Remediation of Hydrocarbon Contaminated Soils

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Introduction

Background

Nigeria's Niger-Delta is contaminated with 9-13 million barrels of oil-spill, posing severe environmental and socio-economic risks to ~31 million inhabitants whose major employment is agriculture, food production and fisheries[1,2].

Although a clean-up exercise was launched in 2016, no specific remediation approach was identified most effective[3].

Aim and Objectives

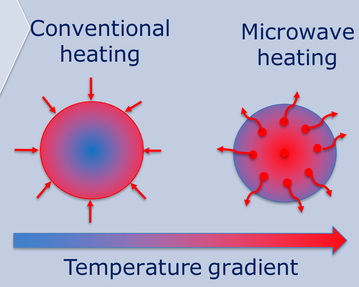
Carry out a robust and systematic technology evaluation for the removal of Total Petroleum Hydrocarbon (TPH) from contaminated soils using conventional and microwave (MW) heating.

- Evaluate these technologies base oil removal efficiency, environmental Impact, treatment time, safety and cost
- Understand how heat energy interacts with contaminated soils
- Assess treated soil quality.

Conductive heating vs MW heating

Compared with conventional heating systems like thermal desorption, MW heating is[4];

- rapid, penetrates, selective and delivers energy directly to MW-absorbing bodies.
- minimizes long heat-up periods, thermal gradients and energy loss to systems.



Methodology

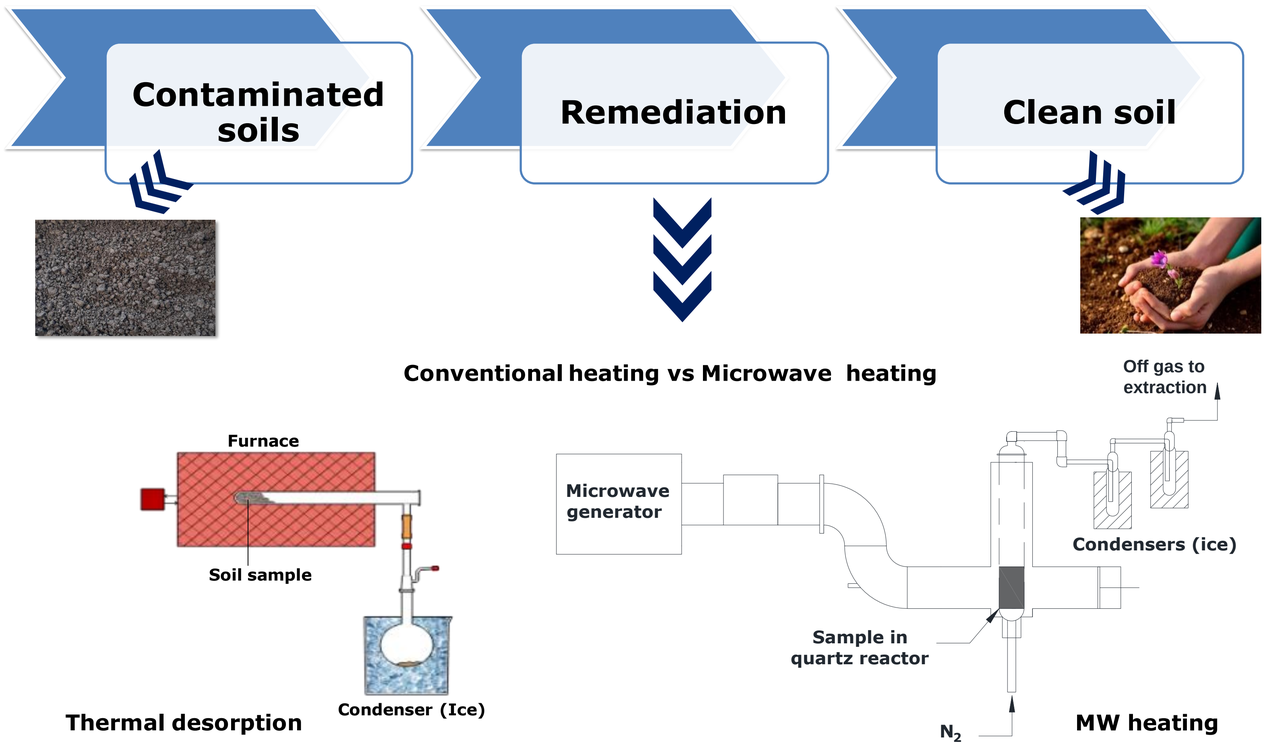


Fig 1: Overview of research methodology

Results and Discussion

Table 1: Oil and moisture contents of contaminated soils (wet basis)

Soil	Oil content %(w/w)	Moisture content %(v/m)
Road planings	2.9 ± 0.14	7.3 ± 0.45

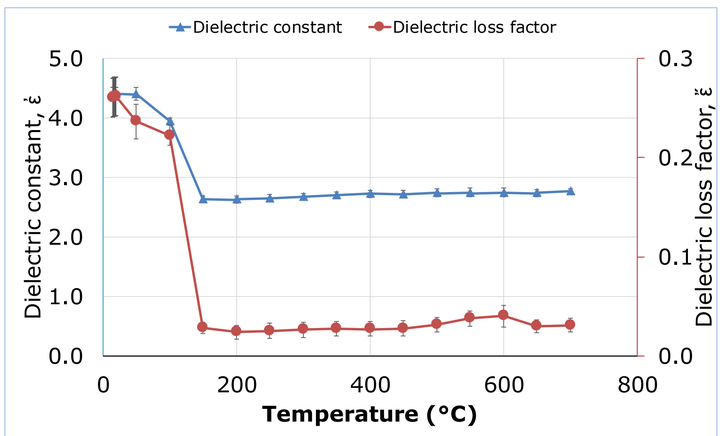


Fig 2: Dielectric properties of road planings at 2.45 GHz

Higher dielectric loss factors at temperatures ≤100°C (Fig. 2) are due to the presence of water phase in the contaminated soil (Table 1).

Loss factors >0.1 will readily absorb MW energy[5,6] and would potentially lead to the removal of hydrocarbons from the road plainings via stripping.

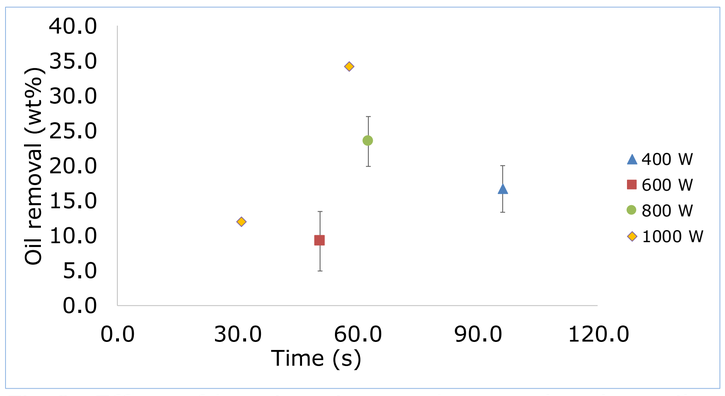


Fig 3: Effect of heating time and power level on oil removal during MW heating of 30 g road planings at 2.45 GHz

From Fig. 3, oil removal increased with increase in both microwave heating time and applied power upon treating 30 g of road planings using single mode cavity. Up to 34wt.% oil removal was achieved using 1000 W.

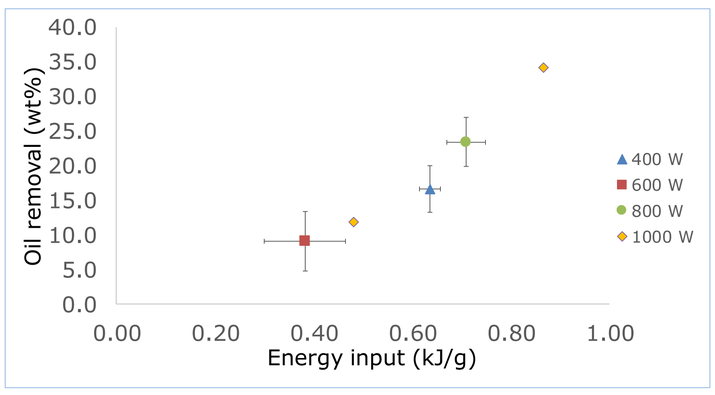


Fig 4: Effect of energy input and power level on oil removal during MW processing of 30 g road planings at 2.45 GHz

The data in Fig. 4 reveals that power density (kJ/g) is the fundamental parameter that governs oil removal and not energy input. As power density increased, a corresponding increase in oil removal was observed.

Conclusion and Future Work

- Microwave heating showed good potential for the remediation of hydrocarbon impacted soils. Treatment using conventional heating (Thermal desorption) will be carried out and compared.
- Oil contaminated soils will be collected from Nigeria for treatment.
- Optimisation of process conditions of power density, soil type and particle size, temperature and heating time will be undertaken.
- Treated soils will be characterized for soil organic matter and porosity.

References

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5. Meredith, R., 1998. Engineers' handbook of industrial microwave heating. Institution of Electrical Engineers, London.
6. Robinson, J.P. et al., 2009. Separation of PAH from contaminated soils using MW heating. Separation and Purification Technology, 69(3): 249-254.

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