Development of a Series Filtration Water Treatment Method for Small Communities

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CERTIFICATE

“To whomsoever it may concern”

This is to certify that **Mr. Saurabh Upadhyay** has carried out his research work presented in this thesis entitled **“Development of a Series Filtration Water Treatment Method for Small Communities”** for the award of Master of technology in ‘Civil Engineering' from Department of ‘Civil Engineering', Babu Banarsi Das University, Lucknow, under my supervision. The thesis embodies results of original work and studies are carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University.

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I hereby certify that the work which is being presented in this thesis entitled **"DEVELOPMENT OF A SERIES FILTRATION WATER TREATMENT METHOD FOR SMALL COMMUNITIES"** in partial fulfilment of award of degree of Master of Technology in **Civil Engineering** submitted in Department of Civil Engineering, Babu Banarasi Das University, Lucknow is an authentic record of my own work carried under the supervision of **Dr. Arif Siddiquie,** Associate Professor, BBD University, Lucknow, India.

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ABSTRACT

Nowadays, water quality has become the major Issue as best quality water is needed for their daily lives. There are many types of treatment to improve water. Water treatment technologies have evolved over the past few centuries to protect public health as more than a billion people on this earth have no access to clean potable water that is free of pathogens. India is one of populated countries in world with poor people who are unable to afford a clean portable water quality. The series filtration system of treating surface water using local materials for filter media was studied for the purposes of determining: The efficiencies of the single media and dual media to remove microorganisms, colour and turbidity.

Keywords: Natural filtration, Coconut husk, Coconut shell.

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(Saurabh Upadhyay)

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LIST OF ABBREVIATIONS

Cm	Centimeter
G	Gram
g/cm^3	Gram per cubic centimeter
BIS	Bureau of *Indian Standards*
Kg	Kilogram
kg/m^3	Kilogram per cubic meter
kN/s	Kilo Newton per second
L	Liter
L/m^3	Liter per cubic meter
M	Meter
m^2/kg	Square meter per kilogram
Mm	Millimeter
N/mm^2	Newton per square millimeter
µm	Micrometer
°F	Degrees Fahrenheit
°C	Degree Celsius
%	Percent
AC	Activated Carbon
DO	Dissolved Oxygen
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TH	Total Hardness
TDS	Total Dissolved Solids

CHAPTER 1

INTRODUCTION

1.1 Overview

All industries of distillery, milk industry, vegetable oil, pouring effluent directly into Gomti and besides this domestic waste water are also discharge into the River Gomti. Industries discharge their liquid waste products into rivers. Our agriculture practice that uses chemical fertilizers and pesticides also contribute to river pollution as rainwater drains these chemicals into the rivers. Domestic wastes that we throw into rivers adds to pollution levels. As population grows, the size of towns and cities also grows. Studies show that domestic and industrial sewage, agricultural wastes have polluted almost all of Indian rivers. Most of these rivers have turned into sewage carrying drains. This poses a serious health problem as millions of people continue to depend on this polluted water from the rivers. Water-borne diseases are a common cause of illness in India today.

Areas of the developing world are populated with poor people who are unable to fulfill the basic needs for Clean water and India is one of them. As the population increasing day by day the demand of water for food production, domestic activities as well as industrial activities also increasing day by day. Water is no doubt essential for life but the large quantity of water in the world is polluted due to the excessive contamination and inputs of untreated industrial effluents, household dirty water and sewage water along with farming wastes and decaying materials of human, animals and plants. The quality of water is vital concern for mankind since it is directly linked with human welfare and due to the limited quantity of available water for use, proper management and prevention is very necessary to fulfill the long term requirement and needs of the vast population for daily house hold use and requirements like agriculture etc. Water treatment plant is being designed for proper filtration of water . Treating it properly after all treatment process or trying to manage the good condition in water . Rain water is an important source to feed the ground water aquifer, which is done directly or by harvesting and recharging. Purification is always a need from the ancient age of civilization. The importance of purification is for reducing the risk of pollutants from the recharging run off rain water and for avoiding the various diseases. So the central and state government are taking effort to provide adequate and safe drinking water to society by constructing water treatment plants in India . In India rapid sand filter are mostly used to removed the suspended and colloidal particles from water in filtration process for the faster rate by setting out the different sand beds in constructing it. The use of sand filter as a technique consider not expensive and commonly use to remove contaminants from water and waste water treatment in industries . The filtration process undergoes degradation at initial and last phase which affect the initial quality of filtrate after back washing . There are some waste to deal with initial filtrate quality problem as filtrate to waste, delay start , slow start and filter conditioning by coagulant during backwashing. Also the use of coconut shells in filtration is act as a dual media in the filtration . Designing 'Dual media filter capped with crushed coconut shells' and coconut husk proves to be more efficient, economical and durable . It improves the performance of filter in terms of high filtration rate, increase filter run, considerably reduce backwashing requirements, high turbidity removal and thus making it more applicable for drinking purpose and for further uses. Slow sand filters or rapid sand filters or using local materials as filter media are considered to be an attractive alternative for producing potable water in rural communities in India. These are as rarely have qualified technicians to operate a conventional coagulation rapid sand filter effectively. The availability of land, labor, local materials, no chemicals required and climatologically conditions in India favour the use of slow sand filters which would be an inexpensive method of treating surface water.

1.2 Water Pollution

Water pollution is a major problem in the global context. It has been suggested that it is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily. An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indian children die of diarrhea sickness every day. Some 90% of China's cities suffer from some degree of water pollution, and nearly 500 million people lack access to safe thinking water. In addition to the acute problems of water pollution in developing countries, industrialized countries continue to struggle with pollution problems as well. In the most recent national report on water quality in the United States, 45 percent of assessed stream miles, 47 percent of assessed lake acres, and 32 percent of assessed bay and estuarine square miles were classified as polluted. Figure 1.1 shows how people pollute the river bank.

Figure 1.1 Pollution at river bank

Figure 1.2 Polluted River Water

1.3 Types of Pollution

Surface water and groundwater have often been studied and managed as separate resources, although they are interrelated. Sources of surface water pollution are generally grouped into two categories based on their origin (Wikipedia, 2010).

1.3.1 Point source pollution

Point source pollution refers to contaminants that enter a waterway through a discrete conveyance, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain. The U.S. Clean Water Act (CWA) defines point source for regulatory enforcement purposes. The CWA definition of point source was amended in 1987 to include municipal storm sewer systems, as well as industrial storm water, such as from construction sites (Wikipedia, 2010).

1.3.2 Non-point source pollution

Non-point source pollution refers to diffuse contamination that does not originate from a single discrete source. NPS pollution is often accumulative effect of small amounts of contaminants gathered from a large area. The leaching out of nitrogen compounds from agricultural land which has been fertilized is a typical example Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest is also cited as examples of NPS pollution (Wikipedia, 2010).

1.4 Causes of Pollution

Many causes of pollution including sewage and fertilizers contain nutrients such as nitrates and phosphates. In excess levels, nutrients over stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs our waterways, use up dissolved oxygen as they decompose, and block light to deeper waters. This in turn, proves very harmful to aquatic organisms as it affects the respiration ability or fish and other invertebrates that reside in water (Krantz and Kifferstein, 1997).

Pollution is also caused when silt and other suspended solids, such as soil, wash off plowed fields, construction and logging sites, urban areas, and eroded river banks when it rains. Under natural conditions, lakes, rivers, and other water bodies undergo Eutrophication, an aging process that slowly fills in the water body with sediment and organic matter. When these sediments enter various bodies of water, fish respiration becomes Impaired, plant productivity and water depth become reduced, and aquatic organisms and their environments become suffocated. Pollution in the form of organic material enters waterways in many different forms as sewage, as leaves and grass clippings, or as runoff from livestock feedlots and pastures. When natural bacteria and protozoan in the water break down this organic material, they begin to use up the oxygen dissolved in the water. Many types of fish and bottom-dwelling animals cannot survive when levels of dissolved oxygen drop below two to five parts per million. When this occurs, it kills aquatic organisms in large numbers which leads to disruptions in the food chain (Krantz and Kifferstein, 1997)

1.5 Water Pollution Sources

The major sources of water pollution can be classified as stated below-

- municipal
- industrial
- agricultural

Municipal water pollution consists of waste water from homes and commercial establishments. For many years, the main goal of treating municipal wastewater was simply to reduce its content of suspended solids, oxygen-demanding materials, dissolved inorganic compounds, and harmful bacteria. In recent years, however, more stress has been placed on improving means of disposal of the solid residues from the municipal treatment processes. The basic methods of treating municipal wastewater fall into three stages:

- Primary treatment, including grit removal, screening, grinding, and sedimentation;
- Secondary treatment, which entails oxidation of dissolved organic matter by means of using biologically active sludge, which is then filtered off.
- Tertiary treatment, in which advanced biological methods of nitrogen removal and chemical and physical methods such as granular filtration and activated carbon absorption are employed. The handling and disposal of solid residues can account for *25* to *50* percent of the capital and operational costs of a treatment plant.

The characteristics of industrial waste waters can differ considerably both within and among industries. The impact of industrial discharges depends not only on their collective characteristics, such as biochemical oxygen demand and the amount of suspended solids, but also on their content of specific inorganic and organic substances. Control can take place at the point of generation in the plant. wastewater can be pretreated for discharge to municipal treatment sources; or wastewater can be treated completely at the plant and either reused or discharged directly into receiving waters.

1.6 Activated Carbon

Activated carbon, is a form of carbon that has been processed to make it extremely porous and thus to have a very large surface area available for adsorption or chemical reactions. The word *activated* in the name is sometimes replaced with *active.* Due to its high degree of microporosity, just one gram of activated carbon has a surface area in excess of 500 m2, as determined typically by nitrogen gas adsorption. Sufficient activation for useful applications may come solely from the high surface area, though further chemical treatment often enhances the adsorbing properties of the material. Activated carbon is usually derived from charcoal Activated carbon has been widely used in many fields, and can be produced from a variety of carbonaceous source materials. Coconut shell is suitable for preparing

microporous activated carbon due to its excellent natural structure and low ash content. Activated carbon can be produced by chemical activation or physical activation. In chemical activation, problems concerning corrosion, wastewater treatment and production cost prohibited further development of this technology. Physical activation with steam or CO_2 as activation agent is simple in process, which does not produce wastewater. However, using this approach, the overall yield of an activated carbon (surface area about 1000m2.g-t) from coconut shell is about 8% (by mass). Air activation is economically attractive for its high yield, overall short activation time and low energy cost, but it is not often used as the high reactivity is very difficult to control. However, it has been shown that the high reactivity can be restrained under some condition. In the three-step process, charcoal needs to be heated to high temperature twice which means much energy is to be consumed and it needs several hours to be cooled down to the oxygenation temperature from the high carbonization temperature before the charcoal is Oxygenated.

1.6.1 Types of Activated Carbon

Normally there are two types of activated carbon used which were as follows-

- Formed Activated Carbon (FAC)
- Granular Activated Carbon (GAC)

Granular Activated Carbon is common in water treatment and very effective for micro-pollutant removal. While FAC is different in shape which is cylindrical shape and effects better hydraulic condition and pore size distribution compared to GAC (John, 2003).
However, according to (Acardio et al, 2003), there were three types of activated carbon which are as follows-

- Powdered Activated Carbon (PAC)
- Granular Activated Carbon (GAC)
- Activated Carbon Fiber (ACF).

1.6.1.1 Granular Activated Carbon (GAC)

It is defined as a highly porous adsorbent material, produced by heating organic matter, such as coal, wood and coconut shell, in the absence of air, which is then crushed into granules. Activated carbon is positively charged and therefore able to remove negative ions from the water such as ozone, chlorine, fluorides and dissolved organic solutes by absorption onto the activated carbon.

1.6.1.2 Activted Carbon Fiber

The activated carbon must be replaced periodically as it may become saturated and unable to absorb. Activated carbon is not effective in removing heavy metals. Activated carbon is often used as a filter in water treatment systems, where water is directed downwards through a stationary bed of activated carbon, leaving organic material to accumulate at the top of the bed. Activated carbon is similarly used to lower radon levels in water. Also available in powdered form (Green Facts, 2007). According to Wikipedia, Granular activated carbon has a relatively larger particle size compared to powdered activated carbon and consequently, presents a smaller external surface. Diffusion of the adsorbate is thus an important factor. These carbons are therefore preferred for all absorption of gases and vapours as their rate of diffusion are high.

1.7 Rapid Sand Filter

Rapid sand filter is commonly used in the treatment of surface water supplies. The filter area is divided into at least two separate units to allow operational flexibility. Some form of pre-treatment of the raw water, such as sedimentation, is usually needed. Most of the conventional water treatment plants are overloaded due to increased demand which highlights the need of higher filtration rate. Dual media and multimedia filters can overcome these limitations of rapid sand filters. Alternatively, higher filtration rates even can be achieved. However, the use of such techniques is limited in India due to unavailability of filter materials apart from sand.

1.8 Capping

Capping of existing rapid sand filters is the promising method of improving the performance of rapid sand filters. Capping is a process of covering the filtration media by appropriates caps such as Anthracite coal, Bituminous coal, Crushed coconut shells, etc. Capping involves the replacement of a portion of the sand with appropriate caps. Such an improved filter, though inferior to the originally designed dual media filter, is better than the conventional Rapid Sand Filters from the point of view of the rate of filtration as well as total filter run. The proposed study was made to assess the use of coconut shell as a capping media.

Figure 1.3 Capping Material-crushed bricks

1.9 Filtration

Filtration is a process that is widely used for removing fine particles from water remains after the process of clarification. Almost all conventional surface water treatment facilities and some groundwater treatment facilities make use of rapid sand filters (RSF). The depth of filter bed is generally 60cm to 75cm thick with sand of effective size 0.45 to 0.70 mm and uniformity coefficient of 1.3 to 1.75. The major drawback of RSF is stratification of filter bed after backwashing as fine particles takes more time to settle as compared to coarser particles (Stoke's Law). Large numbers of existing RSFs are facing the problems like, bad overall performance and unsatisfactory water supply besides unsatisfactory operation and maintenance. Most of the rapid sand filter beds are suffering by the troubles like mud ball formation, unsatisfactory effluent and higher backwash water requirement. Also most of the conventional water treatment plants are overloaded due to increased demand which highlights the need of higher filtration rate. Dual media and multimedia filters can overcome these limitations of rapid sand filters. Alternatively, higher filtration rates even can be achieved. However, the use of such techniques is limited in India due to unavailability of filter materials apart from sand.

1.10 Conventional Water Treatment

For the treatment of raw waters, the conventional pretreatment consisting of chemical mixing flocculation and clarification is necessary to remove the turbidity load before putting the water on the filter beds. The capital as well as the maintenance cost of the conventional pretreatment units are considerably high. At the same time the conventional pretreatment, with the coagulation and clarification processes is the most delicate process to handle in the whole of the water treatment processes. The various chemical reactions involved are complicated and are yet to be understood completely and are still under active research. The mechanical equipments required in the chemical mixing, flocculation, and clarification processes make this problem still more difficult particularly for the construction and maintenance of the small capacity water treatment plants in the villages, in the developing countries.

The 40 year old conventional drinking water treatment plant of the Manipal University at Parkala supplies almost 6 million liter drinking water per day to the whole university campus. The water is pumped from the Baje Dam positioned at the upstream side of Swarna River which is approximately 13km away. The river water is pumped and stored in back pressure tank of 50000 liter capacity at Hiriadka. From there it is finally pumped to the treatment plant where the water passes a 3m diameter aerator to liberate dissolved gasses and volatile substances. After aeration and alum dosage water enters into the clarriflocculator for settlement of heavy clumps of particles and coagulants. From there it is directed towards two rapid sand filters of 39.6m2 area each. Before distribution to the university the filtered water is disinfected by chlorine. Compliance with the drinking water regulation was guaranteed every time.

However, discussion about constant change in the raw water quality due to increasing industrial settling, agricultural run-offs and urbanization around the surface water resulted in thinking about a further improvement of the existing water treatment process with respect to removal of iron, suspended solids and overall organics. This will also help to meet the drinking water standards more strongly. Therefore, in this paper a study is being done using an activated carbon for the filtration process. A lot of agricultural waste and by product have successfully converted to activated carbon for examples

- macadamia nutshell,
- paper mill sludge
- peach stones.

Coconut-based agricultural wastes have gained wide attention as effective biosorbents due to low-cost and significant adsorption potential for the removal of various aquatic pollutants. The various parts of coconut tree such as coir, shell, pith etc. have been extensively studied as biosorbents for the removal of diverse type of pollutants from water. For several years activated carbon has gained wide application in the treatment of waste water. However, this paper deals with AC derived from coconut shell in water treatment for the production of polished water for drinking purpose at commercial level. This technique can also be looked upon as the solitary treatment in the water treatment plant with few modifications in the future.

Due to their high carbon content and hardness, coconut shells are an excellent raw material source to produce activated carbon. Activated carbons that are produced using coconut shells as the raw material are often sourced in geographic regions where coconuts are harvested, including India, Malaysia, Sri Lanka, and the Philippines. Activated carbons produced from coconut shells typically have a tighter, more micro porous pore structure than their coal-based counterparts. This is due to the inherent pore structure of the raw material coconut shell as compared to raw material coals. This micro porosity lends itself towards certain applications where activated carbon is used. Also, coconut shell-based carbons tend to be harder, more resistant to abrasion, and lower in ash than similar grades of coal-based carbons. The major advantage with the coconut shell activated carbon is that it is an outstanding material for applications requiring taste, odor and dissolved organic chemical removal from water with suspended particle present. In addition, its balanced pore structure gives a more efficient adsorption range and it imparts a high "polish" to the filtered water.

The most unique function of this material is its ability to absorb the organic matter present in the water which would otherwise react with the chlorine from disinfection to form 'Disinfection by-products' (DBPs). Studies have suggested that exposure to very high levels of certain DBPs resulted in kidney and liver damage, reproductive effects, and cancer. It has been estimated that almost 90000 nuts are required to yield 1 tone of activated carbon.

1.10.1 HISTORY OF WATER TREATMENT

Water treatment including filtration and its importance to the health and welfare trace back 4000 years: "it is good to keep water in copper vessels, to expose it to sunlight and filter through charcoal." and, " heat foul water by boiling and exposing to sunlight and by dipping seven times into it a piece of hot copper, then to filter and cool in an earthen vessel." In these we can see disinfection, coagulation, sedimentation, and filtration – the same four basic steps are used in water treatment today i.e. a multiple barrier approach. Hence use of rapid filter has proved to be beneficial. Along with some advantages there are some drawbacks in rapid sand filter. Stratification of sand layers at time of backwash, mud ball formation, rapid increase in head loss, low effluent quality these problems are related to rapid sand filters. As the head loss builds up, the filter requires backwashing, and the filter run is reduced. This difficulty can be removed if filtration takes through from coarser to fine media by using rapid sand filter with capping. India is a second country which has a maximum population. As the population increases water demand also increases. So it is necessary to purify raw water."Rapid Sand Gravity Filter" is a best option to remove impurities from water. Arrangement and Working of Rapid Sand Gravity Filters is easy. But there are some Drawbacks. The main drawback is the time of Backwash is less. Due to backwash the Energy needed is high. Which affects on cost. So it is necessary to increase the backwash time. This Backwash time is increased by using suitable material in mechanism. Generally these specific materials are used on the top of all layers in mechanism, so these materials are known as capping materials. Capping materials are: Anthracite coal, Crushed Bricks, Coconut etc. In Rapid sand filtration sand is used as filter media same as used in conventional filter but process is somehow different for the modified rapid sand filter. This is so because in rapid sand filtration coarser sand is used with an effective grain size in the range 0.35-0.60 mm, and the rate of filtration is between 5 and15 m/h. because coarser sand is used, the pores of the filter bed are relatively large and the impurities contained in the raw water settled down into the filter bed. Thus, the capacity of the filter bed to store deposited impurities is much more. Conventional Rapid sand filters, used in India nowadays. BT it has many drawbacks such as mud ball formation, requirement of water is high for backwash etc. So overcome these problems this modified raid sand filtration will be best alternative.

If the history of water treatment is considered for the development of the water treatment processes the important steps can be described as below.

1.10.1.1 Slow Sand Filters

These filters were first developed in England by about 1830 and were then adopted all over the world. The slow rate of filtration of about 100 to 500 l/m2/h, through the fine sand bed of average effective sand size of 0.3 mm and uniformity coefficient up to 2.5, and its cleaning by scrapping the top layer of sand of 1 to 2 cm. for a limiting head loss of 0.5 m, are its main design features. However there is important limitation for the raw water turbidity to be applied on these filters, which should be normally within 30 units. Coagulation is not recommended before this filter for its proper functioning. The main action of the purification of water through this filter bed is said to be done by the biological activity through the various algal and bacterial colonies in the filter bed. Thus this filter is mainly suitable for treating the clean and low turbidity raw waters which are polluted by dissolved organic matters. These filters are more efficient than high rate filters in removing the bacterial load in the raw waters. This special biological aspect of the treatment is not possible in high rate filters. Hence for treating polluted turbid raw waters, high rate pre filters have been provided at some places before the slow sand filters. If the turbid raw water are directly applied on the slow sand filters then there is possibility of early clogging of the filter beds and at times even developing anaerobic conditions in the filter beds.

1.10.1.2 Rapid Sand Filters

These filters were developed first in America in the beginning of this century and were then spread in the other parts of the world. The main advantage of this filter is that, the filter can treat turbid raw water with the adoption of the pretreatment before the filter bed and with the use of back wash, the filter bed can be brought to its original conditions. The rate of filtration adopted is generally from 5000 to 10000 1/m /h, depending on the type of pretreatment method and raw water quality for a limiting head loss of 2 to 2.5 meters. This is the most common filter in use in the world including India at present.

1.10.1.3 Up flow Filters

These filters were first developed in the European countries and USSR and then spread in the other parts of the world. These filters with the same back wash arrangements as that of a rapid sand filter have the additional advantage of effective utilization of the full filter depth due to the upward direction of the flow. When the raw water is fairly clean throughout the year, the up flow filter can be directly adopted, without the necessity of pretreatment, where such filters are known as contact clarifiers. These filters generally require deep beds and are not adopted for the high rate filtration due to the possibility of break-through of the filter-bed due to the buoyancy effect when filter bed gets clogged.

1.10.1.4 Bi flow Filter

A combination of up flow and down flow filter which is known as bi flow filter has also been developed in some countries. However these filters have not become common in practice for the various operational difficulties.

1.10.1.5 Dual and Multimedia Filters

These filters have come into practice during the decade 1960-1970 in America, England and some other countries. This filter can be adopted directly when the raw water is moderately clean throughout the year, as in the case of up flow filter. However, this filter has got some advantages over the up flow filter as the flow direction is downwards as in a rapid sand filter bed, and the depth of the filter bed is considerably less as compared to the up flow filter. In addition to this, there is no buoyancy effect of filter bed as observed in the case of up flow filter bed. These filters can be designed for very high rate of filtration of 10,000 to 15,000 l/m2/h. Thus this filter may be the cheapest as compared to the others and may be a popular filter in the future, provided the suitable quality and cheap filter media are available locally in the required quantities.

1.11 Filter troubles

Some of the potential filter troubles are as follows:

1.11.1 Cracking and clogging of filter bed

Surface cracking and clogging are usually caused by rapid accumulations of solids on the top surface of the filter media. The formation of soft, gelatinous coatings on the sand grains tends to form cracks in the filter, as the head loss is increased. The effect is that it permits the dirty matter to penetrate into the filter media.

1.11.2. Formation of mud balls

Mud balls are conglomerations of coagulated turbidity, floc, sand, and other binders and are formed near the top of the filter media. Mud balls are formed due to insufficient washing of sand grains. Mud may accumulate on the sand surface and may form a dense mat. A 50 % expansion of the sand in washing is effective in minimizing the production of mud balls.

1.11.3 Air binding

The condition of air binding is caused by the release of dissolved gases and air from water , to form bubbles. These air bubbles occupy the void space of the filter media and the drainage system Air binding may be minimized by providing a water depth of at least 1.5 m above the unexpanded filter bed.

1.11.4 Jetting and sand boils.

Jetting and sand boils result during backwashing when back wash water follow path of least resistance and break-through the scattered points due to small differences in porosity and permeability of sand and gravels.

1.12 Performance of rapid sand filter

1.12.1 Turbidity

If the influent water does not have turbidity of more than 35 to 40 ppm, the filter can reduce the turbidity to less than 1ppm.Since coagulation and sedimentation always precede filtration, the turbidity of water applied to filter is always less than 35 to 40 ppm.

1.12.2 Colour

Rapid sand filters are very efficient in colour removal .The intensity of colour can be brought down below 3on cobalt scale. Colourless water can be produced by rapid filtration after the addition of polyelectrolyte.

1.12.3 Iron and manganese

Rapid filters remove oxidized or oxidizing iron, though it is less efficient in removing manganese.

1.12.4 Taste and odour

Unless special treatment such as activated carbon or prechlorination is provided, rapid filters will not ordinarily remove tastes and odours.

1.13 PROBLEM STATEMENT

Studies shows that various factors affecting filtration rates , factors to be considered were the quality of raw water, pretreatment facilities, sand size, bed depth, head conditions and hydraulic conditions in the filter piping, SOME studied the various factors affecting filtration rates , factors to be considered were the quality of raw water , pretreatment facilities, sand size , bed depth , head conditions and hydraulic conditions in the filter piping. The design of filters will use coconut shell and unburnt shredded coconut husk and sand gravel for slow sand media . It is been almost exclusively based on practical experience, which has demonstrated hat satisfactory filter runs can be obtained with usual design and pretreatment during those times of the year when filtration occur in cold weather conditions in high concentrations of very tiny particles bed but this difficulty in condition is not important in Asia . The ability of the sand filter to remove turbidity is a function of the size of the passage through the sand . Thus , sand of 0.5 mm diameter is twice as good in removing turbidity as sand of 0.7 mm size , and sand of 0.35 mm size is twice as good as 0.5 mm sand . The finer sand will produce a better quality of filtered water but it also produces short filter runs . If the effective size of the filter sand is halved , the filter run will be shortened to one quarter of their former length. They all had the same size of sand and were operated at the same rate of filtration , the length of runs were practically indistinguishable but there was a real difference in the water quality produced . The higher the filtration rate is, the shorter the filter run and the worst quality will be during critical periods. The total head loss to which the filter is operated is one of the most critical factors in determining the quality of the filtered water . When a filter is operated at a constant rate, as the bed clogs up, more empty space in the sand is accepted by solids strained out of the water . The water is forced to go up faster through the remaining space to maintain the same total flow . Velocity increases as the loss of head increases , solid materials in the applied water continue to penetrate deeper and deeper into the bed . Another factor that can severely upset the operation of filter is unsteady flow.

1.14 Objective of Current Work

The series filtration system of treating surface waters and wastewater using local materials for filter media was studied for the purposes of determining the efficiencies of the single media and dual media to remove microorganisms, color and turbidity.

CHAPTER 2

LITERATURE REVIEW

Some existing literatures or research papers are discussed in order to present the current work efficiently. These literatures are very useful and also the base of the current work.

Pratibha et.al. [1] state in their research paper that coconut shell carbon was activated by coconut shell. Carbon was converted into activated carbon by chemical activation using different activating agents like Cacl2, H2So4 ,H3Po4, KoH, and Zncl2 and thermally activated. Batch adsorption desulphurization operation was carried out at room temperature for adsorption for selection of final activation agent for continuous process. Characteristics of coconut shell activated carbon was studied such as P.H, Moisture Content, Ash content ,Volatile matter content, Fixed carbon, Iodine Number , BET surface area, Scanning Electronic Microscope (SEM).

Mota Manoj H et al. [2] studied the effect of capping of RSF by the use of coconut shell as a capping media by pilot scale study. This study has shown that rapid sand filter are very common in all conventional water treatment plants. Major problem associated with it is stratification; it restricts the complete use of sand bed. Almost all raid sand filter beds are suffering by problems like high backwash water requirement, unsatisfactory Effluent and mud ball formation. A pilot scale model of filter is constructed using glass columns with an inside area of 0.15m*0.15m along with piping and valves. The co-efficient of uniformity of sand used was 1.7 and effective size was 0.6mm.the co-efficient of uniformity of co-efficient of uniformity of capping media used was about and effective size of 1.91mm. Capping is the process of covering the filter media by caps of crushed coconut shell, bituminous coal, anthrax filter, etc. higher rate of filtration is possible along with less backwash requirement and higher filter run .Backwash requirement for capped RSF caps is less as compared to conventional RSF by 33% .crushed coconut shell as capping media can increase the filter run by 80%.

Shilpa S. Ratnoji et.al.[3] explained in their paper that in India, the quality of raw water available for drinking purpose varies significantly resulting in modifications to the conventional water treatment scheme consisting of aeration, chemical coagulation, flocculation, sedimentation, filtration and disinfection. Different alterations in these stages could lead to improvised levels of water quality. A novel solution to reinstate the sand filtration process is by utilizing activated carbon (AC) derived from coconut shell. A pilot scale study of filtration unit with different grades (on size basis) of coconut shell activated carbon (CS-AC) such as WTD816, WTE830 and WTE124 was carried out. These AC's were assembled at different depths independently as well as in combination. This work examined reduction and removal of iron, turbidity, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in river water by making different arrangements of CS-AC in the filtration unit. Also its comparison with sand, a conventional practice in water treatment plants in India was done to reduce these parameters. Finer grade activated carbon (AC-III) showed the maximum iron removal (95%). It also showed reduction in COD, BOD and to some extent turbidity in all types of arrangement which was not so in case of traditional sand filtration process. This technique is advantageous and it also helps in utilization of an agricultural waste.

Ranjeet Sabale et al.[4] mentioned two pilot filter columns in their paper. One is conventional RSF and other is capped RSF. Conventional filter has sand as filter media; capped RSF has PVC granules as filter media. Conventional rapid sand filter and capped rapid sand filter are compared. Sand media having characteristics as effective size (E.S.-0.35 to 0.60mm),uniformity co-efficient (U.C.-1.30 to 1.70),specific gravity -2.67, limiting head loss-1.80 to 3.0m,depth of sand -60cm,depth of gravel support -40cm, etc. A rapid sand has many advantages like easy operation, more filtration rate, easy backwashing, and output. Due to improper backwashing, major problems shown in the filter media is mud-ball formation. Stratification of sand media takes place at the time of backwashing process. Sand grains having small size come at top layer which reduces the porosity. Filtration process is affected due to the increase in head loss in shorter run time. Capping of rapid sand filter is suggested by the researchers to overcome to these problems. Capping is the process in which upper sand bed layer is replaced with few centimeters of capping material. capping proves efficient techniques for improving performance of RSF. Capping with PVC granules with 3cm depth gives turbidity removal up to 92%.

Miss. Koli Asha et.al.[7] mentioned about Rapid sand filter in their paper. According to them, Rapid sand filters are very common in all conventional water treatment plants. Most of the rapid sand filter beds are suffering by the problems like stratification, mud ball formation and unsatisfactory effluent and high backwash water requirement. Dual media and multimedia filters can overcome the limitations of rapid sand filters. Alternatively, higher filtration rates even can be achieved. The attempts is made to the study of dual media filter using anthracite coal as a filter media along with filter aid along with conventional sand media by pilot scale study. Comparative study shown that higher rate of filtration is possible along with higher filter run and less backwash requirement.

ANSARI MUBESHSHERA AWAIS et al.(2017) the attempt is made to study the effect of capping of the pilot SF by the use of coconut a capping media by pilot scale study. The pilot scale study has shown very encouraging results. Comparative study shown that higher rate of filtration is possible along with higher filter run and less backwash requirement. Top most layer 75cm 2mm to 6mm to 10mm. Intermediate layer 10cm 10mm to 20mm. Bottom layer 10cm 20mm to 50mm. capping with coconut shell proves to be very effective in improving performance of RSF in pilot scale. Use of filter with coconut shell as capping media for longer period will give better efficiency. Backwash requirement for capped RSF is less as compared to conventional RSF by 33%. Higher rate of filtration can be obtained after capping without much effect on the filtrate quality. Capping of RSF using the crushed coconut shell as capping media can increase the filter run by about 80%.

P.K Mallick , 2004 used Mahogany sawdust to develop an effective carbon adsorbent. This adsorbent was employed for the removal of dyes from spent textile dyeing wastewater. The experimental data were fitted to Langmuir and Freundlich models of adsorption.

M.M. Nourouzi and T.G. Chuah in 2009 studied the adsorption behavior on Reactive Black 5 and Reactive red 3 using Palm Kernel Shell Activated carbon. Applications of batch kinetic data to pore and film surface diffusion models were explored.

Jun –jie Gao et al., 2013 produced activated carbon from tea seed shells. They obtained activated carbon of BET surface area 1530 m2/g. The precursor was chemically activated using zinc chloride and pyrolysed in a tubular furnace at 500^{o}C for one hour duration at a heating rate 5^{o}C/min.

Halandemiral et al., 2008, prepared activated carbon from Hazelnut bagasse through chemical activation technique. The surface area developed was significant 1489 m2/g. It was employed to remove Sandolan blue from the water bodies.

Preparation and Characterization of Activated Carbon derived from Fluted Pumpkin Stem Waste was studied by **Ekpete and Horsfall**. Investigators were used fluted pumpkin stem waste for the preparation of activated carbon. Characterization of pH, bulk density, pH, porosity and iodine number was conducted and compared to a commercial activated carbon. Authors were found that there is significant difference in the properties of moisture, pH, porosity, ash content, iodine number, carboxylic acid content, lactones, pH and basic sites content of activated carbons [26].

Characterization of activated carbon prepared by phosphoric acid activation of olive stones was studied by **S.M.Yakout and G.Sharat**. Authors were studied the effect of activating agent concentration on the pore structure and surface chemistry of activated carbon derived from olive stone with chemical activation method using phosphoric acid[27].

Kermit Wilson et.al.were studied select metal adsorption by activated carbon made from peanut shells. Investigators were carried out steam activation, followed by air oxidation of peanut shells for production of activated carbon.and they were compared to metal ion binding by three reference carbons, steam-activated, air oxidized peanut shell carbons showed adsorption properties similar to the best commercial, Coal-based carbons[28].

Pratibha R. Gawande and **Dr. Jayant P. Kaware** carried out review on Preparation and activation of activated carbon from waste materials. Authors were studied different value added waste for preparation of activated carbon is used as adsorbent and chemical activation using different activating agents like $Cacl_2$, H_2SO_4, H_3PO_4, KOH, and $ZnCl_2$[29].

Adsorption of dibenzothiophene on activated carbon from dates stones using phosphoric acid was investigated by **Hisham S.Bamufleh**. Authors were prepared Granular Activated Carbon from dates' stones by chemical activation using phosphoric acid (H_3PO_4) as an activator [30].

Rhoda Habor et.al were studied Production of Activated Carbon and Characterization from Snail Shell Waste (Helix pomatia).Investigators were used Snail shell waste material for the preparation of activated carbon using $ZnCl_2$ and $CaCl_2$ with the temperature ranging from 500˚C to 800˚C. The activated carbon prepared was characterized, showing effect of temperature on ash content, pore volume and porosity [31].

Adsorbents from karanja seed oil cake and applications was studied by **Ashish saksule** and **Pallavi kude.** Karanja Seed Oil Cake is by-product after oil extraction, which otherwise goes waste or as fertilizers, is used as Precursor for Activated Carbon Preparations Investigators were used Karanja Seed Oil Cake which is for preparation of activated carbon which is by product after oil extraction. They were prepared Adsorbent from Karanja seed oil cake in laboratory by various Chemical and Physical Activation Processes [32].

Dipa Das et.al. preparation of activated carbon from green coconut shell and its characterization. Authors were prepared activated carbon from green coconut shells by chemical activation method. Authors were studied different properties like pore size, surface area micro pore volume and thermal stability [33].

Roozbeh Hosein et.al. Preparation and characterization of activated carbon from apple waste by microwave assisted phosphoric acid activation. Authors were prepared activated carbon from apple pulp and apple peel by using phosphoric acid as an activating agent[9].

Characterization of activated carbon prepared by phosphoric acid activation of olive stones was studied **by S.M.Yakout and G.Sharat.** Authors were studied the effect of activating agent concentration on the pore structure and surface chemistry of activated carbon derivedfrom olive stone with chemical activation method using phosphoric acid[34].

Mehdi Jahangiri et.al.preparation of activated carbon from walnut shell They were used chemical activation, using KOH to obtain high efficient adsorptive properties[35].

Hassan M. et.al synthesis and characterization of activated carbon from saudi arabian datestree's fronds wastes .Investigators were used date's fronds waste as a raw material for producing activated carbon. Investigators were used phosphoric acid for activation and they were used various concentration of H_3PO_4 [36].

Adegboyega Surajudeen Olawale et.al Preparation of phosphoric acid activated carbons from Canarium Schweinfurthii Nutshell. Activated carbons were prepared by phosphoric acid activation of Canarium Schweinfurthii spent nutshell[37].

Arenst Andreas Arie, Vincent and Aditya Putranto were studied Activated carbons from KOH activation of salacca peels as low cost potential adsorbents for dye removal. Salacca peel was used to prepare Activated Carbon (AC) by chemical activation with potassium hydroxide[38].

Preparation and Characterization of Activated Carbon from Reedy Grass Leaves in a Two Step Activation Procedure was studied by **Xu Jianzhong and Chen Lingzhi, FengXiaojie.** Preparation of activated carbon from lignin obtained by straw pulping by KOH and K2CO3 Chemical Activation. Investigators were produced Activated carbons by chemical activation with potassium hydroxide [39].

Preparaton of activated carbon from desiccated coconut residue by chemical activation with NaOH was studied by **Mood Adib Yahya**. Investigators were used agricultural waste for preparation of activated carbon. They were investigated the effect of temperature and impregnation ratio on the physicochemical properties of activated carbon prepared from desiccated coconut residue by chemical activation using sodium hydroxide[40].

Tang Shu Hui and Muhammad Abbas was investigated Potassium hydroxide activation of activated carbon. They were used Potassium hydroxide as an activating agent in activated carbon preparation. Authors were used activation temperature lower the boiling point of KOH 1327°C [41].

Arunrat Cheenmatchaya and Sukjit Kungwankunakorn et.al preparation of activated carbon derived from rice husk by simple carbonization and chemical activation for using as gasoline adsorbent. Physical characterization of the activated carbon obtained was performed by scanning electron microscopy [42].

Billy T H Guan et.al. Physical preparation of activated carbon from sugarcane bagasse and corn husk and its physical and chemical characteristics Sugarcane Bagasse and Corn Husk were used for preparation of activated carbon Authors were prepared activated carbon by physical and chemical activation method [43].

CHAPTER 3

METHODOLOGY

Water quality is a multifarious subject, which involves physical, chemical, hydrological and biological characteristics of water and their complex and delicate relations. It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physic-chemical parameters. Selection of parameters for testing of water is exclusively depends upon for what purpose we going to use that water and what level we need its quality and purity. Some physical test should be performed for testing of its physical properties like temperature while chemical tests should be performed for its BOD, COD, Dissolved Oxygen, hardness and other characteristics.

3.1 Materials Collection

3.1.1 Gravel

Gravel which retained on 4.75mm has been used as supporting media for sand layer. The depth of gravel layer in the filtration units is 20cm. Gravel was washed and oven dried thoroughly before using as the supporting filter media layer.

3.1.2 Sand

River sand having uniformity co-efficient 1.7 and effective size 0.60mm is used as filter material. Sand was washed with clean, sun dried and oven dried before using as filter media. The depth of sand layer maintained in the filtration unit is 15cm. Figure 3.1 shows the photograph of capped sand media.

Figure 3.1 Photograph of capped sand media

3.1.3 Crushed coconut shell

Crushed coconut shells having an effective size of 1.91 mm were used as capping media above the sand layer. crushed coconut shell were placed in layers above the sand as capping. The depth of coconut layer in filtration unit was 20 cm. Coconut shells were crushed into pieces manually using a rammer then thoroughly cleaned before using it as capping. Crushed coconut shells were washed and oven dried for 24 hrs.

3.2 Study Area:

The Sample was collected from the **Quari Shahpur, post Rasalpur Deva, Lucknow**. The sample collected was turbid. The sample was collected in cans. The water was transported from the lake to the environmental engineering laboratory and necessary tests were conducted. Water sample was bought to laboratory and it was kept in large containers for sedimentation process with detention period for 3-4 hrs. The supernatant water was collected and then passed through Rapid Sand Filter.

3.3 Fabrication of model:

Project work was carried out in Civil Engineering lab, BBDU, Lucknow. The pilot model was installed at College lab as shown in Figure 1 where the clarified water was used for the performance evaluation of dual media filter. Necessary care has been taken to make the model water tight. To achieve the filtration result some steps are stated as to accomplish the task. The steps are as follows-

1. Glass fiber sheet of thickness 3mm was cut as per the design.

2. Pilot scale model of filter was constructed using glass columns with an inside area of 0.15m X 0.15m along with associated piping and valves.

3. An outlet is provided at the bottom for collection of filtered water. A tap is attached to the outlet opening for controlling the filtration rate.

4. The sand media of desired effective size and uniformity coefficient was prepared by sieving the washed and sun dried stock sand. The coefficient of uniformity of sand and effective size was 0.6mm.

5.Filter layer consisting of gravel bed of 15 cm thickness, sand layer of 20 cm thickness ,crushed coconut shell layer of 15 cm thick and coconut husk layer of 20 cm was spread in the filter unit.

6. The water obtained from the lake stored in a large container for a detention period of about 3-4 hours .The supernatant water after sedimentation process was passed through filter.

7. Influent water is fed into the filter with the help of a dispenser of 70liters capacity has been placed well above the filter unit.

8. A head of water above the filter media in the filtration unit of 10 cm was maintained throughout the test period .the raw water was fed to filtration unit continuously through dispenser placed above the filtration unit.

9. Effluent sample are tested for turbidity, pH, total solids, TDS, Colour.

10. The experimental has been carried out up to 8 hours.

Figure 3.2 Series Filtration

CHAPTER 4
RESULT & DISCUSSION

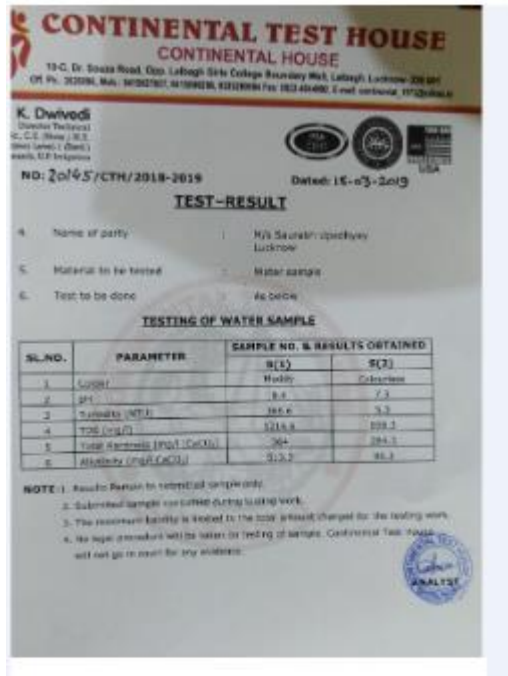
It is extremely fundamental and important to test the water before it is used for drinking purpose . Water is having some diverse types of impurities like floating, dissolved, suspended, microbiological and bacteriological impurities. physical tests have been performed for testing of its physical appearance such as temperature etc., while some chemical tests should be perform for its BOD, COD, dissolved oxygen, hardness and other characters.

The collected sample from the experimental setup of series filtration has been tested in lab. The comparison of parameters of water before filtration and after filtration is shown in the table1.

Table 1. Water quality parameters of collected sample

S.No.	PARMETER	STANDARDS IS 10500:2012 (min – max)	INITIAL READINGS	FINAL READINGS
1	COLOUR	Hazen(units)	MUDDY	COLOURLESS
2	PH	6.5 TO 8.5	8.4	7.3
3	TURBIDITY (NTU)	5 TO 10	366.6	5.3
4	TDS(Mg/l)	500-2000	1216.6	698.3
5	TOATAL HARDNESS (mg/l)	200-600	364	284.3
6	ALKALINITY(mg/l)	200-600	513.3	96.3

The lab report shows the parameters in terms of colour, pH, Turbidity, TDS, Total Hardness and Alkalinity. The test result is shown in figure 4.1.



CONTINENTAL TEST HOUSE

CONTINENTAL HOUSE

19-C, Dr. Souza Road, Opp. Lalbagh Girls College Boundary Wall, Lalbagh, Lucknow [illegible]

[illegible]

K. Dwivedi

[illegible]

NO: 20145/CTH/2018-2019 Dated: 15-03-2019

TEST-RESULT

4. Name of party : M/s Saurabh Upadhyay Lucknow

5. Material to be tested : Water sample

6. Test to be done : As below

TESTING OF WATER SAMPLE

SL.NO.	PARAMETER	SAMPLE NO. & RESULTS OBTAINED	
		S(1)	S(2)
1	Colour	Muddy	Colourless
2	pH	8.4	7.3
3	Turbidity (NTU)	165.6	5.3
4	TDS (mg/l)	1216.8	[illegible]
5	Total Hardness (mg/l CaCO3)	364	[illegible]
6	Alkalinity (mg/l CaCO3)	[illegible]	[illegible]

NOTE : 1. Results Pertain to submitted sample only.
2. Submitted sample consumed during testing work.
3. [illegible]
4. [illegible]

ANALYST

Figure 4.1 Test Result of Water Sample

CHAPTER 5
CONCLUSION & FUTURE SCOPE

5.1 CONCLUSION

The purpose of this research is to bring new low cost technology and make a model of rapid sand filter using coconut husk and coconut shell as a capping media , which can be used in small scale like house hold and reuse the muddy water. Different filter media such as coarse gravel and fine gravel is also been used . The analysis of the performance shows a gradual decrease in different parameters use for characteristic analysis of muddy water. This shows the series filtration method are a good approach of water treatment. We observed that the model of rapid sand filter is, significantly assist in the removal of turbidity ,alkalinity, TDS, hardness, and will improve the pH quality of the effluent. This project will help to understand a new approach of an environmental friendly filtration technique. The above testing results of parameters made some following conclusions-

1. Coconut husk when used as a filter media in the filtration process gives good efficiency.

2. There was considerable reduction in turbidity, total solid, pH and hardness.

3. There was considerable reduction in the color intensity.

4. The reduction in turbidity is up to 90%.

5. The Decrease in the total solids was up to 89%.

5.2 FUTURE SCOPE

In future the series filtration can be made more efficient by enhancing some more practical study. To accomplish this the future study areas are as given below-

1. To study the life span of coconut shells.

2. To make the filtration process more affordable.

3. To study the removal of other parameters like fluoride, iron, manganese etc.

4. To study the backwashing of filters and head loss characteristics.

Further study should also be made at the Pilot Plant Scale utilizing both filter media combinations:

(i) A dual media filter of coconut husk fiber and burnt rice husk.

(ii) A dual media of pea gravel and burnt rice husk.

(iii)Series filtration of using coconut husk fiber as a roughing filter and burnt rice husk as apolishing filter.

Lastly the dual media filters should be tested as potential waste treatment processed for various industrial and municipal wastewaters.

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