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Study of Wastewater Filtrate Properties from Melon Husk Bio-sorbents

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Abstract. Industrial wastewater is a major source of water pollution when discharged in marine habitats without adequate treatment. Chemical treatment of wastewater is expensive, demanding other alternative sources especially from waste materials. In this study, the feasibility of using melon husk (MH) and melon husk bio-char (MHB) to improve the properties of oilfield produced water (OFPW) was investigated. The OFPW was contacted with the MH and MHB through a fixed bed column and filtrates were collected after 30, 60, 90 and 120minutes.

Properties of the OFPW were determined before and after contact with the bio-sorbents. The properties determined were pH, oxidation reduction potential (ORP), total dissolved solid (TDS) and turbidity. Generally, the MHB gave better results than the MH but the TDS were high. Further tests that were thus conducted on the OFPW and only on the MHB filtrate after 120minutes of contact time include biological oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), dissolved oxygen (DO) and concentrations of three heavy metals; cadmium, lead and nickel. Results showed that MHB contains the three heavy metals considered and as such could not reduce their concentrations in the wastewater but it was efficient in drastically reducing the BOD of the OFPW. The MHB failed to reduce the COD and TOC of the wastewater because the TDS was high since the bio-char introduced more dissolved chemicals into the OFPW. Hence, MHB should be used with caution for wastewater treatment but is recommended for elimination of physical pollutants from wastewater.

Keywords. Oilfield produced water, heavy metals, turbidity, concentration, oxygen, pollutant.

INTRODUCTION

Wastewater is a major industrial effluent that is peculiar to the manufacturing, mining, petrochemical and petroleum industries. These industrial wastewaters usually contain chemical contaminants that pollute the environment when disposed without treatment. In the petroleum industry, oilfield produced waters are sources of water pollution when such poorly treated waters are discharged in water bodies such as streams, rivers and oceans. This is because oilfield waters contain compounds that impact negatively on human health, aquatic lives and the ecosystem; it also degrades the marine environment. One reason why oilfield produced waters constitute serious environmental challenge is because of the large scale involved and frequency of production. It is therefore imperative that the subject of produced water treatment be considered because of its composition. It has been reported that oilfield waters contain environmentally degrading composition such as radioactive elements, heavy metals and low molecular weight aromatic hydrocarbons such as benzene, toluene, and xylene (Hedar et al., 2018, Eyankware et al., 2016, Marchant et al., 2019 and Maftouh et al., 2023).

Chemical treatment of produced oilfield waters in order to minimize its hazardous composition is very expensive. The inadequate treatment of produced water can partly be attributed to the high cost of treatment considering the daily enormous volumes of water to be handled and the high cost of chemicals and treatment processes. This no doubt has posed a big challenge to oil and gas producing companies, rendering treated produced water unsuitable for disposal because of its short falls in meeting environmentally approved standards for disposal (Amakiri et al., 2023 and Abbas et al., 2021). It is therefore important to source for cheap, available, effective and eco-friendly materials such as agro wastes, wild plants, grasses and weeds for use in produced oilfield water treatment. In this work, the feasibility of using melon husk and its bio-char to improve the quality of oilfield produced water obtained from the Niger Delta region of Nigeria is investigated.

USE OF MELON HUSK AS ADSORBENTS IN WATERTREATMENT

It has been reported that melon husk has the capacity to reduce or eliminated contaminants from wastewater. The feasibility of melon husk to serve as an absorbent capable of removing zinc from aqueous solutions has been studied. The melon peel was activated using phosphoric acid and zinc chloride. It was observed that the percentage removal of Zn II increased with increase in time up to 70 minutes (Anitha et al., 2017). In another work, melon husk activated with urea was used for adsorption of lead from a simulated industrial effluent. The highest sorption of 97.6% occurred in the first twenty minutes (Nwankwo et al., 2020). In a similar work too, melon husk was activated with sodium hydroxide and used for lead adsorption from waste water. It was observed that the removal of lead ion from waste water does not depend on time (Nwankwo et al., 2024).

Melon husk can be activated using various acid compounds and the type of activation compound used affects its adsorption performance. Activated melon husk with NaOH, H_2SO_4 and $Co(NH_2)_2$ were used for the adsorption of iron and lead ions from water. The study showed that melon husk is suitable for use as an adsorbent but the removal rate of metals varies with contact time and type of activation method deployed (Ajala et al., 2020). Potassium chloride has also been used to activate melon seed husk for use in adsorption of chromium VI from waste water and it was concluded that activated carbon from melon husk is an efficient adsorbent for removal of Cr (VI) ion from waste water (Bernad et al., 2021). A study on the use of modified melon husk using H_3PO_4, NaOH and CH_4N_2O for adsorption of

Pb^{2+} and Cd^{2+} shows that melon husk is effective in the removal of Pb^{2+} and Cd^{2+} from waste water. It was however recommended that H_3PO_4 be used for the modification of melon husk because its adsorption capacity for heavy metals is better (Ogbozige et al., 2020).
The use of bio-chars for environmental remediation and wastewater treatment has drawn the attention of environmental scientists because its low cost of production. Research has shown that bio-chars have the potential to act as a good adsorbent in wastewater treatment and it can be used to control micro pollutants in water (Kearns et al., 2021 and Anderson, 2017). Bio-char is advantageous because it is inexpensive to produce but their sorption capacity varies and this depends on the biomass source, method and temperature of production.

MATERIALS AND METHOD OF STUDY

In this work, oilfield produced water (OFPW) was obtained directly from a separator in an oilfield in the Niger Delta region of Nigeria and its properties were determined. Melon husk (MH) powder and melon husk bio-char (MHB) were used to filter the water and all the water properties determined from the wastewater before filtration were also determined after 30, 60, 90 and 120 minutes contact time with the MH and MHB. The melon husk was first sun dried for four weeks and grinded into powder. The grinded powder of the melon husk was divided into two; one set was heated in the oven for 10minutes to destroy any micro-organisms that may have infested it, while the other set was turned into bio-char by a slow pyrolysis process. The two sets of bio-sorbents were sieved and stored in plastic containers after preparation. Figs. 1A and 1B are the samples of the melon husk powder and bio-char respectively.

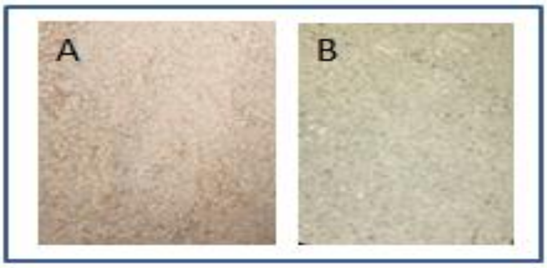

Fig. 1. Dried and grinded (A) Melon Husk Powder and (B) Melon Husk Bio-char.

The capacity of the bio-sorbents to improve the quality of the OFPW was investigated using the fixed bed column arrangement which enhances water contact with the bio-sorbent particles. Water sample filtrates were taken at regular intervals of 30minutes for two hours (30mins, 60mins, 90mins and 120mins) at a constant room temperature of 28.8^{o}C.
Properties of the OFPW were determined before and after filtration through the bio-sorbents (melon husk powder and melon husk bio-char). The water parameters obtained were pH value, total dissolved solid (TDS), oxidation reduction potential (ORP) and turbidity. Further investigations were carried out only on the MHB because its pH values, ORP and turbidity results were better than results obtained from the melon husk powder. Additional tests conducted on the OFPW filtrates from the MHB after a contact time of 120minutes are dissolved oxygen (DO), biological oxygen demand (BOD), chemical Oxygen demand (COD) and total organic carbon (TOC). The capacity of the adsorbent to reduce cadmium, lead and nickel from the wastewater was also investigated.

RESULTS AND DISCUSSIONS

Results of the water quality tests conducted on the oilfield water are presented in Figs. 2 to 9. The pH value results of the wastewater filtrates from the melon husk (MH) and melon husk bio-char (MHB) are presented in Fig. 2. Results show that the pH values of the oilfield water filtrates from the MH which range between 7 to 8 are lower than the pH of the OFPW (which is 8.83) and filtrates from the MHB which range approximately around 9. Interestingly, all the pH values of the wastewater and filtrates are above 7, making them non acidic.

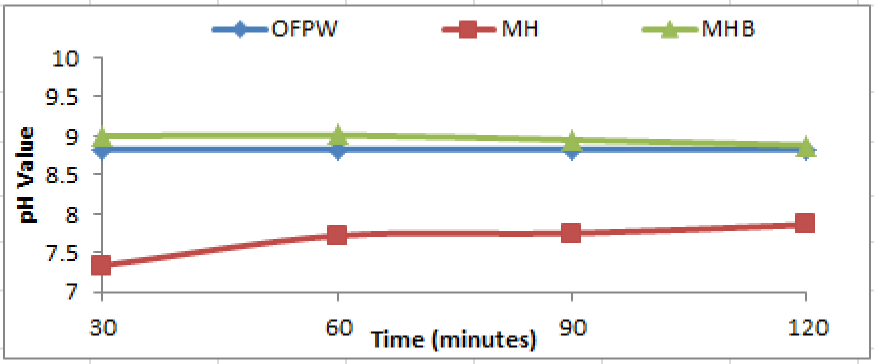

Fig. 2.Results for the pH Values of the Wastewater and Filtrates from the MH and MHB.

Results of the total dissolved solids (TDS) from the oilfield water and filtrates from MH and MHB are presented in Fig. 3. The TDS values of filtrates from the MHB are higher than those of the MH, and the TDS values of filtrates from the MH are higher than the TDS of the oilfield water. This means that both the MH and MHB have dissolved solids that increased the amount of dissolved solids in the OFPW. It is also observed that the TDS of MHB consistently decreased with time. Since the bio-sorbents have their own salts and other dissolved solids, the implication is that if reduction of salt content and TDS are criteria in a wastewater treatment process, all the bio-sorbents will require further processing to eliminate their salt contents and other dissolved solids before use.

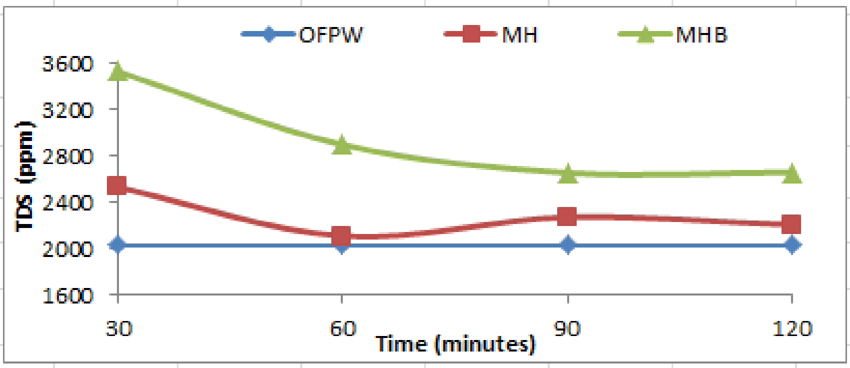

Fig. 3.Results for TDS Values from the Wastewater and Filtrates from MH and MHB.

The oxidation reduction potential (ORP) results of the wastewater and filtrates from the MH and MHB are presented in Fig. 4. The ORP is a critical parameter because it indicates the ability of the water to clean itself; positive and negative values indicate oxidizing and reducing environments respectively. The ORP of the filtrates are all positive, implying that they are oxidizing agents, and they are all higher than the ORP of the wastewater. The ORP of the MH is approximately linear, decreasing with time while that of MHB increased with time up to 90minutes and are the highest values except at 30minutes.

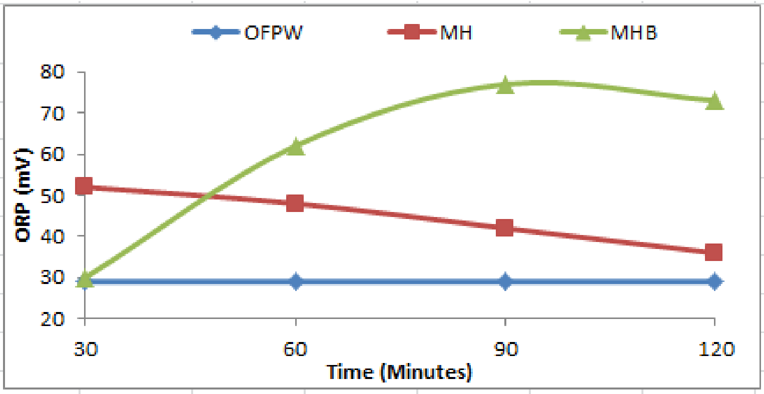

Fig. 4.Results for the ORP of the Wastewater and Filtrates from the MH and MHB.

Results of turbidity of the OFPW and filtrates from the MH and MHB are presented in Fig. 5. Turbidity is a physical property that shows how clear and clean a liquid is, devoid of particles, colloids and suspensions. For water, this property indicates physical cleanliness. For turbidity, very low values are desired since high values indicate pollution and contamination. The results show that the physical level of pollution of the OFPW is high, but the water got physically clearer and cleaner after contacting the MH and MHB because the pollutants are adsorbed onto the bio-sorbents. In fact, the results show that MH and MHB are good adsorbents that eliminate suspended particles from water but the MHB performed better.

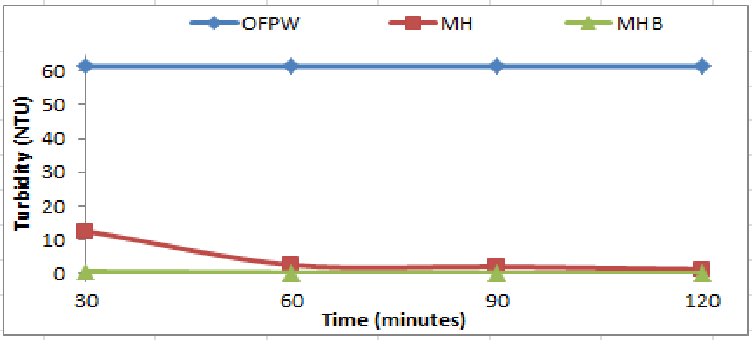

Fig. 5. Results of Turbidity of the Wastewater and Filtrates from the MH and MHB.

Filtrates obtained from the bio-sorbents after 2hours of contact time is presented in Fig. 6. Generally, the MHB gave a better water quality in terms of turbidity, meaning that it has a better adsorption capacity for physical pollutants than its counterpart biomass that was not converted to bio-char. After 2hours of contact time, MHB recorded the lowest turbidity value of 0.2NTU which is very clean as shown in Figure 6. It can be observed that the MHB was able to eliminate colour from the wastewater than the MH which may have added colour to the OFPW from the MH biomass.

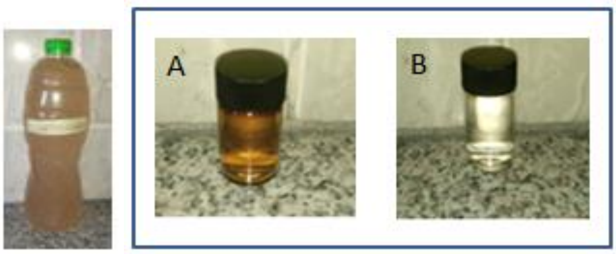

Fig. 6. Turbidity of Filtrates after two hours contact time for (A) MH and (B) MHB.

The percentage physical particles adsorbed by the bio-sorbents, thereby eliminating particles from the OFPW are presented in Fig. 7. It is clear from the result that MHB is more efficient in eliminating physical pollutants from the OFPW than the MH with 99.67% of particle removal after two hours. It is observed that adsorption tends to increase with time for the bio-sorbents.

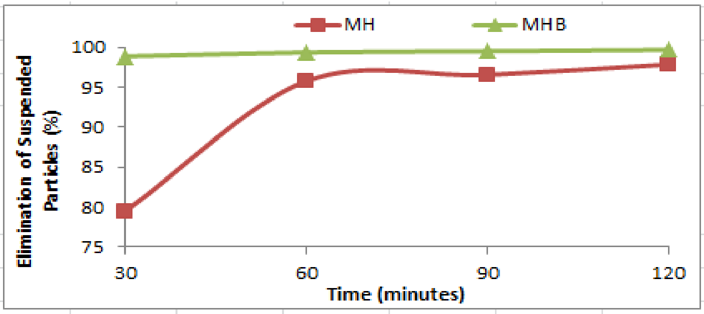

Fig. 7. Percentage of Physical Pollutants Eliminated from the OFPW by the MH and MHB.

Further water quality tests on the organic properties and heavy metal content of the filtrates were conducted for the MHB after two hours of contact time because it gave betters results in terms of pH values, ORP and turbidity. Results of the dissolved (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) and total organic carbon (TOC) of the OFPW and filtrates from the MHB are presented in Fig. 8. It can be observed that the DO in the MHB filtrates is very insignificant instead of increasing as desired which is probably because of the oxidizing characteristics of the bio-char.

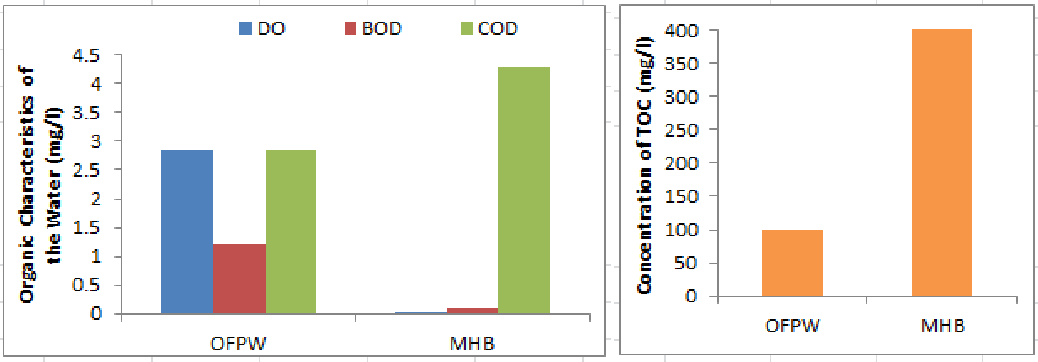

Fig. 8.The DO, BOD and COD of the OFPW and Agro-waste Bio-char Filtrates.

It is also observed that the bio-char was able to drastically reduce the BOD of the OFPW which is very good. But the COD of the filtrate increased instead of reducing which can be attributed to the increased chemical content of the wastewater introduced by the bio-char. Hence, the bio-char was able to drastically reduce the BOD of the OFPW but was not able to reduce the COD and TOC, and was not able to increase the level of DO. The TOC of the OFPW filtrate from the MHB increased because the bio-char introduced more carbon content into the water which is probably why the TDS of the filtrate (Fig. 3) increased. This implies that the bio-char increased the chemical loads in the water which is also the reason why the COD values increased, instead of reducing.

The three heavy metals considered in the OFPW were Cadmium, Lead and Nickel. Results of the concentrations of these heavy metals in the OFPW and MHB filtrate are presented in the first part of Fig. 9. The results show that MHB increased the concentration of all three heavy metals in the OFPW instead of reducing them. This implies that the MHB contains all three heavy metals and introduced them into the OFPW, thereby increasing their concentrations in the wastewater. The second result shows that the MHB added 8.56%, 3.85% and 3.46% of cadmium, lead and nickel to the OFPW respectively.

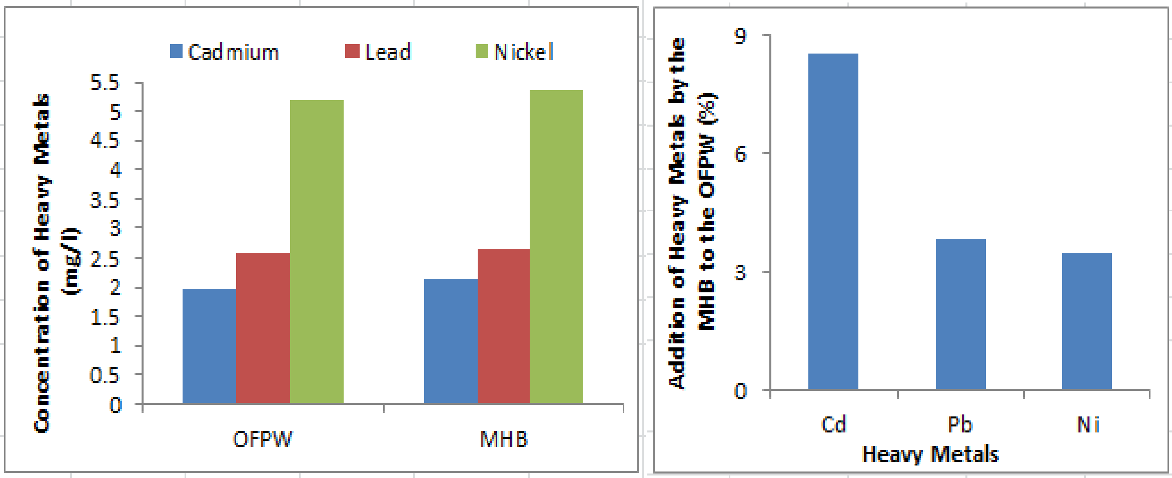

Fig. 9. Heavy Metals in the OFPW and MHB Filtrates, and Additions from the MHB.

One implication of this study is that MHB contains cadmium, lead, nickel and possibly other heavy metals and dissolved solids that were not determined in this study. Therefore, in trying to eliminate heavy metals from wastewater using MHB, there is a possibility of the reverse process taking place if the bio-char contains heavy metals. It is therefore necessary that the heavy metal content of MHB be investigated and determined if it must be considered for use in wastewater treatment. Hence, caution should be exercised in the use of MHB for wastewater treatment, soil improvement and environmental remediation because it contains heavy metals.

CONCLUSION

The wastewater filtrates from MH and MHB show that the bio-sorbents are non-acidic; they are oxidizing agents and are good agents for eliminating physical pollutants and suspensions from wastewater. MHB is more efficient than its biomass in improving the physical quality of wastewater but it has high TDS, COD and TOC and cannot increase the DO level of wastewater. MHB can drastically reduce the BOD of OFPW. MHB did not reduce the concentrations of cadmium, lead and nickel from the OFPW rather it increased their concentrations because it contains these heavy metals. MHB should be used cautiously in wastewater treatment because it contains heavy metals. MHB is recommended for effective elimination of physical pollutants and suspensions from oilfield produced waters and for reducing the BOD.

However, it is not recommended for reducing the TDS, COD, TOC and increasing DO in an OFPW. It is not also recommended for elimination of heavy metals such as cadmium, lead and nickel from wastewater because it contains these heavy metals. Hence, MHB should be used cautiously in wastewater treatment and environmental remediation.

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