Journal of Science and Technology
ISSN: 2456-5660 Volume 5, Issue 3, May-June 2020

www.jst.org.in *DOI: https://doi.org/10.46243/jst.2020.v5.i3.pp72-78*

Water Treatment using Chemically Activated Charcoal

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To Cite this Article
Dr. Anamika Paul, Maham Malik, Mahima Yadav, Ishty Malhotra and Sandeep Gupta, "Water Treatment using chemically Activated Charcoal", Journal of Science and Technology, Vol. 05, Issue 03, May-June 2020, pp72-78

Article Info
Received: 05-02-2020 *Revised: 25-04-2020* *Accepted: 30-04-2020* *Published: 04-05-2020*

Abstract:-*Water scarcity is a widely experienced problem in several countries in the world like Qatar, Israel, Lebanon and many others. Critical steps have to be taken before this becomes a worldwide phenomenon. The current study focuses on cleaning the greywater, which is about 65% of total wastewater from households, using activated charcoal powder prepared from coconut husk. The material is chemically activated. The shell based activated carbon is used for decolorization of three solution samples: Potassium Permanganate (Purple), Potassium Dichromate (Orange) and Copper Sulphate (Blue) as well as treating the sullage water. Change in normality of above-mentioned samples is calculated before and after treatment by activated charcoal using maximum absorbance data for before treatment as standard. Also, sullage water is treated with activated charcoal and comparison of physical and chemical properties is done before and after the treatment.*
Keywords: *Chemical Activation, Maximum Absorbance, Sullage water, Greywater, Colored samples*

I. Introduction

The extent of industrial wastewater generation is largely unknown. Globally, information focusing on the volume of wastewater produced by industry is very deficient. The water may be recycled within a plant or by another linked industry, or it may be simply discharged, returning it to the hydrological cycle for others to use. The study showed that about 80% of the water turns out as wastewater. Out of the wastewater produced, 62% is greywater, 25% is dark grey water 13% is blackwater (Ministry of Urban Development, Thiruvananthapuram, 2011). When separately collected, sullage can be conveniently treated and restored to the original characteristics of tap water (Taydee*t al*., 2015). Sullage water is the wastewater free from fecal contamination generated from households, institutes and offices. Since, Water is one of the most abundant resources but still around 700 million people face a shortage of water. Due to inadequate access to clear water, approximately 200000 people die every year (Shelar*et al*., 2019). Although India occupies 3.29 million km^2 of geographical area and supports 15% of the world's population with 4% of the total water resources (Lambe and Chougule, 20).
Thus, it clearly shows that water scarcity, inappropriate sanitation and waste water pollution are important issues. Due to rapid increase in population and development, there is an urgent need to look after alternative approaches for water availability. Water supply and waste water management problems can be solved by using a decentralised approach which can be done by reuse of greywater (Ghaidiak and Yadav, 2013). Bark and charcoal filters can be used for grey water treatment which helps in reducing their organic amount to irrigation level. This is due to the property of bark filters to remove microorganisms. Whereas, charcoal has a large specific surface area due to which it helps in removal of BOD 5. Similarly, a sand filter provides high nitrification but low nitrogen removal (Dalahmeh, 2013). In the following work, initially activated charcoal is prepared from coconut shell and colour removal of grey water takes place by its treatment with chemically activated charcoal due to which change in physicochemical properties has been observed.

II. Literature Review

Now-a-days, activated carbon is widely used as an adsorbent in the industrial process. It is composed of microporous and homogenous structure with high surface area. But still, the process for producing high-efficiency carbon is not efficiently investigated in developing countries (Thomas and George, 2015). The absorptivity of any absorbent depends upon the size of the molecule being adsorbed as well as the pore size of the adsorbent (Rangari and Chavan, 2017). There are a number of reports available in this field elsewhere.Activated carbons can be produced through thermal processes by using biomass either by direct carbonization-activation process or by first carbonizingthe biomass and later activating it (Bergna *et al*., 2018). Presently, several types of agricultural wastes and fruits are also used for its preparation (Soonmin, 2018). Investigators even studied the preparation and characteristics of activated carbon made from fluted pumpkin stem waste (Ekpete and Horsfall, 2011). Many industrial processes used activated carbon as the economic and stable mass separation agent in the case of removal of surfactants. They are used in order to raise the final product quality. Along with this, activated carbon is playing an important role in science and technology like purification of liquids, catalysis, separation of mixtures etc due to its property of being the adsorbent (Rangari and Chavan, 2017).Similarly, activated carbon can also be used in removal of colour. During a research, an agricultural waste i.e. Coconut shell charcoal (CSC), is used as an adsorbent while basic yellow 13 (BY13) and basic red 14 (BR14) were used as representative dye used in textile manufacturing (Srisorrachatr *et al*., 2016). Similar to this, the coconut husks are carbonated and activated using Zinc Chloride which can be further used to catalyze the reduction of hexamine cobalt (III) to hexamine cobalt (II) (Sodeinde, 2012). Researchers also worked on removal of Congo red, crystal violet, turquoise blue, reactive black 5, and malachite green onto activated carbon. By the investigation of adsorption and equilibrium data, they concluded that adsorption process is an endothermic and spontaneous process (Soonmin, 2018). Similar to this, activated Carbon can also be prepared from Pods of Thespesia as raw material for the removal of orange G dye from aqueous system. (Arulkumar*et al*., 2011). However, activated charcoal can also be used for treating grey water quality.

As mentioned earlier, due to high shortage of water various methods have been adopted by various studies for the treatment of grey water. Beginning from low cost household treatment methods like ceramic candle filter, silver impregnated pot filter, bio sand filter to the activated carbon and resin are adopted to treat water and efficiency of different methods have been tested by researchers (Mande *et al*., 2018). Since grey water has low nutrient and pathogenic content, it can be easily treated to high level water quality by using sand, gravel, activated charcoal etc. Freshwater consumption and wastewater production can be easily reduced if treatment of grey water will take place efficiently (Kadam *et al*., 2018).

III. Methodology

1. Preparation of Activated Charcoal.

Activated charcoal, (also called activated carbon) is a form of carbon having small pores that helps in increasing the surface area available for adsorption. All the activated carbon with more micropores show high specific surface area as well as total pore volume which depends upon the activation time prolonging; the highest ones were around 3100 m^2/g and 1.5 mL/g, respectively (Lin and Zhao, 2016). Coconut is a member of the palm tree family known for its versatility of uses. The shell of coconut contains cellulose, lignin, charcoal, tar, tannin etc. Coconut shell is first collected and then cut into small pieces, followed by washing with simple tap water for removal of dust adhering to it. It was followed by drying in sunlight and grinding into a powdered form called coconut husk. This powdered form is then heated in the oven at 110ºC temperature. Dried materials were kept in the muffle furnace at 150°C for removal of other volatile impurities. This leads to the formation of fixed carbon (charcoal). For the first batch, whole fixed carbon is treated at 300ºC in a muffle furnace for formation of ash for proximate analysis. The sample was carbonized using a 25% concentrate solution of $CaCl_2$ (Gawande and Kaware, 2017). The soaked sample was transferred into a tray and washed repeatedly with distilled water to remove traces of chemical. The washed sample was transferred into an oven at 110℃, cooled and led to formation of chemically activated charcoal (Figure: 1) and stored for use.

Figure: 1 Activated Charcoal

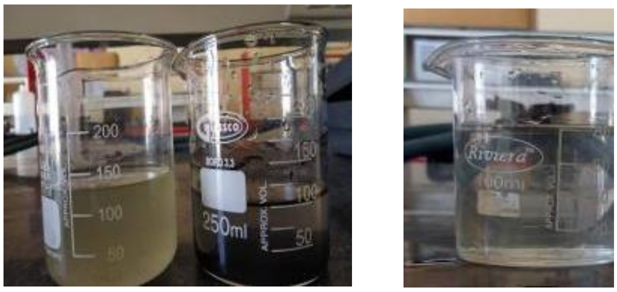

Figure: 2: Treatment of Grey Water

2. *Treatment of Greywater*

Greywater can be called as washwaterie, water from bath, dish, laundry except toilet waste and free of garbage residue. A household grey water flow is around 65% of total waste water flow (Ghaidiak and Yadav, 2013). If properly used grey water can become a valuable resource for horticultural and agricultural practices. Water in bathing and hand washing produce 50-60% whereas, cloth washing produces 25-35% and kitchen washing produces 10% of total grey water (Lambe and Chougule, 20). As greywater flow and composition varies daily, weekly and monthly depending upon the various factors (Dalahmeh, 2013). To understand the area of application, physicochemical tests like BOD, COD (as per ASTM D1252), turbidity etc were performed to study the change in quality before and after treatment of grey water (Figure: 2 (From left to right) Greywater, Charcoal added water, Clear water) with activated charcoal.

Since, grey water contains metals such as Pb, Ni, Vu, Cd, Hg and Cr in appreciable concentration (Eriksson *et al*., 2010). Generally, except Mg and Ca, metals like K, Fe, Zn, Cu, Na, Cd and Cr are higher in grey water compared to tap water, whereas, Pb level is similar in all sources of water (Kariuki *et al*., 2012). Generally, the range of K ions and sulphate ions found in grey water lies between 1-20 mg/L and 2-40 mg/L (Hubicki and Kołodyńska, 2012). These contaminants in grey water indicate the gradual increase in the level of complexity in composition of grey water (Peprah*et al*., 2018).

Along with this, some ions like copper, manganese, cadmium etc also provide colour to it. It is observed that the normal concentration of Cr, Cu and Mn found in grey water lies in the range of 0.2 to 5 mg/L (Inspection Report of STPs in Agra, 2015; The Environment (Protection) Rules, 1986), <3 mg/L (Hubicki and Kołodyńska , 2012; Inspection Report of STPs in Agra, 2015; The Environment (Protection) Rules, 1986) and 1-2.5 mg/L (Inspection Report of STPs in Agra, 2015; The Environment (Protection) Rules, 1986) respectively. In order to study this colour removal, 0.001N, 0.002N, 0.003N and 0.004N solutions have been taken each of $KMnO_4$, $CuSO_4$, and K_2CrO_4 .

3. *Treatment of Colored Samples*

50 ml samples were prepared for 0.001N, 0.002N, 0.003N, 0.004N each of $KMnO_4$, $CuSO_4$, and K_2CrO_4. Their absorbance is measured in UV spectrophotometer. Samples were treated with activated charcoal and change in normality is calculated before and after the treatment taking the absorbance vs normality before treatment as the standard (Figure: 3)

Figure: 3 (from left side) Untreated $CuSO_4$, Treated $CuSO_4$, Untreated $KMnO_4$, Treated $KMnO_4$, Untreated K_2CrO_4, Treated K_2CrO_4.

IV. Results and Discussion

Proximate Analysis provides information on moisture, ash, volatile matter and fixed carbon contents on a dry basis (Iloabachie *etal*., 2018). Carbon plays an important role in the adsorption of substances due to its porous nature which indicates that powdered carbon form of coconut shell can serve as good adsorbent in the removal of metallic ions, colours and other matter from aqueous medium of water and wastewater (Ewansiha*et al*., 2012). The result of Proximate analysis performed shows (Figure: 4) that charcoal from coconut husk contains 74.89% of fixed carbon (800 ^{O}C) (Gawande and Kaware, 2017, Das and Mishra, 2014, Iloabachie *et al*., 2018), 14.18% of Volatile Matter (Iloabachie*et al*., 2018), 7.25% of moisture content (Ewansiha*et al.*, 2012; Said *et al*., 2015) and 3.68% of ash content (Ewansiha*et al*., 2012; Das and Mishra, 2014; Iloabachie*et al*., 2018).

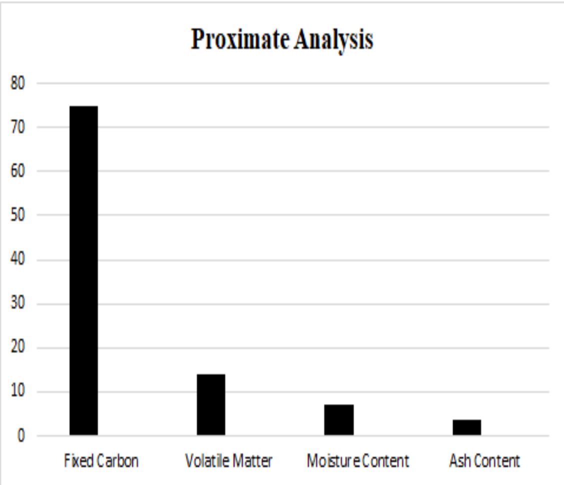

Figure: 4 Proximate Analysis

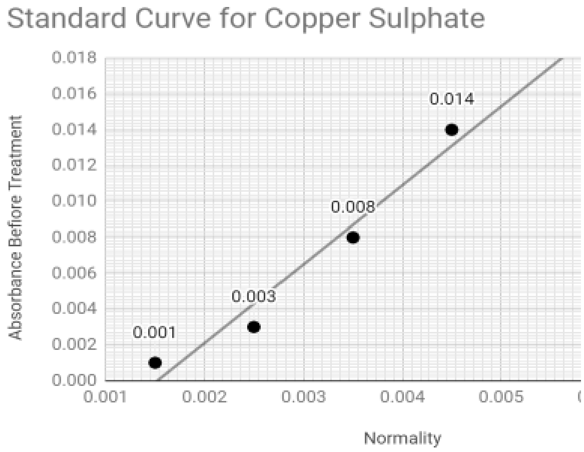

Figure: 5a

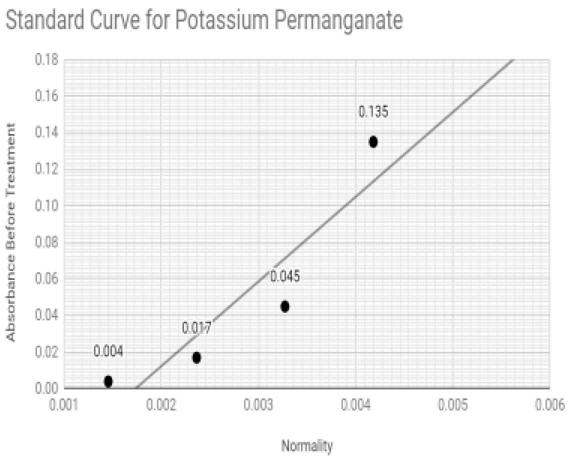

Figure: 5b

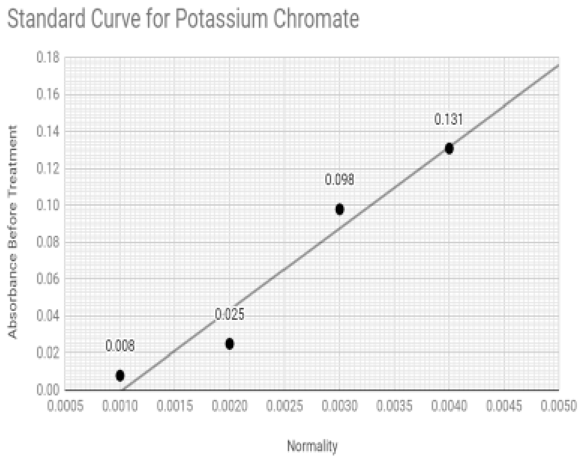

Figure: 5c

Since, the prepared activated charcoal is used to treat the colour samples. The colours that are seen in the solution is due to the ability of the compounds to absorb specific wavelengths of light. The absorbed wavelength of light is determined by electrons present in them. Since, the environment of electrons gets affected by the concentration which affects the absorbance of particular wavelengths. Thus, the relationship is studied to determine absorbance using a wavelength of light in a region of the visible spectrum where the maximum absorbance is observed. This wavelength is known as λmax and is most sensitive to the changes in concentration (Doe and Smith, 2013).

Therefore, by taking the standard (Figure: 5a, 5b, 5c) between the normality and absorbance for the three samples, changes in normalities between before and after treatment have been studied. Using this standard, normality is determined after the treatment with activated charcoal. Hence, the values of normalities have been plotted (Figure: 6a, 6b, 6c) which shows that at higher concentration, normality shows the greater change before and after treatment.

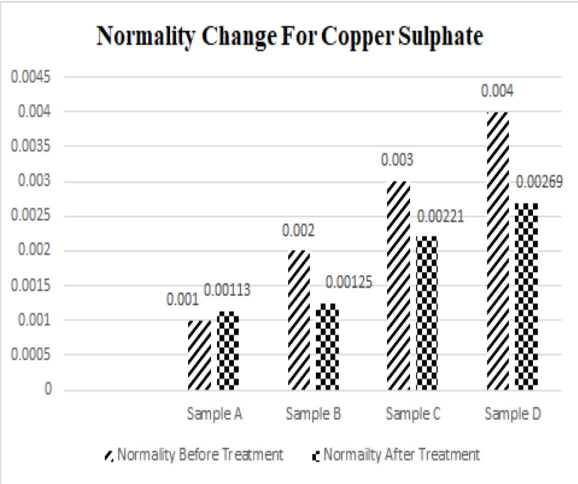

Figure: 6a

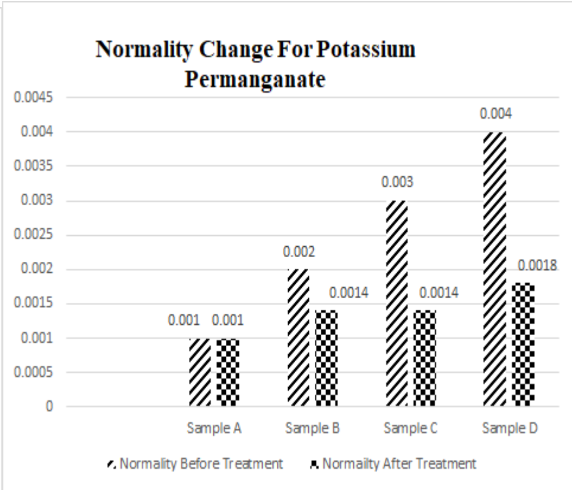

Figure: 6b

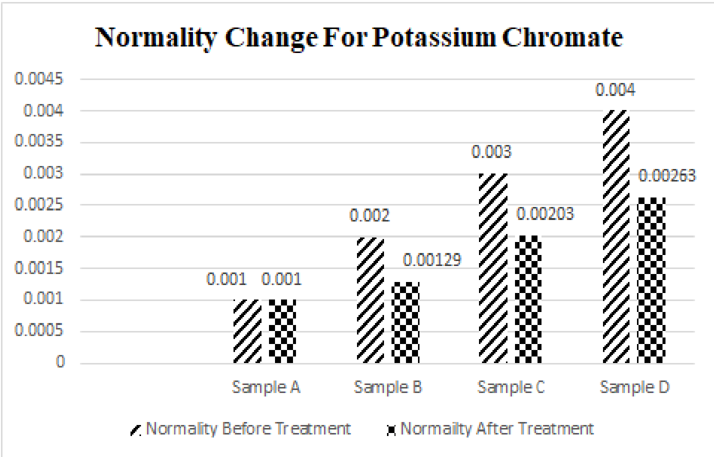

Figure: 6c

Table 1: Removal of Color (Percent)

Initial	Copper Sulphate (%)	Potassium Permanganate (%)	Potassium Chromate (%)
0.001N	Not Detected	Not Detected	Not Detected
0.002N	37.5	28.5	35.5
0.003N	26.33	52.33	32.33
0.004N	32.75	55	34.25

Table: 1 shows the percent reduction that has been observed in normalities which directly shows that colour removal has taken place for the samples at 0.001N, 0.002N, 0.003N and 0.004N solution. Since, colour removal of these samples clearly shows that the change in concentration of Cu, Cd and Mn can take place in greywater by the treatment with activated charcoal. Normally, the temperature range of greywater lies between 18-35^{o}C (Peprah*et al*., 2018). This high temperature favours the growth of mycobacteria which is undesirable and can cause precipitation of calcium carbonate and other inorganic salts which become less soluble at high temperature. The concentration of TSS reported during the other research is in the range of 200 to 550 mg/L (Peprah*et al*., 2018; Edwin *et al*., 2014).

A Physicochemical Parameter (percent reduction) like COD measures the amount of oxygen which is required to oxidize the organic material present in a water sample. Measured COD is an indication of the polluting strength of the greywater generated from all the sources (Bakare *et al*., 2017). It has been observed that the range of COD for untreated grey water lies between 50-1200 mg/L (Boano*et al*., 2020; Katukiza *et al.*, 2015). The measured value of COD is usually more than that of measured BOD because many organic substances can be oxidized chemically rather than biologically. BOD measures the amount of organic compounds that can be oxidised biologically in greywater (Bakare *et al*., 2017). The common value of BOD lies between 100-410 mg/L (Parjane e*t al.*, 2011; Boano et al., 2020; Edwin *et al*.; 2014).

Other parameters like turbidity, pH and total hardness lie in the range of 100-340 NTU, 6-8 and 100-300 mg/L (Gour and Batra, 2018, Parjane and Sane, 2011, Boano*et al*., 2020; Katukiza*et al*., 2015; Sangeetha *et al*., 2019). Calculation of various physicochemical parameters along with their percent reduction is given in Table: 2.

Table: 2 Percent Reduction in Physicochemical Parameters of Grey Water

Physicochemical Parameters	Grey Water Before Treatment	Grey Water After Treatment	Percent Reduction
BOD (mg/L)	148	36.5	75.3
COD (mg/L)	380	160.6	57.7
Ph	7.45	7.2	3.4
Turbidity (NTU)	190	67.10	64.68
Chloride Content (mg/L)	1200	537.4	55.2
Total Hardness (mg/L)	120	115	4.2
Total Solids (mg/L)	780	490	37.2

It is observed by other investigators as well that the turbidity for grey water has been reduced by 98% whereas there is 6.25% decremental in the total hardness. Other than this, BOD level is reduced by 95.5%. and pH level is reduced by the range of 1.38% during their experiment (Gour and Batra, 2018). As per CPCB (2008) guidelines, pH range of treated water for onland irrigation should lie between 5.5-9 whereas the limit for BOD should be <100 mg/L. Similarly, the limit for pH, BOD and COD for inland surface water lies between 5.5-9, 30 mg/l and 250 mg/L (Edwin *et al.*, 2014). The result obtained by the physicochemical parameters after the treatment in our experiment concluded that the water after the treatment can be used for onland irrigation purposes in the agriculture section.

V. Conclusion

1. Chemically activated charcoal in the present project contains 7.25% Moisture Content, 14.18% Volatile Matter, 74.89% Fixed Carbon, and 3.68% Ash content as its Proximate Analysis.
2. Percent removal of colour has been studied by taking 0.001N, 0.002N, 0.003N and 0.004N solutions each of $KMnO_4$, $CuSO_4$, and K_2CrO_4
3. Determination of physicochemical parameters has been performed in order to study the treatment of greywater using chemically activated charcoal.

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