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The Removal of Dye from Textile Effluent Using Wood Ash As Adsorbent

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Abstract
Due to the high level of contamination, textile wastewater effluents are difficult to reuse and this invariably leads to scarcity of water in some communities. Government directives mandating textile industries to treat their effluents before discharge into the natural water body or streams are unfortunately largely unenforceable. The high cost of treating textile effluents is a major challenge which militates against the textile industry operators. These wastes-waters have little or no economic value as it constitutes immense waste which is very difficult to dispose. An appreciable amount of these dyes are toxic in nature, and their existence is of major environmental concern as they are usually very recalcitrant to microbial degradation. In some cases, the dye solution can also undergo anaerobic degradation to form potentially carcinogenic compounds which can contaminate the food chain. Also, highly coloured wastewaters can block the penetration of sunlight and oxygen which are essential for the survival of various aquatic organisms. Synthesized dyes do resist fading on gaining contact with sweat, soap, water, and light or oxidizing agents which renders them stable and less amenable to biodegradation. Numerous approaches including physical and/or chemical processes have been used in the treatment of industrial wastewater containing dye and such methods are often very costly and are not environmentally viable. The removal of dyes from wastewater is a major challenge as most dyes are completely soluble in aqueous solutions. Although, dyes constitute only a small portion of the total volume of waste discharge in textile processing industry, these compounds are not readily removed by typical microbial-based waste-treatment processes. In other words, the use of wood-ash would add economic value and more significantly help to reduce the charges paid on waste disposal.

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I. Introduction

Textile Industry is part of the chemical industries involved in serious water pollution which is characterized by its high water consumption and chemical usage (Schoeberl, 2004). Lots of textile manufacturers use basic dye to give colouring to their products. Dyes in low concentrations affect the aquatic life and threatens the well-being of human beings who are responsible for its removal from wastewater effluents necessary. According to the Environmental Hazards of Textile Industries (2005), many textile manufacturers use dyes that release aromatic amines. Dye bath effluents may contain heavy metals, ammonia, alkali salts, toxic solids and large amounts of pigments most of which are toxic. About 40 % of colorants contain organically bound chlorine, a known carcinogen are used by the textile industry. Natural dyes are rarely of low impact depending on specific dye and mordant used. Mordants' such as chromium are very toxic and have high negative impact. The large quantity of natural dyestuffs required for dyeing, typically equal to or doubles that of the fibers in weight which makes natural dyes prepared from wild plants and lichens to very high impact Grolier encyclopedia of knowledge, (2004).

Dye producing industries and such other industries which make use dyes and pigments generate wastewater characterized by high colour and organic content. Presently, it has been established that about 10,000 different commercial dyes and pigments in estimate exists and over 7×10^5 tones are produced annually worldwide Kumar and Gupta,(2004). The convectional wastewater treatments which rely on aerobic biodegradation have low removal efficiency for reactive and other anionic soluble dyes. Due to low biodegradation of dye, a convectional biological treatment process is not very effective in treating a dye wastewater. It is usually treated by physical or chemical processes. However, these processes are very expensive and cannot effectively be used to treat the wide range of dyes waste (Grag*et al.*, 2003).

The water used directly in almost all food or beverage production processes is potable. The World Health Organization, WHO, defines potable water as water that is limpid and transparent, odorless, with no objectionable taste, and free from any kind of microorganism or chemical substance in concentrations that can cause a risk to human health. For disinfection in many public water treatment facilities, chlorine and chlorine compounds (sodium hypochlorite, chlorine dioxide, and calcium hypochlorite) are used. Chlorine is a powerful oxidizing agent, able to penetrate cells and to act on vital cellular substances, killing microorganisms. The concentration of free residual chlorine in drinkable water should be in the range of 1.5 to 2.0 mg L^{-1} (U.S. EPA, 1999). Many food and beverage industries use water which has been treated with chlorine in city facilities and therefore still contains active chlorine, i.e. some residual chlorine. In other industries, the water from city water distribution plants receives an additional dosage of chlorine so as to guarantee the level of quality required by the process. It is known that there is a natural tendency for chlorine to react with organic substances, forming chloramine which alters the characteristics of the final product such as taste, odour, and total trihalomethanes, (TTHM), associated with an increased risk of cancer as well as damage to heart, lung, kidney, liver, and central nervous system. For this reason, these food and beverage industries have to keep the water used in all processes in which it comes into direct contact with and its products free from residual chlorine. That residual chlorine is removed with activated carbon.

Activated carbon is a porous carbonaceous material prepared through the carbonization and activation of organic substances, mainly of vegetable origin. During carbonization of raw lignocellulosic material, a solid residue (charcoal) and volatile gases are produced. During this process pores, i.e., voids between the graphite crystals, are formed. Activation occurs immediately after carbonization. Activation may be chemical or physical. The intermediate product is removed and the graphite crystals become exposed to the activating agent. This increases the number and dimensions of the pores during activation. The quality of activated carbons is evaluated in terms of their physical properties of adsorption and of superficial area using different analytical methods for liquid and for gas phase adsorption (Gergova*et al*., 1993; El-Hendawy*et al*., 2001). For the gas phase, characterization may rely on measurement of the adsorption of nitrogen and application of one of the different procedures available to determine superficial area, such as the BET method (Brunauer*et al*., 1938) or that of Langmuir (JIS K 1474). For the liquid phase, the characterization may be achieved with iodine or with methylene blue adsorption.

All of the raw materials used in this work, coconut, probably the most typical and traditional raw material for the preparation of biomass activated carbon; babassu; and sugarcane bagasse, are very abundant in the Brazilian Northeast. The primary objective of this study is to develop activated carbon adsorbent from a wood material to clean a textile dye impacted wastewater and to ascertain if ash can serves as a good adsorbent for the removal of colour from dye effluent.

II. materials and methods

2.1 SAMPLING AREA

2.1.1 Wood Ash

Ash was obtained from a canteen at Police Corner, Ojo, Iyana-Iba, Lagos State, Nigeria. It was sieved properly to remove all impurities and get the smooth powdered white ash.

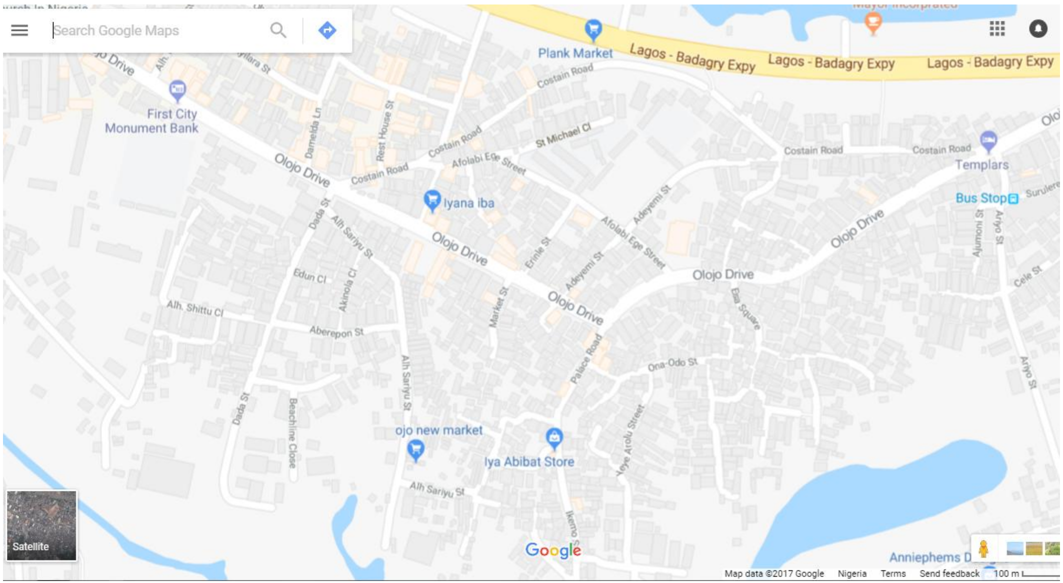

Figure 1: Map of Police Corner, Ojo, Iyana-iba,Lagos state.

Dye

The dye used in this project was obtained from a local textile industry at Abeokuta.

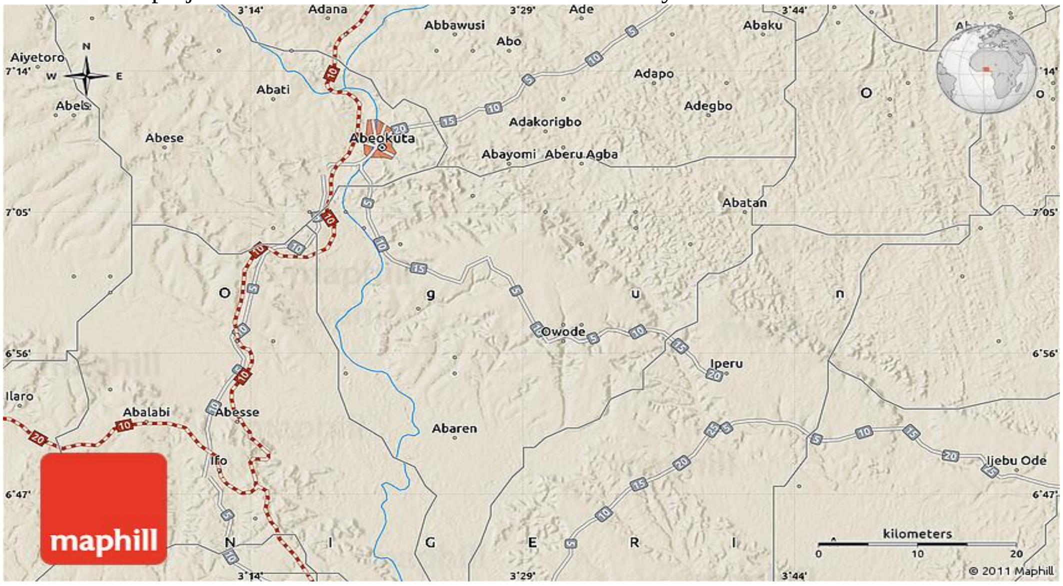

Figure 2: Map of Keesi area, Abeokuta, Ogun state.

2.1.2 Analysis of blue dye solution

The removal efficiency was calculated using this equation;

$$\text{Removal efficiency (\%)} = \left[\frac{C_o - C_e}{C_o} \times 100\right]$$

Where: C_o = Concentration of blue dye in the sample solution before treatment.
C_e = Concentration of blue dye in the sample solution after treatment.

2.2 ADSORPTION STUDY

Adsorption study of the wood ash sample was conducted in order to determine the optimum ash required to clean a textile effluent. Concentration, adsorption time, adsorbent concentration and initial volume were investigated as the key process parameters effecting removal efficiency of the adsorption processes. Batch adsorption experiments were carried out by shaking a known amount of adsorbent with 50 mL of the solution for a period of 15 minutes on a stirrer. The solution was filtered off and the filtrate was placed in the spectrophotometer for analysis. The experiment was performed at room temperature and the experiment was repeated twice. For the adsorption, dosage, concentration, contact time and volume were optimized. The result obtained was recorded for the optimized dosage, concentration, contact time and volume.

2.3 ANALYTICAL TECHNIQUE

2.3.1 Ultra-violet (UV) spectroscopy

The spectrum of the Blue dye solution was analyzed by using UV-visible spectrophotometer (Shimadzu UV-2401) at a wavelength of 552.0 nm which is λmax of the blue dye solution.

III. Results

3.1 ABSORBANCE OF STANDARD DYE SOLUTION

The absorbance of the standard dye solution was determined using ultra violet visible spectrometer. The result is presented in Figure 3.

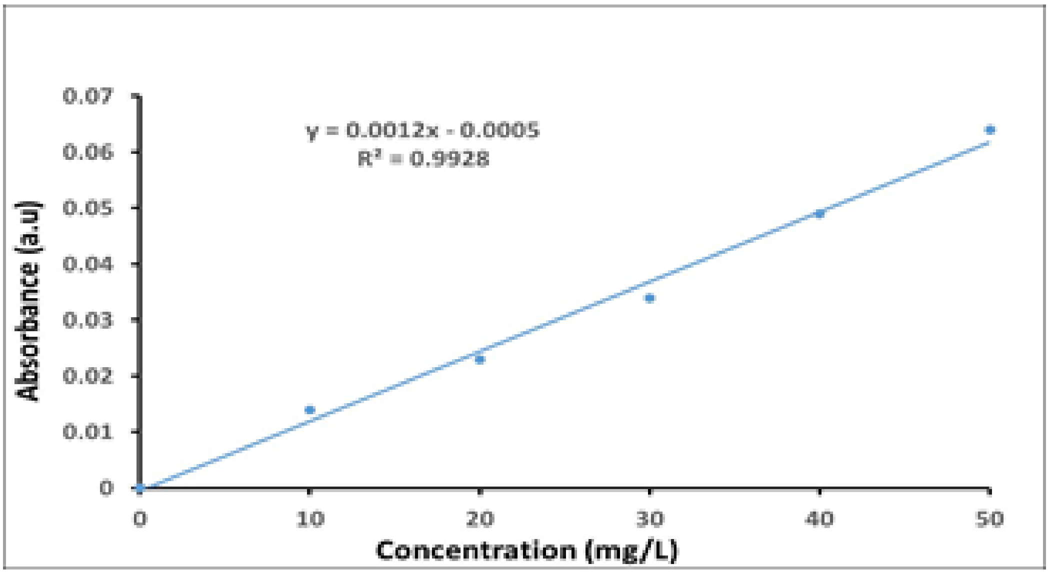

Figure 3 Absorbance of standards dye solution

3.2 OPTIMIZATION OF ADSORBENT DOSAGE

The effect of a considerable amount of absorbent on the removal of dye colour was investigated. For all the experiment, the initial concentration was kept constant at 80ppm, initial volume of 50ml, and constant time of 15 minutes. It shows that removal efficiency increases sharply with increasing amount of ash up to 0.6g. Then the efficiencies did not show any significant changes with increasing amount of absorbent. It shows that the removal efficiency was 26.37% when the amount was 0.2 g, 75.89% for 0.4 g, 93.72% for 0.6 g, 97.65% for 0.8 g and 98.96% for 1.0 g. The result of the dosage optimization is presented in Figure 4.

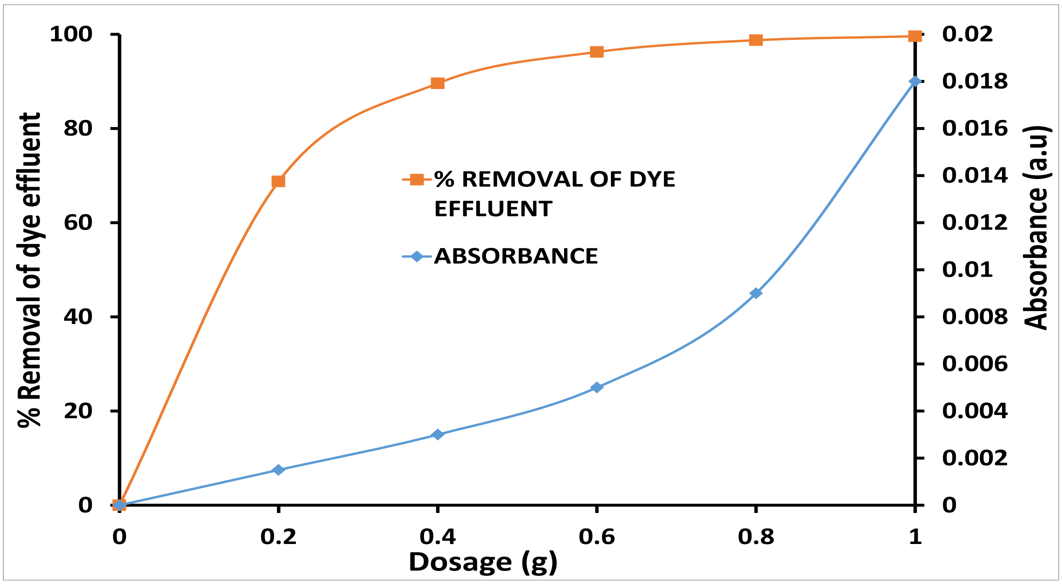

Figure 4: Dosage optimization. Experimental conditions: Concentration = 100 mg/L, Volume = 50 mL, Contact time = 60 minutes,

In other words, the adsorption efficiency increased due to the increased amount of adsorbent. Therefore, removal efficiency reached equilibrium with 0.6 g of wood ash.

3.3 OPTIMIZATION OF CONCENTRATION

For the evaluation of the effect of initial concentration, 50 mL solution of different concentrations was treated onto the adsorbent. Initial concentration was varied from 20 mg/L to 100 mg/L. From this experiment, it was observed that about 97.89% of the dye was removed at initial concentration of 20 mg/L. 93.45% was removed at initial concentration of 40 mg/L. 78.76% was removed at initial concentration of 60 mg/L. 65.52%

was removed at initial concentration of 80 mg/L, and 57.43% was removed at initial concentration of 100 mg/L. The result for the concentration optimization is presented in Figure 5.

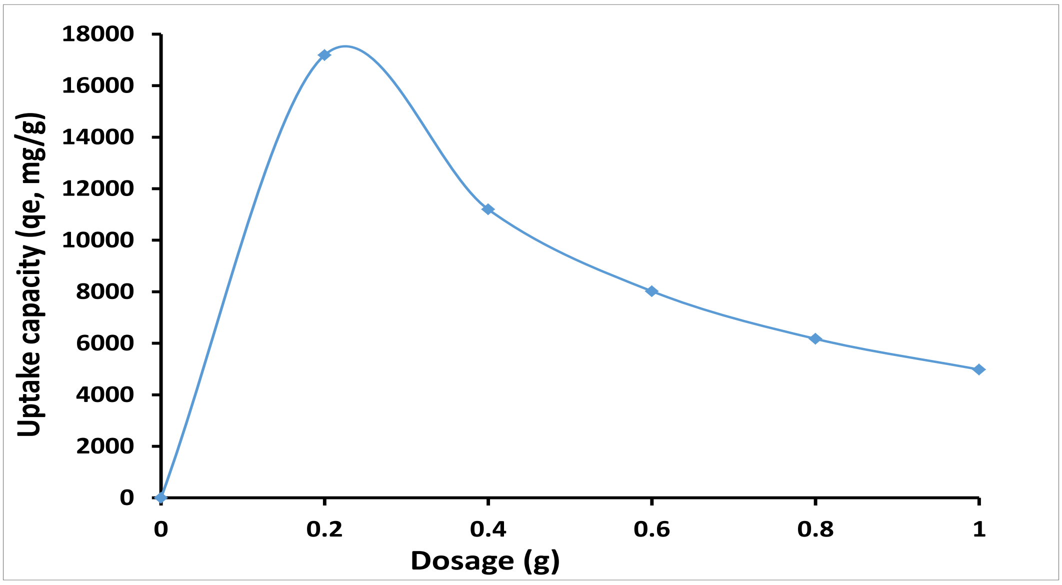

Figure 5: Concentration optimization. Experimental conditions: Dosage = 0.6 g, conc. = 100 mg/l, Volume = 50 mL, Contact time = 60 minutes, n = 3

It shows that removal efficiency decreases with increasing concentration. From the result in Figure 5, at low concentration, most of the dye colour in the sample comes in contact with the adsorbent and when the concentration is increased; all dye solution will not be available to contact the active surface (adsorbent). The removal efficiency decreased with increasing adsorbate concentration. Therefore, the optimum concentration is 40 mg/L as the removal efficiency reached equilibrium at this point and there was no significant change with decreasing concentration.

3.4 OPTIMIZATION OF CONTACT TIME

The effect of the contact time (time used for shaking the adsorbent in the solution) on the removal of color from blue dye solution was also investigated. It could be clearly understood that the removal efficiency increases with increasing contact time. About 99.8% of the colour was removed after shaking for 25 minutes, whereas, 99.49% was removed after shaking for 20 minutes. 98.45% was removed after 15 minutes, 84.82% was removed after 10 minutes and after 5 minutes of shaking the solution, 56.75% of the colour was removed. The result for contact time optimization of the adsorption is presented in Figure 6.

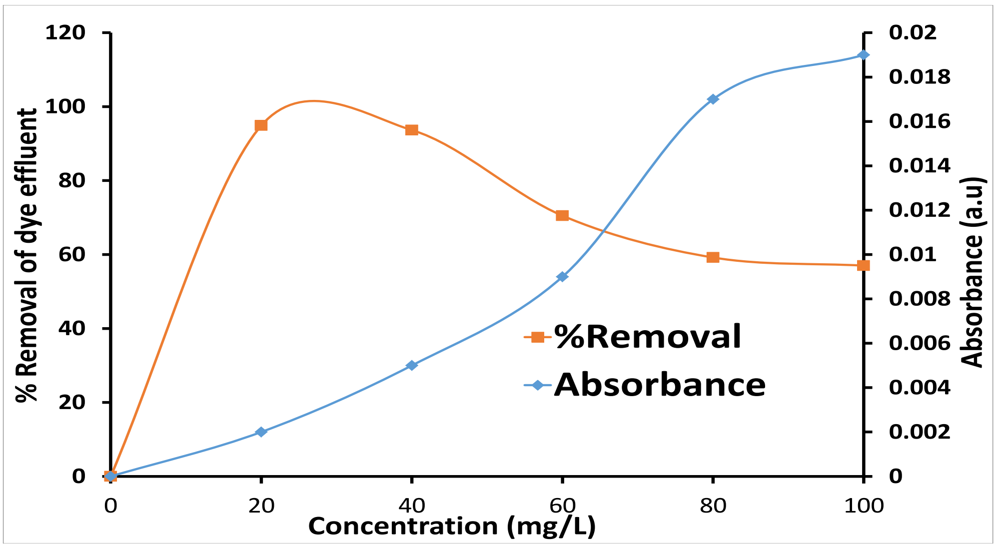

Figure 6: Contact time optimization. Experimental conditions: Concentration = 40 mg/L, Volume = 50 mL, Dosage = 0.6 g, n = 3

Therefore, the optimum contact time for the removal of colour from blue dye solution is 15 minutes as there was no observable change with increasing contact time.

3.5 OPTIMIZATION OF INITIAL VOLUME

It is very important to investigate the effect of volume on the removal of colour from blue dye solution. Different volumes were treated with the wood ash using the optimized concentration of 40 mg/L. It however, shows that the removal efficiency decreases with increasing initial volume. It was observed that the removal efficiency was 65.19% when the volume was at 50 mL, 85.26% when the volume was at 100 mL, 94.8% when the initial volume was at 150 mL, 98.6% for 200 mL and 100% for 250 mL and the results are clearly presented in Figure 7.

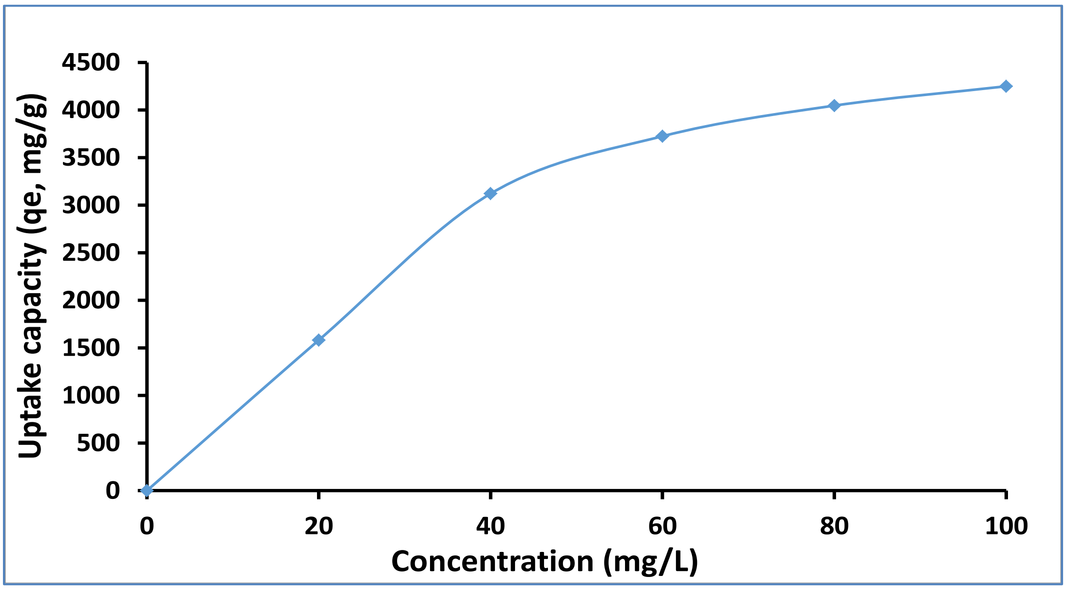

Figure 7: Volume optimization. Experimental conditions: Concentration = 40 mg/L, Dosage = 0.6 g, Contact time = 15 mins, n = 3

The removal efficiency decreased with increasing volume due to the increase in contact of adsorbate with the available adsorbent.

IV. Conclusion

From the results obtained from this study, it may be concluded that the utilization of wood ash as adsorbent may offer practical means for an effective treatment of dye effluent and wastewater contaminated with dye solution.

The findings revealed that textile dye was removed from effluent using wood ash obtained from canteen. Batch adsorption was carried out at initial concentration of 20-100 mg/L. Percentage ash yield tends to decrease with increase in contact time. The dosage treatment shows that the percentage removal of the dye increased with increase in the dosage of the adsorbent. The research further confirmed that wood ash, a low cost adsorbent, could be employed for the removal of textile dye effluent with greater percentage uptake. Adsorption capacity at equilibrium also increases with increase in initial concentration which results to about 99.67 % Blue dye removal. The result of the present study has clearly shown that wood ash treated textile effluent was effective for removing dyes from aqueous solution. The effectiveness increases with increase in the contact time and the amount of adsorbents until the equilibrium is established. This type of adsorbent is economically good for the removal of dyes from textile effluents. The result obtained from this study can be concluded with the following:

- That wood ash waste is a good adsorbent for treating textile waste effluent
- Wood ash is a cheap source of adsorbent for cleaning textile effluent water
- The efficiency and effectiveness of the wood ash was high
- The wood ash removes dye from polluted water at a fast rate.

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