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Design of Low Cost Drinking Water Purifier

A thesis submitted in partial fulfillment of the requirements for the degree of

of

Bachelor of Technology

In

INSTRUMENTATION ENGINEERING

Submitted by

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(A Centrally Funded Institute under Ministry of HRD, Govt. of India)
Website: www.cit.ac.in

JUNE 2016

CENTRAL INSTITUTE OF TECHNOLOGY, KOKRAJHAR

केन्द्रीय प्रौद्योगिकी संस्थान कोकराझार

(A Centrally Funded Institute under Ministry of HRD, Govt. of India)

DEPARTMENT OF INSTRUMENTATION ENGINEERING

Kokrajhar – 783370, BTAD, Assam, India

CERTIFICATE

This is to certify that the project work entitled **"Design of Low Cost Drinking Water Purifier"** is submitted by Alok Saikia (Gau-C-12/L-201), Hemanta Brahma(Gau-C-12/L-196) to the Department of Instrumentation Engineering of Central Institute of Technology, Kokrajhar. The project work has been prepared as per the regulations of Central Institute of Technology and qualifies to be accepted as Major Project-II, in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Instrumentation Engineering.

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Board of Examiners

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2.

DECLARATION

We hereby declare that the project work entitled **"Design of Low Cost Drinking Water Purifier",** is an authenticated work carried out by us under the guidance of Mr. Dipankar Sutradhar, Asst. Professor, Department of Instrumentation Engineering as a partial fulfillment of the requirements for the degree of Bachelor of Technology in Instrumentation Engineering and this work has not been submitted for similar purpose anywhere else, except, to the Department of IE, Central Institute of Technology, Kokrajhar.

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AKNOWLEDGEMENT

It is high privilege for us to express our deep sense of gratitude to all those faculty members who helped us in the completion of the project, especially our guide Mr Dipankar Sutradhar who was always there at hour of need.

We want to thank all the other members of Instrumentation Engineering Department for helping us in the completion of project work. At last we want thank Mrs. Neelu Das Sutradhar, HoD, department of Civil Engineering, CIT Kokrajhar and also Mr. Kailash Barman, department of Food Engineering and Technology, CIT Kokrajhar for allowing us to carry out the tests in their departmental laboratory.

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ABSTRACT

In this project we have studied the existing water purifying methods and implement activated carbon filter ,sand filter, sediment filter, reverse osmosis filter and Ultraviolet disinfection in possible low cost. The purified water quality such as-pH, microbiological, heavy metals, total dissolved solids (TDS) are tested in the laboratory and compared with the standardized values. It is also kept in mind that the purifier maintenances can be done by normal people. With a low cost water filter available, peoples of developing countries could enjoy having safe drinking water and improve quality of life.

List of Contents

Contents **Page No.**

Chapter 1	Introduction	1-2
	1.1 Objectives	1-2
	1.2 Background	2
Chapter 2	Literature Review	3-16
	2.1 Ultraviolet (UV) treatment	3
	2.2 Reverse Osmosis treatment	4
	2.3 Carbon and Sand filter	5
	2.4 Sediment filter	6
	2.5 Filter comparison	7-8
	2.6 Hardware requirement	8
	2.6.1 Arduino UNO board	8-11
	2.6.2 H-Bridge	11-12
	2.6.3 HS-SR04 Ultrasonic Sensor	13
	2.6.4 Power door lock actuator	13-14
	2.6.5 UV chamber	14
	2.6.6 Sediment filter cartridge	15
	2.6.7 75 GPD RO Membrane	15
	2.6.8.75 GPD RO System Booster Pump	16
Chapter 3	Preparation of Activated Carbon	17-19
	3.1 What is Activated Carbon	17
	3.1.1 Methods for Activating Carbon	17
	3.1.2 How does Activated Carbon Work	17-18
	3.2 Preparation of Activated Carbon Used in Experiment	18
	3.2.1 Raw Materials	18
	3.2.2 Procedure of Preparation	18
	3.2.3 Chemical Composition of the Three Activated Carbon	19
Chapter 4	System Design and Implementation	20-21
	4.1 Hardware Block Diagram	20
	4.2 Circuit Diagram for Actuator Driving	20
	4.3 Circuit Diagram for Level Control	21

Chapters		Page No.
Chapter 5	Programming Codes	22-23
	5.1 Arduino Code for Actuator Driving Circuit	22
	5.2 Arduino Code for Level Control	23
Chapter 6	Testing methods and WHO standards	24-25
	6.1 Methods of Testing	24
	6.1.1 Flow Rate Test	24
	6.1.2 Filter Effectiveness Test	24-25
	6.2 WHO Standards	25
Chapter 7	Purified Water Quality Testing and Results	26-37
	7.1 pH Test	26
	7.1.1 Instrument Used	26
	7.2 Microbiological Test	27-29
	7.2.1 Test Method Used	27
	7.2.2 Result of the Microbiological Test of the samples	28
	7.2.3 Instrument used and its Specification	28-29
	7.3 Heavy Metal Test	30-33
	7.3.1 WHO standards for Different Heavy Metals in drinking water	30
	7.3.2 Instrument Used	30-31
	7.3.3 Arsenic test	32
	7.3.4 Cadmium-Lead Test	33
	7.4 Total Dissolved solids (TDS) Test	34-37
	7.4.1 Test Results	35-36
	7.4.2 Instruments Used	36-37
Chapter 8	Result and discussion	38-39
Chapter 9	Future Scope	40
Chapter 10	Conclusion	41
References		42
Appendix A		
Appendix B		
Appendix C		

List of Figures

List of Figures	Page No.
Figure 1- UV Water treatment	3
Figure 2- RO Water treatment	4
Figure 3- Carbon and Sand filter	5
Figure 4- Sediment Filter	6
Figure 5- Pin out diagram of ATmega328P with Arduino functions	10
Figure 6- Pin out diagram of L293DNE	12
Figure 7- HC-SR04 Ultrasonic Sensor	13
Figure 8- Linear door lock actuator	13
Figure 9- UV lamp with chamber	14
Figure 10- Sediment filter cartridge	15
Figure 11-RO membrane	15
Figure 12-RO system booster pump	16
Figure 13- Block Diagram	20
Figure 14- Actuator driving circuit diagram	21
Figure 15- Level control circuit diagram	21
Figure 16- Microbiological test results	28
Figure 17- Working of metalyser HM1000	31
Figure 18- Graph of Arsenic analysis	32
Figure 19- Graph of Cadmium-Lead analysis	33
Figure 20- Graph of TDS analysis using spectrophotometer	35
Figure 21-Spectrophotometer graph with distinct absorption peaks	36
Figure 22-pH test result	38
Figure 23-Heavy metal analysis result	39
Figure 24- TDS analysis graph	39

List of Tables

	Page No.
Table 1- Advantages and Disadvantages of different types of filters	7
Table 2- Contaminants filtered by different type of filter	8
Table 3- Chemical composition of different types of activated carbon	19
Table 4- pH test results	26
Table 5- Microbiological test results	28
Table 6-WHO standard guideline for heavy metals	30
Table 7- Arsenic test results	32
Table 8- Cadmium-Lead test results	33
Table 9- Spectrophotometer results	35

Chapter 1 Introduction

Water is the basic necessity of a human being along with food and air so, it can be termed as the 'Elixir of life'. As we know 71% of the Earth is covered with water but only 1% of them are consumable. So, the drinking water have great influences on people's everyday life. In the developing countries like India, resources of safe drinking water is very limited. Surface water often is the only source, thus water contamination are hard to avoid. Unsafe drinking water causes diarrheal diseases. Statistics shows that ninety percent of all deaths of children in developing countries, where resistance capacity of the children to infections are low only because of the unsafe drinking water.[1]

This project aims to study the available water purifying methods and to implement it. This work will focus in reducing the cost in designing and implementing the purification system maintain their efficiency. With this help of low cost home water purifiers, the risk of the waterborne diseases can reduced to an optimum level and improve the people's quality of life.

Now-a-days many processes available for water purification. Reverse Osmosis (RO) and Ultra Violet (UV) systems are the most reliable method for the purification of contaminated water in the present days.

1.1 Objectives

- To study the existing water purification methods, and use the knowledge to design a water purification system. This water purifier consist of will water purifying component and a valve for easy access of water.

- To design a low-cost and easily manufactured water purification system for the common people. As we know that water is the integral part of human life so, by providing a low cost water purifier to upgrade the quality of life is our main objective.

- Use of simple technology and readily available materials are the prime consideration and try to design it in such a way so that the maintenance of the purifier can be done through normal people, does not required any trained technician.
- Try to implement solar energy as a redundant of electricity. This is because in the developing countries there are various remote places where there is no electricity. Our aim is to make the availability of pure water to every people so that without electricity they can also enjoy pure water and improve their standard of living.

1.2 Background

Most of the people in developing countries do not have easy access to clean drinking water. While safe drinking water is one of the most important part of life because lack of access has resulted in many water related diseases.

Water purifiers are already being used in some developing countries. But the price of the purifier is can't be afford by all the common people. Eureka Forbes which dominating the market of water purifiers, only UV water purifiers with three stage purification technique is cost about INR 6000. If we are going for UV-RO water purifiers its cost goes up to INR 15000. As compared to developed countries developing country like India has low per capita income. In such circumstances affording such price on a filter is considered expensive. Ceramic water filters are also commonly used in some developing countries. These filters are inexpensive and easy to manufacture. They are effective at eliminating bacteria and sediments, but they do not remove chemical contaminants.

So, the main aim of our project is to design a low cost purifier which will eliminate all the organic and non-organic contaminants of water and can be used by every common people.

Chapter 2 Literature Review

To improve the knowledge about the existing water purifying processes, some research was done on five most common types of home use water filters. These common type of water filtration process includes the ceramic filter, sand and carbon filter, sediment filter, Ultra Violate (UV) filter and Reverse Osmosis (RO) filter. We have studied different filter types and comparisons were made on factors including price, functionality, manufacturing process, maintenance and effectiveness.

Based on our result of comparison we have decided to implement all the filtration processes on a cost which is much lower than the water purifiers present in the market and which can be easily affordable by the common people. All the existing purifying processes are describe briefly below-

2.1: Ultra Violate (UV) water treatment

UV treatment is a purification process in which the water is allowed to pass through a special light source. The light source emits ultraviolet rays which deactivate the harmful microorganisms from the water. This emits an ultraviolet spectrum of range 200-300 nm which deactivates UV rays change the nucleic acid (DNA) of viruses, bacteria, molds, and parasites that present in water, so that they cannot reproduce. The process does not add chemicals to water. The UV treatment requires pre filtering process because particles in water can block the UV rays to deactivate the microorganisms. Also, before UV treatment the water should be tasted since hardness, alkalinity and such properties of water can effect UV treatment efficiency. UV system consists of a UV light, protective housing for the bulb, power supply, and filters for pre/post–treatment.[2]

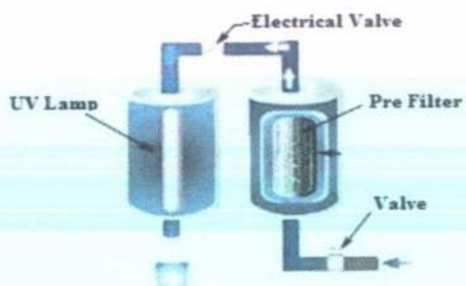

Figure 1: UV water treatment

2.2: Reverse Osmosis treatment

Reverse Osmosis is considered as the best and the most effective water purification technique in the present days. It is considered as the finest water finest method because this method reduces almost all organic and inorganic chemicals, bacteria, microorganisms, salt, metals and particulates that are found in contaminated water. It also improve tastes and odor. Reverse osmosis water purifiers consist of a semi-permeable membrane and a booster pump to obtain high pressure. These ultrafine membranes have pores of approximately 0.0005 microns in size. Water is pressurized to about 40-45 psi and then allows to pass through the membrane, this process removes anything that's larger than 0.001 microns. Pre and post filtrations are usually combined in a reverse osmosis filtration system. Reverse osmosis can remove many contaminants including arsenic, fluoride, hexavalent chromium, nitrates and perchlorate. However, reverse osmosis does not remove chlorine, volatile organic chemicals (VOCs) etc. So the pre and post filtration is required to remove those particles.[3]

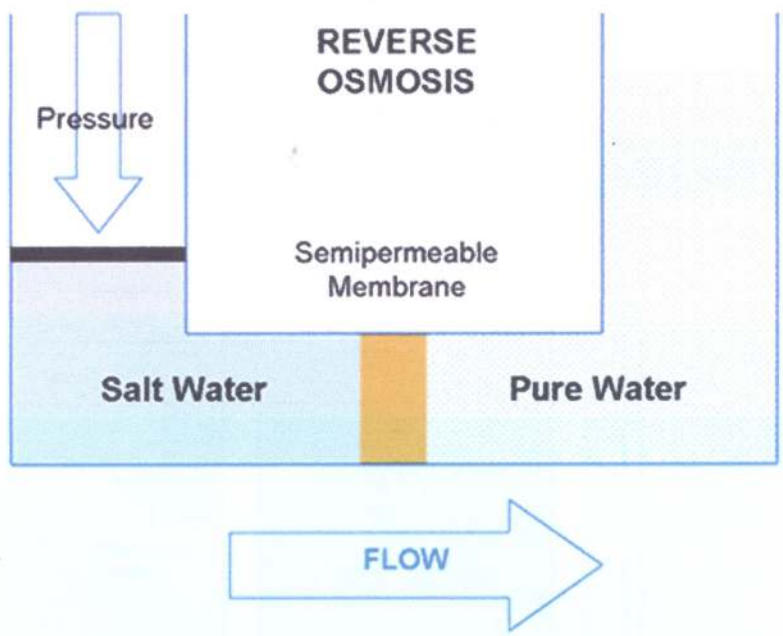

Figure 2: Reverse Osmosis Purification process

2.3: Carbon and Sand filter

Sand filters are constructed with a bed of fine sand as the filtration media, and gravel to support the sand. A complex biological layer, 'Schmutzdecke', which consists of bacteria culture, is grown on the surface of slow sand filter. As water passes through the 'Schmutzdecke' layer, particles of dissolved organic material are adsorbed and metabolized. Slow sand filters can only filter water up to a certain turbidity level, since water with high turbidity clogs up the filter bed quickly. Slow sand filters are very effective at removing heavy metals, and it is often combined with activated carbon to remove organic material as well as to improve odor and taste.[4]

Carbon is known as a popular absorbent of impurities. Activated carbon is processed carbon with a slightly positive charge added to it and is more attractive to chemicals and impurities. It is extremely-porous, thus provides high surface area to volume ratio which increases the rate of absorption. Because of this property, activated carbon is commonly used in water treatment systems. Activated carbon can be used alone to improve tastes and odors, and it is most effective at removing organic compounds including VOCs, radon, and chlorine. It can also be used as pre-treatment for other water purification systems such as reverse osmosis and ultraviolet water filters. Carbon can be obtained from a variety of sources such as coconut shell, wood or coal, rice husk and all of which are readily available practically everywhere in the world.[5]

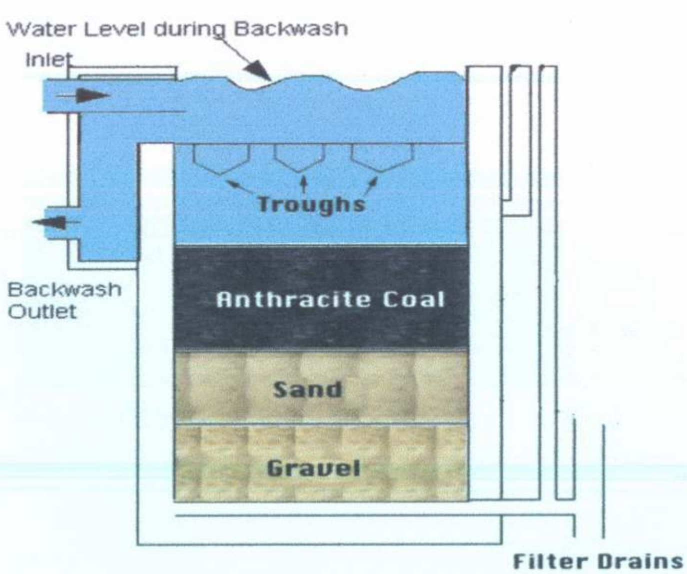

Figure 3: Carbon and sand filter

2.4: Sediment Filter

Sedimentation is a water filtration process which use gravity to eliminate suspended solids from water. Solid particles draw along by the turbulence of moving water may be removed naturally by sedimentation. One simple definition of sediment is matter suspended in a liquid that will settle to the bottom. In a water treatment these particles may be rust flakes from the water pipes, sand grains and small pieces of organic matter, clay particles, or any other small particles in the water supply. A sediment filter works as a sieve to remove these particles. The sediment filter doesn't have the ability to remove chemicals or heavy metals or make the water taste or smell better. In general, sediment filters are rated by a "micron" number. This refers to the particle size that will be stuck by the filter. They are further classified into two, that are "nominal" and "absolute". For example, a nominal 5 micron filter can trap 85 % of particles of five microns and larger; an absolute 5 micron filter can that trap 99.9 % of particles of 5 microns and larger. For most purposes, nominal filtration is fine; when very high grade water is required, an absolute-rated filter may be needed.

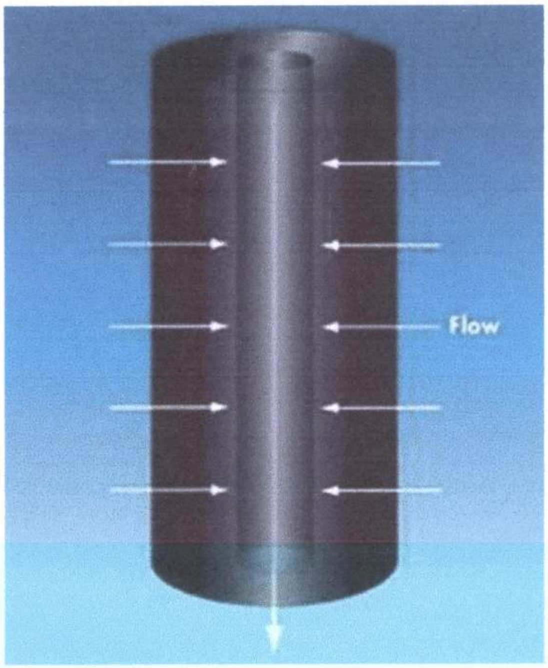

Figure 4: Sediment Filter

2.5: Filter comparison

Tables 1 and 2 summarize the advantages and disadvantages for using each of the described water filtration methods.

Filter type	Advantages	Disadvantages
Ultraviolet treatment	• Inactive viruses, bacteria, molds, and parasites	• Requires electrical power • Should not be used alone since it only removes viruses, bacteria, molds, and parasites
Reverse Osmosis treatment	• Filters most contaminates out of all other filter types.	• Expensive to make • Need pressure to work system • Require pre-filtering
Activated Carbon filter	• Cheap and easy to make • Does not need electrical power and chemicals	• Large in volume • Heavy • Slow filtration rate
Sand filter	• Cheap to make • Material readily available • Usually used as pre filter	• Does not effectively remove bacteria

Table 1: Advantages and disadvantages of various purification methods

	Arsenic	Bacteria and Viruses	Bad Tastes & Odors	Chlorine	Fluoride	Hydrogen Sulphide	Heavy Metals	Nitrates	Radon	Sediment	Iron	VOC's
Ultraviolet	○	●	○	○	○	○	○	○	○	○	○	○
Reverse Osmosis**	●	●	●	●	●	◐	●	●	○	●	●	◐
Slow Sand	◐	●	◐	○	○	○	●	○	○	●	●	◐
Activated Carbon	○	○	●	●	○	◐*	◐	○	●	●	○	●
Ceramic	○	●	◐	○	○	○	○	○	○	●	○	○

● = Effectively Removes ◐ = Significantly Reduces ○ = Minimal or No Removal

Table 2: Contaminates Filtered by Various Water Filters [6]

2.6: Hardware Requirements

1) Arduino UNO board
2) H-Bridge (L293DNE)
3) HC-SR04 Ultrasonic level sensor
4) Power door lock actuator
5) UV chamber
6) Sediment Filter cartridge
7) 75 GPD RO membrane
8) 75 GPD RO system buster pump

2.6.1: Arduino UNO board

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. In this project primarily Arduino is used to operate two linear actuators which controls the flow of water.[7]

(a) Technical Specification

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 Hz

(a) ATmega328P

The ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

(c) Pin Diagram

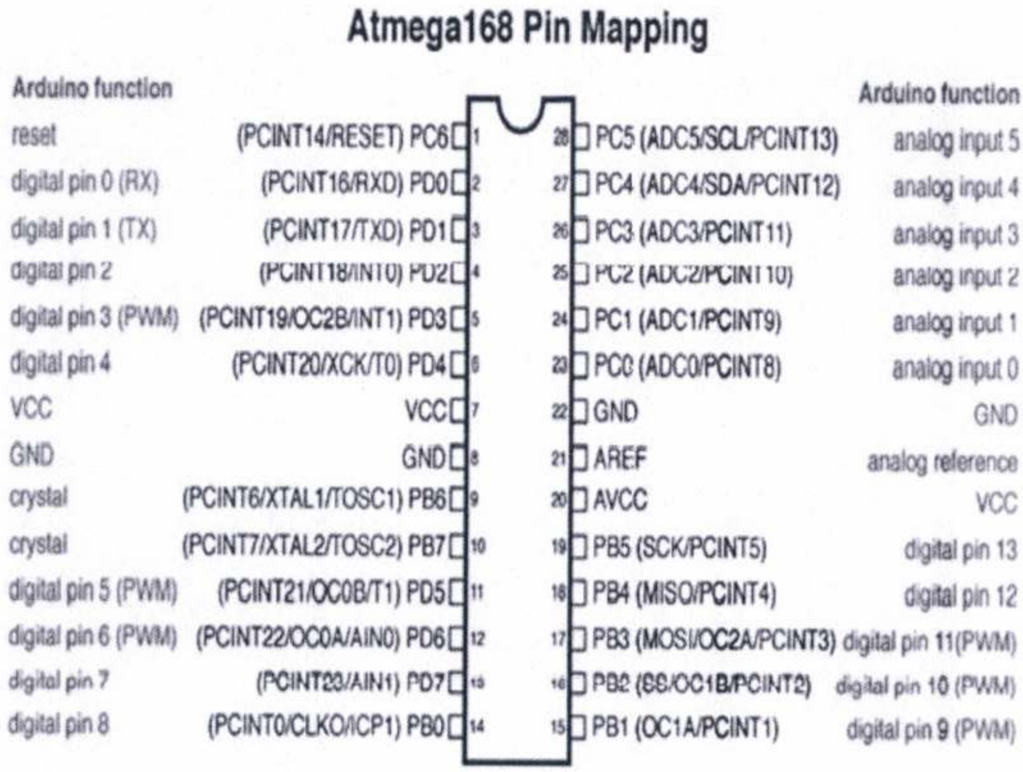

Figure 5: Pin out diagram of ATmega328P with Arduino functions [7]

(a) Pin specialization of ATmega328P in Arduino

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function.

There are a couple of other pins on the board:

AREF: Reference voltage for the analog inputs. Used with analogReference().

Reset: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

2.6.2: H-Bridge

An H-Bridge is an electronic device that enables a voltage to be applied across a load in either direction. In our project we are using L293D driver to interface the actuator with microcontroller and to change the polarity of the current to drive the actuator.

(a) IC- L293DNE

The L293 is a quadruple high-current half-H driver designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. It is designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. . In our project to interface power door lock actuator with microcontroller we use L293D driver.

All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state.

(b) Basic Features

- Supply voltage range 4.5V to 36V
- High current half H drivers
- High noise immunity input
- Output current of 600mA per channel
- Output peak current of 1.2mA per channel
- Thermal shut down
- Output clamp diodes for inductive transient suppression
- Input circuit are TTL compatible
- Output circuit are totem pole with Darlington transistor pair
- Maximum input voltage is 7V
- Output voltage range is -3V to 39V
- Storage temperature range is -65 to 150C
- It is a 16 pin DIP IC configuration

(c) Pin Configuration

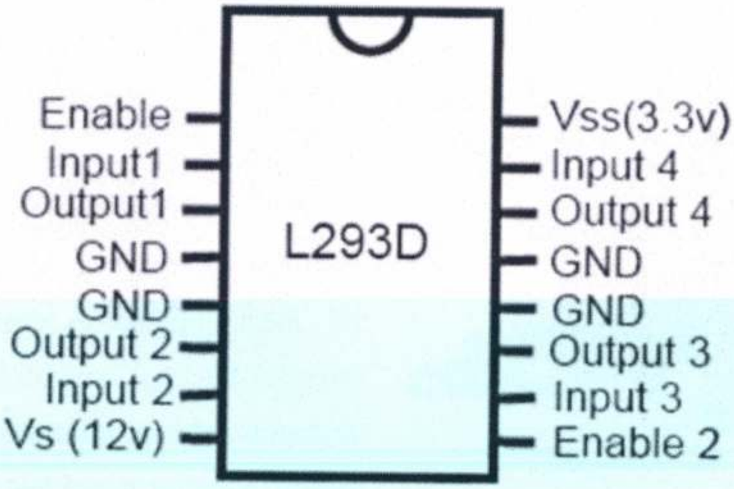

Figure 6: Pin out diagram of L293DNE

2.6.3: HC-SR04 Ultrasonic level sensor

Ultrasonic ranging module HC-SR04 provides 2cm-400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

(1) Using IO trigger for at least 10us high level signal.

(2) The Module automatically sends 40 kHz and detect whether there is a pulse signal back.

(3) If the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

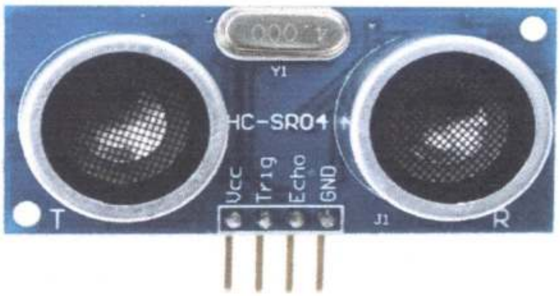

Figure 7: HC-SR04 ultrasonic sensor

Test distance = (high level time × velocity of sound (340M/S) / 2

It has 4 pins:

1. 5V supply
2. Trig. Pin
3. Echo Pin
4. 0V Ground

In our project we are using the sensor to control the opening and closing of a solenoid valve which in turn control the level of the tank.

2.6.4 Power Door Lock Actuator

An actuator converts energy into mechanical motion. The motion can be rotary or linear, depending on the type of actuator. In our project we are using a 12volt DC linear actuator which pushes and pulls a restrictor which restrict flow of water in the water line.

The linear actuator which expands and contracts according to the polarity of current signal. By using this driver IC L293DNE we can drive the actuator in either direction. We give two inputs to move forward (expands) and backward (contracts).


Figure 8: Linear door lock actuator

From the pin out diagram figure 6 Where 2 &7 pin of L293D are inputs from microcontroller ports these input are enable only when 1pin of L293D is high and 3 & 6 pins of L293D are inputs to pneumatic actuator. We give supply to the IC from a 12volt Battery. In this when enable low then actuator stops and when enable is high and both inputs are same that is either high or low then also actuator stops. It works only when one input is high and enable is high.

2.6.4 UV chamber

One of the development of new technologies for decentralized water treatment is UV treatment. One important aspect is to have low-energy consuming systems. In that regard, the UV disinfection using UV lamp or LEDs (Light-Emitting Diode) seems a promising technology. For water disinfection, 250 nm to 282 nm wavelength range UV rays are used. In this project we are using a UV light of 11watt and 260 to 300 nm wavelength range with a UV chamber.

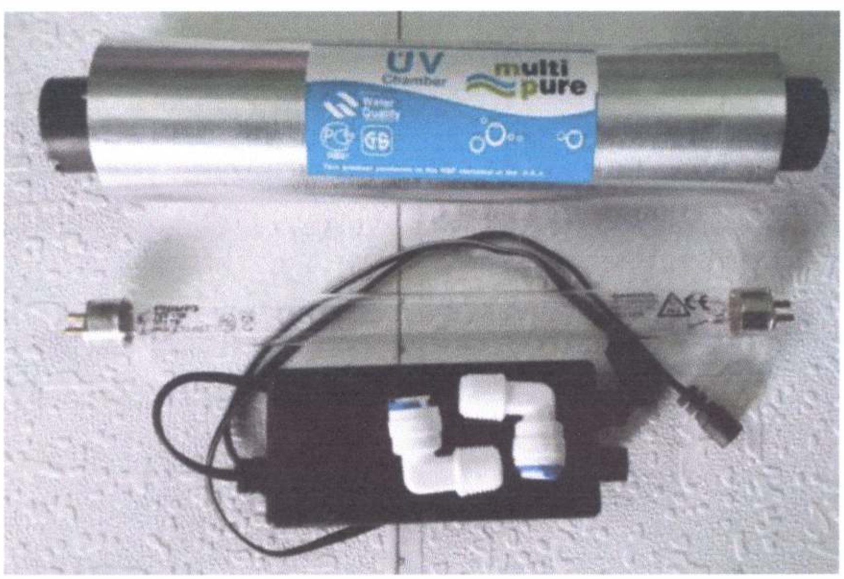

Figure 9: UV lamp with Chamber

2.6.5 Sediment Filter Cartridge

Virtually all cartridge-style sediment filters follow the "radial flow" pattern. In a radial flow design, water flows through the wall of the filter into the inner core. This arrangement provides filtering surface that consists of the entire length and circumference of the cartridge. In this project we are using a 5 micron sediment filter.

Figure 10: Sediment filter cartridges

2.6.6 75 GPD RO Membrane

Reverse Osmosis is a technology that is used to remove a large majority of contaminants from water by pushing the water under pressure through a semi-permeable membrane. In this project we are using a 75 GPD RO membrane. The main specifications of this membrane are-

1. Applied pressure is 50 psig or 3.4 bar
2. Permeate flow rate is 75 GPD or 12 LPH
3. Typical stabilization salt Rejection 99%

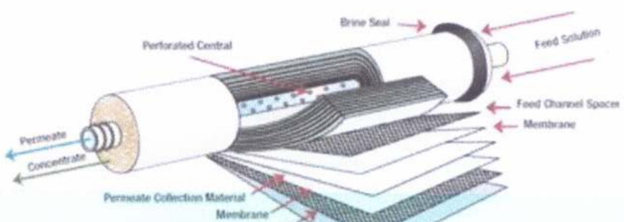

Figure 11: RO membrane

2.6.7 50 GPD RO system booster pump

The RO system booster pump is required in RO water purifiers because RO membrane need atleast 40 psig input pressure for remove the contaminants from water when water passed through it. In this project for RO membrane of 75 GPD minimum 50 psig pressure is needed. The pump specifications are-

1. It can produce upto 80 psig pressure at output.
2. Supply voltage is 24V DC.
3. Maximum current is 0.64 Amps.

Figure 12: RO system booster pump

Chapter 3 Preparation of Activated Carbon

3.1 What is Activated Carbon?

Activated carbon, also known activated charcoal, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions. The carbon-based material is converted to activated carbon through physical modification and thermal decomposition in a furnace, under a controlled atmosphere and temperature. Activated carbon is mainly used in various purification processes such as gold purification, water purification and gas purification and also used in medicine, sewage treatment, air filters in gas masks and respirators and many other applications.

3.1.1 Methods for Activating Carbon

a) Physical activation

It is prepared by Activation or commonly known as Oxidation. In this process raw material or carbonized material is exposed to oxidizing atmospheres (oxygen or steam) at temperatures above 250 °C, usually the temperature is in the range of 600–1200 °C.

b) Chemical activation

Prior to physical activation, it can be done by chemically where the raw material is impregnated with certain chemicals. The chemical used is typically an acid, strong base, or a salt such as phosphoric acid, potassium hydroxide, sodium hydroxide, calcium chloride, and zinc chloride etc. Then, the raw material is carbonized at lower temperatures. The main advantage with this method is the temperature range is smaller than physical activation, It ranges from 450-900°C.

3.1.2 How Does Activated Carbon Work?

Physical adsorption is the primary means by which activated carbon works to remove contaminants from liquid or vapor streams. Carbon's large surface area per unit weight allows for contaminants to adhere to the activated carbon media.

Physical adsorption occurs because all molecules exert attractive forces, especially molecules at the surface of a solid (pore walls of carbon), and these surface molecules seek to adhere to other molecules.

The dissolved adsorbate migrates from the solution through the pore channels to reach the area where the strongest attractive forces are located. Contaminants adsorb because the attraction of the carbon surface for them is stronger than the attractive forces that keep them dissolved in solution. Those compounds that exhibit this preference to adsorb are able to do so when there is enough energy on the surface of the carbon to overcome the energy needed to adsorb the contaminant.

Contaminants that are organic, have high molecular weights, and are neutral, or non-polar, in their chemical nature are readily adsorbed on activated carbon. For water adsorbates to become physically adsorbed onto activated carbon, they must both be dissolved in water so that they are smaller than the size of the carbon pore openings and can pass through the carbon pores and accumulate.

Besides physical adsorption, chemical reactions can occur on a carbon surface. One such reaction is chlorine removal from water involving the chemical reaction of chlorine with carbon to form chloride ions.

3.2 Preparation of Activated Carbon used in the experiment

3.2.1 Raw Materials

In our experiment we have used three raw materials for preparing three individual activated carbon sample. Those raw materials are Areca, Water Hyacinth and Rice Husk. Each sample of activated carbon is used separately in the purifier and the purification rate of each sample is tested in laboratory.

3.2.2 Procedure of preparation

The raw material were incintered in muffle furnace at 700°C for 6 hours. After burning process the ash was allowed to completely inside the furnace. So that it can't absorb the moisture. Then the ash was screened through 250μm sieve to eliminate the oversize particles. Then the ash was stored immediately in airtight container.

3.2.3 Chemical Composition of the three Activated Carbon

Sl. No.	Chemical Constituents (wt.%)	Water Hyacinth Ash	Areca nut Ash	Rice Husk Ash
1	Silicon Dioxide(SiO_2)	4.40	28.44	84.30
2	Aluminum Oxide(Al_2O_3)	2.20	3.60	1.00
3	Ferric Oxide(Fe_2O_3)	1.27	1.91	0.94
4	Calcium Oxide(CaO)	22.61	2.71	1.45
5	Magnesium Oxide(MgO)	14.01	3.87	2.08
6	Sulpher Trioxide(SO_3)	3.09	7.80	1.22
7	Sodium Oxide(Na_2O)	0.35	0.24	0.15
8	Potassium Oxide(K_2O)	14.82	26.52	4.64
9	Loss of Ignition(LOI)	31.45	23.50	2.97

Table 3: Chemical composition of different types of activated carbons

Chapter 4 System Design and Implementation

4.1 Hardware Block Diagram and Description

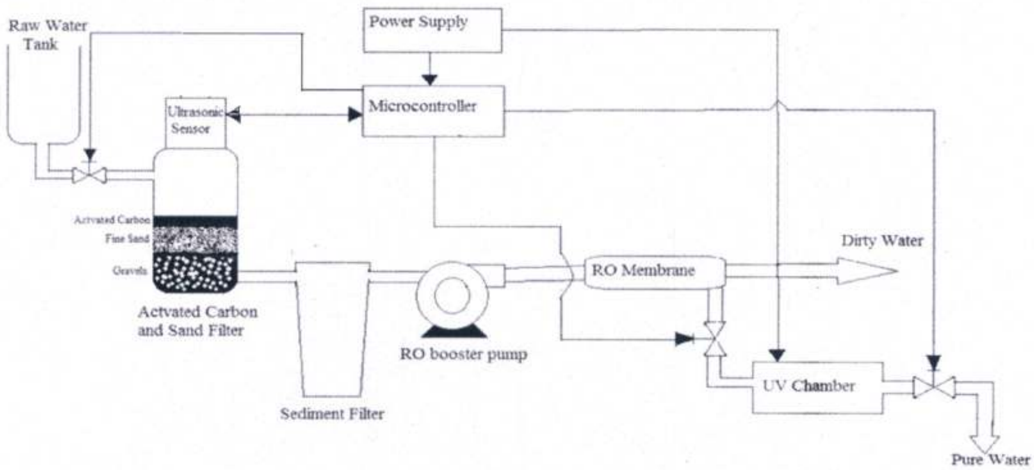

Figure 13: Block diagram

From the raw water tank the raw water flows to the first purification stage that is activated carbon and sand filter through a solenoid valve. The opening and closing of the valve maintains the level of water in the first filtration stage from the raw water tank. The valve is connected to an ultrasonic level sensor through a microcontroller. The ultrasonic sensor measure the level of the tank and sends signal to the microcontroller. According to the microcontroller programming the valve will open and close when the water level exceeds some certain limit or below the certain limit. The water from the first stage fed to the sediment filter stage. Where all the contaminants of size less 5 microns is allowed to pass through it and oversize particles are removed. Then from this purification stage the water is fed to the RO booster pump from where the water is fed to the RO membrane at a pressure of 80 psig. From the RO membrane the water fed to the last stage of purification that is Ultra Violet (UV) disinfection chamber. There are two valves in the inlet and outlet of the UV chamber to keep the water for some time in the chamber for disinfection. The opening and closing of the two valves is so synchronized that the water will remain inside the UV chamber for some time and the continuity of the flow in the outlet is also maintained which is done by the microcontroller. The water in the outlet is pure potable water.

4.2 Circuit Diagram of the actuator driver

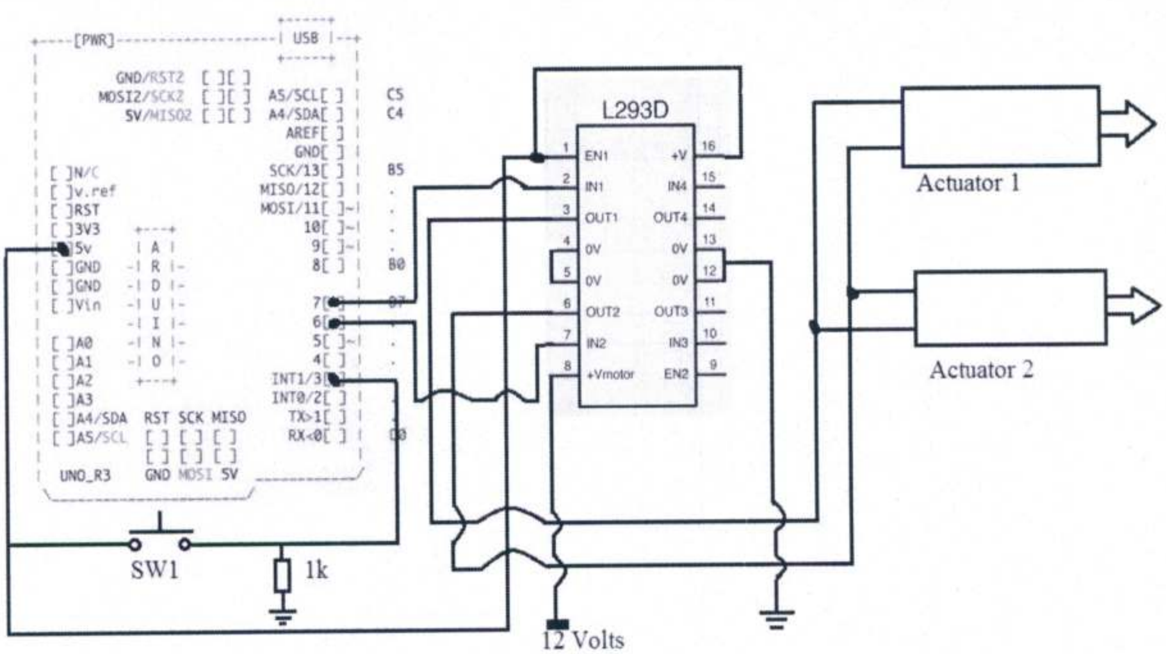

Figure 14: Actuator Driving Circuit diagram

4.3 Circuit Diagram for Level Control

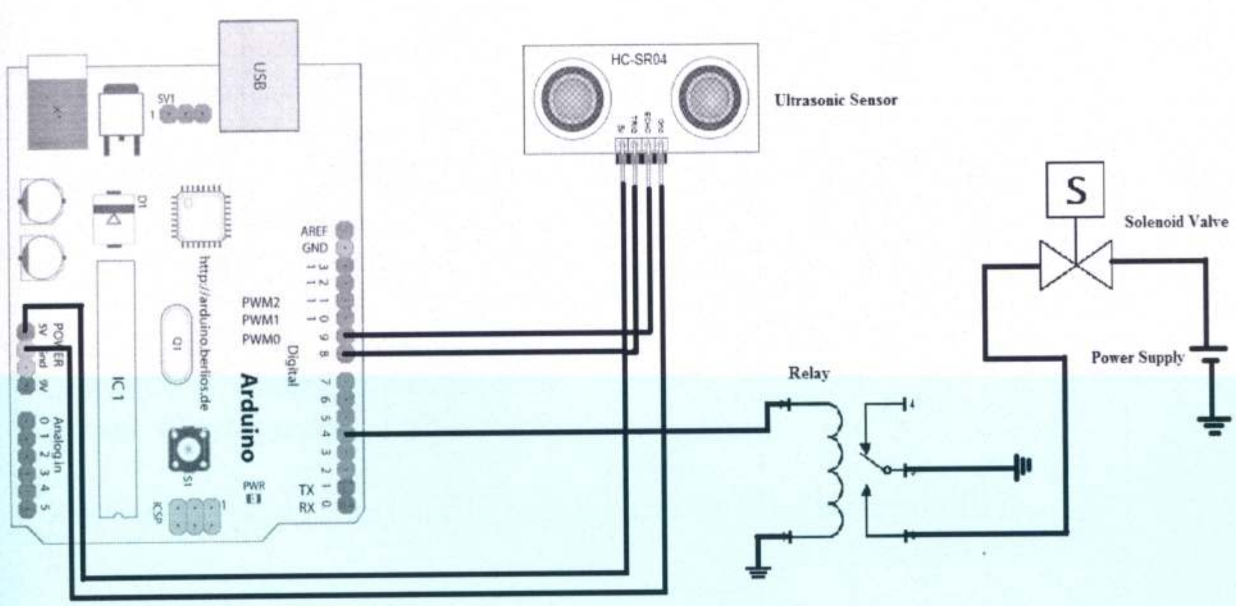

Figure 15: Level control circuit diagram

Chapter 5 Programming Codes

5.1 Arduino Program for Driving Actuator

```
int sw=0;
int actuator_forward = 11;
int actuator_reverse = 12;


void setup()
{
pinMode(2,INPUT);
pinMode(actuator_forward, OUTPUT);
pinMode(actuator_reverse, OUTPUT);
}


void loop(){
sw=digitalRead(2);
if(sw==HIGH)
{
digitalWrite(actuator_forward,1); //terminal D1 will be HIGH
digitalWrite(actuator_reverse,0); //terminal D2 will be LOW
delay(delay time); //creates delay
digitalWrite(actuator_forward,0); //terminal D1 will be LOW
digitalWrite(actuator_reverse,1); //terminal D2 will be HIGH
delay(delay time); //creates a 5 seconds delay
digitalWrite(actuator_forward,0); //terminal D1 will be LOW
digitalWrite(actuator_reverse,0); //terminal D2 will be LOW
delay(5000); //creates a 5 seconds delay
//Motor will stop rotating for 5 seconds
}
//again the loop() will run from the begining until the board is turned OFF }
}
```

5.2 Arduino Program for Level Control

```
#define echopin 9 // echo pin
#define trigpin 8 // Trigger pin
int maximumRange = 20;
long duration, distance;
void setup() {
Serial.begin (9600);
pinMode (trigpin, OUTPUT);
pinMode (echopin, INPUT );
pinMode (4, OUTPUT);
pinMode (13,OUTPUT);
}
void loop ()
{
{
digitalWrite(trigpin,LOW);
delayMicroseconds(2);
digitalWrite(trigpin,HIGH);
delayMicroseconds(10);
duration=pulseIn (echopin,HIGH);
distance= duration/58.2;
delay (50);
Serial.println(distance);
}
if (distance >= 10 ){
digitalWrite (4,HIGH);
digitalWrite (13,HIGH);
}
else if (distance <=2) {
digitalWrite (4,LOW);
digitalWrite (13,LOW);
}
}
```

Chapter 6 Testing Methods and WHO standards

6.1 Methods of testing

- Flow rate test
- Filter effectiveness test
    1. Nutrients test
    2. Metal test
    3. General test

6.1.1: Flow rate test

It is a basic test for the purpose of knowing how much liter of water can be purified by the purifier in an hour or a minute. In our project flow rate of water is almost 0.2ltr/min.

6.1.2: Filter effectiveness test

We can determine the effectiveness of a water filtration system by testing for dissolved solids, pH, hardness, iron, chlorine, lead and copper.

Dissolved solids:

Dissolved solids are the minerals and salts that are contained in the water. The federal guideline for total dissolved solids and maximum contamination level is 500 mg per liter.

pH

pH is an indication of acidity or alkalinity of the water. Ideally, water should be neutral with a pH of 7. Acidic water will have a pH less than 7 and will have a sour taste as acidity increases. Basic or alkaline water will have a pH above 7 and will have a bitter taste as alkalinity increases. Neutral, or nearly neutral water has a pH of about 7 and should have no sour or bitter taste. The pH will affect the amount of minerals and salts that dissolve in natural water.

Hardness

Hardness in water is caused by dissolved minerals, primarily calcium (Ca^{2+}), magnesium (Mg^{2+}), iron (Fe^{2+}), strontium (Sr^{2+}), zinc (Zn^{2+}), and manganese (Mn^{2+}) with calcium and magnesium present in significant concentrations.

Iron

Iron may be present in water as iron(II), $Fe2+$, which can oxidize to iron(III), $Fe3+$. It comes from natural deposits in the environment and from iron pipes in water systems.

Chlorine

Chlorine is the disinfectant most frequently used for water and wastewater treatment. Depending on the source of water in your locality, the amount of chlorine can vary from a slight amount that is hardly noticeable to a higher concentration that some people find objectionable. When chlorine is added to water, it forms hydrochloric (HCl) and hypochlorous (HClO) acids. The hypochlorous acid is responsible for the disinfectant action as well as a bleaching action

Lead

Lead and its compounds are poisonous and accumulate in the bone structure when ingested. Accumulation of significant amounts of lead in the body may cause severe and permanent brain damage, convulsions, and death.

Copper

Copper concentrations in drinking water are usually very low and is not considered a health hazard. When copper concentrations exceed more than 1 mg/L, it can impart a bitter taste to the water.

Arsenic

Arsenic and its compounds are poisonous. Arsenic compounds irritate the stomach severely and affect the heart, liver and kidneys. Accumulation of arsenic in the body will result in nervousness, thirst, vomiting, diarrhea, cyanosis, and collapse. The maximum amount of arsenic permitted in drinking water is 0.05 mg/L.

6.2 WHO standards

The World Health Organization (WHO) published a guideline for safe drinking water standards. This has been summarized in Appendix B. There are other drinking water guidelines that exist. These include guidelines from Canada, and the European Union. The standards from WHO were used because they represent the global drinking water standard. The water filter to be designed should be safe for use in all countries around the world. All water testing results performed in this project will be compared to the recommended values from the WHO guidelines.

Chapter 7 Purified Water quality Testing and Results

7.1 pH test

pH of water is the hydrogen ion (H+) concentration in fluid. pH of distilled water is 7. Lower pH number indicates acidity and higher pH number indicates basicity. According to Bureau of Indian Standard (BIS) the pH of drinking water should be in between 6.5-8.5 (IS 10500:2012). The test is done for three water samples of three different activated carbon. The test results are tabulated below-

Characteristics	Raw Water	Sample 1 (Areca nut ash)	Sample 2 (Water hyacinth ash)	Sample 3 (Rice husk ash)
pH	7.68	7.46	7.42	7.52

Table 4: pH test results

7.1.1 Instrument used

The instrument use for measuring pH is a pH electrode. Generally two electrodes are used one is reference electrode and measuring electrode but now a days both electrodes are combined together to form one electrode. For measuring pH of any unknown fluid just we have to dip the electrode into the fluid it automatically shows the value of pH. The details of the instrument we are using is mentioned below-

Instrument name: pH tester 30

Specifications

- pH Range =1.0 to 15.0 pH
- Accuracy = ±0.01 pH
- Resolution =0.01 pH
- Temperature Display =0 to 50 °C or 32 to 122 °F
- Power = 4 x 1.5V alkaline button cell batteries; >500 hrs
- pH Buffer Options =USA - pH 4.01, 7.00, 10.01, NIST - pH 4.01, 6.86, 9.18

7.2 Microbiological Test

The end-product testing always be a vital part of any food manufacturing control strategy. The products in which microorganisms can survive and grow, routine microbiological analysis is important to confirm that manufacturing control mechanisms are effective. It is also necessary for the checking of raw material quality (e.g. to confirm that they are within specification), or for investigating customer complaints.

7.2.1 Test method used

To test the presence of microorganisms like bacteria and viruses in the purified water Nutrient Agar technique is used. Nutrient Agar is used for the cultivation of a wide variety of microorganisms. The formula for Nutrient Agar as a standard culture medium used in water testing is standardized by the American Public Health Association (APHA) and Association of Official Analytical Chemists (AOAC). Nutrient Agar continues to be a widely used general purpose medium for growing nonfastidious microorganisms.

In our experiment we are using three samples of purified water, sample1 (Areca nut ash), sample2 (Water hyacinth ash) and sample3 (Rice husk ash).

Formula/Liter

Enzymatic Digest of Gelatin (Yeast Extract) = 5 gm.

Beef Extract = 3 gm.

Agar powder = 15 gm.

Final pH = 6.8±0.2 at 25°C

Procedure

1. Suspend 23 gm of medium in one liter of purified water.
2. Heat with frequent agitation and boil for one minute to completely dissolve the medium.
3. Autoclave at 121°C for 15 minutes.
4. Inoculate medium with isolated colonies or a loopful of pure culture from broth. Stack for isolation.
5. Incubate aerobically at 35°C for 18-24 hours or longer if necessary.

Results

Good growth of nonfastidious organisms on Nutrient Agar will appear as translucent colonies.

7.2.2 Result of Microbiological Test of the Samples

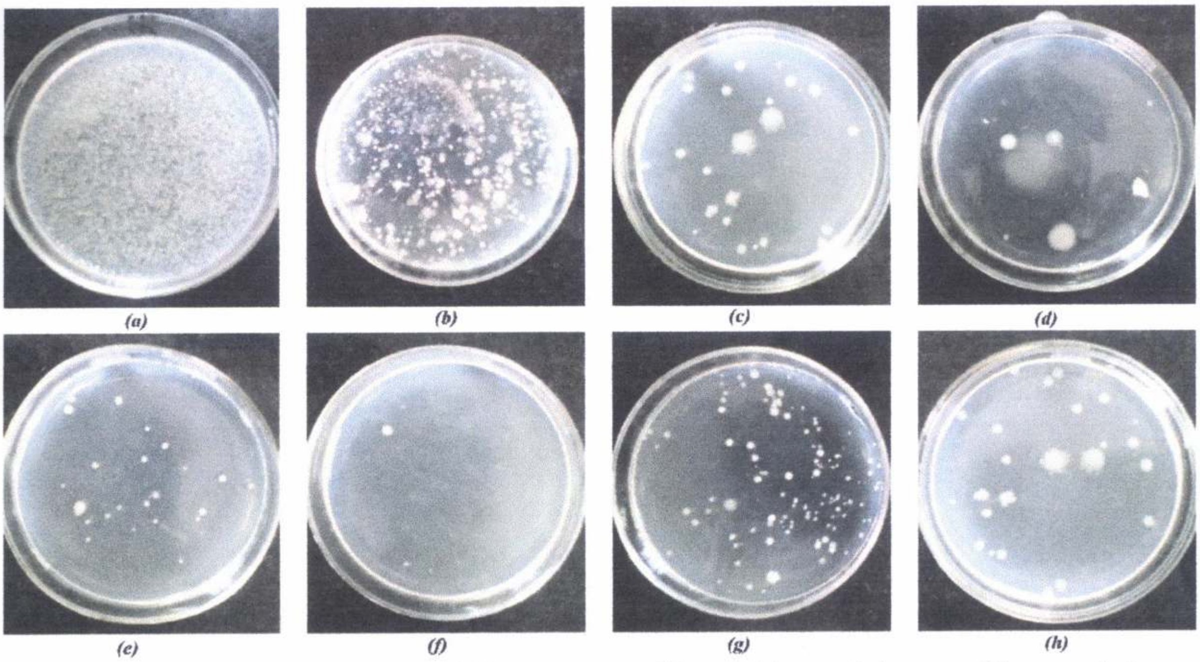

Figure 16:(a)Raw water pure,(b)Raw water diluted,(c)sample1 pure,(d) sample1 diluted (e) sample2 pure, (f) sample2 diluted, (g)sample3 pure, (h) sample3 diluted.

The results in tabulated form

Water Sample	Counts of translucent colonies(Nos.)	
	Pure Sample	**Diluted Sample**
Raw Water	Infinite	Infinite
Sample1 (areca nut ash)	23	7
Sample2 (water hyacinth ash)	19	1
Sample3(Rice husk ash)	76	25

Table 5: Microbiological Test Results

7.2.3 Instruments used and its specification

1. MAC Vertical Autoclave (PASW-20)

It is a portable autoclave. This type o0f autoclaves are most ideal for general laboratory requirement where samples in small batches are required to be sterilized.

Specifications

- Inner Dimensions (Diameter x Height) =350 X 325mm
- Capacity =22 liters
- Heater Load = 2.0 KW
- Controller = μProcessor Based Semi-Automatic Digital Temperature Indicator-cum-Controller
- Timer (Auto time controller) = With Automatic Digital Minute Timer
- Display = Digital LED display for set value (SV) and process value (PV)
- Exhaust of Pressure = Manually through a exhaust valve
- Pressure Gauge = 0-2.1 kgf/cm2 (30 psi)
- Sterilizing Pressure = 0-2.1 kgf/cm2 (15 psi) at 121°C

2. LABWIT incubator shaker (ZWY-211C)

It is horizontal floor model incubator shaker. It offer large capacity all sizes of flasks up to 5 liters. Units are widely used for germ culture, fermentation, biochemical researchers, enzymes and cellular tissues. Sophisticated PID controller provides new units with great flexible choice of constant controlling at one fixed temperature and speed.

Specifications:

- Control = PID microprocessor
- Volume(liters) = 260
- Working temperature = 5-25°C
- Shaking speed = 30-300 rpm
- Temperature range = 4-60°C
- Temperature accuracy = 0.1°C
- Timer = 1 to 9999 minutes

7.3 Heavy Metal Test

The heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb).

7.3.1 WHO Standards for Different Heavy Metals in Drinking Water

World Health Organization (WHO) standardized some guidelines for the presence of heavy metals in drinking water. The values of standardization is mentioned below:

Parameters	Lower Limit of detection(ppb)	WHO Guideline Value (ppb)
Arsenic(As)	5	<10
Cadmium(Cd)	3	<3
Chromium(Cr)	50	<50
Copper(Cu)	5	<2000
Lead(Pb)	5	<10
Manganese(Mn)	5	<100
Mercury(Hg)	5	<6
Nickel(Ni)	10	<70
Zinc (Zn)	5	<4000

Table 6: WHO standard guideline for heavy metals

7.3.2 Instrument Used

For analysis of the heavy metals we are using Trace2O metalyser HM1000 kit. The Metalyser Portable HM1000 instrument is ideal for testing of very low heavy metal concentrations in natural water courses, for example, lakes and rivers. The instrument is used both as a collection and measurement device for at-site analysis. It is very portable using a battery as its power source and can provide results to <10ppb rapidly. The Metalyser Portable HM1000 utilizes a voltammetric technique that allows the analysis to occur.

Components Inside the Kit

The kit is mainly consist of three main electrodes, viz. counter electrode, reference electrode and working electrode.

How It Works

Molecules, ions or atoms that take part in an electrochemical reaction change their oxidation state. The oxidation state is derived from the imbalance of electrons and protons in the species. The Metalyser uses voltammetry which works by applying a voltage to an electrode (the Working Electrode) which has the effect of attracting ions in solution and adsorbing them onto the electrode thus changing their oxidation state.

Where (aq) denotes aqueous (in solution), (s) for solid and (e) stands for electrons. M is the metal adsorbed onto the Working Electrode surface.

This reaction occurs at the half potential reactivity of the cadmium reducing it to its metallic form. The analytical signal which is measured comes from the reverse of the above reaction, i.e. the polarity of the Working Electrode is made less negative (more positive) and the positively charged ions are removed from the electrode then releasing the electrons back into solution creating a current. The magnitude of the current is directly proportional to the concentration of the cadmium in the solution.

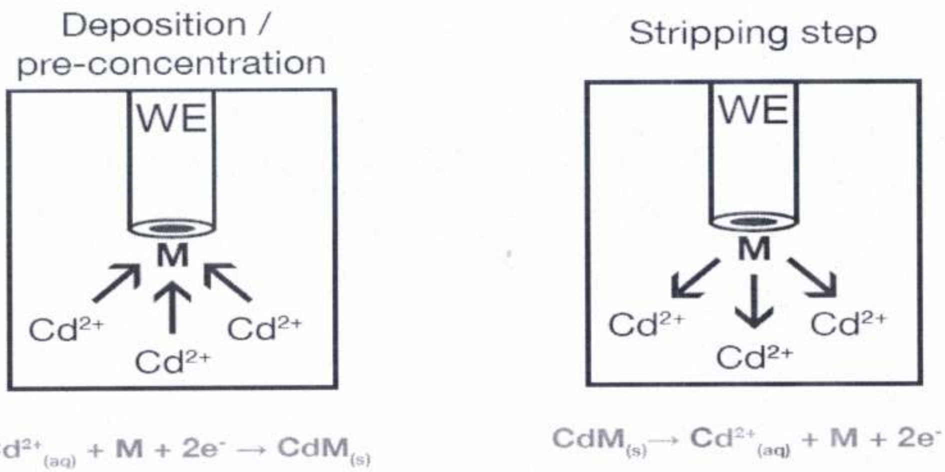

Figure 17: working of the metalyser HM1000

7.3.3 Arsenic Test

Test is perform individually for three different samples of purified water and raw water. The three samples are sample 1(areca nut ash), sample 2(water hyacinth ash) and sample 3(rice husk ash).

Test Results

Sample Name	Presence of Arsenic (in ppb)
Raw water	11.20
Sample 1	3.25
Sample 2	2.679
Sample 3	4.68

Table 7: Arsenic test results

Graphical Representation

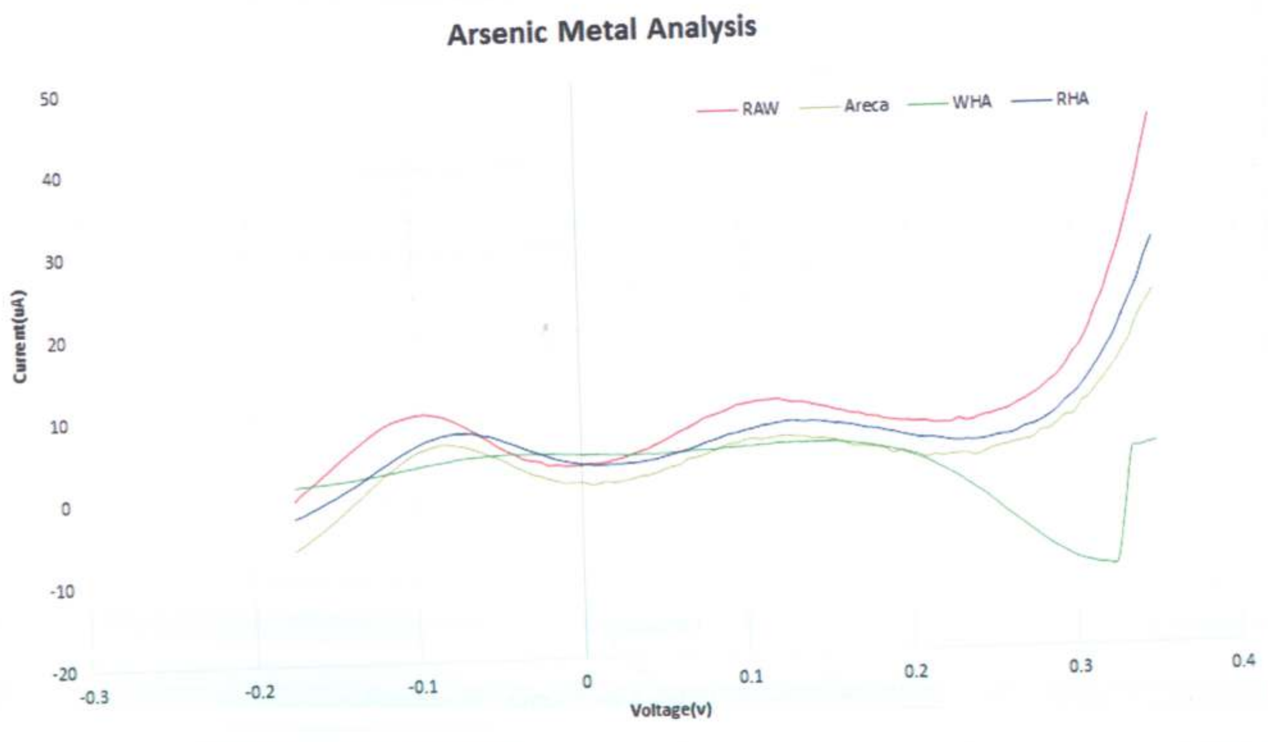

Figure 18: Graph of the arsenic analysis

7.3.4 Cadmium- Lead Test

Same as the arsenic test it also done individually for three different samples, sample 1(areca nut ash), sample 2(water hyacinth ash) and sample 3(rice husk ash).

Test Result

Sample Name	Presence of Cadmium (in ppb)	Presence of Lead (in ppb)
Raw water	2.78	6.72
Sample 1	1.348	3.635
Sample 2	0.857	2.834
Sample 3	2.095	4.367

Table 8: Cadmium-Lead test results

Graphical Representation

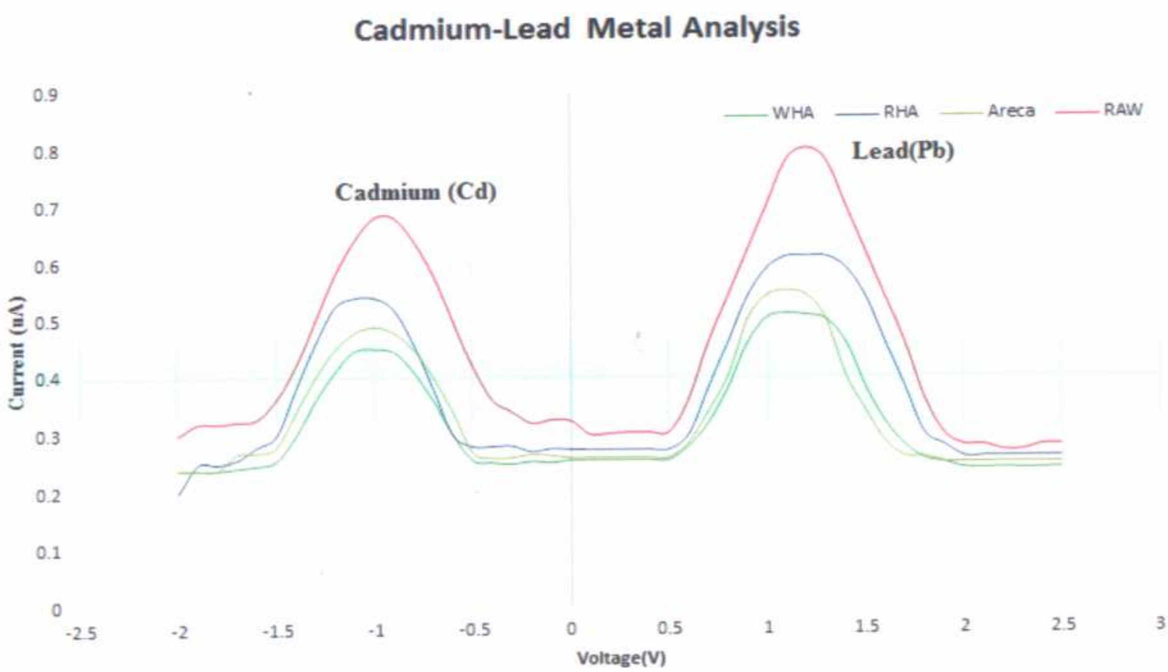

Figure 19: Graph of Cadmium-Lead analysis

7.4 Total Dissolved Solids (TDS) Test

The Total Dissolved Solids (TDS) is measured by using Spectrophotometer. A spectrophotometer consists of two instruments, namely a spectrometer for producing light of any selected color (wavelength), and a photometer for measuring the intensity of light. The instruments are arranged so that liquid in a cuvette can be placed between the spectrometer beam and the photometer. The amount of light passing through the tube is measured by the photometer. The photometer delivers a voltage signal to a display device, normally a galvanometer. The signal changes as the amount of light absorbed by the liquid changes.

When monochromatic light (light of a specific wavelength) passes through a solution there is usually a quantitative relationship (Beer's law) between the solute concentration and the intensity of the transmitted light, that is,

$$I = I_0 \times 10^{-kcl}$$

Where I_0 is the intensity of transmitted light using the pure solvent, I is the intensity of the transmitted light when the colored compound is added, c is concentration of the colored compound, l is the distance the light passes through the solution, and k is a constant. If the light path l is a constant, as is the case with a spectrophotometer, Beer's law may be written,

$$\frac{I}{I_0} = 10^{-kc} = T$$

Where k is a new constant and T is the transmittance of the solution. There is a logarithmic relationship between transmittance and the concentration of the colored compound. Thus,

$$\text{-logT=log}\,\frac{1}{T}\text{=}kc\text{=Optcal Desnsity(OD)}$$

The O.D. is directly proportional to the concentration of the colored compound.

7.4.1 Test Results

The spectrophotometer we used has a wavelength range of 200-1100nm. According Bureau of Indian Standard(BIS) for the Total Dissolved Solids(TDS) the amount of acceptable limit is 500 and permissible limit is 2000. The peak absorption of light wavelength by dissolved solids is obtained at a wavelength of 1098 nm. In this test alsoraw water and three samples of purified water is examined, they are named as sample 241(raw water), sample 242(areca nut ash), sample 243 (water hycinth wash) and sample 244 (rice husk ash). The value of absorbance is mentioned below-

Sample Name	Peak wavelength (nm)	Absorbance
Sample 241	1098	0.21135
Sample 242	1098	0.005255
Sample 243	1098	0.007342
Sample 244	1098	0.009923

Table 9: Spectrophotometer results

Graphical Representation

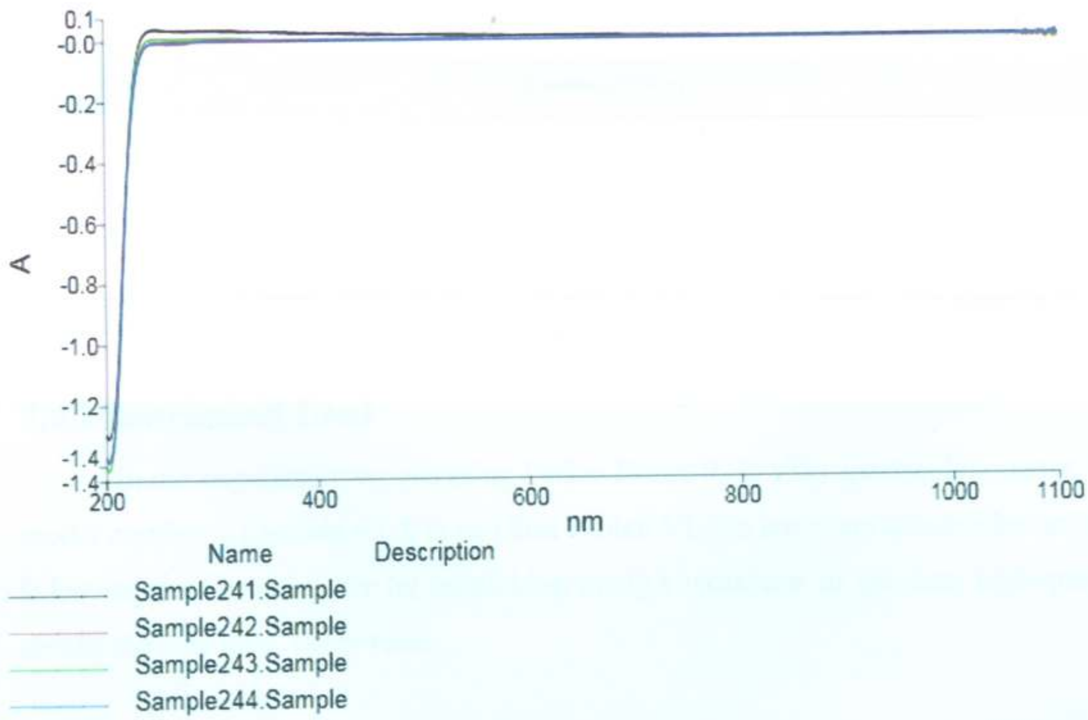

Figure 20: Graph of TDS analysis using spectrophotometer

But in the graph, that is obtained from spectrophotometer the absorbance peaks at 1098 nm wavelength is not clearly visible. So, the variation of the absorbance between the raw water and the three samples distinctly. In order to clearly see the peaks the following graph can be used-

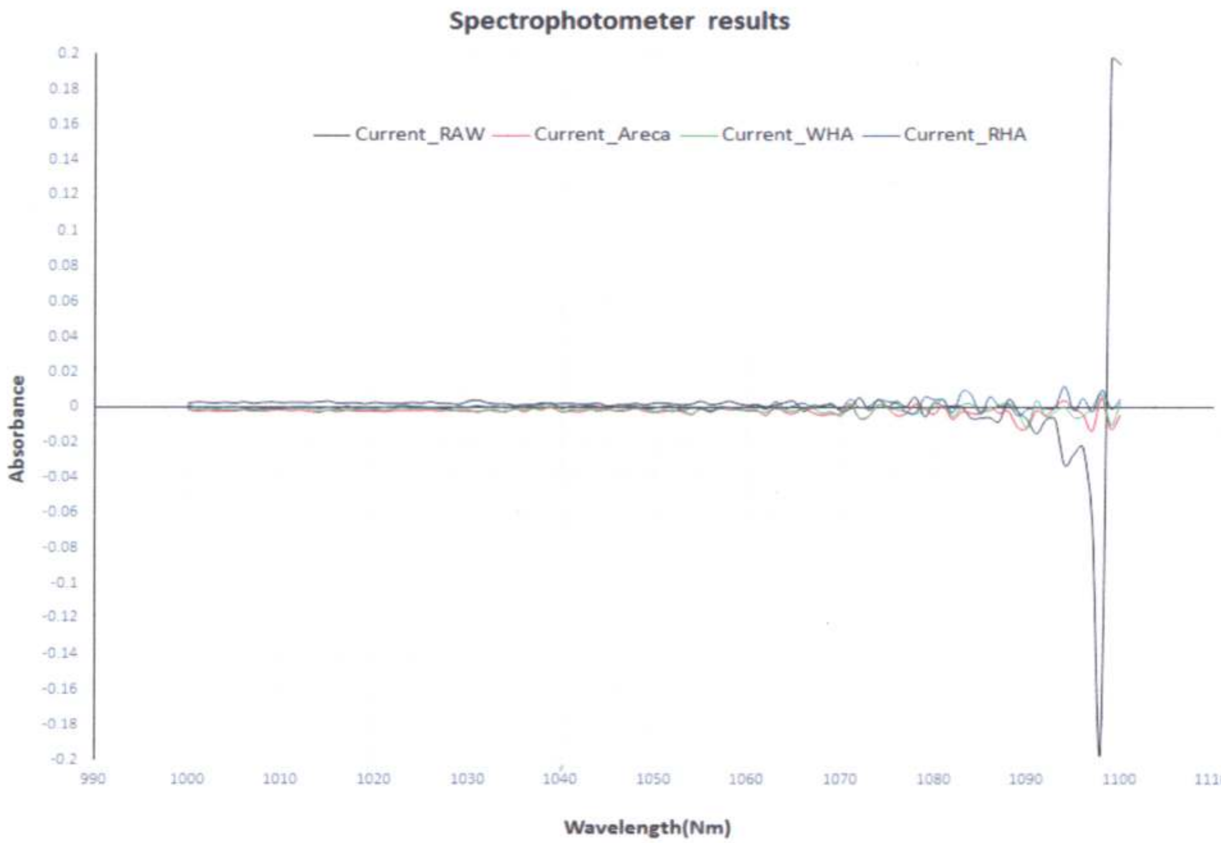

Figure 21: Spectrophotometer graph with distinct absorption peaks

From the graph it clearly visible that the amount of absorption of light is very low in case of the three purified water sample that of the raw water. So it can directly understand that the amount of total dissolved solids is very low.

7.4.2 Instrument Used

In our experiment we are using Perkin Elmer (UV/VIS) spectrophotometer, the model number is Lambda 45. It is an Ultra Violet/ Visible spectrum spectrophotometer. It has increase productivity by mimicking the QA workflow to generate high-quality results the first time, every time.

Specifications

1. Wavelength range= 190-1100 nm
2. Wavelength accuracy= ±0.1 nm
3. Wavelength reproducibility= ±0.05 nm
4. Photometric accuracy= ±0.001 A, ±0.005 A, ±0.010 A
5. Photometric reproducibility= <0.001 A

Chapter 8 Result and Discussion

- In this project we have successfully completed all the stages of water purification process. All the drinking water quality test is carried out and the results are positive and satisfactory.
- At first the pH test is done and have obtained almost same pH value for all the three samples and raw water which is in between 6.5-8.5(standard for pH according to IS 10500-2012). The result is graphically shown below-

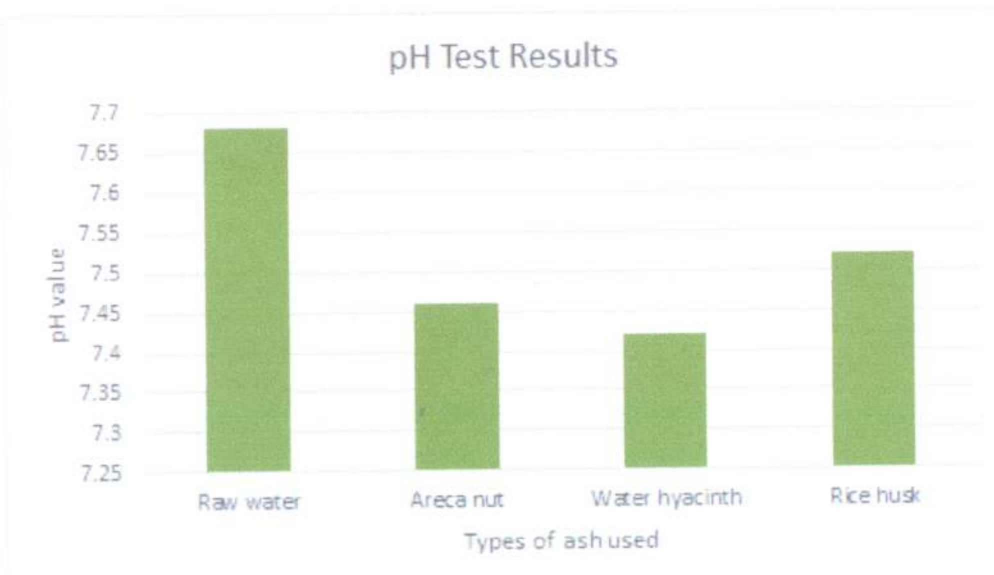

Figure 22: pH test results

- In microbiological analysis of water we have very satisfactory result. For the raw water we have infinite count of translucent colonies of microorganisms. After purification it the count is reduce to 23, 19 and 100 respectively for areca nut ash, water hyacinth ash and rice husk ash.
- In heavy metal testing we have done the test for arsenic, cadmium and lead. Arsenic is reduced by 58% that of the raw water by using rice husk ash, reduced by 76% when using water hyacinth ash and 69% when areca nut ash is used. The cadmium is reduced by 17%, 69% and 24% when areca nut ash, water hyacinth ash and rice husk ash respectively. Lead can also be reduced up to 57% as well. Graphically it shown in the next page.

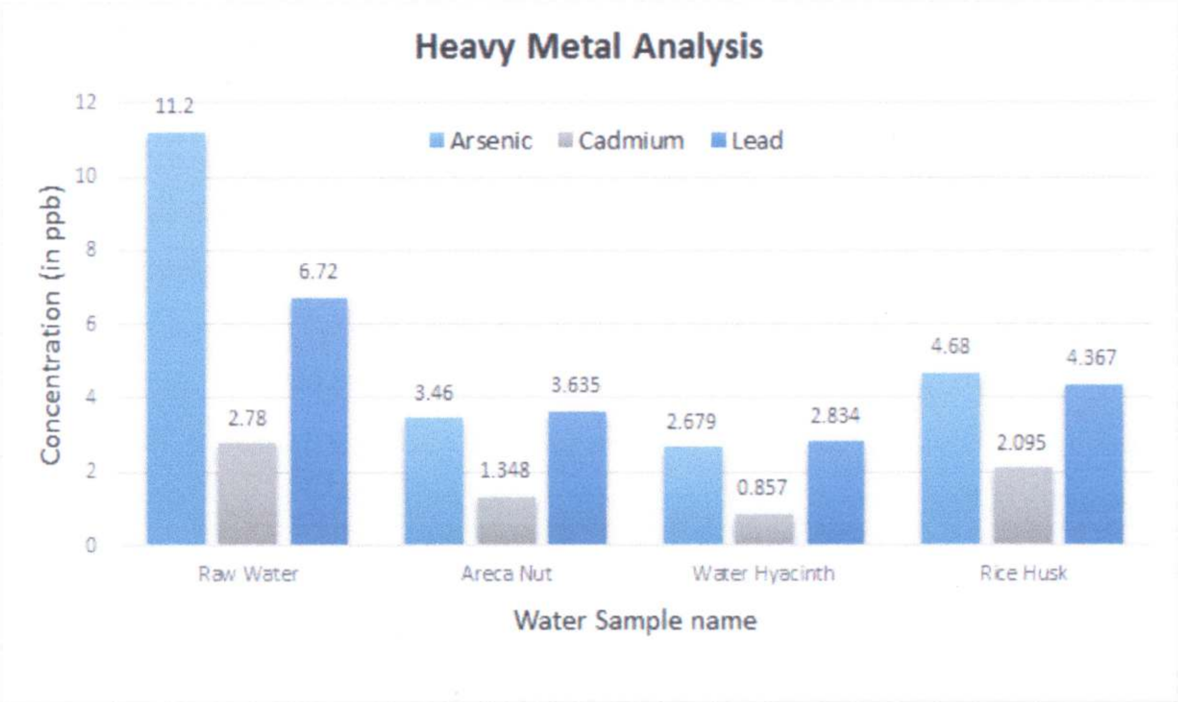

Figure 23- Heavy metal analysis results

- The Total Dissolved Solids (TDS) of raw water and the three purified water samples are analyzed in spectrophotometer and compared. All the purified samples absorb very less amount of light than that of the raw water. This means the purifier is very effective in removing the amount of dissolved solids. Graphically it is shown below-

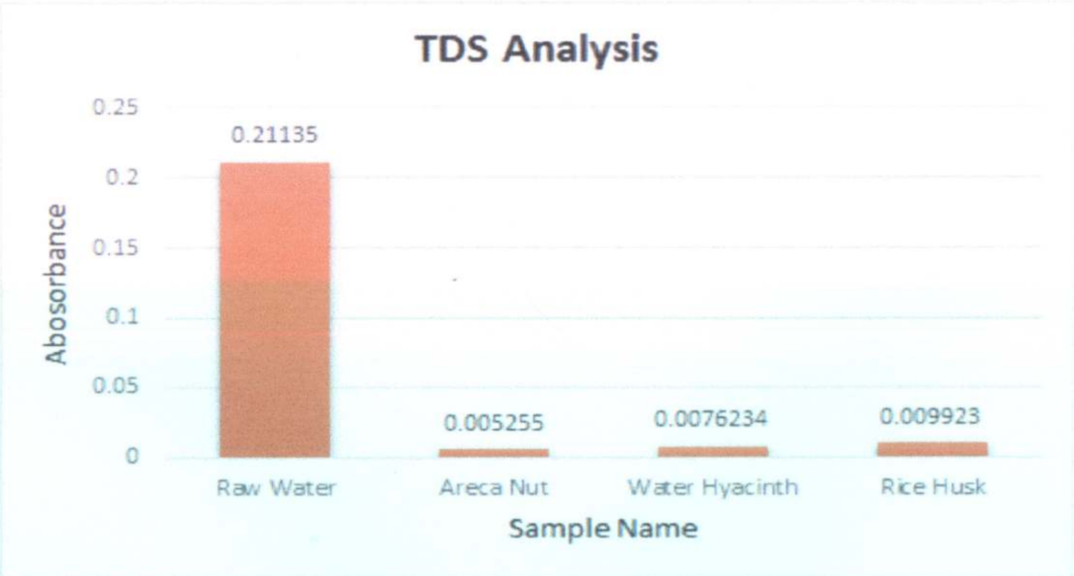

Figure 24: TDS analysis graph

By analyzing all the test results it can be summarized that the purifier can efficiently filtered out most of the harmful particles from the raw water and provides potable drinking water.

Chapter 9 Future Scope

- The samples of activated carbon chemically react with the heavy metals and absorb the heavy metals. So it has to be tested for the stagnation point of absorption by the ash, i.e how long it can absorb the heavy metals and after what period of time it has to be replace for maintain the efficiency of filtration.
- The remaining tests such as for other heavy metals like mercury, chromium, copper etc ,turbidity, hardness all analysis should be done in order to maintain the standard of purification.

Chapter 10 Conclusion

Water is the basic prerequisites for all the living organisms. For human beings water is one of the most necessary thing used from morning to the evening. But the water that is used for drinking must be pure otherwise lack of access has resulted in many water related diseases. In this project we try our best to make a low cost water purifier which cost about INR 2500 and can be afforded by common people. It consist 5 stages of purification consist of Reverse Osmosis filtration and Ultra Violet ray disinfection. We made it successfully done. We have also made three type of activated carbon ash and analyze the purified water individually by using individual activated carbon. All the test results are positive and satisfactory.

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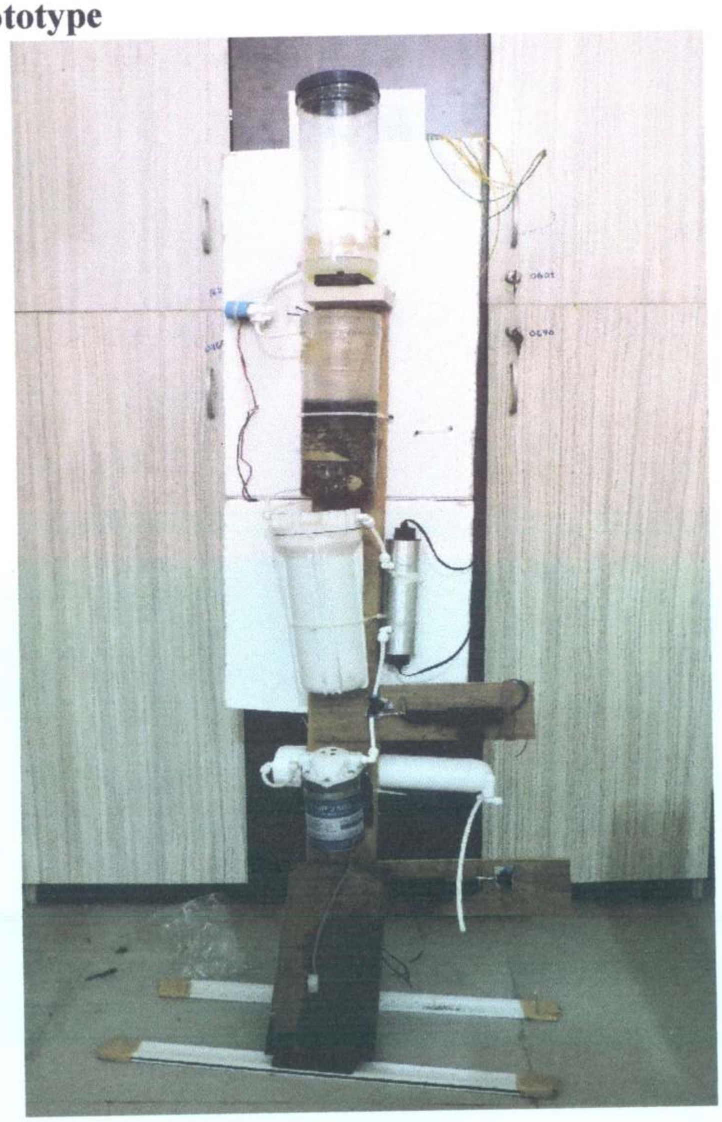
Appendix A

Cost Analysis

Sl. No.	Products	Price
1	UV light with chamber	INR 450
2	Sediment filter with chamber+ 5 mtr. ¾' pipe	INR 310
3	RO membrane	INR 750
4	RO booster pump	INR 1230
	Total Cost	INR 2710

Photo of Prototype



Appendix B

WHO Guideline for Drinking Water

WHO Safe Drinking Water Guidelines

Table A-1 WHO element/substance guidelines for safe drinking water

Element / substance	Symbol / formula	Amount normally found in water	WHO guideline amount
Aluminum	Al		0.2 mg/l
Ammonia	NH_4	< 0.2 mg/l	No guideline
Antimony	Sb	< 4 µg/l	0.02 mg/l
Arsenic	As		0.01 mg/l
Asbestos			No guideline
Barium	Ba		0.7 mg/l
Beryllium	Be	< 1µg/l	No guideline
Boron	B	< 1mg/l	0.5mg/l
Cadmium	Cd	< 1 µg/l	0.003 mg/l
Chloride	Cl		No guideline
Chromium	Cr^{+3}, Cr^{+6}	< 2 µg/l	0.05 mg/l
Colour			Not mentioned
Copper	Cu		2 mg/l
Cyanide	CN^-		0.07 mg/l
Dissolved oxygen	O_2		No guideline
Fluoride	F	< 1.5 mg/l	1.5 mg/l
Hardness	$CaCO_3$ (mg/l)		No guideline
Hydrogen sulphide	H_2S		No guideline
Iron	Fe	0.5 to 50 mg/l	No guideline
Lead	Pb		0.01 mg/l
Manganese	Mn		0.4 mg/l
Mercury	Hg	< 0.5 µg/l	0.006 mg/l
Molybdenum	Mb	< 0.01 mg/l	0.07 mg/l
Nickel	Ni	< 0.02 mg/l	0.07 mg/l
Nitrate & nitrite	NO_3, NO_2		50 mg/l and 3mg/l
Turbidity			Not mentioned
pH			No guideline
Selenium	Se	< 0.01 mg/l	0.01 mg/l
Silver	Ag	5 to 50 µg/l	No guideline
Sodium	Na	< 20mg/l	No guideline
Sulphate	SO_4		No guideline
Tin	Sn		Not mentioned
TDS			No guideline
Uranium	U		0.015 mg/l
Zinc	Zn		No guideline

Table A2 WHO organic compound guidelines for safe drinking water

Group	Substance	Formula	WHO guideline amount
Chlorinated alkanes	Carbon tetrachloride	CCl_4	4 µg/l
	Dichloromethane	CH_2Cl_2	20 µg/l
	1,1-Dichloroethane	$C_2H_4Cl_2$	No guideline
	1,2-Dichloroethane	$ClCH_2Ch_2Cl$	30 µg/l
	1,1,1-Trichloroethane	CH_3CCl_3	No guideline
Chlorinated ethenes	1,1-Dichloroethene	$C_2H_2Cl_2$	No guideline
	1,2-Dichloroethene	$C_2H_2Cl_2$	50 µg/l
	Trichloroethene	C_2HCl_3	20 µg/l
	Tetrachloroethene	C_2Cl_4	40 µg/l
Aromatic hydrocarbons	Benzene	C_6H_6	10 µg/l
	Toluene	C_7H_8	700 µg/l
	Xylenes	C_8H_{10}	500 µg/l
	Ethylbenzene	C_8H_{10}	300 µg/l
	Styrene	C_8H_8	20 µg/l
	PAH	$C_2H_3N_1O_5P_{13}$	Not mentioned
Chlorinated benzenes	Monochlorobenzene	C_6H_5Cl	No guideline
	1,2-Dichlorobenzene	$C_6H_4Cl_2$	1000 µg/l
	1,3-Dichlorobenzene	$C_6H_4Cl_2$	No guideline
	1,4-Dichlorobenzene	$C_6H_4Cl_2$	300 µg/l
	Trichlorobenzene	$C_6H_3Cl_3$	No guideline
Miscellaneous organic constituents	Di(2-ethylhexyl)adipate	$C_{22}H_42O_4$	No guideline
	Di(2-ethylhexyl)phthalate	$C_{24}H_{38}O_4$	8 µg/l
	Acrylamide	C_3H_5NO	0.5 µg/l
	Epichlorohydrin	C_3H_5ClO	0.4 µg/l
	Hexachlorobutadiene	C_4Cl_6	0.6 µg/l
	Ethylenediaminetetraacetic acid	$C_{10}H_{12}N_2O_8$	600 µg/l
	Nitrilotriacetic acid	$N(CH_2COOH)_3$	200 µg/l
	Dialkyltins	R_2SnX_2	No guideline
	Tributyltin oxide	$C_{24}H_{54}OSn_2$	No guideline

Table A3 WHO disinfectant and disinfectant by-products guideline for safe drinking water

Group	Substance	Formula	WHO guideline amount
Disinfectants	Chloramines	NH_2Cl	Not mentioned
	Chlorine	Cl_2	5 mg/l
	Chlorine dioxide	ClO_2	No guideline
	Iodine	I_2	No guideline
Disinfectant by-products	Bromate	BrO_3^-	10 µg/l
	Chlorate	ClO_3^-	70 µg/l
	Chlorite	ClO_2^-	70 µg/l
	2-Chlorophenol	C_6H_5ClO	No guideline
	2,4-Dichlorophenol	$C_6H_4Cl_2O$	No guideline
	2,4,6-Trichlorophenol	$C_6H_3Cl_3O$	200 µg/l
	Formaldehyde	HCHO	No guideline
	MX	$C_5H_3Cl_3O_3$	No guideline
	Bromoform	$CHBr_3$	100 µg/l
	Dibromochloromethane	$CHBr_2Cl$	100 µg/l
	Bromodichloromethane	$CHBrCl_2$	60 µg/l
	Chloroform	$CHCl_3$	300 µg/l
	Monochloroacetic acid	$C_2H_3ClO_2$	No guideline
	Dichloroacetic acid	$C_2H_2Cl_2O_2$	50 µg/l
	Trichloroacetic acid	$C_2HCl_3O_2$	20 µg/l
	Chloral hydrate	$CCl_3CH(OH)_2$	No guideline
	Chloroacetones	C_3H_5OCl	No guideline
	Dichloroacetonitrile	C_2HCl_2N	20 µg/l
	Dibromoacetonitrile	C_2HBr_2N	70 µg/l
	Bromochloroacetonitrile	$CHCl_2CN$	No guideline
	Trichloroacetonitrile	C_2Cl_3N	No guideline
	Cyanogen chloride	ClCN	70 µg/l
	Chloropicrin	CCl_3No_2	No guideline

Table A4 WHO pesticides guideline for safe drinking water

Substance	Formula	WHO guideline amount
Alachlor	$C_{14}H_{20}ClNO_2$	20 µg/l
Aldicarb	$C_7H_{14}N_2O_4S$	10 µg/l
Aldrin and Dieldrin	$C_{12}H_8Cl_6$ and $C_{12}H_8Cl_6O$	0.03 µg/l
Atrazine	$C_8H_{14}ClN_5$	2 µg/l
Bentazone	$C_{10}H_{12}N_2O_3S$	No guideline
Carbofuran	$C_{12}H_{15}NO_3$	7 µg/l
Chlorotoluron	$C_{10}H_{13}ClN_2O$	0.2 µg/l
DDT	$C_{14}H_9Cl_5$	30 µg/l
1,2-Dibromo-3-chloropropane	$C_3H_5Br_2Cl$	1 µg/l
2,4-dichlorophenoxyacetic acid	$C_8H_6Cl_2O_3$	1 µg/l
1,2-dichloropropane	$C_3H_6Cl_2$	30 µg/l
1,3-dichloropropane	$C_3H_6Cl_2$	40 µg/l
1,3-dichloropropene	$CH_3CHClCH_2Cl$	No guideline
Ethylene dibromide	$BrCH_2CH_2Br$	20 µg/l
Heptachlor and heptachlor epoxide	$C_{10}H_5Cl_7$	Not mentioned
Hexachlorobenzene	$C_{10}H_5Cl_7O$	No guideline
Isoproturon	$C_{12}H_{18}N_2O$	9 µg/l
Lindane	$C_6H_6Cl_6$	2 µg/l
MCPA	$C_9H_9ClO_3$	2 µg/l
Methoxychlor	$(C_6H_4OCH_3)_2CHCCl_3$	20 µg/l
Metolachlor	$C_{15}H_{22}ClNO_2$	10 µg/l
Molinate	$C_9H_{17}NOS$	6 µg/l
Pendimethalin	$C_{13}H_{19}O_4N_3$	20 µg/l
Pentachlorophenol	C_6HCl_5O	9 µg/l
Permethrin	$C_{21}H_{20}Cl_2O_3$	300 µg/l
Propanil	$C_9H_9Cl_2NO$	No guideline
Pyridate	$C_{19}H_{23}ClN_2O_2S$	No guideline
Simazine	$C_7H_{12}ClN_5$	2 µg/l
Trifluralin	$C_{13}H_{16}F_3N_3O_4$	90 µg/l

Appendix C

Datasheets

Ultrasonic Ranging Module HC - SR04

Product features:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

(1) Using IO trigger for at least 10us high level signal,

(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.

(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

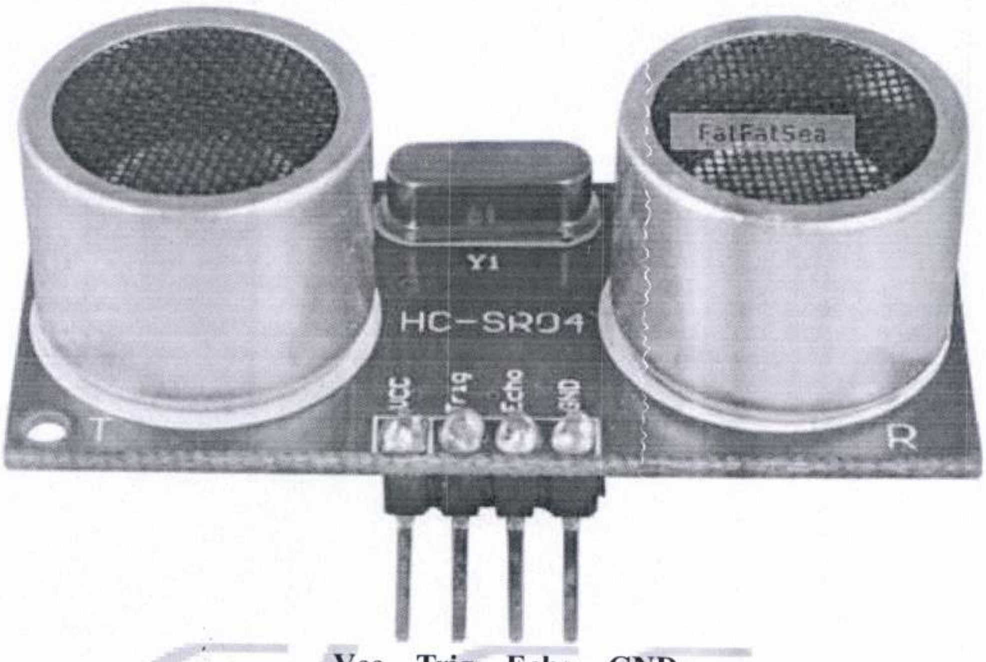
Test distance = (high level time×velocity of sound (340M/S) / 2,

Wire connecting direct as following:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

Electric Parameter

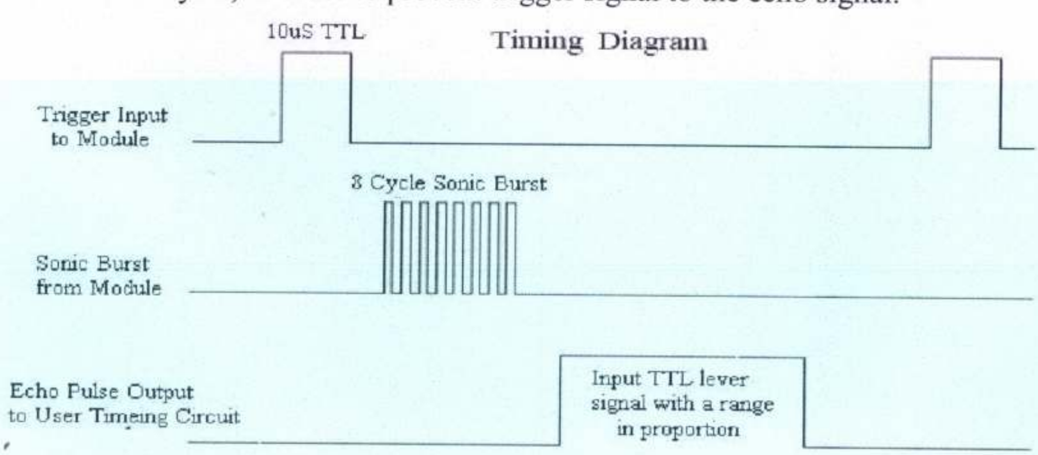
Working Voltage	**DC 5 V**
Working Current	**15mA**
Working Frequency	**40Hz**
Max Range	**4m**
Min Range	**2cm**
MeasuringAngle	**15 degree**
Trigger Input Signal	**10uS TTL pulse**
Echo Output Signal	**Input TTL lever signal and the range in proportion**
Dimension	**45*20*15mm**



Vcc Trig Echo GND

Timing diagram

The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



Attention:

- The module is not suggested to connect directly to electric, if connected electric, the GND terminal should be connected the module first, otherwise, it will affect the normal work of the module.
- When tested objects, the range of area is not less than 0.5 square meters and the plane requests as smooth as possible, otherwise ,it will affect the results of measuring.

www.Elecfreaks.com

Product Data Sheet

DOW FILMTEC™ BW60-1812-75 Element

Next Generation of Residential Reverse Osmosis Elements

Description

DOW FILMTEC™ residential elements are the most reliable, consistent and highest quality in the industry just got even better. Our 75 GPD elements offer the best balance of flow and highest rejection available in the market.

New DOW FILMTEC™ Residential Elements Feature:

- New membrane (BW60) chemistry produces industry leading 99% stabilized salt rejection.
- Even longer lifetimes on high hardness water applications
- Even faster start-up to reach stabilized rejection
- High active membrane area and twin leaf design for optimized performance
- NSF58 safety Certification and reduced certification costs / resources with NSF data transfer Certification
- Fully-automated manufacturing that ensures consistent and high quality elements
- Dry shipping for convenient handling and longer shelf-life
- Proven consistency and reliability for longer membrane life

Product Type

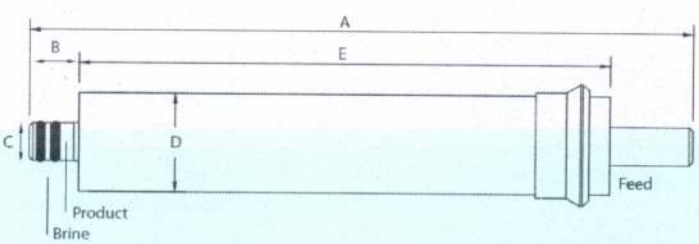
Spiral-wound element with polyamide thin-film composite membrane

Product Specifications

DOW FILMTEC™ Element	Applied Pressure (psig)	Applied Pressure (bar)	Permeate Flow Rate (GPD)	Permeate Flow Rate (l/h)	Typical Stabilized Salt Rejection (%)
BW60-1812-75	50	3.4	75	12	99

1. Permeate flow and salt rejection based on the following test conditions: 250 ppm softened tap water, 77°F (25°C), 15% recovery and the specified applied pressure.
2. Minimum salt rejection is 96.0%.
3. Permeate flows for individual elements may vary ±20%.

Element Dimensions



This component is Tested and Certified by NSF International against NSF/ANSI Standard 58 for material requirements only.

DOW FILMTEC™ Element	A (inc)	A (mm.)	B (in.)	B (mm)	C (in.)	C (mm)	D (in.)	D (mm)	E (in.)	E (mm)
BW60-1812-75	11.74	298	1.17	30	0.68	17	1.75	44.5	9.4	239

1. BW60-1812 Home Drinking Water elements seal at a standard 2.0 inch – 2.05 inch I.D. within pressure vessels

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Figure 2.
Impact of Pressure on Permeate Flow (constant temperature, recovery)

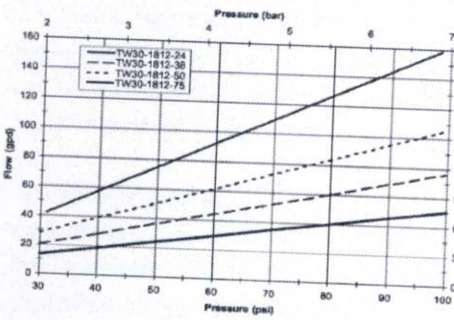
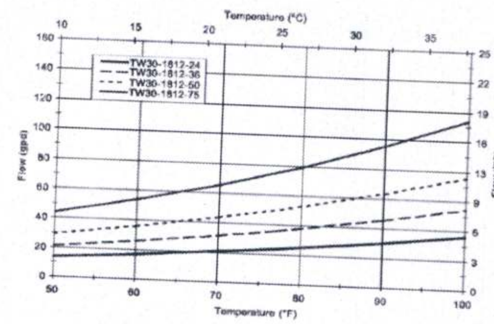


Figure 3
Impact of Temperature on Permeate Flow (constant temperature, recovery)



Operating and Cleaning Limits

Maximum Operating Temperature [a]	113°F (45°C)
Maximum Operating Pressure	150 psig (10 bar)
Maximum Feed Flow Rate	2.0 gpm (7.6 lpm)
pH Range, Continuous Operation [a]	2 – 11
Maximum Feed Silt Density Index (SDI)	SDI 5
Free Chlorine Tolerance [b]	< 0.1 ppm

[a] Maximum temperature for continuous operation above pH 10 is 95°F (35°C).

[b] Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure. Since oxidation damage is not covered under warranty, Dow Water & Process Solutions recommends removing residual free chlorine by pretreatment prior to membrane exposure. Please refer to technical bulletin "Dechlorinating Feedwater" for more information.

Additional Important Information

- It is recommended that systems using these elements rinse the elements for 24 hours, prior to first use, to meet NSF/ANSI 58 Standard.
- The first full tank of permeate must be discarded. Do not use this initial permeate for drinking water or food preparation.
- To ease installation, it is recommended to use a lubricant safe for indirect water contact on all seals. Potential options include water, glycerin based lubricants, and Dow Corning™ 111.
- Rotate the element about a quarter turn to ease installation and removal of the element. Ensure good interface between the o-rings and brine seal with their connection surfaces.
- Keep elements moist at all times after initial wetting.
- To prevent biological growth during prolonged system shutdowns, it is recommended that membrane elements be immersed in a preservative solution. Rinse out the preservative before use.
- The membrane shows some resistance to short-term attack by chlorine (hypochlorite). Continuous exposure, however, may damage the membrane and should be avoided.
- DOW FILMTEC™ Home Drinking Water Reverse Osmosis Elements may be covered under the DOW FILMTEC™ Reverse Osmosis and Nanofiltration Element Three-Year Prorated Limited Warranty, 609-35010-1006 extended to OEMs. Such Limited Warranty is non- transferable. Contact a Dow representative for more information.

If operating limits and guidelines given in this Product Information Bulletin are not strictly followed, the Limited Warranty will be null and void. The OEM is fully responsible for the effects of incompatible chemicals and lubricants on elements. Use of any such chemicals or lubricants will void the Limited Warranty.

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June 2016

Regulatory Note

These membranes may be subject to drinking water application restrictions in some countries; please check the application status before use and sale.

Product Stewardship

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products—from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Customer Notice

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support.

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