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Full Length Research Article

PERFORMANCE OF COCOPEAT AND ASH AS A BIOFILTER USED IN TREATMENT OF LANDFILL LEACHATE

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ABSTRACT
The performance of the bio filter produced from cocopeat and ash as a medium for treating industrial landfill leachate was determined through identifying a criteria necessary for a scale up design of the bio filter by optimization using various concentration of peat-ash in ratio (20:80, 40:60, 50:50, 60:40, and 80:20) to find out the effectiveness of the bio filter in the adsorption study. Adsorption kinetics of the bio filter was determined using Langmuir and Freundlich adsorption isotherm models and then the bio filter(s), before and after treatment with leachate were characterized using the Scanning Electron Imaging – Electron Dispersive X-ray Imaging (SEM-EDX) technique. The two equilibrium models namely, Langmuir and Freundlich fit well to the isothermic experimental data for this study with the regression coefficient of 0.5261 and the maximum uptake capacity of the bio sorbent was estimated to be 0.2457g/g which indicates a favourable adsorption by the bio filter. The SEM and EDX imaging showed a high reduction in pore sizes on the bio filter with 50:50 coco-peat to ash concentration in ratio having the least pores on its surface after treatment with leachate where an increasing property was first observed in the concentration 40:60 of coco-peat to ash after treatment, and uptake of Elements (Na) was also observed on the peaks of its EDX spectra. This study concludes that the bio filter produced from cocopeat and ash is effective, and since cocopeat is freely abundant, locally available, also a low-cost adsorbent and has a considerable high adsorption capacity, it may be treated as economically viable for removal of metal ions from industrial landfill leachate.

Keywords: Cocopeat, Ash, Landfill Leachate, Bio Filter, Adsorption.

INTRODUCTION

Landfills have been identified as one of the major threats to groundwater resources worldwide (Amadi *et al*., 2012). The solid wastes disposed in landfills and open dumps are subjected to groundwater underflow, infiltration from precipitation and any other possible infiltration of water (Mor *et al*., 2006).

During rainfall, the dumped solid waste receives water and the by-product of their decomposition moves into the groundwater through water deposition. The liquid containing innumerable organic and inorganic compounds is called the ‘leachate’. This leachate accumulates at the bottom of the landfill, percolates through the soil and reaches the groundwater (Mor *et al*., 2006).

Leachates percolating into the groundwater is a mixture of highly complex contaminants such as potentially toxic metals e.g. lead, mercury, cadmium, chromium etc. ; persistent organic pollutants (POPs) e.g. dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers PBDEs etc.; inorganic compounds, such as ammonium, sulphates, chlorides as well as bacterial contamination – total coliform and feacal coliform (Galarpe and Parilla; Longe and Balogun, 2010; Mor *et al*., 2006;Oyeku and Eludoyin, 2010; 2012). If not handled properly, leachate migration can affect the soil, the aquatic ecosystem, cause human health problems from poisoning such as heart diseases, teratogenic abnormalities and cancer, it also can be of ill to the environment (Su, 2008). Leachate must be located and contained to prevent these occurrences.

Although the dumping culture in Abuja is not as bad as it is in Lagos, Kano or Ibadan cities which are the most populous cities in Nigeria, Abuja is fast becoming populous and the concerns for dumps are highly increasing. Abuja was established in 1976. It is the capital of Nigeria and is part of the Federal Capital Territory (FCT). It was initially developed in agreement to a Master Plan devised in 1979. This apportioned 2.0% of the FCT area for government activity/usage, 49.0% for residential development, and 32.5% as open/green/recreational areas to add to the aesthetics of the city, with the remaining land (16.5%) being used for ancillary services, light industries, other infrastructure and commercial activities (Imam *et al*., 2008). The Abuja master plan was designed to stimulate growth and provide an opportunity to avoid many of the problems associated with unplanned growth associated with other cities in Nigeria.

Federal Government establishments relocated to Abuja during the 1990s, and all embassies, the headquarters of many national and multinational corporations and many national newspapers are now in Abuja. This rapid expansion far exceeded what had been anticipated in the Master Plan, and the population of Abuja now exceeds the original design capacity. In 1991 the population of the FCT was 378,671, and this had increased to 1,724,205 by 2001. Projected population figures for the Abuja region predict massive growth with 5.8 million people expected by 2026 (Federal Ministry of Environment Report, FMER, 2004). Unfortunately, the opportunity to develop infrastructure (including that for waste management), in phase with city growth and in line with a pre-agreed Master Plan, was lost, and Abuja now shares many of the same problems as other Nigerian cities. Abuja has quite a number of dumpsites scattered indiscriminately around the city due to the unprecedented boom in population and the constant migration from rural areas in search for greener pastures which has given rise to a great number of slums around the city. The Mpape dumpsite was the major site used as landfill for the Federal Capital Territory before relocating to Gosa, around 2006 when the site was filled up (Magaji, 2020), thus this study was performed to examine the effectiveness of natural materials, i.e. coconut peat (Coco-peat) and Ash for heavy metal removal from leachate of Gosa landfill site.

Coco-peat is a multipurpose growing medium made out of coconut husk. The fibrous coconut husk is pre washed, machine dried, sieved and made free from sand and other contaminations such as animal and plant residue (Sawant *et al*., 2020). Coco-peat is a very good alternative to traditional peat moss and rock wool. Its air filled porosity and high water holding capacity makes it, an ideal growing medium for the plant crops. It is 100% organic and eco-friendly, free from soil borne pathogen and weed. It has a pH of 5.7 – 6.5, ec level <1 ms/cm is ideal for plant growth (De, 2020).

MATERIALS AND METHODS

Collection of Sample

Coco peat blocks were purchased from Abart Agro Agricultural Company, Lagos. Nigeria While Ash was gotten from local traditional food vendors in FCT, Abuja. Nigeria. The leachate sample was treated through optimizing the bio filter by combining peat to ash in 5 different concentrations in order to determine the effectiveness of coco peat and ash as an adsorbent in accordance with the procedure used by Detho *et al*. (2021).

Table 1: Coco Peat to Ash in ratio

RATIO	COCOPEAT(g)	ASH(g)
20:80	2	8
40:60	4	6
50:50	5	5
60:40	6	4
80:20	8	2

Exactly 10g filter media was prepared using a mixture of cocopeat and ash in varying ratios, which were then each grounded together for more homogenous mixture using a mortar and a pestle.

Swelling Measurement of used filter media

The pre-weight (Wd) 10g each samples (COCOPEAT + Ash) of different ratios was placed into a 100ml leachate water and left to reach equilibrium for 24 hours at room temperature. The fully adsorbed filter media was then taken out and placed on a filter paper to remove excess water and then measured immediately.
The swelling percent (S %) was calculated from the following equation:

$$\boldsymbol{S}(\%) = \left(\frac{\boldsymbol{Ws-Wd}}{\boldsymbol{wd}}\right) \times \mathbf{100} \quad \textbf{(1)}$$

Where Wd and Ws represent the dry and swollen filter media respectively. (Ayawei, et al. 2015)

Adsorption Studies of filter media

Filter media prepared using cocopeat and ash in varying ratios was arranged in a series of columns and 100ml of water was passed through each column for filtration over a period of 1-2 hours and more sample is added when the previous sample is done passing through. This process was repeated over and over again until a total of 1L of leachate had passed through each one of the columns for maximum adsorption of heavy metals from the leachate.

Adsorption Equilibrium Studies

An adsorption equilibrium study was conducted using the concentration of leachate at initial stage. Isotherm studies was conducted with a constant filter media weight and a constant concentration of leachate sample. The amount of adsorption at equilibrium x/m was calculated using the following mass balance equation:

$$\frac{\boldsymbol{x}}{\boldsymbol{m}} = (\boldsymbol{Co} - \boldsymbol{Ce})\frac{\boldsymbol{v}}{\boldsymbol{w}} \quad \textbf{(2)}$$

Where x/m (g/g) and Ce (g/L) are the adsorbent phase leachate and sample phase leachate at equilibrium, respectively, Co (mg/L), the initial leachate concentration; V (L), the sample volume, and W (g), is the mass of adsorbent. (Ayawei, et al. 2015).

Batch Adsorption Studies

In this study, the change in the concentration of leachate was determined in respect to three variables which were: Adsorbent Ratio, Adsorbate Concentration, and finally ph. Three standards of known concentration of were prepared for the adsorption.

All batch adsorption experiments were performed at room temperature (27°C), in 250mL beaker using a stirrer and spatula. This study was carried out at three different runs, to determine the effect of different variables on adsorption of leachate by the bio-filter in all three cases, the concentration of the adsorbate was determined by taking the difference of initial and final concentration of adsorbate. (Ayawei, et al. 2015)

a) Adsorbent Load

Here, 10g of the adsorbent dosage was weighed and placed in a beaker containing 100mL of leachate sample and the media was allowed by itself for a period of 48hours. The suspension was then removed using a spatula and wiped with 180 mm whattman filter paper and measured immediately and recorded. (Ayawei *et al*., 2015)

b) pH

The pH of the initial (raw) leachate was determined and the final concentration (filtrate) of the leachate were also determined and the results were used to calculate the %removal in each leachate sample using the equation:

$$\% \text{ Removal} = \frac{\boldsymbol{Co - Ce}}{\boldsymbol{Co}} \times 100 \quad \textbf{(3)}$$

Where Co – Initial Concentration
Ce – Final Concentration (Ayawei *et al*., 2015)

Adsorption Equilibrium Models

Using the adsorption data obtained from the batch experiments, Langmuir and freundlich isotherms were analyzed using the data from the biofilter sample which gave the best result based on adsorption. These adsorption isotherms are a graphical representation of the distribution of solute between the liquid and solid phase. This description was done using mathematical relationships of Langmuir and Freundlich models. (Ayawei, *et al*. 2015).

a) Langmuir Isotherm

Langmuir theory is based on the assumption that adsorption is a type of chemical combination or process and the adsorbed layer is unimolecular. It can be represented as thus:

$$\frac{\boldsymbol{Ce}}{\frac{\boldsymbol{x}}{\boldsymbol{m}}} = \frac{\mathbf{1}}{\boldsymbol{qmb}} = + \frac{\boldsymbol{Ce}}{\boldsymbol{qo}} \quad \textbf{(4)}$$

Where:

Ce – Equilibrium concentration (mg/l) x/m – Amount adsorbed at equilibrium (mg/g) qe – Adsorption capacity (mg/g) b – Energy of adsorption (l/mg)
The values of the Langmuir constants qm and b can be calculated from the slope and intercept of the graph of $\frac{Ce}{x/m}$ versus Ce. However, the essential characteristics of the Langmuir isotherm can be calculated using the dimensionless constant known as "Equilibrium Parameter", RL defined as:

$$R_L = \frac{1}{(1+bCo)} \quad \textbf{(5)}$$

R_L values are an indication of the type of isotherm, done mainly to confirm if the process its self is favourable or not.
When (R_L>1) – Unfavourable
(R_L=0) – Irreversible
(0<R_L<1) – Favourable
(R_L=1) – Linear (El-Sayed 2014).

b) Freundlich Isotherm

Freundlich adsorption model on the other hand explains how the ratio of the adsorbed solute to the concentration of the solute is a function of the solution. This model was known to be consistent have an exponential distribution of active centers, which is a characteristic of heterogeneous surfaces. Here, the amount of solute adsorbed, qe, is related to the equilibrium concentration of solute in the solution, Ce. The model is expressed as follows:

$$\mathbf{qe = K_F Ce^{1/n}} \quad \textbf{(6)}$$

Linearizing the above equation by taking logarithm of both sides gives

$$\mathbf{lnqe = lnKF + nlnC_e} \quad \textbf{(7)}$$

The values of the Freundlich constants KF and n are obtained from the intercept and slope of a graph of ln q_e versus ln C_e respectively (El-Sayed, 2014).

Batch Kinetic Studies

The procedure of kinetic adsorption tests is identical to that of batch equilibrium tests. However, the aqueous samples were taken at time intervals. The concentrations of leachate sample were similarly measured. The heavy metal uptake at any time, qt (g/g), was calculated by Eq. (8)

$$qt = \frac{(Co-Ct)v}{W} \quad \textbf{(8)}$$

Where Ct (g/L) is the liquid-phase concentration of leachate at the time, t (h). Co (g/l), the initial leachate concentration; *v* (L), the sample volume, and W (g), is the mass of adsorbent.

Statistical Analysis of Data

Each treatment was repeated three times in triplicate format and results were expressed as means ±SE. Statistical significance was determined using students two-sided t-test with P<0.05 deemed significant.

Scanning Electron Microscopy (SEM) and Electron Dispersive X-ray Spectroscopy (EDS)

Scanning Electron Microscopy with a **Zeiss SEM, EVO LS 10** and **Amatek EDS (Octane Prime)** was used for this analyses. The EDS is a complementary technology of the SEM which was used for the analyses of the elemental composition of the filter media samples. Less than 1g of each sample was coated with a carbon tape placed on the SEM/EDX sample holder. The operation range was selected within 10.0kV while the magnification required for the imaging was selected under a vacuum at 20µm. The output of the EDS was a spectrum depicting the various elements present in the samples was presented in peaks.

Experimental Design; Column Studies

Experiment was carried out based on a previously reported method by Doshi *et al*., (2017); Chen and Park., (2003); Babiano – Cruz *et al* (2016) and was also in accordance to the design by Gini *et al*. (2020) with some modifications.
Columns of 2cm in diameter were packed with 10g of filter materials which were mixed with 100ml of leachate sample and stirred for 20mins with a magnetic stirrer for optimum homogenousity of the filter media.
The bottom of the column was layered with cotton wool and filter paper. The stirred filter media was the last thing to be added in the column. This was allowed to completely drip into a beaker before more solution was added in exactly 15ml. The solution was added slowly into the filter media and allowed to completely pass through before adding more in order for the filter media to be completely saturated and for an optimum result. Essentially, 500ml of leachate solution were pumped onto the filter media in bits of 15ml every 4 hours for a period of 48hours and the process repeated again (refluxing).

RESULTS

Figure 1 represents the swelling capacity of the bio filter sample used. It shows a high swelling level on ratio 50:50 of Coco-peat to Ash at 83.5% and the lowest level bio-filter swelling on ratio 40:60 at 77.4%. Swelling percentage is directly proportional to adsorption of the bio-filter at a given concentration and volume. Figure 2 represents the adsorption of heavy metals by the filter media sample used; it indicates that the sample concentration with the ratio 40:60 Coco peat and Ash is the most effective for adsorbing heavy metals from industrial landfill leachate.
This represents the most effective pH for adsorption of heavy metals from landfill leachate and its result is similar to removal as a function of adsorbate concentration with that of ratio 40:60 as the highest on the graph represented in Figure 3. Figure 4 represents the values for $\frac{x/m}{Ce}$ and Ce for the adsorption of the bio-filter which were plotted against each other, where the plots where drawn based on varying adsorbate concentration and also gave the best fit with the highest R^2 value with Q_{max}. and b as such was represented as the Langmuir isotherm for the bio-filter based on ratio. The Freundlich equation or Freundlich adsorption isotherm is an empirical relation between the concentration of the solute on the surface of an adsorbent to the concentration of the solute in the liquid with which it is in contact. It is represented in Figure 5.

Scanning Electron Microscopy- Electron Dispersive X-ray Spectroscopy (SEM-EDX)

Results from SEM images of varying Bio filter concentrations before and after treatment with landfill leachate were compared and each of the samples were able to perform adsorption, albeit in varying capacities. The SEM for the bio filter with the concentration 20:80 before treatment (fig. 6) appeared to have particles which identify the high amount of ash content and the peaks on EDX (fig. 7). The characterization indicates the presence of Carbon, Oxygen, Magnesium, Aluminium, Phosphorus, Chlorine, Silicon, Potassium and Calcium as the highest peak of all the elements on the K shells

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and Molybdenum on the L shell. And after the treatment of leachate by the bio filter, the SEM (fig. 8) showed oversaturation of the filter media with no visible pores, which could be due to the presence of low fibre content from coco-peat for a complete adsorption by the bio-filter and on the spectra observed after treatment (fig. 9) which shows that the peaks indicated that Zirconium, Niobium and palladium were adsorbed on the L shell in the sample. While some of the elements on the spectra reduced in concentration, Silicon became highest on the peak with an increase in concentration.

The SEM for the bio filter with the concentration 40:60 before treatment (fig. 10) appeared to have a significant number of pores on the surface and particles which identify the amount of ash content, the peaks on EDX (fig. 11) characterization for this sample indicate that the peaks indicate the presence of Carbon, Oxygen, Magnesium, Aluminium, Silicon, Phosphorus, Chlorine, Potassium and Calcium on the K shells with Silicon as highest of the peaks. The peaks also indicate the presence of Molybdenum. And after the treatment of leachate by the bio filter, the SEM (fig. 12) showed an increasing property of the filter media with adsorption and no oversaturation, (fig. 13) shows that the peaks on the EDX spectra indicated that Sodium was adsorbed from the leachate sample.

The SEM for the bio filter with the concentration 50:50 before treatment (fig. 14) appears to have large pores on its surface and lesser appearance of particles and on its EDX spectra (fig. 15) observed. The peaks indicate the presence of Carbon, Oxygen, Magnesium, Aluminium, Silicon, Iridium, Potassium and Calcium on the K shell with Silicon as the highest of the peaks. The peaks also indicate the presence of Niobium on the L shell. The SEM imaging for after treatment (fig. 16) of leachate showed that there was adsorption at equilibrium. The surface of the filter media appears compact, that is, it has reached its maximum adsorption without oversaturating or disintegration. The Ash appears to have bind the Coco-peat too strongly and the EDX spectra (fig. 17) indicates on the peaks that Nitrogen, and arsenic were adsorbed and calcium became the highest element on the peaks with an increase in concentration**.**

The SEM for the bio filter with the concentration 60:40 before treatment (fig. 18) shows the appearance of many scattered pores with little particles present on the surface and the EDX spectra (fig. 19) showed the presence of Carbon, Oxygen, Magnesium, Aluminium, Silicon, Potassium, Calcium on the K shell with Calcium as the highest of the peaks. The peaks also indicate the presence of the presence of Platinum on the M shell. The SEM for after treatment (fig. 20) showed that the adsorption property was reduced in relations to the ratio 50:50 and the binding property of the filter media too reduced. This was due to the decrease in the binding property by mass of Ash to the mixture and the peaks on the EDX spectra (fig. 21) indicated that Phosphorus was adsorbed on the K shell with Carbon as the highest of the peaks. The peaks also indicated the adsorption of Niobium on the L shell.

The SEM for the bio filter with the concentration 80:20 before treatment (fig. 22) showed the appearance of pores and folds on the surface of the bio filter and on the EDX spectra (fig. 23), the peaks indicated the presence of Carbon, Oxygen, Magnesium, Aluminium, Silicon, Phosphorus, Potassium and Calcium all on the K shell with Calcium as highest on the peak. The SEM (fig. 24) for after treatment of landfill leachate shows that the binding property of the sample appears to be very weak due to the almost absent Ash content. But maximum adsorption was achieved and the Coco-peat wasn't over saturated and the peaks on the EDX spectra after treatment (fig. 25) indicate that Phosphorus and Chlorine were adsorbed on the K shell with Silicon as the highest element on the peaks in the spectra. The peaks also indicated that Molybdenum was adsorbed on the L shell.

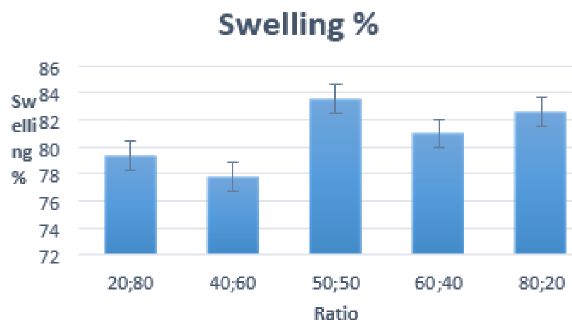

Fig 1: Graphical Representation for Swelling Measurement of Bio-filter Used

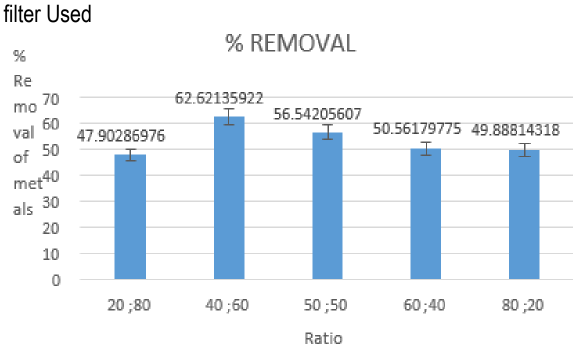

Fig 2: The %Removal of Metals as a Function of Adsorbate Concentration

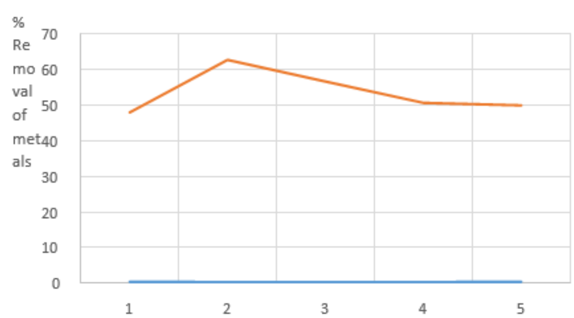

Fig 3: Graphical Representation for Removal of Metals as a Function of pH

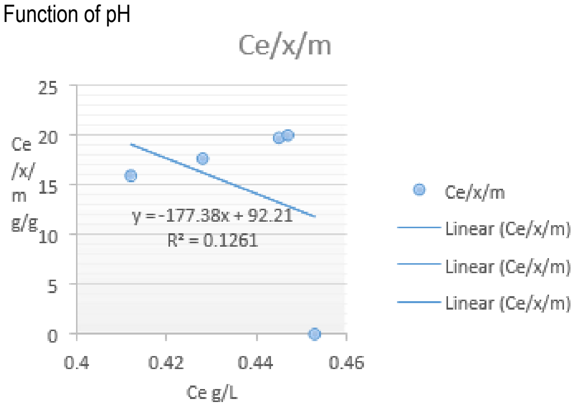

Fig 4: Graphical Representation for the Langmuir Isotherm Model

of Determining Adsorption

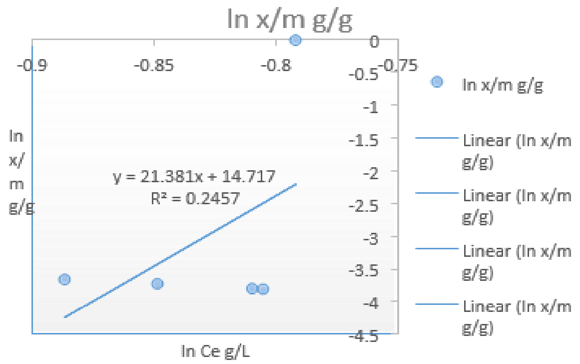

Fig 5: Graphical Representation for the Freundlich Isotherm Model of Determining Adsorption

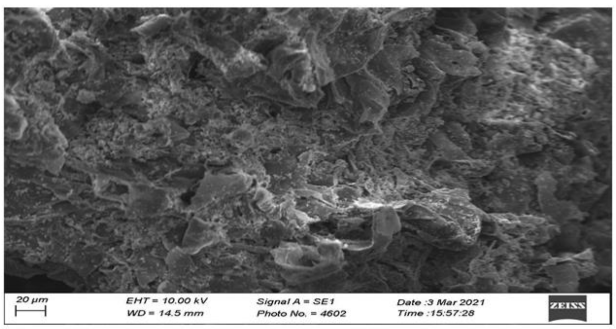

Fig 6: The SEM for 20:80 before Treatment

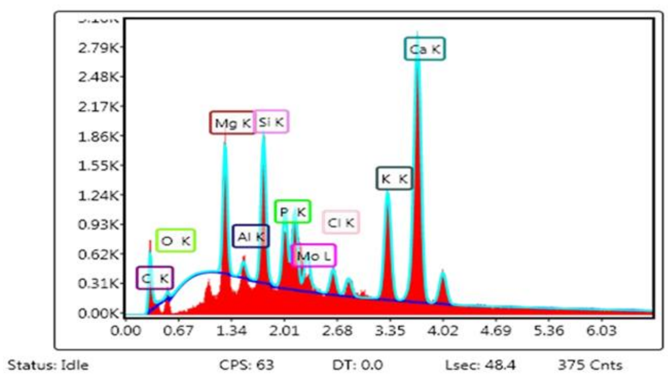

Fig 7: The EDX for 20:80 before Treatment

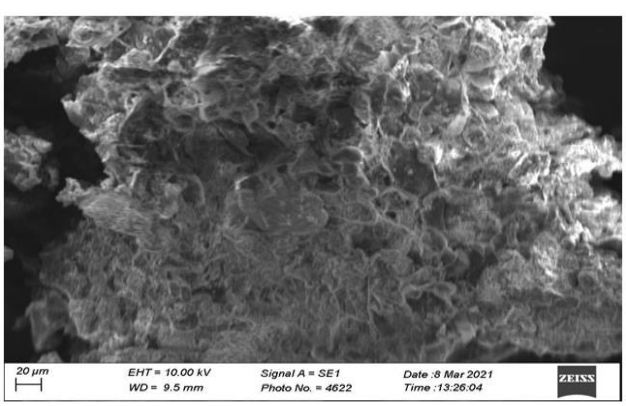

Fig 8: The SEM for 20:80 after Treatment

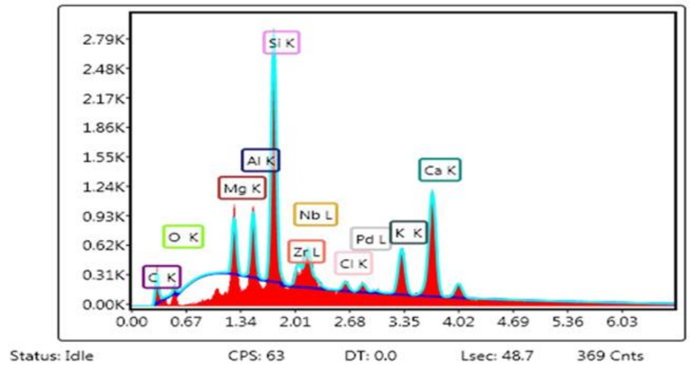

Fig 9: The EDX for 20:80 after Treatment

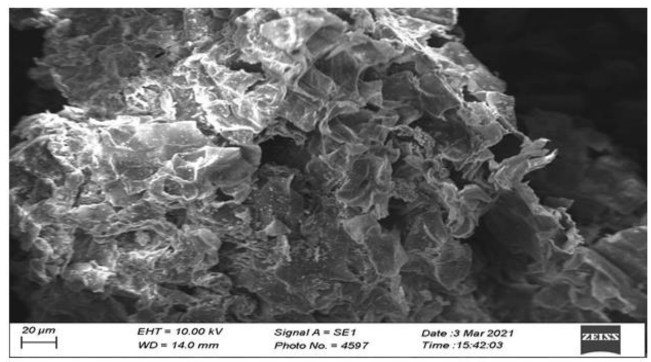

Fig 10: The SEM for 40:60 before Treatment

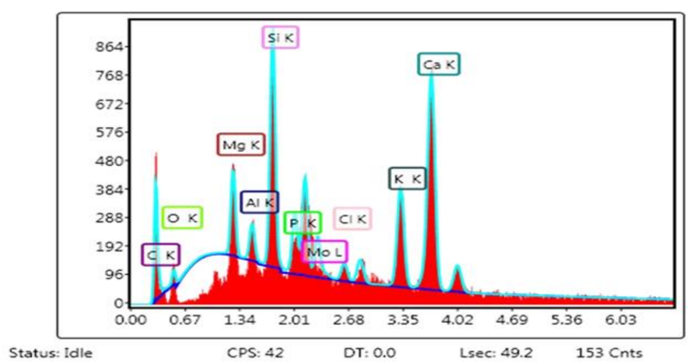

Fig 11: The EDX for 40:60 before Treatment

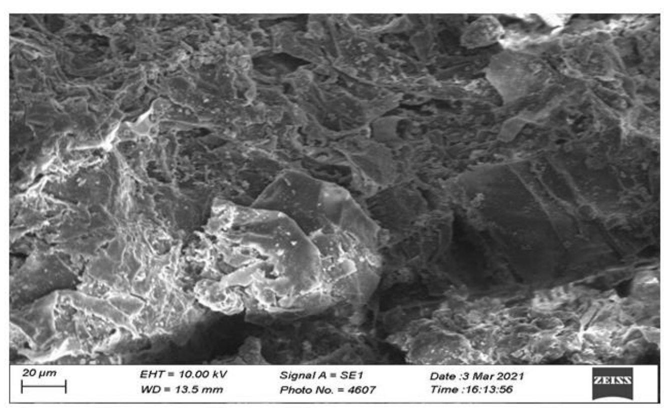

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Fig 12: The SEM for 40:60 after Treatment

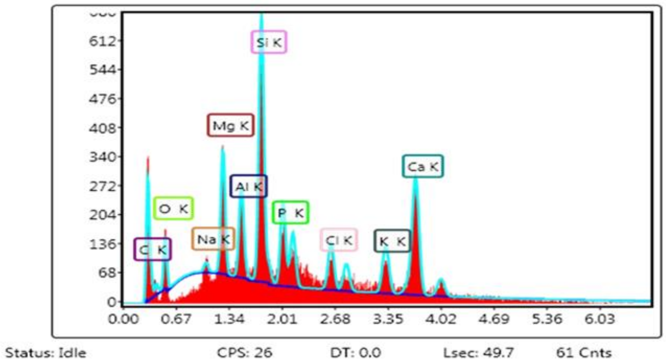

Fig 13: The EDX for 40:60 after Treatment

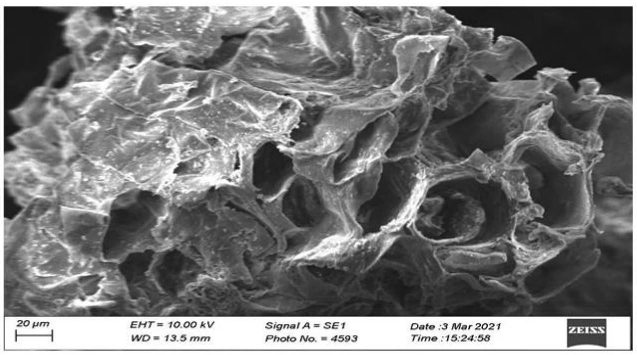

Fig 14: The SEM for 50:50 before Treatment

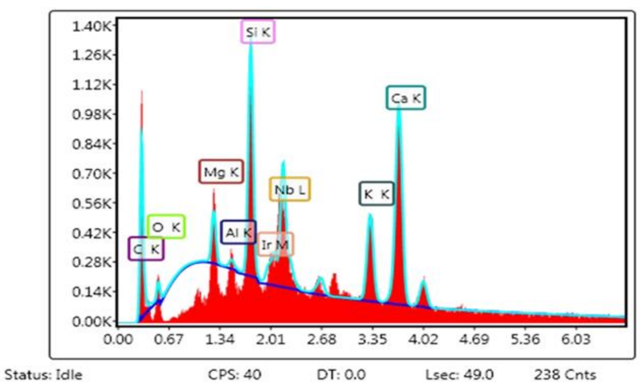

Fig 15: The EDX for 50:50 before Treatment

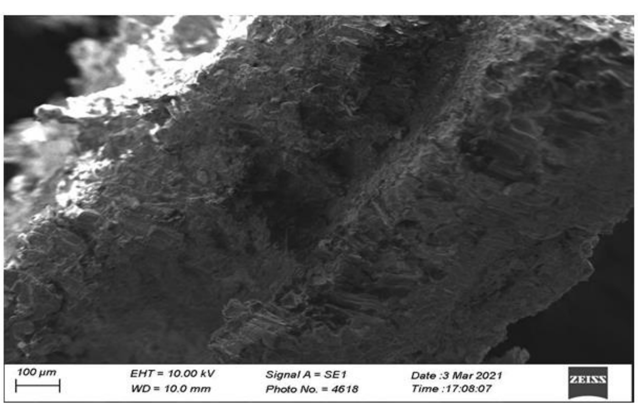

Fig 16: The SEM for 50:50 after Treatment

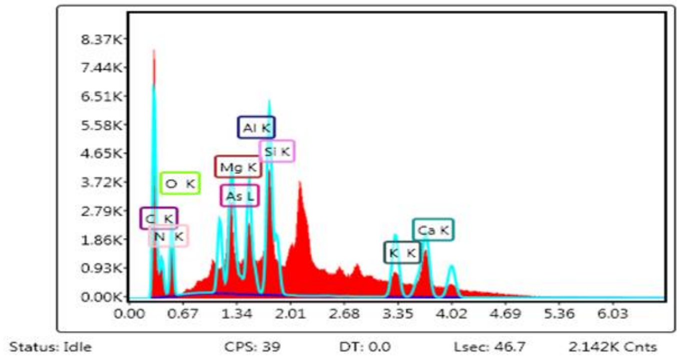

Fig 17: The EDX for 50:50 after Treatment

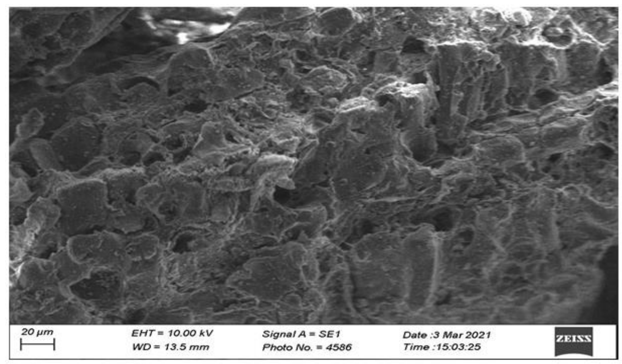

Fig 18: The SEM for 60:40 before Treatment

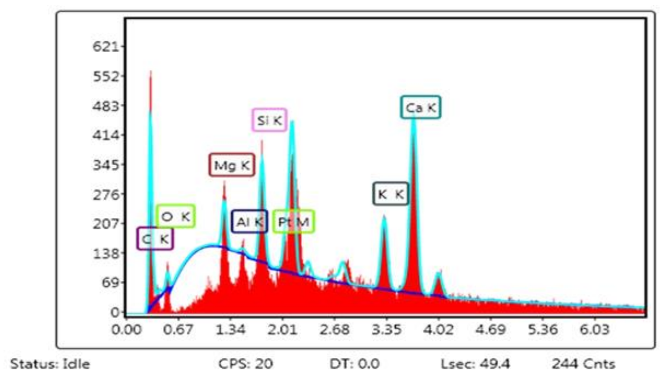

Fig 19: The EDX for 60:40 before Treatment

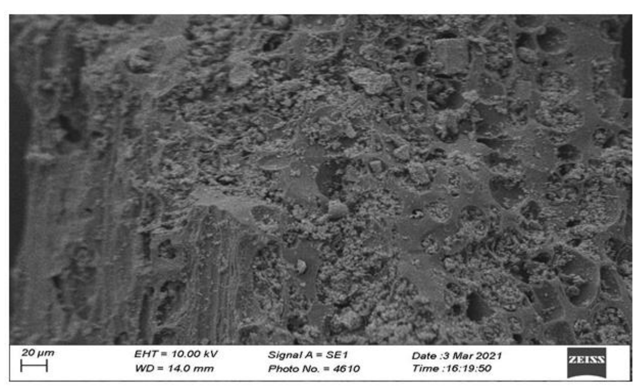

Fig 20: The SEM for 60:40 after Treatment

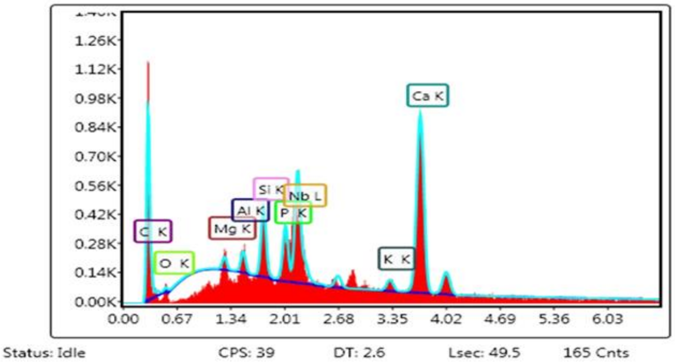

Fig 21: The EDX for 60:40 after Treatment

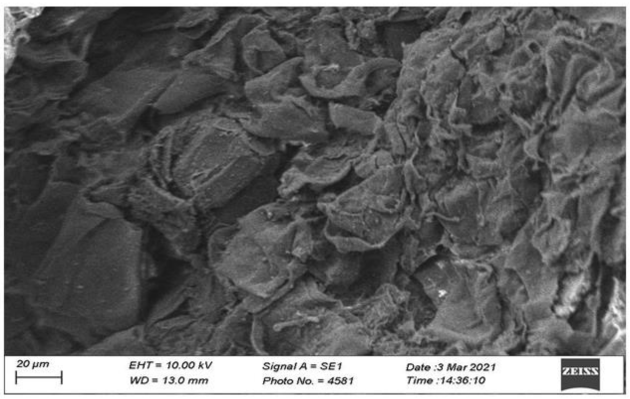

Fig 22: The SEM for 80:20 before Treatment

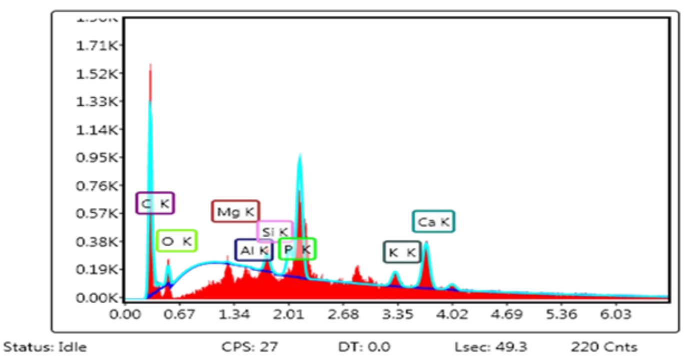

Fig 23: The EDX for 80:20 before Treatment

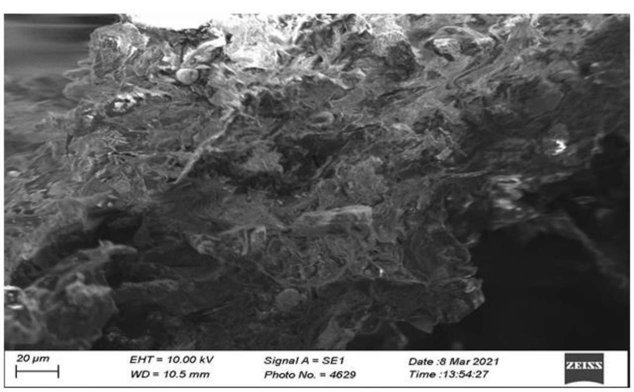

Fig 24: The SEM for 80:20 after Treatment

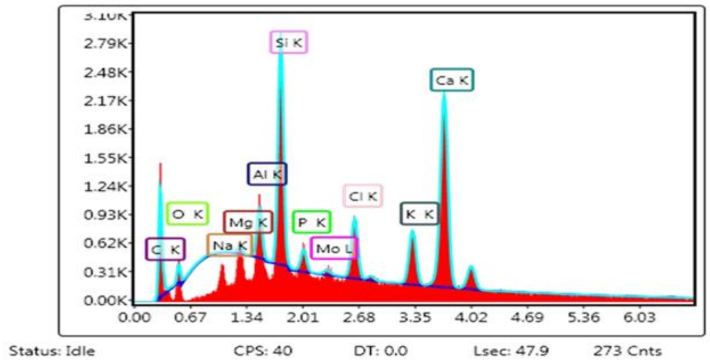

Fig 25: The EDX for 80:20 after Treatment

DISCUSSION

The result for characterization of the bio-filter for the various ratios of the filter media; swelling and adsorption properties through absorption studies estimates showed that the concentration with the highest swelling property was different from the concentration with the highest adsorption of heavy metals from the leachate samples analysed and this could be attributed to the swelling property, which identifies the water retention capacity of a bio filter sample as reported by Meng and Ye (2017).

The adsorption isotherms were well fitted by the Langmuir and Freundlich models. Where the adsorption kinetics of the Bio filter were determined through calculating the regression coefficient represented as R_L of the Langmuir Isotherm derived from the experiment, and the maximum uptake capacity of the bio sorbent (bio-filter) on the Freundlich isotherm. The R_L value in the present investigation was less than 1 and greater than 0, indicating that the adsorption of the metal ion onto the bio filter was favourable. In industrial landfill leachate treatment using the bio filter with coco peat and ash, the removal of metal ions was high whereby, the percentage of removal was more than 60 percent of the initial concentration.

Results from the SEM-EDX study showed that adsorption of heavy metals onto the bio filter increased with the amount of adsorbent (coco peat). This could be explained thus, that adsorption is a surface phenomenon where adsorbate molecules occupy specific sites on the adsorbent. These sites are commonly known as active centres. The concentration of these active centres on the surface is further related to the pore size and pore volume available after impregnation. This could explain why increasing the quantity of adsorbent results in increased adsorption. Results revealed that initially the % removal increased rapidly then decreased with increasing time; however, after a while, the rate becomes almost constant. This is because all the available active centres on the adsorbent have been occupied and there are no further sites and hence no further adsorption is possible. The time when this phenomenon occurs, therefore, may be termed optimum time.

The peaks on the EDX spectra further explains how new elements were adsorbed into the filter media and how the concentrations of some already present elements in the bio filter fluctuated. A study reported by Kangsepp (2008) shows that he determined the number of elements and their concentrations in his used and unused filter mixtures and Sodium was the most adsorbed element with an average of 4000 spiking up to 5500 after treatment and in line with his study, the concentration of the bio filter in this research with the highest percentage removal of metals adsorbed only the

Sodium element. Other elements which were referenced in the research by Kangsepp (2008) such as; arsenic, Niobium and chlorine were also adsorbed by the remaining concentration of bio filter samples used in this research. This research further reiterate the research carried out by Kangsepp (2008) with three types of peat from three different locations mixed separately with carbon containing ash to find out the most effective peat for the treatment of industrial landfill leachate.

Since coco peat is freely abundant, locally available, low-cost adsorbent and has a considerable high adsorption capacity, it may be treated as economically viable for removal of metal ions from industrial landfill leachate.

Conclusion

A design for an optimized, low cost filter based treatment plant for industrial leachate was targeted. The strategy of this experiment was to develop a bio-filter with coco peat and ash at different concentration of ratios to find out the most effective ratio to be used to treat leachate samples, the study was carried out at Nile University of Nigeria Biology and Chemistry laboratories.

The results from this study revealed that:

- Although the bio filter with the ratio 50:50 coco peat to ash had the best swelling measurement, the bio filter with the concentration 40:60 coco peat to ash ratio had the highest adsorption capacity in the treatment of landfill leachate according to the %removal of metals.
- For an effective adsorption of metals to take place by the bio filter, the hydraulic loading rate of the landfill leachate should be slow.
- The R_L value for the Langmuir adsorption isotherm and the uptake capacity for the Freundlich adsorption isotherm indicated that the bio filter produced from coco peat and ash is effective in the treatment of landfill leachate
- The SEM-EDX characterization showed that the most effective adsorption was by ratio 80:20 bio filter where there was an uptake of Na element at 0.62k, however other concentrations adsorbed metals such Molybdenum, chlorine, arsenic and Niobium and similarly ratio 40:60 adsorbed Sodium element at 136.

Recommendations

1. Leachate samples should be collected from many different locations in the same landfill site and homogenized into one.
2. Proper safety measures should be taken while collecting the leachate samples from the site.
3. Proper safety and sanitary measures for self-protection and protection of other laboratory users should be carried out during the experiment; experiment should be carried out in a fume cupboard
4. It is also recommended that coco peat filters be used in combination with conventional treatment methods, i.e. for secondary or tertiary treatment of the leachate
5. Bio filter materials should be sterilized before treatment

The study presented herein shows that a bio-filter made with Coco-Peat and ash can be used in a filter bed for treating and adsorbing metals from industrial landfill leachate. However, some further questions still remain and more research and experimental investigations are needed concerning the following questions:

- What causes the increase in bacterial count in the filtrate leachate samples?
- Will the bio-filter be effective on a large scale treatment system?
- How should one take care of used filter material: in particular, is the option of incineration really viable from an environmental point of view?
- What is the performance of Coco-peat and Ash as a bio-filter compared to the performance of natural forming Peat and Carbon containing Ash as a Bio filter in treating Industrial Landfill Leachate?

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