"TO STUDY PHYSIO-CHEMICAL, BACTERIOLOGICAL EXAMINATION OF WATER SOURCES AND DESIGNING A LOW COST WATER FILTER FOR VASHISTH MANALI (H.P.)"

A

PROJECT

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Dr Ashish kumar
&
Dr Sudhir kumar

By

Sushain Sharma

(131683)

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

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Certificate

This is to certify that project report entitled "To study physio-chemical, bacteriological examination of water sources and designing a low cost water filter for Vashisth Manali (h.p.) ", submitted by Sushain Sharma in partial fulfilment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology,Wakhnaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the Award of this or any other degree or diploma.

Date: **External Examiner**

Dr. Ashok Kumar Gupta
(Head of Department,
Civil Engineering)

Dr. Ashish Kumar
(Associate Professor)

Dr. Sudhir Kumar
(Associate Professor)

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Date: **Sushain Sharma**

(131683)

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ABSTRACT

My project mainly focuses on providing clean drinking water to the people of the rural areas of the vashisth village in Himachal Pradesh by utilizing the locally available water sources. My project dealt with the physio-chemical, bacteriological, heavy metal testing and designing a low cost sand filter which would solve the problems that was there in the water sources.

The chemical, physical and bacterial characteristics of water determine its suitability for potability. While the prime objective of my project is to help the rural people of vashisth to find a suitable natural resource and provide them with a low cost water filter which could be used at a time of any natural calamities like floods, avalanches, landslides and earthquake.

INTRODUCTION

1.1 GENERAL: Water is the basic necessity of all human beings. We cannot deny the fact that the growth of one nation is somehow related with its potable water supplying capacity to its population. Due to increasing population and global warming our fresh water reserves are fast depleting. It is becoming a great challenge for the government to cope up with the growing demand of fresh water supply for every corner of the country. To tackle this problem we took a small pilot project in Himalayan village of vashisth which is around manali in kullu district of Himachal Pradesh. It is located at an altitude of 2050 m (6,730 ft) above mean sea level. Providing safe drinking water to its inhabitants and the increasing population remains a major challenge for the governing authorities which are responsible for supplying water to the village.

My final year project basically deals with study and examination of the present water sources which are available there and focuses on its physiochemical ,bacteriological ,heavy metal analysis using Atomic absorption spectroscopy (AAS) PERKINELMER **,** AAnalyst 400 as well as designing a economical water filter for purifying the naturally locally available water in that area. We have carefully examined all the parameters and have designed a safe water filter which can be easily assembled from locally available materials. My project can be effectively used at a time of heavy rainfall, floods, earthquakes and other natural calamities, when there is huge scarcity of safe potable water.

REVIEW OF LITERATURE

The main problem around the world is the availability of clean drinking water. Inadequate drinking water supply and poor sanitation are the major cause of morbidity and mortality all around the world. According to World Health Organization (WHO), 80% of human diseases in developing countries are waterborne. Enteric pathogens are disease-causing microorganisms, predominantly of fecal origin and are major causative agents of waterborne disease. Around 1.1 billion people globally drink unsafe water and the vast majority of diarrhoea disease in the world (88%) is attributable to unsafe water, sanitation and hygiene.

The main objective of our project is to provide safe drinking water to the people specially belonging to the rural areas of developing countries at very low\no cost and sustain their living. For this purpose, we have tested number of water samples from various sources. we have designed a water filter which is effectively removing the total dissolved solids to the specified drinking standards. Our design is easy to assemble and its cost is less than 20 rupees which is really encouraging for us. Our water filter design has undergone all laboratory scale studies for monitoring and accurate results on regular basis. Our design can really help the rural regions of india in times of natural calamity like floods, landslides and earthquake by providing them with clean drinking water.

2.1 Total Coliform Bacteria can be detected by doing Total Coliform Bacteria count and it includes thermotolerant coliforms and bacteria of fecal origin, as well as some bacteria that are isolated from environmental sources. Therefore, the presence of total coliform cannot fully indicate fecal contamination which grows on a lactose rich media and at an ambient temperature of 35 or 37 °C. They can be detected by the production of acid and gas upon lactose fermentation (National Health and Medical Research Council 2003).

2.2 Fecal Coliform or Thermotolerant Bacteria are found in the gut and feces of warm blooded species of animals. Fecal coliforms are considered the good indicators of animal and human waste. Fecal coliforms types include *Esherichia coli, Citrobacter, Enterobacter* and *Klebsiella* species. They are gram negative, aerobic or facultatively anaerobic, non spore forming rod shaped bacteria. They are oxidase negative and nitrate reducing bacteria. Fecal coliforms can also be used as indicator of pathogenic micro-organisms because they are present in large number and are technically easier to detect and quantitate. The members of this group can cause mild to severe diseases. (Sulehria et al. 2011; Tortorello M. 2003).

2.3 Study on Bacteriological Parameter of Drinking Water

Analysis of Bacteriological parameter helps in determination of bacteriological contamination in drinking water which is as important as study of Physico-chemical contamination. Bacteriological contamination causes the water borne disease which may pose a risk to human health and to environment. We took the sample from various sites and performed MPN test to detect the presence of coliform bacteria. MPN test is the most probable number test. This number is the statistical estimate of the mean number of coliform present in the sample. The precision of this method is low and depends upon the number of tubes used for analysis. The time required for obtaining result is higher than the membrane filter technique. Yet it is more popularly used as it is easy to implement and inexpensive. (Rompre et al.2002).

Sulehria et. al (2011) conducted the MPN test for fecal coliform. Water samples were collected from different sites. All samples revealed the presence of coliform bacteria. The counts were higher than the standards established by World Health Organization (WHO). The bacterial counts were higher in consumer taps (3.99-4.39 log cfu/100 ml), followed by distribution line (3.65-4.25 log cfu/100 ml) and main reservoir (3-3.96 log cfu/100 ml). The pH was found within the limits of WHO standard (6.5-8.5), however, there was no sign of residual chlorine in any sample of drinking water. Therefore, they conclude that the quality of drinking water in Mughalpura is not up to WHO standards.

MPN can be performed by a technician with basic microbiological training. However, it is also relatively inexpensive, as it requires unsophisticated laboratory equipment. Another method which could be used for detection of coliform bacteria is Membrane filtration method. The concentration of larger samples on a membrane filter is a key benefit of the technique over the MPN procedure as well as over Pour Plate and Spread Plate techniques.

2.4 Study of various design and features of slow sand filter

Reynolds and Richards et.al 1996 Chlorine is an effective disinfectant due to its ability to oxidize enzymes of microbial cells Chlorine disinfectant that is commonly added to water systems is generally referred to hypochlorous acid (HOCl) and the hypochlorite (OCl–) ion or bleach and usually known as free chlorine. When free chlorine reacts with ammonia or organic nitrogen present in the water, chloramines known as monochloramine, dichloramine, and trichloramine are quickly formed (Hach, 2014). These chloramines are also known as combined chlorine. The combinationof free chlorine and combined chlorine is called total chlorine. The level of total chlorine will always be higher than or equal to the level of free chlorine.

Peter-Varbanets, et.al 2010 Gravity Driven Membrane (GDM) is an ultra-low pressure membrane filtration technology that requires gravity as the only input to remove bacteria and viruses. It is based on ultra-low pressure membrane filtration technology which requires no back washing. During ultra-low pressure filtration, formation of a biofilm occurs and counteracts the resistance caused by deposition of particles.

Huisman and Wood, et.al 1974. Slow sand filters can be constructed from local materials, mainly from properly graded sand/gravel, concrete/clay, and standard piping, can operate without the use of specialized equipment, and is much less labor intensive than rapid filters. Slow sand filters operate under gravity flow conditions, and energy, its on-going energy demand is minimal. Thus, slow sand filtration is an attractive treatment alternative for local communities. Finally, there is very little water wastage during cleaning of the filters and the production of sludge is much less than rapid sand filters. The sludge can subsequently be handled in its dry state, preventing recontamination of surface water; and can be used to improve agricultural fertility

Weber-Shirk and Dick, et.al 1997 The major types of transport mechanisms in slow sand filtration is straining or screening, where particles larger than the pore size of media are physically removed. However, as the pore size of the media progressively decrease due to particle deposition and biofilm growth; straining will become more efficient in capturing particles that are even smaller in size

Van Dijk and Ooman, et.al 1978 It is suggested that slow sand filtration can achieve between 99 and 99.9% of pathogenic bacterial removal. However, removal efficiencies may be somewhat site specific as there is some variation in the findings from several authors. The variation in bacteria removals can be attributed to differences in source water quality conditions and filter operational conditions. This highlights the importance of onsite pilot testing to determine treatment performance under the prevailing water quality and operational conditions.

Taj Ali Khan et.al 2016 Describes the efficiency of a slow sand filter that was constructed using a 200 l drum for the treatment domestic as well as industrial wastewater. The samples were again tested after the filtration and results were compared with pre-filtration results. Fecal and total coliform bacteria removal efficiency of the filter was found 100%, whereas turbidity was reduced about 88%. Similarly, aesthetic of the water was highly improved when compared with clean water. Chloride and nitrate levels have also shown reduction of about 4% and 23% respectively.

MATERIALS AND METHOD

3.1 Materials- water samples, glasswares, chemicals (Mac Conkey agar, EMB agar, triple sugar iron, LB broth, hydroxylamine, 1, 10 –phenanthroline)

3.2 Methods

3.2.1 Sampling- Water samples were collected from the Vashisth Temple near Manali on 18/08/2016, 29/09/2016 and 12/10/2016 respectively. This was done in order to check for the seasonal variation in the coliform count. We also collected water from Jogni Falls ,Tap water supply and Stream Water near Vashisth on 29/09/2016 and 12/10/2016 respectively. Refer to table no. 1

Table no.1: List of the samples we analysed in our project.

Sample no.	**Water Samples**
1	Main kund of Vashisth Temple
2	Jogni falls near Vashisth

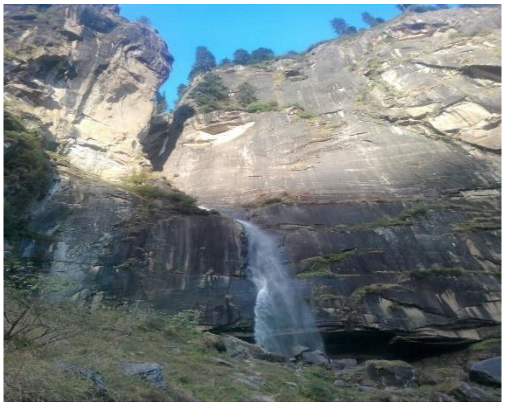

Fig No.1 JOGNI FALLS

Fig No.2 VASHISTH KUND

Fig No.3 VASHISTH STREAM

Fig No.4 TAP WATER

3.2.2 Methods of Detection of Coliform Bacteria

(Approved by US Environment Protection Agency EPA)

- o Multiple Tube Fermentation Method or Most Probable Number Method
- o Membrane Filter Technique
- o Enzymatic Methods
- o Molecular Methods

3.2.2.1 Multiple Tube Fermentation Method

The Multiple-Tube Technique is a two staged test that begins with a **presumptive test** using lactose fermentation tubes inoculated with the water sample to determine if acid and gas fermentation of lactose occurs indicating the presence of coliforms. Three different volumes of sample water are used to inoculate lactose fermentation tubes in replication. If gas and acid fermentation of lactose has occurred in any of the tubes after incubation, coliforms are presumed to be present in the water sample (Fig 3). If the tubes show an orange coloration it indicates the presence of lactose fermenting bacteria. The orange coloration is due to the decrease of pH caused due to acid production (Fig 13). If the tube shows a yellow coloration it indicates the presence of non lactose fermenting bacteria. The second stage of this method uses **Eosin-Methylene Blue agar** as a **confirmatory** method to identify the positive lactose fermentation tubes as fecal coliforms. The tube showing positive presumptive test can then be streaked onto EMB agar. The result of MTF is expressed in terms of **Most Probable Number (MPN)** (Rompre et al.2002).The MPN value is calculated by the table standardized by WHO

Table no.2: MPN values per 100ml of sample (when five 10-ml, five 1-ml and five 0.1ml test portions are used)

10ml	1ml	0.1ml	MPN Index/100ml
0	0	0	<2
0	0	1	2
0	1	0	2
0	2	0	4
1	0	0	2
1	0	1	4
1	1	0	4
1	1	1	6
1	2	0	6
2	0	0	4
2	0	1	7
2	1	0	7
2	1	1	9
2	2	0	9
2	3	0	12
3	0	0	8
3	0	1	11
3	1	0	11
3	1	1	14
3	2	0	14
3	2	1	17
4	0	0	13
4	0	1	17
4	1	0	17
4	1	1	21
4	1	2	26
4	2	0	22
4	2	1	26
4	3	0	27
4	3	1	33
4	4	0	34
5	0	0	23
5	0	1	30
5	0	2	40
5	1	0	30
5	1	1	50
5	1	2	60
5	2	0	50
5	2	1	70
5	2	2	90
5	3	0	80
5	3	1	110

5	3	2	140
5	3	3	170
5	4	0	130
5	4	1	170
5	4	2	220
5	4	3	280
5	4	4	350
5	5	0	240
5	5	1	300
5	5	2	500
5	5	3	900
5	5	4	1600
5	5	5	>1600

3.2.2.2 Membrane Filter Technique

This method consists of filtering water sample on a sterile filter with a 0.45 micrometer pore size which retains bacteria, incubating filter on selective medium and enumerating colonies on the filter. The most widely used media for this method is m-Endo-type media. This is selective and differential media that inhibits the growth of gram positive bacteria and enhances the growth of gram negative. Coliform bacteria form red colonies with a metallic sheen on Endo-type medium containing lactose. Mac Conkey agar can also be used as a media. The presence of high number of heterotrophic bacteria has shown a decreased coliform recovery by this method. This method cannot detect stressed or injured coliforms. A significant advantage over MTF method is that through MF examination of larger volumes of water is feasible thus increasing its sensitivity and reliability.

3.2.3 Miscellaneous Tests Performed

- EMB
- Mac Conkey

3.2.3.1 EMB Test

This test uses the Eosin-methylene blue agar which is a selective and a differential media. It allows the growth of gram-negative bacteria and inhibits the gram-positive. The bacteria that ferment lactose in the medium form colored colonies, while non lactose fermenting forms colorless colonies.

EMB agar contains peptone, lactose, sucrose, eosin Y and methylene blue dyes. The dye methylene blue in the medium inhibits the growth of gram-positive bacteria. Eosin dye responds to changes in the pH, going from colorless to dark purple under acidic conditions. The medium contains lactose and sucrose as energy sources. This medium detects the presence of fecal coliforms on their ability to ferment lactose. Therefore, a lactose fermenting bacteria will acidify the medium, the dye produces a dark purple complex which may or may not be associated with a green sheen. A slow fermenter of lactose will give a brown-pink coloration of growth. Colonies of a non-lactose fermenting bacteria appears translucent or pink

3.2.3.2 Mac Conkey Test

This test uses the Mac Conkey agar which is used for the isolation and differentiation of gram-negative enteric bacilli. It consists of lactose as a carbon source. Enzymatic Digest of Gelatin, Enzymatic Digest of Casein and Enzymatic Digest of Animal Tissue are the nitrogen and vitamin sources. During lactose fermentation pH drops around the colony causing a color change in the pH indicator, Neutral Red and bile precipitation. Bile Salts mixture and Crystal Violet are the selective agents, inhibiting Gram-positive bacteria and allowing only Gram-negative to grow.Pink colored colonies show the presence of fecal coliforms (Ananthanarayan R. & Paniker. C.K. 2009)

3.2.4 Physio-chemical Analysis for the Drinking Water Quality

Parameters for drinking water quality typically fall under two categories - Chemical and Physical. Chemical parameters causes chronic health risks through built up of heavy metals whereas physical parameters affect the aesthetics and taste of drinking water. Drinking water is analyzed for various parameters such as turbidity, pH, nitrate, fluoride, chloride, residual free chlorine and other ions.

The pH of water is extremely important. The fluctuations in optimum pH ranges may lead to an increase or decrease in the toxicity of poisons in water bodies. The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. pH has no direct adverse effects on health, however, higher values of pH accelerate the scale formation in water heating apparatus and also reduce germicidal potential of chloride. High pH induces the formation of tri-halomethanes which are toxic (Kumar *et al*., 2010) . Another important Physico-chemical parameter is turbidity of water which is actually the expression of optical property in which the light is scattered by the particles present in the water. Change in water color from transparent to light-yellowish, reddish or grayish indicates the increase in turbidity. High turbidity in water also interferes with chlorine disinfection process and provides a growth medium to pathogenic microbes. Similarly, when the fluoride concentration in water increases more than 1.5 mg/L, it induces a teeth disease in calcification stage of children. The pathological condition becomes evident from yellow to brown patches on teeth. When fluoride concentration exceeds the level 8 mg/l, it may cause endemic, cumulative fluorosis with resultant skeletal damage in both children and adult. People become old in short age. Their joints are almost finished at the age of 30-40 (Meena *et al.,* 2011). Major source for fluoride contamination is the industrial effluent run off and geological source. Similarly, groundwater contains nitrate contamination due to leaching with the percolating water. Runoff from agricultural fields contributes major in nitrate pollution. Excessive concentrations of nitrates cause blood disorders.

Nitrate after reduction to nitrite in body deplete oxygen in blood resulting in methemoglobinemia or what is commonly known as "blue baby syndrome" disease **(**Mathur *et al*., 2012**).** Some recent studies have shown that nitrates in drinking water besides causing methemoglobinemia can result in various other clinical manifestations like recurrent stomatitis, recurrent respiratory tract infections (RRTI) etc**.** Another important parameter is the presence of iron in drinking water. Iron in water is predominantly present as Fe3+. It is necessary to reduce Fe3+ to Fe2+. This is accompanied by addition of reducing agent hydroxyl amine. Fe^{2+} is quantitatively complexed by 1, 10 –phenanthroline in the pH range from three to nine. Sodium acetate is used as buffer to maintain pH 3.5. Detection of iron-phen complex is performed by spectrometer at 508nm. Iron compounds can have more serious effects on health than the element itself. Water soluble compounds like iron chloride can cause lethal effects upon a concentration of 200mg, and are toxic for adults upon the dose of 10-50g . Heavy metals are metals with high molecular weights that are of concern because they are generally toxic to animal life and human health if naturally occurring concentrations are exceeded. Heavy metal toxicities are relatively uncommon. However, failure to recognize and treat heavy metal toxicities can result in significant morbidity and mortality. Dehydration is common. Encephalopathy is a leading cause of mortality in patients with both acute and chronic heavy metal toxicity. For example at lower doses, copper ions can cause symptoms typical of food poisoning (headache, nausea, vomiting and diarrhea) (Abdul et al.2012). Thus, physico-chemical analysis is important to determine quality of drinking water as well as in water management studies.

3.3 Slow sand water filter

3.3.1 Historical Background

Slow sand filtration is one of the best economical way of treating raw water. The first installation of slow sand filtration was completed in Lancashire, England and its filter's main purpose was to improve the potable quality of the water. The first slow sand filter which was constructed for public purposes was done in Paisley, Scotland, 1804. During 1885, it was realised that slow sand filter sand can remove the bacteria from the water.

3.3.2 Aspects of Slow sand filter

In 1980, it was found that slow sand filteratiom can remove *Giardia lambia* ,an intestinal parasites. It was found in research of logsdon et.al 2002 that slow sand filter has great possibilities in removing these parasities from raw water.

In the research of Bellamy 1985 , he showed that when a water containing a concentration of Giardia lambia of 2770 cysts\L ,the filtered watered only contained 26 cysts\L.

Slow sand filter is one of the best way of pre-treatment for small rural community in less developed countries. Filteration rate also plays a very important role in the efficiency of the filtered water. Filteration rate can be increased by increasing the hydraulic rate but this change can decrease the filtering quality of the water filter.

The term filter bed refers to the part of the filter which contains the sand layer. Sand paricles play a major role in the filteration purposes. In research of campos in 2002, it was shown that sand particles whose diameter was between 0.1 to 0.3 millimetres have high efficiency of filtering . the efficiency of filter also depend upon the layering of sand particles over the layers of different grades of gravel. A good filter bed helps in the removal of the turbidity and protozoa from the raw water.

The schmutzdecke which forms on the top of the filter bed, provides very good and efficient sieve like properties for removal of both small water particles and microbes.

Mechanism of slow sand filters

Simple straining is the key mechanism which a slow sand filter follows. The unwanted particles which are larger than the sand pore particles ,gets trapped and the filtered water is allowed to move through it ,thus it forms a layer of filter cake. As the finer particles keeps on trapping in the filter cake , the efficiency of the filter goes on increasing with it.

Since the unwanted paricles removal efficiency increases therefore the filteration rate decreases. When this situation arrives ,then it is an indication the the filter maintaince and reinstallation. Sand should be washed before installing into the filter. This is done to ensure that the sand particles do not contribute to the total dissolved solids and turbidity level of the filtered water. When the sand is washed, the turbidity level should again be measured so that it does not effect the efficiency of the filter.high efficiency of the filtering

3.3.3 Temperature variation

Bellamy in 1985, in his research showed that the efficiency of the slow sand filter decreases at low temperature for the removal of coliforms. It generally tends to start decreasing when it starts to reach at a temperature of about 5*C.

3.4 Material used for water filter

The construction of slow sand filter requires very basic material which can be easily available. In our project we have designed two types of filter design that is , sand gravel filter and charcoal sand gravel design. These are the following components of our proposed slow sand filter.

3.4.1 Storage container

For storage assembly we are using a normal 1 litre filtered water bottle. In this bottle, we have made few changes. Firstly, we have cut its bottoms and made few holes in its cap opening.

Fig No.5 plastic one litre bottle

3.4.2 Filter bed of Sand

we have used sand from the stone quarry which is generally recommended for the use as sand filter bed to be used as the filter media. It is normally of size between 0.1 mm to0.3 mm. In our first design we have used a sand filter bed of 6 cm and In second design we have used a sand filter bed of 5 cm.

Fig No.6 Sand

3.4.3 Activated charcoal or wood charcoal

Activated charcoal can help in trapping impurities in water which includes solvents, pesticides, industrial waste and other chemicals like flourides. Smaller the size of the charcoal, better is the efficiency of it. Charcoal is used in charcoal sand gravel filter with two layers of 1cm respectively.

Fig No.7 activated charcoal

3.4.4 Gravel bed

Generally the gravel bed is organised from smaller diameter to the largest diameter. This layer of gravel helps preventing the sand from leaving with the filtered water or clogging the Filter effluent.. In our first design we have used a gravel filter bed of 6 cm and 10 cm respectively whereas in our second design we have used a gravel filter bed of 3 cm and 5 cm respectively.

Fig No.8   coarse aggregates/gravels

3.4.5 Cotton bandage

In our project design we have used cotton bandage. The cotton bandage serves as layer of sepration between the sand and gravel. It also holds the sand layer in its place.

Fig No.9   Cotton bandage

3.5 Assembling of water filter

For this project, we have used two different types of water filter design. In first filter, we have used layer gravel, sand ,cotton bandage as filter and gravel(top to bottom). We have termed the first filter design as sand gravel filter.

In the second filter design we have used, gravel, activated charcoal, sand, charcoal, cotton bandage and gravel layer(top to bottom). We have termed the second filter design as charcoal sand gravel filter.

Fig No.10 Top view of water filter

For this project, we undertook a pilot project for 30 days period on both the types filter that is sand filter and charcoal sand filter, which were changed with a new assembly on the completion of 15 days period. We have observed 15 days as the threshold of our water filter as filtration rate tends to decrease. We took different kinds of water sample of varying range of turbidity and total dissolved solids. We collected the filtered sample from both these filters and tested for the same parameters of turbidity and total dissolved solids.

Fig No.11 Sand gravel filter

Fig No.12 Charcoal sand gravel filter

Results and Discussion

4.1 Physio-chemical properties of water samples

4.1.1 pH analysis

The pH of water samples range varies from 7.3 to 7.6 with a mean of 7.6 & 7.3. According to Indian IS 10500-1991, for drinking water quality the permissible limit of pH is 6.5 to 8.0. The statistical analysis of physio-chemical properties of drinking water quality are given in Table 3.

Table 3 The statistical analysis of Physio-chemical properties of water samples.

Parameters	pH of vashisth sample	pH of jognifall sample
Number of Samples tested	2	2
Minimum	7.4	7.3
Maximum	7.6	7.3
Permissible limits	6.5-8.0	6.5-8.5

For an effective chlorination the pH range should be 6.5 to 8.0. The pH measured falls within this range therefore the disinfection procedure is being properly implemented and the water is fit for human consumption

4.1.2 Result of physiological tests

Table 4 The results of the physio-chemical tests conducted on vashisth & jognifall sample

Physicochemical Properties	Experimental Values of Vashisth sample	Experimental Values of Jognifall sample	Standard Value	Inference
Total Dissolved solids	400 mg\l	213 mg\l	500 mg\l	Potable
Dissolved oxygen	6.05 mg\l	7 mg\l	7 mg\l	Potable
Biochemical oxygen demand	5.64 mg\l	0 mg\l	30 mg\l	Potable
Chemical oxygen demand	128 mg\l	0 mg\l	250 mg\l	Potable

Alkalinity	180 mg\l	21 mg\l	200 mg\l	Potable
Hardness	44 mg\l	48 mg\l	300 mg\l	Potable
Chloride	146 mg\l	59 mg\l	250 mg\l	Potable
pH	7.5	7.3	6.5-8.5	Potable

From the above physiological parameters result, it is clear that the vashisth and jognifall sample is fit for drinking in all aspects as per Indian IS 10500-1991 and WHO standards.

4.1.3 Analysis of water using MPN method

Table 5 Result of MPN analysis was performed using Vashisth sample and Jognifall sample

Water sample	MPN(1)	MPN(2)	Permissible limit	Human consumption
Vashisth sample	350cfu/100ml	280cfu/100m	0cfu/100ml	UNFIT
Jognifall sample	0cfu/100ml	0cfu/100ml	0cfu/100ml	FIT

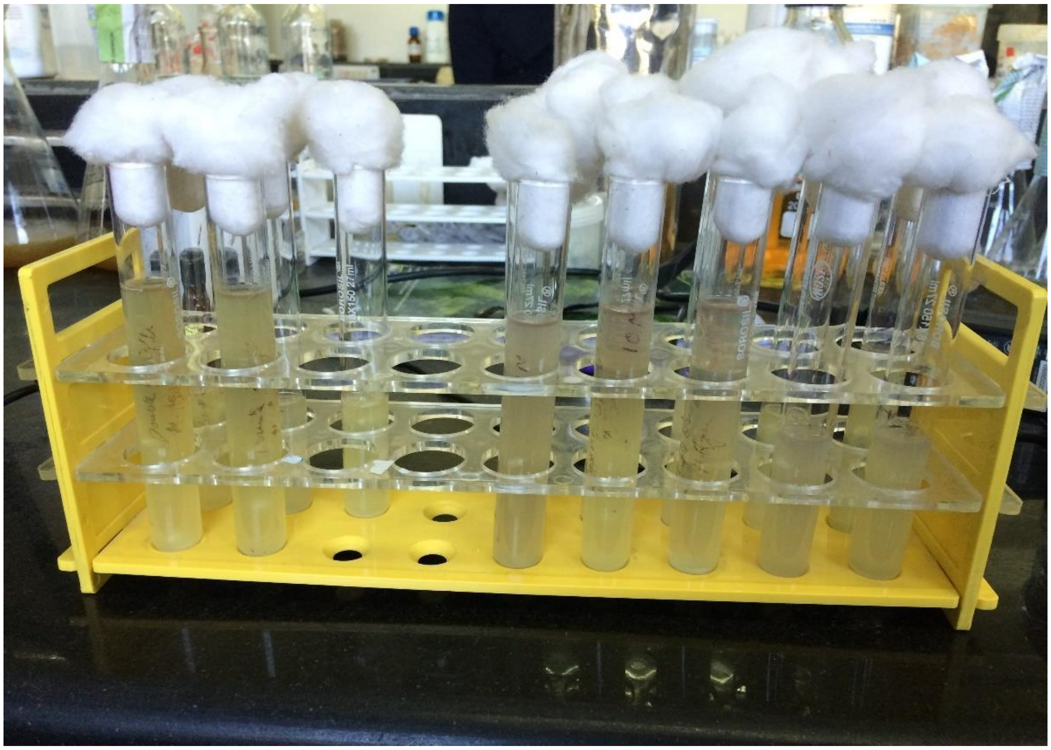

Fig No.13 Macconkey broth & water sample with inverted durhams tube for incubation

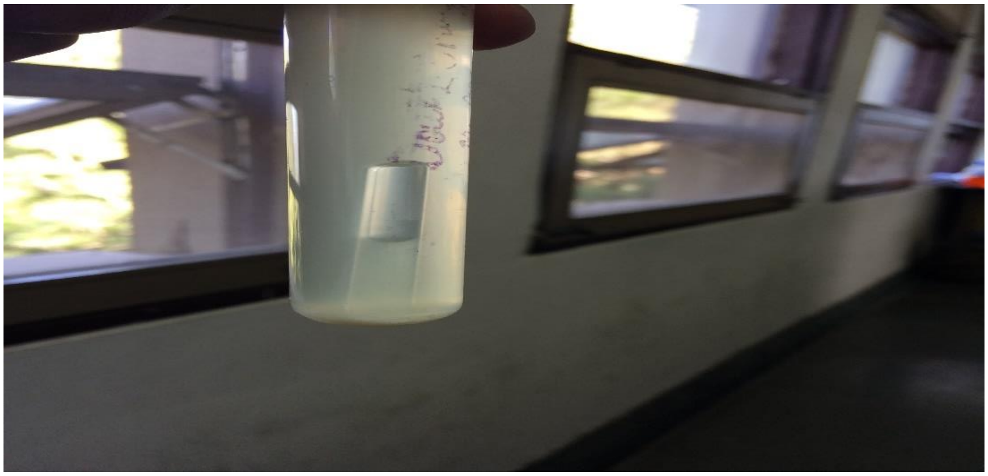

Fig No.14 Formation of air bubble in durhams tube

Fig No.15 Working in the laminar airflow (LAF) for plating of incubated sample

Fig No.16 Spreading of incubated sample on EMB Agar

Fig No.17 Sterilization of stirrer near the burning lamp

Fig No. 18 Petri plates being tested after 24 hour of incubation period

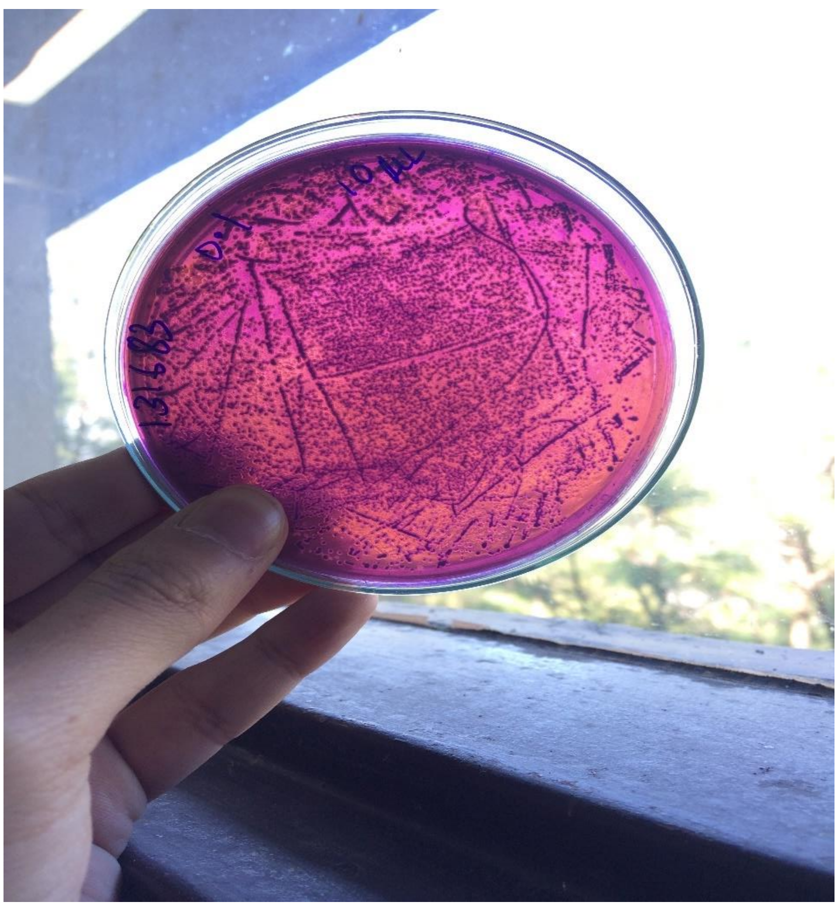

Fig No.19 Formation of E-coli colonies in the petri dish

4.1.4 Heavy and rare earth elements analysis using AAS

The concentrations of Chromium (Cr), Nickel(Ni),Cobalt(Co), Copper(Cu), Zinc(Zn), Aluminum(Al) in drinking water samples are presented in Table 6. The concentration of Cr in water samples was found to be 0.090 mg/L within desirable limit of Cr specified as 0.05 mg/L for drinking water (WHO 2004) .Cr is not acutely toxic to humans. Cr+6 is more toxic than Cr+3 because of its high rate of adsorption through intestinal tracts. The concentration of Ni in the water samples ranges from 0.023 to 0.136 mg/L. The desirable limit for Ni is 0.2mg/L for drinking water. Ni compounds induce nasal, laryngeal and lung cancer (Lessard et al. 1978). Co concentration in the water samples was nil. The concentration of Cu in the water samples ranges from 0.027 to 0.070 mg/L. The desirable limit of Cu in the drinking water is 0.05 mg/L (ISI 1983). 12.5% of the samples show high Cu concentration. High doses of Cu can cause stomach and intestinal distress, liver and kidney damage and anaemia (USEPA 1999). Acute Cu toxicity causes headache, nausea, vomiting, gastrointestinal irritation (Stenhammar 1999). The concentration of Zn in drinking water samples ranges from 0.025 to 0.092mg/L. The desirable limit of Zn in drinking water is specified as 3 mg/L. All the water samples are within the desirable limits of WHO. High concentration of Zn can be toxic, plays a very important role in the physiological processes of many organisms (Pillai 1983). Al concentration in water samples ranges from 0.29 to 0.36 mg/L. However the desirable limit of Al in drinking water is 0.2mg/L. 90% of the samples show high Al concentration. Al has been considered to be a causative agent for various neurological disorders including the Alzheimer's disease (Gardner and Gunn 1995).

Table 6 Concentration of trace and heavy metals in Vashisth and jogni falls water sample.

Elements	**Vashisth**	**Jogni falls**	**Standard values**
Chromium(Cr)	0	0	0.05
Nickel(Ni)	0	0	0.02
Cobalt(Co)	0 .039	0.021	N.A
Copper(Cu)	0.037	0	0.05
Zinc(Zn)	0	0	3
Iron(Fe)	0.114	0.085	N.A

The concentration of Cr ,Ni ,Co ,Cu ,Zn and Fe was in permissible limit of drinking water quality. As per the atomic absorption spectroscopy analysis the both the water sample are fit for drinking purposes as per Indian IS 10500-1991 and WHO standards.

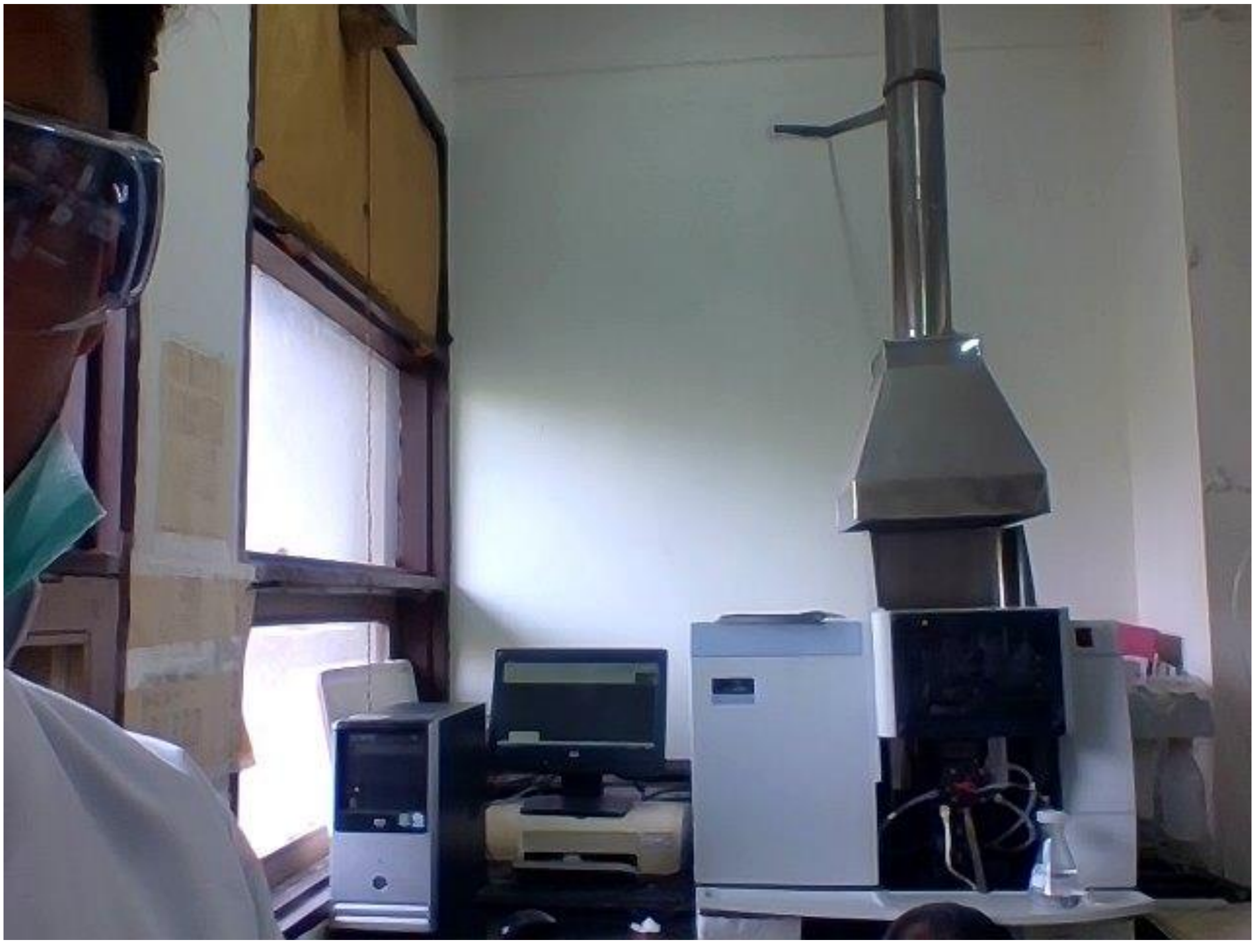

Fig No. 20 Heavy metal testing using Atomic absorption spectroscopy (PERKIN ELMER , AAnalyst 400)

Fig No.21 Use of safety measures during heavy metal testing

4.2 Results of water filter

We did testing for 30 days period on both the types filter that is sand filter and charcoal sand filter, which were changed with a new assembly on the completion of 15 days period. We have observed 15 days as the threshold of our water filter as filtration rate tends to decrease. We took different kinds of water sample of varying range of turbidity and total dissolved solids. We collected the filtered sample from both these filters and tested for the same parameters of turbidity and total dissolved solids. As per the TDS and turbidity analysis the filtered water sample is fit for drinking purposes as per Indian IS 10500-1991 and WHO standards. Sand gravel filter has a rate of filtration is 2.5 L\hr whereas for charcoal sand filter has a rate of filtration is 1 L\hr.

4.2.1 Sand gravel filter

Table 7 Turbidity results of sand gravel filter during first 15 days.

SAMPLE NO.	TURBIDITY(mg\l) RAW WATER	TURBIDITY(mg\l) FILTERED WATER
1	110	2
2	180	0
3	223	0
4	190	0
5	210	0
6	200	0
7	150	0
8	180	0
9	187	0
10	207	0
11	120	0
12	123	0
13	175	0
14	180	0
15	210	0

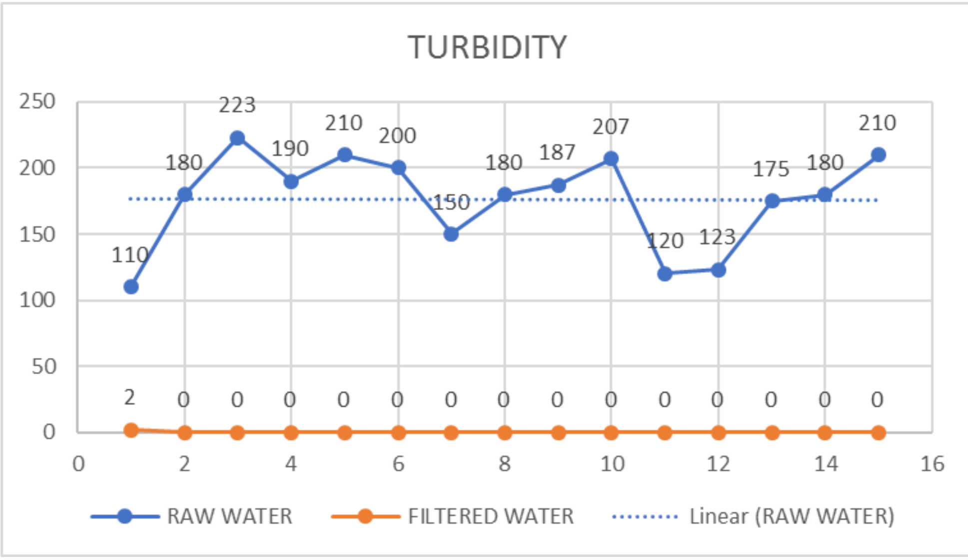

Fig No.22 Turbidity graph of sand gravel filter during first 15 days.

Table 8 TDS results of sand gravel filter during first 15 days in a new assembly.

SAMPLE NO.	TDS(mg\l) RAW WATER	TDS(mg\l) FILTERED WATER
1	600	200
2	1040	240
3	1600	240
4	1400	210
5	1360	220
6	1357	205
7	800	210
8	990	218
9	1020	225
10	1350	220
11	750	200
12	780	205
13	950	210
14	1030	245
15	1350	220

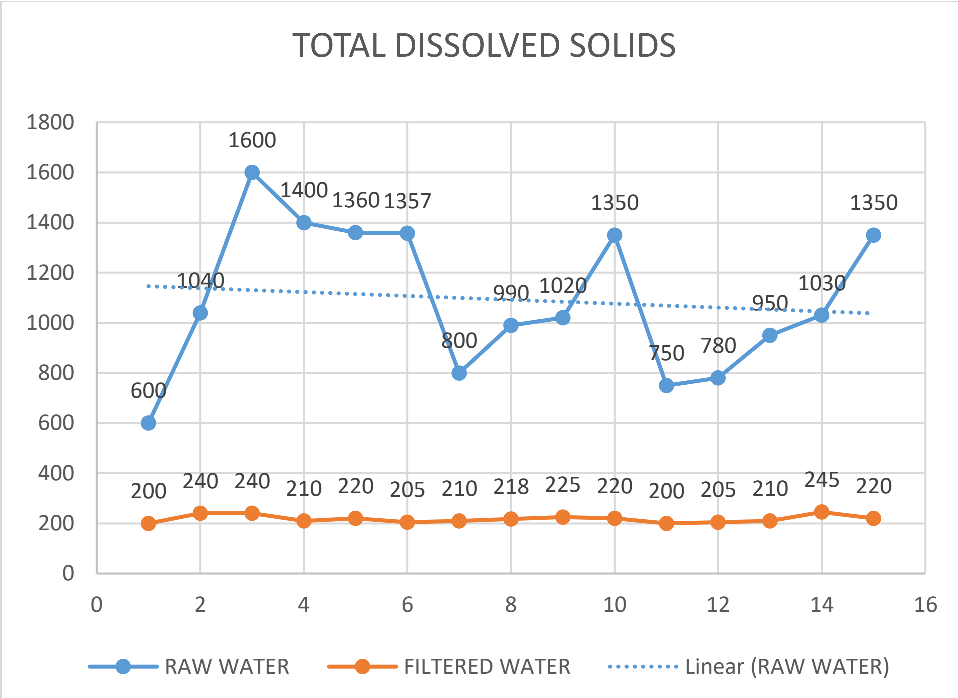

Fig No.23 TDS graph of sand gravel filter during first 15 days in a new assembly.

Table 9 Turbidity results of sand gravel filter during next 15 days in a new assembly.

SAMPLE NO.	TURBIDITY(mg\l) RAW WATER	TURBIDITY(mg\l) FILTERED WATER
1	210	0
2	190	0
3	180	0
4	160	0
5	130	0
6	128	0
7	170	0
8	110	0
9	225	0
10	195	0
11	200	0
12	180	0
13	125	0
14	165	0
15	189	0

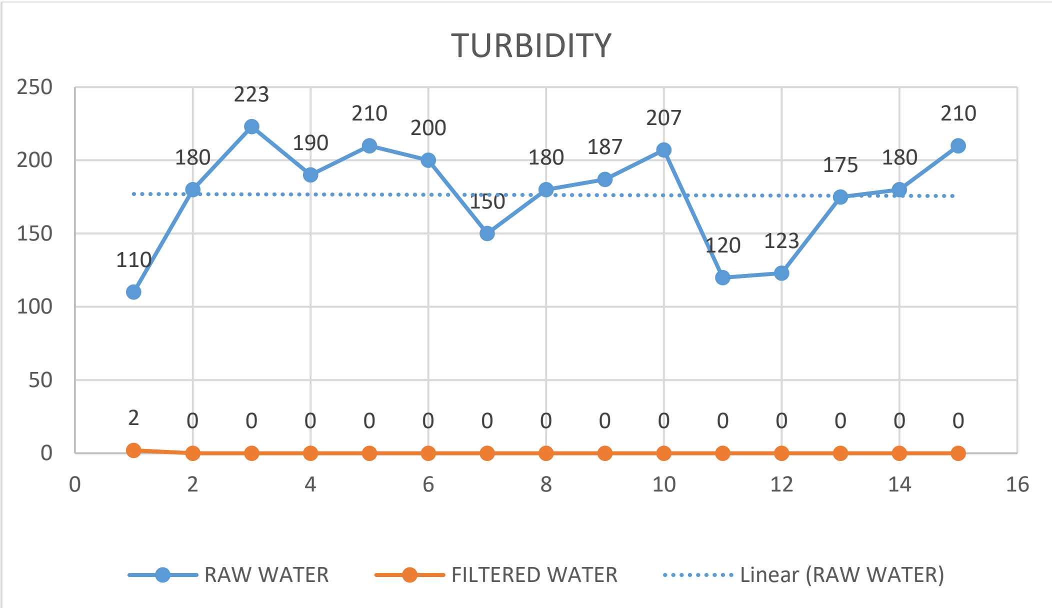

Fig No.24 Turbidity graph of sand gravel filter during next 15 days in a new assembly

Table 10 TDS results of sand gravel filter during next 15 days.

SAMPLE NO.	TDS(mg\l) RAW WATER	TDS(mg\l) FILTERED WATER
1	1325	220
2	1035	225
3	990	220
4	900	205
5	720	200
6	780	210
7	950	220
8	750	205
9	1500	205
10	1325	210
11	1370	210
12	1035	245
13	625	202
14	920	207
15	1055	215

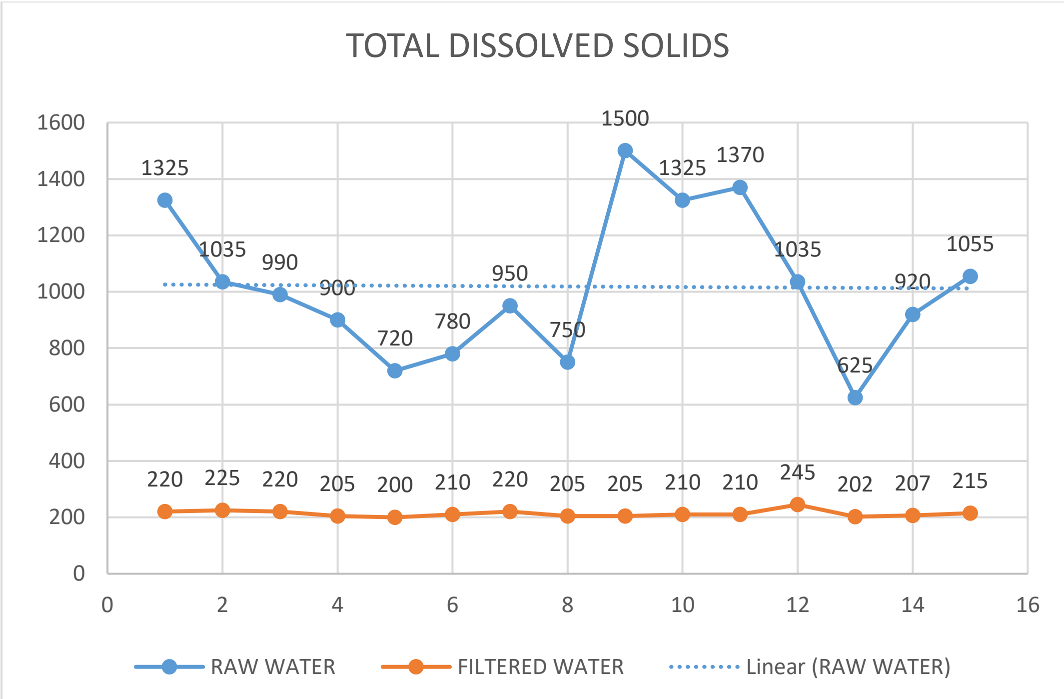

Fig No.25 TDS graph of sand gravel filter during next 15 days.

4.2.2 Charcoal sand gravel filter

Table 11 Turbidity results of charcoal sand gravel filter during first 15 days.

SAMPLE NO.	TURBIDITY(mg\l) RAW WATER	TURBIDITY(mg\l) FILTERED WATER
1	214	0
2	210	0
3	187	0
4	174	0
5	154	0
6	178	0
7	198	0
8	210	0
9	240	0
10	205	0
11	219	0
12	195	0
13	167	0
14	208	0
15	225	0

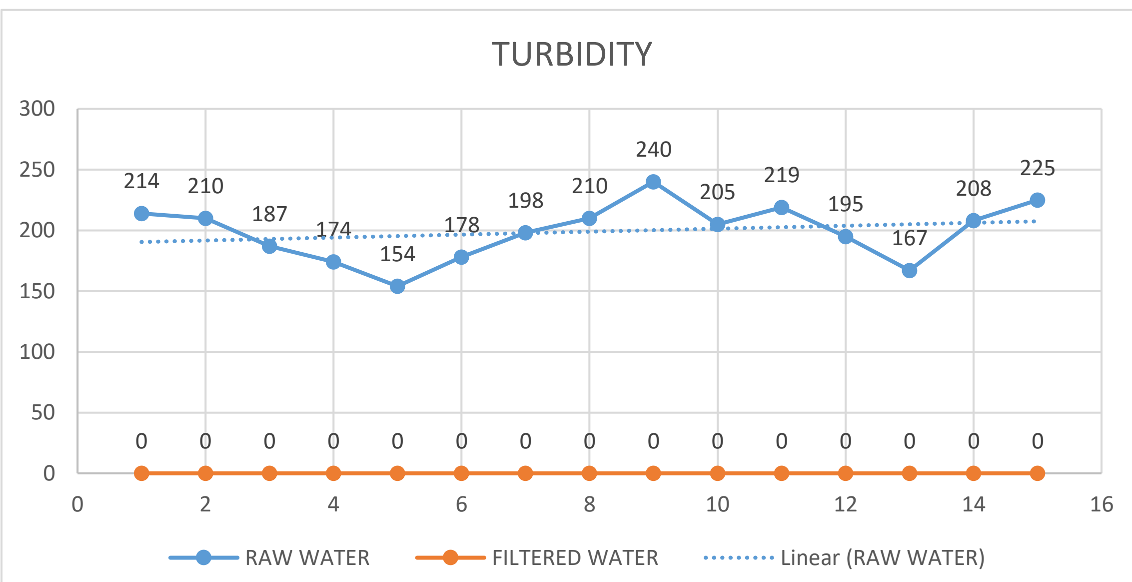

Fig No.26 Turbidity graph of charcoal sand gravel filter during first 15 days.

Table 12 TDS results of charcoal sand gravel filter during first 15 days.

SAMPLE NO.	TDS(mg\l) RAW WATER	TDS(mg\l) FILTERED WATER
1	950	220
2	758	210
3	924	217
4	1574	230
5	1340	210
6	1047	210
7	950	210
8	780	214
9	720	205
10	1274	210
11	1284	214
12	1070	218
13	750	215
14	940	215
15	1037	217

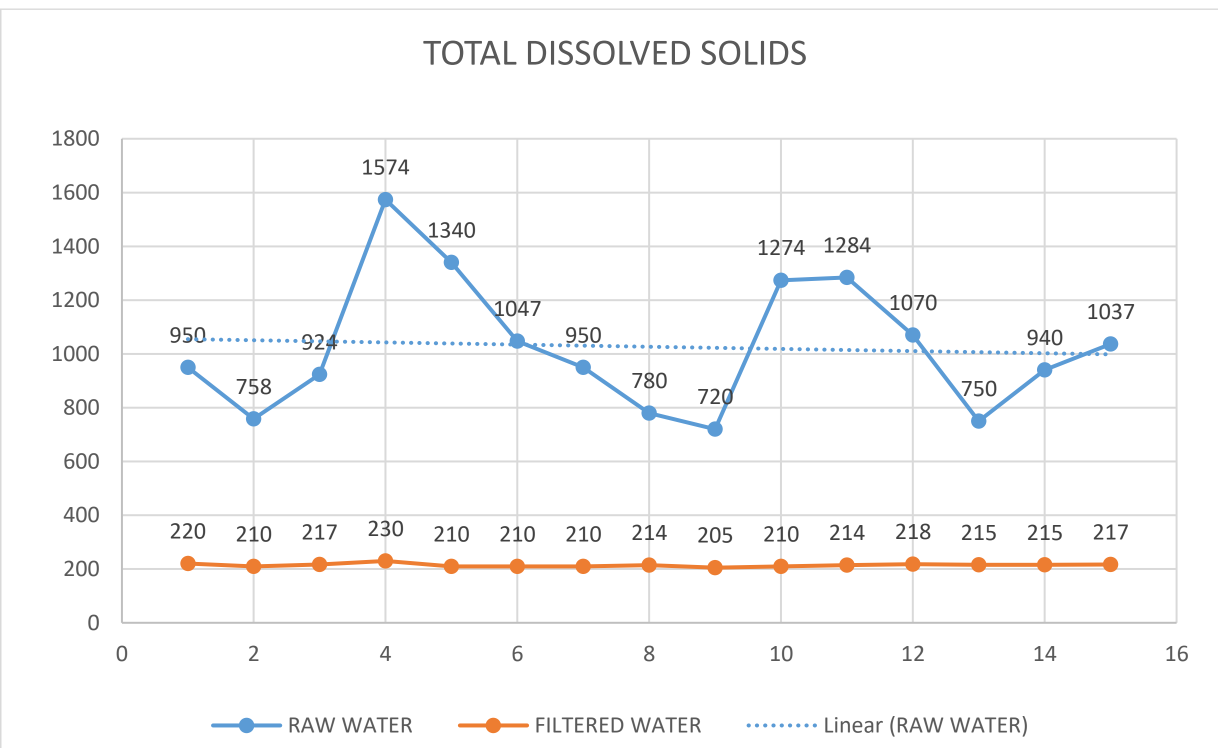

Fig No.27 TDS graph of charcoal sand gravel filter during first 15 days.

Table 13 Turbidity results of charcoal sand gravel filter during next 15 days.

SAMPLE NO.	TURBIDITY(mg\l) RAW WATER	TURBIDITY(mg\l) FILTERED WATER
1	225	0
2	205	0
3	195	0
4	165	0
5	140	0
6	150	0
7	170	0
8	115	0
9	214	0
10	186	0
11	200	0
12	184	0
13	165	0
14	204	0
15	189	0

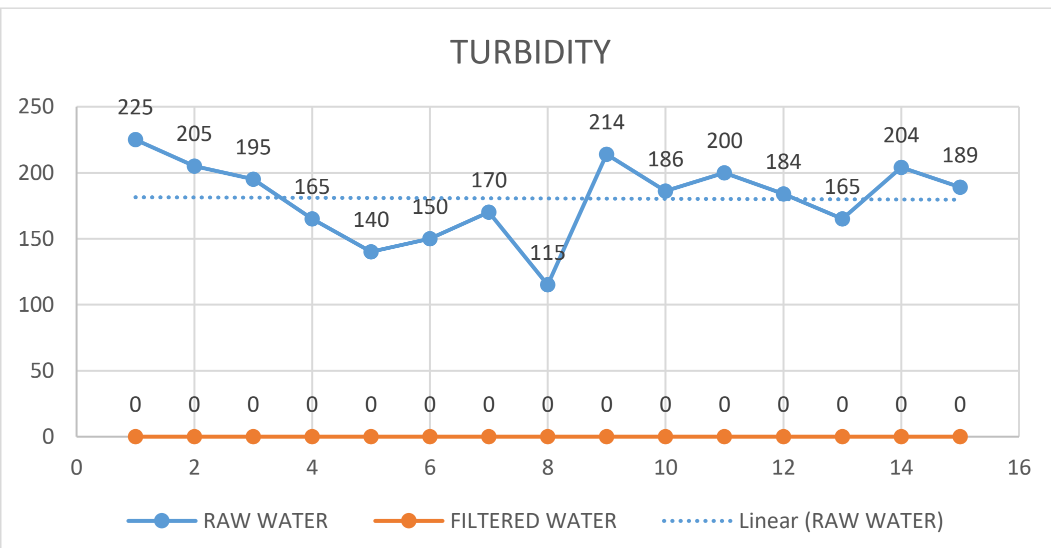

Fig No.28 Turbidity graph of charcoal sand gravel filter during next 15 days.

Table 14 TDS results of charcoal sand gravel filter during next 15 days.

SAMPLE NO.	TDS(mg\l) RAW WATER	TDS(mg\l) FILTERED WATER
1	925	204
2	1057	225
3	924	217
4	727	205
5	1325	210
6	945	210
7	1067	210
8	750	214
9	1474	205
10	1278	210
11	1384	214
12	1057	218
13	745	215
14	952	220
15	1084	216

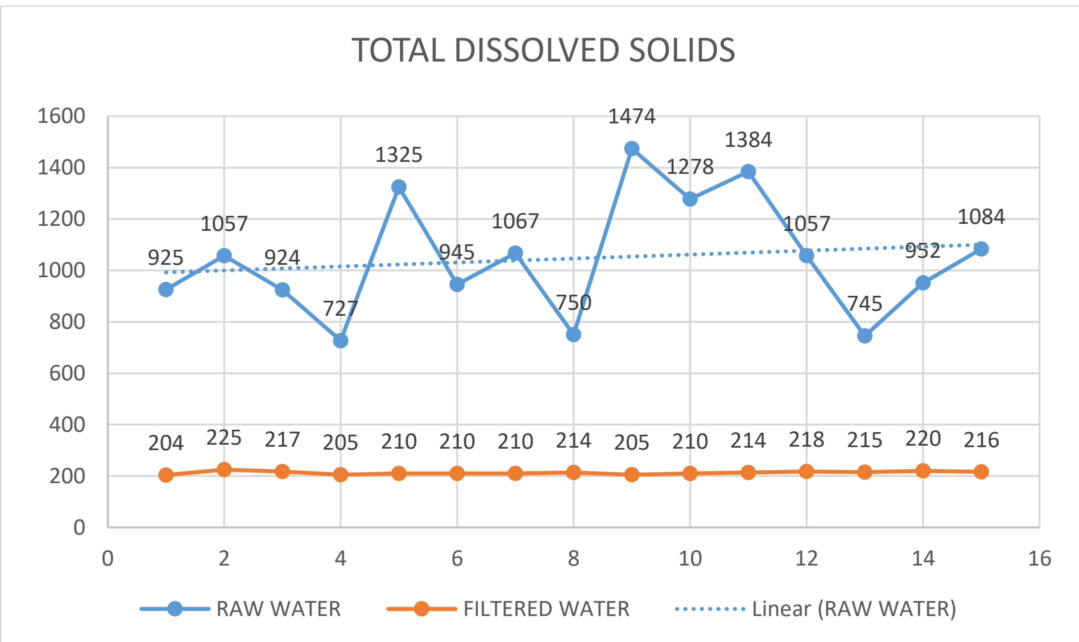

Fig No.29 TDS graph of charcoal sand gravel filter during next 15 days.

Conclusion

Water is an essential natural resource for sustaining life. Contamination in drinking water results in rise of epidemic and increase death rate of the community. Therefore, it is important to maintain the drinking water quality to protect the environment and to maintain public health. In our study, water samples were collected from vashisth kund , jogni falls of vashisth Region . Analysis of Physio-chemical parameters were found to be within the permissible limits but the Bacteriological parameters of vashisth were found to be above the permissible limit prescribed by the IS 10500-1991 and WHO. Coliform was detected in vashisth water samples. These coliform can be easily treated with the help of chlorination, exposure of water to UV rays, Iodination and distillation. As per Atomic absorption spectroscopy (PERKINELMER **,**AAnalyst 400) results shows that all the water samples are under permissible limits and fit for consumption as per the guidelines laid by IS 10500-1991 and WHO**.**

In the first phase of my project included physiochemical ,biological and heavy metal testing of the vashisth and jognifall water samples. Jognifall water samples succeeded in all the three results parameters were under the desirable limits. After all the first phase testing and examination, we selected the jognifall water sample.

In the second phase of my project, we initiated the designing of the water filter which can really help us in proper filteration of the jognifall water. The problem with the jognifall water was that during rainy seasons and natural calamities there was huge possibility of increased level of total dissolved solids and biological interference with the water. But the main problem was designing a low cost water filter which could easily filter the raw water and remove the unwanted dissolved particles from the water. We have designed a water filter which gave us really good results and the level of TDS removal efficiency was really encouraging. Our second design which was charcoal sand gravel filter performed better and has a rate filteration of 1 L\hr. Thus our project objective is successfully achieved and we have covered all the possible alternatives that we could have. Our design and studies will surely help the people of that rural community.

We all know that India is booming country with a large growing population and it is great mammoth task for any government to provide the basic necessities to all individuals like safe drinking water. In future it is estimated that there is going to be a huge shortage of safe drinking water, therefore it is a duty of every government and citizen to protect every source that is available to us and to make its best use. This may result in a number of substantial benefits to individual and to the society.

References

- Abdul M. Rasheed, & Mutnuri Lakshmi, & Dattatreya J. Patil, & Mohan A.Dayal (2012) Assessment of drinking water quality using ICP-MS and microbiological methods in the Bholakpur area, Hyderabad, India. Environ Monit Assess. 184:1581–1592.

- Bellamy, W.D., Hendricks, D.W., Logsdon, G.S. (1985). Slow Sand Filtration: Influences of Selected Process Variables. Journal of the American Water Works Association,77 (12), 62- 66.

- Centre for Science and Environment New Delhi (2010). Decentralised Wastewater Treatment- A Way to Manage Septage in Shimla.

- Chiu .C, & Su .L, & Chu. C (2004). *Salmonella* enteric Serotype *choleraesuis*: Epidemiology, Pathogenesis, Clinical Disease and Treatment. Clinical Microbiology Review. 17 (2). 311-322.

- FPT committee on Drinking water (2013). Guidance on Waterborne Bacteria Pathogens. Canada. Retrieved from http://www.hc-sc.gc.ca/ewh-semt/alt_formats/pdf/pubs/water-eau/pathogens-pathogenes/pathogens-pathogenes-eng.pdf

- Forbes B.A., & Sahm D.F., & Wiesfield A.S. (2002). Diagnostic microbiology (11 ed.)

- Gardner, M. J., & Gunn, A. M. (1995). Speciation and bioavailability of aluminum in drinking water. Chemical Speciation and Bioavailability, *7*, 9–16.

- Kumar A, & Bisht B.S., & Joshi V.D., &Singh A.K., &Talwar A (2010) Physical, Chemical and Bacteriological Study of Water from Rivers of Uttarakhand. Journal of Human Ecology. **32**(3): 169-173.

- Kumar Naresh, Singh Ankusha and Sharma Priya .To study the Physico-Chemical properties and Bacteriological examination of Hot Spring water from Vashisht region in Distt. Kullu of HP, India.

- Kumar A., Bisht B.S., Talwar A. and Chandel D. (2010). Physico-Chemical and Microbial Analysis of Ground Water from Different Regions of Doon Valley. International Journal of Applied Environmental Sciences. **5**(3): 433–440.

- Lessard, R., Reed, D., Maheux, B., & Lambert, J. (1978). Lung cancer in New Caledonia, a nickel smelting island. Journal of occupational Medicine, *20*, 815– 817

- Mathur R, Sharma R, Suthar A., Sharma A., Sharma S. and Sharma P. K. (2012). Determination and Removal of Nitrate in Ground Water of Western Rajasthan with special reference to Barmer Region. Journal of Chemical, Biological and Physical Sciences. 2(2): 1054-1060.

- Messer W. James, & Dufour P. Alfred (2005).A Rapid, Specific Membrane Filtration Procedure for Enumeration of *Enterococci* in Recreational Water. Applied and Environmental Microbiology, 64,678-680.

- McEgan Rachel, & Mootian Gabriel, & Goodridge D. Lawrence, Schaffner W. Donald, & Danyluk D. Michelle(2013). Predicting *Salmonella* Populations from Biological,Chemical, and Physical Indicators in Florida Surface Waters. Applied and Environmental Microbiology,79,4094-4105

- Moreno Y., Botella S., Alonso J., Ferru's M, Herna'ndez M., Herna'ndez J. (2003): Specific Detection of *Arcobacter* and *Campylobacter* Strains in Water and Sewage by PCR and Fluorescence In Situ Hybridization. Applied and Environmental Microbiology, **69**, 1181-1186.

- National Health and Medical Research Council (2003). Recommendations to change the use of coliforms as microbial indicators of drinking water quality. Australia. Retrieved from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh32.pdf

- Prescott L.M., & Harley J.P., & Klein D.A. (1993). Microbiology (2 ed.).Boston.

- Pillai, K. C. (1983). Heavy metals in aquatic environment, Water pollution and management (Varshey C.K.). New Delhi:Wiley, pp. 74–93.

- Rompre, A., & Servais, P., & Baudert , J., & Roubin , M., & Laurent A. (2002).Detection and enumeration of coliforms in drinking water: Current methods and emerging approaches. Journal of Microbiological Methods, 49, 31-54

- Riyaz- Ul-Hassan S., Verma V. 2004. Rapid Detection of *Salmonella* by PCR. Molecular and Cellular Probes, **18**, 333-339.

- Skillern K. J, & Overman L. T (1983). Oxidase Testing from Kligler's Iron Agar and Triple Sugar Iron Agar Slants. Current Microbiology, 8,269-271.

- Sulehria , A., & Butt, Y., & Hussain, A., & Faheem M., & Munir T.(2011). Eumeration of coliform bacteria in drinking water of Mughalpura, Lahore. Biologia, 57(1&2),75-80

- Spectrophotometric Determination of Iron in Drinking Water. Retrieved from http://web.pdx.edu/~atkinsdb/teach/427/Expt-IronSpec.pdf

- Shittu O.B., Olaitan J.O. and Amusa T.S. (2008). Physico-Chemical and Bacteriological Analyses of Water Used for Drinking and Swimming Purposes in Abeokuta, Nigeria. African Journal of Biomedical Research, **11**(3)**,** 285 – 290.

- Stenhammar, L. (1999). Diarrhea following contamination of drinking water with copper. European Journal of Medical Research, *4*, 217–218.

- Taj Ali Khan, Kalsoom Rehman, Khurram Sheraz. Development and Testing of Low Cost Sand Filter for the Treatment of Industrial and Domestic Wastewater.

- Tortorello, M. (2003). Indicator Organisms for Safety and Quality—Uses and Methods for Detection. Journal of AOAC International, 86, No.6.

- Tantawiwat S., Tansuphasiri U., Wongwit W., Wongchotigul V., Kitayaporn D (2005). Development of multiplex PCR for the detection of total coliform bacteria for *Escherichia coli* and *Clostridium perfringens* in drinking water. Southeast Asian Journal of Tropical Medicine and Public Health, **36**(1), 162-169.

- USEPA (1999). National Primary Drinking water Regulation. United States Environmental Protection Agency .

- WHO (2004). Guidelines for Drinking Water Quality. Vol. 1.