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Preparation and Use of Activated Carbon from Periwinkle Shell for Water Treatment in Nkanu East Local Government Area of Enugu State, Nigeria

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ABSTRACT: *Activated carbon is normally produced from various carbonaceous materials of both plant and animal origin. This work was focused on the preparation of activated carbon from periwinkle shells gotten from kenyetta market in Enugu, and its use as an adsorbent for water treatment in Nkanu East Local Government Area of Enugu State. The activated carbon, (AC) is prepared by acid activation method at temperature of 600^0C. The effects of carbonization and acid impregnation time on the adsorption potential of the activated carbons on adsorption of nickel and lead from inyaba river water in Amagunze, in Nkanu East L.G.A, was examined. The results show that the concentrations of nickel and lead before purification are 1.86mg/l and 0.08 mg/l respectively. After purification, lead was not detected in any of the samples while the concentrations of nickel reduced from 1.86 mg/l to 0.30 mg/l. Thus, this study showed that activated carbon produced from periwinkle shell is suitable for the adsorption of Ni^{+2} and Pb^{+2} ions and as such could be used as a costeffective and locally accessed adsorbent in the treatment of contaminated river water.*

KEW WORDS*:* preparation, activated carbon, periwinkle shell, water treatment, heavy metals

INTRODUCTION

Healthy environment begets healthy life. Unhealthy environment has been of a great concern to the whole universe. Rapid urbanization and population increase place greater demands on the planet and stretch the use of natural resources to the maximum.It is certain that the earth can no longer meet up with the demands placed on it by large numbers of human population and over use of water and other natural resources, negatively affects or often results in environmental and nature's degradation (Chamara and Koichi, 2017,and Ochola, 2018). The study of the components

of the Environment is multi-disciplinary in nature, involving academic field which systematically studies human interaction with the environment. It evolves from the integrated use of many disciplines such as sciences, humanities, Commerce, geography and other Social Sciences in order to collectively seek for solution for prevailing environmental problems. The interaction taking place in the environment could be of chemical, biological, economic, social, agricultural and technological in nature. All these environmental interactions and human activities have introduced a lot of environmental problems including, pollution, resource depletion, environmental degradation, climatic change into the environment. These problems have been of great concern to the global world, of which that, if not well addressed, will pose serious threat to the existence of people and hinder sustainable development.

Heavy metal is one of the main environmental pollutants due to its toxicity to human life. The possible sources of heavy metals include; water waste treatment plant, manufacturing industries, mining, rural Agricultural cultivation and fertilization. These metals get into the organism through water, air, food, vegetables and fruit resulting to different health challenges as cancer, skin defect, liver and kidney damage (Almad and Danish, 2018). Pollution of source water may be due to agricultural and industrial activities such as release of untreated waste water generated within the rural community, manure spreading on soils, water from polluted sites, industrial effluents, land runoff (Fekadu, Alemayehu, Dewil, and Van der Bruggen. (2019). (Izah, Chakrabarty & Srivastav (2016;) identified some of these metals that are essential to plants and animals when present in acceptable low concentration, but become harmful when they accumulate beyond the maximum permissible level, as copper (Cu), nickel (Ni), iron (Fe) and zinc (Zn). Non-essential heavy metals which can be tolerated at low levels, but becomes harmful at higher concentration are also identified as Arsenic, cadmium, lead, mercury, plutonium, tungsten and vanadium according to (Johri, Jacquillet and Unwin, 2010). The toxic heavy metals under consideration in this work are nickel and lead.

Nickel, is the 24th most common element in the earth and the 5th most abundant element with respect to weight after iron, oxygen, silicon and magnesium (Genchi, Carocci andcatalano (2020). It occurs in sulphide and laterite (Harasim and Filipek, 2015), and is introduced to the water through dissolution from nickel ore, industrial wastes, combustion of solid and liquid fuel, nickel mining and plating (Khodadoust, Reddy and Maturi, 2004). Exposure to the high concentration of nickel results in the symptoms like nausea, vomiting, diarrhea, visual discomfort, abdominal discomfort and high exposure may lead to pneumonia and death, cancer of the respiratory tract, lungs, nose, throat, kidney, Cardiovascular diseases and stomach (Genchi, Carrocci& Catalano, 2020).

Some Lead compounds such as tetraethyl lead and tetramethyl lead on the other hand,are introduced into the environment as a result of human activities such as, combustion of solid wastes;

solid, liquid and gaseous fuel; industrial, Agricultural and other domestic activities. The compounds decompose in the presence of sunlight to mono, di and triethyl lead which are easily soluble in water.TEL [Tetra ethyl lead (iv)] is also an additive used, in the treatment of fuel,it gradually deposits and accumulates lead substance in the car engine. Thiseventually degenerate to engine knock. To remedy the situation, another fuel additive known as 1, 2-dichloro or 1, 2-dibromo ethane is also added. During combustion, a reaction occurs inside the enginewhich can convert TEL to lead bromide or lead chloride.This lead compound is laterreleased into the air through the exhaust pipes of automobile vehicles.Partly, the larger particles of lead, are dropped on the ground and thereby polluting both soil and ground water, while the tiny particles, remain in the air, and eventually get into rainwater during rainy season. High exposure to lead causes remarkable damage to kidney, brain, reproductive system, liver, cardiovascular, nervous and neuromuscular disorders which can eventually lead to seizures, unconsciousness, coma and death. (Food Safety Authority of Ireland, 2009; Izah and Angaye; 2016). Since lead and Nickel metals have been associated with health problems as earlier identified, it therefore becomes necessary to work towards eliminating them from our environment using locally available and very cheap material as adsorbent.

Periwinkle is a marine mollusk. It is generally found in rocky shores, oceans, muddy areas, swamps, in Nigeria, it is mostly found in Niger Delta lagoons and mudflats between Calabar and Badagry (Gamus and Okpeku 2015). People in this region eat the edible portion as sea food and use the shell as coarse aggregate in concrete for control of water logged areas Ochalo (2018). periwinkle shell has been found to be good material for production of activated carbon, a highly porous structure, with large surface area that is used as a powerful adsorbent and in this way helps to reduce cost of waste disposal. Periwinkle shell used for this study is gotten from large waste bins at Kenyetta market. It is a cheap and renewable source of activated carbon.

Activated carbons are generally prepared by carbonization involving pyrolysis of carbonaceous material (periwinkle shell) in the absence of active air (oxygen), followed by conversion of the carbonized product to a porous activated carbon with high surface area. While carbonization creates initial porosity (Odetoye, Abubakar and Titiloye, 2019), the activation enhances the carbon structure by increasing the pores, surface area in order to increase the porosity (Yang, Feng, and Zhang, 2019). Pyrolysis is thermal decomposition of carbonaceous material at a very high temperature, in the absence of oxygen. During Carbonation process, the volatile compounds were removed producing a residue with low surface area.

Activation is carried out by physical or chemical methods (Ao, Fu, Mao, Kang, Ran and Lui…and Dai, 2018). While Physical method involving treating the char from carbonization with gasification reactant or oxidizing gases (air, steam or CO_2) (Ahmida, Darmoon, Al-Tohami,

Erhayem, and Zidan, 2015) at high temp of between 400-1000^{0}C, chemical method involves the use of chemical agents like, acid, bases, metal oxide, alkaline metals (Yahya, Mansor, Zolkarnaini, Ruslin, Aminuddin, Mohamad and Ozair. 2018)Activated carbon can be used as catalyst and co catalyst for removal of pollutants from gas, liquids and chemical recovery(Afif, Rahman, Tasfiah Azad, Zaini, Islan, and Azad, 2019), in domestic, commercial and industrial settings, activated carbon helps to remove varieties of contaminants such as metallic and non-metallic pollutants, dyes, taste, odor from aqueous medium (Din, Ashraf, and Intisar, 2017) They are also used in food industry in decolourization, deodorization and taste removal; to remove heavy metals from liquid, in gas cleaning applications and air filter and also in general air conditioning application (Yusufu, Ariahu, and Igbabul2012). Adsorbtion is among the effective, easy and efficient techniques used for removing toxic metals from water sources (Suguna, Nadavala, Vudagandla, Boddu, and Aburi, 2017). The adsorption activity has been reported by (Kwaghger and Ibrahim, 2013), it is also used in pharmaceutical industry and in research laboratories as decolorizing agent and catalyst support (Yaumi, Mustafa; Isah; Babagana, and Ojih, 2015) and in medicine for adsorption of harmful chemicals and drugs (Nwankwo, Nwaiwu & Nwabanne (2018).

A lot of researches has been carried out on the production of activated carbon from different plants and animal originated wastes such reports from plants origin include; corn cobsh Ekpete and Horstall (2017); rice husk (Nasehir, et al, 2010; Goodhead and Dagde, 2011) Oil palm shell (To, Hadi, Hui, Liu and Mikay, 2017); shea nut shell (Itodo and Itodo, 2011); almond shell (daud and Ali, 2004). Those from animal origin include; periwinkle shell, (Nworie, Onukwuli, Ekebafe, Ezeugo, 2020); animal horns (Aliyor & Badmus, 2008). The activated carbons prepared from different agricultural waste were used in the elimination of toxic metal compounds from water and waste water and for maintaining a sustainable healthy environment, not only inNigeria but in different part of the world. The use of periwinkle shell to produce activated carbon is highly cost effective, enhances economic efficiency and promotes full utilization of agricultural waste which is very helpful in a sustained environment.

Statement of Problem

The experienced problems observed amongst the secondary school children during the researcher's supervision in Amagunze in Nkanu Local Government, drew the researcher's attention to the prevailing health condition of the school children in this area. During the supervision exercises, it was noticed that students were not very regular to the classes to the clear observation of the researcher. When probed into the reason for that, the researcher was made to understand that, these children affected were always (off and on good health) suffering from, stomach upset, some, sinuses, vomiting and some others, retire to their benches as early as 10, o'clock in the morning when the teacher has just done about 2 lessons. Further interaction with the students revealed that

this, community, just like somany other communities in Enugu State, do not have access to portable water. Their main source of drinking water is from river inyaba. In and around this water used for drinking without treatment is where, the villagers carry out their agricultural and other domestic activities such as, washing of all kinds, fermenting of cassava and other activities like refuse dumping around the river. As a chemistry educator, the researcher was confronted with two questions, could this problem be from the source of water, if yes, what in water could be the cause of these health issues. On the bid to look for the solution for the problem, the idea of this research came up and hence the need for this investigation.

Based on the seriousness of the health issues associated with the presence of heavy metals in water bodies due to the growth in technological, agricultural and petrochemical activities that introduce heavy pollutant to the environment, it therefore becomes imminent for frequent preparation and use of available and cheap raw materials for reducing or total elimination of the concentration of these heavy metals in the water bodies as part of water treatment measures.

Purpose of the study

The purpose of the study is to prepare activated carbon from periwinkle shell and use it for the purification of water**.**

MATERIALS AND METHOD

Preparation of materials

All reagents were of analytical grade distilled water was used except otherwise stated. Periwinkle shells were obtained from kenyeta Market, Enugu State and were crushed and sieved to tiny Particles and used for this study. The water was collected from Inyaba River in Amagunze, in Nkanu East local Government Area of Enugu State.

Carbonization and activation preparation of sampled materials.

During carbonization process, sample of periwinkle shell was weighed and heated to about 600^0C in an oven for 4 hours in order to produce a carbonized product as shown below:

Periwinkle shell was heated for 4hrs $\xrightarrow{\Delta}$ @600^0c C + CO_2.

Two portions of 200 g of the carbonized periwinkle shell were separately weighed into two 1000 cm^3 beakers, and mixed with 10cm3 of 2M solution of phosphoric acid. The first sample was left for 54 hours while the second was left for 78 hours after which, Activated carbon (AC) and carbon (iv) oxide are released. Each of the samples was divided into two and carbonized at

600^0C for two and three hours separately. The samples were allowed to cool and washed with distilled water until a neutral pH was attained. The sample were dried, further crushed and stored in airtight plastic containers.

Carbonized periwinkle shell was heated for $\xrightarrow[\Delta]{}$ 54/78hrs (AC) + CO_2

The first portion of the activated carbon samples from periwinkle shell labeled E and F was acid impregnated for 54 hours, and carbonized for 2 and 3 hours respectively. The second portion of the samples labeled G and H was acid impregnated for 78hours, and carbonized for 2 and 3 hours respectively. The commercial activated carbon (CAC) labelled K was used as a control.Samples E-K were analyzed for ash, moisture and fixed carbon contents. The samples were thereafter arranged in different columns maintained at equal length and diameter. The sampled water from inyaba river was passed through them at the same retention time. Their ability to purify water through adsorption for the removal of nickel and lead contents were determined by atomic absorption spectrophotometric method.

Ash content tests

3g of dry activated carbon was weighted into a crucible, and heated in a furnace for 2 hours at the temperature of 800^oC. The sample and crucible were reweighed (m) and the percentage ash content determined according to the method described by Ekpete and Horsfall, (2011) thus:

$$\textbf{Percentage ash content} = \frac{3.0 - M}{3} \times 100$$

Moisture content tests

3g of the activated carbon was weighed and transferred into a known weight of crucible. It was placed in oven for 6hrs until a steady temperature of 110^0C was obtained. The sample was quickly transferred to a desiccator in order not to be interfered with moist air. The sample and the crucible were reweighed. This procedure was repeated at 1hr interval until a constant weight was obtained. The percentage moisture was therefore determined as follows:

$$\textbf{Moisture content} = \frac{\text{Weight loss}}{\text{Initial weight of sample}} \times 100$$

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Fixed carbon content tests

This was done by subtracting the sum of the percentage of ash, volatile and moisture content from 100%. Fixed carbon content (%) = 100 – moisture content % + ash content % + volatile maker %.

Nickel and lead tests

Both were determined by atomic absorption spectrophotometric method.

RESULTS

Parameters	54hrs acid Impregnation		78hrs acid impregnation		control
	E	F	G	H	K
Ash Content (%)	6.02	5.40	7.94	6.50	7.10
Moisture(%) Content	3.30	2.72	4.53	3.70	4.00
FixedCarbon Content (%)	87.40	89.80	87.10	88.40	87.60

Table 1: Shows some properties of the AC from periwinkle shells (PWS) and the commercial activated carbon (CAC).

Parameter	NIS Limit for Safe Water	Concentration before Purification	Concentration after Purification				
			E	F	G	H	K
nickel(mg/l)	0.34	1.86	0.73	0.30	0.84	0.80	0.63
Lead (mg/l)	0.01	0.08	N.F	N.F	N.F	N.F	N.F

Table 2: Shows the analyzed chart of nickel and lead content before and after purification.

NIS = Nigerian Industrial Standard for Drinking Water Quality

N.F means Not found

DISCUSSION OF FINDINGS

From the result of the physical properties of the produced activated carbon and the purchased commercial sample presented in Table 1. It was found out that, the increased time for carbonization reduced the ash content of the sample [see the ash contents of F (5.40) and H (6.50)]. This showed that further heating lead to De volatilization of lignin content of sampled material leading to the release of more gaseous compounds with reduced solid ash. The ash content was highest in sample

G (7.94), due to the action of acid in decomposition of cellulose and leaving more carbon content exposed, leading to more ash in G than in E.

The moisture content from table 1, decreases with carbonization time between sample E and F. The same thing is applicable to G and H. However, the values are within the standard range. Table 2 shows the result of the concentration of nickel and lead before and after purification with activated carbon. The result of nickel and lead before purification is 1.86 and 0.055mg/l respectively. After the purification, the concentration of nickel is 0.73 for sample E, 0.30 for F, 0.84 for G, 0.80 for H and 0.63 for K which is the control. The concentration of nickel decreases with carbonization period within the trend from E to K, while that of the lead, after purification, was not detected in any of the samples.

The carbonization period also affected the quantity of carbon content as indicated in table 1. Increase in acid impregnation period decreased the fixed carbon content between E and G, and F, and H. Nevertheless, the fixed carbon content for the control (the commercial sample) is not far from the values of the experimental samples produced by the researcher in this work, although there is no knowledge of the production parameters and method used for the commercial sample.

CONCLUSION

The result of the present work, showed that periwinkle shell can be effectively used as a raw material for the synthesis of activated carbon used as an effective adsorbent for water treatment. The degree of adsorption depends on time of acid impregnation with phosphoric acid as well as the duration of carbonization process.

The activated carbon produced upon treating the sample in acid for 54 and 3 hours carbonization at 600^0C is better than others with the highest carbon content of 89.80 as observed in F.

Recommendation

The local Industries in Nigeria should begin to use these indigenous agricultural by-products which are readily available, economically viable, and cost effective adsorbent for the purification of the environment and to solve environmental related problems like water pollution.

More researches should be done in schools and research institutions to find out other agricultural wastes materials that can be used to produce activated carbon either singly or as blended products for more effective result.

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