

**A STUDY OF WATER TREATMENT EFFICIENCY OF ACTIVATED
CARBON COATED SAND**

THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE AWARD OF THE DEGREE OF

**MASTER OF TECHNOLOGY
IN
ENVIRONMENTAL ENGINEERING**

SUBMITTED BY

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JULY, 2018

CERTIFICATE

It is certified that the work presented in this report entitled “**A STUDY OF WATER TREATMENT EFFICIENCY OF ACTIVATED CARBON COATED SAND** ” by Ishan Sahajpal, Roll No. 2K16/ENE/011 in partial fulfillment of the requirement for the award of the degree of Master of Technology in Environmental Engineering, Delhi Technological University (Formerly Delhi College of Engineering), Delhi, is an authentic record. The work is being carried out by him under our guidance and supervision in the academic year 2018. This is to our knowledge has reached requisite standards.

The work embodied in this major project has not been submitted for the award of any other degree to the best of our knowledge.

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It is a matter of great pleasure for me to present my thesis report on “**A STUDY OF WATER TREATMENT EFFICIENCY OF ACTIVATED CARBON COATED SAND**”. First and foremost, I am profoundly grateful to my project guides Mrs Geeta Singh Assistant Professor of Environment Engineering Department for their expert guidance and continuous encouragement during all stages of this project. Their help in the form of valuable information and research thoughts at proper time has brought life in this project. I feel lucky to get an Opportunity to work with her. I am thankful to the kindness and generosity shown by them towards me, as it helped me morally to complete the project.

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DECLARATION

I, hereby declare that the work being presented in the Project Report entitled “**A STUDY OF WATER TREATMENT EFFICIENCY OF ACTIVATED CARBON COATED SAND**” is an original piece of work and an authentic report of our own work carried out during the period of 4th Semester as part of our major project.

The data presented in this report was generated & collected from various sources during the above said period and is being utilized by us for the submission of our Major Project Report to complete the requirements of Master’s Degree of Examination in Environmental Engineering, as per Delhi Technological University curriculum.

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TABLE OF CONTENT

CERTIFICATE.....	i
ACKNOWLEDGEMENT.....	ii
LIST OF FIGURES.....	vi
LIST OF ABBREVIATIONS.....	vii
ABSTRACT.....	vii
CHAPTER 1 : INTRODUCTION	1
1.1)GENERAL WATER PROBLEMS.....	1
1.2)WATER TREATMENT	2
1.3) WASTE WATER TREATMENT	3
1.4)WATER PURIFICATION USING SAND	3
1.5)WATER FILTRATION USING ACTIVATED CARBON	3
1.6)OBJECTIVES OF THE STUDY	3
CHAPTER 2 : LITRATURE REVIEW	5
2.1) ACTIVATED CARBON	5
2.2) PREPARATION OF ACTIVATED CARBON	5
2.2.1)PYROLYSIS.....	6
2.3)ACTIVATION.....	6
2.3.1)PHYSICAL ACTIVATION	6
2.3.2) CHEMICAL ACTIVATION.....	7
2.3.3) COMBINATION OF PHYSICAL AND CHEMICAL ACTIVATION.....	7
2.4) A REVIEW ON ACTIVATED CARBON PREPARATION USING CHEMICAL ACTIVATION	7
2.5) APPLICATION OF ACTIVATED CARBON	12
2.6) ADVANTAGES OF ADSORPTION OVER OTHER METHODS	12
2.7) ADSORPTION PROCESS	13
2.8) ADSORBENT	13
2.9)TECHNIQUES OF FILTRATION.....	14
2.9.1)FILTRATION	14
2.10)ACTIVATED CHARCOAL ADSORPTION.....	15
2.11)METHOD OF ACTION	16
2.12) COST CONSIDERATIONS.....	19
2.13)OPERATION AND MAINTENANCE.....	20
2.14)APPLICABILITY	20
CHAPTER 3 :METHODOLOGY	21
3.1) MATERIALS	21

3.1.1) PREPARATION OF SAND	21
3.1.2) PREPARATION OF SUGAR SOLUTION.....	21
3.2) CARBON COATING OF SAND.....	22
3.3) SAND ACTIVATION.....	23
3.4) WATER SAMPLING	24
3.5) SAND BED PREPARATION.....	24
3.6) WATER FILTRATION	25
3.7) WATER SAMPLE TESTING	26
3.7.1) TDS TEST	27
3.7.2) COD TEST.....	28
CHAPTER 4 :RESULT AND DISCUSSION	30
4.1) 5% SAND RESULTS.....	30
4.1.1)TDS REDUCTION	30
4.1.2)pH CORRECTION	31
4.1.3)COD REDUCTION.....	32
4.2) 10% SAND RESULTS.....	33
4.2.1)TDS REDUCTION	33
4.2.2)pH CORRECTION	34
4.2.3)COD REDUCTION	35
4.3)15% SAND RESULTS.....	36
4.3.1)TDS REDUCTION	36
4.3.2)pH CORRECTION	37
4.3.3)COD REDUCTION	38
4.4) COMPARISON OF EFFICIENCIES.	39
4.4.1)TDS REMOVAL EFFICIENCIES.	39
4.4.2)COD REMOVAL EFFICIENCIES.	40
CHAPTER 5 :CONCLUSION	41
REFRENCES	42

LIST OF FIGURES

FIGURE 1.1 : WATER TREATMENT FLOW CHART	02
FIGURE 3.1 : WEIGHED SAND AND SUGAR SAMPLE	21
FIGURE 3.2 : COOKING OF SAND WITH SUGAR SOLUTION ON HEATER	23
FIGURE 3.3 : CONC. ACID ADDED TO SAND	23
FIGURE 3.4 : PVC PIPES FILLED WITH DIFFERENT % SAND FILTERING WATER	24
FIGURE 3.5 : WATER SAMPLES AFTER FILTERING OUT WATER FROM DIFFERENT BEDS	25
FIGURE3.6 : TDS MEASURING INSTRUMENT	26
FIGURE3.7 : PH MEASURING INSTRUMENT	28
FIGURE 4.1 : TDS REDUCTION BY 5% SAND	29
FIGURE 4.2: REDUCTION OF PH WHEN PASSED THROUGH 5% SAND	30
FIGURE 4.3:REDUCTION OF COD OF WATER WHEN PASSED THROUGH 5% SAND	31
FIGURE 4.4 : TDS REDUCTION BY 10% SAND	32
FIGURE 4.5: REDUCTION OF PH WHEN PASSED THROUGH 10% SAND	33
FIGURE4.6:REDUCTION OF COD OF WATER WHEN PASSED THROUGH 10% SAND-	34
FIGURE 4.7 : TDS REDUCTION BY 15% SAND	35
FIGURE 4.8: REDUCTION OF PH WHEN PASSED THROUGH 15% SAND	36
FIGURE4.9: EDUCTION OF COD OF WATER WHEN PASSED THROUGH 15% SAND-	37
FIGURE 4.10 : TDS REMOVAL EFFICIENCIES OF DIFFERENT SAND TYPE	38
FIGURE 4.11 : COD REMOVAL EFFICIENCIES OF DIFFERENT SAND	39

LIST OF ABRIVATIONS

WHO	WORLD HEALTH ORGANIZATION
IMD	INDIAN METROLOGICAL DEPARTMENT
BIS	BUREAU OF INDIAN STANDARDS
LPM	LITER PER MINUTE
WQI	WATER QUALITY INDEX
TDS	TOTAL DISSOLVED SOLIDS
COD	CHEMICAL OXYGEN DEMAND
BOD	BIO-CHEMICAL OXYGEN DEMAND

CHAPTER 1 : INTRODUCTION

The depleting amount of water resource is a major concern most of the major cities in the world are dealing with the problem of lack of clean fresh water, it is said to be the most severe problem of our generation. This condition is reached by continuous unchecked depletion of fresh water and lack of recharge which will make the effect irreversible eventually. Like the unchecked use of ground water and its slow recharge have lead to the permanent lowering of water table. This will have negative impact on environment on earth. It is said that almost one third of the world population is living in water scarcity for a period of not less than month .

Apart from the problem of availability of water there is problem of availability of clean water, most of the developing countries are facing this problem . Almost half of the world's population did not have access to safe drinking water.

1.1) General Water Problems

There are many entangled problems related to water crises

- Availability of clean and safe water.
- Inadequate sanitation leading to diseases outbreak.
- Ground water depletion.
- Reduction in agricultural yield.

Water borne diseases are the major cause of most of diseases outbreak thus safe water is a necessity. Mostly of infants under the age of 5 require very safe drinking water as they can catch diseases very easily.

India being in a geographically beneficial location as the tropic of cancer the amount of rainfall in India is fairly good which is about 120 centimeters annually. Also due to presence of Himalayan mountains in the north will feed some of the perennial rivers of the region like Ganga and Yamuna which are the life line of most of the northern regions of India. In India currently only about 6% of rainfall water is stored which should be increased specially in the aired regions where water is available only during the monsoon period of the year.

Due to lack of water management and careless and unchecked over exploitation of water sources there become condition of scarcity of safe water. Many industries that are setup by the side of river banks emit wastes which if not taken care of immediately will mix with river water leading to its contamination.

1.2) Water Treatment

Water that is consumed in day to day life is extracted from water source which might be from river or from ground water but before it reaches the consumer it is first made safe for use by water treatment done by water treatment plants.

In water treatment various chemical and physical processes are applied to remove the impurities of water , and made it safe for consumption. Typical treatment processes

- Screening .
- Sedimentation , Coagulation flocculation.
- Sand filtration.
- Softening .
- Disinfection.

Some industries require even more clean water for that few more processes are included.

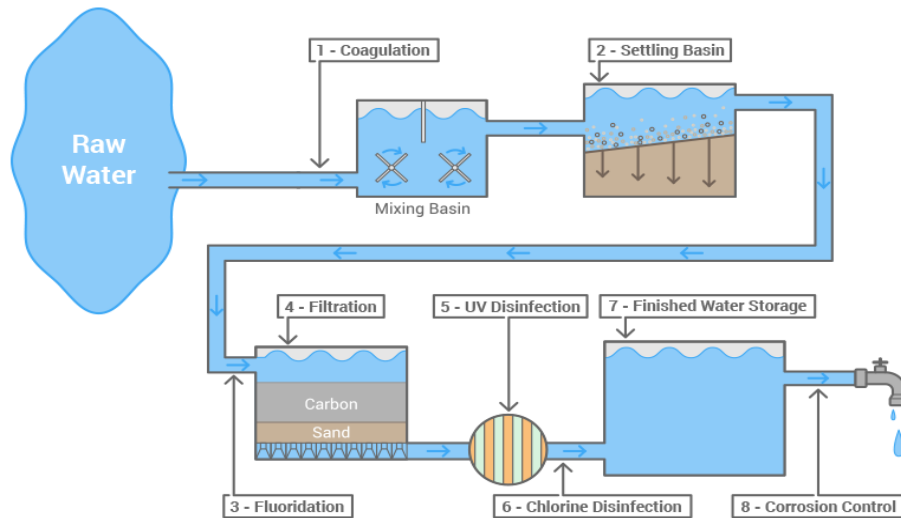


Figure 1.1 : Water treatment flow chart.

Source : WHO water treatment report 2009

1.3) Waste Water Treatment

Waste water should also be treated before it is disposed off so that it would not harm the receiving body. Major problem with waste water is the presence of high concentration of organic both dissolved and settleable form. In most of the waste water treatment the water is seeded with active micro-organisms and allowed to degrade and consume this organic matter and the biomass formed as a result can be removed from water. Thus the water recovered can be safely disposed.

1.4) Water Purification using Sand

Sand bed are used to filter water for a very long time two basic sand bed used are Slow Sand filter and Rapid Sand Filter. In slow sand filters fine sand is used to filter water and remove very fine particles and organics if present, where as in rapid gravity filter the sand used is slightly coarser thus the filtration rate is some what 40 times faster but filtration efficiency is less. Water cleaned by coagulation flocculation is not filtered with slow sand filter.

1.5) Water filtration using Activated Carbon

Activated Carbon have high surface area and thus have the property of surface adsorption thus the fine particles causing colloidal effect in the water sample and also the organics present in the water. It is specially used in removing color and odor from the water. Trace amount of toxic chemicals will also be removed.

Activated Carbon based filters are used in various compact water filtration units specially in places where other huge treatment cannot be provided also in case of emergencies which AC membrane along with Chlorination can be used for easy fast clean water.

1.6) Objectives of the Study

1. First objective is to make carbon coated sand with different concentrations of sugar solution which is further activated and used to filter water samples.

2. The parameters of water sample considered are

- TDS (total dissolved solids)
- pH
- COD (Chemical oxygen demand)

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

CHAPTER 2 : LITRATURE REVIEW

2.1) Activated Carbon

Activated carbon also called activated charcoal, is a form of carbon that has been processed with oxygen to create millions of tiny pores between the carbon atoms. Commercial activated carbons have internal surface area ranging from 500 to 1500 m²/g. Activated carbon can be prepared from feedstock with high carbon and low inorganic content. The most common feed stocks used for the production of activated carbon are wood, coconut shell, bituminous coal, peat etc. The chars obtained from them could be activated easily to produce reasonably high quality activated carbons. During the activation process, the unique internal pore structure is created, which provides the activated carbon its outstanding adsorptive properties. Activated carbons have a number of unique characteristics such as large internal surface area, chemical properties and good accessibility of internal pores. According to IUPAC definitions three groups of pores can be identified.

1. Macropores (above 50nm diameter)
2. Mesopores (2-50 nm diameter)
3. Micropores (Under 2 nm diameter)

Micropores generally contribute to a major part of the internal surface area. Macro and micropores can generally be regarded as the highways into the carbon particle, and are crucial for kinetics. The desirous pore structure of an activated carbon product is attained by combining the right raw material and suitable activation procedure.

2.2) Preparation of Activated Carbon

Most carbonaceous substances can be converted into activated carbon, the final properties of the carbon will depend significantly on the nature of the starting material. A large number of processes for making activated carbons have been developed over the past century. However, most processes consist of the pyrolysis of the starting material, followed by a stage of controlled oxidation or vice versa. The purpose of the oxidation stage is to activate the carbon.

2.2.1)Pyrolysis

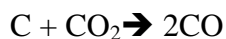
Pyrolysis step (or also called as Carbonization) involves heating the source materials to temperatures ranging between 600 to 900°C in the absence of air (Cooney 1999). This process is to eliminate most of the non-carbon elements such as hydrogen, nitrogen, oxygen and sulphur as volatile gaseous products. Low molecular weight volatiles are first released, followed by light aromatics and finally the hydrogen gas, the resultant product being a fixed carbonaceous char. The residual carbon atoms are grouped into condensed sheets of aromatic ring with a cross-linked structure in a random manner. The mutual arrangement of these aromatic sheets is irregular and leaves free interstices between the sheets, which may be filled with the tarry materials. To remove these tarry materials, activation process is carried out. It also enlarges the diameters of the pores, which were created during the carbonization process and creating new porosity (Smisek&Cerny 1970).

2.3)Activation

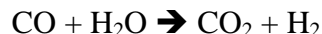
The basic characteristics of a carbon are established during the pyrolysis, and the ensuing oxidation step must be designed to complement the pyrolysis step. During this step, the oxidising agent increasingly erodes the internal surfaces of the carbon, develops an extensive and fine network of pores 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.

2.3.1) Physical activation

Physical activation or partial gasification is generally carried out at elevated temperatures between 750 and 1100 C using oxidants such as steam, carbon dioxide, air or mixture of these gases. Chlorine, sulphur vapours ,sulphur dioxide, ammonia and a number of other substances having activation effects are rarely used. Gasification of the carbonized material with steam and carbon dioxide occurs by the following endothermic reactions:



The reaction of steam with carbon is accompanied by the water gas formation reaction, which is catalyzed by the carbon surface as,



Since the reaction of carbon with steam and with carbon dioxide is both endothermic, external heating is required to drive the reactions and to maintain the reaction temperature. The activation process can be manipulated to produce products of desired characteristics. Activation temperature, steam and CO₂ flow rates control the pore development, which in turn affect pore size distributions and the level of activity of the activated carbon.

2.3.2) Chemical activation

Chemical activation is usually carried out by impregnating the raw or pre-carbonized material with an activating agent and pyrolyzed between 400 and 800 °C in the absence of oxygen. The most commonly used activating agents are phosphoric acid, hydrochloric acid, sulphuric acid, alkalis namely KOH and NaOH, zinc chloride and alkaline metal compounds. Phosphoric acid and zinc chloride are used for the activation of lignocellulosic materials. Phosphoric acid is the most preferred activating agent because of its low environmental impact when compared to zinc chloride. The resultant activated carbon is washed, dried till constant weight is obtained and ground to required size. Activated carbons produced by chemical activation generally exhibit a very open structure and bottle shaped, ideal for the adsorption of large molecules.

2.3.3) Combination of physical and chemical activation

A combination of physical and chemical activation can be used to prepare granular activated carbons with a very high surface area and porosity adequate for certain specific applications such as gasoline vapour control, gas storage, etc. Activated carbons of this types have been reported using ligno cellulosic precursors chemically activated with phosphoric acid and zinc chloride and later activated under a flow of carbon dioxide. Uniform, medium-size microporosity and surface areas above 3600 m²/g are obtained with this mixed procedure (Bansal 1988).

2.4) A review on Activated Carbon Preparation using chemical activation.

The term chemical activation refers to the treatment of the precursor with an activating agent used for restricting tar formation during the thermal step. During thermal treatment, chemical activating agents such as phosphoric acid and zinc chloride among others, provoke carbonization of the precursor by dehydration, depolymerisation and redistribution of biopolymers and cross linking of lignocellulosic materials (Jagtoyen and Derbyshire 1998). Several coals (Ehrburger et al 1986, Ahmad pour & Do 1996, Teng et al 1998, Lozano et al 2001), polymers (Park & Jung 2002, Puziy et al 2002), and some agricultural by-products and forest wastes (Savova et al 2001, Garcia et al 2003, Villegas et al 1993) have been used as raw materials to prepare activated carbon.

Phosphoric acid activation has been used for a wide variety of cellulosic precursors such as coconut shells (Laine et al 1989), white oak (Jagtoyen & Derbyshire 1993), peach stones (Monlina et al 1996), nut shells (Toles et al 1998), cotton stalks (Girgis & Ishak 1999), almond shells (Bevia et al 1984, Toles et al 2000), pecan shells (Dastgheib & Rockstraw 2001), Arundo donax cane (Vernerson et al 2002) and apple pulp (Garcia et al 2002), peanut hull (Girgis et al 2002) and sugarcane bagasse (Girgis et al 1994, Ahmedna et al 2000).

Ruiz et al (1984) prepared activated carbon from almond shell using various activating agents like H_3PO_4 , ZnCl_2 , K_2CO_3 and Na_2CO_3 at 700°C under N_2 flow. Of the different activating reagents studied, zinc chloride gave the highest surface area of $2111\text{ m}^2/\text{g}$. The surface area was drastically reduced to $700\text{ m}^2/\text{g}$ for carbonization of ammonium chloride impregnated almond and hazelnut shell in the flow of N_2 at 700°C (Balci et al 1994). A good BET surface area activated carbon was reported ($1071\text{ m}^2/\text{g}$) at lower activation temperature (500°C) using pecan shell in the presence of air and phosphoric acid (Dastgheib & Rockshaw 2001). Series of activated carbons from almond, olive and peach stones chars by direct chemical activation with zinc chloride at 800°C yielded a wide range of pore size distribution (Rodriguez & Molina 1992). Hu & Vansant (1995) reported a similar wide range of pore size distribution of activated carbon from walnut shell char using potassium hydroxide in the absence of air at $500\text{-}900^\circ\text{C}$. They found that higher temperatures, longer activation times and larger amounts of potassium hydroxide favoured high adsorption capacity and wide pore size distribution.

Philip & Girgis (1996) produced activated carbon from apricot stones using phosphoric acid which yielded high surface area and microporous structure. Activated carbon produced from palm oil shell, coconut shell, almond, hazelnut, walnut shell, pistachio nut and apricot stones using K_2CO_3 (Hayashiet al 2002) at $900^\circ C$ and $ZnCl_2$ (Aygün et al 2003) under N_2 flow at $750^\circ C$, yielded high surface area and well-developed micropore structure respectively. A similar well-developed microporous structure with very small proportion of mesoporous network was obtained by the activation of peach stones using phosphoric acid. These have been further activated in a CO_2 gas flow at $825^\circ C$ for various range of burn-off (Molina et al 1995, 1996).

Phosphoric acid, potassium hydroxide and zinc chloride were used as activating agents for various nutshell species. Girgis et al (2002) and Guo & Lua (2000) produced activated carbon from peanut hull and oil palm stones using all three agents and activated at 500 and 650 C respectively. They reported that zinc chloride and phosphoric acid activation yielded essentially microporous network whereas the use of potassium hydroxide gave well developed mesoporous activated carbon.

Production of activated carbon from biological sludge (Martin et al 2002) and sewage sludge (Rozada et al 2003) by chemical activation using phosphoric acid at $700^\circ C$ for 30 min yielded mesoporous network with certain percentage of macropores. Preparation of activated carbon from cork waste using potassium hydroxide at $800^\circ C$ for 2h yielded surface area of $1415\text{ m}^2/\text{g}$ (Carvalho et al 2003) .

Srinivasa kannan et al (2004) carried out a two-stage process for the preparation of activated carbon from rubber wood saw dust. The two-stage process with semi-carbonization up to $200^\circ C$ for 15 min followed by activation at 400 and $500^\circ C$ for 30, 45, 60 and 90 min. Phosphoric acid was used as an activating agent with various impregnation ratio (dry wt. of H_3PO_4 /dry wt. of rubber wood saw dust) of 1, 1.5, and 2. At the optimal conditions of activation, activated carbon with iodine number and surface area of $1096\text{ m}^2/\text{g}$ and $1496\text{ m}^2/\text{g}$ respectively were obtained.

Corcho et al (2006) prepared activated carbon from vineyard shoot using phosphoric acid as the activating agent. They found the activated carbons porosity was better when the raw material was impregnated and heated at intermediate temperatures.

Haimour & Emeish (2006) reported phosphoric acid activated date pit carbon, the iodine number increased with increasing activation temperature. Impregnation increases caused an oscillation in the iodine number.

Senthilkumaar et al (2006a) prepared activated carbon from male flowers of coconut tree and jute fibre using 15% phosphoric acid in the ratio 1:3. They found a porosity of 72.36% and 76.14%, surface area of 328 and 680 m²/g and pH zpc of 6.23 and 4.56 for coconut flower carbon and jute fibre carbon respectively indicating that the fibrous materials gave a higher surface area than the other cellulosic materials. The porosity of the carbon varied based on the activating agent, activated carbon prepared from coconut male flower using phosphoric acid and sulphuric acid (Senthilkumaar et al 2006b) yielded carbons with 72.36% and 65% porosity respectively.

Baccar et al (2009) prepared activated carbon from olive-waste cake using phosphoric acid as a activating agent, carbon preparation parameters such as concentration of the activating agent, impregnation ratio and activation time were optimized. They found the surface area of the sorbent increased rapidly from 716 to 1020 m²/g with an increase of acid concentration from 35 to 65% phosphoric acid, and further increase in the acid concentration (85%) did not show an appreciable increase in the surface area.

Chan et al (2009) prepared activated carbon from bamboo wastes by folding using phosphoric acid. They found the surface area up to 2500 m²/g of the activated carbon increased with impregnation ratio (2.4) and activation temperature (400 or 600°C).

Lim et al (2010) prepared activated carbon from palm shells by phosphoric acid impregnation. They prepared carbon at low activation temperature (425°C) and activation time (30 min), while varying the impregnation ratio of phosphoric acid from 0.5 to 3. The yield of activated carbon was not vary with the impregnation ratio and was found to be about 50%. The textural characteristics were found to improve with increase in the impregnation ratio, up to 2 and further increase in IR the textural character decreased. The BET surface area of activated carbon corresponding to an impregnation ratio of 3, with an iodine number of 1035 m²/g was found to be 1109 m²/g with a pore volume of 0.903 cm³/g and an average pore diameter of 3.2 nm. The textural characteristics of activated carbon reveal that the poresize is widely distributed with the contribution of micropores around 50%.

Fabiana et al (2010) prepared activated carbon from piassava fibres using chemical activation with zinc chloride and phosphoric acid and physical activation with carbon dioxide or water vapour. Zinc chloride gave the highest surface area of 1190 m²/g and phosphoric acid activated carbon gave largest pore volume of 0.543 cm³/g.

Li et al (2010) reported that activated carbon prepared from *Polygonum orientale* Linn by phosphoric acid activation gave a surface area of 1398 m²/g.

Bhari et al (2012) prepared activated carbon from grape seeds using chemical activation with phosphoric acid. Grape seeds were pre-treated with sulfuric acid to improve its wettability. Microporous activated carbons with some contribution of mesoporosity were obtained. The best results in terms of surface area (1139 m²/g) and mesopore volume (0.24 cm³/g) development were observed for a grape seeds to phosphoric acid ratio of 1:3 and a carbonization temperature of 500°C. They found the activated carbon morphology had an egg shell structure that favored applications in liquid phase.

Mohamad & Paul (2012) studied the pore characteristics of activated carbons obtained from the phosphoric acid activation of cotton stalks. They concluded that the textural characteristics of the derived activated carbons were found to be strongly dependent on the impregnation ratio and activation temperature. The mesopore volume attained a maximum value (0.61 cm³/g) in the case of activated carbons produced at the highest impregnation ratio and activation temperature.

Aghdas et al (2014) revealed the impregnation ratio of the activating agent highly influenced the surface area and the porosity development during activated carbon preparation. They prepared highly microporous activated carbon from *Eucalyptus camaldulensis* wood by chemical activation with H₃PO₄, ZnCl₂ at different impregnation ratios as well as by pyrolysis, followed by activation with KOH. Varying the H₃PO₄/biomass ratio from 1.5 to 2.5, the prepared activated carbon displayed BET surface areas in the range of 1875–2117 m²/g with micropores content of 69–97%. For the ZnCl₂ activated carbon, BET surface areas varied from 1274.8 to 2107.9 m²/g with micropores content of 93–100% for impregnation ratios of 0.75–2.0. The activated carbon obtained by KOH activation had the largest BET surface area of 2594 m²/g and a high micropore of 98%. From the above they found that the activating agent and its concentration strongly influenced the textural characteristics of the eucalyptus wood based activated carbon.

Alicia et al (2014) studied the influence of activation atmosphere used in the chemical activation of almond shell on the carbon characteristics. They found activated carbons prepared at low and intermediate impregnation ratios showed higher yields. This could be attributed to the decomposition of the polymeric structures of the activated carbons during the activation stage that release most elements different from carbon (N, H and O). Activating agent employed permits the dehydration, depolymerization and redistribution of the constituent polymers, and the

conversion of aliphatic groups to aromatics, increasing the yield of the activated carbons. Higher impregnation ratios produce a higher elimination of tars of the pores decreasing the yield.

However, there are only a few publications reporting the preparation of activated carbon from Agave sisalana fibre (Sisal fiber) and Puning agranatum Peel (Pomegranate Peel) using phosphoric acid as activating agent. One can design activated carbon for adsorption of specific adsorbate, using approximate precursor and by optimizing the activation process conditions. Cost effectiveness, cheap availability, higher adsorbate loading capacity, relatively high surface area and high binding affinity were the main criteria for choosing activated carbons to remove dyes from aqueous solution. Taking this criteria into consideration, the present study was carried out to determine the feasibility of using the relatively common, cheap and thrown away waste Agave sisalana fibre (Sisal fiber) and Puning agranatum Peel to prepare highly effective carbon with a large surface area. These carbons were prepared using phosphoric acid as the impregnating agent by chemical activation method followed by their characterization, for the adsorption of reactive dye, acid dye and basic dye from aqueous solutions and effluent, the studies being carried out in both batch and column mode.

2.5) Application of Activated Carbon

Activated carbon is a unique and effective agent for purification and isolation and recovery of trace material. During the last three decades, treatment with active carbon has become an important unit process for separation and purification in wide range of industries. The various applications can be broadly divided into two categories,

- (i) liquid-phase applications
- (ii) gas-phase applications.

2.6) Advantages of adsorption over other methods

Colour in dye house effluents has always been a difficult problem to solve and the utilization of dyes has made it even more serious. Cooper (1993) summarized the technologies used until then in order to remove or atleast reduce colour, mentioning that some them have certain efficiency:

Coagulation and/or flocculation, membrane technologies, chemical oxidation technologies, biochemical oxidation and adsorbent utilization. Among various treatment technologies, adsorption onto activated carbon has proven to be one of the most effective and reliable physicochemical treatment methodology (McKay 1996, Sankar et al 1993).

Ramesh et al (2007) reviewed the advantages and disadvantages of various treatment techniques. The adsorption process has an edge over the other treatment methods due to its sludge free operation, and complete removal of dyes even from dilute solutions. The wide usefulness of activated carbon is a result of its chemical and mechanical stability, high adsorption capacity and high degree of surface reactivity (Malik 2003).

Cost effectiveness and adsorption properties are the main criteria for choosing an adsorption process to remove dyes from aqueous solution. Adsorption process has higher selectivity. Adsorption based process offer a more reliable and highly efficient in the removal of complex structure dyes than many other conventional treatment methods.

The adsorption process achieves higher removal levels in a wide range of solution conditions and generally reduces the quantity of sludge or solid residuals that need to be disposed (Smith 1996). The adsorption phenomenon has still been found to be economically appealing for the removal of toxic dyes from textile effluents by choosing adsorbents under optimum operating conditions. Therefore, the adsorption process is reported to be the best method for removal of textile dyes.

2.7) Adsorption process

Adsorption (Slejko 1985, Suzuki 1990, Noll et al 1992) involves the preferential partitioning of substances from the gaseous or the liquid phase accompanied by its accumulation or concentration onto the surface of a solid substrate. The adsorbing phase is the adsorbent, and the material concentrated or adsorbed at the surface of that phase is the adsorbate.

2.8) Adsorbent

Adsorbents (Noll et al 1992, Oscik et al 1982) are porous materials that contain many miniscule internal pores. The most common industrial adsorbents are activated carbon, silica gel and activated alumina, because they present enormous surface areas per unit weight. Activated carbon is produced by thermal degradation of organic material to decompose it to granules of carbon. Agro waste and animal waste are the common source. Typical surface area are as are 300 to 1500 m²/g. Silica gel is a matrix of hydrated silicon dioxide. Silica is used to separate hydrocarbons. Typical surface areas are 300 to 900 m²/g. Activated alumina are commonly used to remove oxygenates and mercaptans from hydrocarbons and fluorides from water. Typical surface areas are 200 to 400 m²/g. The adsorbent such as zeolite, carbon molecular sieve, bone

char, iron and manganese coated sand, kaolinite clay, hydrated ferric oxide, activated bauxite, titanium oxide, silicium oxide and other synthetic media are also widely used. Activated carbons are known as very effective adsorbents due to their highly developed porosity, large surface area, variable characteristics of surface chemistry, and high degree of surface reactivity (Bansal et al 1988).

However, due to high production cost, these materials tend to be more expensive than other adsorbents. Currently there are many studies on the development of low-cost adsorbents, namely by using waste materials for that purpose.

Activated carbon production costs can be reduced by either choosing a cheap raw material or by applying a proper production method(Lafi 2001); nevertheless, it is still a challenge to prepare activated carbon with very specific characteristics, such as a given pore size distribution, and using low-cost raw materials processed at low temperature (less energy cost)(Sudaryanto et al 2006). Therefore, it is of extreme relevance to find suitable low-cost raw materials that are economically attractive from the point of view of their contribution to decrease the costs of waste disposal, therefore helping environmental protection (Joana et al 2007).

2.9) Techniques of filtration

Not all techniques by themselves will mitigate all hazards. Although flocculation followed by filtration has been suggested as best practice^l this is rarely practicable without the ability to carefully control pH and settling conditions. Ill-advised use of alum as a flocculant can lead to unacceptable levels of aluminium in the water so treated. If water is to be stored, halogens offer extended protection.

2.9.1) Filtration

Portable pump filters are commercially available with ceramic filters that filter 5,000 to 50,000 litres per cartridge, removing pathogens down to the 0.2–0.3 micrometer (μm) range. Some also utilize activated charcoal filtering. Most filters of this kind remove most bacteria and protozoa, such as *Cryptosporidium* and *Giardia lamblia*, but not viruses except for the very largest of 0.3 μm and larger diameters, so disinfection by chemicals or ultraviolet light is still required after filtration. It is worth noting that not all bacteria are removed by 0.2 μm pump filters; for example, strands of thread-like *Leptospira spp.* (which can cause leptospirosis) are thin enough

to pass through a 0.2 μm filter. Effective chemical additives to address shortcomings in pump filters include chlorine, chlorine dioxide, iodine, and sodium hypochlorite (bleach). There have been polymer and ceramic filters on the market that incorporated iodine post-treatment in their filter elements to kill viruses and the smaller bacteria that cannot be filtered out, but most have disappeared due to the unpleasant taste imparted to the water, as well as possible adverse health effects when iodine is ingested over protracted periods.

While the filtration elements may do an excellent job of removing most bacteria and fungi contaminants from drinking water when new, the elements themselves can become colonization sites. In recent years some filters have been enhanced by bonding silver metal nanoparticles to the ceramic element and/or to the activated charcoal to suppress growth of pathogens.

Small, hand-pumped reverse osmosis filters were originally developed for the military in the late 1980s for use as survival equipment, for example, to be included with inflatable rafts on aircraft. Civilian versions are available. Instead of using the static pressure of a water supply line to force the water through the filter, pressure is provided by a hand-operated pump, similar in function and appearance to a mechanic's grease gun. These devices can generate drinkable water from seawater.

The Portable Aqua Unit for Lifesaving (short PAUL) is a portable ultrafiltration-based membrane water filter for humanitarian aid. It allows the decentralized supply of clean water in emergency and disaster situations for about 400 persons per unit per day. The filter is designed to function with neither chemicals nor energy nor trained personnel.

2.10) Activated charcoal adsorption

Granular activated carbon filtering utilizes a form of activated carbon with a high surface area, and adsorbs many compounds, including many toxic compounds. Water passing through activated carbon is commonly used in concert with hand pumped filters to address organic contamination, taste, or objectionable odors. Activated carbon filters aren't usually used as the primary purification techniques of portable water purification devices, but rather as secondary means to complement another purification technique. It is most commonly implemented for pre- or post-filtering, in a separate step than ceramic filtering, in either case being implemented prior to the addition of chemical disinfectants used to control bacteria or viruses that filters cannot remove. Activated charcoal can remove chlorine from treated water, removing any residual

protection remaining in the water protecting against pathogens, and should not, in general, be used without careful thought after chemical disinfection treatments in portable water purification processing. Ceramic/Carbon Core filters with a 0.5 µm or smaller pore size are excellent for removing bacteria and cysts while also removing chemicals.

2.11) Method of Action

As with most filtration methods, water is carefully introduced to one side of the filter, which acts to block the passage of anything larger than the pore size.^[1] Typically bacteria, protozoa, and microbial cysts are removed but the filters are not effective against viruses since they are small enough to pass through to the other "clean" side of the filter. Ceramic water filters (CWF) may be treated with silver in a form that will not leach away. The silver helps to kill or incapacitate bacteria and prevent the growth of mold and algae in the body of the filter.

Ceramic filtration does not remove chemical contaminants per se. However, some manufacturers (especially of ceramic candle filters) incorporate a high-performance activated carbon core inside the ceramic filter cartridge that reduces organic and metallic contaminants. The active carbon absorbs compounds such as chlorine. Filters with active carbon need to be replaced periodically because the carbon becomes clogged with foreign material.

The two most common types of ceramic water filter are pot type and candle type filters. Ceramic filter systems consist of a porous ceramic filter that is attached to, or sits on top of a plastic or ceramic receptacle. Contaminated water is poured into a top container. It passes through the filter(s) into the receptacle below. The lower receptacle usually is fitted with a tap.

Contaminants larger than the minute holes of the ceramic structure will remain in the top half of the unit. The filter(s) can be cleaned by brushing them with a soft brush and rinsing them with clean water. Hot water and soap can also be used.

In stationary use, ceramic candles have mechanical, operational and manufacturing advantages over simple inserts and pots. Filter candles allow sturdy metal and plastic receptacles to be used, which decreases the likelihood of a sanitary failure. Since their filter area is independent of the size of the attachment joint, there is less leakage than other geometries of replaceable filter, and more-expensive, higher-quality gaskets can be used. Since they are protected by the upper receptacle, rather than forming it, they are less likely to be damaged in ordinary use. They are

easier to sanitize, because the sanitary side is inside the candle. The nonsanitary part is outside, where it is easy to clean. They fit more types of receptacles and applications than simple pots, and attach to a simple hole in a receptacle. They also can be replaced without replacing the entire upper receptacle, and larger receptacles can simply use more filter candles, permitting filter manufacture to be standardized. If a filter in a multifilter receptacle is found to be broken, the filter hole can be plugged, and use can continue with fewer filters and a longer refill-time until a replacement can be obtained. Also, standardizing the filter makes it economical to keep one or a few filters on hand.

There are also portable ceramic filters, such as the MSR Miniworks, which work via manual pumping, and in-line ceramic filters, which filters drinking water that comes through household plumbing. Cleaning these filters is the same as with the clay pot filter but also allows for reverse-flow cleaning, wherein clean water is forced through the filter backwards, pushing any contaminants out of the ceramic pores.

The major risks to the success of all forms of ceramic filtration are hairline cracks and cross-contamination. If the unit is dropped or otherwise abused, the brittle nature of ceramic materials can allow fine, hard to see cracks, and can allow larger contaminants through the filter. Work is being done to modify clay/sawdust ratios during manufacture to improve the brittle nature and fracture toughness of these clay ceramic water filter materials.^[2] Also, if the "clean" water side of the ceramic membrane is brought into contact with dirty water, hands, cleaning cloths, etc., then the filtration will be ineffective. If such contact occurs, the clean side of the filter should be thoroughly sterilized before reuse.

Activated carbon filtration is a commonly used technology based on the adsorption of contaminants onto the surface of a filter. This method is effective in removing certain organics (such as unwanted taste and odours, micropollutants), chlorine, fluorine or radon from drinking water or wastewater. However, it is not effective for microbial contaminants, metals, nitrates and other inorganic contaminants. The adsorption efficiency depends on the nature of activated carbon used, the water composition, and operating parameters. There are many types of activated carbon filters that can be designed for household, community and industry requirements. Activated carbon filters are relatively easy to install but require energy and skilled labour and can have high costs due to regular replacement of the filter material.

The use of carbon in the form of charcoal has been used since antiquity for many applications. In Hindu documents dating from 450 BC charcoal filters are mentioned for the treatment of water. Charred wood, bones and coconut charcoals were used during the 18th and 19th century by the sugar industry for decolourising solutions (CECEN 2011). Activated carbon is a material prepared in such a way that it exhibits a high degree of porosity and an extended surface area.

During water filtration through activated carbon, contaminants adhere to the surface of these carbon granules or become trapped in the small pores of the activated carbon (AMIRAULT et al. 2003). This process is called adsorption. Activated carbon filters are efficient to remove certain organics (such as unwanted taste and odours, micropollutants), chlorine, fluorine or radon, from drinking water or wastewater. However, it is not effective for microbial contaminants, metals, nitrates and other inorganic contaminants. Activated carbon filtration is commonly used in centralised treatment plants and at household level, to produce drinking water and in industries to treat effluents. It is also an upcoming treatment applied for the removal of micropollutants both in drinking water production and for the purification of treated wastewater before disposal (see also surface disposal or surface and subsurface groundwater recharge).

There are two basic types of water filters: particulate filters and adsorptive/reactive filters. Particulate filters exclude particles by size, and adsorptive/reactive filters contain a material (medium) that either adsorbs or reacts with a contaminant in water. The principles of adsorptive activated carbon filtration are the same as those of any other adsorption material. The contaminant is attracted to and held (adsorbed) on the surface of the carbon particles. The characteristics of the carbon material (particle and pore size, surface area, surface chemistry, etc.) influence the efficiency of adsorption.

The characteristics of the chemical contaminant are also important. Compounds that are less water-soluble are more likely to be adsorbed to a solid. A second characteristic is the affinity that a given contaminant has with the carbon surface. This affinity depends on the charge and is higher for molecules possessing less charge. If several compounds are present in the water, strong adsorbers will attach to the carbon in greater quantity than those with weak adsorbing ability.

The medium for an activated carbon filter is typically petroleum coke, bituminous coal, lignite, wood products, coconut shell or peanut shell. The carbon medium is “activated” by subjecting it to steam (a gas like water, argon or nitrogen) and high temperature (800-1000°C) usually without oxygen. In some cases, the carbon may also undergo an acidic wash or be coated with a compound to enhance the removal of specific contaminants. The activation produces carbon with many pores and a high specific surface area. It is then crushed to produce a granular or pulverised carbon product.

Activated carbon units are commonly used to remove organics (odours, micropollutants) from drinking water at centralised and decentralised level. At centralised level, they are generally part of one of the last steps, before the water is fed into the water distribution network. At decentralised level, activated carbon filtration units can either be point-of-use (POU) or point-of-entry (POE) treatment. A POE device is recommended for the treatment of radon and volatile organic compounds because these contaminants can easily vaporise from water in showers or washing machines and expose users to health hazards. POU devices are useful for the removal of lead and chlorine. The structure of POU devices can either be in-line, line-bypass faucet mounted (see also advanced filters) or pour-through (similar to the design of ceramic candles, colloidal silver or biosand filters).

Activated carbon filters can also be used as a tertiary treatment in wastewater treatment plants to remove micropollutants from municipal effluents or recalcitrant contaminants from industrial effluents.

2.12) Cost considerations

Factsheet Block Body (Adapted from AMIRAULT et al. 2003)

Installation costs are moderate but additional technical equipment is required. Operating costs are usually limited to filter replacement. Depending on the type and concentration of the contaminant being removed, some carbon filters may require special hazardous waste handling and disposal, which can be costly.

2.13) Operation and maintenance

Factsheet Block Body(Adapted from LEMLEY et al. 1995)

Carbon filters are relatively easy to install and maintain but skilled labour is required at least occasionally for monitoring the removal performance over time of both POU and POE equipment. Activated carbon filters have a limited lifetime. After long-term use, their surfaces are saturated with adsorbed pollutants and no further purification occurs. The filter material therefore has to be replaced at regular intervals, according to manufacturer's instructions. Replacement intervals should be calculated based on the average daily water use through the filter and the amount of contaminant being removed. Cartridge disposal depends on usage. A carbon cartridge can be backwashed and then reused or discarded if non-toxics have been adsorbed.

2.14) Applicability

Activated carbon filters are widely used to produce drinking water at household and community level (to remove certain organics, chlorine or radon from drinking water) and to treat industrial or municipal wastewaters. It is not efficient for disinfection and nitrates removal. Adsorption on activated carbon is a simple technology based on materials such as fossil fuels (petroleum coke, lignite...) and even agricultural waste (e.g. coconut shell, wood, etc.).

To choose the most applicable type of activated carbon for a given application it is important to analyse the composition of the influent water previously. The carbon filter has to be replaced or regenerated regularly to remain efficient. Activated carbon can also be used as a pre-treatment to protect other water treatment units.

CHAPTER 3 : METHODOLOGY

3.1) Materials

3.1.1) Preparation of Sand

Fine sand is taken from the banks of Yamuna river in wazirabad. The sand is cleaned with clean water about eight to ten times to remove clay particles , dust , plastics, scrap particles, waste particles and anything other than sand. A small amount (about 30 ml) weak acid 10-15% is poured over the sand , it will remove the deposited salts in sand , it is thoroughly mixed and is cleaned again with clean water about 8-10 times to remove and remaining trace of acid. Sand is then dried in hot air over at 95⁰C for an hour to remove water. Dried sand is left to cool down to room temperature.

Sand is then passed through IS 90 sieve with sieve size of 90 micrometer to remove larger particles. Sieved sand is weighed and is divide into samples of 500 grams atleast 5 such such samples are prepared.



Figure 3.1 : weighed sand and sugar sample

3.1.2) Preparation of sugar solution

Store brought sugar is used for this experiment which is conventionally used in Indian household. Sugar particles are cleaned by blowing air to remove dust particle. Sugar particle are then weighed for different concentration of carbon coating example for 500grams of sand and 5% of carbon coating we take 25 grams of sugar and dissolve it in 200 ml of distilled water. Likewise for 10% 50 grams and for 15% 75 grams of sugar is weighed is dissolved in distilled water .

3.1.3) Carbon coating of sand

Sand sample is taken and prepared sugar solution is mixed with it. The sample is then poured in a metal container and the container is put on content heat coil heater with temperature at 95°C.

The mixture is stirred constantly, with time the water will evaporate away giving mixture of sand and sugar with constant stirring sugar is coated to sand particles. Heat with time breaks down the sugar particles which are seen by changing color of sand. Color of sand change to green then brown and after that it will start burning and will give out a lot of white fumes. Stirring is continued if not lumps will be formed. After about 2 hours of heating a dark colored sand is obtained.

Dark sand obtained then heated in hot air oven the temperature of oven is set 95°C for time of 15 minutes, then temp. increased by 10-15°C every 10 minutes and made to acclimatize at that temperature for 10 minutes then it is taken out and is mixed over, this process is repeated till the temperature of 200°C is not reached. When temperature is reached to 200°C then sand is taken out and is thoroughly mixed and put back for one hour. Sugar have melting point of 198°C thus when at 200°C the sugar particles will flow over sand particles and is coated uniformly. After one hour we get uniform 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 3.2 : Cooking of sand with sugar solution on heater.

3.1.4) Sand activation

Prepared sand samples are activated by acid treatment, that is soaking in the carbon coated sand in concentrated acid. For 1gram of sand 1ml of concentrated (95%) sulfuric acid is used, sand is soaked and is left undisturbed for half an hour (30minutes) after which excess acid is removed and sand is cleaned several times with distilled water. The sand we got is dried at 95°C for one hour in hot air oven. Dried sand we got is activated and is ready to be used water filtration. Thus if it is to be stored to be used after days it is to be stored in an air tight box.



Figure 3.3 : Conc. Acid added to sand.

3.2) Water sampling

Sample of water is taken from Trans Yamuna (Western Yamuna canal) canal from near rohini sector 16. 9 liters of water sample is taken from the canal on Tuesday taken in parts of 3 liters each at different times of the day in morning at 9:00 am , 2:00pm and 7:00pm. All the samples are mixed thoroughly and will further be used for filtration.

3.3) Sand bed preparation

PVC pipes of 152.4cms (5') and 3.81cms (1.5") is used and is filled with activated carbon coated sand upto 100cms for all the sands. Bottom end is closed by cotton wrapped with cotton cloth stick by paper tape.

Thus three PVC pipes containing 5%, 10%, 15% sample is prepared.



Figure 3.4 : PVC pipes filled with different % sand filtering water

3.4) Water filtration

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

In the end we got 10 samples of water

Sample No.	Sample
1	Blank
2	Water passed through 5% sand once
3	Water passed through 5% sand twice
4	Water passed through 5% sand thrice
5	Water passed through 10% sand once
6	Water passed through 10% sand twice
7	Water passed through 10% sand thrice
8	Water passed through 15% sand once
9	Water passed through 15% sand twice
10	Water passed through 15% thrice



Figure 3.5 : water samples after filtering out water from different beds.

3.5) Water Sample Testing

3.5.1) TDS test

The total dissolved solids concentration is the addition of the cations (positively charged ions) and anions (negatively charged ions) in the water. Therefore, the total dissolved solids test provides a qualitative measure of the amount of dissolved ions but the nature or ion relationships is undetermined. Therefore, the 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 present in the sample water.

TDS meter used to test water purity for Reach and Wash window cleaning

TDS meter will determine the TDS of water based on the ions which dissociate and conduct electricity i.e. inorganic salts, thus dissolved organics will not affect the value of TDS of water sample

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.



Figure3.6 : TDS measuring instrument.

3.5.2) 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.

COD of water sample is determined by closed reflux method where water sample is allowed to get oxidized by and oxidizing agent like potassium di chromate. The consumed amount of oxidizing agent will give relate to the COD of sample which can be determined by titrating the sample to find excess oxidizing agent remaining in the sample. For potassium dichromate the sample is titrated with ferrous ammonium sulphate FAS and ferroin is used as an indicator which gives very sharp brown color change.

3.5.3) pH test

The pH scale typically ranges from 0 to 14. Thus, measured pH values will lie mostly in the range 0 to 14, though values outside that range are entirely possible. Pure water is neutral with $\text{pH}=7$.

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 aqueous solutions, indicating its acidity or alkalinity expressed in terms of pH. The pH meter measures the difference in electrical potential between a pH electrode and the reference electrode, thus the pH meter is sometimes referred to as a "potentiometric pH meter".

The difference in electrical potential relates to the concentration of hydrogen ions in solution or pH of the solution. The pH meter is used in many applications ranging from laboratory experimentation to quality control in water chemistry.



Figure 3.7 : pH measuring instrument.

CHAPTER 4 : RESULT AND DISCUSSION

The sample taken from the banks of trans Yamuna canal is passed through different sand beds made in PVC pipes and after passing reduction in TDS, pH and COD is found out. Water sample is passes again and again through same sand to find cumulative reduction in parameters for this we used water passed through bed once, twice, thrice. The best reduction results can be seen in the water passed three times through the sand, it is true for all type of sands.

4.1) 5% Sand Results

4.1.1) TDS Reduction

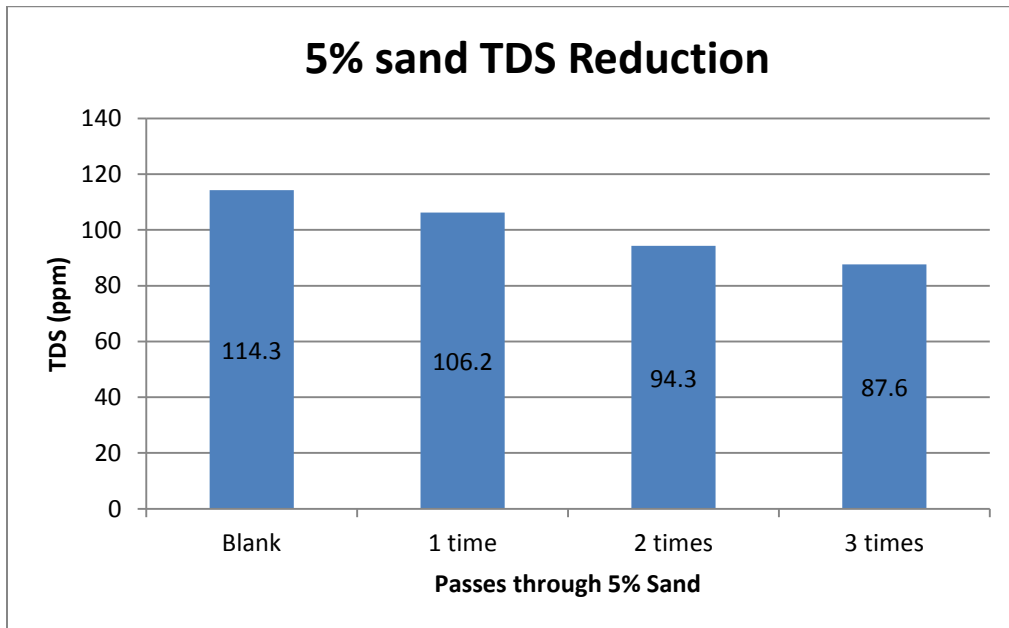


Figure 4.1 : TDS reduction by 5% Sand

Blank is the sample taken from the canal and is preserved for testing to compare with the reduced values.

- A small reduction is seen in water passed only once, thus for better reduction water is passed though sand bed a number of times for 5% sand.
- Overall reduction of TDS in seen to be about 23.4%.
- Reduction of TDS after each passage through bed is almost similar.
- More the number of passage though bed more will be the reduction.

4.1.2) pH Correction

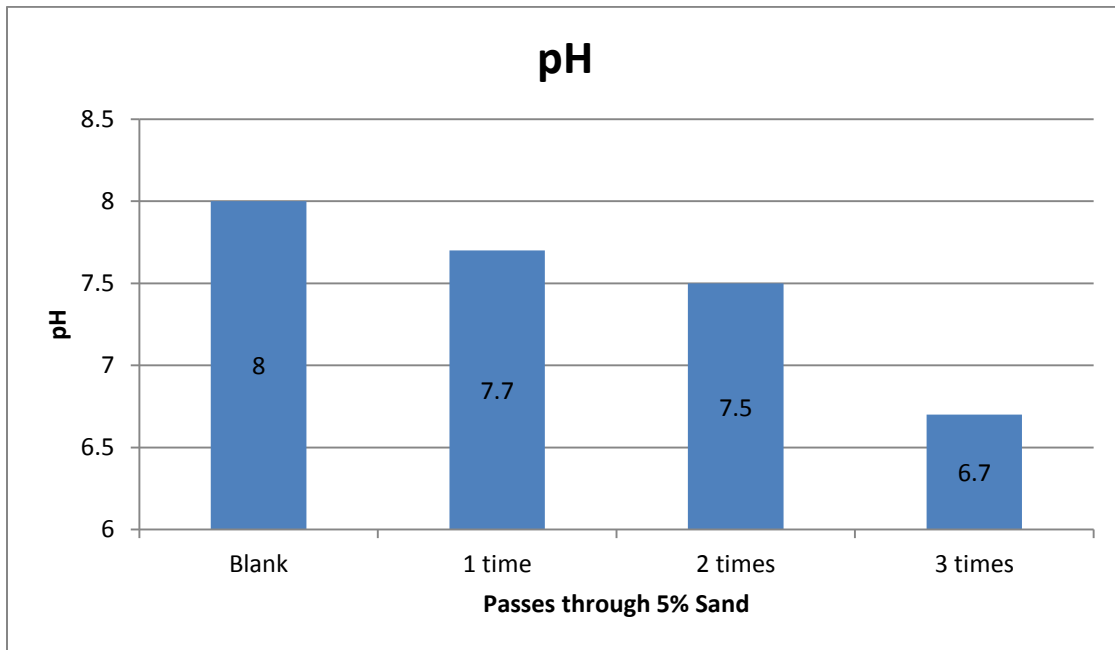


Figure 4.2: reduction of pH when passed through 5% Sand

As the sand is previously treated with conc. Acid after more contact period the pH of water fall below 7.

- 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 more number of passes through the sand.

4.1.3) COD Reduction

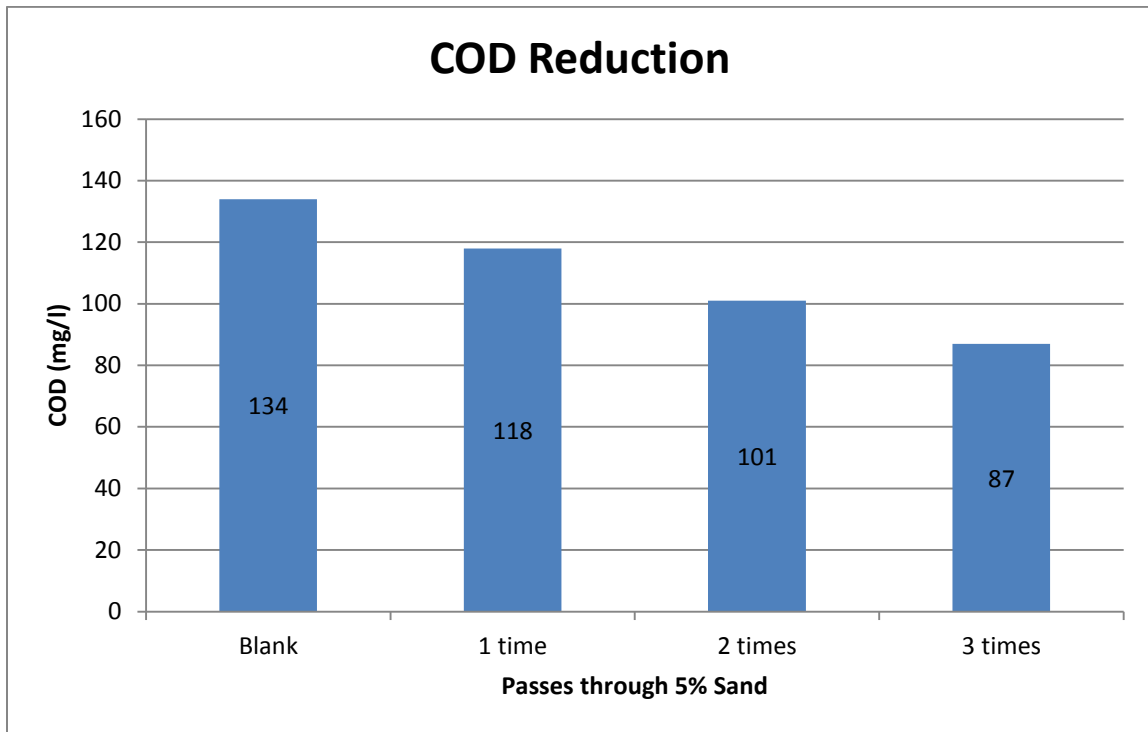


Figure 4.3 : reduction of COD of water when passed through 5% sand.

COD of sample water is found to be 134mg/l which is a little bit higher than expected but due to various reasons it is justifiable.

- COD represents the amount of organics in water sample, these results show that it can be used to remove organic particles also.
- Significant COD removal can be seen which is higher as the number of passes through sand increases.
- Overall reduction of COD is about 35%. For higher reduction efficiency either the number of passes or the bed depth is increased.
- Larger organics should be previously removed by passing sample through filter paper.

4.2) 10% Sand

4.2.1) TDS Reduction

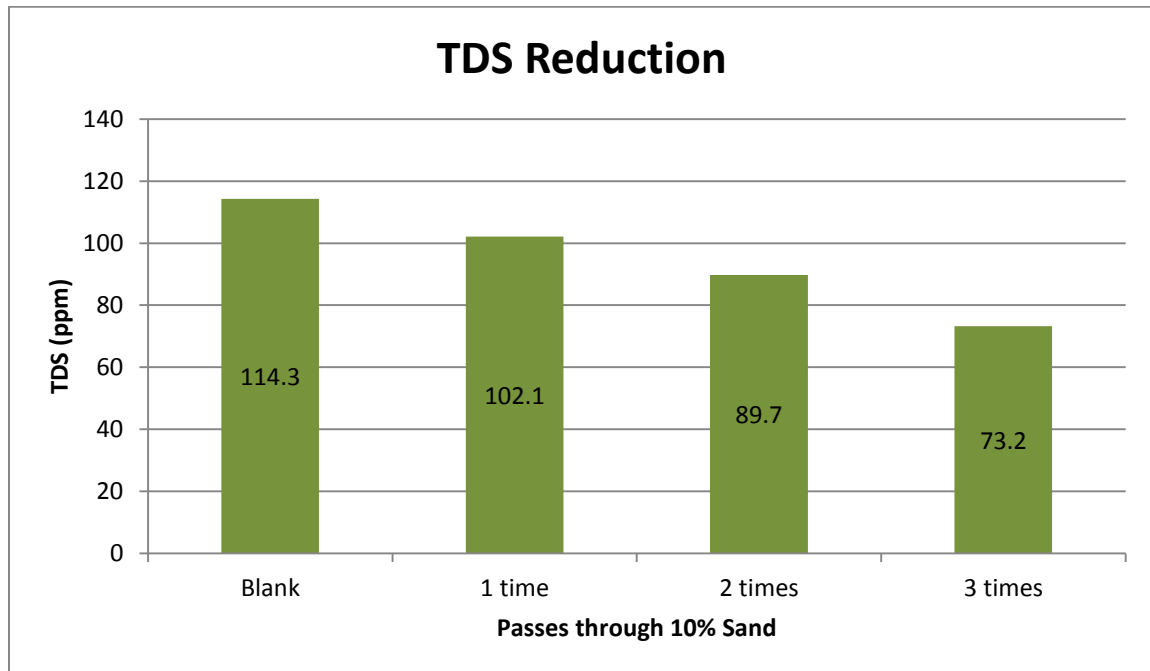


Figure 4.4 : TDS reduction when sample is passes through 10% sand .

The amount of TDS reduction in 10% sand is slightly higher than that of 5% sand.

- TDS caused by dissolved inorganic ions is reduced by adsorption of these ions on the surface of activated carbon coated sand particles.
- Overall TDS reduction by 10% sand sample is about 36% (35.96%) which is higher than in case of 5% sand.
- More the number of times sample passed through the bed more is the TDS reduction.

4.2.2) pH Correction.

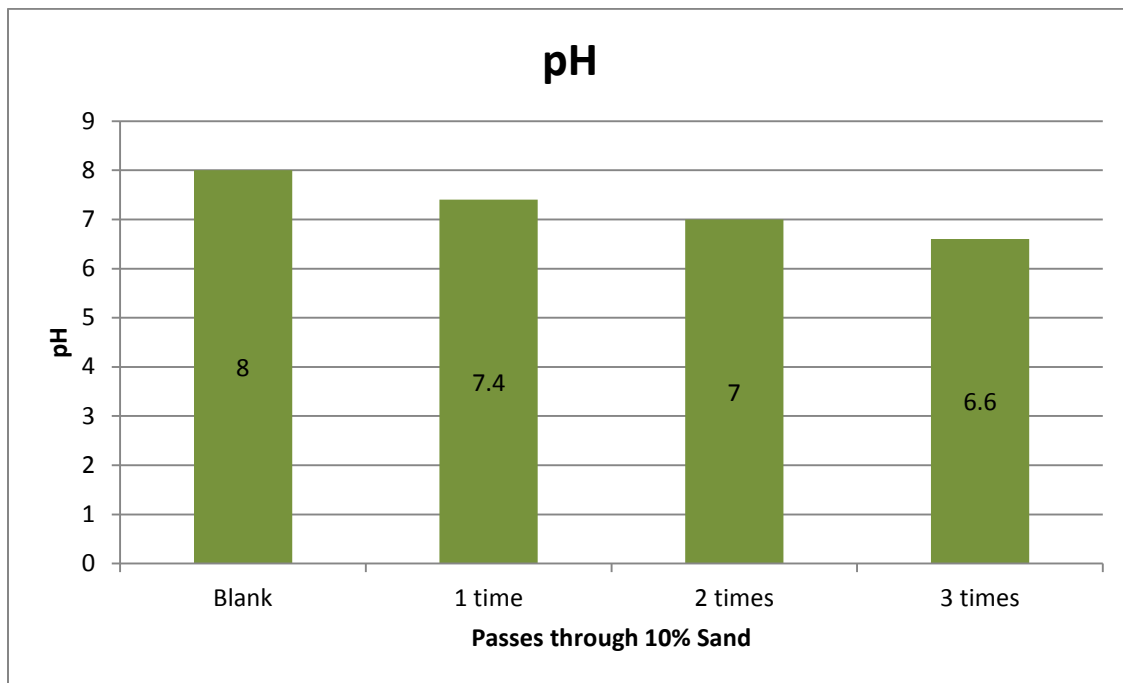


Figure 4.5 : pH value of samples of water when passed through 10% sand.

pH of sample water i.e. water from the canal is slightly alkaline this might be due to some contamination of water.

- 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.
- After 3times passage of water pH becomes slightly acidic this might be due to release of acidic ions in water, it is assumed that after more number of passage of water through bed the pH value will stabilize to neutral.
- To remove the acidic ions the bed can removed and washed again with demineralized water.

4.2.3) COD Reduction

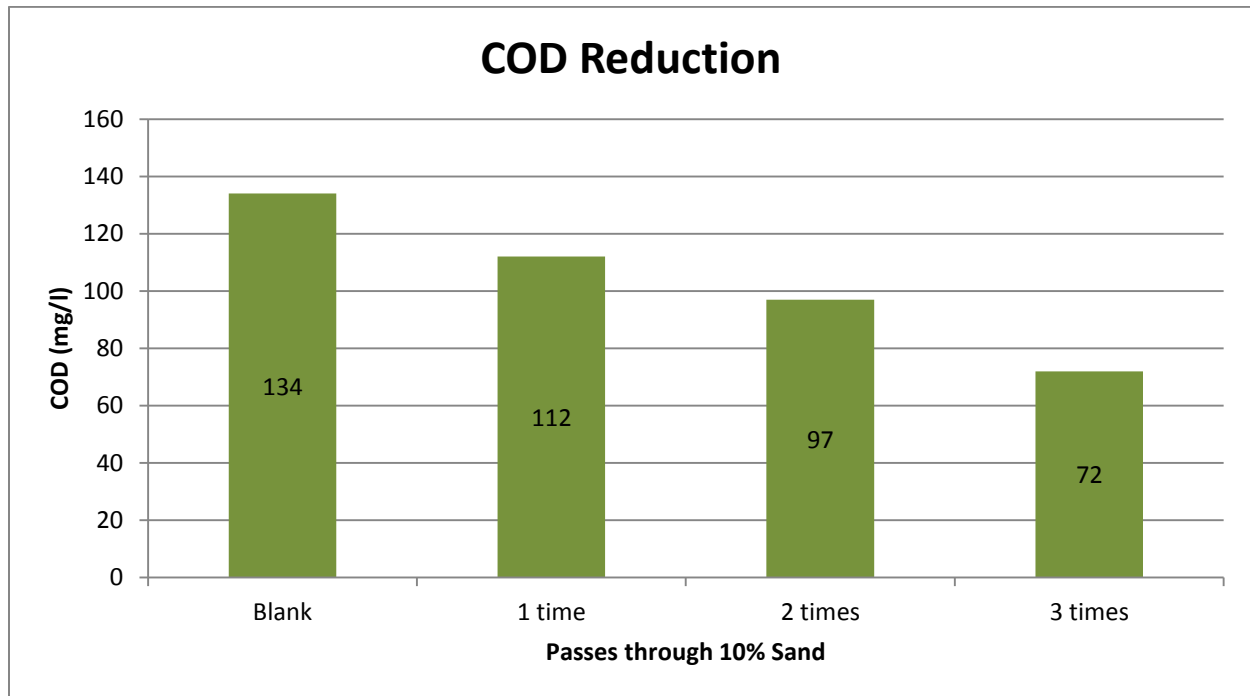


Figure 4.6 : the reduction in COD of water samples when passes through 10% sand.

COD of water represents the amount of organics in the water, the high amount of COD in sample water shows that there must be some contamination.

- COD Reduction in water passed through 10% sand is more than that of 5% sand representing that more is the amount of sugar more will be the coating on sand of carbon.
- More the number of passage of water through sand bed more is the reduction.
- Overall reduction in COD is about 46.3% when passed through 10% sand after 3 times.

4.3) 15% Sand

4.3.1) TDS Reduction

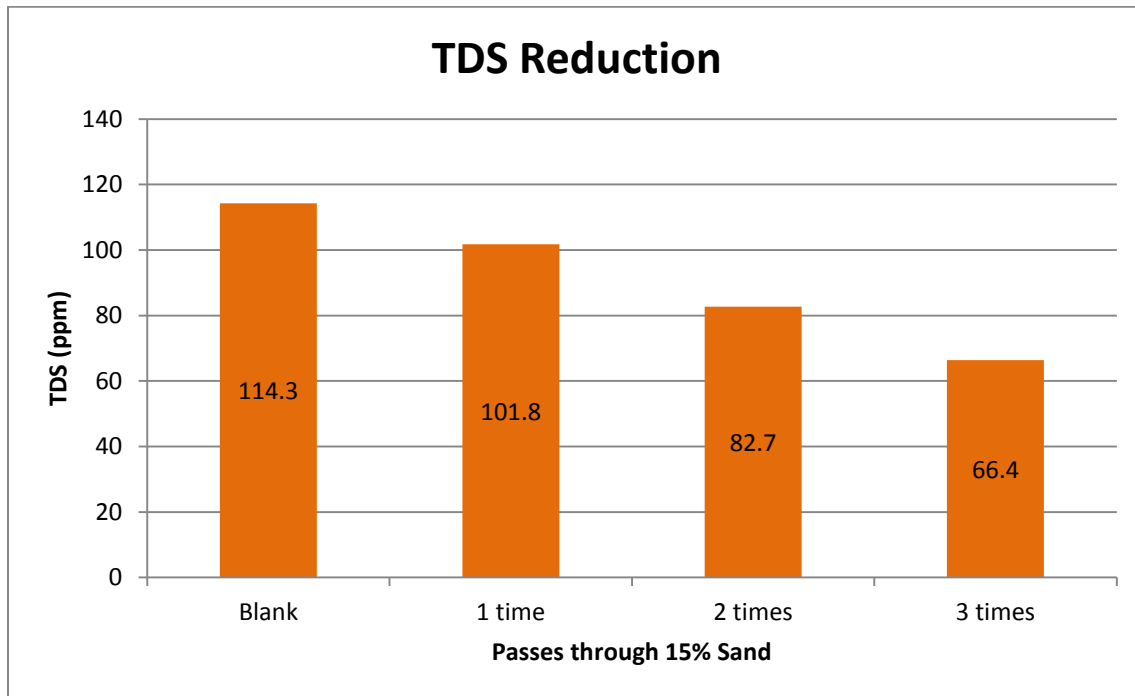


Figure 4.7 : TDS Reduction of water when passed through 15% sand.

15% sand is better in filtration than that of 5% and 10% sand.

- TDS Removal by 15% sand is more than that in case of 5% and 10% sand thus it can be inferred that higher the concentrations of sugar will give better results in water filtration.
- Overall TDS removal efficiency is better than other both which is about 42% after 3rd pass of water through the bed.
- Thus for higher efficiency number of passage can be increased or bed depth.

4.3.2) pH Correction

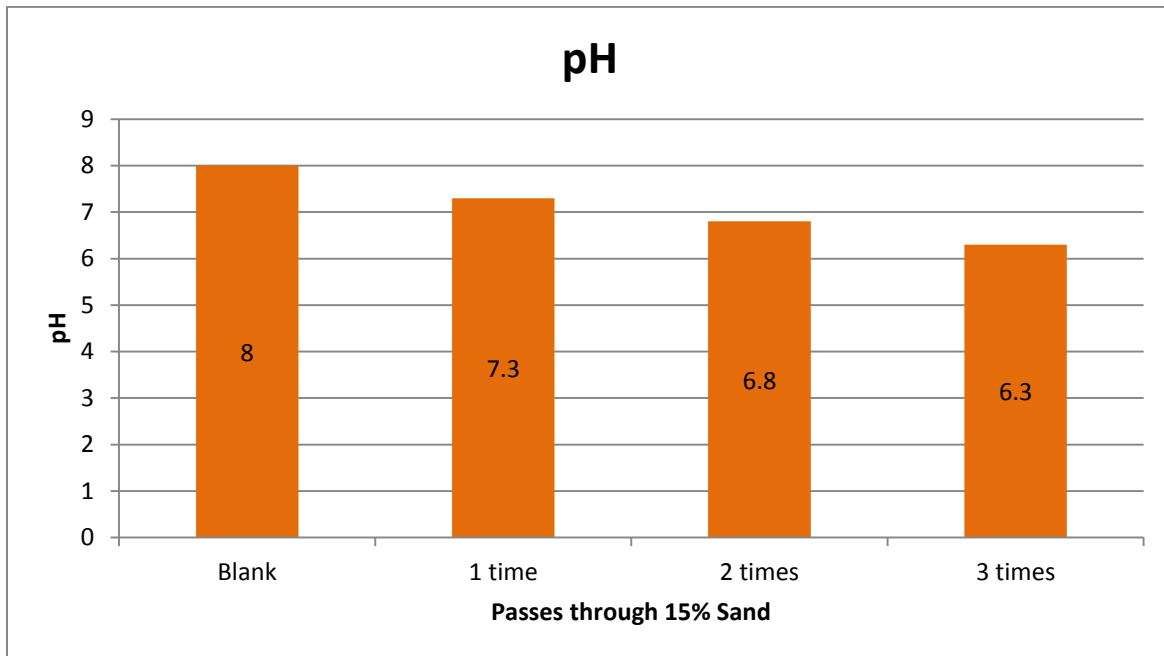


Figure 4.8 : pH change in water sample when passed through 15% sand.

pH of the water sample is reduced after each passage of water through the 15% sand bed.

- Alkaline pH of water is reduced on passage of water through the sand bed this is due to adsorption of causing ions.
- Decline of pH to acidic level might be due to the release of acidic ions into water by the bed which might be present due to insufficient cleaning of bed.
- The pH value will stabilize after more number of passage of water through the sand bed.

4.3.3) COD Reduction

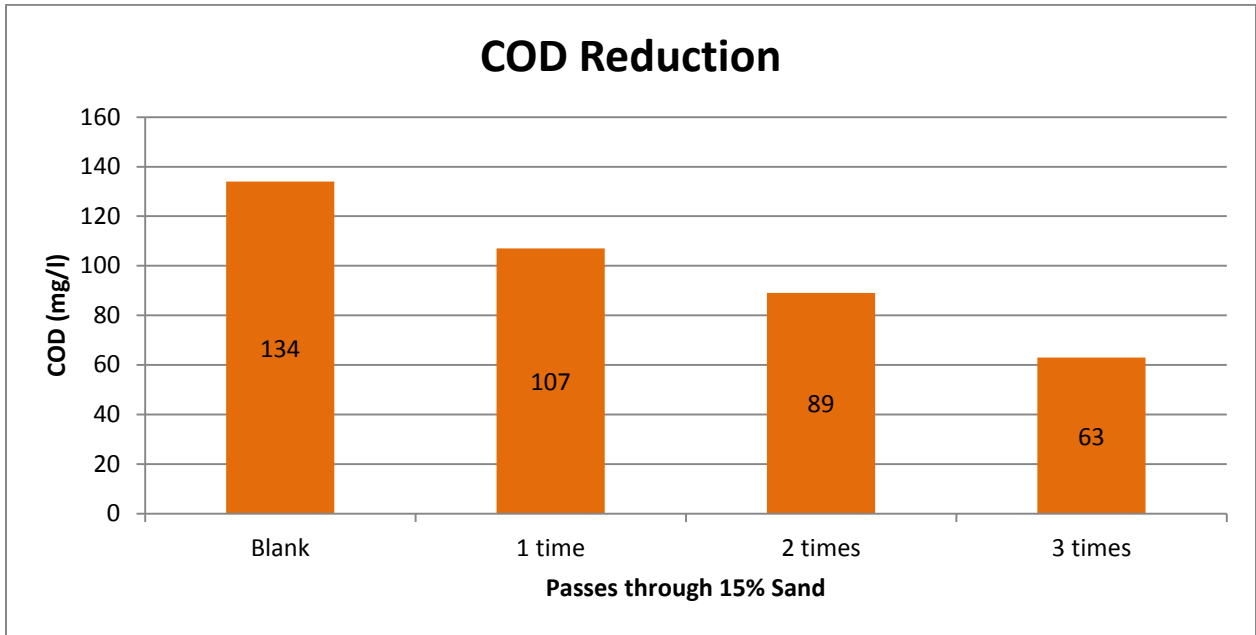


Figure 4.9 : reduction in the COD of sample on passing through 15% sand.

COD represents the amount of organics biologically degradable and biologically non degradable organics, its high amount in sample will represent contamination of water source.

- COD reduction in case of 15% sand is more than that of 5% and 10% sand thus signify that more reduction can be achieved with higher concentrations.
- More the number of passage of water through sand bed more is the reduction thus for better efficiency in this sand more number of passage is required.
- Overall removal efficiency of COD when passed through 15% sand bed is about 53%.

4.4) Comparison of efficiencies.

4.4.1) TDS Removal Efficiencies.

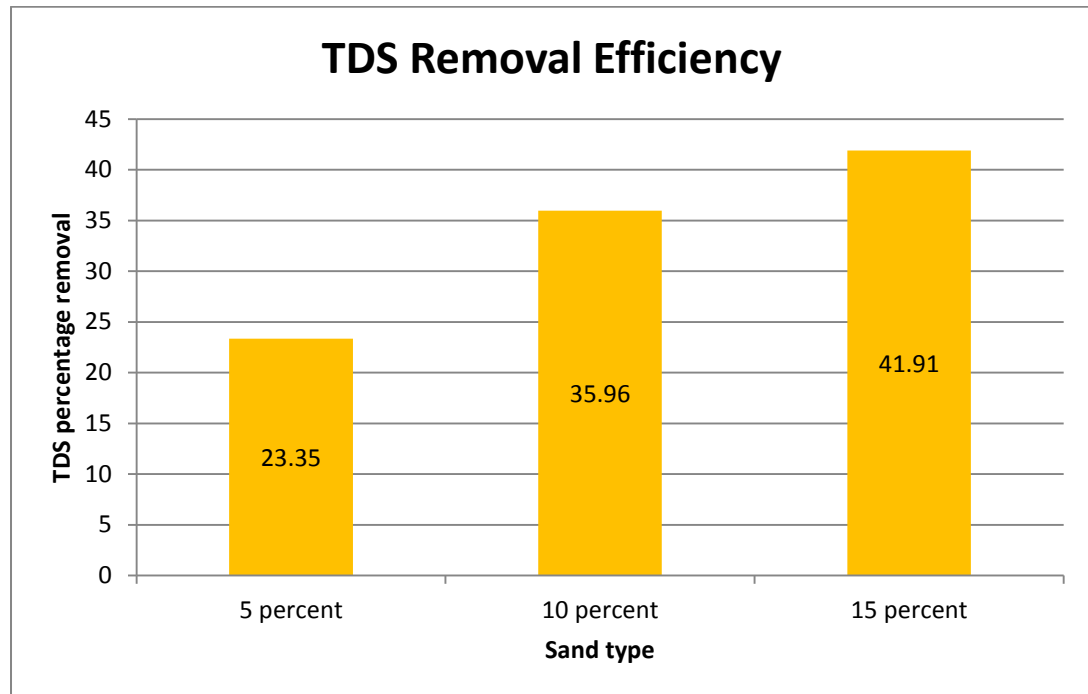


Figure 4.10 : TDS removal efficiencies of different sand type.

TDS removal is achieved by the adsorption of dissolved ions on the sand bed activated particles.

- Highest TDS removal efficiency is achieved by 15% sand after 3rd passage of water through bed.
- TDS removal efficiency increases as the sugar conc. In sand increases this proves that higher conc. of sugar will give more carbon thus more activated surface area for adsorption.
- Higher efficiency of removal can be achieved with high conc. sand beds.
- Incremental increase in removal efficiency is not linear with conc. increase, that is about 12.5% when 5% sand to 10% sand and about 6% when 10% sand to 15% sand.
- Higher the conc. sand will work for longer period of time.

4.4.2) COD Removal Efficiencies.

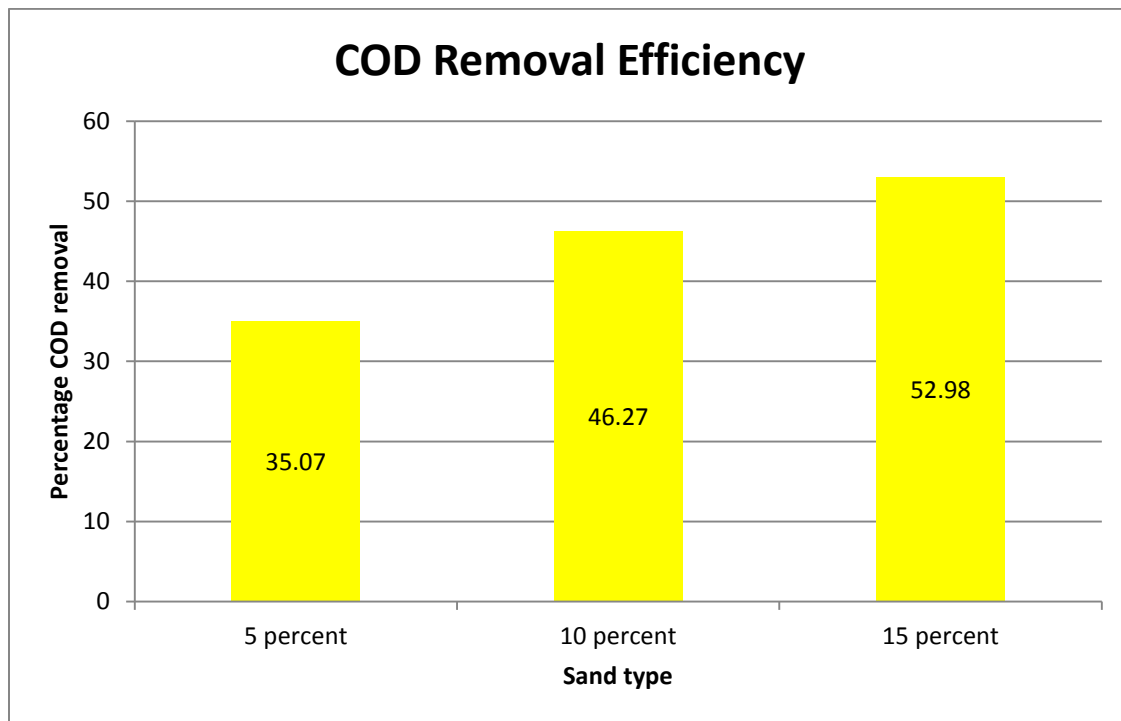


Figure 4.11 : COD removal efficiencies of different sand.

COD removal is a significant process of water treatment as if it is not removed there is always possibility of occurrence of diseases causing microorganisms.

- Highest COD removal efficiency is seen in 15% sand when passed 3rd time.
- COD removal efficiency increases as the sugar conc. in sand increases this proves that higher conc. of sugar will give more carbon thus more activated surface area for adsorption.
- Higher efficiency of removal can be achieved with high conc. sand beds.
- 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.

CHAPTER 5 : CONCLUSION

This work has determined the significant information about the quality as well as efficiency of treatment can be done by low cost activated carbon coated sand. In this study we came across lot of conclusions.

1. Sugar solution can be used as a source of carbon that can be coated on the sand particles by thermal degradation.
2. Carbon coated sand can be activated by chemical treatment like treating with concentrated acids.
3. 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.
4. More the number of times the water is passed through sand bed more will be the adsorption thus better is the treatment efficiency.
5. Maximum efficiency of treatment is achieved in case of 15% sand when passed through 3 times through it which is about 42% for TDS and 53% for COD.
6. Minimum efficiency of treatment is achieved in case of 5% sand when passed through only once which is about 23% for TDS and 35% for COD.
7. pH of water sample decreases due to adsorption of alkalinity causing ions.
8. Water sample which is passed again and again through sand bed is better treated as because of continuous adsorption process.

This treatment process can be used in place of conventional sand filtration process as it will have better efficiency of treatment. In place of slow sand filter this activated carbon coated sand bed can be used easily. But before that further study in this is required which contains depth required, headloss, working life of bed, best coating which should be applied, also the grain size distribution of sand particles.

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