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Comparative Study of Percentage Removal of Iron from Water Media Polluted with PMS and AGO using Different Particle Size and Mix Ratios of Adsorbent

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Abstract

The need to monitor the degree of comparative study of percentage removal of iron from water media contaminated with petrol motor spirit (PMS) and diesel (AGO) by the application of molded adsorbent in solid form. The adsorbent is made of clay soil with mixed of either of the agro-based materials listed, which include plantain Ogonic Red (POR), plantain Agbagba 1 (PA1) Banana Ogoni Red (BOR) and Banana Native (BN). The particle sizes of $150\mu m, 1.18mm,\ 300\mu m$ *and* $600\mu m$ *was used in the production of the adsorbent and the mix ratio of R5:5, R1:9, R2:8, R3:7 and R4:6, was obtained in combination of the various mixed ratio of different particle size of clay soil with the agro – based materials prepared. The performance of the effect of particle sizes and mixed ratio of each adsorbent was monitored after immersed in the contaminants environment for the removal of iron (Fe) from the various water media of fresh water and salt water medium. The efficiencies of the adsorbents were monitored with the rate of performance in terms of contaminants reduction in concentration. The research shows increase in AGO and PMS concentration in terms of percentages removal in the magnitude order of particle size of* $150\ \mu m > 1.18\ mm > 300\ \mu m > 600\ \mu m$ *as well as the mix ratio of R1:9> R2:8> R4:6> R3:7> R5:5. The investigation further revealed that the performance of the adsorbent varies from water medium studied as well as the type of contaminant, in which the adsorbent was immersed in.*

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Keywords: Contaminant, potential, AGO, comparative, PMS, study, particle, size, mix, ratio

INTRODUCTION

Natural actions of the Sun, Weather and Wave could promote the breakdown oil spilled on water surfaces. If oil spill does not threaten wild life or close to populations, the tendency is usually to leave it and let natural actions take care of the spill especially if the quantity spilled is small [1, 2]. Lighter oils will disperse faster than heavier oils. When oil breaks down as a result of natural actions, they mix with water, sand and other particles to form tar balls [3]. Tar balls eventually scatter over the coastal surfaces. They are seen not as a serious danger to the environment [4]. The disadvantage of this process is that the weathered oil

may create secondary films on water surfaces that may require further clean-up through other processes [5].

Dispersants are chemicals that are sprayed on oil spill surfaces to cause a breakdown of the oil into smaller droplets [6]. Dispersants contains certain surfactants chemicals that contain both water and oil compatible ends. At a certain concentration of mixtures, the surfactant molecules attach to the oil and reduce the interfacial tension between oil and water. This reduction allows oil droplets to break off from the slick and minimizes the tendency to re-coalesce [7]. The use of dispersants over the years has been discouraged due to high toxic effects observed when degreasers were applied to the "Torry Canyon oil spill". The impacts to communities were very extensive. Though research has produced dispersants with less toxic effects its use as a means of oil spill clean-up is highly regulated and, in some cases, actually banned [8].

Controlled (in-situ) burning refers to the burning of oil slick at sea or close to site. Controlled burning burns off the oil in water thereby reducing the quantity of oil-in-water. This system is only possible under low windy conditions [9]. There is a limited use of this process due to the problems and issues generated by it including the air pollution from heavy smoke and respiratory problems it could cause, formation of extremely viscous and dense residue which sinks at sea and of course the safety concerns from this method [10,11].

Bioremediation in oil spill clean-up refers to the addition of materials to contaminated environments to cause an acceleration of the biodegradation process. It is becoming a promising method of oil spill clean-up with little impact to the habitat [12]. The process uses decomposers or their enzymes to improve the condition of the contaminated environment. For example, Bacteria can be used introduced to remove specific contaminants such as hydrocarbon present in crude oil and its products.

MATERIALS AND METHODS

Materials

Six different samples are required for this research as follows: Water, Clay, Plantain Stem, Banana Stem, Diesel and Petrol, plastic containers,

Water Sample

The water samples were collected from water bodies in areas where illegal refining activities were prominent in the Niger Delta as follows: as well as described in Figures and plates.

River Nun Creek in Bayelsa State – Nigeria

River Nun – Source: Google Maps

The river Nun in present day Bayelsa State of Nigeria flows directly from the river Niger. It flows through fresh water and mangrove swamps and finally empties into the Atlantic Ocean at Akassa in Bayelsa State Figure 1.

It was a major source of trade between indigenous people and Europeans in the 19th Century. The advent of oil business would change the activities around this river. The trans Niger oil pipeline and other flowlines crisscross this river making it a source for the illegal refining activities in recent times.

This River was therefore of interest for this research as samples from it will provide a good study for its clean up or remediation when polluted Figures 2–10.

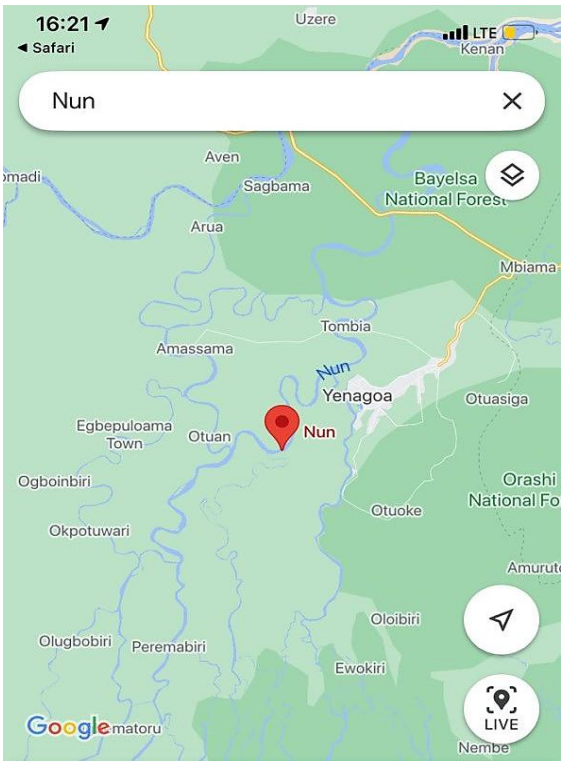

Figure 1. Map of River Nun Creek in Bayelsa State – Nigeria.

Figure 2. Illegal refining activity along the banks of the river Nun.

50 litres of water samples were collected from this river on the 29th September, 2021 as shown below: Figures 3-6.

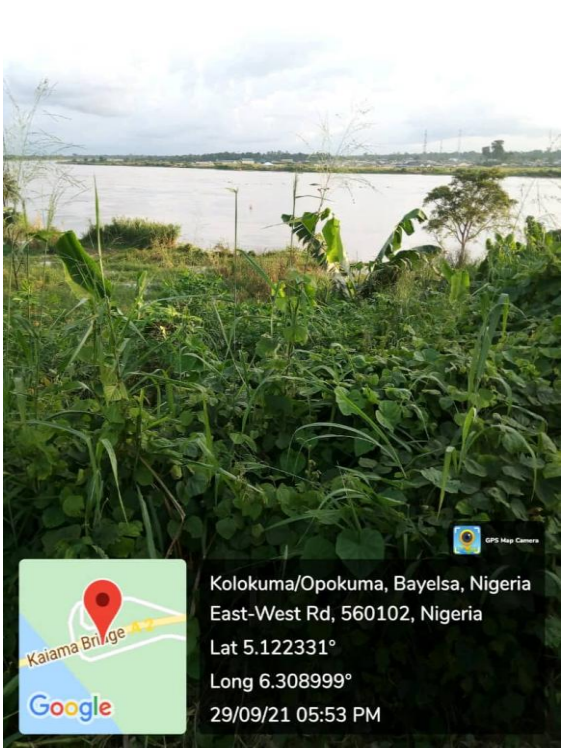

Figure 3. Green Vegetation without Pollution.

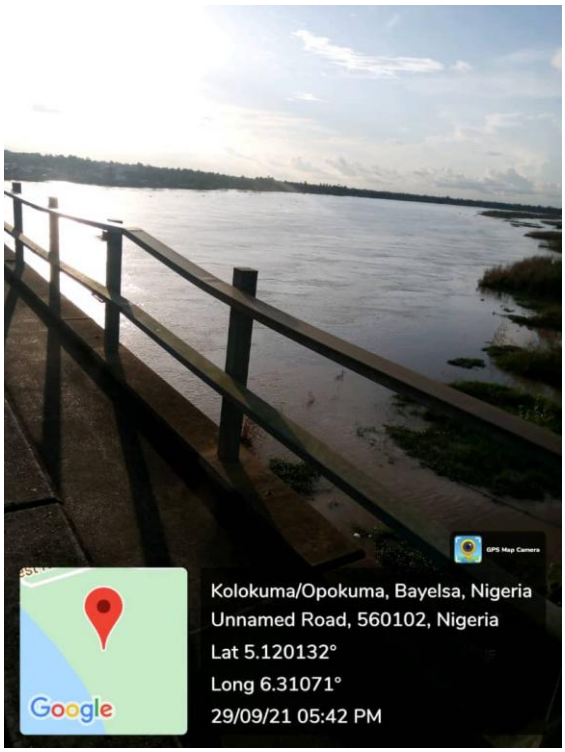

Figure 4. Bodo Creek in Ogoni, Rivers State – Nigeria.

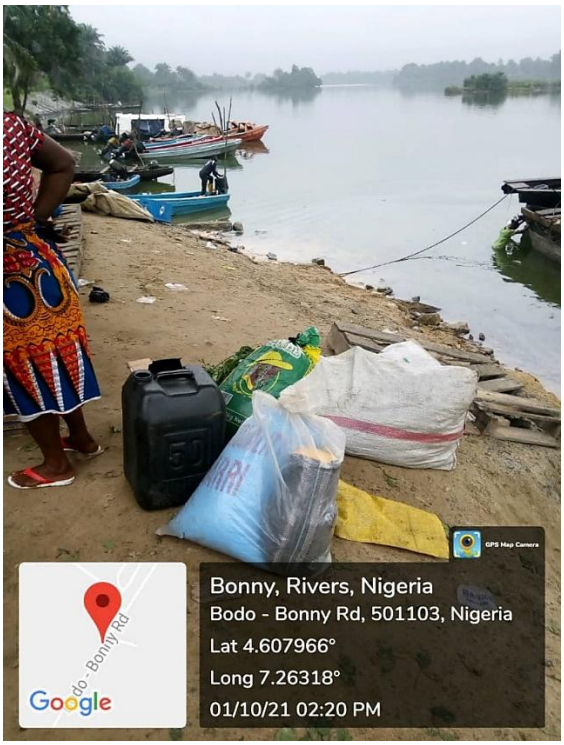

Figure 5. Activities in Sea

Figure 6. Water Samples.

Clay Description

Clay is a type of soil which are deposits created from rocks due to physical, chemical and biological processes. The physical process results from weathering which causes the disintegration of the rock while the chemical process is responsible for the decomposition of the rock through oxidation, reduction and hydrolysis. The soil formed could be transported to other locations. This is typically the history of Niger Delta soils.

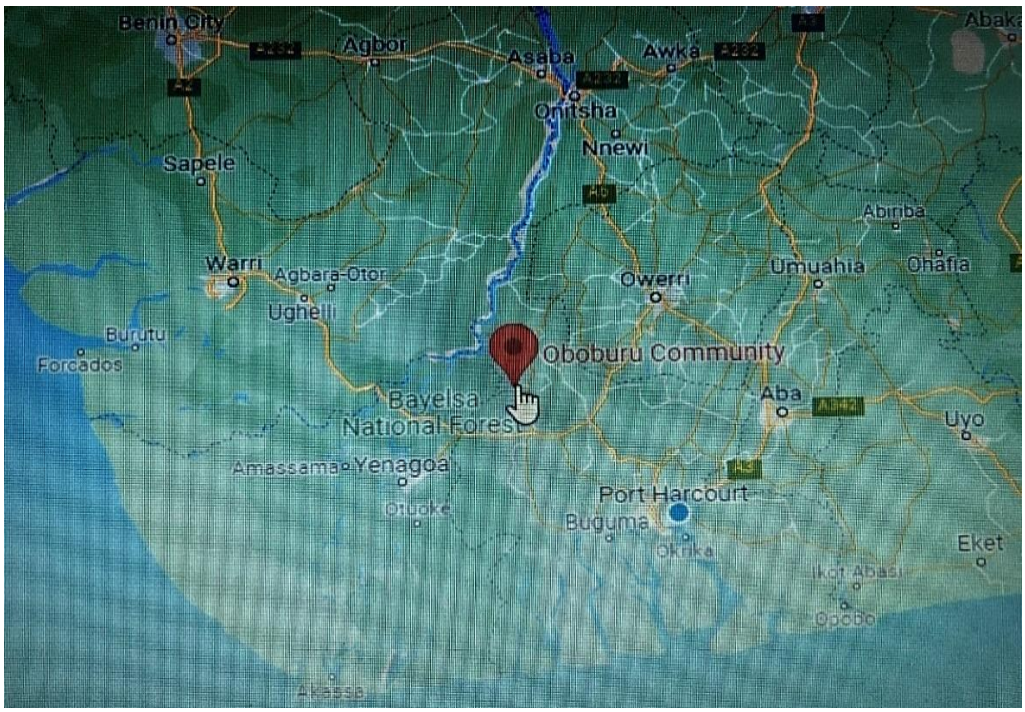

Figure 7. Clay deposits at Oboburu Swamp.

Figure 8. Oboburu Swamp.

Figure 9. Clay Deposit at Oboburu.

Figure 10. Clay Samples.

Clay is a very dominant type of soil in the Niger Delta. Clay is an earthly material that is plastic when moist and hard when fired. It is composed mainly of hydrous aluminium silicate and other minerals. It is formed from sedimentary activity. Clay possesses the following characteristics: They are sticky when wet, they could absorb and hold more water than most other soils and the volume could increase when wet and shrink when dried. The above characteristics lend clay to become a good agent for adsorption and its studies. The clay for this study was obtained from Oboburu community in Ogba/Egbema/Ndoni Local Government of Rivers State. Due to the abundance of this soil, the community is noted for its product of pottery. The clay is predominantly located in swamps around this community.

Plantain and Banana Stem Description

Plantain *(Musa Paradisiaca*) and Banana (*Musa Coccinea*) are tropical edible fruits which abounds in the Niger Delta of Nigeria. They are eaten cooked, boiled, fried or dried. They are known to possess many health benefits. Plantain and Banana stems are mainly made of cellulose fibres. This is the interesting part to this research.

Cellulose fibres have good reactivity and adsorption properties. This work will explore these potentials in a mixture with clay to study the remediation of water polluted with Diesel and Petrol. For the purpose of this study, the samples of Plantain and Banana stems were obtained from their plantations at the Rivers State Agricultural Program (ADP) farm located in Okoro-Odo in Obio/Akpor local Government of Rivers State. This program was established in 1988 to formulate and implement agricultural development programs part of which includes the development of nurseries, varieties and species to support farmers for improved production in agriculture. For the purpose of this research, two varieties each of Banana & Plantain were chosen as follows: Banana – Native Variety, Banana – Ogoni Red Variety, Plantain – Agbagba 1 Variety and Plantain – Ogoni Red Variety.

5meters each of the stalk were taken to the Chemical/Petro-Chemical laboratory of the Rivers State University where they were sliced to 2mm and left at room temperature for 5hours. This is to enable the samples loss its moisture content to at least 0.1% Figure 11.

Figure 11. Slices of Plantain.

Figure 12. Slices of Banana.

Figure 13. Crushed Banana & Plantain.

The dried chips were thereafter crushed in a fine crusher. The crushed particles were packed into airtight plastic containers in the laboratory Figure 12.

The Banana and Plantain samples were sieved into three particle sizes of 150micron, 300microns, 600 microns and 1.18mm Figure 13.

Diesel and Petrol Description

Diesel and Petrol are two kinds of fuel obtained from the fractional distillation of crude petroleum. They are used as fuel for engines. They are pollutants when discharged to water bodies. In Nigeria, Diesel and Petrol are produced in the refineries and distributed to various depots through pipelines. These pipelines are sometimes sabotaged causing large spillages into water bodies causing pollution with its attendant problems. This research is looking into methods of remediation of polluted water using local material of clay, plantain and banana mixtures. For the purpose of this study, Petrol & Diesel samples were obtained from the NNPC Service Station located in Port-Harcourt, Rivers State.

Sampling, Monitoring and Analyses

Each of the sample vessels now referred to as our Reactor were left for the adsorption to take place. The reactors were labelled as follows for identification and sampling purposes:

R_1, R_2, R_3, R_4, R_5 for Reactors 1, 2, 3, 4, 5 respectively and F_W for Fresh Water, S_W for Salt Water, POR for Plantain Ogoni Red, PA1for Plantain Agbagba 1, BOR for Banana Ogoni Red

BN for Banana Native

Therefore, a sample named R_1PORF_WAGO is contained in Reactor 1 with Plantain Ogoni Red and Diesel

Similarly

R_2BNS_WPMS is contained in Reactor 2 with Banana Native in Fresh Water and Petrol

PMS for Petrol

RESULTS AND DISCUSSION

The research showcases the obtained results in terms of Figure as demonstrated below with the aim to compare the percentage removal of iron from water media contaminated with PMS and AGO as well as the effect of particle size mixed ratios.

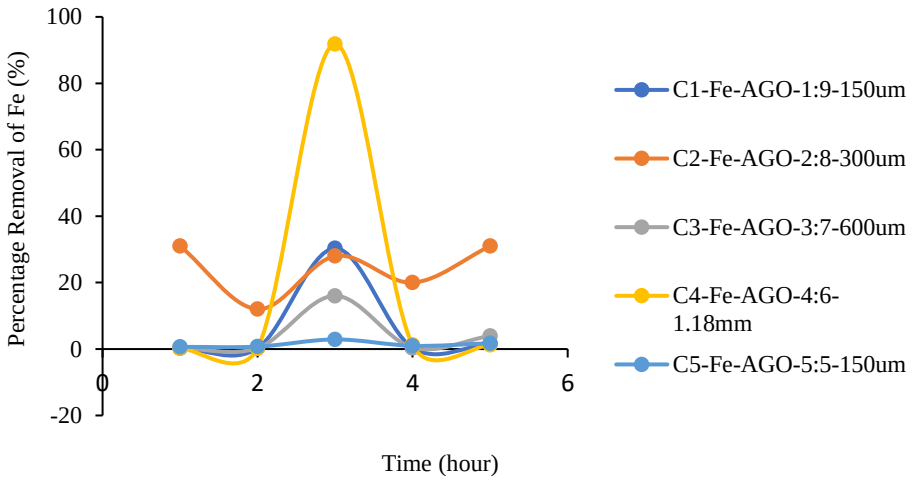

Figure 14. Comparison of Percentage Removal of Iron versus Time for Plantain Ogoni Red in Fresh Water with AGO Pollution of Different Particle Size and Mix Ratios.

Figure 14 showcases the comparison of the percentage removal of iron (Fe) by the formulated adsorbents which was monitored with increase in contact time. decrease in percentage adsorption of iron (Fe) for adsorbent mix ratio of C2-Fe-AGO – 2:8 - 300 µm was experienced before sudden increase was observed for a period of 1 hour starting from 2 hours to 3 hours. But in the cases of adsorbent mix ratios of C1-Fe-AGO – 1:9 - 150 µm, C3-Fe-AGO – 3:7 - 600 µm, C4-Fe –AGO – 4:6 – 1.18mm and C5-Fe-AGO – 5:5- 150 µm demonstrate increase in percentage removal of iron (Fe) from hour 1 to hour 3 before sudden leaching processes was experienced as shown in Figure 14.

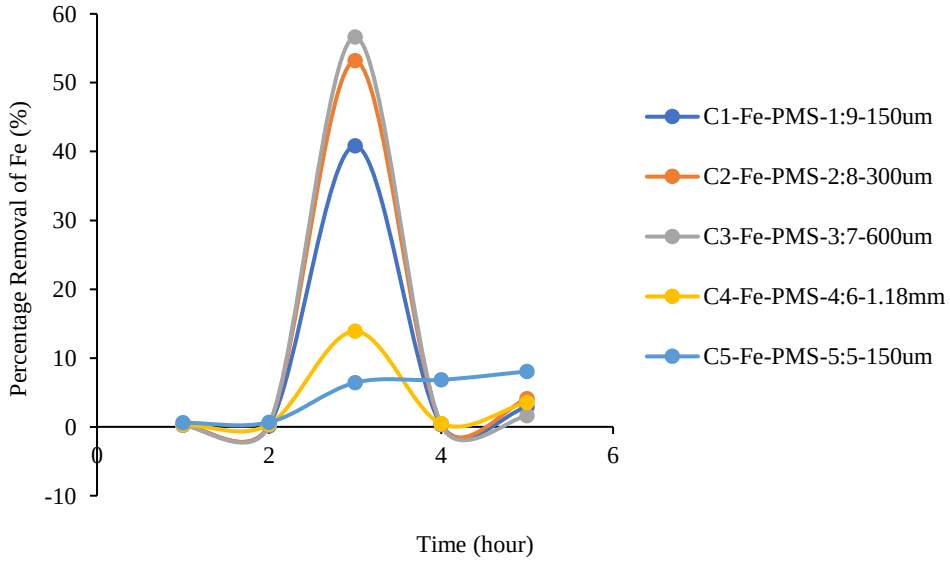

Figure 15. Comparison of Percentage Removal of Iron versus Time for Plantain Ogoni Red in Salt Water with PMS Pollution of Different Particle Size and Mix Ratios.

Figure 15 shows the trend of comparison of percentage removal of iron (Fe) from all the formulated adsorbents immersed in the salt water environment polluted with PMS. The percentage removal of iron

(Fe) with the performance of each adsorbent was monitored with increase in time and the obtained data revealed increase in percentage removal of iron Fe from hour 1 to hour 3 before the characteristics of leaching processes occurred. The adsorbents were made of Plantain Ogoni Red and clay soil.

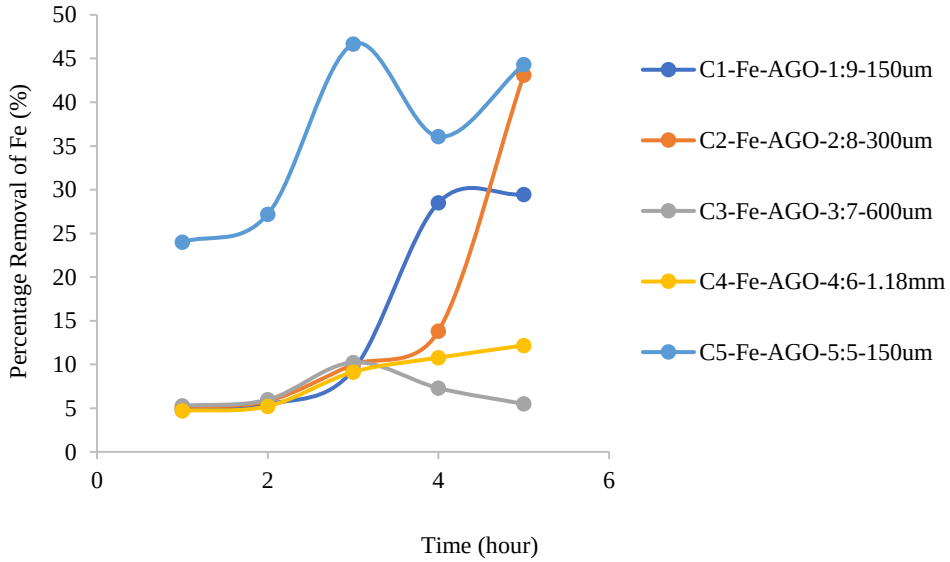

Figure 16. Comparison of Percentage Removal of Iron versus Time for Plantain Agbagba 1 in Fresh Water with AGO Pollution of Different Particle Size and Mix Ratios.

Figure 16 reveals the comparison of the adsorbents used in terms of percentage removal of iron (Fe) from the contaminated fresh water environment with AGO and the process was monitored with respect to increase in time. However, the performance of each adsorbent mix ratio was rated good and possess the characteristics of iron removal in high proportional from the polluted fresh water environment. The adsorbents were made of clay soil and Plantain Agbagba 1.

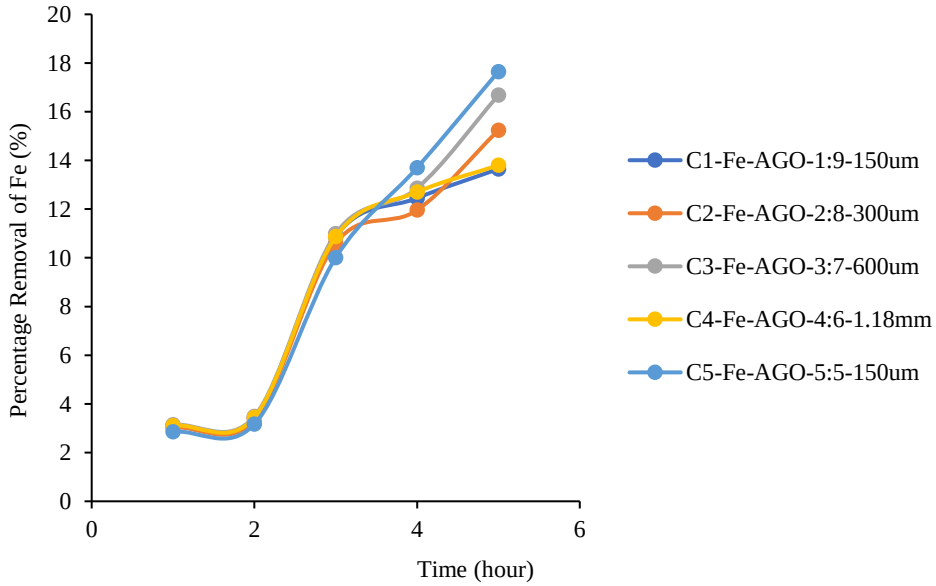

Figure 17. Comparison of Percentage Removal of Iron versus Time for Plantain Agbagba 1 in Salt Water with AGO Pollution of Different Particle Size and Mix Ratios.

Figure 17 shows the comparison of percentage removal of iron Fe by the various adsorbents formulated with increase in time. The data obtained in the efficiency of the formulated adsorbent in

enhancing the increase in percentage of iron Fe removed by the adsorbents immersed in the polluted mixture contained in the containers. No leaching was experienced and the performance of each adsorbent was classified good and was recommended as good mix ratios for iron Fe removal, because of high rating in terms of percentage removal.

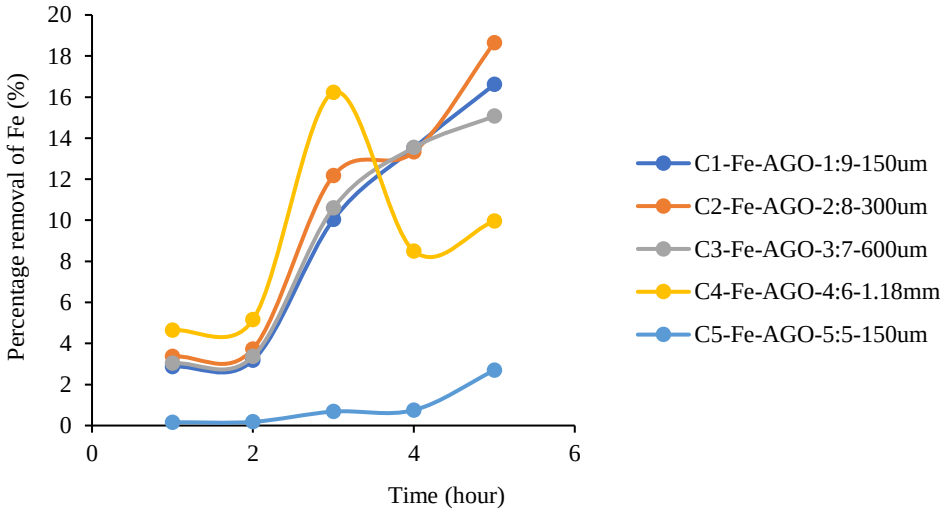

Figure 18. Comparison of Percentage Removal of Iron versus Time for Plantain Agbagba 1 in Salt Water with AGO Pollution of Different Particle Size and Mix Ratios.

Figure 18 showcases the comparison of percentage removal by the adsorbents immersed in polluted salt water environment with AGO and the rating of the percentage removal with respect to the period of exposure (contact time) for various adsorbents formulated. The adsorbents were produced using the clay soil and Plantain Agbagba 1 and data obtained revealed leaching experienced for adsorbent mix ratio of C4-Fe-AGO – 4:6 – 1.18mm after 3 hours whereas other mix ratios performance were rated good, because no leaching was experienced for the period of monitoring the performance of the adsorbents as illustrated in Figure 18. Indeed, the performance of the following adsorbents are close C2-Fe-AGO- 2:8 - 300µm, C3-Fe-AGO – 3:7 - 600µm, C4-Fe-AGO – 4:6 – 1.18mm and C5-Fe-AGO – 5:5 - 150µm compared to C1-Fe-AGO – 1:9 - 150µm.

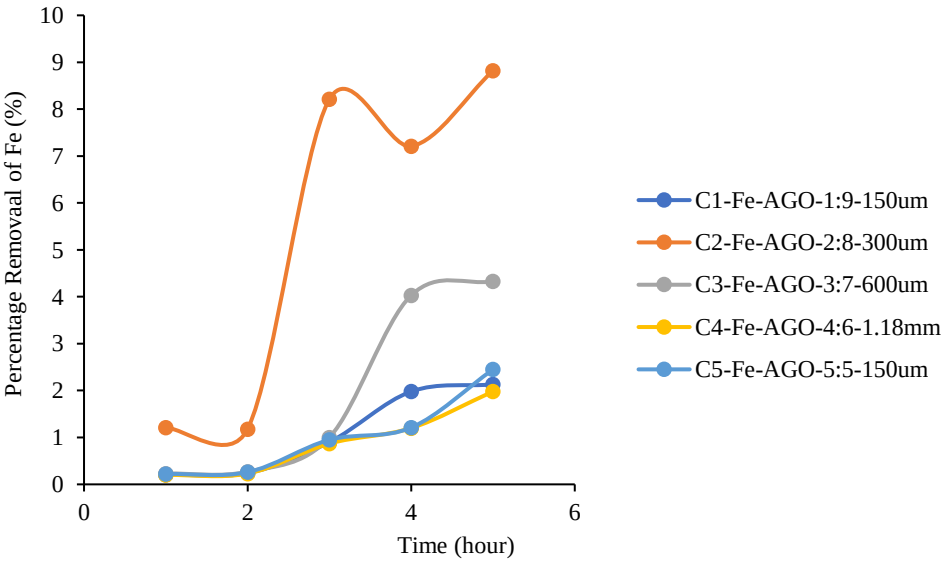

Figure 19. Comparison of Percentage Removal of Iron versus Time for Banana Ogoni Red in Fresh Water with AGO Pollution of Different Particle Size and Mix Ratios.

Figure 19 shows the comparison of percentage of iron (Fe) removal from fresh water environment polluted with AGO. Increase in percentage removal of iron (Fe) was achieved with increase in contact time, before slight leaching was observed for mix ratio of C2-Fe-AGO – 2:8 - 300µm whereas other show close range of value in terms of percentage removal of iron Fe in each contaminated container as demonstrated, which include C1-Fe-AGO – 1:9 - 150µm, C3-Fe-AGO – 3:7 - 600µm, C4-Fe-AGO- 4:6 – 1.18mm and C5-Fe-AGO - 150µm. The results obtained in this case revealed that all the formulated adsorbents are rated good and possess the potential of adsorbing iron Fe from fresh water environment polluted with AGO. The adsorbent produced was made of Banana Ogoni Red and clay soil.

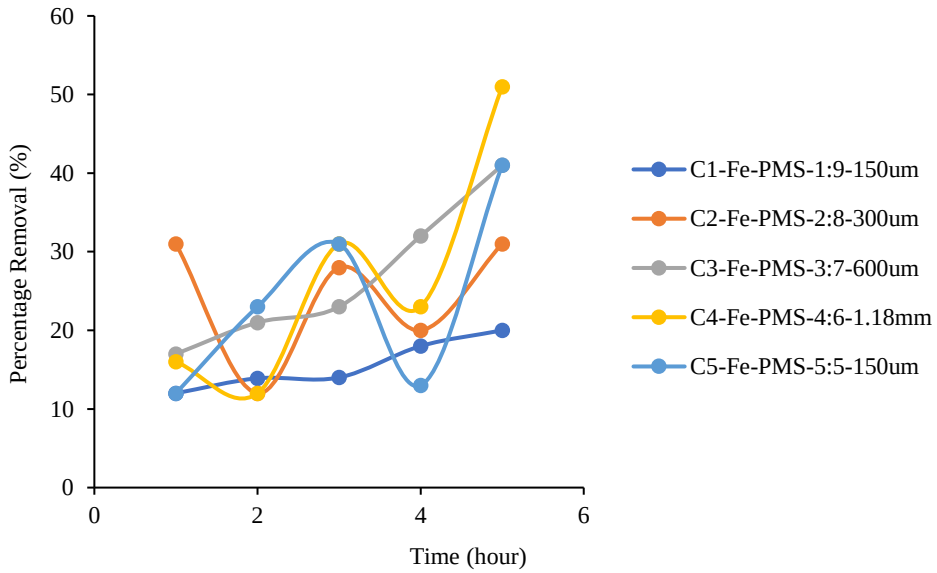

Figure 20. Comparison of Percentage Removal of Iron versus Time for Banana Ogoni Red in Salt Water with PMS Pollution of Different Particle Size and Mix Ratios.

Figure 20 showcases the comparison of the percentage removal of iron (Fe) from salt water environment contaminated with PMS. The process was monitored with increase in period of exposure (contact time) and the result obtained illustrates increase in percentage adsorption of C1-Fe-PMS – 1:9 - 150µm and C2-Fe –PMS – 2:8 - 300µm when compared with C3-Fe-PMS – 3:7 - 600µm, C4 – Fe-PMS – 4:6 – 1.18mm and C5-Fe –PMS – 5:5 - 150µm which demonstrates occurrence of leaching processes in the case of percentage removal. The adsorbent obtained was made of clay soil and Banana Ogoni Red.

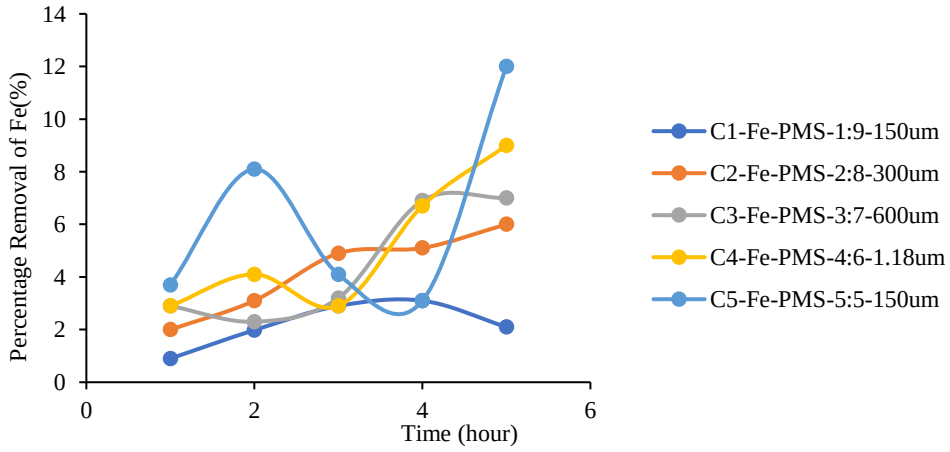

Figure 21. Comparison of Percentage Removal of Iron versus Time for Banana Ogoni Red in Fresh Water with AGO Pollution of Different Particle Size and Mix Ratios.

Figure 21 showcases the comparison of percentage removal of iron Fe from the fresh water environment polluted with PMS and the process was monitored with increase in time. Indeed, the percentage removal of Iron (Fe) was significant of mix ratio of C1-Fe-PMS- 1:9 - 150µm followed by C5-Fe-PMS – 5:5 - 150µm whereas other experienced leaching which include C2-Fe-PMS – 2:8 - 300µm, C3-Fe-PMS – 3:7 - 600µm and C4-Fe-PMS – 4:6 – 1.18mm. The performance of each adsorbent was rated good and possess the characteristics and potential of adsorbent. The adsorbents were made using clay soil and Banana Ogoni Red.

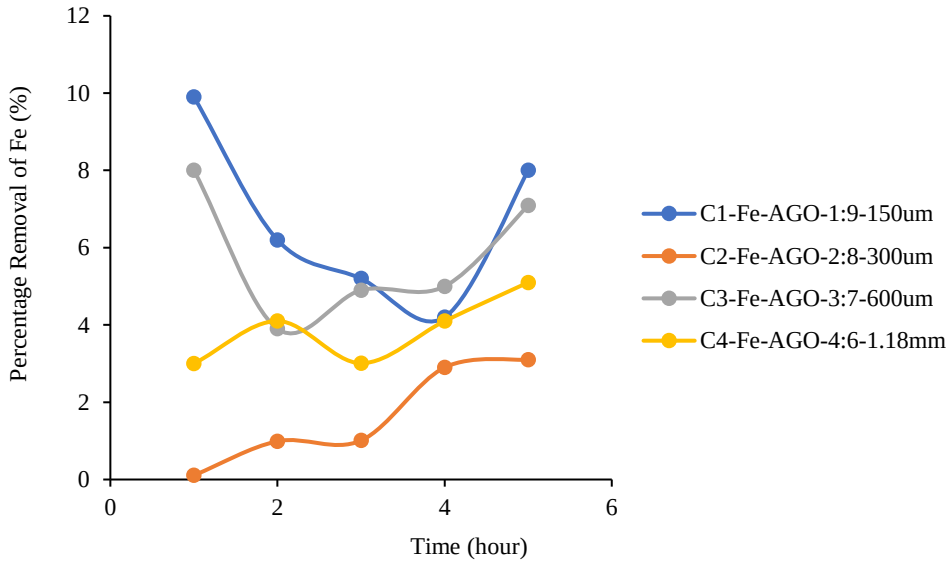

Figure 22. Comparison of Percentage Removal of Iron versus Time for Banana Native in Salt Water with AGO Pollution of Different Particle Size and Mix Ratios.

Figure 22 shows the comparison of percentage removal of iron Fe from salt water environment polluted with AGO and the percentage removal of iron (Fe) was monitored with increase in time of sampling. However, the mix ratios of C2-Fe-AGO – 2:8 - 300µm shows a better result followed by C4-Fe-AGO- 4:6 – 1.18mm compared to the mix ratios of C1-Fe-AGO – 1:9 - 150µm and C3-Fe-AGO – 3:7 - 600µm which demonstrate decrease in percentage of iron Fe removed by each adsorbent. The adsorbents in this case is obtained by mixing clay soil with Banana Native (BN).

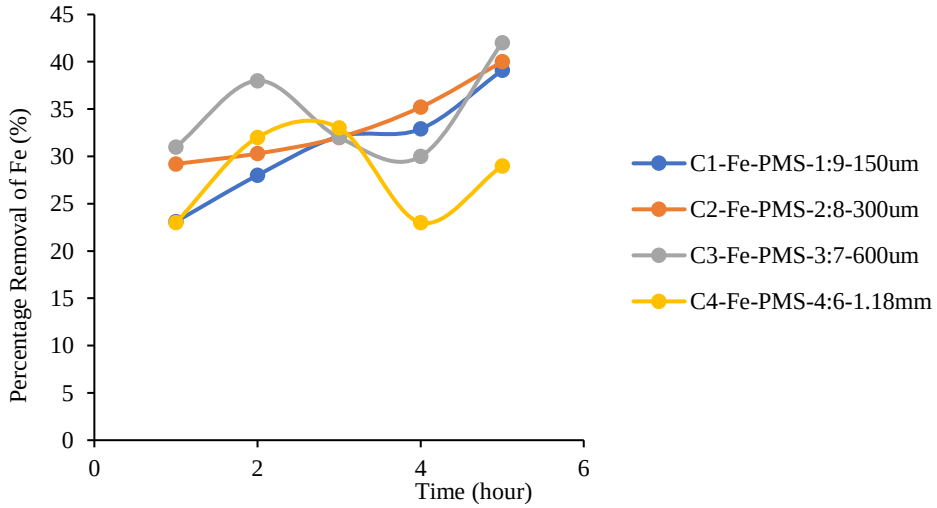

Figure 23. Comparison of Percentage Removal of Iron versus Time for Banana Native in Salt Water with PMS Pollution of Different Particle Size and Mix Ratios

Figure 23 shows the comparison of adsorbent performance in iron (Fe) removal in terms of percentage rating. The data revealed smooth percentage removal by the adsorbent mix ratio of C1-Fe-PMS – 1:9- 150µm followed by C2-Fe-PMS – 2:8 - 300µm whereas the C3-Fe-PMS – 3:7 - 600µm and C4-Fe –PMS – 4:6 – 1.18mm demonstrates leaching in the process. The percentage removal of iron Fe shows very close result and the performance of the adsorbents were rated good, because of their characteristics and potential possess by each adsorbent. The adsorbents were produced using clay soil and Banana Native (BN).

CONCLUSION

This research has revealed the following contributions to knowledge as demonstrated below:

i. The clay soil mixed with agro-based of Plantain Agbagba 1 (PA1) of mix ratio of C4 – S -AGO - 4:6 – 1.18mm (99.5%) immersed in salt water medium performance is higher than any other formulated adsorbent in sulphur (S) removal, whereas for iron (Fe) it is Plantain Ogoni Red (POR) of mix ratio of C – Fe – AGO – 4:6 -1.18 mm (95%) in fresh water environment. Furthermore, in terms of PMS the adsorbent formulation of C3 – NH3 – PMS – 3:7 - 600 µm of 60% possesses the highest potential in ammonia removal in salt water and 58% for iron (Fe) of mix ratio of C3 – Fe – PMS – 3:7 – 600 µm.
ii. The formulated adsorbents were able to withstand its strength in water environment without dissolving, but possesses the characteristics of adsorbing the liquid contaminant.
iii. The research further addresses the significance of clay soil and some of the agro-based materials used in the formulation of the adsorbents as well as its effectiveness in removal of AGO and PMs in extension polar solvent in fresh and salt water environment.
iv. The concept of varying the mix ratios of clay and agro-based materials was to select the most suitable adsorbent for treatment of AGO and PMS in water medium. The research revealed that the formulated with high percentage of clay soil in mix ratio performed well compared with the once with low or equal mix ratio.

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