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PERFORMANCE ASSESSMENT OF A CARBON DIOXIDE EXTRACTOR IN A SOLID WASTE MANAGEMENT FACILITY IN AKURE, NIGERIA

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ABSTRACT

The contributing effect of carbon dioxide (CO_2) emissions from solid-wastes to the increasing global warming was studied. This study assessed CO_2 removal by adsorbents in a solid-wastes management facility in Akure, Ondo State, Nigeria.

An exploratory study design with an intervention component was adopted. A CO_2 extractor utilizing adsorbents consisting mixtures of Sawdust and Potassium Hydroxide (SKH), Sodium Hydroxide (SSH) and Calcium Hydroxide (SCH), all at ratio1:1 was designed and fabricated. Five replicates of adsorbents were integrated into the equipment to capture CO_2 from 5kg samples of solid-wastes burnt under controlled conditions. The potential CO_2 was determined by ultimate analysis, while the concentration of CO_2 adsorbed was obtained by finding the difference between the

concentrations of the CO_2 at the inlet and outlet chambers of the extractor measured with P-Sense plus CO_2 meter AZ-7755. The effectiveness of the extractor combined with adsorbents was determined by comparing adsorbed with potential CO_2. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$.

The mean potential CO_2 was 160.0±42.0ppm. The mean CO_2 adsorbed were 99.0±24.0, 45.0±24.1 and 30.0±13.0 ppm for SKH, SSH and SCHrespectively.

The effectiveness of SKH in the capture of CO_2 was 61.9% as against 20.8% and 18.8 % obtained from SSH and SCH respectively.

Keyword: Carbon dioxide emissions,Effectiveness of Extractor, Carbon dioxide adsorption,Global warming.

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1. INTRODUCTION

The disposal of municipal solid waste is one of the main urban issues [1]. Development of integrated solid waste management facilities is necessary in order to prevent, recycle and manage solid waste in ways that most effectively protect human health and the environment [2]. Carbon dioxide is considered a major contributor to GHG Scientists found out that CO_2 emission plays a critical role in the acceleration of global warming trends [1, 2]. Furthermore, the global model suggests that an increase in CO_2 level leads to increasing oceanic vaporization resulting in a warming cycle [3]. Land filling is one of the most common ways of municipal solid waste (MSW) disposal. MSW is made up of different organic and inorganic fractions like food, vegetables, paper, wood, plastics, glass, metal and other inert materials. In cities, it is collected by respective municipalities and transported to designated disposal sites. The insanitary methods adopted for disposal of waste cause serious health and environmental problems [4]. The poorly maintained landfill sites are prone to groundwater contamination because of leachate percolation [5]. Furthermore, they cause bad odors and risks of explosion of methane gas that can accumulate at the landfill site [6]. Typically, the landfill gas consists of 50-60 %Vol of methane and 30-40 Vol% carbon dioxide with numerous chemical compounds such as aromatics, chlorinated organic compounds and sulfur compounds [7]. Landfills comprise the principal source of anthropogenic methane emission and are estimated to account for 3-19% of anthropogenic emission globally [8]. Most of the work on carbon dioxide capture from the atmosphere has been focused on the energy and transportation sector. Few reports have been documented in the developing countries especially in the solid wastes disposal sector. It is therefore important to look into the possibility of achieving the prevention of carbon dioxide emissions into the atmosphere from the waste sector through the development of a Carbon Dioxide Extractor (CDE) using locally available materials. This is aimed at reducing global warming. This study therefore assessed the performance of a CDE in a transfer station with a solid waste management facility in Akure, South West Nigeria.

2. MATERIALS AND METHODS

2.1. Study Area

Akure is the capital of Ondo State in Nigeria. It is an indigenous African town that lies between latitude 7° 15′ 0″ N and 5° 11′42″ East of prime meridian. The present population of the city according to the 2013 Census Projection is more than 387,087 people. The majority of the people are "Yoruba" while other ethnic groups constitute a smaller proportion of the population. Most of the people are engaged in petty trading and small-scale business, while others are civil/public servants. Akure has several public, private and social amenities such as the Ondo State Specialist Hospital, banks, industries, post offices, higher institutions such as the Federal University of Technology Akure (FUTA), Federal College of Agriculture, Akure, Water Corporation and over 700 schools made up of both public and private nursery, primary and secondary schools.The Integrated Waste Recycling Plant at Akure has a conceptualized capacity of 25 Tons/day, 5Tons/day and 5Tons/day for Organic Fertilizer, Plastic recycling and Metal Scrap Recycling respectively.

2.2. Study Design

An exploratory study design was adopted. The study involves modeling the performance of a carbon dioxide extractor and then assessing the performance in relation to some selected adsorbents.

2.3. Evaluation of the Performance of the Carbon Dioxide Extractor

2.3.1. Preparation and Production of Sawdust Char/Adsorbents

2.3.1.1. Preparation of Sawdust

The sawdust wascollected from the Ogendengbe Sawmill at the Idashen Area of Owo, Ondo State. Its disposal is a problem and is generally considered as wasteSawdust samples were sieved (pore size of 0.25 mm),washed several times to remove dust and first sun- dried for 24 hours as reflected in plates 2. The sun-dried saw dust was later dried at 110°Cfor 24hours in a drying oven at the Laboratory of the Ondo State Water Corporation, Alagabaka, Akure.

2.3.1.2.. Production of Sawdust Char with Potassium Hydroxide (K OH)

150g of sawdust was well mixed with 150 g of KOH pellets which was thoroughly soaked and mixed with 150ml of distilled water. The sample was then left for 5 minutes until it became stable. The stable sample was then transferred to the Techmel and Techmel Furnace at 500°C for 5 hours.

2.3.1.3.. Production of Sawdust Char with Sodium Hydroxide (Na OH)

150g of sawdust was well mixed with 150 g of NaOH pellets which was thoroughly soaked and mixed with 3000ml of distilled water. This was because of the high reactivity of the activation agent (NaOH). The sample was then left for 5 minutes until it became stable. The stable sample was then transferred to the Techmel and Techmel Furnace at 500°C for 5 hours.

2.3.1.4. Production of Sawdust Char with Calcium Hydroxide $Ca(OH)_2$

150 g of sawdust was well mixed with 150 g of $Ca(OH)_2$ pellets which was thoroughly soaked and mixed with 150ml of distilled water. The sample was then left for 5 minutes until it became stable. The stable sample was then transferred to the Techmel and Techmel

Furnace at 500ºC for 5 hours. The sun drying, oven drying and preparation of the sawdust char and the Techmel and Techmel Furnace are shown in Figure 1

Figure 1: Preparation of Sawdust Char (a) Sun Drying of Sawdust (b) Drying of Sawdust in an oven (c) Preparation of Sawdust with KOH (d) Furnace in Operation at 500ºC

2.4. Characterization of Sawdust Char

The particle properties of the sawdust char samples were investigated using a Scanning Electron Microscope (SEM), Make: Phenom proX SEM, Model No: 800-07334 operated at 25kV at the Mechanical Engineering Department at the Covenant University, Ota. The produced sawdust char and KOH, sawdust char and NaOH and sawdust char and $Ca(OH)_2$ and the SEM is shown in Figure 2.

Figure 2: Characterization of Sawdust Char (a) Sawdust char produced from sawdust and KOH (b) Sawdust char produced from sawdust and NaOH (c) Sawdust char produced from sawdust and $Ca(OH)_2$ (d) Microscope (SEM), Make: Phenom proX SEM, Model No: 800-07334)

2.5. Monitoring of Carbon Dioxide Absorbed by Extractor and Different Sawdust Char

Five Wooden frames made up of Tie rods of sizes 0.5, 0.75, 1.00, 1.25, and 1.50 m^3 respectively were constructed as shown in Figure 3a. A thick Nylon Sheet was then used to cover the wooden frames. This is to prevent the gas fumes from escaping to the atmosphere. The adsorbent made up of sawdust and KOH was placed in the plastic container. The extractor was then placed in between two of the wooden frames of sizes wooden frames of sizes 0.5 and 0.75 m^3 (inlet and outlet) which were adequately covered with a black thick nylon as reflected in Figure 3b. Five (5) kg of solid wastes was kept in a medium sized pot as shown in Figure 3c was set ablaze and allowed to burn for 5 minutes to release the emissions. The pot was then placed in the inlet wooden frame. The baseline concentration of the CO_2 was then measured with a CO_2 Meter AZ-7755 shown in Figure 3d. The extractor was then switched on and the inlet fan operated for 10 minutes. The post concentration of the CO_2 at the inlet chamber was then measured. There was another interval of another 10 minutes, before the expiration of the interval, the pre-concentration of the CO_2 at the outlet chamber was then measured. After the expiration of the 10 minutes interval, the outlet fan of the extractor picked up and operated for another 10 minutes and the post concentration of the carbon dioxide was then measured. This was repeated for 0.75 and 0.75 m^3, 1.0 and 0.75 m^3, 1.25 and 0.75 m^3 and 1.50 and 0.75 m^3; (inlet and outlet) respectively. The measuring of the

pre-concentration of the CO_2 is shown in Figure 3e. The exercise was then repeated for the other treatment of adsorbent of (Sawdust + Na OH) and (Sawdust + $CaOH)_2$)by replacing the adsorbents in the plastic container of the carbon dioxide extractor respectively.

Figure 3. Monitoring of Carbon Dioxide Absorbed by Extractor and Different Sawdust Char (a) Naked Frames of Containers from 0.50 to 1.50 m^3 (b) Carbon dioxide Extractor placed between the covered inlet and outlet chambers (c) Solid wastes burnt in medium size pot as source of emissions (d) P-Sense Plus CO_2 Meter Az-7755 (e) Measurement of pre-concentration of the CO_2emissions

2.6. Evaluation/ Prediction of the Performance of the Extractor (Sawdust char).

2.6.1. Modelling and prediction of the performance of extractor combined with sawdust char

To predict the performance of the sawdust char in terms of the CO_2 adsorbed by each of the sawdust char (Sawdust + Alkaline), the following was used to generate the concentration of CO_2 in the system:

1) Conc. of CO_2 inlet in ppm = (post – pre) concentration of CO_2 at inlet
2) Conc. of CO_2 at outlet in ppm = (post – pre) concentration of CO_2 at outlet
3) Conc. of CO_2 Adsorbed in ppm = Conc. of Co_2 inlet in ppm - Conc. of CO_2 at outlet in ppm

The size of the inlet CO_2 chamber i.e. (1.5, 1.25, 1.00, 0.75and 0.5 m^3) was plotted against the Concentration of CO_2 adsorbed respectively using the Mathematical Laboratory Software (MATLAB) and the corresponding model equations for each of the material which would predict the concentration of CO_2 adsorbed was generated using the software.

2.6.2. Assessment of the effectiveness of the extractor combined with sawdust char

2.6.2.1. Calculation of potential carbon dioxide

Five samples of 200g of solid waste were collected and characterized. The samples were then equally divided into two groups of five samples of 100g each. Five samples of 100g were then burnt for five minutes and the other five samples left unburnt, after which both groups were taken to the Agronomy Department of Institute of Agricultural Research and Training, Ibadan, Oyo State. Ultimate analysis were conducted on the burnt and unburnt waste to obtain the % CO_2. The difference of the % CO_2 of the unburnt and burnt wastes for the five samples for each sawdust char/adsorbents were found and was calculated as the mean potential carbon dioxide. The percentage was then converted to parts per million (ppm).

2.6.2.2. Calculation of adsorbed carbon dioxide

The Adsorbed CO_2 was calculated by finding the mean difference between the concentration of CO_2 at the inlet chambers in ppm and the concentration of CO_2 at outlet chambers in ppm for each treatment of the sawdust char for the five sizes of the inlet chambers.

2.6.2.3. Determination of effectiveness of extractor combined with sawdust char

The effectiveness was then determined by comparing the mean adsorbed CO_2 for each sawdust char with the mean potential CO_2.

2.8 Data Analysis

Data analysis was carried out using descriptive Statistics and ANOVA at 5% level of significance.

3. RESULTS

3.1. Evaluation of performance of carbon dioxide extractor

3.2.1 Characterization of burnt and unburnt waste

Figure 4a shows the components of wastes that was burnt during the evaluation of the carbon-dioxide extractor. The percentage composition by weight of the physical components

that were burnt were as follows: 46.0 26.0 9.0, 7.0, 7.0 and 5.0% for Organic waste, Sawdust, Paper, Nylon, Leaves and wood respectively.

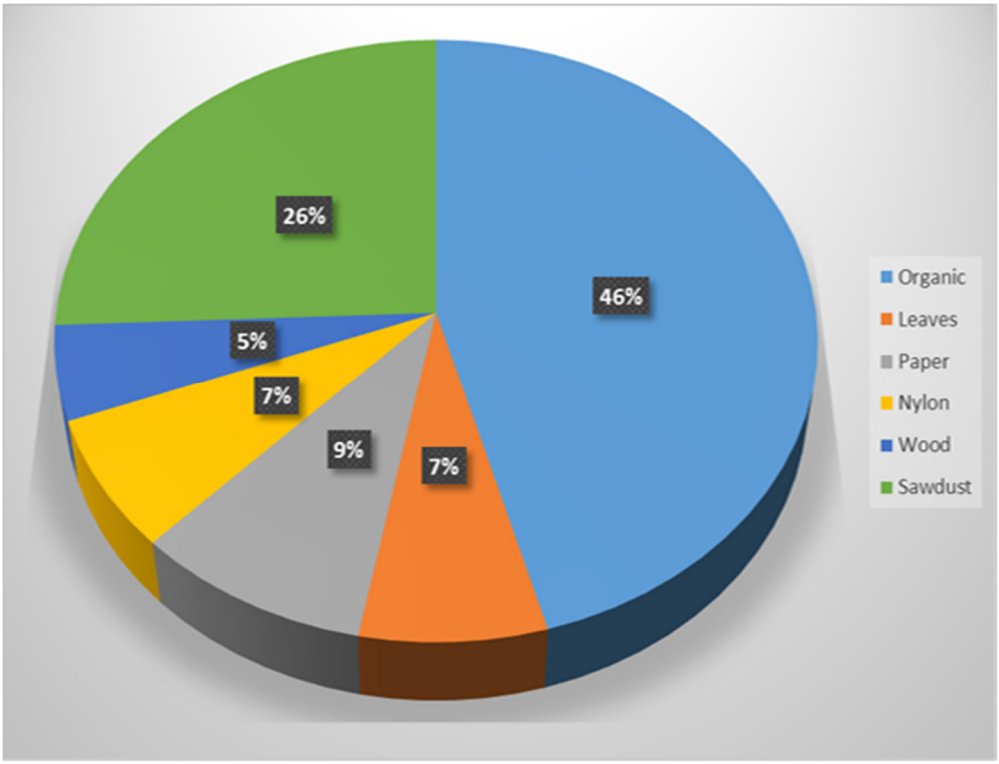

Figure 4 Percentage composition of burnt and unburnt solid waste

3.2.2 Ultimate analysis of unburnt and burnt waste

The Ultimate Analysis of the unburnt and burnt waste was reflected in Figure 4b. For % carbon, 41.6 and 57.5% were obtained for the unburnt and burnt refuse respectively, 7.3 and 5.6% were obtained for hydrogen, while 35.8 and 33.8% for % oxygen; 0.17 and 0.06% for nitrogen and 0.021 and 0.037% for carbon-dioxide for unburnt and burnt refuse respectively.

3.2.3. Performance of carbon dioxide extractor and the chemically sawdust char

3.2.3.1. Characterization of the Different Sawdust char

Table 1 shows the particle properties of the various adorbents produced. For the properties weighted by volume the circle equivalent diameter were 88.0, 47.5 and 27.7µm for sawdust with KOH, sawdust with NaOH and swadust with $Ca(OH)_2$ resectively. For the properties weighted by count the circle equivalent diameter were 34.2, 27.3 and 20.8µm for sawdust with KOH, sawdust with NaOH and sawdust with $Ca(OH)_2$ resectively. Figure 5 shows the scanning electron microscopy images for sawdust with KOH, sawdust with NaOH and sawdust with $Ca(OH)_2$ respectively.

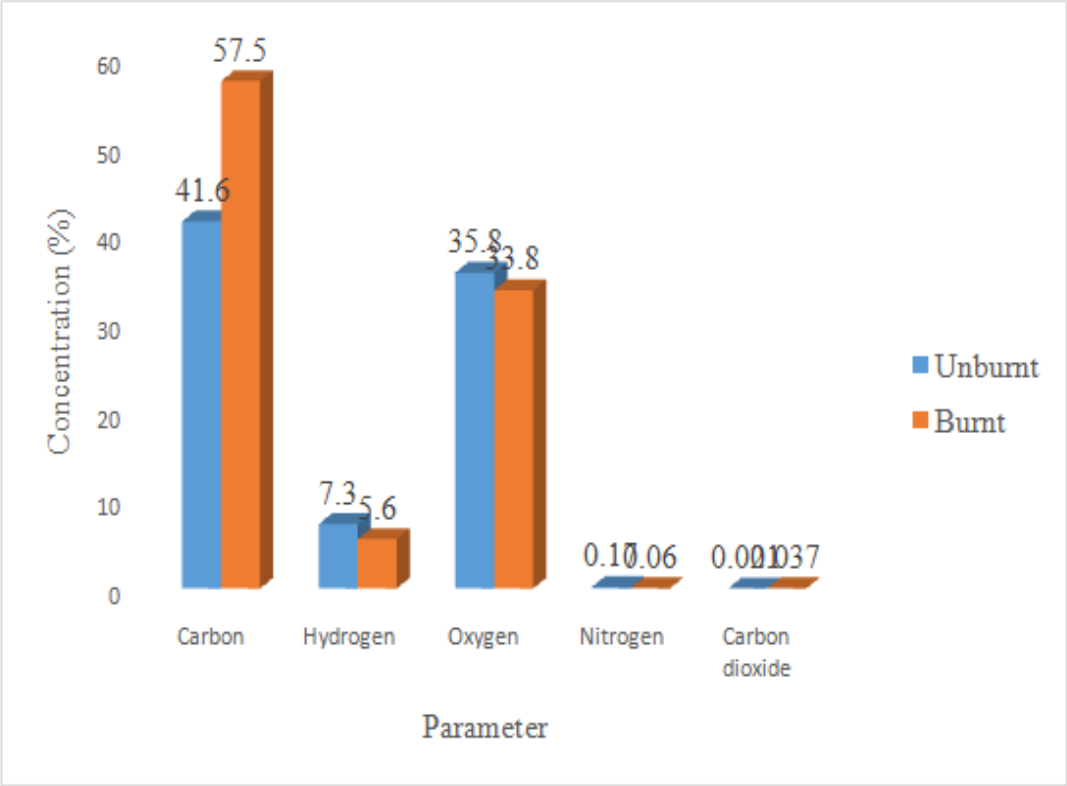

Figure 4 Ultimate analysis of burnt and unburnt solid waste

3.2.3.2. Monitoring of carbon dioxide adsorbed by the extractor and different sawdust char

Table 2 shows the CO_2 adsorbed by the extractor for different sawdust char. For sawdust with KOH, at the inlet chamber the difference in the pre and post concentration of the CO_2 were 66.0, 95.0, 125.0, 135.0 and 121.0 ppm for 0.50,0.75, 1.00, 1.25and 1.50 m^3 respectively with an average value of 108.4 $\pm$ 27.9 ppm, while at the outlet chamber of 0.75 m^3 the difference in the pre and post concentration of the CO_2 were 4.0, 7.0, 9.0, 15.0 and 13.0 ppm respectively with an average value of 9.6 $\pm$ 4.5 ppm implying that the concentration of CO_2 adsorbed were 62.0, 88.0, 116.0, 120.0 and 108.0 ppm respectively with an average value of 99.0 $\pm$ 24.0 ppm. For Sawdust withNaOH, at the inlet chamber the difference in the pre and post concentration of the CO_2were 26.0, 60.0, 84.0, 94.0 and 90.0 ppm for 0.50,0.75, 1.00, 1.25and 1.50 m^3 respectively with an average value of 70.8 $\pm$ 28.3ppm, while at the outlet chamber of 0.75 m^3 the difference in the pre and post concentration of the ppm, were 16.0, 22.0, 39.0, 40.0 and 14.0 ppm respectively with an average value of 26.2 $\pm$ 12.5 ppm implying that the concentration of ppm, adsorbed were 10.0, 38.0, 45.0, 54.0 and 76.0 ppm respectively with an average value of 45.0 $\pm$ 24.1 ppm. For Sawdust with $Ca(OH)_2$, at the inlet chamber the difference in the pre and post concentration of the CO_2, were 47.0, 76.0, 106.0, 116.0 and 102.0 ppm for 0.50,0.75, 1.00, 1.25and 1.50 m^3 respectively with an average value of 89.4$\pm$27.9 ppm, while at the outlet chamber of 0.75 m^3 the difference in the pre and post concentration of the CO_2 were 34.0, 50.0, 77.0, 84.0 and 54.0 ppm respectively with an average value of 59.8$\pm$20.5 ppm implying that the concentration of the CO_2 adsorbed were 13.0, 26.0, 29.0, 32.0 and 48.0 ppm respectively with an average value of 30.0 $\pm$ 13.0 ppm.

Table 1 Particle properties of various adsorbents

Parameter	Average (µm)		
	Sawdust + KOH	Sawdust +NaOH	Sawdust + $Ca(OH)_2$
CED weighted by volume	88.0	47.5	27.7
CED weighted by count	34.2	27.3	20.8

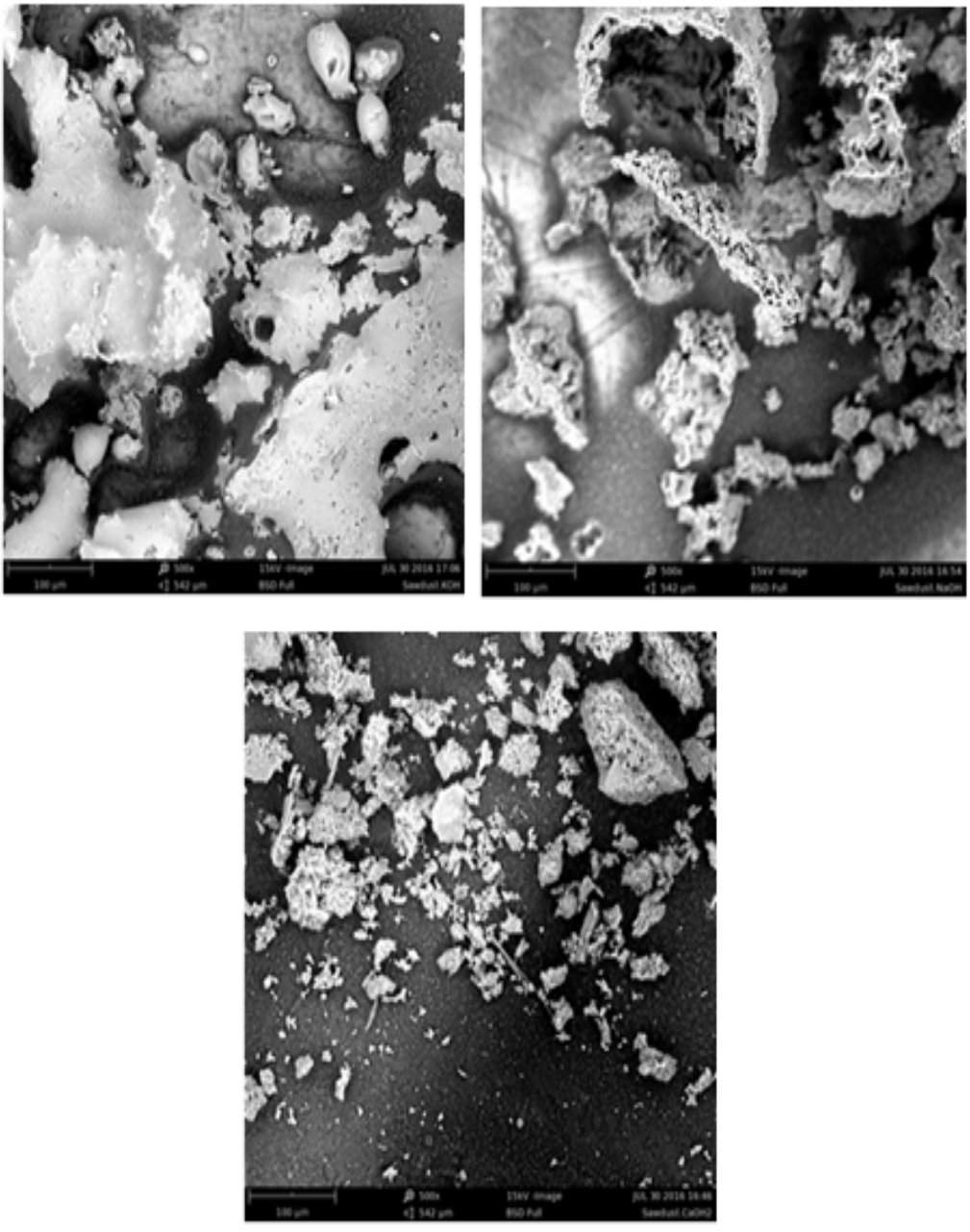

Figure 5: Scanning electron microscopy images. (a) SEM Image of sawdust char from sawdust and KOHat 500 times showing the particle size weighted by volume (b) SEM Image of sawdust char from sawdust and NaOHat 500 times showing the particle size weighted by volume (c) SEM Image of sawdust char from sawdust and $Ca(OH)_2$ at 500 times showing the particle size weighted by volume.

Table 2 Carbon dioxide adsorbed by extractor combined with different activated carbon

Size (M^3)	Inlet			Outlet			Concentration of CO_2 Adsorbed (ppm)
	CO_2 (ppm)			CO_2 (ppm)			
	Pre	Post	Difference	Post	Pre	Difference	
Saw Dust With KOH					`		
1.50	584	518	66.0	470	466	4.0	62.0
1.25	595	500	95.0	465	458	7.0	88.0
1.00	592	467	125.0	467	458	9.0	116.0
0.75	585	450	135.0	482	467	15.0	120.0
0.50	590	469	121.0	495	482	13.0	108.0
Mean			108.4± 27.9			9.6 ± 4.5	99.0 ± 24.0
Saw Dust With NaOH							
1.50	560	534	26.0	485	469	16.0	10.0
1.25	572	512	60.0	508	482	22.0	38.0
1.00	580	496	84.0	510	471	39.0	45.0
0.75	592	498	94.0	539	499	40.0	54.0
0.50	601	511	90.0	533	519	14.0	76.0
Mean			70.8 ± 28.3			26.2 ± 12.5	45.0 ± 24.1
Saw Dust With $Ca(OH)_2$					`		
1.50	581	534	47.0	478	444	34.0	13.0
1.25	585	509	76.0	532	482	50.0	26.0
1.00	573	467	106.0	538	461	77.0	29.0
0.75	597	481	116.0	566	482	84.0	32.0
0.50	569	467	102.0	533	479	54.0	48.0
Mean			89.4± 27.9			59.8± 20.5	30.0 ± 13.0

3.2.3.3. Prediction of concentration of carbon dioxide adsorbed from size of inlet Chamber

A. Sample sawdust char with KOH

Figure 6a reflects the relationship between the volume size of the inlet chamber (in m^3) and the concentration of CO_2 adsorbed (ppm) by saw dust char with KOH From the graph, the polynomial equation showing is given as:

$C_a = 0.036V_i^4 - 0.00\ 14\ V_i^3 + 0.0017\ V_i^2 - 0.08\ V_i + 0.024$

Where, C_a is the concentration of CO_2 adsorbed and V_i is the volume size of CO_2 inlet chamber

B. Sample sawdust char with NaOH

Figure 6b reflects the relationship between the volume size of the inlet chamber (in m^3) and the concentration of CO_2 adsorbed (ppm) by saw dust char with NaOH. From the graph, the polynomial equation showing is given as:

$C_a=0.0012V_i^4-0.0047\ V_i^3+0.0068\ V_i^2-0.0041\ V_i+0.086$

Where, C_a is the concentration of CO_2 adsorbed and V_i is the volume size of CO_2 inlet chamber.

C. Sample sawdust char with Ca (OH)₂

Figure 6c reflects the relationship between the volume size of the inlet chamber (in m^3) and the concentration of CO_2 adsorbed (ppm) by saw dust char with $Ca(OH)_2$. From the graph, the polynomial equation showing is given as:

$C_a=0.089V_i^4-0.0036\ V_i^3+0.0051\ V_i^2-0.003\ V_i+0.063$

Where, C_a is the concentration of CO_2 Adsorbed and V_i is the volume size of CO_2 inlet chamber.

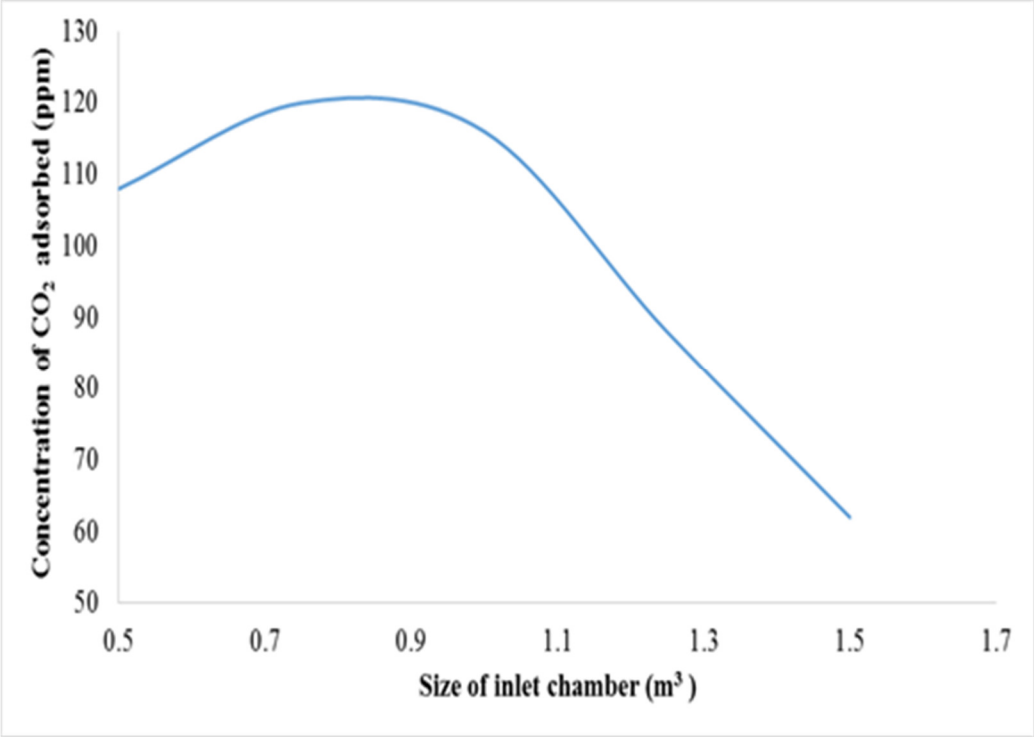

Figure 6a Graph of concentration of CO_2 adsorbed (ppm) against volume size of inlet chamber (m^3) for sawdust char with KOH

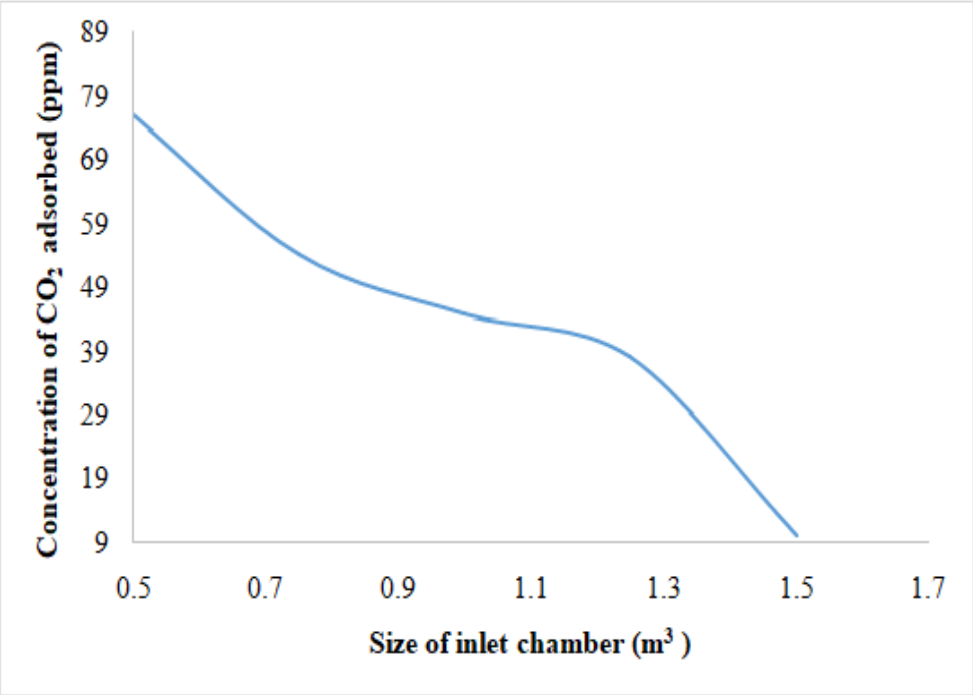

Figure 6b Graph of concentration of CO_2 adsorbed (ppm) against volume size of inlet chamber (m^3) for sawdust char with NaOH.

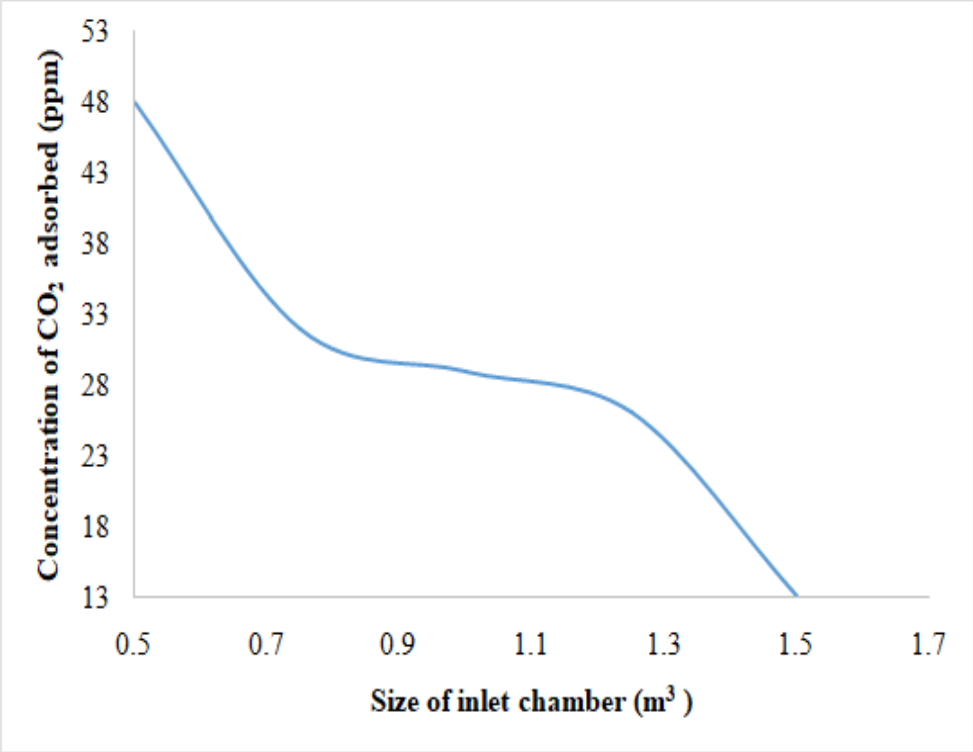

Figure 6cb Graph of concentration of CO_2 adsorbed (ppm) against volume size of inlet chamber (m^3) for sawdust char with Ca *$OH)_2$.

3.2.3.4. Assessment of the effectiveness of extractor combined with adsorbents in the extraction of carbon dioxide

Table 3 reflects the comparism of adsorbed CO_2 with potential CO_2 from burnt and urburnt solid waste while Table 4 reflects the effectiveness of the extractor combined with the chemically activated sawdust. This was obtained by the comparison of

Table 3 Comparison of adsorbed CO_2 with potentialCO_2 from burnt and unburnt solid waste

Size (m^3)	CO_2 (ppm)			CO_2 (ppm)		
	KOH	NaOH	$Ca(OH)_2$	Unburnt	Burnt	Difference
1.50	62.0	10.0	13.0			
1.25	88.0	38.0	26.0			
1.00	116.0	45.0	29.0	210.0	370.0	160.0
0.75	120.0	54.0	32.0			
0.50	108.0	76.0	48.0			
Mean	99.0 $\pm$ 24.0	45.0 $\pm$ 24.0	30.0 $\pm$ 24.0			

Table 4 Effectiveness of CO_2 adsorption by the extractor combined with adsorbents

Sawdust char	Mean CO_2 Adsorbed (ppm)	Potential CO_2 In Waste (ppm)	Effectiveness of Extractor combined with Adsorbents= (Mean CO_2 Adsorbed / Potential CO_2 In Waste * 100) (%)	P< 0.05
KOH	99.0	160.0	61.9	
Na OH	45.0	160.0 160.0	28.0	0.00
Ca $(OH)_2$	30.0		18.8	

adsorbed CO_2 by each treatment of chemically sawdust char from sawdust with the potential CO_2 from the burnt solid waste in ppm. 99.0 $\pm$ 24.0 ppm of carbon dioxide out of the potential 160.0 ppm which makes the effectiveness of the extractor combined with sawdust chemically activated with potassium hydroxide to be 61.9% as againt 45.0 $\pm$ 24.1 ppm of CO_2 out of the potential 160.0 ppm which makes the effectiveness of the extractor combined with sawdust chemically activated with sodium hydroxide to be 28.1% and 30.0 $\pm$ 13.0 ppm of CO_2 out of the potential 160.0 ppm which makes the effectiveness of the extractor combined with sawdust chemically activated with calcium potassium hydroxide to be 18.8% respectively.

It was observed that the extractor combined with sawdust chemically activated by potassium hydroxide (KOH) performed optimally with an effectiveness of 61.9%. This was followed by the extractor combined with sawdust chemically activated with sodium hydroxide (NaOH) with an effectiveness of 28.1% and extractor combined with sawdust chemically activated with calcium hydroxide $Ca(OH)_2$ with an effectiveness of 18.8%. What obtained was in agreement with the findings of **[12]** who stated and concluded that a porous carbon material made from sawdust and KOH performs better than the currently available ones. The reasons adduced is that the KOH treatment creates pores in the sawdust structure by oxidation of carbon and carbon gasification from K_2CO_3 decomposition. This is evidenced in the circle equivalent diameter weighted by volume of 88.0 µm as compared to 47.5 and 27.7 µm and the circle equivalent diameter weighted by count of 34.2 µm as compared to

27.3 and 20.8 µm of the adsorbent produced from sawdust and NaOH and sawdust with $Ca(OH)_2$respectively. The big pores sizes are responsible for material uptake capabilities as it provides more surface area for adsorption of CO_2 bestowing it with capacity as high as 4.8 mmol CO_2/g.The material has good selectivity for CO_2 over Nitrogen and fast adsorption rates and can easily be regenerated. This also agrees with [9] that starch cellulose and sawdust derived carbon sorbents prepared through KOH activation are reported to have CO_2 uptakes of up to 21.2% under 1bar CO_2 and 25° C respectively. The reasons deduced for a better performance of KOH activated sawdust according to [10] was that KOH had more tendency to bind with carbon dioxide than NaOH and $Ca(OH)_2$. Suchinteractions lead to cross linking reactions with some volatility thereby retaining them in the solid matrix. This would result in increase in the net mass of the sample thereby leading to increase in density thereby encouraging higher adsorption of the gas. The activation with KOH according to [11] reported a series of porous carbon with adjustable surface areas and narrower micro-pore size distribution. This encourages a high uptake carbon dioxide and CO_2/N_2 sensitivity which makes such carbon activated with KOH more promising for CO_2 capture and separation. Similarly, [12] reported a chemically activated synthesis (KOH) as activated agent of highly porous N-doped carbon for CO_2 capture. This ensures the chemically sawdust char with KOH to have a large CO_2 adsorption capacity. Furthermore, the capture of CO_2 with this kind of carbon takes place at high adsorption rates more than 95% of the CO_2 in two minutes. The performance of the CO_2 extractor as evidenced by 61.9% which was obtained with the combination of the extractor with adsorbent made from sawdust and potassium hydroxide was in agreement with [13] who posited that it was possible to move air mechanically but only at speeds that are easily achieved by natural flows. The method of considering chemical adsorption from natural air flow passing over some recyclable sorbents such as sawdust chemically activated with potassium hydroxide was also confirmed. The utilization of a rechargeable battery to power the extractor also made more appreciable because it prevented the device to also be a source of emission as there is no need for fuel. Also the production of a unit of the extractor is more cost effective than the use of a wind mill because the extractor was designed to operate at a natural air low velocity of 2.75 m/s than that of 10 m/s which is wind stronger than is usually assumed to prevail in wind mill operations [14]. The approach of utilizing the device for extracting carbon dioxide from the air was also effective because of the property which enables CO_2 to mix easily with air. This does not distort atmospheric CO_2 concentrations. The CO_2 enriched air mixes rapidly with ambient air to maintain constant levels of CO_2. Air depleted in CO_2 will also mix rapidly and return to ambient conditions. This mixing rate sets the limit of how one could space CO_2 extraction [15]. To maximize extractability of CO_2 by the devise as stated, the designed contact time of 10 minutes for the extractor was selected. The major advantage of carbon capture from air is that it does not require abandonment of existing facilities and infrastructure. Extraction from the air could therefore be introduced in parallel to other methods that sequester CO_2 directly captured at source. Another advantage of the extractor compared to other methods of carbon sequestration is its portability, which enables to be movable. Most methods are usually stationary. From the aforementioned, if more efforts are concentrated on the improvement of the CO_2 extractor, it would go a long way of mitigating the menace of high atmospheric CO_2 levels and its attendant effects on the environment. In this study, the performance of the CO_2 extractor was quite low compared to the established findings from literatures. This is as a result of the extractor being utilized in an outdoor environment while the referred works were conducted in a laboratory. Furthermore, the tendency in losses of gas due to leakages on the casing and factors such as power loss based on the efficiency of the battery affected the fan power thereby reducing extraction capacity of the extractor.

4. CONCLUSIONS

It was observed during the course of study that not much work had been done on the capture of atmospheric carbon dioxide from the solid wastes management sector, especially in developing countries like Nigeria. At the end of the study, the following conclusions were drawn: Adsorbent prepared from sawdust with KOH had pore size of 88.0 and 34.2 µm for circle equivalent diameter for properties weighted by volume and properties weighted by count respectively compared with 47.5 and 27.3 µm and 27.7 and 20.8 µm for circle equivalent diameter for properties weighted by volume and properties weighted by count for sawdust prepared with NaOH and sawdust prepared with $Ca(OH)_2$ respectively. Incorporation of sawdust chemically activated with KOH combined with the carbon dioxide extractor improves the effectiveness of carbon dioxide extraction as the effectiveness of the extractor combined with KOH was 61.9% as against 20.8% and 18.8% of sawdust and NaOH and sawdust and $Ca(OH)_2$ respectively.

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