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Research Article

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Comparative Assessment of Using Activated Charcoal from Hard and Softwood for the Treatment of Wastewater

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Abstract This research used the waste water collected from Cadet Mess at Nigerian Defence Academy Kaduna for the comparative assessment of using activated charcoal (carbon) from hardwood and softwood for its treatment. Activated charcoal is commonly used for water treatment to remove water contaminants from wastewater, due to its excellent adsorption capacity. In this research, two types of activated carbon were used; hardwood activated carbon and softwood activated carbon to compare their performance in wastewater treatment. The two activated charcoals were prepared. The collected wastewater was analyzed before and after the treatment. The water samples were tested based on pH, turbidity test, Total suspended solid, hardness and alkalinity. The results obtained after the filtration revealed that that the hardwood activated carbon performs better than the softwood activated carbon in reducing turbidity: with a value of 272NTU as against 1050NTU before the filtration, total suspended solids: decreased from a value of 110mg/L to 10mg/L after filtration, alkalinity: with a value of 140mg/L as against 280mg/L before the filtration and dissolved solids also decreased from a value of 600ppm to 400ppm. The water obtained from the activated carbon filters of both hard and soft wood was found to be free from impurities, odor, taste, dissolved solids and turbidity. The resulting water can be used for irrigation purposes, cleaning, flushing and other domestic activities.

Keywords Activated charcoal, Assessment, filtration, Waste Water, Hard and Soft wood

1. INTRODUCTION

Wastewater from domestic activities is usually less offensive but the colour is usually black and grey. The black wastewater usually comes from toilets (faeces, urine, possible toilet paper and flush water), while the greywater is as results of other domestic activities which includes water from bathtubs, showers, hand basins, kitchen sinks and laundry. The quest for water by man is not limited to its necessity for survival but also for socio-economic development, no matter how scarce or abundant fresh water is, it is used for daily household activities and after which it becomes wastewater. Activated carbon with traces its root to wood char commonly known as charcoal, which was well pronounced with the Sumerians and Egyptians around 3750 BC. Activated carbon which is a form of carbon obtained from a wide range of carbon occurring in the amorphous form in which all its non-carbon impurities have been removed and its surface is chemically oxidized in order to increase its surface area and obtain a higher degree of porosity (Inglezakis, 2006). The use of active carbon in recent times is beginning to receive substantial attention due to its remarkable adsorption properties to toxins ingested by bacteria which helps to reduce their toxic effects. Like sand, charcoal which is similar to activated carbon has been reportedly used as far back as 450 BC as filter medium for the purification of potable water. Activated carbon has demonstrated great efficiency in water treatment by removing foul taste and odor which is mainly attributed to the presence of chlorophenols presence in water during the chlorination stage of water treatment (Sontheimer, 1988).

Report by Bansal (2005) on how drinking water was stored in the pore spaces of charcoal in the wrecks of Phoenician trading ships as a preservative method has also emphasized the use of charcoal in water treatment. Wood chars have also been shown to have medicinal uses, a technology which can be traced back to the time of Hippocrates (ca. 460 370 BC) and Pliny the Elder (AD 2379) (Hassler, 1963).Powdered activated carbon (PAC) which is a form of activated carbon has been in used in the United States for controlling taste and odor in drinking water since 1929 (Sontheimer, 1988). The use of active carbon in filters for removing odor and taste in its granular form, known as granular activated carbon (GAC) was first reported in Germany and USA in 1929 and 1930 respectively. About 400 water treatment works were reported in USA teo years later to have fully incorporated activated carbon into their water treatment schemes for odor and taste control, a number which grew to 1200 by 1943. In 1961, at Hopewell, GAC was incorporated into the treatment of water for public consumption for the first time in the USA (Hung, 2005).

When water which has been used and released as grey or black water is reused before its release to the natural water cycle, such water is termed reclaimed water (Rock, *et al., 2012*). In accordance with United States environmental protection agency (USEPA, 2008), water recycling happens when treated water is reused for beneficial purposes like agricultural and land scape irrigation, industrial uses, toilet flushing or for ground water recharge.

A lot of researchers have attempted to improve the conventional waste water treatment processes; Amuda (2005) in his study on coconut shell waste discovered its high adsorption efficiency and experimented it as natural adsorbent material for treating industrial wastewater, it was discovered that coconut shell waste can be reused as natural adsorbent in industrial wastewater treatment. Ohioma *et al.,* (2009) maintained that wastewater from textile factories effluents contain severe contaminants that are insidious to the environment. Many developed countries like USA, and virtually all the European and Asian countries have effective wastewater treatment policies while majority of the developing countries are facing severe challenges such as fund for implementation.

Idris *et al.,* (2013) mirrored domestic wastewater disposal in Nigeria and observed that lack of reclaim and reuse of domestic wastewater is a major challenge to wastewater management in the country. Domestic and industrial wastewater reclamation, if properly implemented can provide an effective remedy to the challenges posed by effluent disposal in the environment (Adewumi and Oguntuase, 2016).

Samwel, (2005) opined that wastewater generated due to human activities in households is referred to as domestic wastewater i.e. wastewater from the wash basin, shower, kitchen, toilet and laundry. Asano, (2002) identified the three principles that serve as the bedrock of wastewater reuse, these includes; meeting the basic water quality requirements by the use of efficient wastewater treatment, protection of public health and acquiring public consent. Despite the abundance of water resources in nature, there have been several challenges in providing adequate portable water for both consumption and other domestic and Agricultural uses to many regions in Nigeria over the years Komolafe, eta l,(2013).

A report by the World Health Organization (WHO) showed that potable water is not available to 1.1 billion people, of the 4 billion diarrhea disease cases reported, 88% was reported to be due to the consumption of unsafe water alongside poor hygiene and sanitation. The report also put the death figure from the reported diarrhea cases at a disturbing 1.8 billion yearly. However, 94% of the reported diarrhea cases can be prevented through proper environmental sanitation and improved access to safe water for drinking as opined by WHO. Reduction of death due to waterborne diseases has been a major goal for the public in developing countries and this can be achieved by adopting several measures such as home treatment of drinking water by filtration, disinfection, chlorination and proper water storage (WHO, 2007).

This research captured the comparative study of using activated charcoal from hardwood and softwood as a filtration media for the treatment of waste water for domestic and Agricultural uses to promote environmental sustainability.

2. MATERIALS AND METHODS

2.1 Materials

The materials for the study includes: activated charcoal from hardwood which is of the lroko specie (chlorophora excelsa] and softwood is of the gmelina specie (GmelinaArborea) all gotten from the timber market, fine aggregates, course aggregate and wastewater from Nigerian Defence Academy cadets mess.

2.2 Methods

The Charcoal was prepared by burning the hardwood and softwood locally with limited oxygen supply at 300^0C for two hours. The charred wood was allowed to cool at room temperature. The charred material for hardwood and softwood was crushed separately using mortar and pistol. For chemical activation, 120cm^3 of 0.1M HCI was added to 100 g each of carbonized hardwood and softwood collected into two separate beakers. The mixtures were stirred thoroughly until it forms a paste. The formed pastes were transferred into crucibles which were heated for two hours, the activated samples were then cooled at room temperature and washed with distilled water to a pH of 6 - 7, and later dried in an oven at 105^0C for three hours. The final products were collected into air tight polyethylene bags, ready for use.Wastewater was collected by grab sampling, individual sample was collected 'within a period of over 15 minutes. The grab sample is a representative of the wastewater conditions at the time of sample collection. 5 liters of the sample was collected near the center of the flow channel at the cadets mess of the Nigerian Defence Academy, Kaduna at approximately 40-60% of the water depth where the turbulence is at maximum and possibility of solids setting is minimized.The filtration unit used for the analysis compose of three layers : Activated charcoal/charcoal, fine aggregates and coarse aggregates, as shown below

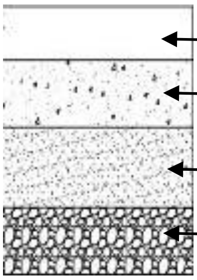

Fig. 1 Filtration Unit

3. RESULTS AND DISCUSSION

Table 1 is the summary of the results for the six (6) parameters that were tested for the assessment using activated charcoal (carbon) from hardwood and softwood for its treatment.

Table 1: Summary of results for the tested parameters

S/N	Sample	pH	Turbidity (NTU)	TSS (mg/L)	TDS (ppm)	Alkalinity (mg/L)	Hardness (mg/L)
1	Raw Wastewater before filtration	11	1050	110	600	280	121.7
2	Wastewater after the filtration using softwood activated charcoal	8.9	317	10	450	200	53.1
3	Wastewater after the filtration using hardwood activated charcoal	8.12	272	10	400	140	53.1

pH

pH is an important quality parameter in drinking water. Its standard range is from 6.5 to 8.5. From Table 2, the pH value of the untreated wastewater was obtained as 11. Activated charcoal is very effective in balancing the pH of water. From Fig.1, Hardwood activated charcoal decreased the pH of the wastewater to the value of 8.9 after filtration, which is slightly alkaline, at the same time a lower value of 8.12 was obtained from the softwood activated charcoal which is better than the later as shown in figure 2 below.

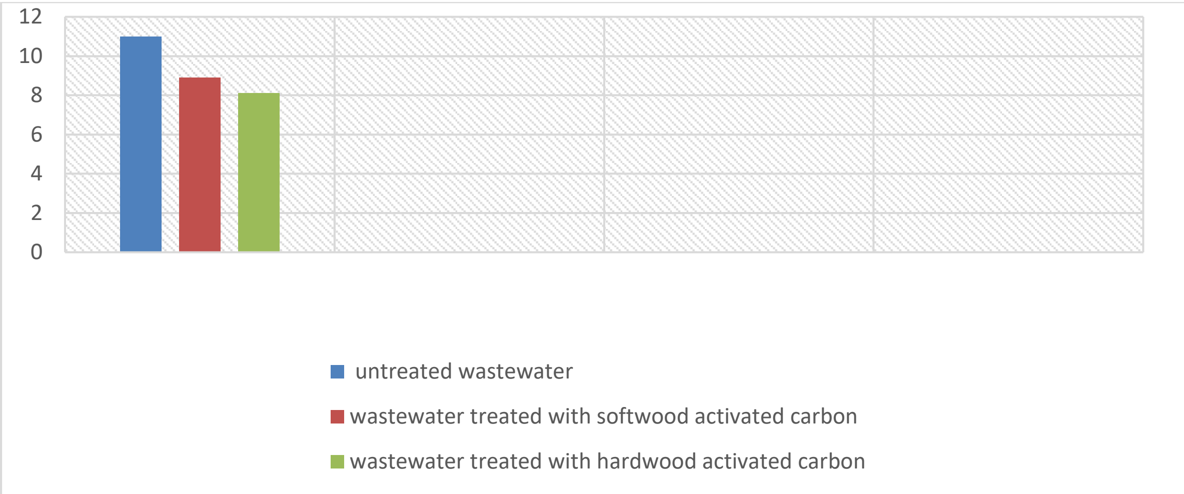

Fig. 2 pH values

Turbidity

Turbidity indicates the quality of drinking water with respect to colloidal and residual suspended matter. The turbidity of the wastewater before the fitration was obtained as 1050NTU. The use of activated charcoal from hardwood and softwood reduced the turbidity effectively to 317 and 272 respectively as indicated in figure 3 below:

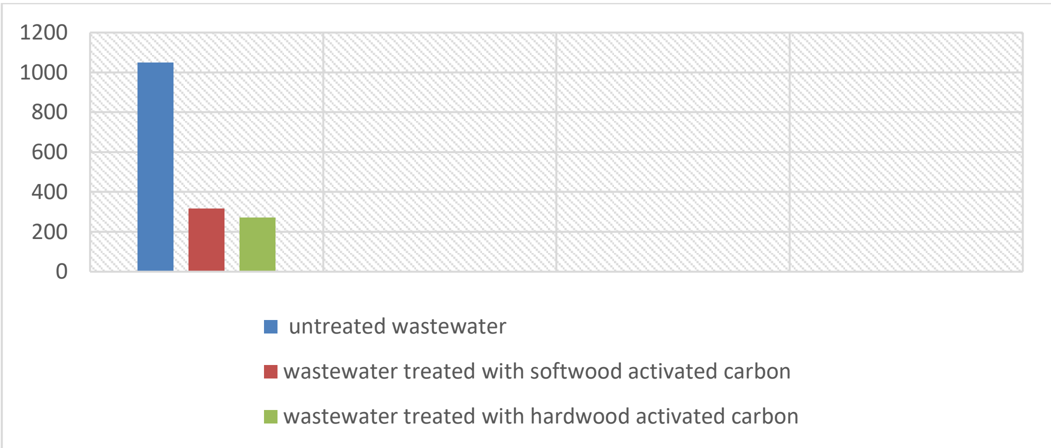

Fig. 3 Turbidity values

Total Suspended Solid (TSS)

The total suspended solid test measures the residue remaining after the water evaporated and dried at a specific temperature (103 to 105 °C). The total suspended solids of the wastewater initially tested was obtained as 110mg/L. However, the use of activated charcoal for both hardwood and softwood reduced the TSS values to very low values as shown in figure 4 below and in table 1 respectively.

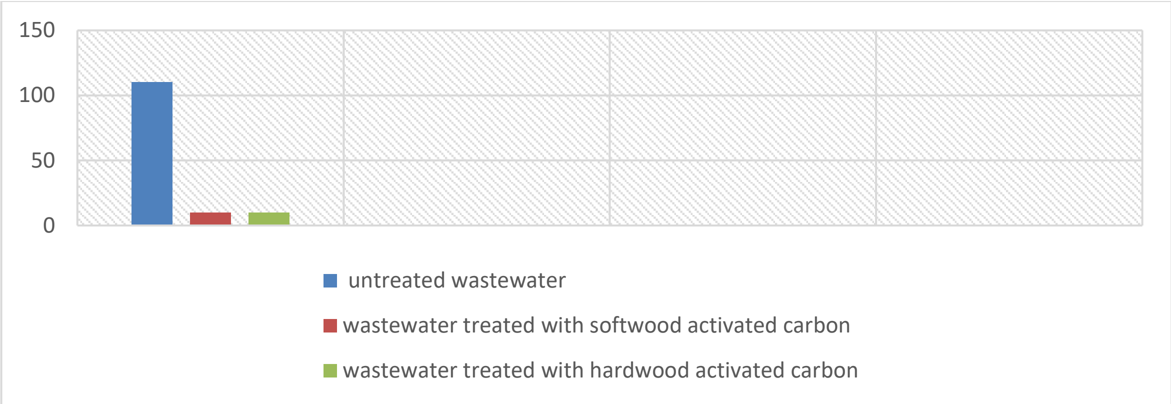

Fig. 3 Total suspended solid values.

Alkalinity test

A measure of the concentration of all the substances which are alkaline when dissolved in water and can both attract and release hydrogen is the total alkalinity. Buffering against change in pH occurs when there is interference with hydrogen. Alkalinity is important in considering the treatment of wastewater because it influences cleaning processes such as anaerobic digestion. Alkalinity of the untreated water was found to be 280mg/l. When treated with softwood and hardwood activated charcoal the alkalinity dropped to 200mg/l and 180mg/l respectively.

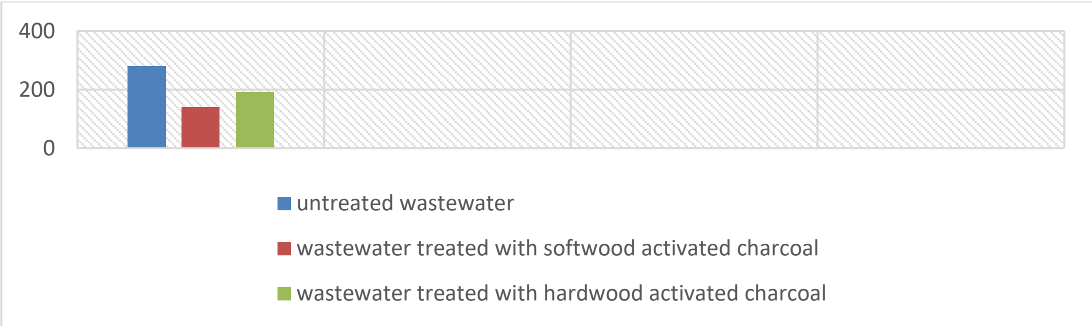

Fig. 5 Alkalinity Values

Hardness Test

A measure of the amount of dissolved magnesium and calcium in water is the hardness of the water. Hardness of water interferes with the action of soaps and detergents and can results in deposits of calcium carbonate, Calcium hydroxide and magnesium hydroxide inside pipes and boilers, causing lower water flows. The untreated wastewater has a hardness value of 121.7mg/l. When treated with both softwood activated charcoal and hardwood activated charcoal the value dropped to 53.1mg/l in both cases as shown in the figure below.

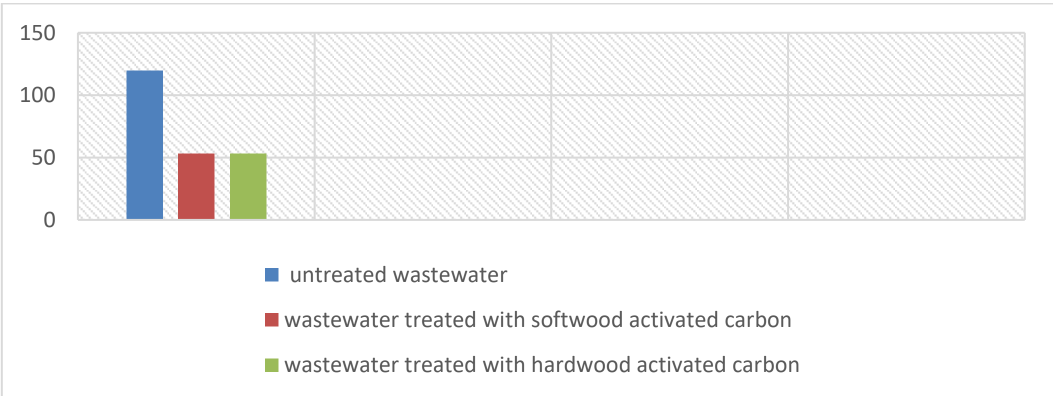

Fig. 6 Hardness values

Total dissolved solids test

The amount of all substances of organic or inorganic origins present in dissolved forms in ionized, molecular or micro-granular suspended form in a liquid is termed its Total dissolved solids (TDS). The major elements are usually the reactive metals like potassium, sodium, calcium and magnesium cations and carbonate, chloride, sulfate, and nitrate anions. The untreated wastewater has a TDS value of 600 ppm, when treated with softwood and hardwood activated charcoal it reduced to 450 ppm and 400 ppm as shown in the figure below.

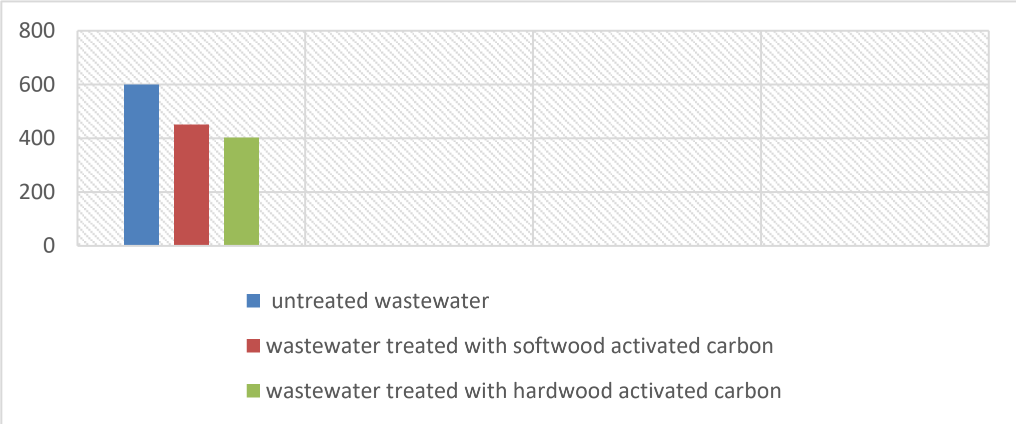

Fig. 7 Total dissolved solids values

4. CONCLUSION

Activated charcoal was used as a filter media in water treatment systems because of its excellent adsorption capacity. The pores of activated charcoal trapped and locked with taint water during the process of treatment. However, different activated charcoals have different surface area and porosity. In the physical assessment analysis conducted, hardwood activated charcoal showed good results with lower pH in comparison with that of the wastewater. Besides that, hardwood activated charcoal showed a reduction in the turbidity of water as compared to softwood activated charcoal. Furthermore, the hardwood activated charcoal eliminates the total suspended solid of wastewater effectively when compared with softwood activated charcoal. The hardwood activated charcoal successfully reduced the total dissolved solids of the wastewater remarkably. The Activated charcoal filtration has a good scope and now being increasingly used in developed nations.

5. RECOMMENDATION

Based on results obtained, it is recommend that hardwood activated charcoal should be used effectively in the treatment of wastewater, specifically in rural areas where access to waste water treatment plants is not feasible.

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