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Prospecting for electrochemically-active hydrocarbon-degrading microorganisms for use in bioelectrochemical remediation of petroleum hydrocarbons.

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Background/motivation

Petroleum hydrocarbons pollution is commonplace in the environment owing to accidental spillages, leakages and indiscriminate disposal. Globally, it is estimated that between 1.7-8.8 million tonnes of oil is released into the aquatic environment annually (Dadrasnia and Agamuthu, 2013) and from 1970-2020, 5.86 million tonnes of oil has been spilled as a result of tanker incidents (ITOPF, 2021).

Remediating these spills is a great priority due to their negative impacts on the environment e.g. irreversible habitat loss and threat to the survival of living organisms (UNEP, 2011) and public health e.g. genotoxic, mutagenic and/or carcinogenic effects (Ghosal et al., 2016).

Unfortunately, a Nigerian Niger Delta region that houses the largest wetland in Africa and world's 3rd mangrove forest (Wetlands International, 2016) is one of the most oil polluted region in the world (Figure 1). With over 9-13 million barrels of oil spills, some of the rich ecosystems of this region have been reduced to wastelands (Kadafa 2012).

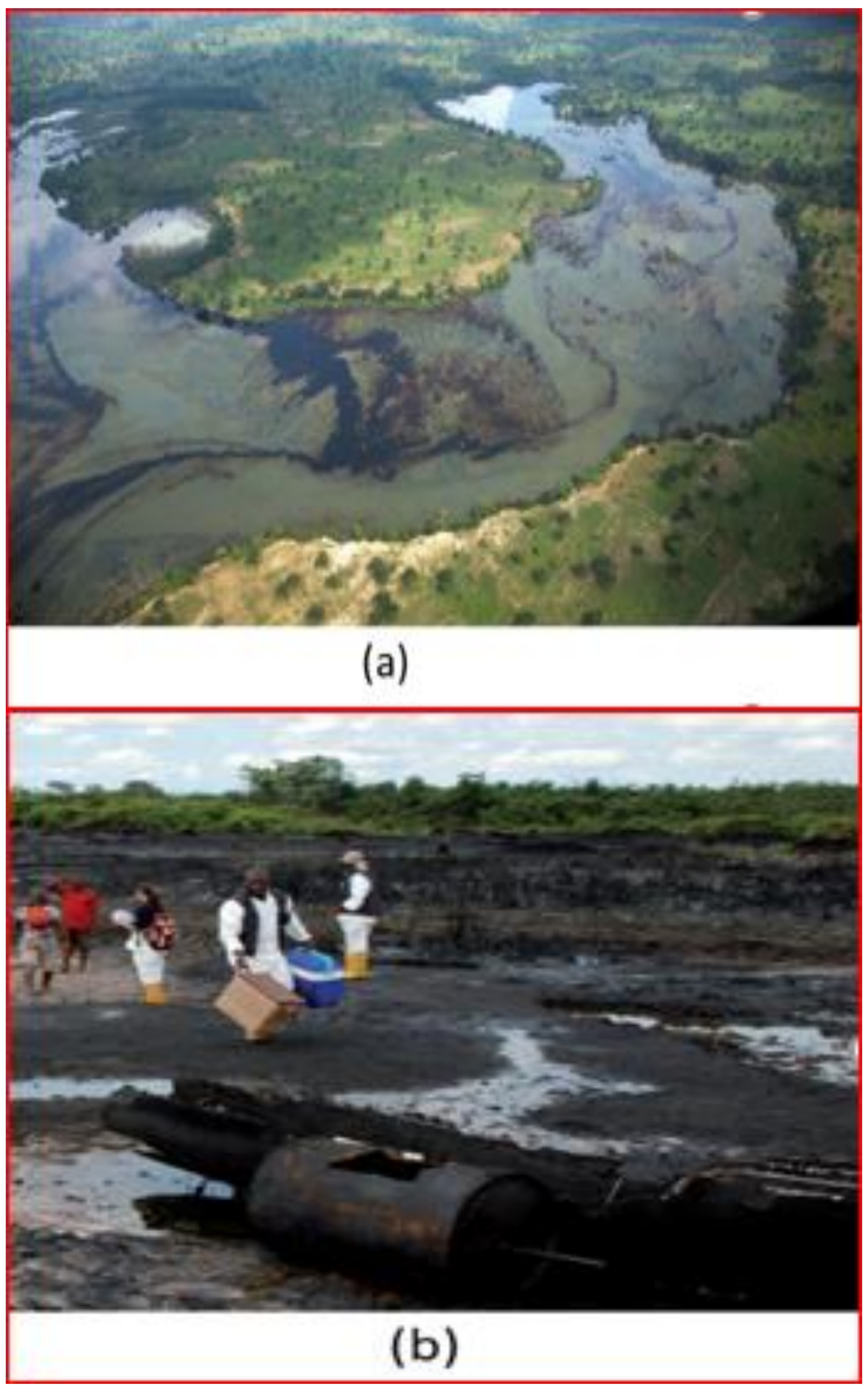

Figure 1. Oil pollution in Ogoniland, Nigeria; (a) aerial view of an oil spill; (b) oil-contaminated soil (UNEP, 2011).

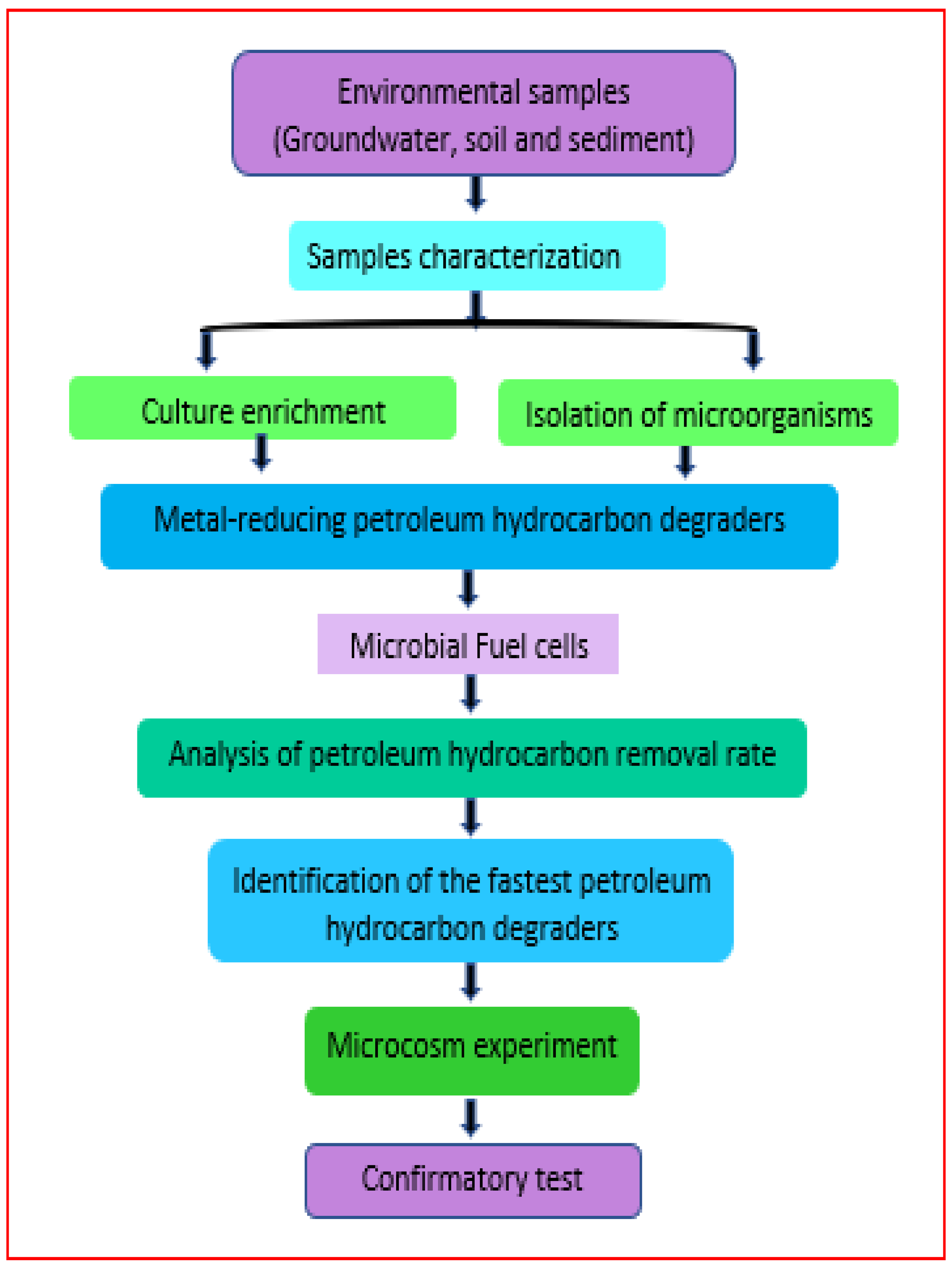

Figure 2: *Experimental design for the prospecting of electrochemically-active hydrocarbon-degrading microorganisms.*

Previous and current technological approaches

Previous approaches that have been employed in the remediation of the polluted sites are either expensive, energy intensive, ineffective or too slow. Using conventional methods of remediation, 2 out of the many sites were estimated to cost 1 billion USD for the first 5 years for a 30 years remediation period (UNEP, 2011). Currently, a project known as Hydrocarbon Pollution Remediation Project (HYPREP) is utilising landfarming and biopiles for the remediation (HYPREP, 2020). With at least 5 m depth of pollution as reported by UNEP in 2011, the major challenges with these approaches are cost of excavation and energy requirements. However, the HYPREP project is in its infancy and data are yet to be available to ascertain its effectiveness.

Aim of the study

To develop and test bioelectrochemical systems-based petroleum hydrocarbon remediation technologies at laboratory scale in environmentally-relevant conditions with a view for field deployment.

Methodology

This research is focusing on utilising indigenous microorganisms from petroleum hydrocarbons contaminated matrices (soil, sediment and groundwater) for remediation. Isolates from these matrices that are identified to be electrochemically active petroleum hydrocarbon degraders will be inoculated into microbial fuel cells as pure cultures and as microcosms. Using petroleum hydrocarbons as the sole substrate, isolates with high degrading efficiencies and rates will be determined in the laboratory. Figure 2 shows the flow of experimental activities for identifying these isolates.

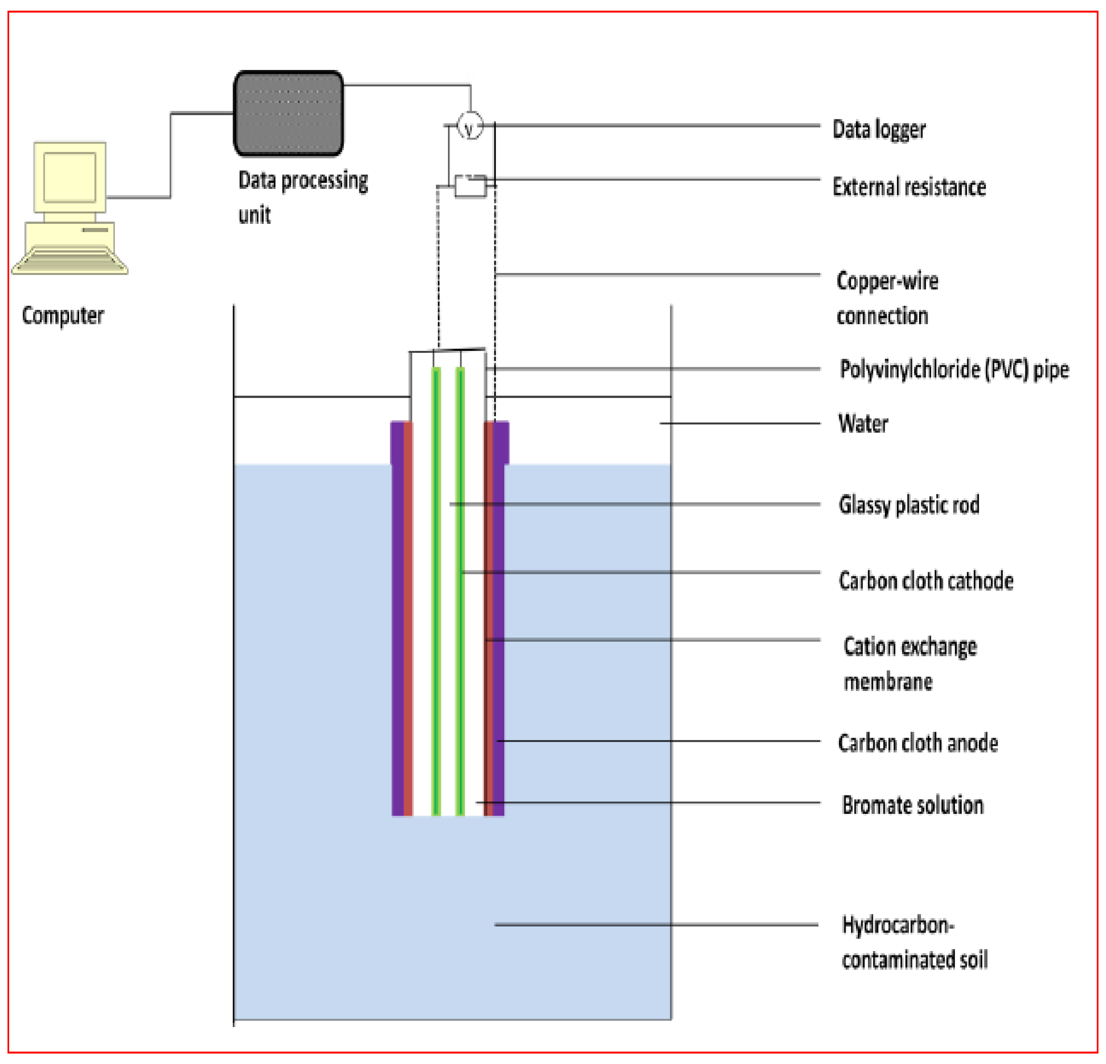

Figure 3*. Schematic of a soil microbial fuel cell. Many such tubular MFCs could be inserted in contaminated soils to bring about remediation*

Expected outcome

It is expected that at the end of the study, identified electrochemically active isolates with high petroleum degrading efficiency will be used for bioaugmentation in a field trial. Figure 3 is one of the potential MFCs design to be used for field trials.

References

Dadrasnia, A., Agamuthu, P. (2013) Diesel fuel degradation from contaminated soil by *dracaena reflexa* using organic waste supplementation. *J. the Japan Petro. Inst.*, 56(4), 236-243.

Ghosal, D., Ghosh, S., Dutta, T.K., Ahn, Y. (2016). Current State of Knowledge in Microbial Degradation of Polycyclic Aromatic Hydrocarbons (PAHs): A Review. *Frontiers in Microbiology.* 7 1369.

Hydrocarbon pollution remediation project (HYPREP), (2020). Remediation work. https://hyprep.gov.ng/remediation-work/ Accessed on 5 June, 2021.

International Tanker Owners Pollution Federation (ITOPF), (2021). Oil tanker spill statistics 2020. https://tinyurl.com/4ws9jdms Accessed on 27 July, 2021.

Kadafa A. A., (2012). Environmental Impacts of Oil Exploration and Exploitation in the Niger Delta of Nigeria. *Global Journal of Science Frontier Research. Environment & Earth Sciences, 12 (3), 19-28.*

United Nations Environment Programme UNEP, (2011) Environmental Assessment of Ogoniland. https://tinyurl.com/trv8tetz Accessed on: 5 March, 2020.

Wetlands International, (2016). Conserving and restoring wetlands in Nigeria's Niger River Delta. https://tinyurl.com/3wmbtr88 accessed on 12 January, 2021.

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