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Research Article

Analysis of Filtration Efficiency of Activated Carbon Coated Sand Beds

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Abstract

Sourcing the clean water has remained of the great importance ever since the civilisation has come into the existence. Continuous efforts are being made to find out the innovative methods and techniques to treat water efficiently and economically. In this study, an attempt is made to make efficient water filter, to be used at large scale in water treatment plants, economically and commercially viable. It is made from activated carbon coated sand acquired from thermal degradation of sugar on river sand particles. The carbon coated sand is activated by chemical treatment. It is found that filter function satisfactorily in removing the TDS and dissolved organics from polluted water. The high concentration of carbon on sand have better adsorption power (15% sugar on sand is better than 5% sugar in sand) and higher the number of passes through filter facilitate the better results. Though "ordinary sand" used in conventional systems is good in removing organics but do not removes inorganic dissolved particles. It also could be done by this type of filters. Higher amount of chemicals used in every sector reach back to the prime sources of water. Which requires to be "re-treated" by water treatment plants. Thus, it becomes a necessity to find out innovative techniques to treat water.

Keywords: Adsorption, Activated sand, Filtration, Organics, Sand bed, TDS

Introduction

Carbon has been the most versatile material used for water purification in history.[1, 2] Very early account of the use of charcoal in water purification is found in the Vedic literature The most widely used material for water purification today is activated carbon (AC) derived from plant sources.[3-7] It has the best possible surface area and could be produced at low cost, making it the most affordable adsorption medium in diverse applications Advanced techniques such as membrane filtration, reverse osmosis and ion-exchange can be used in treatment and removal of contaminants from water.[8, 9] However, higher cost limits the large-scale application of such treatment techniques in developing countries. biologically derived carbon is perhaps the most affordable and chemically most versatile. Materials derived from plant sources may even be eco-friendlier than those from fossil source[10] such as petroleum. Among the simplest of natural sources of carbon are sugars[11], which upon dehydrogenation get converted completely to elemental carbon, leaving only water to escape. For example:

$C_{12}H_{22}O_{11} \rightarrow 12\ C + 11\ H_2O$

In this article, find grained sand is cooked with different concentrations of sugar solution on heating the sugar change to carbon and gets coated on sand particles, the carbon coated sand is activated by chemical treatment and is used as absorption bed for water filtration.

Objectives of the Study

1. Make carbon coated sand with different concentrations of sugar solution (5%, 10% and 15%) which is farther activated.
2. Measure water sample parameter:

- TDS
- pH
- COD

3. Comparison of different efficiencies of filtration of different sand type.

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Sand Activation

The basic characteristics of a carbon are established during the pyrolysis and the ensuing oxidation step must be designed to complement the pyrolysis step. During this step, the oxidising agent increasingly erodes the internal surfaces of the carbon, develops an extensive and fine network of pores in the carbon, and changes the atoms lying on the surface to specific chemical forms which may have selective adsorption capabilities. This activation step is done by two methods physical activation or chemical activation.

Materials and Methods

Raw material used are common sugar, sand and sulphuric acid. Sugar is obtained from local market, sand from banks of Yamuna River and sulphuric acid from college supplier. Water sample is taken from western Yamuna canal.

Carbon Coating of Sand

- Four Sand sample weighed for about 600grams each are prepared
- Sand sample is cleaned with clean water to remove clay particles ad very fine particles, as the sand particles are heavier they settle in water and excess water containing clay particles can be removed. This is repeated till we get clear excess water
- Mild Acid (about 30%) is poured on wet sand about 15-20ml and then thoroughly mixed, this will remove any dissolved salts present
- Mixture is again cleaned with clean water to remove salt and excess acid
- Sand is dried in Hot Air Oven at temperature 100^{0}C for one hour
- Dried sand is passed through sieve IS:90 to remove larger particles
- Sieved sand is taken and weighed for 500grams sample
- Sugar is weighed for particular % sand (25grams for 5% sand) and dissolved in sufficient amount (80-100ml) of clean water
- Sand sample is poured in metal container with sugar solution on it, both are thoroughly mixed and then put on constant heating coil heater which is put at temperature 95^{0}C
- The mixture is constantly stirred with heating temperature fixed at 95^{0}C
- With constant heating the water from sugar solution dries up and sticky sugar is coated on sand here constant stirring is required or else lumps will form
- Sugar will start degrading and the colour of sand changes from light green to brown then finally black, this process will give dense white fumes
- The Sample is stirred till it become black and fumes stop coming out, it will take about 2 hours
- The black sample is then poured in metal pan and is put in Hot Air Oven and the temperature is raised in steps of 10-15^{0}C from 95^{0}C to 200^{0}C , sample is allowed to settle for 15minutes at each temperature
- Before every step up in temperature the sample is take out and mixed thoroughly
- When the sample finally reaches the temperature of 200^{0}C, it is stored at this temperature for one hour
- After One hour the sample we get is black Carbon coated sand
- Same procedure is followed for different concentrations of sugar. Thus, three samples of carbon coated sand are made 5%, 10% and 15%

Figure 1.Cooking of sand with sugar solution on heater

Sand Activation

- Prepared Carbon coated sand is cooled to room temperature
- For Activation concentrated (about 95%) sulphuric acid is used
- For 1gram of sample 1ml of acid is used (higher ratios 5ml per gram can be used for better results)
- Thus 500ml of concentrated acid is poured in each sample and then left undisturbed for 30minutes
- After 30 minutes excess acid is removed sample is cleaned with distilled water 10-15times this is done with caution
- Cleaned sample is dried and we finally got Activated Carbon Coated Sand

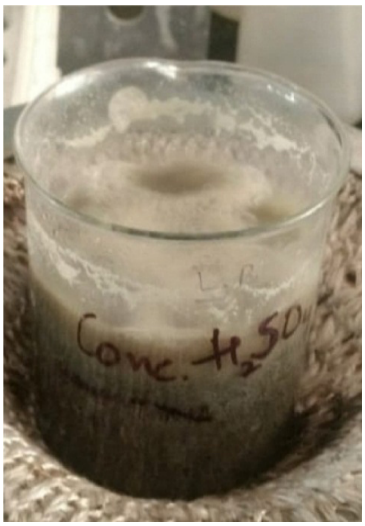

Figure 2.Concentration acid added to sand

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Sand Bed Preparation

Water sample is to be passed through the sand samples prepared for that sand bed is required

1. PVC pipes are used to contain sand samples
2. Three PVC pipes of size 152.4 cms (5') length and 3.81 cms dia (1.5") are used
3. Base of the pipes are covered with water permeable cloth and binded with pipe with paper tape
4. Sand sample is poured upto 2/3rd height i.e. about 100cms for each sample
5. Thus we got pipe for different sand sample, three pipes containing 5%, 10% ,15% sand sample

Figure 3.PVC pipes filled with different % sand filtering water

Water Sample Testing

Three pipes are used with 5%, 10% and 15% samples in them, the water sample obtained is passed through them one by one.

- Water sample passed through filter bed in cycle to get sample which is passed through thrice. For each sand bed sample
- Thus we got 3 water samples each of which is passed through each of sand bed thrice
- We will test these samples against the blank sample of water
- In the end, we got 4 samples of water

TDS Test

Total Dissolved Solids test is basically used as an indicator test to find the general quality of the water. The sources of TDS can include all of the dissolved cations and anions.

TDS measurement of water sample is done by electronic TDS meter which will determine the TDS of water sample on based on the conductivity of ions presnt in the sample water.

The most accurate way to measure all TDS in water in a laboratory is to evaporate the water leaving behind dissolved solutes as residue, and then weighing the residue.

COD Test

COD is the chemical oxygen demand of water which is a quantitative measure of signifying dissolved organic compounds in the water sample in terms of amount of oxygen consumed to decompose all dissolved organics be it biologically degradable or biologically non-degradable. COD is thus used to signify the amount of organic present in water sample which will eventually degrade and in process consume oxygen thus reduce dissolved oxygen level of water and also the presence of organic may lead to growth of pathogenic micro- organisms.

pH Test

A pH less than 7 is acidic, and a pH more than 7 is alkaline. As the pH scale is logarithmic, pH is a dimensionless quantity.

The pH meter is an instrument that measures the hydrogen-ion activity in aquas solutions, indicating its acidity or alkalinity expressed in terms of pH. Measured by glass probe pH meter.

Analysis

Samples tested for TDS, COD, pH the analysis can be done to find out the change in the parameters and if it is beneficial, if so how can this effect be increased.

Percentage reduction in TDS, COD is calculated for different samples.

Results

Sample: water sample taken has a pH of 8.0, TDS of 114.3 mg/l and COD of 134mg/l.

5% Sand Results

TDS Reduction

Overall reduction of TDS in seen to be about 23.4%.

pH Correction

- Originally the sample is a little alkaline with pH of 8.0
- pH will be corrected when passed through sand as alkalinity causing are being absorbed by the activated particles
- After 3 passes the water sample had become a little acidic this can be reduced by a greater number of passes through the sand
- Final after 3rd pass is 6.7

COD Reduction

Overall reduction of COD is about 35%. For higher reduction efficiency either the number of passes or the bed depth is increased.

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10% Sand

TDS Reduction

Overall TDS reduction by 10% sand sample is about 36% (35.96%) which is higher than in case of 5% sand.

pH Correction

- pH is reduced due to adsorption of some ions causing alkalinity or due to release of ions attached on bed at the time of activation
- Final pH after 3rd pass is 6.6

COD Reduction

Overall reduction in COD is about 46.3% when passed through 10% sand after 3 times.

15% Sand

TDS Reduction

Overall TDS removal efficiency is better than other both which is about 42% after 3rd pass of water through the bed.

pH Correction

- The pH value will stabilize after a greater number of passages of water through the sand bed
- Final pH after 3rd pass is 6.3

COD Reduction

Overall removal efficiency of COD when passed through 15% sand bed is about 53%.

Discussion

Comparison of Efficiencies

1. TDS Removal Efficiencies

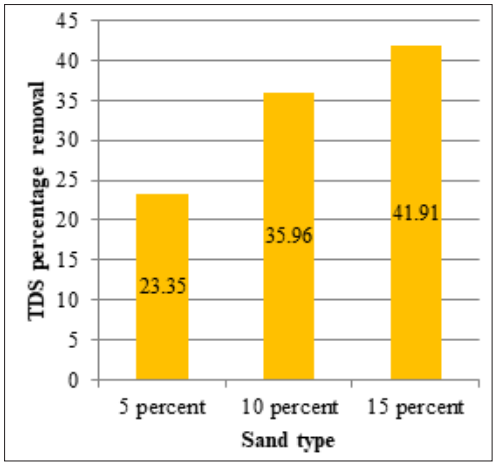

Figure 4.TDS removal efficiency

- Highest TDS removal efficiency is achieved by 15% sand after 3rdpassage of water through bed
- TDS removal efficiency increases as the sugar conc. In sand increases this proves that higher conc. of sugar will gave more carbon thus more activated surface area for adsorption
- Incremental increase in removal efficiency is not linear with concentration increase, that is about 12.5%, when 5% sand to 10% sand and about 6% when, 10% sand to 15% sand

2. COD Removal Efficiencies

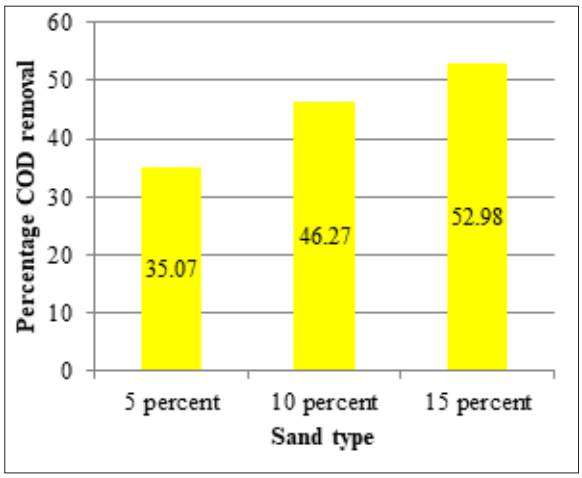

Figure 5.COD removal efficiency

- Highest COD removal efficiency is seen in 15% sand when passed 3rdtime
- COD removal efficiency increases as the sugar conc. in sand increases this proves that higher conc. of sugar will gave more carbon thus more activated surface area for adsorption
- Incremental increase in removal efficiency is not linear with conc. increase, that is about 11% when 5% sand to 10% sand and about 6.5% when 10% sand to 15% sand. Thus, it is rather decreasing curve

Conclusion

This work has determined the significant information about the quality as well as efficiency of treatment that can be done by low cost activated carbon coated sand. In this study we came across conclusions like Sugar solution can be used as a source of carbon that can be coated on the sand particles by thermal degradation. Carbon coated sand can be activated by chemical treatment like treating with concentrated acids.

Higher the concentration of sugar more will be the carbon to get coated on the surface of sand particles, thus more will be surface area of adsorption better is filtration efficiency. More the number of times the water is passed through sand bed more will be the adsorption.

Maximum efficiency of treatment is achieved in case of 15% sand when passed though 3times through it which is about 42% for TDS and 53% for COD. Minimum efficiency of treatment is achieved in case of 5% sand when passed through only once which about 23% for TDS and 35% for COD. pH of water sample decrease due to adsorption of alkalinity causing ions.

This treatment process can be used in place of conventional sand filtration process as it will have better efficiency of

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treatment. In place of slow sand filter this activated carbon coated sand bed can be used easily. But before that farther study in this is required which contains depth required, headless , working life of bed, best coating which should be applied, also the grain size distribution of sand particles.

Conflict of Interest: None

References

1. S S Gupta, Sreeprasad TS, Maliyekkal SM et al. "Graphene from Sugar and its application in Water Purification". *ACS Appl Mater Interfaces* 2012; 4: 4156-4163.
2. Pradeep T. Anshup. Noble metal nanoparticles for water purification: A critical review. *Thin Solid Films* 2009; 517(24), 6441−6478.
3. Gupta R. Kulkarni GU. *Removal of Organic Compounds from Water by Using a Gold Nanoparticle–Poly(dimethylsiloxane) Nanocomposite Foam*. *ChemSusChem* 2011; 4(6): 737−743.
4. Matheson LJ. Tratnyek PG. Reductive Dehalogenation of Chlorinated Methanes by Iron Metal. *Environ Sci Technol* 1994; 28(12): 2045−2053.
5. Bootharaju MS. Pradeep T. Understanding the Degradation Pathway of the Pesticide, Chlorpyrifos by Noble Metal Nanoparticles. *Langmuir* 2012; 28, 2671−2679.
6. Goyal M, Bhagat M, Dhawan RJ. Removal of mercury from water by fixed bed activated carbon columns. *Hazard J Hazard Mater* 2009, 171(1-3): 1009−1015.
7. Hager DG. Activated carbon used for large scale water treatment. *Environ Sci Technol* 1967; 1(4): 287−291.
8. Ghosh PK, Philip LJ. Performance Evaluation of Waste Activated Carbon on Atrazine Removal from Contaminated Water. *Environ Sci Health* 2005; 40(3): 425−441.
9. Zhang S, Xiao-yan L, Paul Chen J. Preparation and evaluation of a magnetite-doped activated carbon fiber for enhanced arsenic removal. *Carbon* 2010; 48(1): 60-7.
10. Novoselov KS, Geim AK, Morozov SV et al. Electric field effect in atomically thin carbon films. *Science* 2004; 306(5696): 666-9.
11. Goyal M, Bhagat M, Dhawan RJ. Removal of mercury from water by fixed bed activated carbon columns. *J Hazard Mater* 2009; 171: 1009-15.
12. Ghosh PK, Philip L. Performance evaluation of waste activated carbon on atrazine removal from contaminated water. *J Environ Sci Health* 2005; 40: 425-41.
13. Semião AJC, Schäfer AIJ. Removal of adsorbing estrogenic micropollutants by nanofiltration membranes. *Membr Sci* 2011; 381: 132-41.
14. Al-Rifai JH, Khabbaz H, Schäfer AI. Technol. Removal of pharmaceuticals and endocrine disrupting compounds in a water recycling process using reverse osmosis systems. *Separation and Purification Technology* 2011; 77: 60-7.
15. Ruan G, Sun Z, Peng Z et al. Growth of graphene from food, insects, and waste. *ACS Nano* 2011; 5(9): 7601-7.
16. Ruiz-Hitzky E, Darder M, Fernandes FM et al. Supported graphene from natural resources: easy preparation and applications. Adv Mater 2011; 23(44): 5250-5.
17. Van Oss CJ. A review of: active carbon. *Journal of Dispersion Science and Technology* 1990; 11(3).
18. Ahmadpour A, Do D. The preparation of active carbons from coal by chemical and physical activation. *Carbon* 1996; 34(4): 471-9.
19. Ehrburger P, Addoun A, Addoun F et al. Carbonization of coals in the presence of alkaline hydroxides and carbonates: formation of activated carbons. *Fuel* 1986; 65(10): 1447-9.
20. Hu Z, Vansant EF. Chemical activation of elutrilithe producing carbon-aluminosilicate composite adsorbent. *Carbon* 1995; 33(9): 1293-300.
21. Haimour NM, Emeish S. Utilization of date stones for production of activated carbon using phosphoric acid. *Waste Manag* 2006; 26(6): 651-60.
22. Metcalf & Eddy Inc, Tchobanoglous G, Burton FL et al. *Wastewater Engineering: Treatment and Resource Recovery*. McGraw-Hill Education, 2013.
23. Plappally AK, Yakub I, Brown LC et al. Physical properties of porous clay ceramic-ware. *J Eng Mater Technol* 2011, 133(3): 031004.
24. Puziy AM, Poddubnaya OI, Martinez-Alonso A et al. Synthetic carbons activated with phosphoric acid: I. Surface chemistry and ion binding properties. *Carbon* 2012; 40(9): 1493-505.
25. Philip ChA, Girgis BS. Adsorption capacities of activated carbons derived from rice. *J Chem Technol Biotechnol* 1996; 67: 248.
26. Rashwan WE, Girgis BE. Adsorption capacities of activated carbons derived from rice straw and water hyacinth in the removal of organic pollutants from water. *Adsorption Science and Technology* 2004; 22(3): 181-94.

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