Journals Pub

International Journal of
Chemical Engineering and Processing

ISSN: 2455-5576
Volume 10, Issue 1, 2024
DOI (Journal): 10.37628/IJCEP

https://chemical.journalspub.info/index.php?journal=JCEP

Research IJCEP

Investigation of Adsorbent Morphology Characteristics of some Agro-Based Materials for Treatment Integration

Ukpaka, C. P. [1*], Nnadi, V. G. [2]

Abstract

Research conducted on the investigation of adsorbent morphology characteristics of some agro-based materials for the purpose of treatment application was carried out to examine the potential in terms of element present in it. The agro-based material considered are plantain Ogoni Red (POR), Banana Ogoni Red (BOR), Banana Native (BN), Plantain Agbagba 1 (PA1), Plantain Agbagba 2 (PA2) and 34 banana of different particle size examined. The result of elements of the morphology of each adsorbent by weight percent was determined using the conceptual procedure of x-ray florescence (CPXRF) and energy dispersive X-ray florescence (EDXRF) concepts. The research further revealed the possible element present in each of the agro-based material with the effect of particle size. The elements identified are silicon (Si), Magnesium (Mg), calcium (Ca), Aluminium (Al), Potassium (K), Sulphur (S) and Oxygen for 34 Banana sample, whereas for plantain Agbagba 2 (PA2), Iron (Fe) was present but Magnesium (Mg) and Sodium (Na) were absent. In the case of Plantain Agbagba 1 (PA1) the following elements was identified for Banana calcium (Ca), Magnesium (Mg), Oxygen (O), Carbon ©, Silicon (Si), Iron (Fe), Potassium (K), Sodium (Na) and Sulphur (S) and same element were identified for Banana Native (BN) and Banana Ogoni Red (BOR). The element weight percent of each sample vary with effect of particle size and sample specie. This research has shown that the element weight percent of sample determination in term of morphology is dependent of particle size as well as sample specie.

Keywords: Investigation, adsorbent, morphology, characteristics, agro-based materials, treatment, integration

INTRODUCTION

Adsorption is a mass transfer process that is a phenomenon of sorption of gases or solutes by solid or liquid surfaces. The adsorption on the solid surface is that the molecules or atoms on the solid surface have residual surface energy due to unbalanced forces. When some substances collide with the solid surface, they are attracted by these unbalanced forces and stay on the solid surface. According to the different adsorption forces, the adsorption process can be divided into two categories: physical adsorption and chemical adsorption (Dahuke and Johnson, 1990., Munte, 1985Schollenherger, 1927., Sorersen et al, 1971). Physical adsorption is produced by the interaction of intermolecular forces (i.e., van der Waals forces), for example, the adsorption of activated carbon for gas. Physical adsorption is generally carried out at a low temperature, and fast adsorption rate, low adsorption heat, and nonselective. As the effect of intermolecular attraction is weak, the structure of the adsorbate molecules hardly changes, the adsorption energy is small, and the adsorbed substance is easily separated again. The adsorption due to the action of chemical bonds is chemical

***Author for Correspondence**
Ukpaka, C.P.
E-mail: peter.ukpaka@ust.edu.ng

[1]Professor: Department of Chemical/Petrochemical Engineering, Rivers State University Port Harcourt, Rivers State, Nigeria.
[2]Research Student: Department of Chemical/Petrochemical Engineering, Rivers State University Port Harcourt,. Rivers State, Nigeria.
Received Date: June 14, 2024
Accepted Date: July 05, 2024
Published Date: July 31, 2024

Citation: Ukpaka, C.P., 2Nnadi, V.G.. Investigation of Adsorbent Morphology Characteristics of some Agro-Based Materials for Treatment Integration International Journal of Chemical Engineering and Processing. 2024; 10(1): 27–40p.

adsorption. Chemical adsorption process includes the formation and destruction of chemical bonds. The absorption or release of adsorption heat is larger, and the activation energy required is also larger. Physical adsorption and chemical adsorption are not isolated and often occur together. In wastewater treatment technology, most of the adsorption is the result of several kinds of adsorption processes. Due to the influence of adsorbents, adsorbates, and other factors, some kind of adsorption may play a leading role (Lowther et al. 1990., Ozean and Ozean, 2006., Schiute and Hopkins, 1996., Drymalski and Gelderman, 1990).[1-3]

To clean up sites polluted with petroleum products, adsorption comes into play. Sorbents are material which recover petroleum products through absorption or adsorption. Sorbents could be natural or synthetic (Maternyi and Durackova, 1994., Fox, et al. 1964., Jackson 1953). Research has focused on agriculturally based sorbents because of their biodegradability and low cost (Deschamps *et al,* 2003; Choi and Cloud, 1992). Some natural sorbents have been reported to show good oil sorption capacity and, in some cases, higher oil sorption capacity than synthetic sorbents. Bundy and Sturgul (1884) examined a hollow cellulosic kapok fibre, and reported the fibre oil sorption capacity was approximately 1.5 – 2.0 times greater than that of polypropylene mat a commonly used synthetic sorbent in oil spill clean-up. Similarly, the cellulosic fibres milkweed (*Asciepias*) and cotton were shown to sorb significantly higher amounts of crude oil than polypropylene fibre and polypropylene web (Conibs, 1995., Bundy and Meisinger, 1994 Menilich, 1984) [46]

Materials and Methods

Conceptual Scanning Electronic Microscope (CSEM)

The conceptual scanning electronic microscope (ESEM) approach was use to examine the characteristics of the various adsorbent's raw materials in terms of the morphology examination. The procedure allows sample preparation for the purpose of removing all debris and the sample is then subjected into scanning. The aim is to achieve the morphology characteristics of the various samples used for the formulation of the mix ratio for adsorbent production, which is examine to ascertain its potential in terms of capability for adsorption of oil up take. The image of the various samples in terms of morphology are presented in chapter 4 of this thesis.

Conceptual Procedure of X-Ray Florescence (CPXRF) and Energy Dispersive X-Ray Florescence (EDXRF)

The conceptual application of the energy dispersive x-ray fluorescence in this investigation was for purpose of identification of the possible elements present in each adsorbent material used for this investigation. The type of x-ray florescence used is made of SKYIRAY model of EDX3600B of x-ray florescence spectrometer integrates XRF technology for the purpose of fast conduction with precise analysis in terms of complex composition. The instrument possesses the characteristics of identifying elements within the range of magnesium – Mg – atomic number (Z) = 12 as well as Uranium – U – atomic number (Z) = 92 and great resolution as well as fast analysis.

Preparation of Sample

In the case of non-homo generous sample, the concept of sample will require crushing to achieve fine homogeneous size as well as sample then pelletized. [79]

The Procedures for Testing Steps

The following testing steps were adopted which include;

i. Starting processes
ii. Procedure of calibration as well as initialization through the mechanism of pure silver standard
iii. Procedure that allows selection of the workable curve to achieve the aim with accordance to the conceptual sampling
iv. Procedures for the test samples
v. Procedures from the Excel output
vi. Procedure to end

Results and Discussion

Result of Morphology of the Adsorbents Used for this Research

The morphology of the different species of the agro-based materials used in the formulation of the adsorbent was experimental determined for the following samples such as Banana Ogoni Red (BOR) Banana Native (BN) Plantain Agbagba 1 (PA1) Plantain Agbagba 2 (PA2) and 34 Banana. The result of the morphology of this research is demonstrated from Figure 1 to 19. [1011] The surface area of the adsorbents was determined with the aid of the morphology analyzer and which further identified the possible elements and their percentage by weight of those element as demonstrated in Figures shown below.

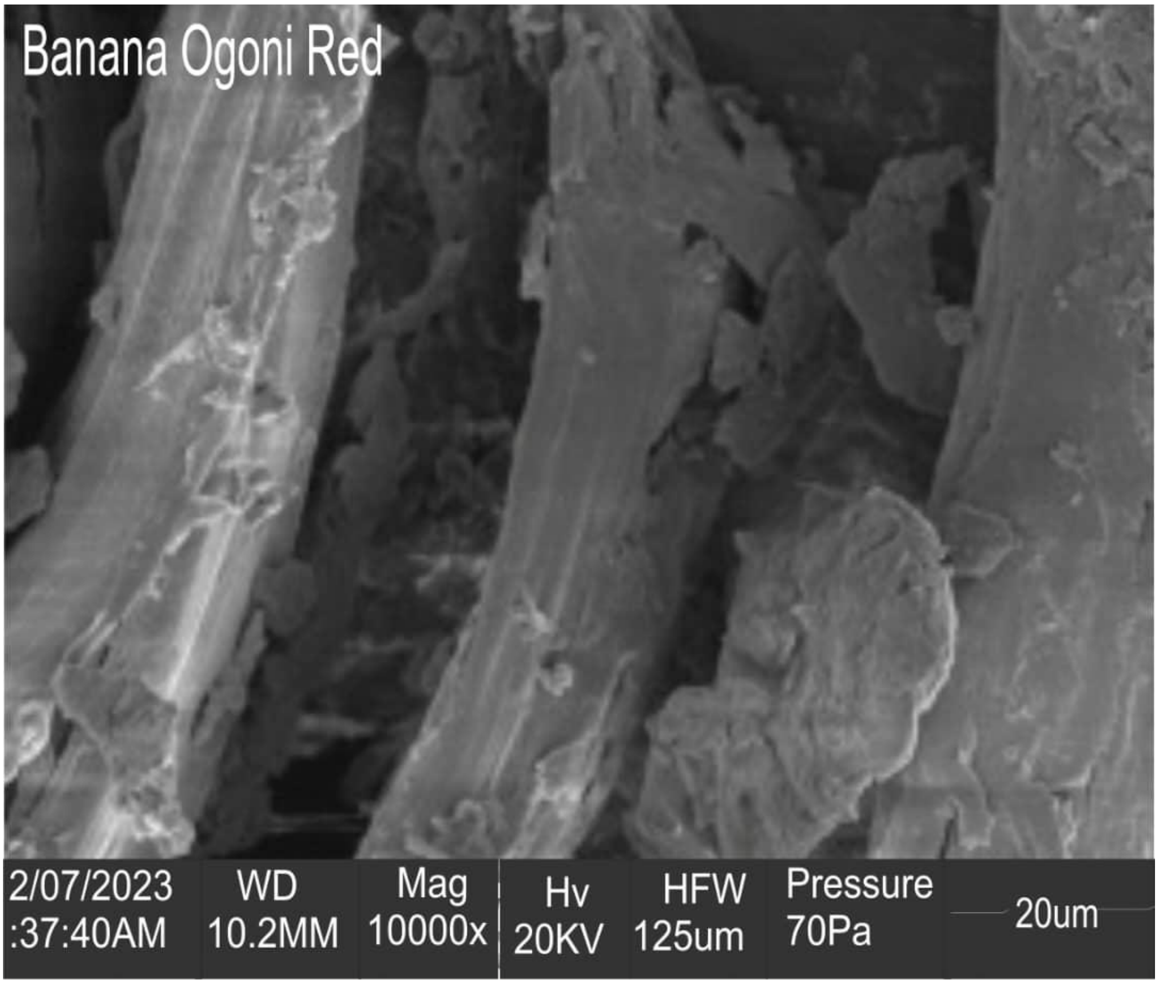

Figure 1: Morphology of the adsorbents of Banana Ogoni Red (BOR) with weight diameter of 10.2 MM

Figure 1 shows the morphology result of the Banana Ogoni Red (BOR) specie used for the research. The morphology results revealed weight diameter (WD) of 10.2 mm, Mag value of 10000x, high voltage value of 20 KV, HFW value of 125 µm, pressure 70Pa of particle size of 20µm.

Figure 2 show the characteristics of the morphology result of the Banana Ogoni Red sample. The composition with respect to the element present as well as the percentage of each element in weight was obtained as illustrated in Figure 2 and furthermore the result shows potassium value of 1.2 %, oxygen value of 22.2 %, carbon value of 8.0 % silicon value of 45.4 %, iron value of 1.6%, sulphur value of 6.1 %, sodium value of 2.7 %, magnesium value of 2.4 % and calcium value of 10.4 %. In the

BOR sample, the morphology result demonstrates the present of element of silicon with percentage in weight of 45.4% and the presence of Si enhance adsorption process also. In this case the percentage in weight of elements is in the order of silicon (Si) 45.4 % > oxygen (O) 22.2 % > calcium (Ca) 10.4 % > carbon (C) 8.0 % > sulphur (S) 6.1 % > sodium (Na) 2.7 % > iron (Fe) 1.6 % > potassium (K) 1.2 %. The composition in weight in terms of percentage of the element present in the morphology test of the BOR revealed its potential to be

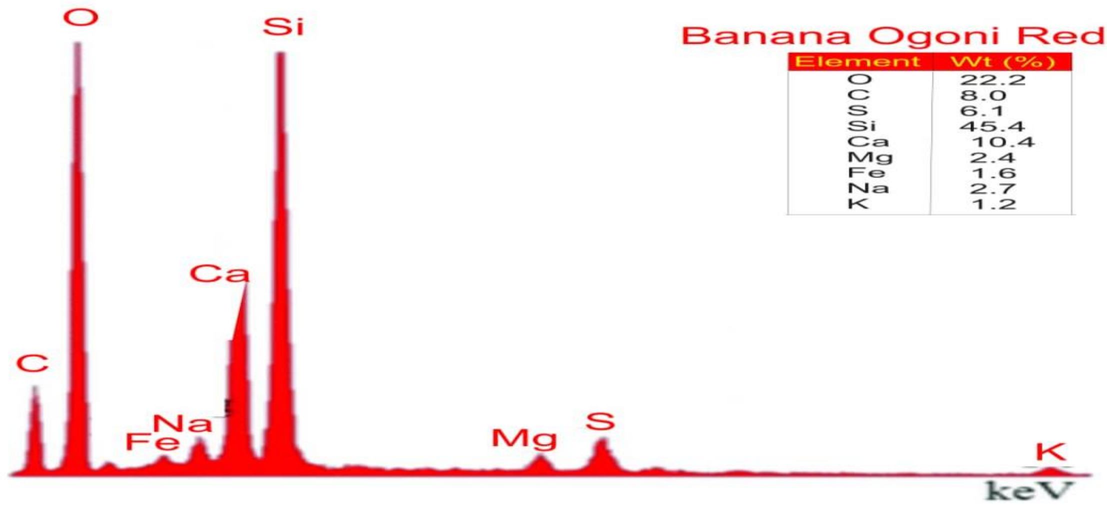

Figure 2: Results of Elements of the Morphology of the adsorbents of Banana Ogoni Red (BOR) in Weight Percent

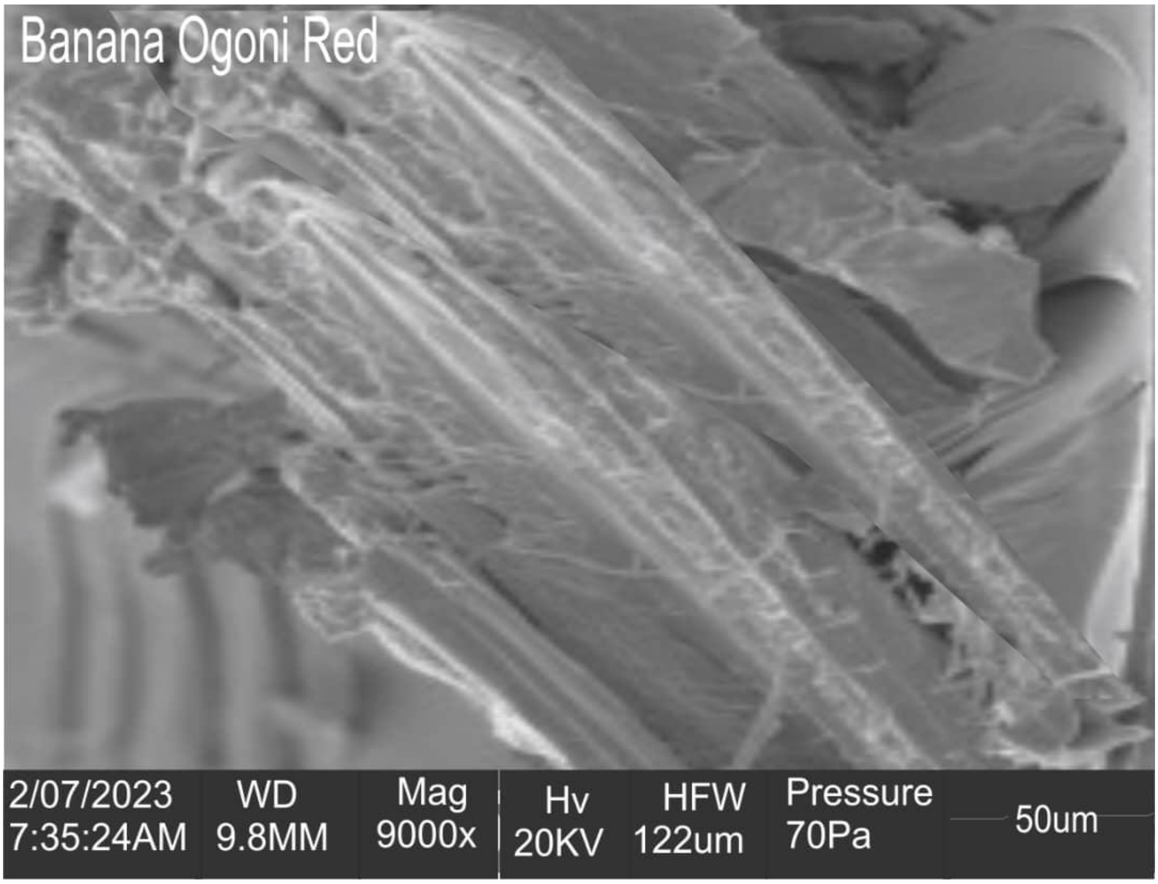

Figure 3: Morphology of the adsorbents of Banana Ogoni Red (BOR) with weight diameter of 9.8 MM

Figure 3 shows the operational shape of the Banana Ogoni Red (BOR) in terms of the surface area as demonstrated by the morphology. However, the reading of the operational value reveals WD value of 9.8 mm, HFW value of 122 µm, Mag value of 9000x and pressure value of 70 Pa for particle size of adsorbent of 50um. The through shape of the adsorbent was showcased by morphology analyizer.

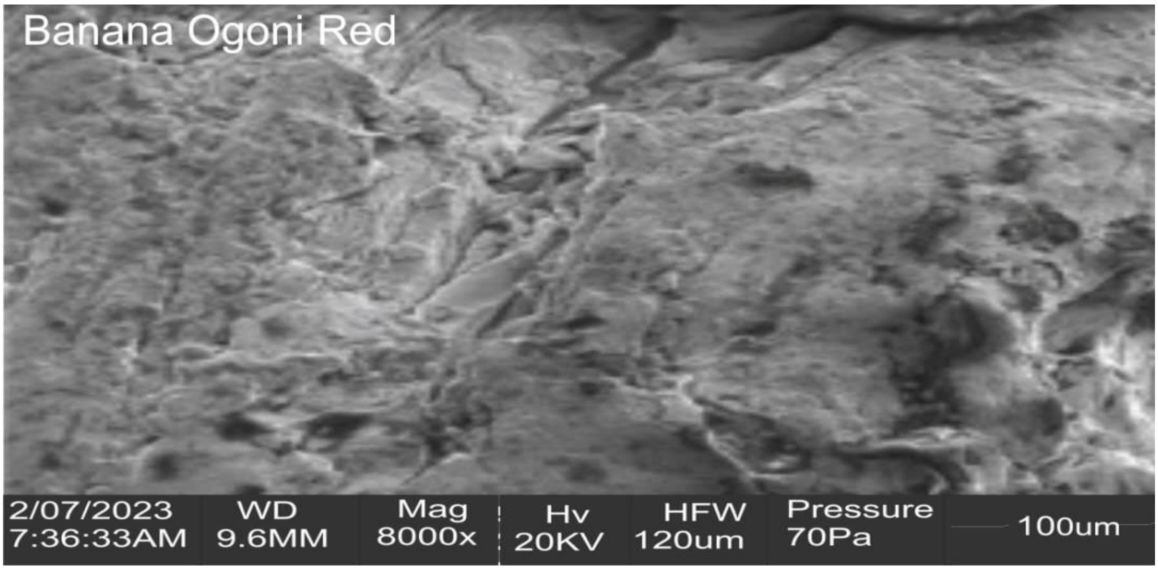

Figure 4: Morphology of the adsorbents of Banana Ogoni Red (BOR) with weight diameter of 9.6 MM

Figure 4 shows the morphology result of the Banana Ogoni Red (BOR) specie used for the research. The morphology results revealed weight diameter (WD) of 9.6 mm mag value of 8000x, high voltage value of 20 KV, HFW value of 120 µm, pressure 70 Pa of particle size of 100 µm.

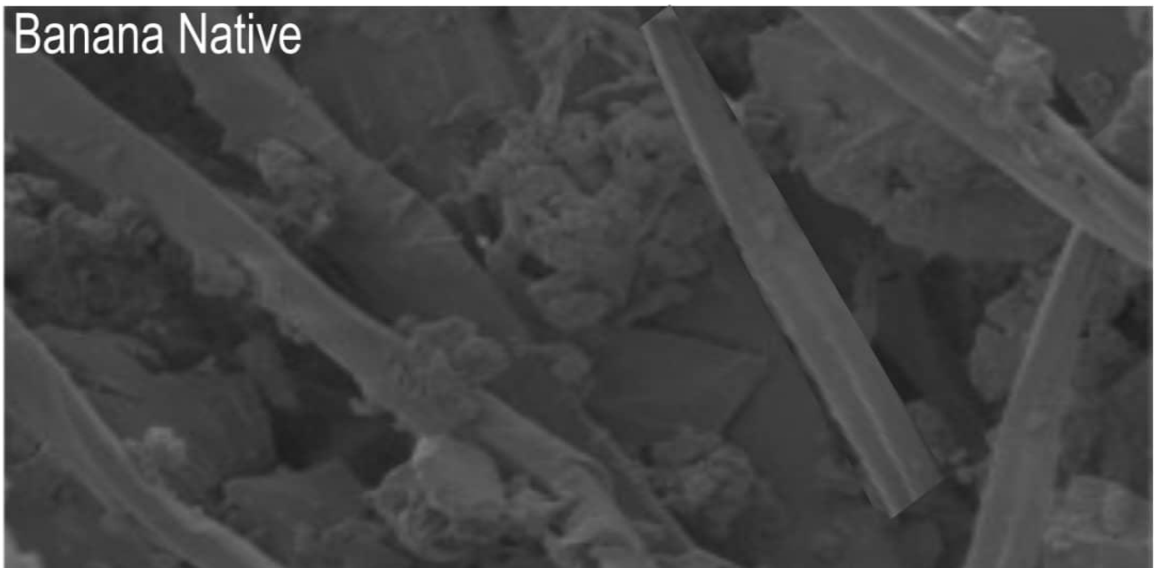

Figure 5: Morphology of the adsorbents of Banana Native (BN) with weight diameter of 10.4 MM

Figure 5 reveals the morphology of the Banana Native (BN) sample subjected into analysis for the determination of the surface area. The colour looks dark and the particle size of the adsorbent used is 100µm. Indeed, the operational conditions demonstrates WD value of 10.4 mm, Mag value of 8000x, HV value of 20 KV, HFW value of 126 µm and pressure value of 70 Pa

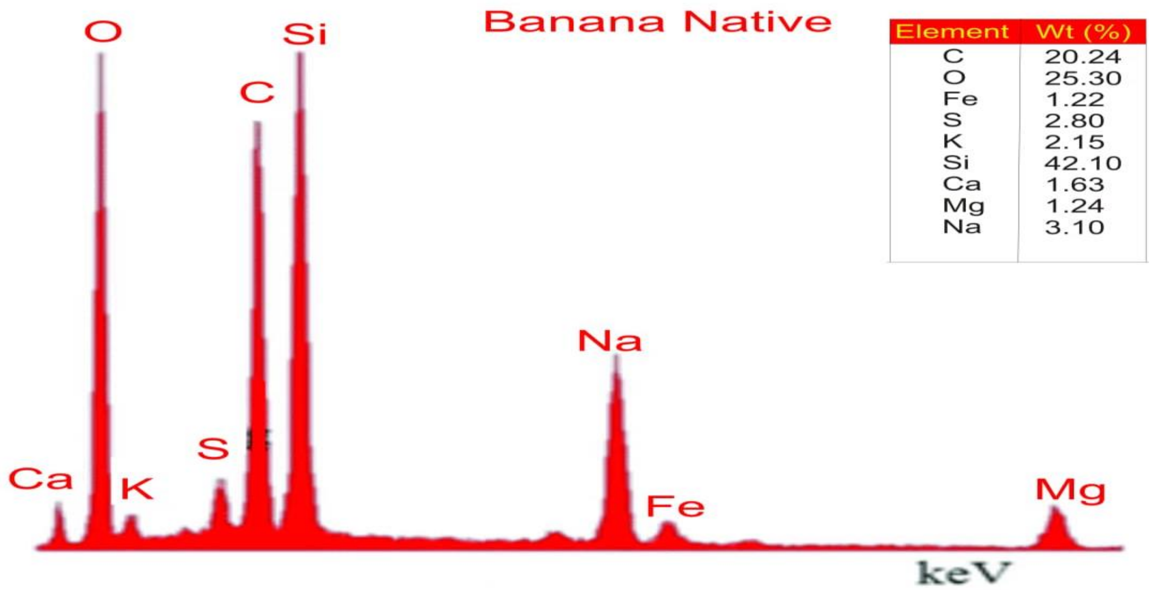

Figure 6: Results of Elements of the Morphology of the adsorbents of Banana Native (BN) in Weight Percent

Figure 6 shows the composition of the Banana Native morphology elements present in it. The analysis revealed the presence of the following weight in percent of elements such as carbon (C) 20.24 %, oxygen (O) 25.30 %, iron (Fe) 1.22 %, sulphur (S) 2.80 %, potassium (K) 2.15 %, silicon (Si) 42.10 %, calcium (Ca) 1.63 %, magnesium (Mg) 1.24 % and sodium (Na) 3.10 %. The percentage weight of the various elements is in the order of silicon (Si) > oxygen (O)> carbon (C) > sodium (Na) > sulphur (S) > potassium (K) > calcium (CA) > magnesium (Mg) > iron (Fe). The silicon is a good bonding agent as well as possesses the characteristics of good adsorbent material and peak value in the morphology shows the same trend.

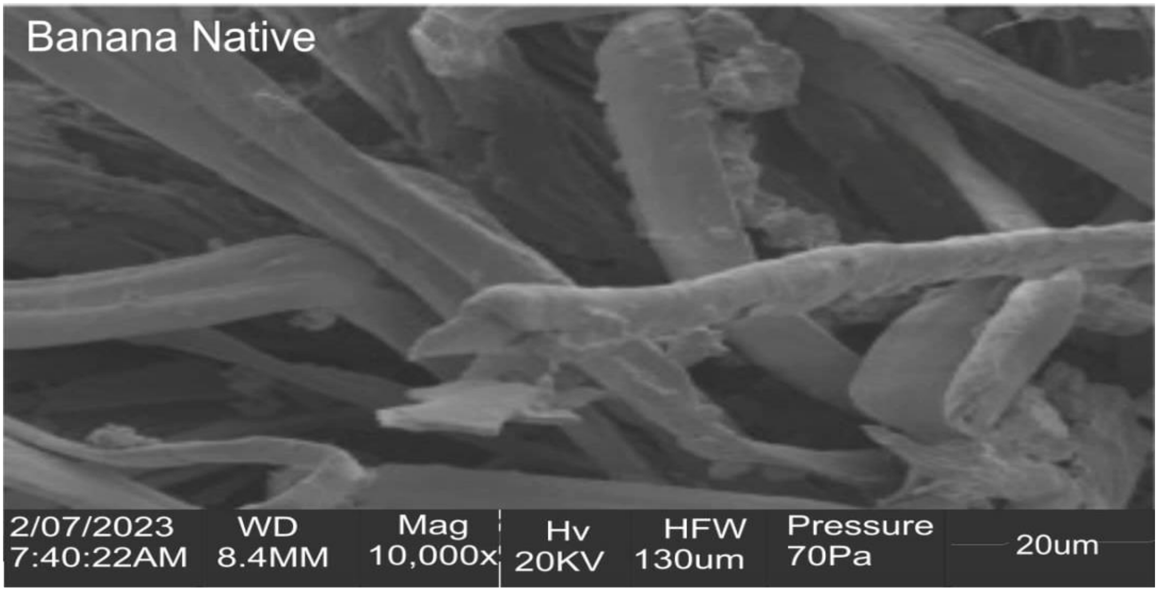

Figure 7: Morphology of the adsorbents of Banana Native (BN) with weight diameter of 8.4 MM

Figure 7 shows the morphology of particle size of 20 µm and the surface area of the Banana Native and operational characteristics shows WD value of 8.4 mm, Mag value of 10,000x HIV value of 20 KV, HFW value of 130 µm and pressure of 70 Pa

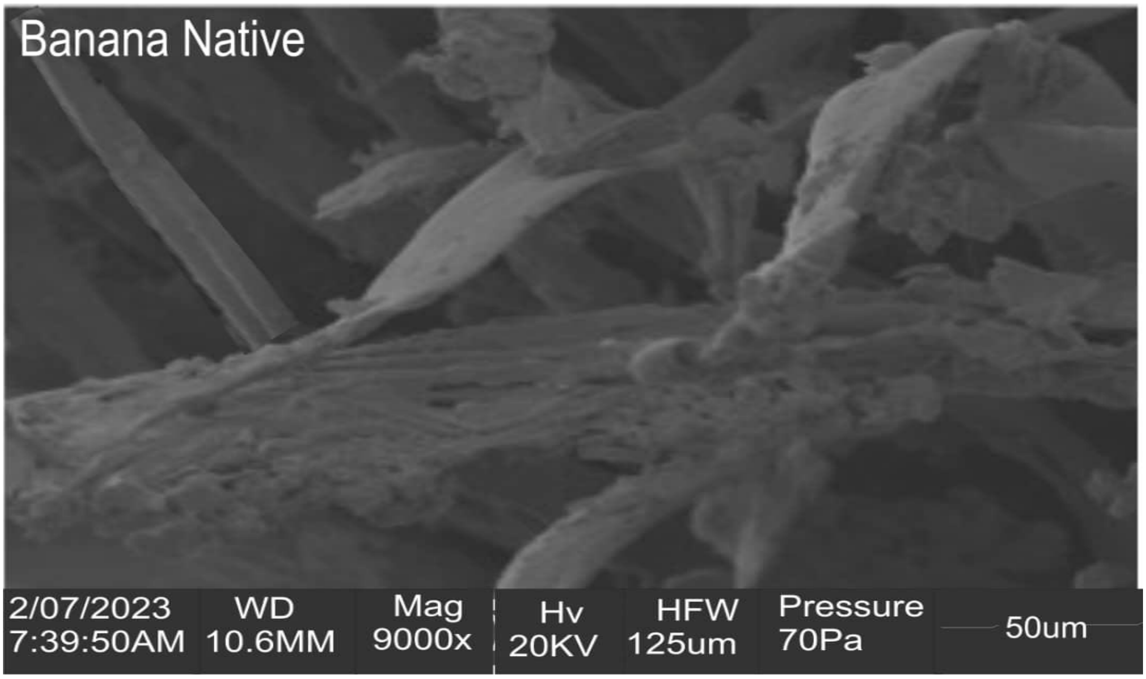

Figure 8: Morphology of the adsorbents of Banana Native (BN) with weight diameter of 10.6 MM

Figure 8 shows the significance of surface area examination through the application of morphology analysis. The morphology analysis demonstrates the following properties of WD value of 10.6 mm, Mag value of 9000x, HV value of 20 KV, HFW value of 12 5µm and pressure value of 70 Pa for particle size of Banana Native (NB) of 50 µm

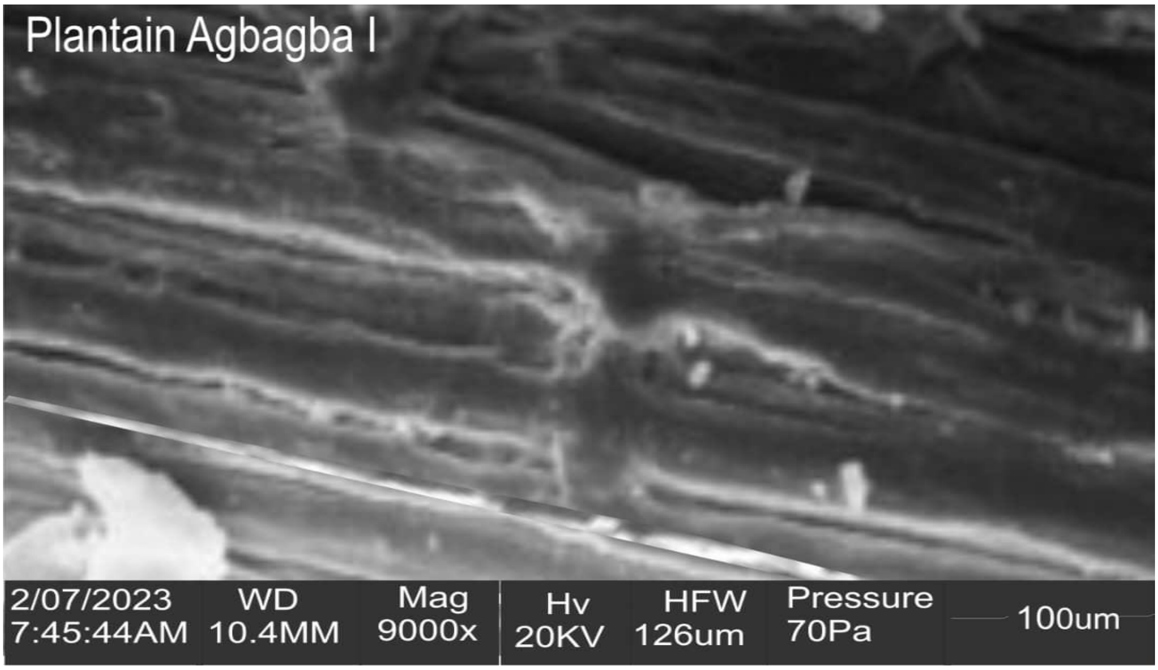

Figure 9: Morphology of the adsorbents of Plantain Agbagba 1 (PA1) with weight diameter of 10.4 MM

Figure 9 shows Plantain Agbagba 1 morphology shape of the sample with the operational analysis properties of WD value of 10.4 mm, Mag value of 9000x, HV value of 20 KV, HFW value of 126 µm and pressure value of 70 Pa for particle size of 100µm. The morphology characteristics give us the overview of the surface area of the Plantain Agbagba 1 used in the formulation of the adsorbent

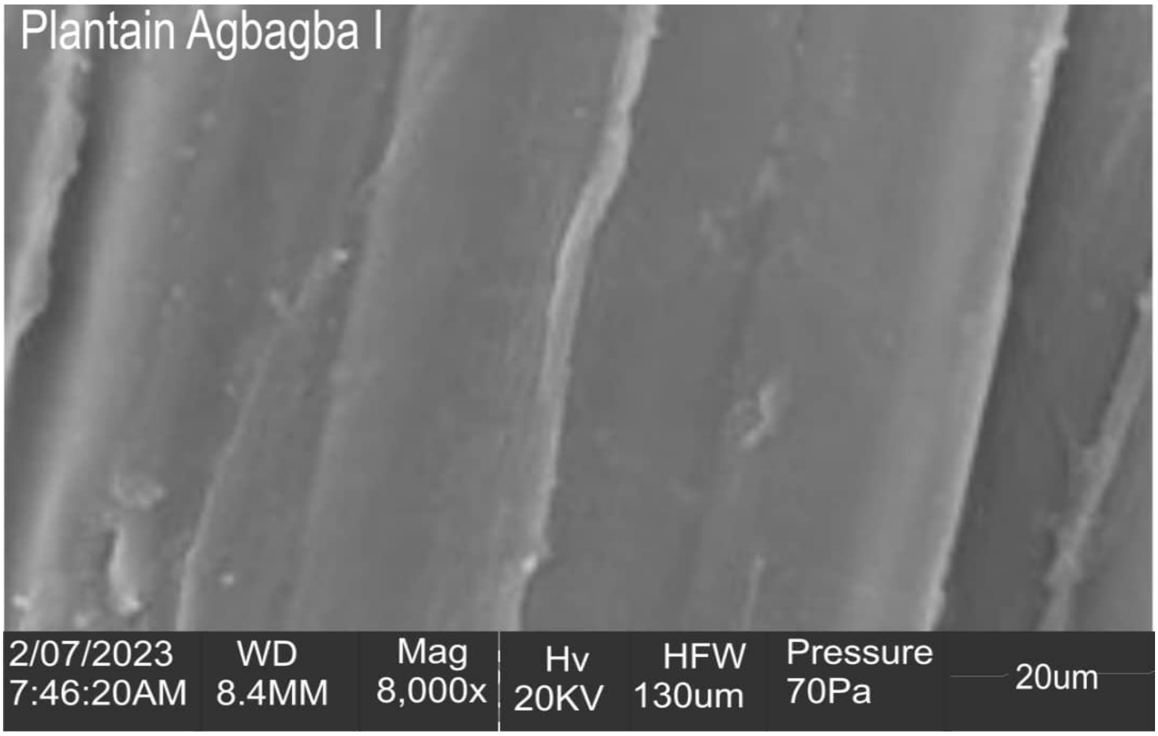

Figure 10: Morphology of the adsorbents of Plantain Agbagba 1 (PA1) with weight diameter of 8.4 MM

Figure 10 shows the operational analysis characteristics of sample parameters of the Plantain Agbagba 1 of particle size of 20µm. The parameters are WD value of 8.4 mm, Mag value of 8000x, HV value of 20 KV, HFW value of 130 µm and pressure value of 70 Pa. The surface area of Plantain Agbagba 1 was showcased from the view of the morphology characteristics.

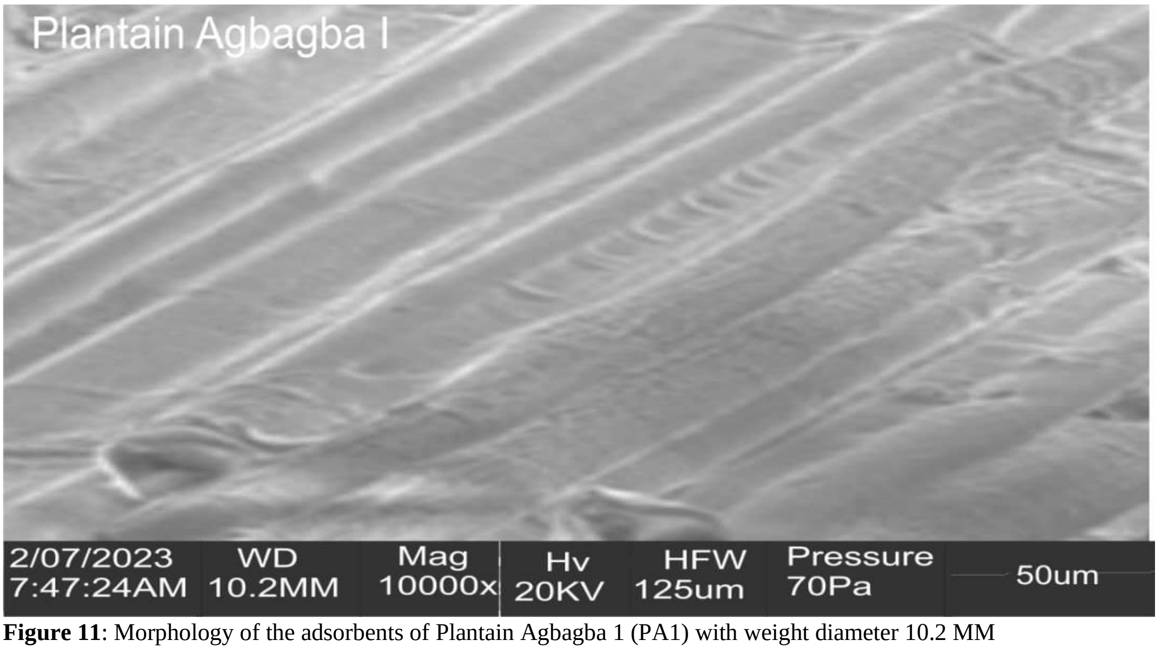

Figure 11: Morphology of the adsorbents of Plantain Agbagba 1 (PA1) with weight diameter 10.2 MM

Figure 11 shows the morphology of the particle size of 50µm of the plantain Agbagba 1 in view with the operational values of WD 10.2 mm, Mag 10000x, HV 20 KV, HFW 125 µm and pressure 70 Pa. The shape of the surface area was showcased through the medium of the morphology analysis.

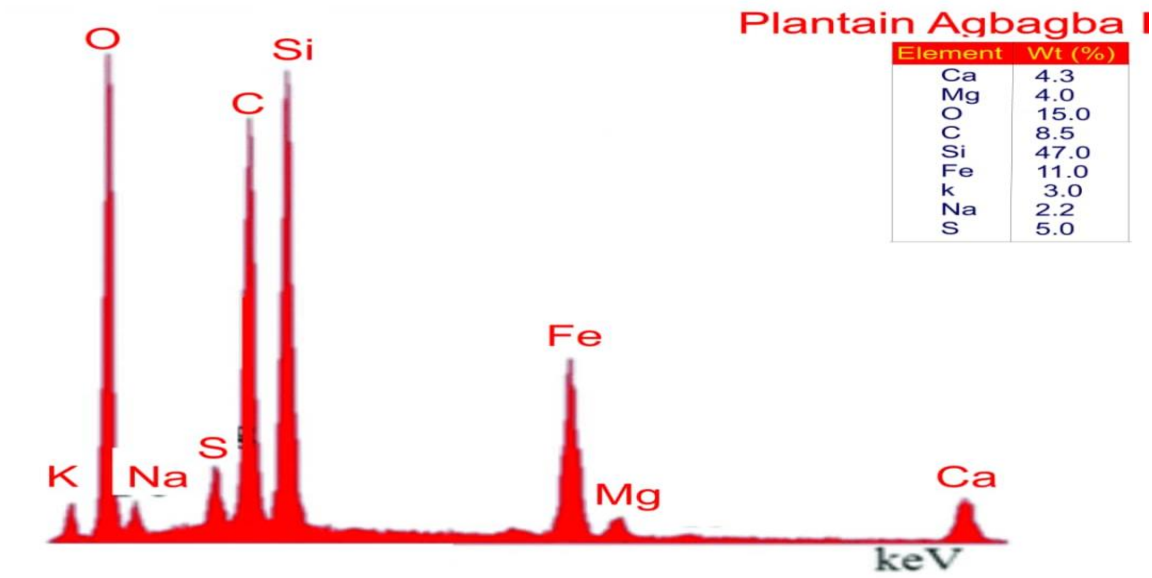

Figure 12: Results of Elements of the Morphology of the adsorbents of Plantain Agbagba 1 in Weight Percent

Figure 12 shows the magnitude of element present in the Plantain Agbagba 1 adsorbent sample subjected into the morphology test. However, the analysis result revealed the percentage in weight of the following elements, which include calcium (Ca) 4.3 %, magnesium (Mg) 4.0 %, oxygen (O) 15.0 % carbon (C) 8.5 %, silicon (Si) 47.0 %, iron (Fe) 11.0 %, potassium (K) 3.0 %, sodium (Na) 2.2 % and sulphur (S) 5.0 %. The morphology result of the Plantain Agbagba 1 shows that the order of percentage in weight of the element is 47.0 % of Si > 15.0 % of O > 11.0 % of Fe > 8.5% of C > 5.0 % of S > 4.3 % of Ca > 4.0 % of Mg > 3.0 % of K > 2.2 % of Na. From the result presented in Figure 4.186 it is observed that the composition of the individual elements demonstrates that Plantain Abgagba 1 is a good adsorbent especially high percentage in weight of the presence of the silicon.

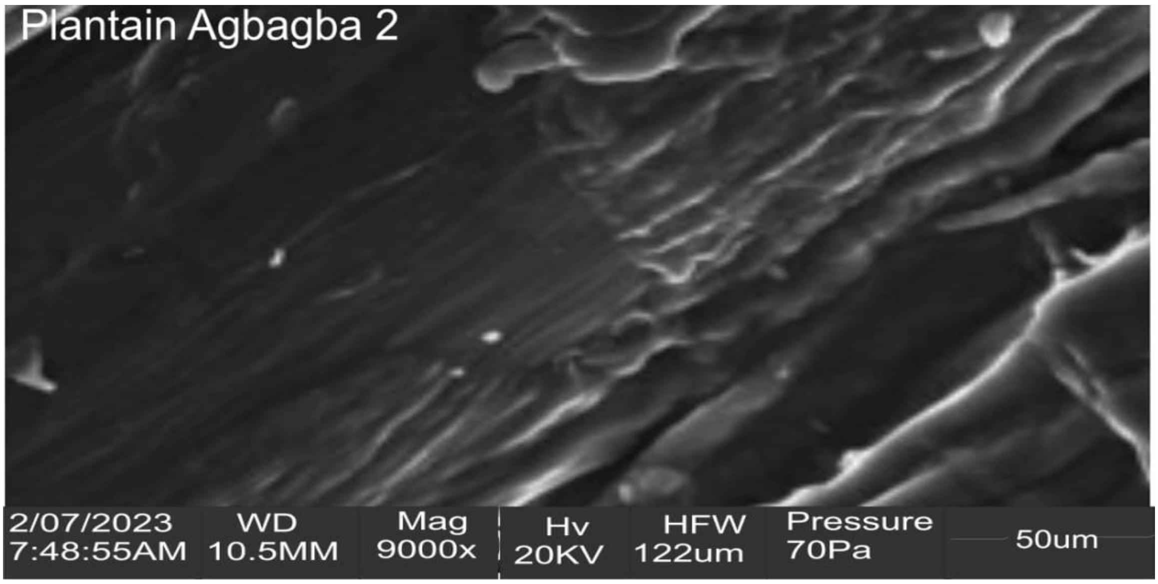

Figure 13: Morphology of the adsorbents of Plantain Agbagba 1 (PA2) with weight diameter of 10.5 MM

Figure 13 shows the conceptual parameters for the morphology analysis of the Plantain Agbagba 2 and the parameters reveals WD value of 10.5 mm, Mag value 9000x, HV value 20 KV, HFW value 1.22 µm and pressure value 70 Pa for particle size of 50µm. Indeed, the surface area was demonstrated by the application of the morphology analyizer

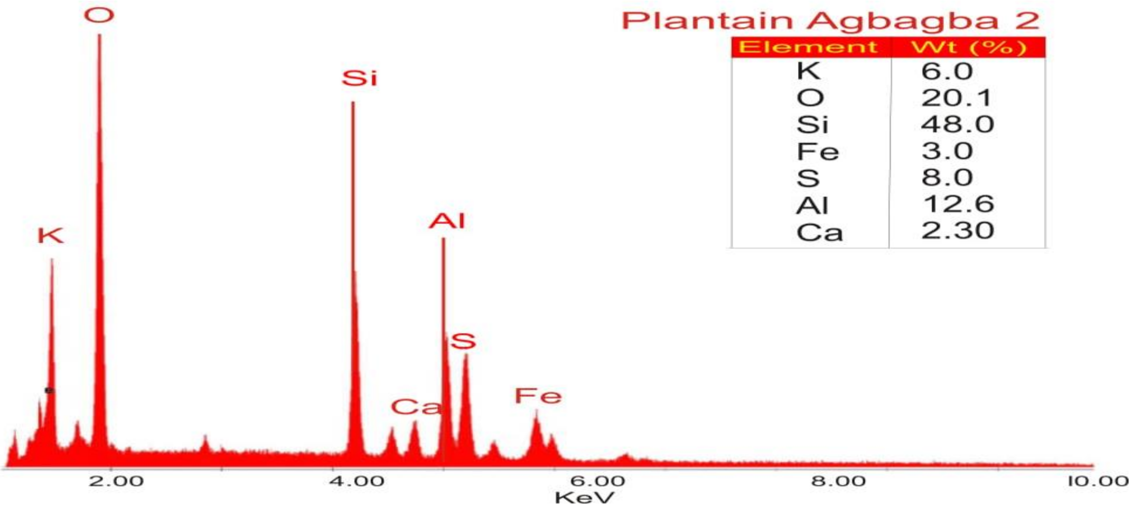

Figure 14: Results of Elements of the Morphology of the adsorbents of Plantain Agbagba 2 in Weight Percent

Figure 14 shows the characteristics of the morphology result of the Plantain Agbagba 2 sample. The composition with respect to the element present as well as the percentage of each element in weight was obtained as illustrated in Figure 4.188 and furthermore the result shows potassium value of 6.0 %, oxygen value of 20.1 %, silicon value of 48.0 %, iron value of 3.0 %, sulphur value of 8.0 % aluminium value of 12.6 % and calcium value of 2.30 %. In the Plantain Agbagba 2 sample, the morphology result demonstrates the present of element of aluminium with percentage in weight of 12.6 % and the presence of AL enhance adsorption process also. In this case the percentage in weight of elements is in the order of silicon (Si) 48.0% > oxygen (O) 20.1% > aluminium (Al) 12.6 % > sulphur (S) 8.0 % > potassium 6.0 % > iron (Fe) 3.0 % > calcium 2.30 %. The composition in weight in terms of percentage of the element present in the morphology test of the Plantain Abgagba 2 revealed its potential to be used as adsorbent.

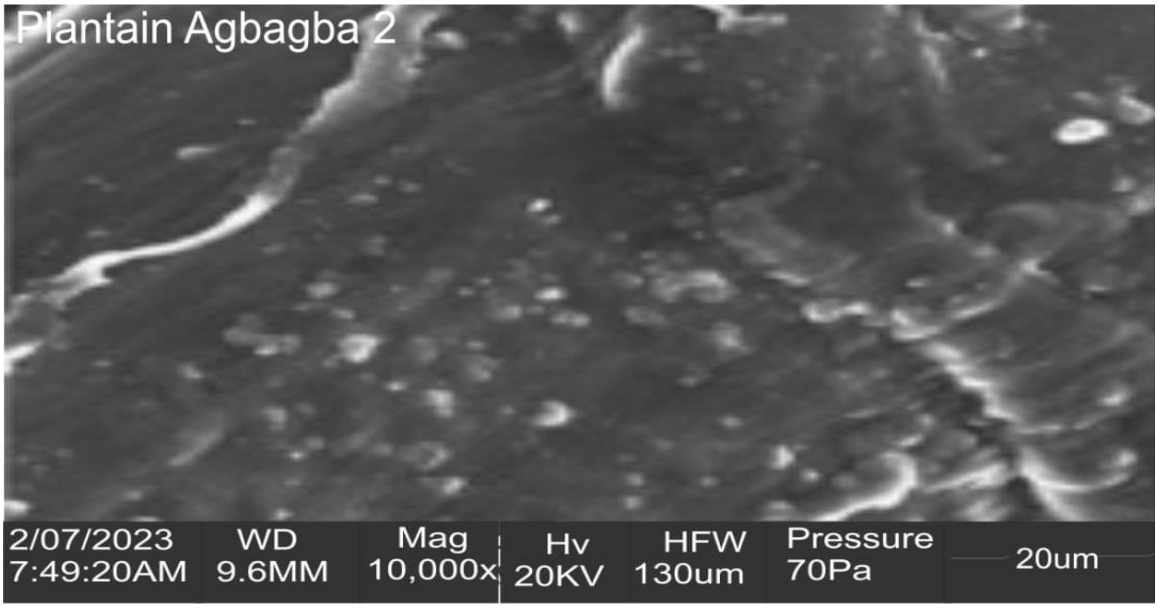

Figure 15: Morphology of the adsorbents of Plantain Agbagba 2 (PA2) with weight diameter of 9.6 MM

Figure 15 shows the morphology shape of Plantain Agbagba 2 with particle size of 20 µm and the operational properties of the morphology analyizer demonstrates that the WD value is 9.6 mm, Mag value is 10000x, HV value is 20 KV, HFW value is 130 µm and pressure is 70 Pa.

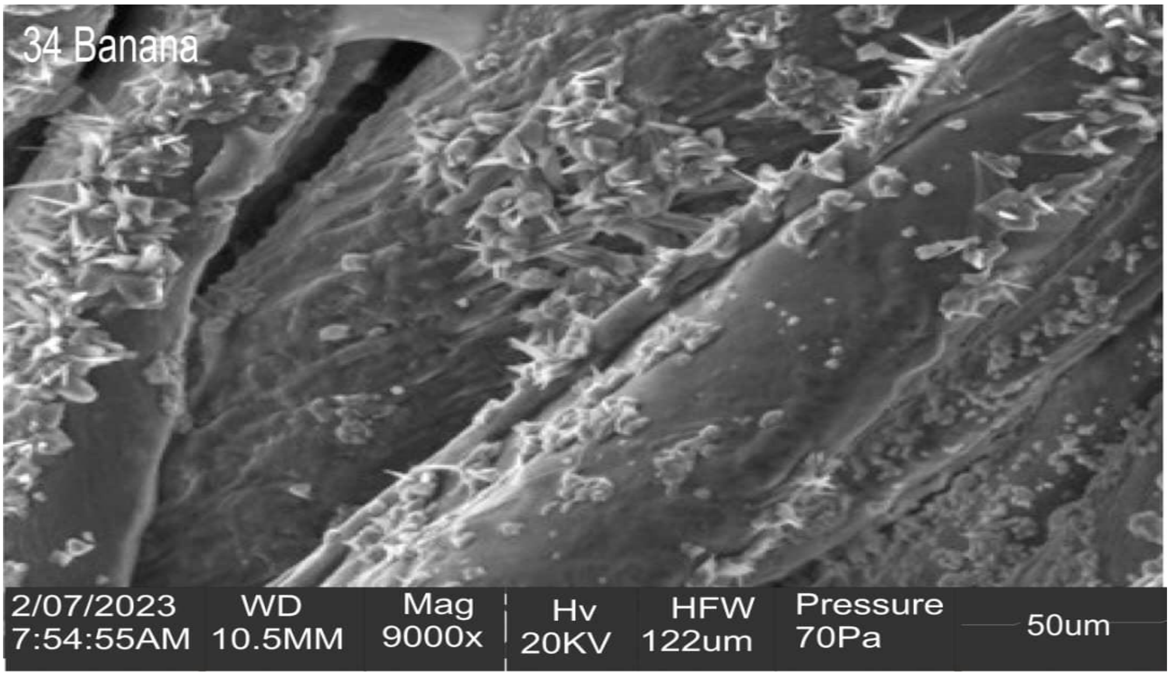

Figure 16: Morphology of the adsorbents of 34 Banana with weight diamter of 10.5 MM at 9000x Mag

Figure 16 shows the morphology conceptual shape and surface area of 34 Banana sample of particle size of 50µm and operational component monitored are WD with value of 10.5 mm, Mag with value of 9000x, HV with value of 20 KV, HFW with value of 122 µm and pressure 70 Pa. The shape of the morphology analysis result is well documented as shown in Figure 16

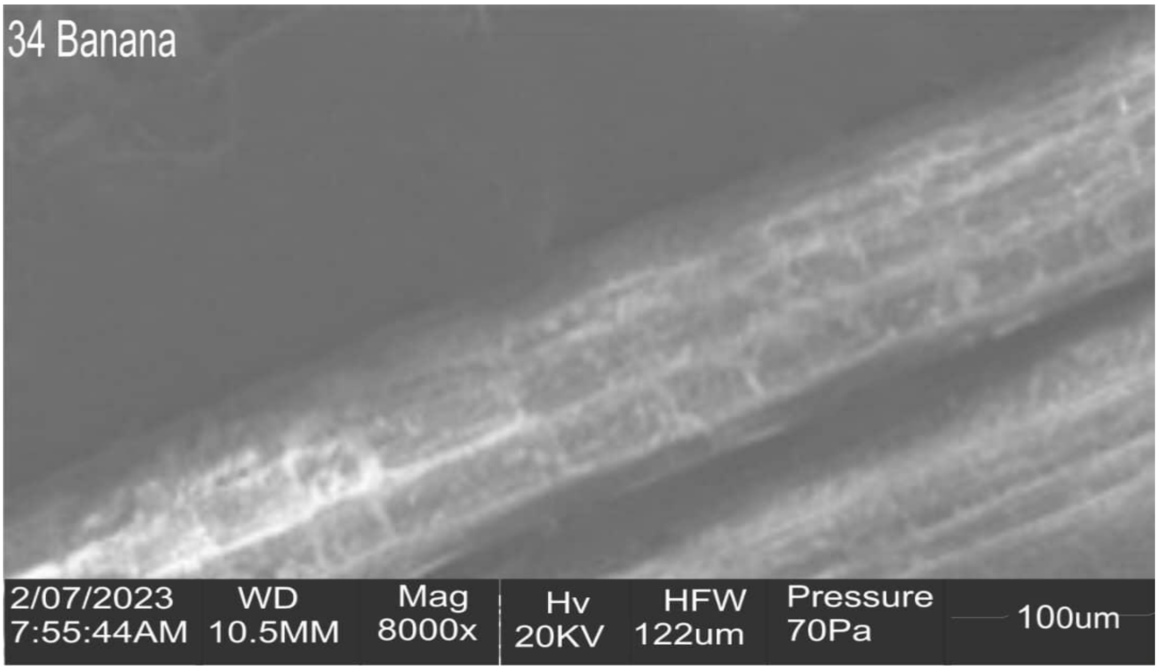

Figure 17: Morphology of the adsorbents of 34 Banana with weight diamter of 10.5 MM at 8000x Mag

Figure 17 shows the morphology shape of 34 Banana with particle size of 100µm and the operational properties of the morphology analyizer demonstrates that the WD value is 10.5 mm, Mag value is 8000x, HV value is 20 KV, HFW value is 122 µm and pressure is 70 Pa.

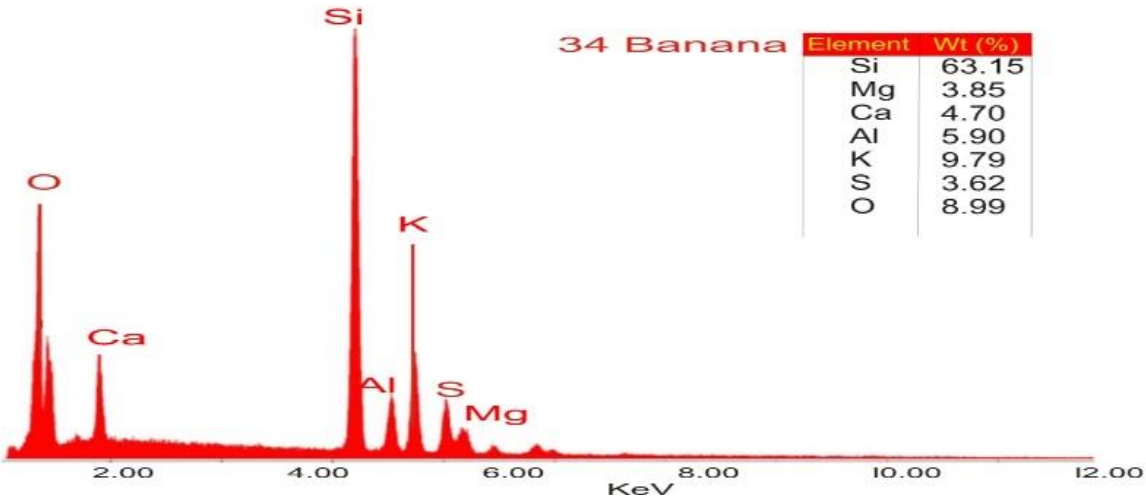

Figure 18: Results of Elements of the Morphology of the adsorbents of 34 Banana in Weight Percent

Figure 18 show the characteristics of the morphology result of the 34 Banana sample. The composition with respect to the element present as well as the percentage of each element in weight was obtained as illustrated in Figure 18 and furthermore the result shows potassium value of 9.79 %, oxygen value of 8.99 %, silicon value of 53.15 %, iron value of 3.0 %, sulphur value of 3.62 % aluminium value of 5.90 %, magnesium value of 3.85 % and calcium value of 4.70 %. In the 34 Banana sample, the morphology result demonstrates the present of element of aluminium with percentage in weight of 12.6 % and the presence of aluminium enhance adsorption process also. In this case the percentage in weight of elements is in the order of silicon (Si) 63.15 % > potassium (K) 9.79 % > oxygen (O) 8.99 % > aluminium (Al) 5.90 % > calcium 4.70 %. > magnesium (Mg) 3.85 % > sulphur (S) 3.62 %. The composition in weight in terms of percentage of the element present in the morphology test of the Plantain Abgagba 2 revealed its potential to be used as adsorbent.

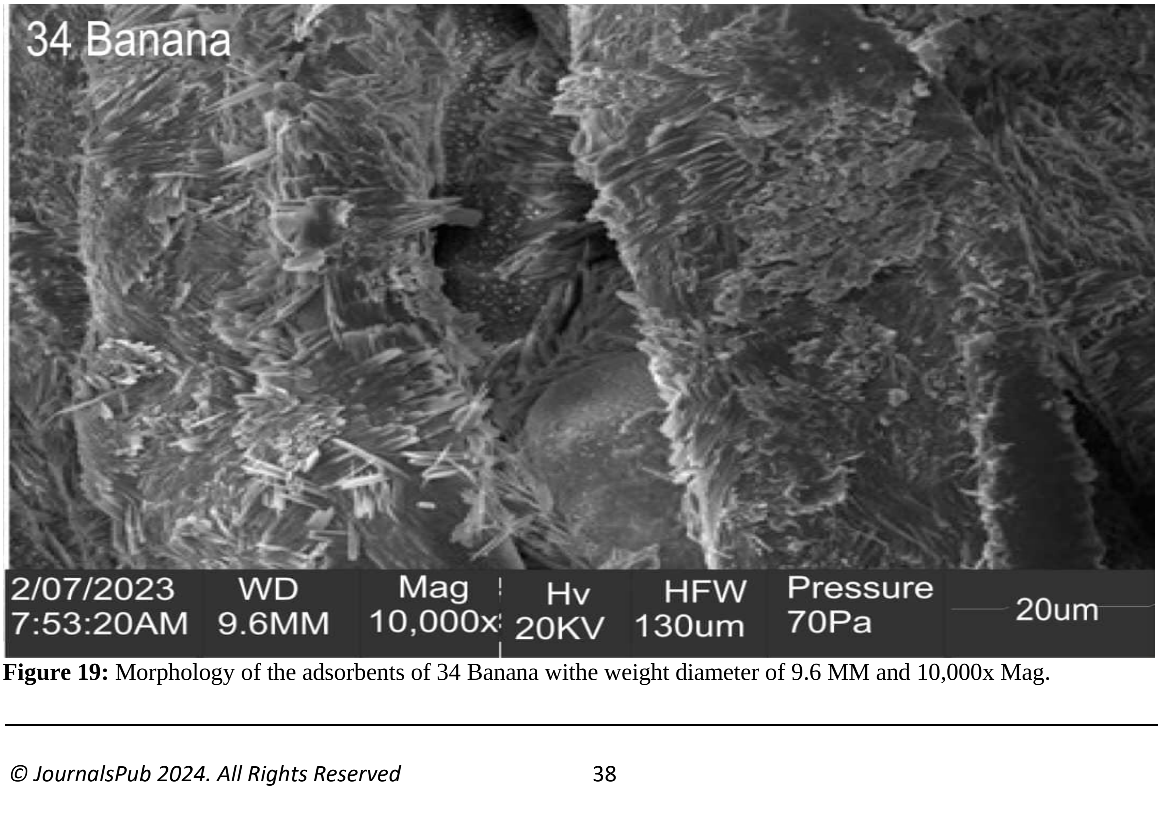

Figure 19: Morphology of the adsorbents of 34 Banana withe weight diameter of 9.6 MM and 10,000x Mag.

Figure 19 shows the morphology shape of 34 Banana with particle size of 20 µm and the operational properties of the morphology analyizer demonstrates that the WD value is 9.6 mm, Mag value is 10000x, HV value is 20 KV, HFW value is 130 µm and pressure is 70 Pa. [1215]

CONCLUSION

The morphology of the bio-adsorbent was considered, because of its role on the adsorption processes. However, the morphology of the Banana Ogoni Red (BOR), Banana Native (BN), Plantain Agbagba 1 (PA1), Plantain Agbagba 2 (PA2) and 34 Banana were considered. The element in weight in terms of percentage of composition of banana native in relationship to the morphology versus KeV reveals element wt. % of C (20.24), O (25.30), Fe (1.22), 5(2.80), K (2.15), Si (42.10), Ca (1.63), Mg (1.24) and Na (3.10). The thesis further demonstrated the element wt. (%) of Plantain Agbagba 1 as follows: Ca (4.3), mg (4.0), O (15.0), C (8.5), Si (47.0), Fe (11.0), K (3.0), Na (2.2) and S (5.0). From the morphology analysis of the Plantain Agbagba 2 the element weight percent revealed K (6.0), O (20.1), Si (48.0), Fe (3.0), S (8.0), Al (12.6) and Ca (2.30). Indeed, the morphology analysis on the 34 Banana shows that the element in weight percentage obtained are silicon Si (63.15), manganese Mg (3.85), calcium Ca (4.780), aluminium Al (5.90), potassium K (9.79), sulphur S (3.62) and oxygen O (8.99). Following the morphology data obtained it demonstrate that carbon C is only present in Banana Native and Plantain Agbabgba 1 with high value of element weight percent of 20.24 for Banana Native against 8.5 for Plantain Agbagba 1. For oxygen O, it revealed that BN – (25.3)> PA2 – (20.1)> PA1 – (15.0)> 34 Banana – 8.99, and in the case of iron Fe, we have PA1 – Fe (11.0) > Banana Native – Fe (1.22) showing that the iron content was more in Plantain Agbagba 1 than Banana Native, whereas in Plantain Agbagba 2 and 34 Banana species does not contain iron content. For sulphur content the morphology data obtained illustrates the present of it in all the agro-based materials sampled and data shows morphology value of element weight in percent as Plantain Agbagba 2 – PA2 – 8.0 > Plantain Agbagba 1 – PA1 – 5.0 > 34 Banana – 3.62 > Banana Native 2.80. In the case of calcium Ca 34 Banana 4.7 > Plantain Agbagba 1 – PA1 – 4.3 > Plantain Abgagba 2 – PA2 – 2.3 > Banana Native – BN – 1.63 and the presence of potassium is only notice on the Banana species which revealed value of 9.79% for 34 Banana specie and 2.15% for Banana Native species. The silicon content from the morphology data revealed 34 Banana 63.15 > Plantain Agbagba 2 – 48.0> Plantain Agbagba 1 – 47.0 > Banana Native – BN – 42.0 and the magenese Mg content from the morphology data demonstrates the presence of substance in 34 Banana specie – 3.85 > Plantain Agbaba 1 – 4.0> Banana Native – BN – 1.24.

The morphology of sodium Na showcases the weight percent of 3.10% for Banana Native (BN) greater than 2.2% of Plantain Agbagba 1 (PA1) whereas the species of Plantain Agbagba 2 (PA2) and 34 Banana has no trace of sodium content. The morphology data of all the different plant tested show the presence of aluminium AL in Plantain Agbagba 2 (AP2 – 12.5% in eight > 5.90% in weight of 34 Banana specie, whereas Banana Native BN and Plantain Agbagba 1 has not trace.

The morphology analysis and the data obtained has shown the possible potential element weight percent available in each sample and surface area. The presence of these elements aided the effectiveness of the formulated adsorbent for the treatment of PMS and AGO removal from the polluted salt and fresh water environment or media.

REFERENCES

1. Bundy, L.G. & Meisinger, J. J. (1994). Nitrogen availability indices. 951-984. In R.W. Weaver et al (ed.) Methods of Soil Analysis, Part 2, 3rd ed. Agron. Monogr. 9. ASA and SSSA, Madison, Wis.
2. Bundy, L.G. & Sturgul, S.J. (1994). Soil nitrate tests for Wisconsin cropping systems. Univ. of Wisconsin Ext. Pub. A3624.
3. Dahnke, W.C. & Johnson, G.V. (1990). Testing soils for available nitrogen. p. 127-139. In R.L. Westerman (ed.) Soil Testing and Plant Analysis, 3rd ed. SSSA, Madison, Wis.

4. Matejovic, I & Durackova. A. (1994). Comparison of Mehlich 1-, 2-, and 3-, calcium chloride-, Bray-, Olsen-, Enger-, and Schachtschabel-extractants for determinations of nutrient in two soil types. *Comm. Soil Sci. Plant Anal.*, 25: 1289-1302
5. Munter, R. C. (1988). Laboratory factors affecting the extractability of nutrients. . 8-10. In W.C. Dahnke (ed.). Recommended chemical soil test procedures for the North Central Region. North Central Region Publication 221 (revised). ND Agric. Exp. Stn., Fargo, N.D
6. Combs, S. M. (1995). Effect of soil name and management on profile SO_4-S levels. Unpublished data presented at Wisconsin Fertilizer, Aglime and Pest Management Conference.
7. Fox, R. L., Olson, R. A. & Rhoades. H. F. (1964). Evaluating the sulfur status of soils by plant and soil tests. *Soil Sci. Soc. Am. Proc.*, 28:243-246.
8. Sorensen, R. C., Oelsligle, D. D. & Knudsen, D. (1971). Extraction of Zn, Fe, and Mn from soils with 0.1 M hydrochloric acid as affected by soil properties, solution: soil ratio and length of extraction period. *Soil Sci*. 111:352-359.
9. Drymalski, S.M. & Gelderman, R.H. (1990). A routine colorimetric method to determine soil chloride. 267. Agron. Abstracts, ASA, Madison, Wis
10. Schulte, E. E. & Hopkins, B. G. (1996). Estimation of soil organic matter by weight-loss-on ignition. Chap.3. In F. R. Magdoff et al. (ed.). Soil Organic Matter: Analysis and Interpretation. SSSA Spec. Publ. 46, SSSA, Madison, Wis.
11. Lowther, J. R., Smethurst, P. J. Carllyle, J. C. & Nambiar, E. K. S. (1990). Methods for determining organic carbon on podzolic sands. *Comm. in Soil Sci. Plant Anal.*, 21:457-470.
12. Jackson, M. L. (1958). Soil Chemical Analysis. Prentice-Hall, Inc. Englewood Cliffs, N.J.
13. Mehlich, A. (1984). Photometric determination of humic matter in soils: A proposed method. *Comm. Soil Sci. Plant Anal*., 15:1417-1422.
14. Schollenberger, C. J. (1927). A rapid approximate method for determining soil organic matter. *Soil Sci*. 24:65-68
15. Ozean A.S. & Ozean A. (2004). Adsorption of Acid Dye from Aqueous Solutions onto Acid-Activated Bentonite. *Journal of Colloid and Interface Science*, 276, 39 – 46.

