TREATMENT OF WATER USING LOW COST NATURAL MATERIALS

Submitted in partial fulfilment of the requirements for the degree of

Bachelor of Engineering

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This is to certify that, **Poshekar Anas Mohd Amin (16DCES80), Sakharkar Shifa Adam (16DCES82) and Shaikh Sajid Ali Wajid Ali (14CES44)** has satisfactorily completed and delivered a Project report entitled, **"Treatment Of Water Using Low Cost Natural Materials"** in partial fulfilment for the completion of the **B.E.** in **Civil Engineering** Course conducted by the University of Mumbai in Anjuman-I-Islam's Kalsekar Technical Campus, New Panvel, Navi Mumbai, during the academic year 2018-19.

Dr.Shabiimam M.A.

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Project Report Approval for B. E.

This B. E. Project entitled **"Treatment Of Water Using Low Cost Natural Materials"** by **Mr. Poshekar Anas, Ms. Shifa Sakharkar** and **Mr. Shaikh Sajid Ali** approved for the degree of ***"Bachelor of Engineering"*** in ***"Department of Civil Engineering".***

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Date:

DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

Water scarcity has been listed by the World Economic Forum as the largest global risk in terms of potential impact over the next decade. One-third of the global population live under conditions of severe water scarcity. Technically, there is a sufficient amount of freshwater on a global scale, for humanity to get by. However, due to unequal distribution and lack of accessibility, humanity is facing a water crisis. So, in order to avoid a water deficient future, it has become essential for every country all around the globe to take a step towards water conservation.

Apart from water scarcity one major area of concern is water quality. Lack of clean drinking water has put billions of people's health at risk Diseases like malaria, cholera, hepatitis A, typhoid fever and many other diseases are spread because of the consumption of contaminated water. That is why treatment of water before consumption is necessary.

In view of all the above parameters, we are proposing a portable as well as affordable water filter which is ready to filter water on the go. The filter will consist of layers of different filtering media. These filtering materials are required to be natural and affordable. So the target of this project will be basically rural areas. Natural substitutes will be used as a filtering medium which are cheap in cost or which may be a by-product of any agricultural or manufacturing process. For example, coconut shells, rice husk, bagasse, sand and gravel. The filtration system will be of gravitational type and the backwashing process will be of pressure type. An optional pressure pump can be provided with the device to aid backwashing.

As far as the disinfection of water is concerned, chlorination is by far the most suitable method of disinfecting water of pathogens. Provisions can be made to supply optimum dosage of chlorine and if residual chlorine is already present in water, then neutralizing it for drinking.

Keywords: water treatment, filtration, natural materials, activation process, filter media

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ABBREVIATION NOTATION AND NOMENCLATURE

NTU	Nephelometric Turbidity Unit
SS	Suspended Solid
TSP	Total Suspended Solid
TDS	Total Dissolve Solid
RH	Rice Husk
RHA	Rice Husk Ash
AC	Activated Carbon
RSF	Rapid Sand Filtration
UF	Ultra Filtration
RO	Reverse Osmosis
BIS	Bureau of Indian Standards
KCl	Potassium Chloride

Chapter 1

Introduction

1.1 General

In a developing country like India, rainfall is the most important source of water, which the country receives abundantly, but due to its uneven distribution as well as absence of proper rainwater harvesting, many regions all across the country suffer with water scarcity. Apart from rainfall, other water sources which are of course fed by the rainfall may be used. For example, lakes, rivers, ponds, ground water, etc. These water sources are proving inefficient because of haphazard growth of the country's population and deterioration of water quality due to pollutants and contaminants. As per the data collected by NITI Aayog, 54 percent of Indians face high to extremely high water stresses. Water stress refers to the lack of availability of water or, if at all it is available, the quality is not up to the drinking standards set up by WHO.

Water treatment involves a number of processes such as coagulation, adsorption, filtration and disinfection. In coagulation, the finely suspended matters which do not settle due to gravity are made to form flocs with the help of a coagulant. These flocs are then settled owing to their weight. In adsorption, the water is passed through a media of adsorbent on the surface of which the fine matters present in the water get stuck, thus cleaning the water. One of the most important process required for improving the quality of water is Filtration. Filtration removes the minute suspended particles, bacteria, pathogens as well as heavy metals such as arsenic, lead, etc. and makes the water safe for drinking. With the advancement in technology, a number of filtration techniques are now available worldwide.

However, countries like India still face water borne epidemics, as the level of pollution in the country is quite high. The mostly impacted due to this are the rural areas. Lack of good quality water has deteriorated the people's health. As a result, it has become necessary to opt for cheaper alternatives by using naturally available materials for the treatment of water at small scale as well big scale.

1.2 Health impacts due to water pollution

Water pollution related diseases cannot be dodged because, anyhow, we need to use water either for drinking, cooking or washing. The diseases related to water might be of any type viz. viral, bacterial, protozoal, helminthic and leptospiral. (Aisha Parveen and Shifa Zaidi , 2017)

Viral Diseases: Diseases that spread through viruses include viral Hepatitis A, Hepatitis E , Poliomyelitis , Rotavirus , Diarrhoea in infants , etc.

Hepatitis A: This virus causes Inflammation in lever, Jaundice, Pain in Belly and fatigue, fever and nausea.

Hepatitis E: Presence of this virus causes mild fever, fatigue, loss of appetite, yellowish skin and dark urine.

Poliomyelitis: Also known as polio, this disease is categorised into two different forms viz. Paralytic polio and Non paralytic polio. Some of the symptoms of polio are loss of reflexes, severe spasm and muscle pain, loose and floppy limbs, sudden paralysis, deformed limbs, etc.

1.3 Necessity of using natural materials

Water treatment involves a number of chemical processes because the treatment consists of many physical and biological methods. In most of the developing nations, these chemicals are not available or they are not able to produce those chemicals. So it becomes necessary for them to import those chemicals. Due to these reasons, a large amount of money is spent on the treatment of water. So, in order to reduce these expenses, researches have to be done to find natural substitutes for these chemicals, which will not only be economical but also eco-friendly. These substitutes may be in the form of agricultural by-products, seeds or processed materials.

Tamarind seeds, Moringa Oleifera (Drumstick Seeds), Cicer Arietinum (Chickpea), Dolichos Lablab (locally called as 'Vaal Paapdi') can be used as coagulants while rice husk and activated carbon can be used as adsorbents. These are some of the options that can be used as a part of the research. Of course there are a number of natural gifts that can be utilized for the purpose of water treatment.

1.4 Filtration

A water filtration system is a setup which removes impurities from water by means of a fine physical barrier, a chemical process and biological process. Filtration controls entirely on particle or droplet size (and, to some extent, shape), such that particles below a certain size will pass through the hurdle, while larger particles are retained on or in the barrier for later removal [1].

1.5 Various water filtration techniques

1.5.1 Rapid Sand Filtration

Rapid sand filtration is a purely physical drinking water purification method. Rapid sand filters (RSF) provide rapid and efficient removal of relatively large suspended particles. Two types of RSF are typically used: rapid gravity and rapid pressure sand filters. For the provision of safe drinking water, RSFs require adequate pre-treatment (usually coagulation-flocculation) and post-treatment (usually disinfection with chlorine). Both construction and operation is cost-intensive. It is a relatively sophisticated process usually requiring power-operated pumps, regular backwashing or cleaning, and flow control of the filter outlet. Rapid sand filtration is common in developed countries for the treatment of large quantities of water where land is a strongly limiting factor, and where material, skilled labour, and continuous energy supply are available.

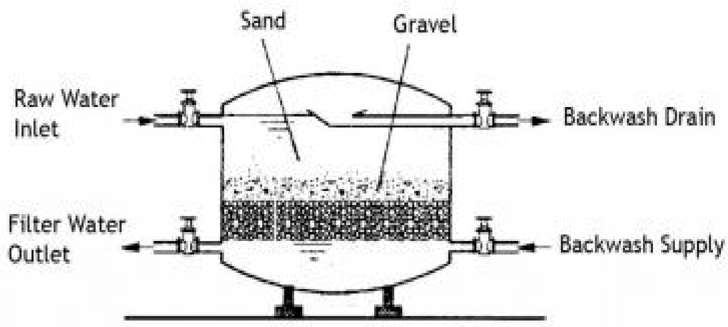

Figure 1.1 Closed rapid sand filter (pressure filter). Source: WHO (1996)

This filtering process is determined by two basic physical principles. First, relatively large suspended particles get stuck between the sand grains as they pass the filter medium (mechanical straining). Second, smaller particles adhere to the surface of the sand grains caused by the effect of the van der Waals forces (physical adsorption). A chemical filter-aid (i.e. coagulant or flocculant) might be added to promote additional adhesion (Schmitt & Shinault 1996).

Figure 1.2 Schematic of basic filtration principles. Source: SCHMITT & SHINAULT (1996)

Advantages

i) Highly effective for removal of turbidity (usually < 0.1-1 NTU)

ii) High filter rate (4’000 – 12’000 litres per hour per square metre of surface), small land requirements

iii) No limitations regarding initial turbidity levels (if coagulant or flocculant is available and correctly applied)

iv) Cleaning time (backwashing) only takes several minutes and filters can be put back into operation instantly

Disadvantages

i) Not effective in removing bacteria, viruses, fluoride, arsenic, salts, odour and organic matter (requires pre- and post-treatment)

ii) High capital and operational costs

iii) Frequent cleaning (backwashing) required (every 24-72h)

iv) Skilled supervision essential (e.g. for flow control and dosage of disinfectant)

v) High energy input required

vi) Backwashing water and sludge needs treatment; sewage system or stabilisation ponds required

1.5.2 Micro-filtration

Micro-filtration (or MF for short) is one of the pressure-driven membrane processes in the series micro-filtration, ultra-filtration (UF), Nano-filtration (NF) and reverse osmosis (RO). The micro-filtration process uses a membrane – a simple permeable material – which, in the case of micro-filtration, only allows particles smaller than 0.1 microns to pass through it. The micro-filtration membrane can consist of various materials like, for example, polysulfone, polyvinyl difluoride (PVDF), polyether sulfone (PES), $ZrO2$ and carbon. The pore size varies between 0.1 and 5 microns. Because the pores are large compared to other mentioned filtration techniques, pressure – needed to send the liquid through a micro-filter membrane – is limited to 0.1 to 3 bar.

In addition to the specific membrane configurations, one can also identify a few set-ups. The 2 most commonly used methods are dead-end and cross-flow set-ups. The names refer to the way in which the supply is sent to the membrane. In dead-end MF, the supply is sent directly to the membrane. The pollution layer will thus form on the supply side of the membrane surface. This layer contains all particles that have been separated on the basis of their size (sieve effect). This layer is periodically rinsed away by briefly re-sending the produced liquid (permeate) through the membrane in an opposite direction to the production flow. This helps to loosen the hardened layer, and makes it ready for disposal. This is referred to as a semi dead-end set-up.

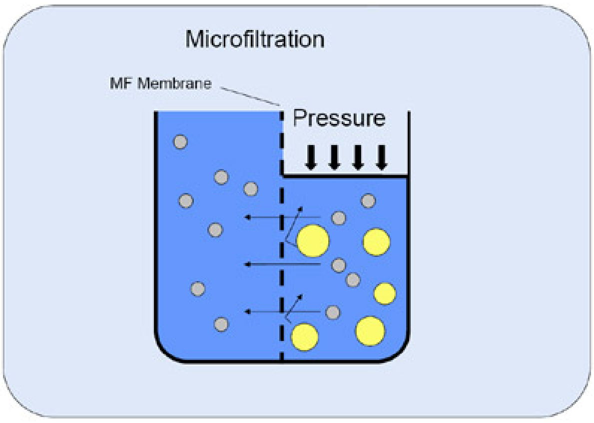

Figure 1.3 Microfiltration

Advantages:

i) Low operating pressure required;

ii) Low energy consumption for semi dead-end set-up, compared to nano-filtration or reverse osmosis;

iii) Few manual actions required;

iv) Relatively cheap;

v) No energy-consuming phase transfer needed, such as e.g. evaporation techniques;

vi) Quality of the produced permeate is not determined by the management.

Disadvantages:

i) Only suspended matt

er and bacteria removed (~log 5 removal);

ii) Sensitive to oxidative chemicals (e.g. nitric acid, sulphuric acid, peroxide and persulphate in high concentrations);

iii) Damage can be caused by hard and sharp particles > 0.1 mm, whereby pre-filtration is necessary;

iv) Membrane damage if re-rinsed at pressure in excess of 1 bar.

1.5.3 Ultra-filtration

Ultra-filtration (or UF in short) is one of the pressure-driven membrane processes. The ultra-filtration process uses a membrane – a simple permeable material – which, in the case of ultra-filtration, only allows particles smaller than 20 nm to pass through it. The pore size varies between 20 nm and 0.1 microns. Ultra-filter membranes are offered in various configurations by suppliers, with each configuration having a specific use and accompanying advantages and disadvantages. Possible membrane configurations include:

i) Pipe-shaped membranes: capillary, hollow fibre or tubular;

ii) Plate-shaped membranes: flat plate or spiral.

In addition to the specific membrane configurations, one can also identify a few set-ups. The 2 most commonly used methods are dead-end and cross-flow set-ups. The names refer to the way in which the supply is sent to the membrane. In dead-end UF, the supply is sent directly to the membrane. The pollution layer will thus form on the supply side of the membrane surface. This layer contains all particles that have been separated on the basis of their size (sieve effect). This layer is periodically rinsed away by briefly re-sending the produced liquid (permeate) through the membrane in an opposite direction to the production flow. This helps to loosen the hardened layer, and makes it ready for disposal. This is referred to as a semi dead-end set-up.

This re-rinsing may not be enough to remove the layer from the surface if the hardened layer is too strongly compressed or if the bond with the membrane is very strong. In this case, chemical cleaning must be implemented with, for example, bleach, peroxide, acid and alkali or detergent.

Advantages

i) Low operating pressure required (higher than MF);

ii) Lower energy consumption than nano-filtration or reverse osmosis;

iii) Few manual actions required;

iv) Relatively cheap;

v) Good permeate yield depending on the supply water and membrane choice;

vi) Disinfection through removal of bacteria. To a certain extent, UF allows viruses, phage, colloids and macro molecules to be removed.

Disadvantages

i) Only removes suspended matter and bacteria;

ii) Sensitive to oxidative chemicals (e.g. nitric acid, sulphuric acid, peroxide and persulphate in high concentrations); NaOCl exposure determines the life-span of the membrane and is typically 150.000 to 500.000 ppmh and pH dependent;

iii) Damage may occur when trying to prevent hard and sharp particles > 0.1 mm;Membrane damage at pressure > 3 bar.

1.5.4 Reverse osmosis

RO is a water purification technology that uses a partially permeable membrane to remove ions, unwanted molecules and larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property, that is driven by chemical potential differences of the solvent, a thermodynamic parameter. Reverse osmosis can remove many types of dissolved and suspended chemical species as well as biological ones (principally bacteria) from water, and is used in both industrial processes and the production of potable water. The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side. To be "selective", this membrane should not allow large molecules or ions through the pores (holes), but should allow smaller components of the solution (such as solvent molecules, i.e., water, H_2O) to pass freely.[1]

In the normal osmosis process, the solvent naturally moves from an area of low solute concentration (high water potential), through a membrane, to an area of high solute concentration (low water potential). The driving force for the movement of the solvent is the reduction in the free energy of the system when the difference in solvent concentration on either side of a membrane is reduced, generating osmotic pressure due to the solvent moving into the more concentrated solution. Applying an external pressure to reverse the natural flow of pure solvent, thus, is reverse osmosis. The process is similar to other membrane technology applications.

Reverse osmosis differs from filtration in that the mechanism of fluid flow is by osmosis across a membrane. The predominant removal mechanism in membrane filtration is straining, or size exclusion, where the pores are 0.01 micrometers or larger, so the process can theoretically achieve perfect efficiency regardless of parameters such as the solution's pressure and concentration. Reverse osmosis instead involves solvent diffusion across a membrane that is either nonporous or uses nanofiltration with pores 0.001 micrometers in size. The predominant removal mechanism is from differences in solubility or diffusivity, and the process is dependent on pressure, solute concentration, and other conditions.[2] Reverse osmosis is most commonly known for its use in drinking water purification from seawater, removing the salt and other effluent materials from the water molecules.

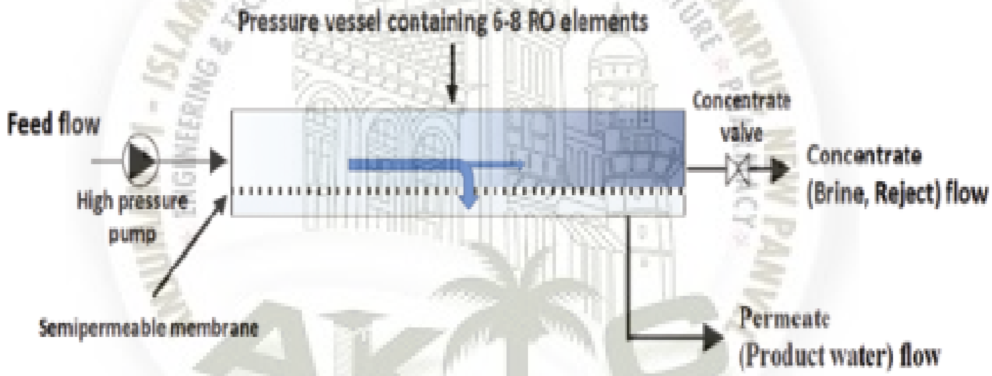

Figure 1.4 Schematic of a reverse osmosis system (Adapted from DOW Manual)

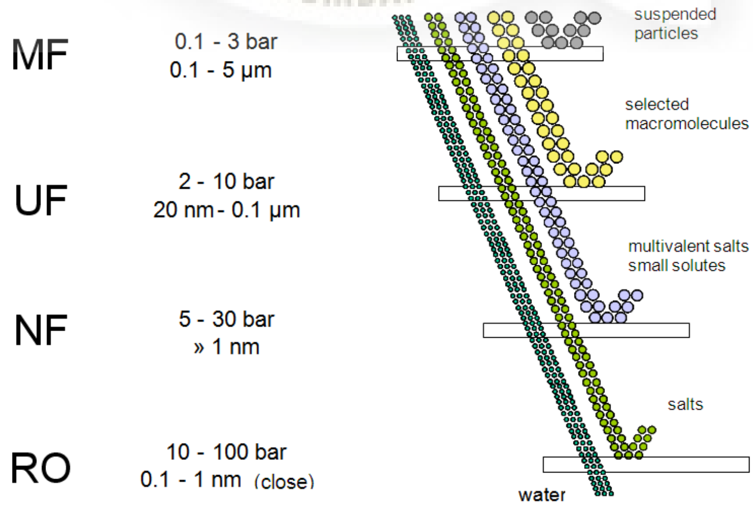

Figure 1.5 Comparison of various filter processes

1.6 BIS Standards for drinking water

Drinking water shall comply with the requirements given in Table below:

Test parameter	Acceptable limit	Permissible limit (In the absence of alternate source of water)
pH value	6.5-8.5	No relaxation
Turbidity	1	5
Total hardness as CaCo3, mg/l, Max	200	600
E.coli presence/absence	Shall not be detectable in any 100ml sample	Shall not be detectable in any 100ml sample
Total iron as Fe, mg/l, Max	0.3	No relaxation
Taste	Agreeable	Agreeable
Odour	Agreeable	Agreeable

Table 1.1 BIS Standards for Drinking Water

1.7 Aim of the Project

The project aims at finding the most suitable natural materials that are economical and can be used for treatment of water in urban as well as rural areas. The primary goal is to test various materials for their suitability as a filter media in such a way that they can be used in a portable filter by keeping the cost as low as possible. Also the materials are required to be recyclable and if not recyclable, they must be easily changeable by any user who does not have much technical knowledge.

1.8 Objectives

1. To collect the naturally available local materials.

2. To convert the materials into filter media by changing their chemical and physical properties.

3. To do various experiments for finding the suitability of natural materials as water treatment materials.

4. To do cost analysis of the materials.

5. To make a water treatment unit for domestic use using the most suitable combination of natural materials.

Chapter 2

Literature Review

2.1 General

Following literature papers were read and reviewed carefully and effectively to treat the waste water:

S.Sharma A. Bhattacharya et al. (2017)

In their paper, the authors discussed about the various contaminants of water, their effects on human health and various water treatment techniques. The following water treatment techniques were briefly discussed in their study:

i) Precipitation and coagulation, which involves softening of water, removal of heavy metals, removal of arsenic, removal of phosphorus, removal of fluoride, removal of dyes.

ii) Distillation, which removes a broad range of contaminants (toxic chemicals, heavy metals, bacteria, viruses, parasites)

iii) Adsorption which is carried out by materials like Activated carbon, Activated alumina, Zeolite, Silica gel, Ion exchange

iv) Membrane water treatment which involves Reverse osmosis, Electro-dialysis membrane treatment

A.A.M. Daifullah A et al. (2002)

Rice husk, a by-product of the rice milling industry, accounts for about 20% of the whole rice. With the estimated annual rice production of 500 million tonnes in developing countries, approximately 100 million tonnes of rice husk are available annually for utilization in these countries alone. However, the amount of rice husk available is far in excess of any local uses and, thus, has posed disposal problems. Rice husk (RH) was chosen to be applied as a precursor material due to its granular structure, insolubility in water, chemical stability, high mechanical strength and its local availability at almost no cost. The advantage in the application of these adsorbents is that there is no need to regenerate them because of their low production costs.

Results and discussion: The rice husk used was a locally available material and had the following approximate dimensions: 8– 10 mm long, 2.0– 2.5 mm wide and 0.1– 0.15 mm thick. The RH sample was analysed according to standard ASTM: D-3172-73 method and was found to contain 64.3% volatile matter, 15.9% fixed carbon and 19.8% ash . Moreover, the main constituents of the metallic residues (ash content) are: silica 94.5%, calcium oxide 0.25%, magnesium oxide 0.23%, sodium oxide 0.78%, potassium oxide 1.10%, ferric oxide trace (< 0.5), phosphorous pentoxide 0.53% and Sulphur oxide 0.6%.

Saravanan J. et al.(2017)

Wastewater was obtained from Nachiyaar Paper Mills, Sivakasi as raw wastewater before entering into the nearby screening cum sedimentation tank. Coagulants were prepared from seeds and flowers of various plants by drying and powdering them and finally sieving them in 600 microns IS Sieves.

Jar Test was carried out to evaluate the initial and final turbidity values (in NTU) before and after the coagulation process using natural coagulation. We have conducted 3 tests to take the average turbidity value for every coagulant dosage.

Mohanad El-Harbawi et al. (2010)

The purpose of this paper was to develop a personal, portable dual purposes handy water filter to provide an easier way to get safe, clean and healthy drinking water for human wherever they go. The designed system can be used in filtering water taken from public drinking fountains or other public water sources. The methodology of the design started from selecting the materials, designing the filter, testing the filter and the water quality and finally obtain the result. The portable water filter design consisted of three parts; the filter medium, the housing and the heater. The cylindrical hollow filter cartridge had a combination of filter pads consisting of five layers; activated carbon, silica sand, zeolite, bio-ball, and mineral sand. There was no content of organic matter in the water after the test was conducted. The result of the Turbidity Test was found to be within the WHO standards. The appearance of ceramic and Bio-Balls in the designed filter proved effective in removing the iron content.

Edwin I. Ekwue et al. (2013)

This paper describes the design, fabrication and testing of a portable potable water treatment plant. The device was designed using a gravitational flow treatment process with no need for a conventional power source. The water flows through the system by means of gravity passing through a simple locally made filter of sand, clay and gravel. After filtration, the effluent is then passed through a chlorination chamber and then through a carbon filter into the storage tank located at the base of the system. The device was tested using three types of untreated water: rain water, pond water and river water. The results were compared favorably with the World Health Organization Standards for drinking water. The angle at which the filter was orientated affected the quality of the water produced and the best angle of the ones tested (13o to the horizontal), was determined through experimentation. The results obtained after the experiment are as shown in the table below.

Table 1. Mean values of some properties of raw water sources and their effluents when passed through the water

	Colour (Hu) Standard*: <15.0			Electrical conductivity (mg/L) Standard: 33.0			PH Standard: 6.5 - 8.0			Turbidity (NTU) Standard: <5.0		
Water sources	Rain	Pond	River	Rain	Pond	River	Rain	Pond	River	Rain	Pond	River
Intake water	13.3**	63.3	70.0	17.2	54.7	60.9	6.1	6.9	7.8	2.0	12.0	22.0
Position of Sand and clay filter	Effluents of raw water from the three sources passed through the system with sand and clay filter tilted at different angles											
0°	1.7	16.7	26.7	25.1	30.1	41.0	6.7	7.0	7.7	3.7	9.0	2.7
13°Optimal)	0.0	11.7	13.3	25.9	29.8	28.9	6.8	6.9	7.2	1.0	3.3	2.7
26°	3.3	18.3	20.0	36.7	46.2	34.6	5.8	6.5	6.6	2.7	7.3	5.3
39°	8.3	18.3	26.7	45.1	58.2	39.5	4.6	6.6	6.8	3.0	8.0	7.3

	Dissolved oxygen (mg/L) Standard*: >4.0			Total chlorine (mg/L) Standard: 10.0			Free chlorine (mg/L) Standard: 0.5 - 5.0			Flow rates (L/s)		
Water sources	Rain	Pond	River	Rain	Pond	River	Rain	Pond	River	Rain	Pond	River
Intake water	7.5	6.7	5.6	0.5	0.8	0.4	0.4	0.7	0.1	na***	na	na
Position of Sand and clay filter	Effluents of raw water from the three sources passed through the system with sand and clay filter tilted at different angles											
0°	7.5	7.2	6.1	1.4	1.4	1.0	0.7	1.0	0.7	0.069	0.071	0.022
13° (Optimal)	7.8	7.3	7.8	2.7	2.4	2.2	2.1	2.0	1.4	0.078	0.078	0.058
26°	8.1	7.8	8.1	1.1	2.8	2.9	0.9	1.1	1.8	0.072	0.072	0.049
39°	8.0	7.7	8.3	0.7	1.8	3.2	0.6	1.2	2.0	0.061	0.063	0.038

Remarks: * WHO (2011a) Standards. ** All values are means of three replicates. *** Not applicable

Table 2.1 Before and after results for the experiment

Shivani Batra et al. (2017)

A prototype following the designing of the water filter was constructed. Layers of sand, cloth, activated charcoal, and cotton containing compartments were built for carrying out water analysis. Most probable number index of Vellore Institute of Technology lake water was compared with that of filtered water. Complete water analysis was done, and the sand filter layer was observed to be responsible for a maximum of the antimicrobial action of the filter. The study demonstrated that the proposed design of water filter is efficient in removal of turbidity, odour, and microbial content of lake water along with decreasing the acidity of water. Leaves of Tulsi (Ocimum tenuiflorum), Guava (Psidium guajava), Neem (Azadirachta indica), and Duranta repens were tested for antibacterial properties by preparing a leaf extract of each of the leaf samples. Small filter paper tablets were dipped in water extract solution each leaf to make an extract tablet. This along with a whole dried leaf was taken to test for the zone of inhibition when placed on a Petri plate containing Nutrient Agar (2.8 g/100 mL) streaked with serially diluted lake water. These plates were incubated at 37°C for 24 hrs and observed.

Ami Cobb et al. (2012)

A simple, inexpensive, and effective activated carbon production process using local agricultural waste byproducts was assessed for the community of Bluefields, Nicaragua. Coconut shell charcoal was produced on site, and various chemical activation techniques were investigated. The adsorption capacity of three separate chemically activated coconut shell charcoals was analyzed, with sodium chloride—common table salt—being the most efficient and cost effective activating agent. To determine if chemically activated carbon could be produced in the developing world, this project started with a field visit to Bluefields, Nicaragua.

Activated carbon can be developed from many sources, such as cherry stones, macadamia nut shells, and palm husks [10]. Although CaCl2 and ZnCl2 have been proven to successfully produce activated carbon from charcoal,26 they are difficult to obtain and are prohibitively expensive in most regions of the developing world. An inexpensive chemical that could effectively activate charcoal would be necessary if the activated carbon production was going to be feasible. Since CaCl2 is a chloride salt, we performed an experiment with another more readily available chloride salt, NaCl. Since a 25% solution of CaCl2 has been shown to successfully create activated carbon from charcoal, a 50% solution of NaCl was tested to provide an equal concentration of positive and negative charge in solution. As evidenced in Figure 2 below, the charcoal treated with the 50% NaCl solution produced positive results. To potentially reduce costs even further, charcoal treated with a 25% solution of NaCl was tested as well and produced similar results. A blank coconut shell charcoal without any chemical activation step was also tested to ensure that the (non-activated) charcoal was not providing any adsorption. No color change or associated methyl orange removal was observed during this experiment. The positive qualitative results from the tests in Bluefields, given the obvious color change of the methyl orange solution, suggested that common table salt could be used as a replacement for the normal chemical activation agents. However, given the limited instrumentation available, there was no way to quantify and compare the adsorption capacities.

Hajira Tahir Et Al. (2016)

Waste product of sugar mill (bagasse) was used as low-cost adsorbent in its natural, and modified forms for the removal of malachite green (MG) dye. Chemical treatment of sugar cane bagasse (SB) was carried out with formaldehyde and sulfuric acid which produced carbonaceous bagasse (C-SB). The sugar cane bagasse (SB), carbonaceous bagasse (C-SB) and fly ash bagasse (FA-SB) were tested as adsorbents for the removal of malachite green (MG) dye from aqueous solutions. The removal of dye was carried out by the adsorption process under the optimized conditions of concentration of dye, amount of adsorbent, temperature and contact time. The spectrophotometric technique was adopted for the estimation of concentration of dye before and after the adsorption. The reagents used in the study were, sodium hydroxide [NaOH] [pellets pure], hydrochloric acid [HCl] [37% pure], formaldehyde [HCOH] [40% pure], sulfuric acid [H_2SO_4] [98%] and malachite green dye [$C_{23}H_{25}ClN_2$]. Sugar cane bagasse was collected from a local sugar mill. It was washed thoroughly with water to remove the colors and dried in sunlight and kept in electric oven at 100 °C for 24 h. The dried bagasse was ground and sieved to the desired particle size of about 50 μm and used for adsorption studies.

F.V Adams et al. (2014)

Rice hull ash containing amorphous silica was produced from locally available rice hulls (unparboiled and parboiled), using a muffle furnace at 800°C. The ashes obtained from the two rice hulls samples were washed with distilled water and characterized using scanning electron microscope with electron dispersive spectroscopy (SEM/EDS) and BET analysis. The laboratory filtration experiments were carried out in order to study the performance of the rice hull ash in removing turbidity from water. This was done using water with an initial turbidity, pH and total dissolved solids (TDS) of 88 NTU, 6.63 and 127 ppm respectively. The parboiled rice hull ash (PRHA) sample showed higher surface area, but lower pore volume and pore sizes compared to the unparboiled rice hull ash (URHA) sample. Also, PRHA contained higher silica content and sum of the other elemental compositions than the URHA sample. All the ashes used showed controlled pH to the acceptable level (7.00-8.50). A good percentage of turbidity removal up to 96% with increasing TDS (816 ppm) was reached.

Chapter 3

Materials

3.1 Sugarcane Bagasse

Bagasse is sugarcane fibre waste left after juice extraction. Bagasse contains mainly cellulose, hemi cellulose, pentosanes, lignin, sugars, wax and minerals. Sugarcane bagasse was collected from a local sugarcane juice centre in Byculla. It was first washed thoroughly with tap water and again washed with distilled water to remove dirt and metallic impurities and after which it was dried in the oven at about 105 degrees Celsius for 3 hours and 24 hours dried in sun light. The dried bagasse was grounded and made like fine particles to increase its surface area and 0.1M HCL was added in 100gram bagasse. This was used as an adsorbent along with sand as a base material.

Figure 3.1 Sugarcane Bagasse (Sun-dried)

3.2 Rice husk

Rice husk possesses a granular structure, is insoluble in water, and has chemical stability and high mechanical strength, making it a good adsorbent material for treating various wastes from water and wastewater. Rice husks are the hard protecting covering of grains of rice. Around 20% of the paddy weight is Husk. Scientific name for rice is Oryza Sativa. The chemical composition of Rise husk is similar to that of many common organic fibres and it contains of cellulose 40-50%, lignin 25-30%, ash 15-20% and moisture 8-15 %(by Hwang and Chandra 1997). After burning, most evaporable components are slowly lost and the silicates are left. Low value agricultural by rice husk can be made purification of water. Rice husk was collected from a local mill in Byculla. The rice husk was sieved in the mesh in the range of 600 microns in order to increase its surface area. This was used as an adsorbent along with sand as a base material. Obiora-Okafo Ifeoma A. et al. in (2013) studied the removal of fluoride from groundwater by aluminum hydroxide coated Rice husk ash [2]. Activated aluminum hydroxide has been used for activating the RHA surface which forms a complex with fluoride ion in water and accelerates the process of removal.

Figure 3.2 Rice Husk

3.3 Coconut Shell

Coconut shell, a once discarded outer hard cover of a coconut is now a product of great demand. Coconut shell is located in between the coconut flesh and coconut husk. Coconut shells are widely used to make charcoal which is used as fuel and these coconut charcoals are far better than other charcoals. Coconut shell charcoal is widely used to produce active carbon. Over 50,000 coconut shells are required to produce about 1 Tonne of coconut charcoal. It has enormous adsorbing properties and therefore it is used as a food supplement in both animals and humans to promote good health and immunity. A whole lot of eco-friendly uses have made it preferable in many industries like manufacturing of air and water purifiers, odour eliminators and even building golf courses. We collected coconut shells from a local vendor in Byculla Fruit Market and converted the shells into activated carbon in our laboratory.

Figure 3.3 Coconut shells

3.4 River Sand

It removes coliform bacteria, algae, color, and iron and manganese content of water [3,5]. Sand filters work using a complex biological film that grows naturally on the surface of the sand which merely functions as a substrate for the filtration. Slow sand filters work through the formation of a gelatinous layer or biofilm on the top of a layer of fine sand which consists of bacteria, fungi, and protozoa [6]. The surface biofilm is the layer that provides the effective purification in potable water treatment, the underlying sand providing the support medium for this biological treatment layer. As water passes through the hypogeal layer, particles of foreign matter are trapped in the mucilaginous matrix and soluble organic material is adsorbed. The contaminants are metabolized by the bacteria, fungi, and protozoa. The water produced from a slow sand filter is expected to be of excellent quality with significant bacterial cell count reduction [4]. We purchased sand from a shop and the type of sand we got was Gujarat river sand. The sand was sieved through appropriate sized sieves to obtain uniformity in size.

Figure 3.4 River Sand

3.5 Activated Charcoal

Carbon is an extremely porous material that attracts and holds a wide range of harmful contaminants. Activated carbon is carbon which has a slight electropositive charge added to it, making it even more attractive to chemicals and impurities. As the water passes over the positively charged carbon surface, the negative ions of the contaminants are drawn to the surface of the carbon granules [7,8]. It removes chlorine, sediments, and volatile organic compounds that cause pollution and bad odor and improve tastes [4,9]. Activated carbon removes contaminants from water by two mechanisms, adsorption for removal of organic compounds and catalytic reduction involving the attraction of negatively-charged contaminant ions to the positively-charged activated carbon in the removal of residual disinfectants such as chlorine and chloramine. However, it is not effective in removal of minerals, salts, and dissolved inorganic compounds and so hardness cannot be removed.

Figure 3.5 Activated Charcoal

3.6 Gravels

Filter Gravel is an extremely effective filter media because of its ability to hold back precipitates containing impurities present in water. It removes coarser particles present in water. Filter sand size, angularity and hardness are the important filter sand characteristics to ensure proper filtering. The bigger size of the gravels helps to hold back relatively larger sized particles which would otherwise clog the sand layer and thereby reduce the rate of filtration. We obtained gravels from a local construction site in New Panvel for zero cost. The other main purpose of providing the gravel layer at top is that it prevents the sand layer from getting disturbed when water is poured into the filter.

Figure 3.6 Gravels

3.7 Muslin Cloth

We used muslin cloth as a layer to separate two different materials so that the layers stay in their respective positions. Additionally, the cloth also acts as a filter media. In order to increase the effectiveness of cloth, it can be folded twice or thrice and then kept between the material layers.

Chapter 4

Methodology

4.1 Collection of Materials

Containers: Purchased from a local market in Mumbra, Thane.

Coconut Shells: Collected from a local coconut vendor in Byculla.

Rice husk: Rice husk was collected from a rice mill in Vashi

Bagasse: Collected from a local Sugarcane juice shop near AIKTC college campus

Normal Activated Carbon: Bought from D-mart

Chemicals: Chemicals were easily available in our college laboratory

4.2 Experimental Setup

For conducting the experiment and making a model, we have first taken 2 containers having volume of about 1 liter each. The bottles we selected was nearly transparent and it was not having any design or sticker on it keeping in mind that it should not cause any barrier in observation. We kept the bottles one on each other. The top bottle consisted of filter media and some space for supernatant water. We also made tiny holes with the help of a needle at the bottom of the top bottle. We controlled the rate of filtration by opening and closing these holes. The bottom bottle was used to collect the filtered water.

Then we have placed our materials in layers each having the thickness of 3 cm. We have restricted the thickness of each layer to 3 cm only, because we needed to keep the weight as low as possible. The bottom most layer was of activated carbon having size of about 1mm to 5mm, the middle layer was of sand, which was passing through 2.36 mm and retaining on 1.7mm, and the final top most layer was coarse aggregate having size of about 10mm to 20mm

Figure 4.1 Experimental Setup

4.3 Preparation of AC from Coconut Shells

We needed to convert the coconut shells into activated carbon and for that, we did the following procedure:

1. First, we sundried the coconut shell for 24 hours to remove the moisture from it. We did this because if we directly put the coconut shell into the furnace, then the oil and water will leak out of it which will cause damage to the equipment.

2. Then we heated it in an anaerobic environment, for that we used muffle furnace at 900 degree Celsius for about 3 hrs.

3. We let the burnt coconut shells to cool down completely and then we crushed the coconut shells and obtain a uniform size in the range of 3 mm to 5 mm.

4. After burning, what we get is only charcoal not an activated carbon. To convert it into activated carbon, we need to activate it either by steam heating method at 1000℃ or by chemical activation method. We adopted chemical activation method. For this, we use 50% NaCl solution. NaCl is nothing but sodium chloride that is table salt which is easily and readily available and also cost friendly. Another method of chemical activation is by using zinc chloride (ZnCl) or calcium chloride(CaCl) for which 25% solution is required to activate the carbon. But these chemicals are quite expensive and may not be available in rural areas. So we suggest to use NaCl solution.

5. The charcoal is now activated and can be used for filtration.

6. Before using the activated carbon it is recommended to wash it with clean water to remove blackish colour from it.

Figure 4.2 Burnt Coconut Shell

Figure 4.3 Muffle Furnace

4.4 Preparation of bagasse

For preparation of bagasse,we adopted the following procedure:

1. We thoroughly washed the collected bagasse with clean water for removing any possible contaminants and for removing any sugar content left.

2. Then it was sundried for 24 hours for removing moisture. The main purpose of sun drying the bagasse was to make it dry and crunchy so that it can be easily ground into smaller particles.

3. Then it was washed again till clear water was obtained.

4.Now, the bagasse was ready to use in our filter.

Figure 4.4 Bagasse

4.5 Preparation of Rice Husk Ash

The method used in preparing the rice husk ash (RHA) samples are discussed below:

1. Rice husk samples were washed using distilled water to remove contaminants and thereafter dried at 110 °C for 24 hours in an oven.

2. Incineration of the rice husks was done under static air in a porcelain crucible for 4 hours before obtaining the final ash by burning the incinerated ash in a muffle furnace (Model BTL) at 800 ℃ for 7 hours.

3. The RHA was ground using mortar and pestle and were classified to obtain 0.2 mm particle size.

4.Now, the RHA is ready to be used in the filter.

Figure 4.5 Rice Husk Ash

4.6 Test for Turbidity

We tested the turbidity of the filtered water with the help of digital turbidimeter. Before testing, we calibrated the instrument with KCl solution having a turbidity of 400 NTU. Then the water samples were tested and the results were noted.

Figure 4.6 Digital Turbidimeter

Chapter 5

Results and Discussions

5.1 Summary

It is a well-known fact that turbidity removal efficiency depends greatly upon the rate of filtration. Proper removal efficiencies are achieved with longer contact time. Therefore, we tested the turbidity removal efficiencies of materials by changing the rate of filtration and see which combination of layers gives better results.

5.2 Using combination of gravel, sand and readily available activated carbon from the market

Weight of the filter = 1.48 kg

The following efficiencies were recorded for different filtration rates:

Table 5.1 Observations for readily available AC

Filter rate (ml/min)	Final Turbidity (NTU)	% Removal
250	15.04	68
200	13.16	72
150	8.93	81
100	5.64	88
50	3.76	92
Initial Turbidity of the water was 47 NTU		

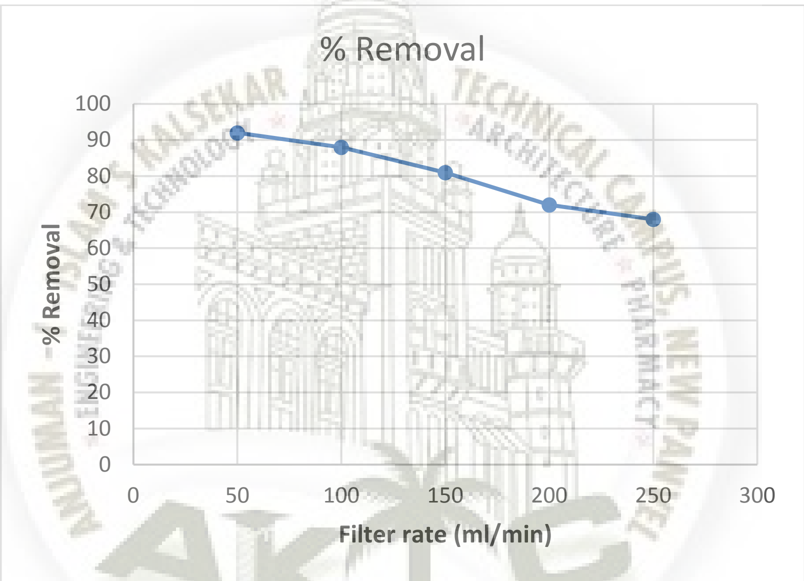

Figure 5.1 Filter rate v/s Efficiency for readily available AC

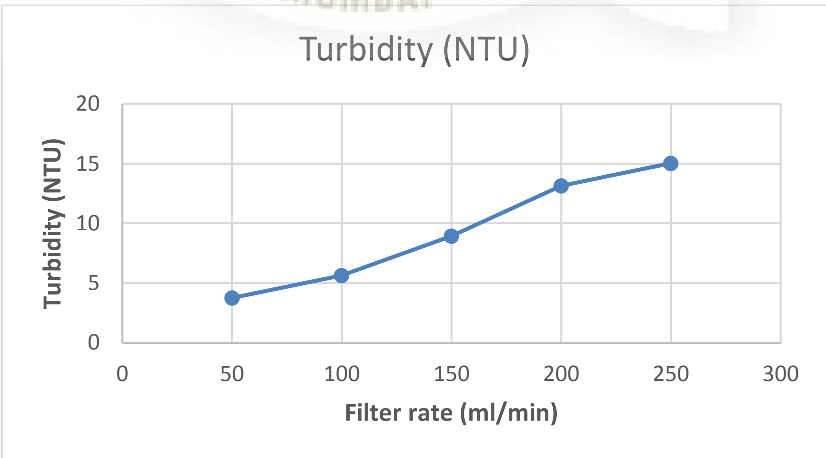

Figure 5.2 Filter rate v/s Final turbidity for AC

5.3 Using combination of gravel, sand and coconut shell based AC

Weight of the filter = 1.48 kg

The following efficiencies were recorded for different filtration rates:

Table 5.2 Observations for Coconut Shell AC

Filter rate (ml/min)	Final Turbidity (NTU)	% Removal
250	22.05	55
200	16.17	67
150	12.25	75
100	5.4	89
50	4.41	91
Initial Turbidity of the water was 49 NTU		

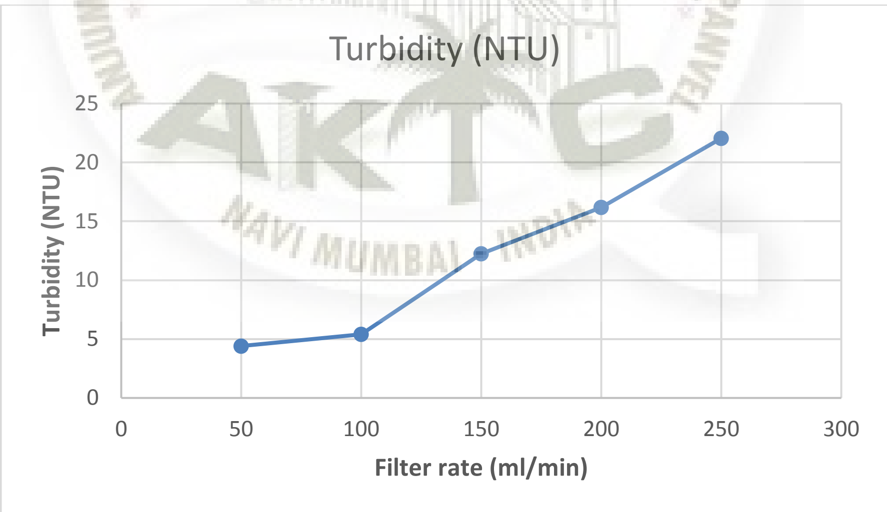

Figure 5.3 Filter rate v/s Final turbidity for coconut shell AC

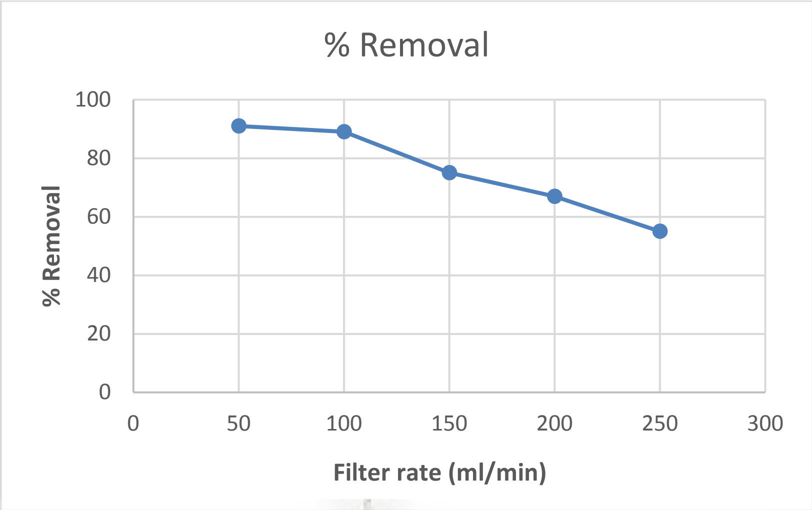

Figure 5.4 Filter rate v/s Efficiency for coconut shell AC

5.4 Using combination of gravel, sand, bagasse and coconut shell based AC

Weight of the filter = 1.6 kg

The following efficiencies were recorded for different filtration rates:

Table 5.3 Observations for Coconut Shell AC, bagasse and sand

Filter rate (ml/min)	Final Turbidity (NTU)	% Removal
250	16.92	64
200	13.16	72
150	10.34	78
100	3.29	93
50	1.88	96
Initial Turbidity of the water was 47 NTU		

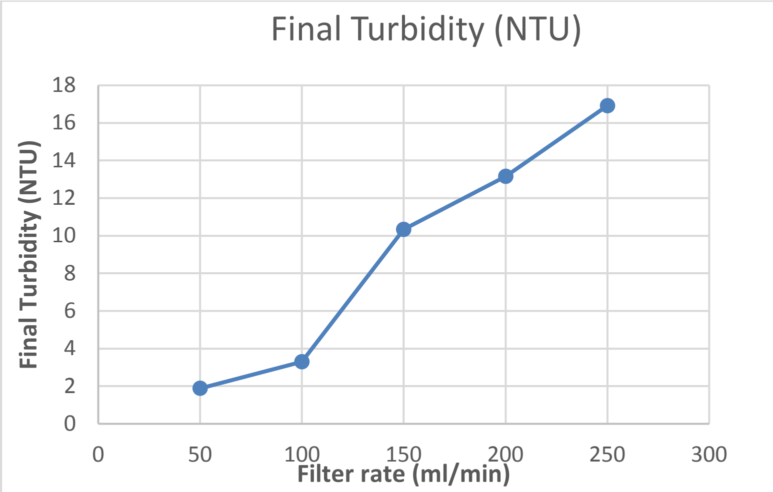

Figure 5.5 Filter rate v/s Final turbidity for coconut shell AC, bagasse and sand

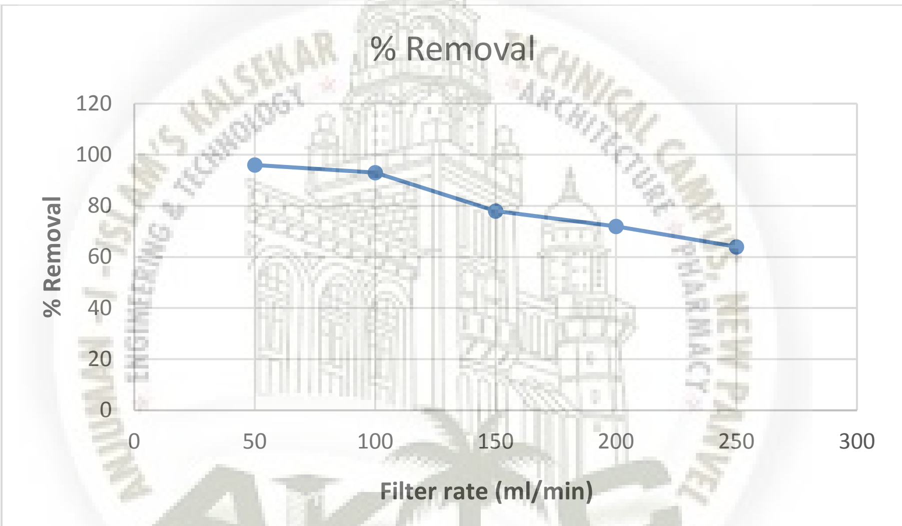

Figure 5.6 Filter rate v/s Efficiency for coconut shell AC, bagasse and sand

5.5 Using combination of gravel, bagasse and coconut shell based AC

In this setup, we replaced sand completely with bagasse in order to reduce the weight of filter to make it truly portable.

Weight of the filter = 840 g

The following efficiencies were recorded for different filtration rates:

Table 5.4 Observations for Coconut Shell AC, bagasse

Filter rate (ml/min)	Final Turbidity (NTU)	% Removal
250	27.84	42
200	25.92	46
150	23.52	51
100	17.28	64
50	16.8	65
Initial Turbidity of the water was 48 NTU		

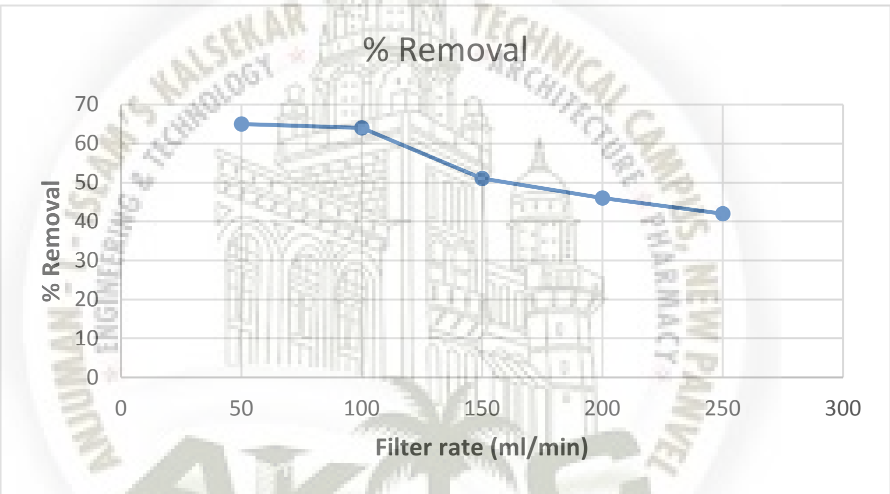

Figure 5.7 Filter rate v/s Efficiency for coconut shell AC and bagasse

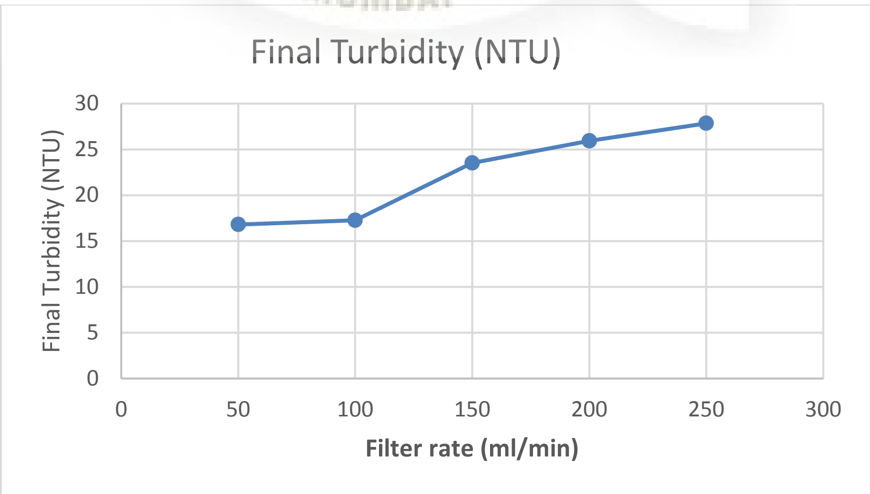

Figure 5.8 Filter rate v/s Final turbidity for coconut shell AC and bagasse

5.6 Using combination of gravel, sand and RHA

Weight of filter = 1.3 kg. The following results were observed:

Table 5.5 Observations for RHA and sand

Filter rate (ml/min)	Final Turbidity (NTU)	% Removal
250	24.48	49
200	22.56	53
150	18.24	62
100	13.44	72
50	7.2	85
Initial Turbidity of the water was 48 NTU		

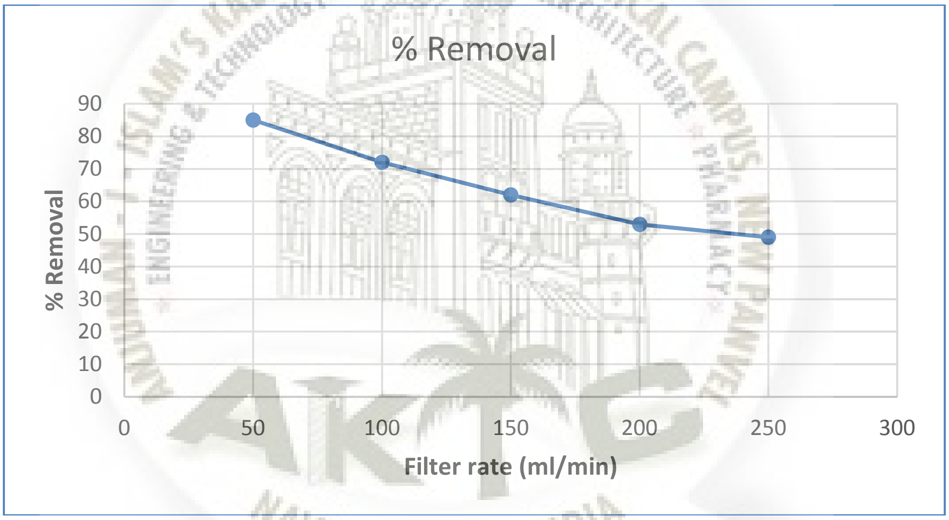

Figure 5.9 Filter rate v/s Final turbidity for coconut shell AC and bagasse

5.7 Effect on pH

The pH of water was not affected significantly by the process no matter which combination of layers we used. There was only a slight difference of 0.1 to 0.3 pH in the before and after results. This is because filtration is a physical process and it does not much effect on the chemical properties of the water. Any ways, the water we collected from the lake had a pH ranging between 6.7 to 7.9 which is already in the permissible range of 6.5 to 8.5. The pH test was conducted in our laboratory by using a digital pH meter.

Chapter 6

Conclusion

By considering all the results, we would like to conclude that the best combination of materials was of gravel, sand, bagasse and coconut shell based activated carbon, which gave the optimum turbidity removal i.e. 96%. But using all the layers increased the weight of the filter. The lightest weight was achieved when sand was completely replaced with bagasse. But the turbidity removal was not efficient enough. The combination of gravel, sand, and coconut shell based activated carbon gave appreciable results by not only removing the turbidity but also maintaining the weight of the filter. Rice Husk ash also gave good results, but they were not better than coconut shell based AC.

Coconut Shells are easily available everywhere, especially in rural areas. So they can be used as a an alternative to other materials for Activated Carbon and used in water filters. Also they can be easily manufactured in small scale as well as large scale.

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LIST OF PUBLICATIONS

Project Exhibition

Participated In 5th National Level Project Exhibition Cum Poster And Paper Presentation At Universal College Of Engineering, Vasai and secured **3rd Prize**.

Publications

Published a paper titled "Treatment of water using various filtration techniques: A Review Study" at NICMAR International Conference held in Pune.