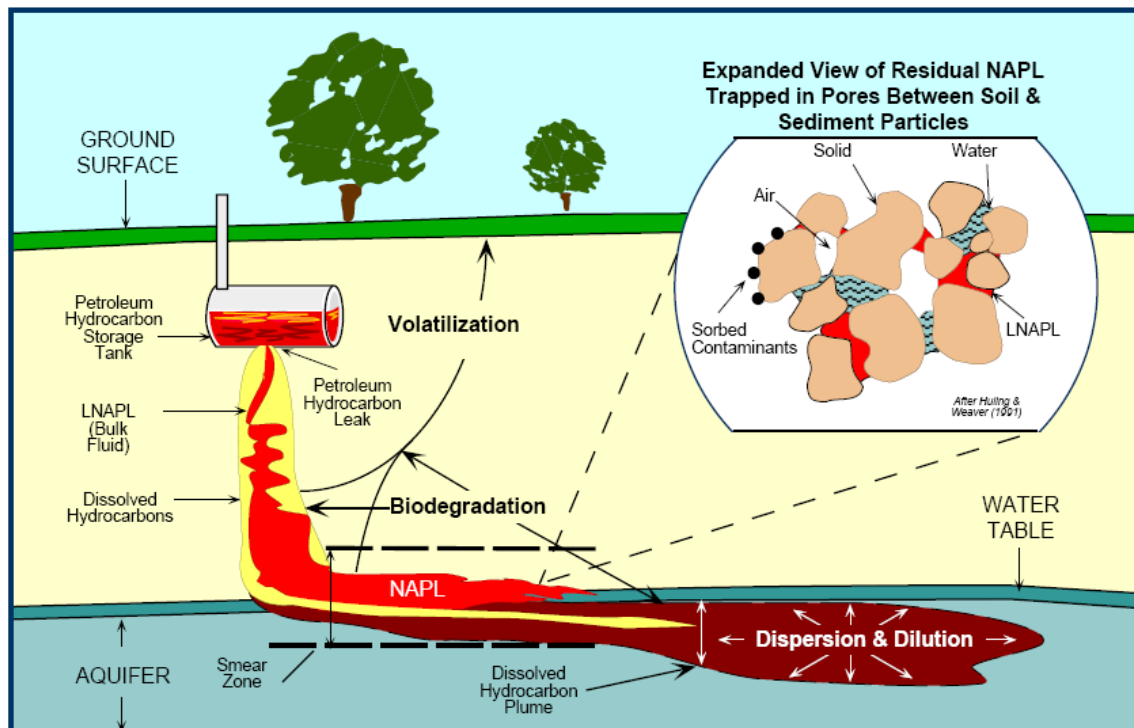
	Groundwater TPH	Surface water TPH
UNEP, 2011	0.053-42.2 ppm	0.011-2.35ppm

Region	Phenol analysis	Result in Mg/L	EPA
<b>Groundwater Ogale</b>			3.4mg/l
Sample 1	1.738	737.09	
Sample 2	1.704	720.09	
Sample 3	1.844	787.57	
Sample 4	1.849	789.95	
<b>Groundwater Amadi Ama</b>			
Sample 1	0.234	20.90	
Sample 2	0.234	20.90	
Sample 3	0.234	20.90	

- ❖ TPH concentrations were uniformly low compared to previously published data (UNEP 2011)
- ❖ Preliminary phenol data indicate gross exceedances of guideline values

# Planned work: Core Flooding experiments

- To simulate local soil/sediment structure and assess subsurface migration processes.
- To inform conceptual models of groundwater transport of contaminants, and inform risk management or remediation approaches



# Planned work: Adsorption studies

- Assessing the potential for using activated carbon (AC) techniques for contaminant adsorption and mitigation
- Column and batch adsorption studies using AC, biochar and other amendments (inc locally-derived materials) for locking away/adsorbing contaminants such as Phenol, Toluene and PAH



# Institutional challenges

- There are issues of institutional mandates, effective laws, human capacity and logistical support, which all impact on Local/National institutions' capacity to address the problems
- National institutions tasked with managing the oil industry and environmental protection were unable to exercise their oversight effectively
- Natural resilience of environmental systems around Ogoniland has been surpassed.
- The communities' own resilience is adversely affected due to the degradation of their production base

# Merci / Thank you

## Acknowledgements:

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