Global Research in Environment and Sustainability
April 2023, Vol. 1, No. 2, pp. 47-63.

The Value Addition of Agricultural Waste (Pig dung) in Producing Activated Carbon for Use in Veterinary Medicine, Agriculture and Environmental Remediation: A Review

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Abstract:
The expansion of agricultural production has naturally resulted in increased quantities of livestock wastes, agricultural crop residues and agro-industrial by-products. Pig waste is a biomass that changes rapidly from the time of excretion thereby creating a serious pollution problem. The odor from pig dung is capable of diminishing air quality which brings tension and complaints between pig farmers and their neighbors resulting to litigations and risk of possible closure of farms. A review on agricultural wastes such as pig dung is desirable because of their contribution to environmental degradation and the need to convert them to value-added products such as activated carbon (AC). Activated carbon also called activated charcoal is a solid, porous, tasteless and black carbonaceous material prepared from a variety of carbon containing materials, including agricultural wastes. Activated carbon is capable of adsorbing various toxic substances which makes it suitable for use as universal poison antidote, feed additive, water purification, and environmental remediation.

Keywords: Agricultural wastes, pig dung, activated carbon, veterinary medicine, agriculture and environmental remediation.

INTRODUCTION

Agricultural wastes are residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products and crops. Agricultural wastes and by-products are being advocated for the production of adsorbents such as activated carbon (AC) due to their carbon content and the possibility of mitigating environmental pollution through such a process (Schmidt *et al.*, 2019). Activated carbon or activated charcoal or biochar as it is synonymously described when produced from agricultural wastes have been found to be renewable and relatively less expensive when compared to other activated carbon precursors of industrial and petroleum origin such as wood, coal and lignite (Mohammed *et al.*, 2018). Activated carbon also called activated charcoal is a solid, porous, tasteless and black carbonaceous material prepared from a variety of carbon containing materials, including agricultural residues (AAFCO, 2012). Emerging reports revealed that activated charcoal adsorbs more toxins than any natural substance known to mankind (Maklad *et al.*, 2012).

A classical and frequently cited early demonstration with charcoal was a lethal dose of strychnine that was mixed with charcoal by Tovery in 1831, with no harmful effect observed due to the simultaneous ingestion of charcoal. Activated charcoal is therefore one of the best antidotes against poisons such as mushroom poisoning, brown recluse spider, insect sting and different types of snake bites (Maklad *et al*., 2012). For example, in an experiment by Cooney (1980), 100 times the lethal dose of cobra venom was mixed with activated charcoal and injected into a laboratory animal without any harmful effect observed. Indeed, it is capable of adsorbing a thousand times its own weight of gases, heavy metals and poisons (Schmidt *et al.*, 2019). It is this high adsorption property that makes activated carbon useable in water purification and in the removal of undesirable odours and impurities from food. Bad odours caused by skin ulcers have been eliminated by placing charcoal-filled cloth over plastic cast on the sore. It has been effectively used to adsorb wound secretions, bacteria and toxins (Schmidt *et al.,* 2019). Activated charcoal is required by law to be part of the standard equipment in many ambulances as first aid against poisoning. Activated carbon is a very effective adsorbent for reducing the levels of mycotoxins in feed when compared with other mineral adsorbents such as aluminosilicates and bentonite (Huwig *et al.,* 2001; Bhatti *et al.,* 2018).

When mixed with water and swallowed to counteract poisoning, activated charcoal adsorbs the poison or drug, inactivating it and then carries it inert through the entire length of the digestive tract out of the body. Hence charcoal is not digested, absorbed, neutralized nor metabolized in the body (Davis, 2005).

AVAILABILITIES OF AGRICULTURAL WASTES AND RESIDUES (PIG DUNG)

The generation of agricultural wastes will continue to increase globally as developed and developing countries continue to intensify their farming systems. Generally, the sources of biomass include wood, energy crops, agricultural residues, industrial wastes; sawmill residues, and animal wastes. An estimate in 2001 gave the total number of cattle, sheep, goats, horses, pigs and poultry in Nigeria as 245 million, which all together produce 0.78 million tonnes of animal waste daily including pig dung (Akorede *et al*., 2017).

Pig waste is a biomass that changes rapidly from the time of excretion thereby creating a serious pollution problem. It is more offensive to the human environment than any other animal waste (Iregbu et al., 2014) with the chemical composition of pig manure dependent on several factors like age, water intake, digestibility of the ration, housing environment and waste management. The environmental and health concerns in all pig production systems have to do with the waste management problems (Okoli *et al.,* 2006). The odour emitted from intensive pig production system is a very serious nuisance to people living in the vicinity of pig farms and has led to health problems. Some of these odorous compounds are capable of affecting both the health and production efficiency of animals. The odour which is mainly formed from the microbial conversion of organic compounds in manure is emitted into the air from building or external manure storage sites (Lee *et al.,* 2005). Besides the foul odour, the hydrogen sulphide, ammonia and other gases emitted by pig manure can diminish air quality. This can lead to tension and complaints between pig farmers and their neighbours which in some cases can result to litigations and risk of possible closure of farms.

MANAGEMENT OF PIG DUNG

The need for more animal protein to sustain the increasing teeming population has led to an obvious increase in livestock production through the establishment of large-scale farm (Iregbu *et al.*, 2014). This invariably had given rise to monumental increase in animal wastes especially pig dung resulting to waste management challenges. The challenges of handling pig dung are recognized as a major issue in sustaining the growth of pig industry in Nigeria (Okoli *et al.,* 2006).

Twenty-two co-operative farmers' societies at Oke-Aro in Ogun State, Nigeria which host the largest pig farm in West Africa was granted 25 million naira in 2007 by the World Bank through FADAMA programme in order to buy a machine that can convert their pig dung into dry organic manure which are sold to crop farmers. This notwithstanding, there is a desperate and urgent need to extend this technology further to ensure the removal of all animal, human and industrial wastes from the environment (Iregbu *et al.*, 2014) and transform them to other value-added products. One of such technologies would be the conversion of animal dung especially pig dung to value added products like activated charcoal through thermal pyrolysis using physical method of activation (Lima and Marshal, 2004) for use in varying adsorptive applications in homes, agriculture, pharmaceutical companies and in environmental remediation.

PRODUCTION PROCESSES OF ACTIVATED CARBON

The most frequently used method of preparation of activated carbon is the carbonization of the precursors at high temperature in an inert atmosphere followed by activation process (IBI, 2015). The activation process could be achieved through physical and chemical methods.

Physical Activation

Physical activation process involves treatment of char obtained from carbonization with oxidizing gases using steam or carbon dioxide at high temperature (400-1000°C) depending on the type of precursor (Matali *et al.*, 2013; Hagemann *et al.*, 2018).

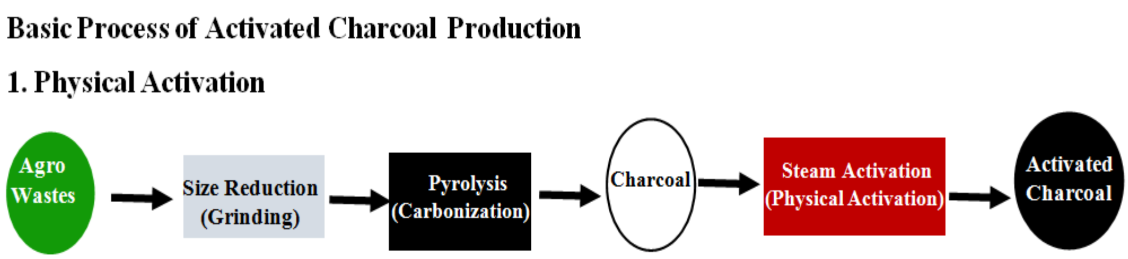

Fig. II: Flow chart for carbonization and physical activation in preparation of activated charcoal

(Source: Hidayu and Muda, 2016).

Chemical Activation

In chemical activation, the starting material is mixed with activating reagent and the mixture heated in an inert atmosphere (Ioannidou and Zabaniotou, 2005; Allwar *et al.*, 2012,). This process is usually done at a lower temperature and activation time, and it produces higher surface area and better pores when compared to physical activation ((HirunPraditkoon *et al.*, 2011). Several studies have shown that chemical activation has more benefits over physical activation in terms of lower temperature, higher yield and surface area (Zhu *et al.*, 2008; Schmidt *et al.*, 2019). On the other hand, there are some disadvantages associated with chemical activation such as washing that is required to remove impurities arising from activating reagents due to their corrosive actions. A flow chart of the chemical activation process is shown in figure 3.

2. Chemical Activation.

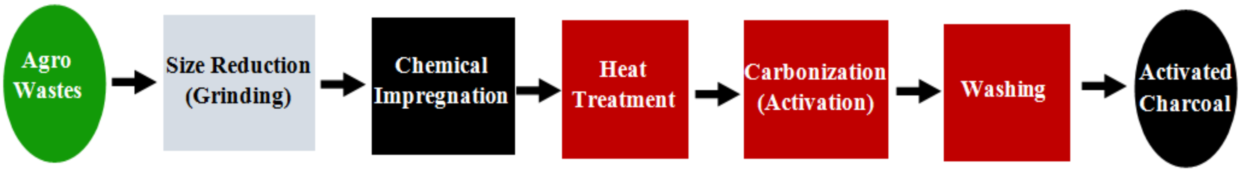

Fig. III: Chemical activation

The nature of the starting material plays a vital role in determining the quality, characteristics and properties of the resulting activated charcoal (Cagnon *et al.*, 2009; Camphell *et al.*, 2012; Abechi *et al.*, 2013). The properties of the activated charcoal produced can also be influenced by the type of activating reagents, time of activation, impregnation condition and carbonization temperature (HirunPraditkoon *et al.*, 2011).

Factors Influencing Activated Carbon Yield and Its Physico-Chemical Properties

Chemical Activating Agents:

The most widely used activating agents are phosphoric acid (H_3PO_4), zinc chloride ($ZnCl_2$) and potassium sulphide (K_2S) (William and Reed, 2004). The hydroxide of alkali metals, magnesium and calcium chloride and other substances are also used. $ZnCl_2$ is efficient in producing micropore structure and greater surface area in the activated carbon, while H_3PO_4 effectively produces mesopores resulting in higher pore volumes and diameters (Donald *et al.*, 2007). Phosphoric acid is however preferred over zinc chloride which could pose environmental hazard such that activated carbon produced is contra-indicated in food and pharmaceutical industries (Al-Qudah and Shawabkah, 2009). More so, in using H_3PO_4, it is easier to recover AC during processing by only rinsing with water. It also gives higher yield of activated charcoal and has no toxic properties. The use of potassium hydroxide (KOH) as activating agent has been found to be effective in producing AC with narrow pore size distribution. The use of H_3PO_4 or KOH has been suggested to be more eco-friendly as compared to $ZnCl_2$ (Khezami *et al.*, 2007).

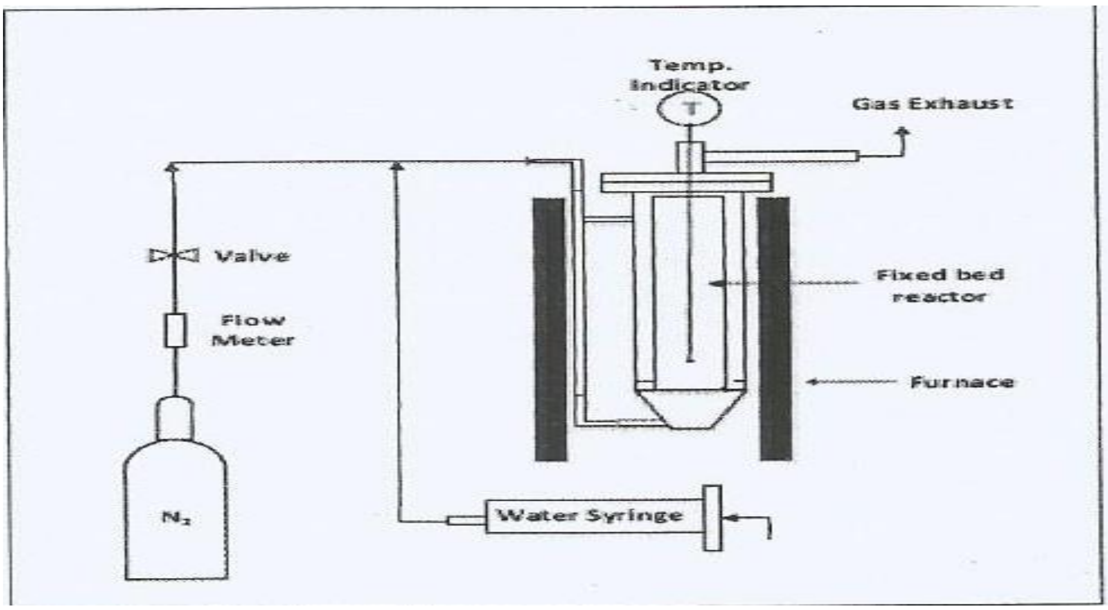

Fig. IV: Experimental set-up for preparation of activated carbon.

Source: Hidayu and Muda, 2016

Fig. V: Activated carbon Sample.
Source: Okoli, 2020

Impregnation Ratio:
An important factor in chemical activation is the degree of impregnation or impregnation co-efficient. This is the weight ratio of the anhydrous activating agent to the precursor. Impregnation ratio has significant effect on the development of pores and the adsorption capacity. Giraldo and Moreno-Pirajan (2012) used $ZnCl_2$ and KOH as activating reagents and varied the ratio from 2 to 3 and discovered that the surface area and total pore volume increased. Malik *et al.* (2006) observed similar effect in which case the increased ratio of $ZnCl_2$ brought about increase in surface area and pore volume but with a decrease yield of activated charcoal. Mdoe and Mkayula (2002) studied the properties of activated carbon derived from rice husk using KOH as activating agent and noted increase in both the surface area and the adsorption capacity but with reduced carbon yield.

It has been discovered that the development of pores in activated carbon may be influenced by the concentration of the chemical activating agents used. The effect of H_3PO_4 and $ZnCl_2$ concentration on the surface characteristics affects the development of pores with cracks found at the surface at the highest concentration of H_3PO_4 (80 wt %). More so, Ucar *et al.* (2009) used different concentration of $ZnCl_2$ to study pores development of the activated carbon derived from pomegranate seeds and noted that the external surfaces had different pore sizes and irregularly formed cavities.

Effect of Carbonization and Activation Temperatures:
Carbonization temperature will affect the activated charcoal production along with heating rate, nitrogen flow rate and carbonization time. Increased temperature would eventually increase the

release of volatiles and increase ash formation which would reduce carbon yield. Mozammel *et al.* (2002) studied the effect of temperature, time and impregnation ratio on the activated carbon yield produced from coconut shell using $ZnCl_2$ as activating agent and reported that higher temperatures resulted in better activation but lower activated carbon yield. Tsai *et al.* (1998) prepared activated carbon from corn cob and found that high temperature increased the surface area, total pore volume, density and porosity but with lower yield. More so, Alau *et al.* (2010) studied the effect of preparation conditions on quantity of activated charcoal produced from neem husk by using three different activating agents namely $ZnCl_2$, H_3PO_4 and KOH. They found that each chemical agent had different optimum activation temperatures which were 400, 500 and 350°C for $ZnCl_2$, H_3PO_4 and KOH, respectively. Also, Allwar *et al.* (2012) observed the textural characteristics of activated charcoal produced from palm kernel shell using $ZnCl_2$ as activating agent at a temperature range of 400-800°C and noted that the maximum micropore volume was 0.74cm^3g^{-1} at a temperature of 500°C. The micropore volume of the activated carbon increased with increased temperature from 400 to 500°C and decreased with further increase in activation temperature.

Nature of Agricultural Bio-Waste Material:

Several studies have shown that one of the most important factors that affect the texture of activated carbon is the nature of the starting material (Verheijen *et al*., 2010). Different agricultural bio-waste would produce activated carbon having different texture characteristics even with the same method of treatment or activation method. Khalil *et al.* (2013) prepared activated carbon from three different biomass: oil palm empty fruit bunch (EFB), bamboo stem and coconut shell using potassium hydroxide as activating agent under atmospheric nitrogen and reported irregular cavities or pores that differed from each other. Also, Martinez *et al.* (2006) observed that the texture of the carbon yield as well as development of pores is strongly affected by the nature of precursor material. They investigated two biomass materials, walnut shells and olive pits and showed that the former has a homogenous structure of carbon, while the later develops rough texture of carbon with heterogeneous surface under different concentration of the activating agent (KOH).

Other critical determinants of activated carbon quality include level of non-starch polysaccharides (NSPs) namely hemicelluloses, cellulose and lignin, pore structure, level of volatile and non-volatile fractions, and carbon and ash contents (Olivares, 2006; Dhyani and Bhaskar, 2017). Woody biomass (Baski *et al.*, 2006; Madu and Ladije, 2013), palm fruit fibre and palm kernel shell yield good activated carbon due to high content of NSPs and good pore structure. The level of volatile and non-volatile fractions can be determined by chemical analysis. These parameters influence the heating value (HV) of precursors and activated carbon quality. Chaniwala and Parikh (2002) expressed the relationship between heating value (HV) and elemental composition of precursors as.

$$HV\ (MJ/kg) = 0.3491\ (C) + 1.1783\ (H) – 0.10\ (S) – 0.0134\ (O) – 0.0151\ (N) - 0.0211\ (A).$$

The levels of the various NSPs in precursor can be evaluated by chemical analysis and they influence the decomposition temperature and behavior of precursors during pyrolysis with a range of 215-315, 315-400 and 160-900°C for hemicelluloses, cellulose and lignin, respectively (Yang *et al*., 2007).

Table: 5: Activated charcoal yield from physical and chemical activation using palm kernel shell as precursor material.

Method	Activating agent concentration (%)	Yield (%)
Physical Activated charcoal From PKS	Steam flow 10% of solid per minute for 1 hour	22
Chemical Activated Charcoal From PKS	$ZnCl_2$ 60% of solid	44

Source: Hidayu and Muda (2016).

Uses of Activated Carbon in Veterinary Medicine and Agriculture

Use of Activated Charcoal in Detoxification and in Treatment of Poisoning:

Activated carbon has been used for medical and veterinary purposes as universal poison antidote due to its physical and chemical properties, including surface area, pore size and its adsorption capacity (AACT, 1999; Alkhtib and Al Zailey, 2015; Schmidt *et al.*, 2019). It is considered as the first-line of treatment of poison after several hours after ingestion with no complications associated with its use. Chronic exposure to toxins from food and environment cause cellular damage, allergic reaction, compromised immunity leading to a more rapid aging (Chyla *et al.*, 2005). Regular use of AC helps the body to eliminate these toxins from the body to promote healthy digestive system and brain thereby making the individual feel renewed and vibrant (AACT, 1999; Alkhtib and Al Zailey, 2015). The intake of AC will remove toxic heavy metals from the body including pathogenic bacteria before they spread and multiply. It is an effective treatment for many poisons as it prevents swallowed poisons and drugs from being absorbed from the gut into the blood stream to cause harm. Activated carbon has a negatively charged porous surface that attracts the positively charged toxins or poison resulting in their binding and subsequent elimination through the entire length of the digestive tract and out of the body. This binding or adsorption is made possible by lots of pores on the AC particles that increase the surface area and available binding sites. Pore structure of activated carbon are typically classified into micropore (1 nm), mesopore (1-25 nm), and macropore (25 nm and above) based on the pore radius (Lowell and Shields, 1998; Gerd and Tondeur, 2001).

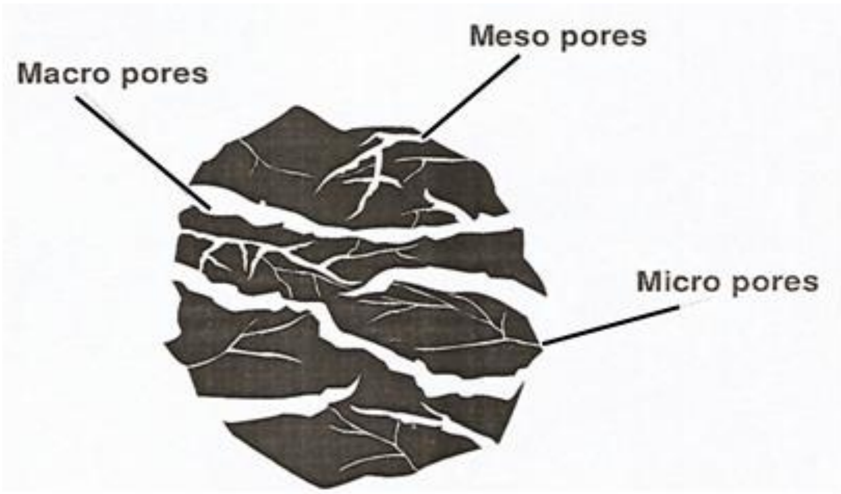

Fig. VI: Pore structure of activated carbon.

Source: Gerd and Tondeur, 2001

Gastrointestinal decontamination is accomplished in an emergency room using AC which is usually mixed with water and given to patient to drink or through feeding tube. Activated carbon has historically been used to clean water and as a treatment for many ailments. An early demonstration of the adsorptive properties of AC was in 1813 when a French chemist Bertrand drank 5 grams of a very poisonous substance (arsenic trioxide) mixed with activated carbon and survived. It should be noted that the efficacy of AC depends on how quickly it is given and the poisonous substance swallowed (Chyla *et al.*, 2005; Schmidt *et al.*, 2019). The earlier the AC is given after a drug or chemical is swallowed, the better it works. The best long-term study on the detoxification benefit of AC in animal was conducted by researchers at University of Wyoming and Duke University. They were able to establish that monkeys on the African Island of Zanzibar near East Africa eat activated carbon from burnt tree stumps in order to detoxify their digestive system. In another experiment, 100 times the lethal dose of cobra venom was mixed with AC and injected into a laboratory animal which was not harmed. It was on this basis that Cooney (1980) concluded that AC adsorbs poisons or toxins more than any other substance known to mankind and is capable of adsorbing a thousand times its own weight in gases, heavy metals and poisons.

Use of AC as Feed Additive in Improving Health and Performance in Poultry:
Activated carbon obtained from bamboo for example is a universal adsorbent because it contains a complex network of pores of various shapes and sizes (Zhao *et al.*, 2008). It was reported to have higher absorption capacity than wood charcoal, because of the special micro-pore structure of bamboo stems (Chungpin *et al.*, 2004). It has been used in powder form as oral antidote to reduce the absorption of poisons from the gastrointestinal tract. Bamboo vinegar is an acidic by-product of bamboo charcoal production which contain many compounds including phenolics, alkanes, alcohol, aldehydes and various organic acids, especially acetic acids (Lin *et al.*, 2008; Velmurugan *et al.*, 2009). These acetic acids component is capable of controlling the balance of intestinal microflora and pathogens and affects intestinal functions and metabolism (Rattanawut *et al.*, 2017; Rattanawut *et al.*, 2021). The mixture of bamboo activated carbon and vinegar has been shown to induce a significant increase in egg production by stimulating intestinal functions of laying hens in early phase of production (Yamauchi *et al*., 2010).

It has reported that AC given orally reduced intestinal *Salmonella enteritidis* and minimized the removal of normal bacteria flora (*Enterococcus faecium*) from the intestinal tract (Watara and Tana, 2005; Abit *et al*., 2014). Rattanawut *et al.* (2017) reported that bamboo activated carbon improved egg shell quality through several mechanisms including decreasing gut pH which inhibited the growth of pathogens and enhancement of the growth of beneficial intestinal organisms. The digestion and utilization of mineral nutrients were also increased due to increased secretion of digestive enzymes as a result of reduced pH level. In the same study, the intestinal villus height in the duodemm and jejumm were increased when feeding bamboo charcoal powder at 1.0% and 1.5% inclusion levels. The increased villus size provided greater absorptive surface area and a better capacity for absorbing available nutrient. Gilmore and Wang *et al.* (2003) reported that villus height is increased due to enhanced efficiency of digestion and absorption in the small intestine coupled with the increases in population of beneficial bacteria that supply nutrients and promote the vascularization and development of the intestinal villi. Choct (2009) found shorter villi when counts of pathogenic bacteria increased in the gastrointestinal tract, resulting in fewer absorptive and secretory cells.

Majewska (2011) carried out experiment to determine the effect of hard wood charcoal supplementation on the performance and carcass characteristics of broiler at varying inclusion level in the diet. The results showed that at 3% dietary supplementation, the birds were 5 and 3.5% heavier than the control and the dressing percentages and the relative weights of the muscles were also improved at 21 and 42 days respectively. The author corroborated this with the results of her earlier studies in 1999 and 2002 and attributed the results to the presence of available microelements and to the detoxifying effects of charcoal, thereby lowering the surface tension of the intestinal digesta to support liver function with respect to fat digestion. More so, the adsorption properties of AC acts curatively on the gastrointestinal tract (GIT), adsorbing gases such as hydrogen sulphide and ammonia that are formed there, including bacterial toxins and mycotoxins produced by fungi (Abit *et al.*, 2014; Kim *et al.*, 2017).

In another research by Dim *et al.* (2018) to ascertain the effect of dietary supplementation of AC on growth, haematology and serum lipid profiles of broilers, the final body weight, average daily weight and FCR favored birds placed on 6% charcoal inclusion than other groups and the control after 56 days trial period. The author noted that the results were in conformity with the report of Jiya *et al.* (2013) whose results also improved performance on inclusion of activated carbon. More so, Dim *et al.* (2018) noted that the white blood cell (WBC) count and the packed cell volume (PCV) were not affected at both the starter and finisher phases. However, the haemoglobin concentration (Hb) and the red blood cell (RBC) count were significantly improved, while the cholesterol and lipoprotein levels were significantly reduced with no effect on triglyceride at both phases. This was attributed to the ability of the birds fed activated charcoal to maximally utilize the vitamin-mineral premix in the diet, especially iron and B-complex vitamins probably due to the binding of activated charcoal with toxins and anti-nutritional factors in the gut of bird which enhanced the utilization of vitamin and minerals for the production of RBC and Hb better than in the control.

Use of Activated Carbon in Fish Pond:

The earthy odours of organic compounds namely geosmin and 2 methylisoborne (MIB) have been a problem not only in potable water supply but also in pond-based fish farming (Boonanuntanasarn *et al*., 2014). These are secondary metabolic products of some blue-green algae and bacteria which fish absorb from the surrounding water primarily through their gills and intestines on ingestion. Fish absorb them in the bottom of the pond with the highest concentration of geosmin and 2 methylisoborne (MIB) found in their intestines. These odour substances in fish ponds have made fish production a very risky business due its contribution to disease outbreaks and fluctuations in water quality (Boonanuntanasarn *et al.*, 2014). There has been limited scientific research regarding the use of activated carbon as feed additive in aquatic animals (Majewska *et al*., 2009; Ruttanawut *et al.*, 2009). Recently many types of activated charcoal including granular and powdered AC have been demonstrated to be suitable for the removal of geosmin and MIB from drinking water (Matsui *et al.*, 2013). In the study carried out by Boonanuntanasarn *et al.*, 2014), the result showed that activated carbon supplementation led to a significant reduction in the level of geosmin in fish, while MIB was not detected at inclusion rate of 30mg kg^{-1} and 10mg kg^{-1} for 2 and 4 weeks respectively.

***Use of Activated Carbon in Prevention of Mycotoxicosis*:**

Mycotoxins are toxic metabolites synthesized by certain naturally growing fungi on animal feed, feed ingredients and other agricultural crops. They constitute one of the major factors suppressing poultry productivity and product quality, hence, the control of their impact is very critical (Oguz, 2011). According to FAO (2013) approximately 25% of world's grain supply is contaminated with mycotoxins. The contamination of poultry feeds with mycotoxins is one of the major challenges associated with the poultry industry. However, research and industrial activities in Nigeria seem to neglect these realities about mycotoxins in animal production and this has probably contributed to the observed poor performance of commercial birds in the country (Ukwu, 2013).

Activated carbon is effective in the elimination of mycotoxins, such as aflatoxins that contaminate feed ingredients (Bhatti *et al.,* 2018). The adsorption effect of activated charcoal on mycotoxins and other detrimental organic compounds would positively influence the growth of broilers and layers, their immunity and carcass quality. Several studies have shown that it was effective in removing various types of mycotoxins such as aflatoxins, fumonisins, ochratoxin A, trichothenes and Zearalenone (Bhatti *et al.,* 2018). Its use in the prevention of mycotoxins contamination of feeds appears to be more effective than various minerals adsorbents such as aluminosilicates and bentonite (Huwig *et al.*, 2001; Bhatti *et al.*, 2018).

Use of Activated Carbon in Poultry Litter for Odour Control:

Activated carbon produced from agro-residue are extremely porous and excellent natural filter with a huge internal adsorption capacity for water, ammonia, ions, and other irritants than any other organic material (Sashikala *et al*., 2012). There is an immediate and obvious need to reduce or eliminate gases and odours emanating from manures in farming environment (Anukam, 2013), since these have led to complaints and litigation from the public (Iregbu, 2014).

Researchers have shown that biochar captures 63% of ammonia and other gases such as methane, nitrous oxide, hydrogen sulphide, urea, organic acids, ketones, volatile vapours and noxious liquids found in animal manures (David, 2015). The effects are achieved when 5-20% of biochar is blended with conventional litter and spread on the floor as an air purifier. Lowering of the build-up of odourless gases and improvement in air quality and livestock health has also been reported by Durunna *et al.* (2018) when graded levels of AC were incorporated in to the diets of broilers. Lower moisture content and ammonia levels curtail risk of footpad diseases, skin lesions and respiratory diseases which will ultimately improve vitality, egg production and weight gain. Depending on the type of litter, biochar can be mixed at the rate of 5-10% by volume with litter, with the effects being strong at 5% biochar but reaching saturation beyond 15%. Biochar can also be added and mixed when making silage to conserve moisture, buffer pH, retain cation and anions and provide stable environment for fermenting organisms.

Use of Activated Charcoal in Water Purification:

Water sources available to most developing countries including Nigeria are rivers, natural ponds and rainfall. A common feature about these water bodies is that they are contaminated or polluted by heavy metals discharged from industries (Tumin *et al*., 2008). Studies by Etuk *et al.* (2014 and 2016) have specifically shown that such water sources commonly used in animal feeding have negative effects on the physiological performances of broilers. One of the major ways of cleaning contaminated water is by the use of activated carbon in the adsorption of metallic ions and bacterial toxins from waste water (Schmidt *et al.,* 2019). The metal ion adsorption is more related to the surface properties of activated charcoal than their specific areas. Since most activated charcoal sold in Nigeria for this purpose is imported, the need to produce and characterize activated carbon locally becomes imperative. This will not only improve water treatment technology in Nigeria but reduce the foreign exchange spending on importation of this industrial raw material. It will also help prevent water bone disease epidemics and deaths frequently reported in Nigeria due to water pollution and contamination.

Use of Activated Carbon in Oil Spill and Environmental Remediation:

A wide range of adsorbent materials have actually been used in cases of oil spillage and water remediation in adsorbing oil including activated carbon. The adsorption property of activated charcoal is highly made use of in remediation of petroleum-contaminated water in cases of oil spillage frequently witnessed in oil producing communities (Tabbakh and Barhoun, 2018). Pollution by petroleum oils affects marine life, economy and tourism activity because of the coating properties of oil that harms the beauty of polluted sites. This brings about strong odour that can be felt several kilometers away from the affected area. It also destroys the growth of green algae and alters sea colour and landscape with monumental effects on the marine and aquatic lives (Tabbakh and Barhoun, 2018). Most importantly, activated carbon produced from agricultural wastes is one of the commonest used techniques for remediation of contaminated water. The use of agricultural residues as activated carbon precursors has also been found to be renewable and relatively less expensive and ultimately could utilize the waste effectively into wealth (Malik, 2006).

Activated carbon is also widely used as an absorbent in the purification of liquids and gases coupled with newer applications that are emerging concerning environmental protection and technological development. This purification is made possible by the vast system of pores within the carbon particles (Gerd and Tondeur, 2001). In addition, the properties of AC are also influenced by the type of activating reagents, time or duration of activation, impregnation condition, carbonization temperature and the level organic impurities (Olivares *et al.,* 2006).

Use of Activated Carbon as Soil Additive:

Activated carbon also described as biochar enhances soil water retention and improves plant nutrient availability and uptake (Zheng *et al.*, 2013; Van Zwietan *et al.*, 2010; Sandhu *et al.*, 2019) thereby improving plant productivity. This may be of significance in agricultural areas where soil nutrients are naturally depleted, prone to leaching or were draught risk successful crop production. It has additional fertilizer value and may enhance crop productivity by providing important plant macro and micro-nutrients. Nitrogen and phosphorus are two of the limiting nutrients with regards to plant growth. As a result of this, they are frequently used in agricultural systems as fertilizers to promote the growth of crops. One of the richest sources of nitrogen and phosphorus used in agricultural production is fertilizers. Fertilizers produced from livestock manure or activated carbon derived from them is high in nitrogen and phosphorus concentration (Steiner, 2008; Sandhu *et al.,* 2019).

The use of rice husk activated charcoal to fertilize the rice field has been a common practice in Asia for hundreds of years (Steiner, 2008). Adding activated carbon to the soil will help replace carbon, nitrogen and other plant nutrients that are worn out from the land during multiple harvests or due to continuous cropping. The carbon in biochar is highly stable in the soil and can be sequestered for years (Laird, 2008). Mollinedo *et al.* (2015) have also demonstrated the use of activated carbon to improve the water holding capacity of different soil samples. In their study, treatment of the soil increased the water retention in soil for up to 25% when compared with the control sample. Umeojiakor *et al.* (2018) showed that animal manure as an organic carbon source was effective in mineralizing pyrene, a polycyclic aromatic hydrocarbon (PAH) in clay soils from south-eastern Nigeria.

CONCLUSION

The expansion of agricultural production has naturally resulted in increased quantities of agro-industrial by-products, agricultural crop residues and livestock waste such as pig dung. A review on pig dung is desirable because of its contribution to environmental pollution and the need to convert it to value-added products such as activated carbon (AC). Activated carbon has been used for medical and veterinary purposes as universal poison antidote due to its physical and chemical properties, including surface area, pore size and its adsorption capacity. It is also widely used as feed additive, water purification and in odor control in poultry and fish production. The properties of the activated charcoal produced can also be influenced by the type of activating reagents, time of activation, impregnation condition and carbonization temperature. Other critical determinants of activated carbon quality include level of non-starch polysaccharides (NSPs) namely hemicelluloses, cellulose and lignin, pore structure, level of volatile and non-volatile fractions, and carbon and ash contents. The non-conversion of agro-wastes to value added products such as activated carbon is not only hazardous but a waste of economic resources when most of the activated carbons used for various adsorptive purposes in Nigeria are imported.

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