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Performance Analysis Combination of Activated Carbon and Resin for Hard Water Softening

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Abstract: The Water Quality analysis for five samples of Surface water source and five samples of groundwater sources were carried out in an up flow type of water filter reactor. The filter media consisted of two separate columns made of transparent acrylic material of 1m length each mounted on a wooden board with plumbing fixtures connected, first column consisting of Activated Carbon (using $Cacl_2$ as activity inducing agent) and second column consisting of cation resin. The filtration process is performed and the analysis carried out for parameters like PH, T.D.S, Electrical conductivity, Turbidity, Total Hardness, Calcium, Magnesium, Chloride, Alkalinity, Potassium all Parameters are in permissible limits. The resin media being submerged in water leads to release of sodium in excess amount. The use of some other activity inducing agents like HNO_3, H_2SO_4, NH_3PO_4 or Salts like $Zncl_2$, $Mgcl_2$, K2S, $Fecl_3$, and $Alcl_3$ for providing activity to Carbon can be also checked. The down flow type of filter reactors could be analyzed for testing water quality parameters.

Keywords: Activated Carbon, Ground water, Filtrations, Reactors, Resin, Surface water, Water Quality.

I. INTRODUCTION

"Water is life" is such a common expression that we use it almost as a cliché. However, that phrase is probably one of the most powerfully true messages the whole creation bears witness to. If, as we learn from geography, the earth is 2/3 water, and science says the human body is 70% water, and then it goes without saying that no life can be sustained without water. So much has been written about the importance of water. From an early age we have been taught the water cycle and how it sustains life, but we still continue to take it for granted. We pollute water basins, rivers, and even the atmosphere that provides us with this precious commodity. [13] So water is a very vital resource available on earth and which on the verge of depletion. Hence as a citizen of world we have a moral duty to save, conserve and avoid the wastage and misuse of water.

Sources of water on earth

The Water resources in India are available in two basic sources:

a. **Primary Source**

- Rain fall

b. **Secondary Source**

- Surface Water
- Ground Water

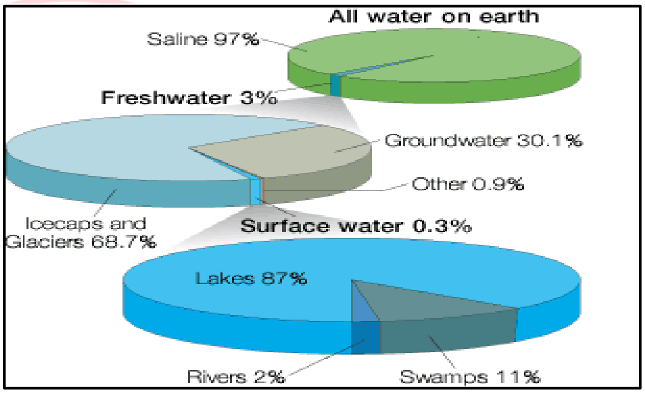

Image1: Classification of Water Sources available on Earth

Considering the Secondary sources which are readily available to us it becomes necessary to know the various water quality parameters as a consumer.

Quality of water for Ground water and surface water

a. Ground water quality

The study has found that the ground water contains more minerals as compared to surface water. The hardness is ground water is ought to be more as the water when percolates in ground it gets mixed with the minerals in the earth's crust and thus the water turns hard in nature. If excess hard water is found it has to be provided for water softening. The classifications of hard water are shown in table below:

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Sr.No	Hardness Range (mg/l as $CaCo_3$)	Degree of Hardness
1	0 - 75	Soft
2	75 – 150	Moderately
3	150 – 300	Hard
4	Above 300	Very Hard

Table1: Classification of Hard Water

Physical and chemical properties of Tube well water as per IS10500-2012

Sr. No	Parameter	Unit	Permissible limit
1	PH	-	No relaxation
2	Turbidity	NTU	5
3	Total Dissolved Solids	mg/l	2000
4	Calcium	mg/l	200
5	Chloride	mg/l	1000
6	Magnesium	mg/l	100
7	Total Alkalinity	mg/l	600
8	Total Hardness	mg/l	600
9	Sodium	mg/l	-

Table2: Water quality parameters for tube well water

b. Surface water

The surface water has found to be possessing lower level of hardness compared to the ground water. But it doesn't mean that water has zero level of hardness. Some hardness in water is found to be present in the water. It is due to the run-off water being flowing over the ground surface consisting of minerals like carbonates of Calcium, Magnesium. Hence to determine just the levels of hardness in the surface waters. Surface water quality monitoring for hardness along with other conventional parameters hence is essential

Sr. No	Designated Best Use	Class	Criteria
1	Drinking water source without conventional treatment but after disinfections	A	*Total coliform organisms MPN/100mL shall be 50 or less. *pH between 6.5 and 8.5 *Dissolved oxygen 6 mg/l or more *Biochemical oxygen demand 2 mg/l or Less
2	Outdoor bathing (organised)	B	*Total coliform organisms MPN/100ml shall be 500 or less *pH between 6.5 and 8.5 *Dissolved oxygen 5 mg/l or more *Biochemical oxygen demand 3 mg/l or Less
3	Drinking water source with conventional treatment followed by disinfection	C	Total coliform organisms MPN/ 100ml shall be 5000 or less *pH between 6 and 9 *Dissolved oxygen 4 mg/l or more *Biochemical oxygen demand 3 mg/l or Less
4	Propagation of wild life, fisheries	D	*pH between 6.5 and 8.5 *Dissolved oxygen 4 mg/l or more *Free ammonia (as N) 1.2 mg/l or less
5	Irrigation, industrial cooling, controlled waste disposal	E	*pH between 6.0 and 8.5 *Electrical conductivity less than 2250 micro mhos/cm *Sodium absorption ratio less than 26 *Boron less than 2mg/l

Table 3: Surface water use and water quality parameters

Water Treatment Process

A combination selected from the following processes is used for municipal drinking water treatment worldwide:

- Pre-chlorination for algae control and arresting biological growth
- Aeration along with pre-chlorination for removal of dissolved iron when present with small amounts relatively of manganese
- Coagulation for flocculation or slow-sand filtration
- Coagulant aids, also known as polyelectrolytes – to improve coagulation and for more robust floc formation
- Sedimentation for solids separation that is the removal of suspended solids trapped in the floc
- Filtration to remove particles from water either by passage through a sand bed that can be washed and

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reused or by passage through a purpose designed filter that may be washable.

- Disinfection for killing bacteria viruses and other pathogens.

From the above treatment processes we are dealing with the filtration process in detail for water in our project work. Filtration process is last but one process in the entire water treatment and is one of the vital one because the resultant water after sedimentation will not be pure, and may contain some very fine suspended particles and bacteria in it. To remove or to reduce the remaining impurities still further, the water is filtered through the beds of fine granular material, such as sand, etc. The process of passing the water through the beds of such granular materials is known as Filtration.

ADSORPTION

- Adsorptive filtration is a technique based on the coating of the filter medium with adsorbents, resulting in modified media that can simultaneously act as a filter and as an adsorbent.
- Activated carbon filtration is a commonly used technology based on the adsorption of contaminants onto the surface of a filter. This method is effective in removing certain organics (such as unwanted taste and odours, micro pollutants), chlorine, fluorine or radon from drinking water or wastewater.[14]
- Adsorption is integral to a broad spectrum of physical, biological, and chemical processes and operations in the environmental field. Purification of gases by adsorption has played a major role in air pollution control, and adsorption of dissolved impurities from solution has been widely employed for water purification. Adsorption is now viewed as a superior method for **waste**water treatment and water reclamation.

Materials Used for Adsorption

The adsorptive filtration process can be carried out by using various type of materials. Some commonly used materials are given below.

1. Carbon
2. Ceramic
3. Sand
4. Diatomaceous Earth.

Since we have used activated carbon as an adsorptive filtration material in our project work, we will discuss about activated carbon in detail.

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

Ion Exchange Process

In the context of water purification, ion-exchange is a rapid and reversible process in which impurity ions present in the water are replaced by ions released by an ion-exchange resin. The term “ion exchange” describes the process: as water flows through a bed of ion exchange material, undesirable ions are removed and replaced with less objectionable ones. For example, in softening processes, calcium and magnesium ions (hardness) are exchanged for sodium ions. In dealkalization, the ions contributing to alkalinity (carbonate, bicarbonate, etc.) are removed and replaced with chloride ions. Other dealkalization processes utilizing weak acid cation resin or strong acid cation resin in a split stream process, exchange cations with hydrogen. This forms carbonic acid which can be removed in a decarbonator tower. The impurity ions are taken up by the resin, which must be periodically regenerated to restore it to the original ionic form.

So we are using activated carbon in combination wih the cation resin for water filtration of surface water sources and ground water sources five samples from each i.e surface water and ground water.

II. LITERATURE REVIEW

Smita R. Jadhav et.al. (2017)in this paperwork they collected sample from four sites at Kotithirtha Lake. In order to achieve drinking water properties in the water sample, they came to conclusion its undesirable to drinking and also for other uses. Water contamination is far beyond filtration; contamination not just crosses permissible level but also gets highly polluted. By conducting various experiments on the samples they calculated the WQI of sample, and using water quality index as the rating scale for the physic-chemical parameters of water sample. Range of rating scale (Vr) and significance for the physic-chemical parameters

Range of Rating Scale (Vr)	Significance
100	Clean
80-99.99	Slightly Polluted
60-79.99	Moderately Polluted
40-59.99	Excessively Polluted
Excessively Polluted	Severely Polluted

Table4: Physico-chemical Rating scale of water

As per the above table, station had 45.4 WQI so it is considered heavily polluted. So, the station 2 is 42.5, Station 3 is 45.4 and station 4 is 42.5 had highly polluted WQI.

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A. A. Lole et.al. (2016)this research paper contained the parameters of Atigre village Bore well water and further studies, 25 samples of various bore well water sources collect in one- litre bottles to experimental studies. The Concentration of different chemical parameters of water samples of study area divided in two stages in pre-monsoon season and post-monsoon. The chemical quality of bore well and surface water samples of Atigre Village, reveals that 100% samples of pre and post-monsoon seasons represent Ca +Mg >Na+K (alkaline earths exceed alkalies) hydrochemical facies. Similarly, 100% water samples belong to HCO3 +CO3> Cl+SO4 (weak acid exceed strong acid) hydrochemical facies in pre and post-monsoon seasons.Classification of groundwater based on Piper Trilinear diagram indicates the Electrical conductivity activities related to quality of water, and it is clear or say fit to use for irrigation purpose.

Abhijeet S. Ghone et.al. (2015)in this research paper deep study about rankala lake pollution and water quality studies conduct. By visually analysis of the lake it is clear that municipal waste is dumping into the lake at various points, so researcher chose the 5 points around the lake to collect the samples exact opposite points where waste water is dumping into lake by four various points such as Sham Society Nalla, Sairnaik Colony Nalla, PartalaNallla, DeshmukhNalla. Many other activities such as bathing on lake, washing animals, vehicals and clothes, Ganesh idols and nirmalya immersion, dumping remaing foods from chawpati in lake is also contributing pollution in lake area. According to the readings Average pH of water is around 6 to 7.2 and having calcium hardness, because of the high chloride content it makes water rich inorganic constitutes which helps to promotes excessive plant growth and decay, favours certain weedy species. Still the pollution around lake is moderate, but water is unsuitable for human use.

K. B. Koli et.al. (2014)this paper conducted physicochemical analysis of Tulashi Tank dam water analysis. Tulashi tank is artificially earthen dam with masonry spillway. The purpose of the paper is to observed levels of studied parameters with the corresponding WHO and BIS guidelines values for drinking-water quality. The method to study of physicochemical parameters of water carried out during the period of January 2008 to December 2008, the sample was collected by 4 station respectively from human or animal interference from 1 to 1.5 meter depth, in 2-3 liter capacity containers. Temperature and pH check at the time of collection. According to physical parameters, water is transparent and varied from 32.45 cm to 44.56 cm, so after laboratory testing Turbidity of water recorded within the range from 0.68 to 2.95 NTU in permissible limits. pH of water is averaging 7.5, the temperature is 27^{o}C. D.O. of water is within 6.48 – 8.52 mg/l, Alkalinity 126.42 – 162.42 mg/l, Total hardness 82.48 – 156.26 mg/l. After testing all results of various parameters of water it is concluded that water quality of Tulashi Tank meets the Permissible limits of water standards. It is cleared that certain water body is free from human activities and didn't get polluted by other reasons.

Mangalekar. S. B. et.al. (2012) in this review paper conducts the study on groundwater analysis and availability to meet future requirements and studied on present condition also level of water table. To know the present status of groundwater in the study area, secondary data related to Kolhapur district such as population, number of industries, different uses of groundwater, groundwater level, groundwater quality was collected from various Government departments such as Maharashtra Pollution Control Board (MPCB), Groundwater Survey and Development Agency (GSDA), Central Groundwater Board, Ministry of Water Resources Government of India, Kolhapur Collector office, Kolhapur ZilhaParishad, Kolhapur Municipal Corporation, and various research papers related to groundwater in Kolhapur district. By studying various research papers and review papers predicting future of groundwater conditions in Kolhapur.

PatilShilpa G. et.al. (2011) conducted Shivaji university campus lakes survey of physical and chemical parameters analysis for drinking and other useful purposes. They tested water collected one liter for 6 month period and come to conclusion on the reading analysis that water is polluted through various activities by the local residential public.The deference's in physicochemical parameters such as Temperature, Transparency, Turbidity, Total Dissolved Solids, pH, Dissolved Oxygen, Free Carbon dioxide, Total Hardness, Chlorides, Alkalinity, Phosphate, Nitrates, and MPN were analyzed form a period of September 2010 to February 2011. The Rajaram lake water testing results found such as Temperature 14.33 – 25^{O}C, pH varies 7.7 – 8.3, Turbidity 6.6 – 10.1 NTU, Hardness 89 – 206 mg/l, Alkalinity 52 – 161 mg/l, Acidity 15.6 – 32.6 mg/l, D.O. 3.2 – 4.7 mg/l, B.O.D. 6.7 – 33.71 mg/l, C.O.D. 24.2 – 152.3 mg/l, Phosphate 1.51 – 1.73 mg/l, Chloride 39.2 – 41.8 mg/l, MPN 68-860.

Another lake is present in the university campus near the Music Department which provides water to the Distance Education staff and Girls hostel water requirements. The Storage capacity of that lake is 99.5 million cubic feet but storage by the average it never rises above 1.86 million cubic feet. The physical & chemical changes in time variation of six months are as follows: Temperature 13.5 – 25^{o}C, pH 6.85 – 8.05 more like alkaline water present in the lake. Turbidity 4.05 – 7.3 NTU, Hardness 58 – 263 mg/l, Alkalinity 56 – 228 mg/l, Acidity 15 – 23.5 mg/l, D.O. 3.4 – 4.8 mg/l, B.O.D. 6.5 – 33.78 mg/l, C.O.D. 23.3 – 159 mg/l, Phosphate 1.47 – 2.63 mg/l, Nitrate 1.47 – 2.63 mg/l, Chloride 16.3 – 45.16 mg/l, MPN 55 - 1260.

S.D.Jadhav et.al. (2011)this research paperwork carried out to evaluate borewell water quality of AjaraTahsil for

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drinking and domestic purpose. Bore well sample collected from 51 villages of Ajara for physicochemical parameters testing in April month 2011.only certain parameters considered important like temperature, pH, Electric conductivity, and hardness, chloride and Dissolved oxygen. Sample temperature within 19 – 21^{o}C and pH ranged 6.5 to 8.4 all in permissible range. Electric conductivity varies between 0.12 – 1.22 mmhos which indicates some ions present in water, Alkalinity 10 – 92 mg/l, Hardness due to Calcium is 8.02 – 72.18 mg/l and due to Magnesium 6.16 – 86.42 mg/l. The final conclusion of analysis based on the hardness of sample, 43 out of 51 bore well samples are within limits & fit for drinking purpose.

Arthur H. Lundquist (2011)this information paper provides an in-depth review of filtration (including adsorption and ion exchange) as a pathogen and particulate reduction mechanism when treating natural waters. This paper is intended to assist the reader in evaluating the capabilities of Individual Water Purification Devices (IWPDs) using size exclusion, adsorption, and/or ion exchange to reduce disease-causing bacteria, virus, and protozoan cyst populations, as well as turbidity causing particulate matter.

For the purpose of this paper, filtration will be used broadly to incorporate separation by (1) granular media, (2) size exclusion (e.g., membranes), (3) electrochemical adsorption (e.g., activated carbon), and (4) ion exchange (e.g., anion, cation exchange). Filtration is a well-studied process for drinking water treatment. Naturally, as groundwater migrates in the subsurface, contaminants are removed from the water due to ionic attraction as well as sieving based on size. Concurrently, contaminants such as iron and manganese may be dissolved into the groundwater.

Alaa H. Jalil (2011)the following study demonstrates the possibility of producing different activated carbons from a mixture of waste tires and tubes. The mixture was pyrolyzed at different temperatures namely (400,450 and 500oC) for two hours for the determination of best condition of heating. It was found through the study that semi carbonized marital produced via pyrolysis at 500^{o}C was the best; thus it was used as a precursor for producing different activated carbon samples. The aforementioned precursor was converted into activated carbons via different method of activation i.e. thermally activation and steam activation at 800^{o}C for two hours as well as microwave heating at 450 watt for four minutes.

Adsorption from solution technique was used to determine the surface areas of the produced chars using I2 and methylene blue as solutes. The produced carbons showed the presence of microporosity with development in mesoporosity. This was detected from the higher surface area by I2 adsorption and lower surface area using methylene blue.

Langmuir and Freundlich models of adsorption were used to analyze the adsorption date of the produced carbon adsorbents. The results showed that Langmuir model was more suitable than Freundlich to analyze the adsorption data. Thus, it was used to determine the monolayer coverage of solutes through this study. Also, adsorption isotherms followed Langmuir type of adsorption according to Giles classification which indicates the micro porosity of the prepared activated carbon.

PrapatPentamwa et.al., (2011) it representsthe capacity of waste polystyrene plastics for hardness groundwater removal was investigated in this study. The wastes of polystyrene were prepared from foam of food packaging and air bubble plastic. They were synthesized into active adsorbent cationic resin. The water hardness was pumped through the designed column with combination of made resin and sand-gravel filters for groundwater treatment. The results revealed that the hardness removal efficiency of added made resins in the system was higher than no added resin (43% vs. 12%) and they were below the acceptable Thailand standard for groundwater drinking water of 300 mg CaCO3/L. However, there was no difference in term of hardness efficiency capability for different types of polystyrene plastics and the thickness of resin used in the study.

The synthetic resins were prepared from wastes polystyrene foam for food packaging and air bubble polystyrene plastics. The method for resin preparation was applied from Bekri-Abbes (2008). Briefly, both of polystyrene foam and plastics were crushed to obtained size of 0.2-0.3 cm2 for the total weight of about 30 g. Each 5 g of raw material was transferred in flask with 100 ml 95%.

A. MIANOWSKI et.al (2005)it stated the specific surface area determination of activated carbons by means of the low-temperature argon adsorption (the BET method) was compared with the measurement of the surface area based on the adsorption of I2 from the aqueous KI solution. It is proposed to recalculate the iodine adsorption number for the BET surface area. It is shown that the SIN method can be used for a quick estimation of the structure development of porous carbonaceous materials. The acceptance of the hexagonal lattice results from the simplified assumption of the physical significance of the micro pores volume filling mechanism similarly as it has been accepted in the case of the BET isotherm. There is a technological justification for the method of preparing of cheap activated carbons on the basis of steam activation of chars proposed in the present work. From a technological point of view, the recalculation of the iodine adsorption number to the specific surface area can be a rapid and efficient method for the evaluation of the surface area with

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a systematic error of a few m2/g in relation to the *SBET* value.

II. LITERATURE SUMMARY

Kolhapur city is one of the major cities in Maharashtra and well source of water bodies available in the western region of Maharashtra. But still facing the water scarcity in summer days due to the polluted water is unfit to use. Kolhapur district and city have major problems with water quality. Some of the parts of district are blessed with River or lakes but due to human activities pollute the surface water sources. Groundwater table is lowering day by day or getting contaminated due to industrial activities. So basically, it is not fit for drinking and irrigation purpose. This research paper analysis the groundwater and surface waters physicochemical parameter and also the magnitude of the parameters with remedies to mitigate the pollution enhancing elements.

Parameters	Readings
Temperature	13.5 – 25^{o}C
pH	6.85 – 8.05
Turbidity	4.05 – 7.3 NTU
Hardness	58 – 263 mg/l
Alkalinity	56 – 228 mg/l
D.O.	3.4 – 4.8 mg/l
B.O.D.	6.5 – 33.78 mg/l
C.O.D.	23.3 – 159 mg/l
Phosphate	1.47 – 2.63 mg/l
Nitrate	1.47 – 2.63 mg/l
Chloride	16.3 – 45.16 mg/l
MPN	55 - 1260

Table 5: Parameters for Surface water

Parameters	Readings
Temperature	19 – 21^{o}C
pH	6.5 – 8.4
Electric conductivity	0.12 – 1.22 mmhos
Alkalinity	10 – 92 mg/l
Calcium	8.02 – 72.18 mg/l
Magnesium	6.16 – 86.42 mg/l

Table 6: Parameters for Ground water

From the results of above research papers, it is concluded that most of the surface water is polluted by human activities and groundwater storage is limited. Surface water quality is very poor that it is not potable for domesticpurpose. Groundwater is in the permissible limit but quantity is very adequate. By analyzing various properties of waterit is found that both surface and ground water are contaminated by lead, excessive zinc, heavy metals, pesticides, plastics, cloths and other polluted constituents.

The above paper provides an in-depth review of filtration (including adsorption and ion exchange) as a pathogen and particulate reduction mechanism when treating natural waters. This paper provides a deep insight of the Individual Water Purification Devices using size exclusion, adsorption, and/or ion exchange to reduce disease-causing bacteria, virus, and protozoan cyst populations, as well as turbidity causing particulate matter

III. MATERIALS AND METHODOLOGY

Necessity of Using Granular Activated Carbon and Resin as filter media.

Solid waste generated from Thermal processes is mainly carbon residues like ashes, granules of carbon. The carbon obtained from these processes as a waste have purification properties and could be used for water treatment. Hence best out of waste concept hold good in this project. The carbon materials achieved as a waste is utilized in our project for water purification.

Reasons for using Activated Carbon

- The base material i.e. carbon is easily available from any of thermal treatment process subjected for any of the material.
- Being a waste residue it is economically cheap.
- Multifunctional nature of activated carbon in water treatment.
- Filters installed at domestic, industrial or at laboratory level is possible.

Resin

Resin is used at both industrial and domestic level only difference is that the quantity in domestic use is less and in industrial level is more. Few ion-exchange resins remove chlorine or organic contaminants from water – this is usually done by using an activated charcoal filter mixed in with the resin.

Activated Carbon

The Project work carried out for water treatment in up flow type reactor is with granular activated carbon obtained from the pyrolysis of wood and then impregnating it with calcium chloride for chemically activating. The mean size of the granulated carbon was about 0.6 to 0.7 cm. typical surface area for activated carbon is approximately 1,000 square meters per gram (m^2/gm.)the quantity of carbon used in the reactor is 500 gm.

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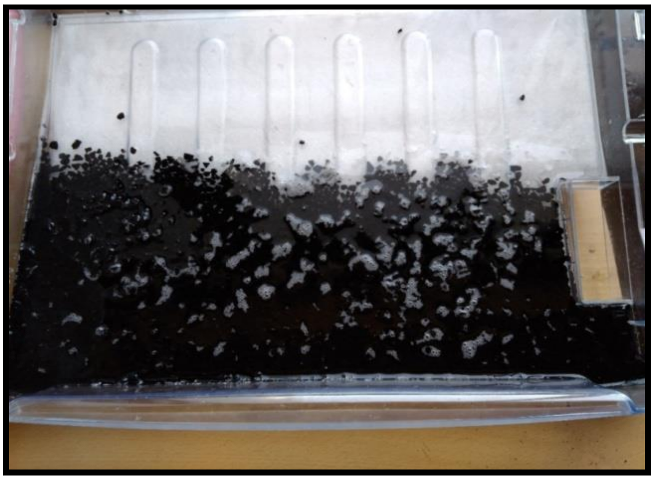

Image 2: Carbon impregnated with Calcium chloride

Procedure of Preparation of Activated Carbon is given below:

1. The carbon material was obtained from the burnt wood residue taken from lumber ware house.
2. The carbon was crushed to granular size and stored.
3. The chemical used for impregnating the carbon is Calcium chloride
4. The calcium chloride solution was prepared in the ratio of 1:3 for calcium chloride and water respectively. Actual quantity of calcium chloride taken is 250 gm and water as 750 ml.
5. Carbon used is 500 gm and rinsed in the $CaCl_2$ Solution and kept stagnant for 2 days.
6. After two days of rinsing the carbon, excess solution was drained out and carbon was collected and kept for oven drying for 3 days at 110°C.

Resin

Ion exchange resins are used to produce deionized (demineralized or "DI") water. These resins are small plastic beads that are composed of organic polymer chains that have charged functional groups built into the resin bead. Each functional group has either a fixed positive or negative charge.Calcium is more strongly attracted to a cation resin bead than sodium.

Cation resin has a negative functional group and therefore attracts positively charged ions. There are two types of cation resins, weak acid cation (WAC) and strong acid cation (SAC).Weak acid cation resin is used mainly in de alkalization and other unique applications.

1.Resin preparation is possible at industrial level, hence the resin was bought from the market.

2. We have used weak acid cation for our project work.

3.It was Ion exchange water softener resin, the resin was a cation type.

4.The cation resin has Na^+ bond.

Image 3: Cation Resin used in the Project

Construction of Filter Reactor Model

The water to be treated was allowed to fall from a height of 8m and reached the inlet of the reactor model. The Two Acrylic pipe reactors containing filter media as Activated Carbon and Resin are shown. The right hand side reactor consist of Activated Carbon whereas the left hand side reactor consist of resin. The Fitting operations were performed and the model was ready to be installed on a wall. The model was installed in our college project room as shown in the image below.

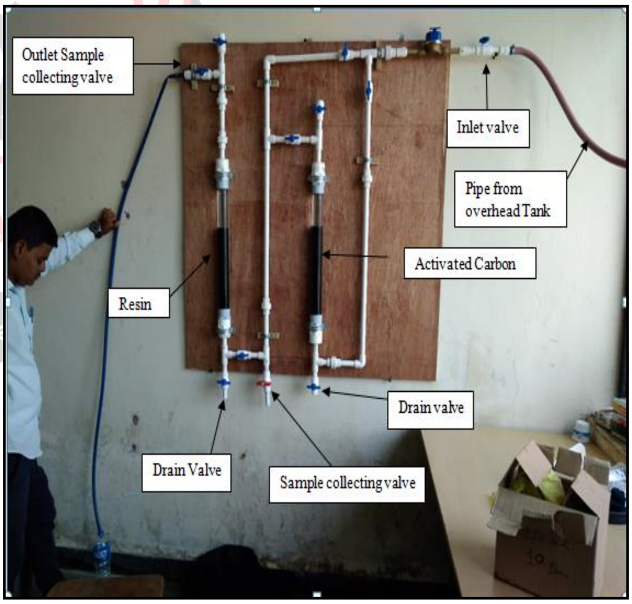

Image 4: Filter reactor Model

IV. METHODOLOGY

The Filter reactor model figure is shown below. The methodology performed is as follows.

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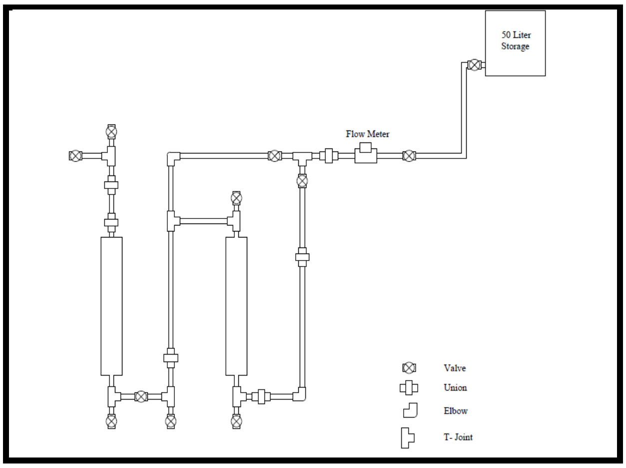

Figure1: Filter Reactor Model

The model set up is shown in figure above. The model consists of a water tank placed at a height of 6.8 meters from base of 50 liter top storage tank till the inlet valve level.

Purpose of Various plumbing components

- The first inlet valve of the model serves the purpose of just allowing the entry of water from the elevated tank.
- Further the inlet pipe is bifurcates in two pipes, one downward along the reactor containing activated carbon and other horizontally towards the outlet joint of reactor with activated carbon.
- The Water is then passed further to reactor with resin and there comes the third valve.
- At the bottom 3 valves
- Two valves for sample collecting

Trial testing 1

- The trial test for the flow of water without the material in the reactor was carried out.
- The leakages were detected and fixed.
- The flow required in the system was checked and correspondingly the valve to be rotated was set.
- The inlet valve was set for supplying required amount of flow in the system.

Filling of material

- The Reactor 1 consisted of Activated Carbon and Reactor 2 consisted of Cation Resin.
- Filling up of carbon was done by using a big funnel directly in the reactor 1.
- Filling up of Resin was done by first mixing the resin with water and then adding it to the reactor 2.

Trial Testing 2

- The trial 2 was carried out after filling up of the filtration materials.
- The performance of the materials in the reactors was observed.
- The leakages, spilling up of filtration materials along with water was checked and fixed.
- Flow was adjusted and set for the inlet valve.
- Experimentation
- The Topmost storage tank was filled up with the water sample to be tested.
- The valves were properly adjusted for the treating water from both the reactors.
- The outlet valve was kept open and a bucket for collecting water was set.
- The water was allowed to flow from the entire filter reactor model and the flow velocity was determined by manual method.
- Initially the water was allowed to pass from the filter reactor model and drain out for about 2 hours.
- The sample was collected after 2 hours and tests for water parameters were carried out.
- The process was followed for both surface water sources and ground water sources.

V. RESULT AND DISCUSSIONS

The Parameters tested during water quality analysis are as follows:

1. PH
2. T.D.S
3. Electric Conductivity
4. Turbidity
5. Total Hardness
6. Calcium
7. Magnesium
8. Alkalinity
9. Chlorine
10. Potassium
11. Sodium

The readings were found to be in permissible limits. The below graphs shows the readings and its characteristic nature of the different parameters with respect to the different water source samples. Here S.W represents Surface water whereas G.W represents Ground water.

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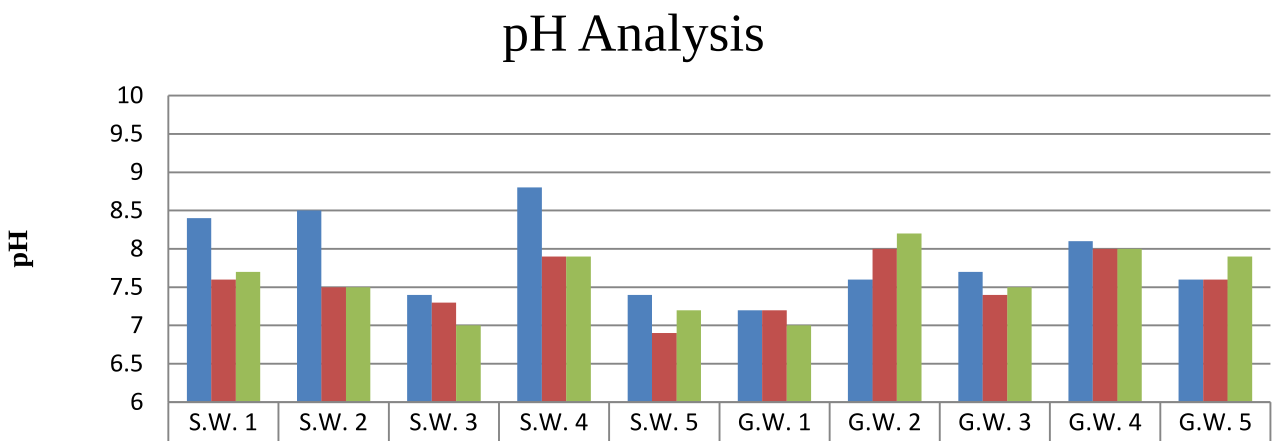
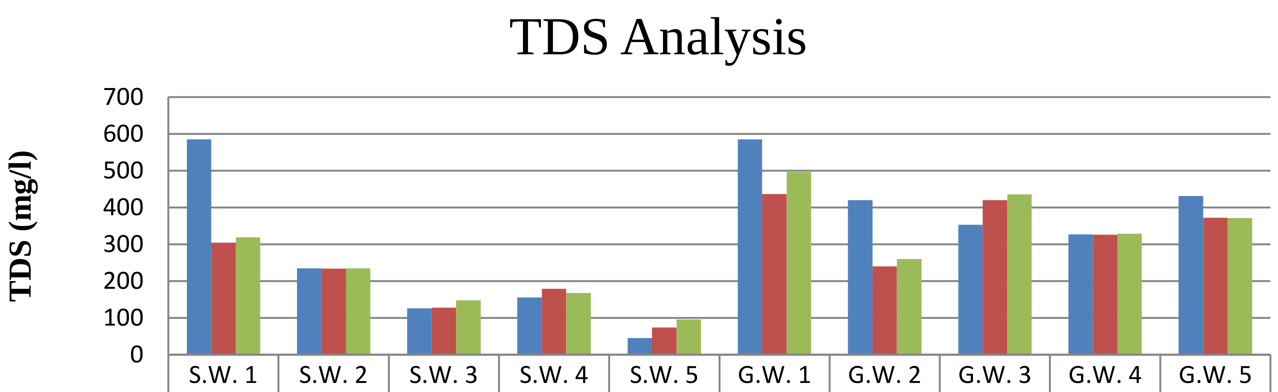
1. PH



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	8.4	8.5	7.4	8.8	7.4	7.2	7.6	7.7	8.1	7.6
GAC	7.6	7.5	7.3	7.9	6.9	7.2	8	7.4	8	7.6
GAC+Resin	7.7	7.5	7	7.9	7.2	7	8.2	7.5	8	7.9

Graph1: PH for various surface water sources and ground water sources

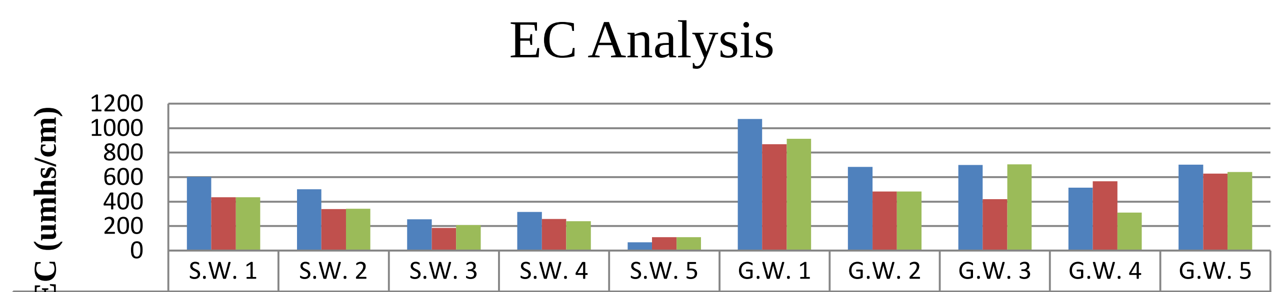
2. T.D.S



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	585	235	126	156	45	585	420	353	327	431
GAC	304	234	128	179	74	437	240	420	326	372
GAC+Resin	319	235	148	168	96	497	260	436	329	371

Graph2: TDS analysis for various surface water sources and ground water sources

3. Electric Conductivity



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	602.55	500	255.95	314.87	67.21	1073.95	684.04	698.94	514.8	701.31
GAC	435.68	339.26	185.7	258.88	110.8	868.22	481.53	419.04	565.42	630
GAC+Resin	435.68	341.04	208.02	241.11	108.92	913.48	482.59	705.8	309.52	640.68

Graph3: EC analysis for various surface water sources and ground water sources

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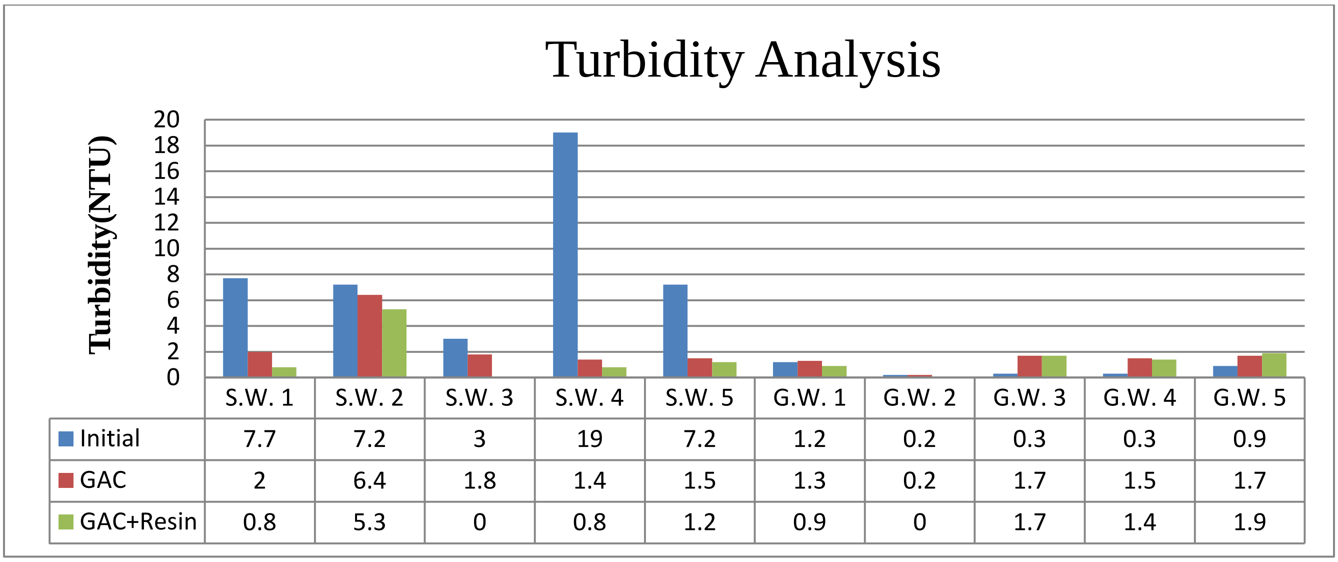
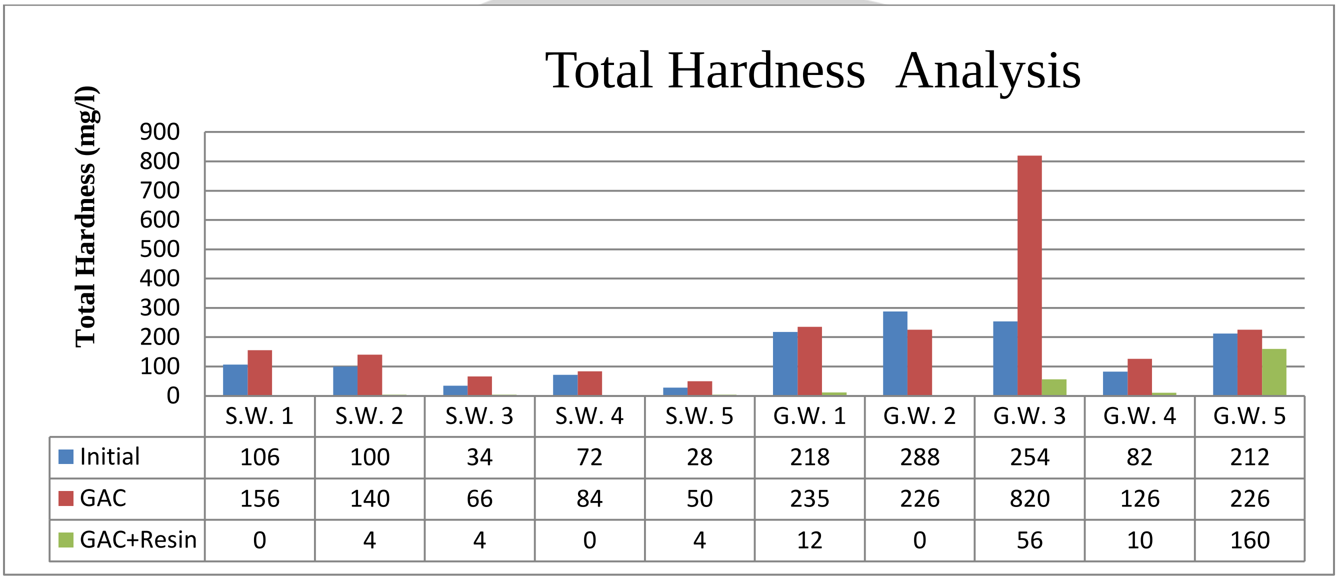
4. Turbidity



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	7.7	7.2	3	19	7.2	1.2	0.2	0.3	0.3	0.9
GAC	2	6.4	1.8	1.4	1.5	1.3	0.2	1.7	1.5	1.7
GAC+Resin	0.8	5.3	0	0.8	1.2	0.9	0	1.7	1.4	1.9

Graph4: Turbidity analysis for various surface water sources and ground water sources

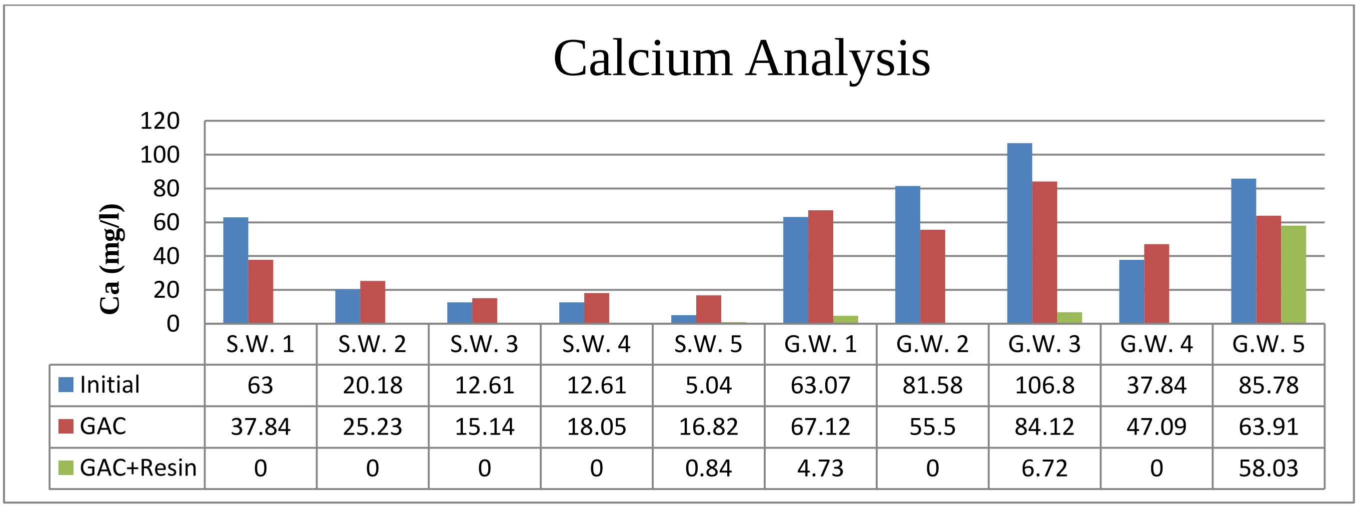
5. Total Hardness



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	106	100	34	72	28	218	288	254	82	212
GAC	156	140	66	84	50	235	226	820	126	226
GAC+Resin	0	4	4	0	4	12	0	56	10	160

Graph5: Total Hardness analysis for various surface water sources and ground water sources

6. Calcium Content



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	63	20.18	12.61	12.61	5.04	63.07	81.58	106.8	37.84	85.78
GAC	37.84	25.23	15.14	18.05	16.82	67.12	55.5	84.12	47.09	63.91
GAC+Resin	0	0	0	0	0.84	4.73	0	6.72	0	58.03

Graph6: Calcium analysis for various surface water sources and ground water sources

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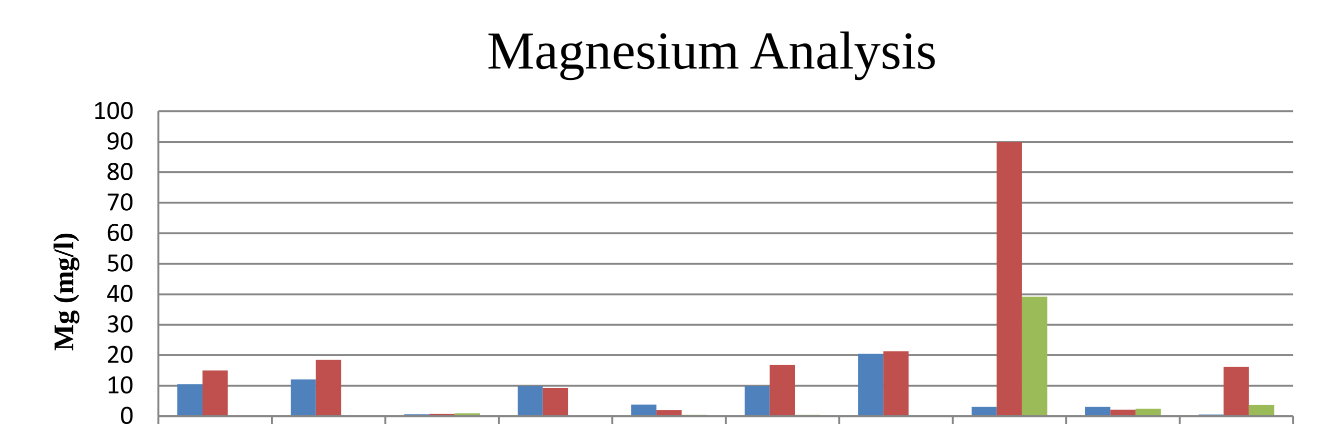
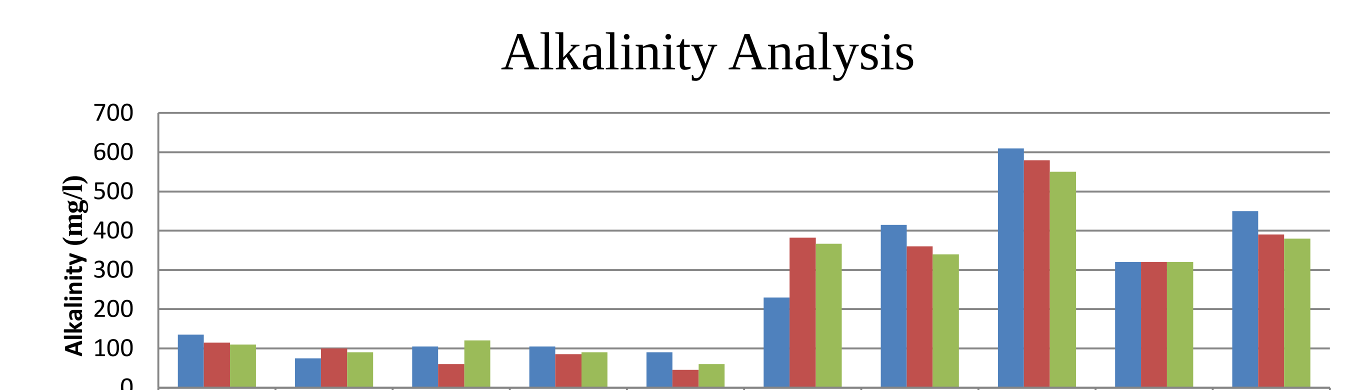
7. Magnesium Content



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	10.45	12.05	0.607	9.84	3.74	9.84	20.49	3.08	3.03	0.5
GAC	15	18.47	0.73	9.2	1.95	16.79	21.24	89.94	2.04	16.14
GAC+Resin	0	0	0.97	0	0.46	0.36	0	39.2	2.43	3.67

Graph7: Magnesium analysis for various surface water sources and ground water sources

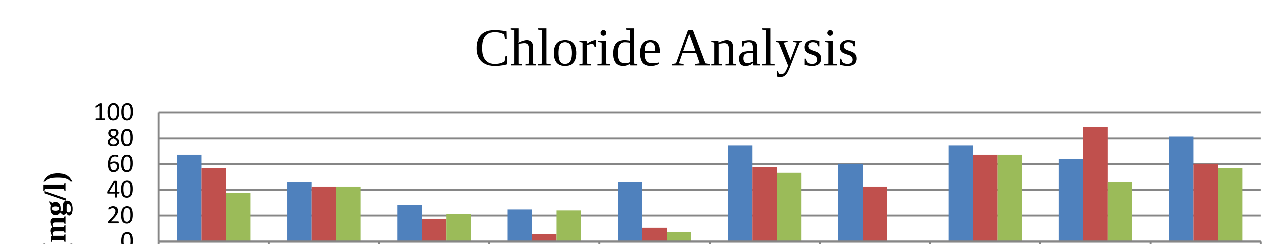
8. Alkalinity



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	135	75	105	105	90	230	415	610	320	450
GAC	115	100	60	85	45	382	360	580	320	390
GAC+Resin	110	90	120	90	60	367	340	550	320	380

Graph8: Alkalinity analysis for various surface water sources and ground water sources

9. Chloride



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	67.35	46.03	28.36	24.81	46.08	74.44	60.26	74.44	63.81	81.53
GAC	56.72	42.54	17.73	5.672	10.64	57.63	42.54	67.35	88.62	60.26
GAC+Resin	37.35	42.54	21.27	24.18	7.09	53.42	0	67.35	46	56.72

Graph9: Chloride analysis for various surface water sources and ground water sources

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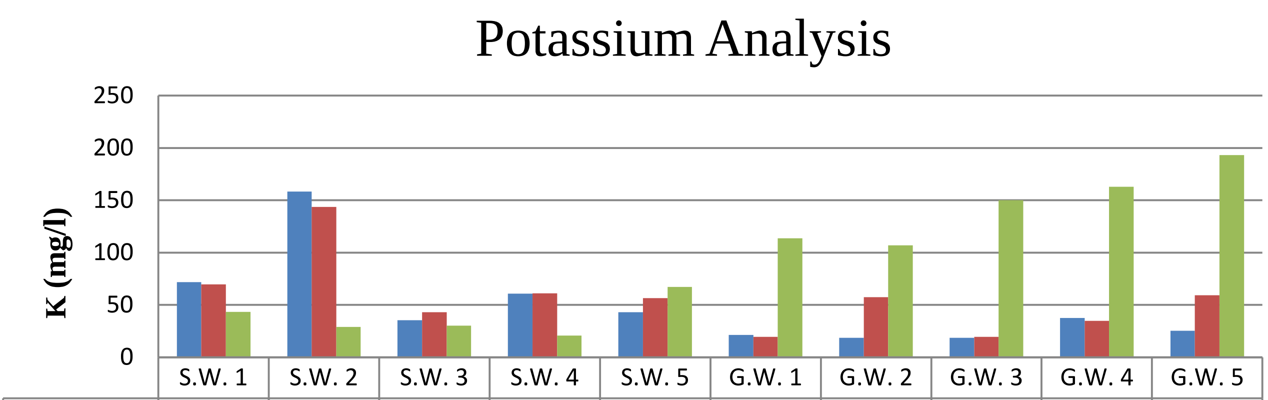
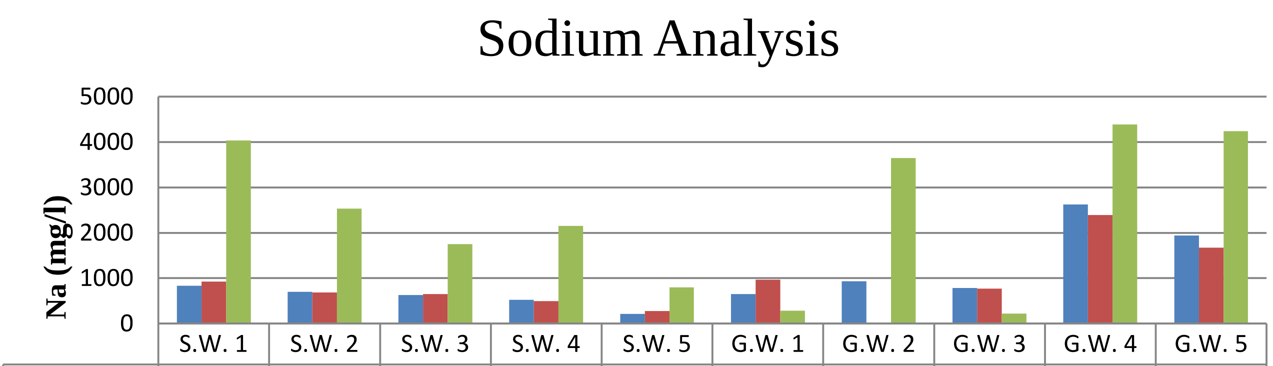
10. Potassium Content



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	71.61	158.4	35.42	60.57	43.04	21.33	18.66	18.66	37.33	25.14
GAC	69.71	143.6	43.08	60.95	56.33	19.42	57.32	19.42	34.66	59.04
GAC+Resin	43.42	28.95	30.09	20.57	67.04	113.52	107	150	163	193.1

Graph10: Potassium analysis for various surface water sources and ground water sources

11. Sodium Content



	S.W. 1	S.W. 2	S.W. 3	S.W. 4	S.W. 5	G.W. 1	G.W. 2	G.W. 3	G.W. 4	G.W. 5
Initial	835.6	696.8	625.6	521.6	216	650.4	933.2	780.8	2624	1941.2
GAC	928.4	684.4	653.2	493.2	273	970.8	23.61	768	2389.2	1670.4
GAC+Resin	4038	2531.2	1749.6	2149	797.2	286.6	3645.6	219.76	4390	4240.8

Graph11: Sodium analysis for various surface water sources and ground water sources

DISCUSSION

Surface water

a. In all Surface water at initially the pH range is within 7.4-8.8, after GAC process it's within 6.9-7.9, and at final GAC + Resin process it's within 7-7.7.
b. The Total Dissolve Solids range is within 45-585 mg/l, after GAC process it's within 74-304 mg/l, and at final GAC + Resin process it's within 96-319mg/l.
c. The Electric Conductivity range is within 67.21-602umohs/cm, after GAC process it's within 435.68-110.8umohs/cm, and at final GAC + Resin process it's within 108.92-435.68umohs/cm.
d. The Turbidity range is within 3-19 NTU, after GAC process it's within 2-6.4 NTU, and at final GAC + Resin process it's within 0-5.3 NTU.
e. The Total Hardness is within 28-106 mg/l, after GAC process it's within 50-156 mg/l, and at final GAC + Resin processes it's within 0-4 mg/l.
f. The Calcium is within 5.04-63 mg/l, after GAC process it's within 15.14-37.84 mg/l, and at final GAC + Resin processes it's within 0-0.84 mg/l.
g. The Magnesium is within 0.607-12.05 mg/l, after GAC process it's within 0.73-18.47 mg/l, and at final GAC + Resin processes it's within 0-0.97 mg/l.
h. The Alkalinity is within 75-135 mg/l, after GAC process it's within 45-115 mg/l, and at final GAC + Resin processes it's within 60-120 mg/l.
i. The Chloride is within 24.81-67.35 mg/l, after GAC process it's within 5.6-56.72 mg/l, and at final GAC + Resin processes it's within 7.09-42.54 mg/l.
j. The Potassium is within 35.42-158.4 mg/l, after GAC process it's within 43.08-143.6 mg/l, and at final GAC + Resin processes it's within 20.57-67.04 mg/l.

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k. The Sodium is within 216-835.6 mg/l, after GAC process it's within 273-928.4 mg/l, and at final GAC + Resin processes it's within 797.2-4088 mg/l.

Ground water

- In all Ground water at initially the pH range is within 7.2-8.1, after GAC process it's within 7.2-8, and at final GAC + Resin process it's within 7-8.2.
- The Total Dissolve Solids range is within 327-585 mg/l, after GAC process it's within 240-437 mg/l, and at final GAC + Resin process it's within 260-497mg/l.
- The Electric Conductivity range is within 514.8 - 1074umohs/cm, after GAC process it's within 481.5-868 umohs/cm, and at final GAC + Resin process it's within 309-913.5 umohs/cm.
- The Turbidity range is within 0.2-1.2 NTU, after GAC process it's within 0.2-1.7 NTU, and at final GAC + Resin process it's within 0- 1.9 NTU.
- The Total Hardness is within 82-288 mg/l, after GAC process it's within 126-820 mg/l, and at final GAC + Resin processesit's within 0-160 mg/l.
- The Calcium is within 37.84-106.8 mg/l, after GAC process it's within 47.09-84.12 mg/l, and at final GAC + Resin processes it's within 0-58.03 mg/l.
- The Magnesium is within 0.5-20.49 mg/l, after GAC process it's within 2.04-89.94 mg/l, and at final GAC + Resin processes it's within 0-39.2 mg/l.
- The Alkalinity is within 230-610 mg/l, after GAC process it's within 320-580 mg/l, and at final GAC + Resin processes it's within 320-550 mg/l.
- The Chloride is within 60.26-81.53 mg/l, after GAC process it's within 42.54-88.62 mg/l, and at final GAC + Resin processes it's within 0-67.35 mg/l.
- The Potassium is within 18.66-37.33 mg/l, after GAC process it's within 19.42-57.32 mg/l, and at final GAC + Resin processes it's within 107-193.1 mg/l.
- The Sodium is within 262.4-1941.2 mg/l, after GAC process it's within 23.61-2389.2 mg/l, and at final GAC + Resin processes it's within 286.6-4240.8 mg/l

V. CONCLUSION

Parameters	Initial	GAC	GAC + Resin	BIS Standards
Temperature(°C)	25.8-31	26.4-31	26.2-31	25
Ph	7.2-8.8	6.9-8.0	7.0-8.0	6.5-8.5
TDS (mg/l)	45-585	74-420	96-497	500-2000
EC (umohs/cm)	67.21-1074	110.8-868.38	108.92-705.8	Up to 50,000
Turbidity(NTU)	0.2-19	0.2-6.4	0-5.3	1-5
Total Hardness (mg/l)	28-288	50-820	0-160	200-600
Ca(mg/l)	5.04-106.8	15.14-84.12	0-58.03	75-200
Mg (mg/l)	0.5-20.49	2.04-89.04	0-39.2	30-
Alkalinity (mg/l)	75-610	45-580	60-550	200-600
Cl (mg/l)	24.81-81.53	5.67-88.62	0-67.35	250-1000
K (mg/l)	18.66-158.4	19.42-69.71	20-193.1	82-164
Na (mg/l)	216-2624	23.61-2389.2	286.6-4390	120-500

Table 7: Water quality parameters after testing water through filter reactor model

- Successfully preparation of activated carbon process in lab base by using $CaCl_2$ solution.
- Analysis was carried out at initial as well as both point sources.
- As per analysis pH, Total Dissolve Solids, Electric conductivity, Turbidity, Total Hardness, Calcium, Magnesium, Chloride, Alkalinity, Potassium all parameters are in permissible limits.
- Due to being submergible when reactor 2 is not in process, Cation Resin release maximum sodium in reactor, when the next batch comes in process the sample outlet contains excessive amount of sodium ions.
- Due to continuous release of sodium ion from resin while being submerged in reactor sodium bond breaks and layers are formed in the reactor, hence even though passing the water sample batches in succession sodium is found in excessive amount.
- However, it has been estimated that a total daily intake of 120–400 mg will meet the daily needs of growing young children, and 500 mg those of adults. However, sodium may affect the taste of drinking-water at levels above about 200 mg/litre.

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