SOLAR ENERGY AND ENHANCED REVERSE OSMOSIS BASED MOBILE HYBRID WATER PURIFIER

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Abstract: Due to global warming, climate change and pollution water is becoming scarce. A solution for this crisis is desalination or water purification. Here desalination is done using enhanced reverse osmosis. A layer of nano particle is applied over the reverse osmosis membrane that makes the process enhanced. In this project reverse osmosis is followed by Ultra Filtration (UF) and Ultra Violet (UV) filtration. This helps in making the water more clean and drinkable. In rural areas, in spite of the availability of lakes and brackish water, the fresh water is inadequate and there comes the need of water purification. This system comes up with an idea of mobile and hybrid desalination unit that uses renewable energy as a source of power supply. The power is provided from a solar tracker that tracks the solar power during the day and maximum power is received. An IoT enabled controller circuit is used for monitoring the solar power. The whole system enhances desalination as well as uses renewable energy instead of fossil fuel.

Keyword: Solar Tracker, IoT, Water Purifier, AC-DC converter**,**

I. INTRODUCTION

Water scarcity has become the largest global risk and it affects all continents. Waster is the basic need of living beings and the case is worse when it became unavailable [1]. Water scarcity is the unavailability of fresh water to meet the demand. About four billion people around the world face severe water scarcity at least for a month in every year. 97% of water in the word is saline, about 3% of water is unavailable to reach and the remaining 0.014% of water if fresh and drinkable [2]. Sufficient amount of water is technically available in the world but it is unequally distributed as some area is very wet and some are geographically dry.

Water scarcity can be discussed both globally and nationally. Globally it is geographic and there is a mismatch between the availability and demand of freshwater [3]. The rise in population, changes in the pattern of consumption, improvements in the life style of people, over usage of land for irrigation are the main reason for increasing the demand of fresh water. Deforestation, pollution, increases in the amount of greenhouse gases, climate change, and waste and unclean water lead to insufficient supply of water [4]. Water scarcity is the result of physical scarcity and economic scarcity. Physical water scarcity is the inadequate supply of water in a region and economic water scarcity is the poor management of water. Most of the countries face this problem due to poor water

management [5]. Some part of the country have sufficient amount of water for satisfying domestic and irrigation needs, while other parts of the country face scarcity of water. Here, managing the supply of water has become the problem. The major symptoms of this issue include over use and exploitation of water, declining of ground water and degradation of water [6] [7].

Economic water scarcity is due to the lack of infrastructure or the difficulty of people to satisfy their demand for water. Due to this economic water scarcity one quarter of the people are affected. In some areas people have to travel long distance in order to fetch water. Africa is the largest example for the area that faces water unavailability. Large part of this place is in lack of water. For increasing access to pure drinking water UN framed the Millennium Development Goals and it was replaced by sustainable development goals in the year 2016. All these will have a very worse effect on environment [8]. The depletion of fresh water even the ground water is becoming a crucial problem. Climate change is a problem that causes the lake to shrink, reduce the flow of water in the river and precedes glaciers [9] [10]. The effects of water crisis are plenty and some of its manifestations are as follows:

- Security of food in North Africa
- Over drafting ground water
- Pollution and overuse of water
- Unavailability of safe drinking water

In this scenario it is necessary to come up with an efficient technology for water purification and that should be cost effective [11] [12].

II. PROPOSED SYSTEM

The system uses enhanced reverse osmosis membrane for water purification. The proposed system is hybrid and portable. A solar tracker is used for tracking maximum solar power and this power is used for powering the reverse osmosis booster pump [13]. The excess power from the tracker is given to the grid. The solar power is stored in a battery and this power is used in the absence of solar energy during the night [14]. An IoT enabled solar monitoring circuit is used for continuously monitoring the power. The Figure 1 shows the filtration part of the system. The water to be purified is given to a sediment filter where it filters out the sediment particle like sand and clay from the water. From the sediment filter it is given to a pre-carbon filter. The pre-carbon filter removes smaller particles, volatile organic compounds (VOC), chlorine, taste and order from the water. It uses 280grams of silver impregnated granular activated carbon made from coconut shell [15] [16].

The even smaller particles are filtered using post carbon filter that uses 100 grams of silver impregnated granular activated carbon made of coconut shell. After this process it is supplied to the reverse osmosis membrane using a reverse osmosis booster pump. This pump is powered using the power from solar tracker [17]. The enhanced reverse osmosis membrane is highly efficient for water purification. On comparing with the current models it has 30% permeability, it resists membrane fouling and removes chemicals present in the water without damaging the membrane. It also reduces the power consumption and feed pressure [18]. Later the water is given to an ultra filter where bacteria and micro organisms are destroyed. It also reacts with disinfectants. After ultra filtration the water is supplied to the mineral filter where essentials minerals like calcium, magnesium, sodium, potassium are added to the water. At last ultra violet filtration is done where 99.99% of harmful micro organisms are destroyed without the addition of chemicals.

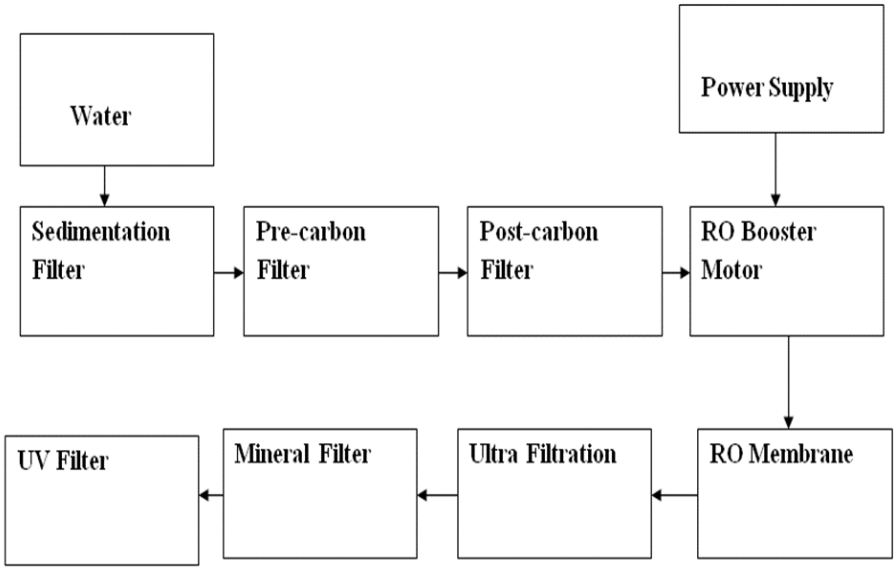

Fig. 1 Block diagram of filtration part of the system

The solar power is tracked using a solar tracker that converts solar energy in to electrical energy. The power from the tracker is given to a regulator where it regulates the power and removes harmonics and is stored in a battery. In the absence of solar power, the battery is charged using ac supply. The power in the battery is DC which is converted to AC using an inverter. The power from the inverter is used for running the motor as depicted in Figure 2. The motor used is reverse osmosis booster pump. The excess power can be given to the grid. The power from the tracker is continuously monitored using an IoT enabled solar monitoring circuit, so that any variation in the power can be displayed in the screen.

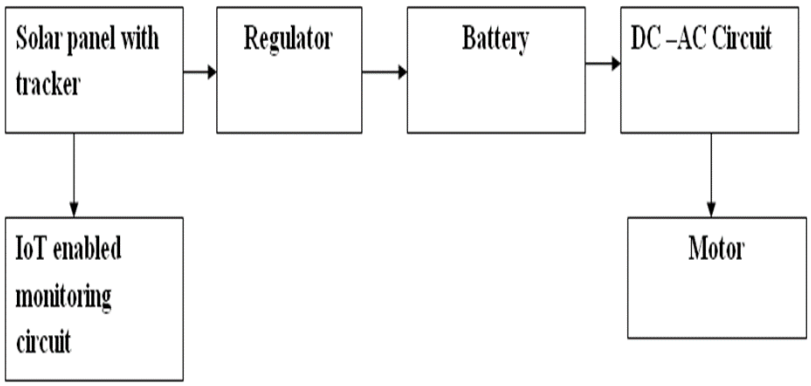

Fig. 2 Block diagram of power supply part

Figure 3 shows the block diagram of the solar tracking circuit. The power from the sun is converted to electrical energy using a solar panel. The voltage from the panel is sampled using a voltage sampling circuit and it is then given to the microcontroller AT89S5.

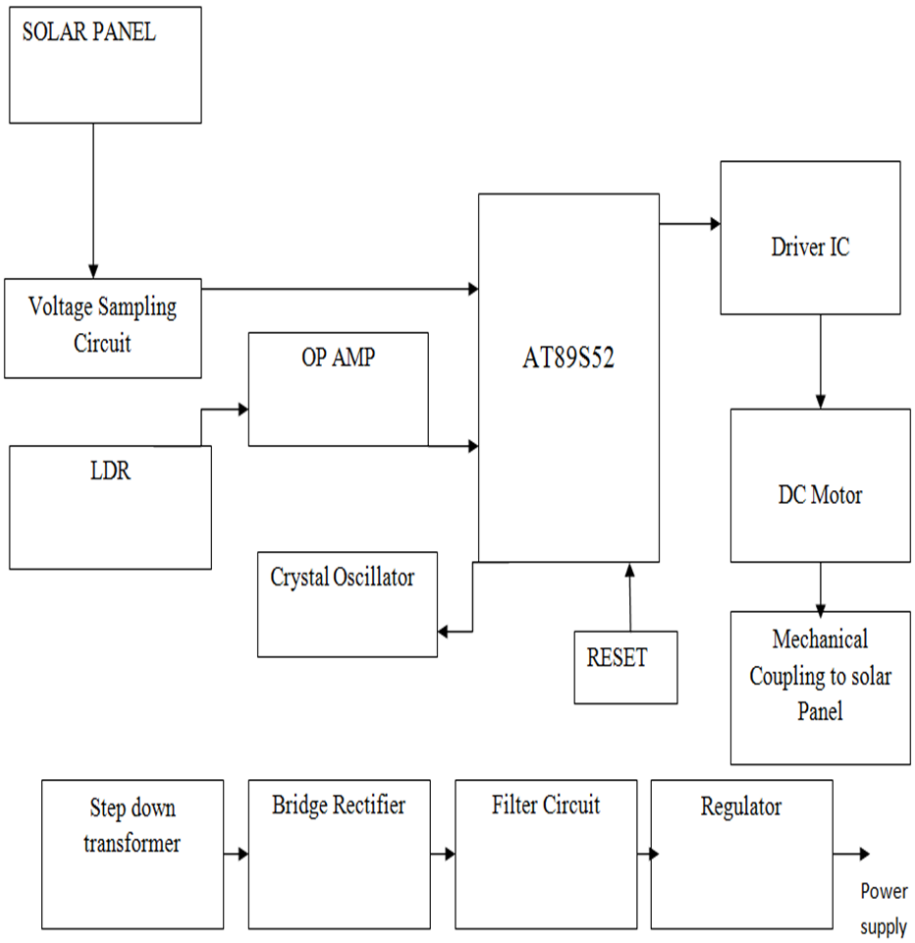

Fig. 3 Block diagram of solar tracker

A light dependent resistor LDR is used to sense the sun light during the day. From the LDR the power is amplified using an operational amplifier and it is then given to the microcontroller. The crystal oscillator provide clock signal for the micro controller. A stepper motor is used for rotating the solar panel. It is connected to the microcontroller through a driver IC. The DC motor is connected to the mechanical coupling of the solar panel for rotation. The power from the mains is step down using a step down transformer. The AC voltage from the transformer is converted to DC power using a bridge rectifier. This power may contain ripples that are filtered using a filter circuit. A regulator is used for converting the voltage into 5 volts. This 5V is used to power the microcontroller as shown in Figure 4.

The sunlight that falls on the panel is converted to electrical signal. The voltage and current are measured using voltage and current sensors. It is then regulated to an applicable value. All these values are given to Node MCU. A Wi-Fi module is used for storing data in the cloud. This can be displayed in a smart phone that connected to a Wi-Fi module via hotspot. The node MCU is powered by a 5V supply

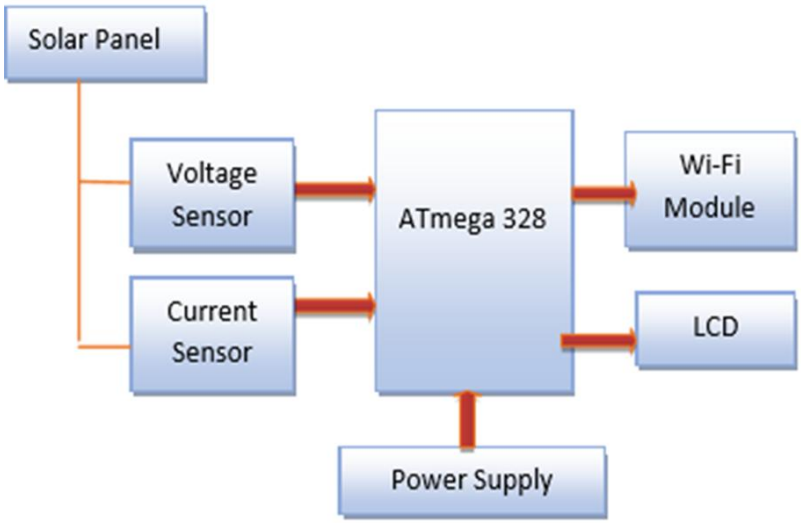

Fig 4. Block diagram of solar monitoring circuit

III. HARDWARE IMPLEMENTATON

Figure 5 shows the hardware set up of filtration part of the system. This system uses the concept of enhanced reverse osmosis where a thin film composite membrane is used with ordinary membrane. A sediment filter is used to filter out sand and clay particles.

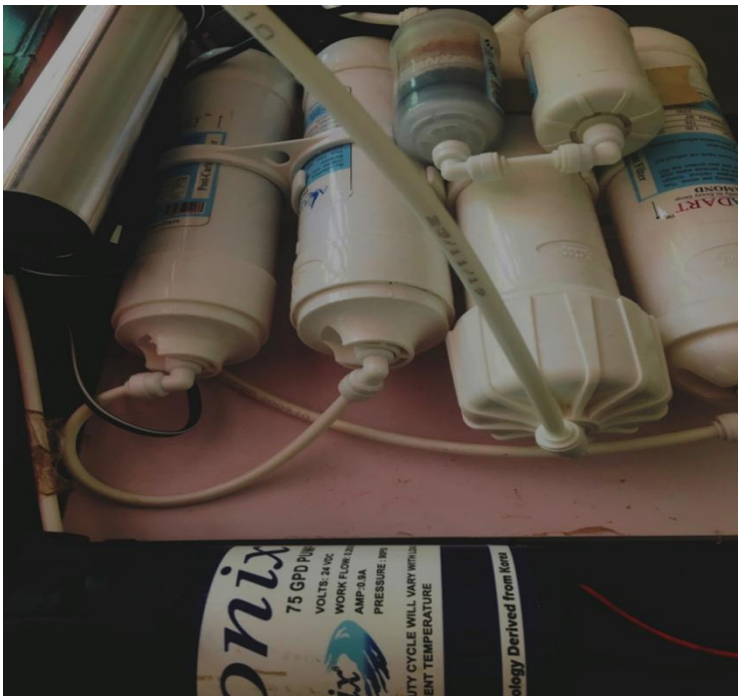

Fig. 5 Water purification system

It is followed by pre and post carbon filter and then it is given to enhance reverse osmosis membrane. A booster pump is used for applying pressure required for reverse osmosis process. After this process it undergoes ultra filtration, mineral filtration and ultra violet filtration.

Figure 6 represents the circuit diagram of solar tracker. It uses a microcontroller Arduino UNO, two Light Dependent Resistors (LDR), servo motor, resistors, etc.. The LDRs are connected through resistors of 10K. A resistor R1 of 10K is connected parallel to the LDR circuit. A terminal of servomotor is connected to the micro cotroller, one terminal is given to the LDR circuit and other terminal is grounded. The LDR circuit is given to the microcontroller through a switch. This system is used for tracking solar power to the maximum.

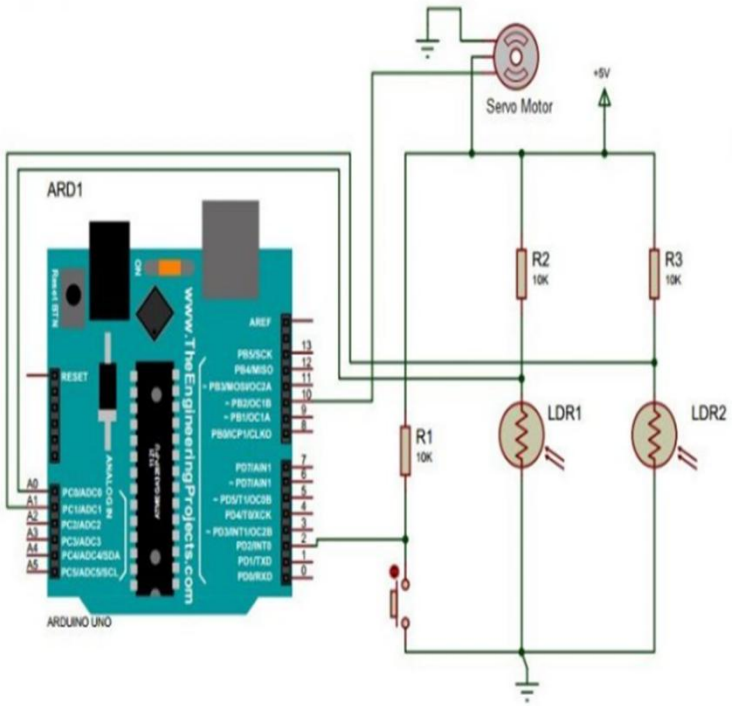

Fig. 6 Circuit diagram of solar tracker

The sunlight striking on the panel is converted to electrical signal by using a solar panel. As the sun moves from east to west the solar panel will also move accordingly. It is programmed in a microcontroller and with the help of servo motor it moves with the sun. The Light Dependent Resistors are used for sensing the sunlight.

Figure 7 depicts the circuit diagram of the IoT enabled solar power monitoring circuit. It uses a node MCU ESP8266 which has an inbuilt wifi module for storing data in to the cloud. The current and voltage from the panel is sensed using current and voltage sensors. It is then given to the Node MCU through resistors. A regulator is used to the voltage into desired value of 5V.

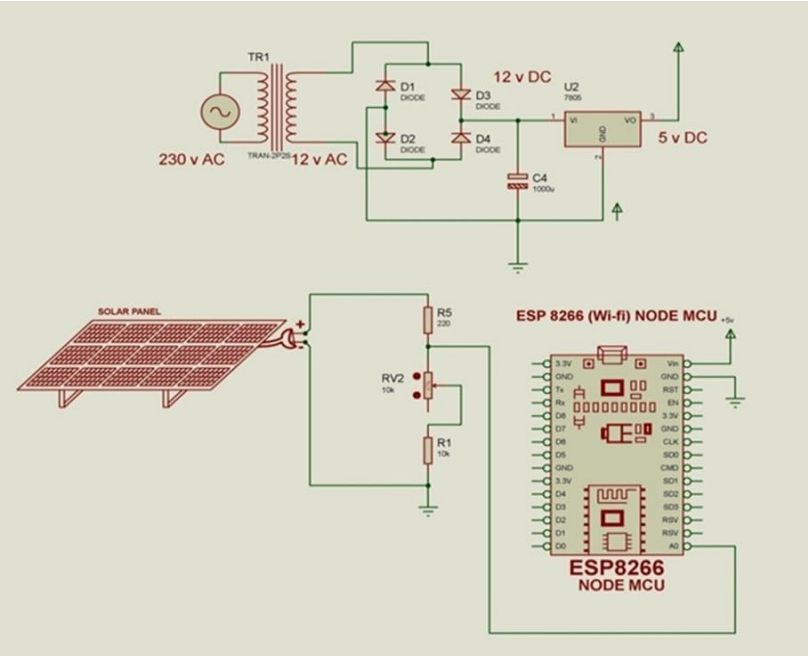

Fig. 7 Circuit diagram of IoT enabled solar monitoring system

Figure 8 represents the solar tracking circuit coupled with solar monitoring circuit.

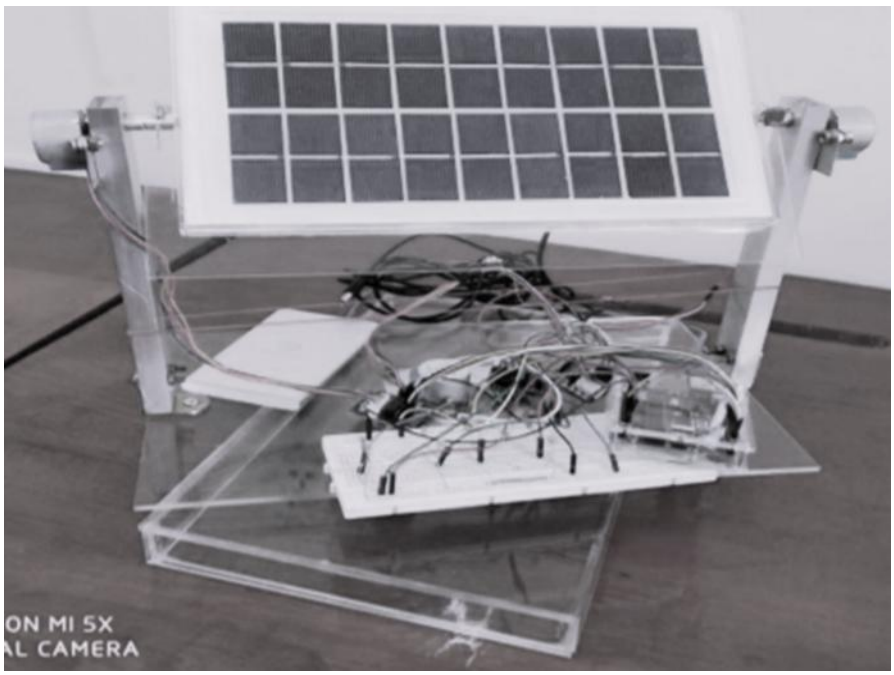

Fig. 8 Solar tracking system

Here the solar tracker is coupled with the IoT enabled solar monitoring circuit. The solar tracks maximum solar power and convert it into electrical energy. This power is monitored using solar monitoring circuit and the data can be viewed using a smart phone.

IV. RESULTS AND DISCUSSIONS

The annual product flow is given in Figure 9. From this it is clear that the need of water is more in summer and it is due to increase in sea feed water temperature and there comes the need of water purification. The salt concentration in water during summer is more and desalination should be done. This system will be very effective and it uses a solar tracker so that power from the mains can be saved.

Fig. 9 Product water flow –monthly averages

The salt concentration in the product tank after desalination will be very less compared to that in the tank before desalination. The salt concentration in the product tank water is plotted in the graph of Figure 10.

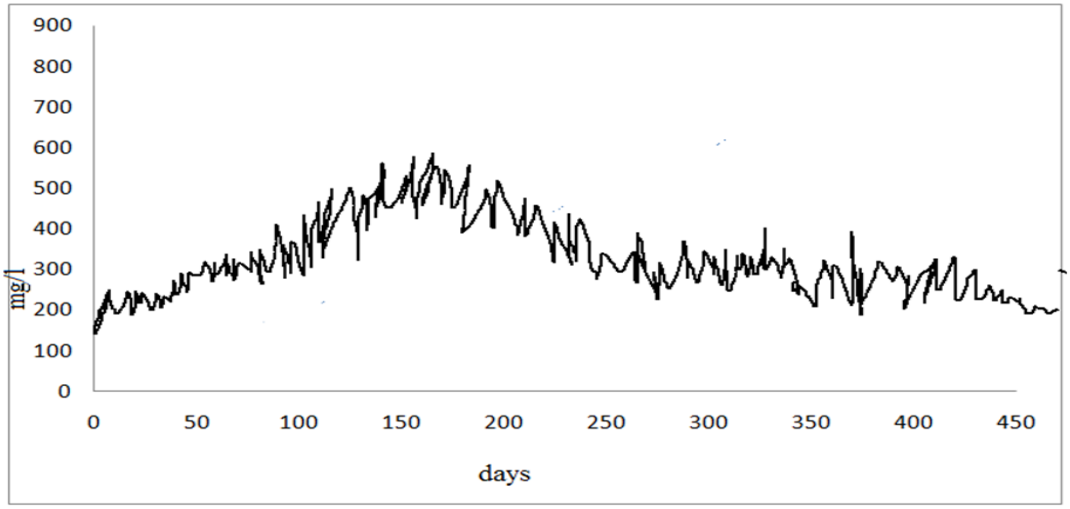

Fig.10 Salt concentration of product water tank

Figure 11 shows the graph plotted between loading concentration and water flux. It is very clear that on increasing load concentration the water flux is increases for a while and remains almost constant.

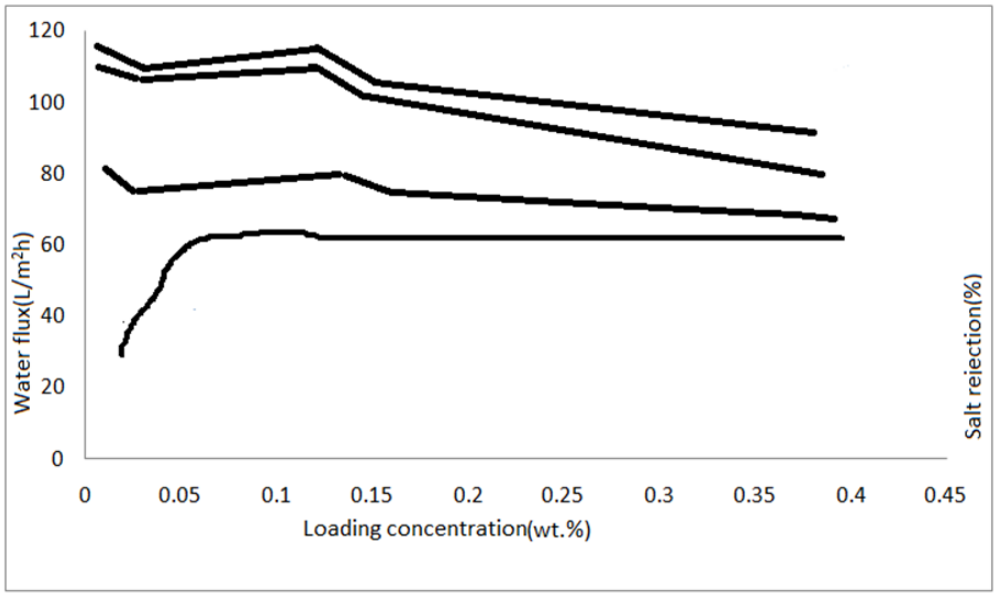

Fig.11 Loading concentration versus water flux

Figure 12 represents the graph plotted on normalized water flux versus time in hours. It is concluded that on increasing time the normalized water flux decreases.

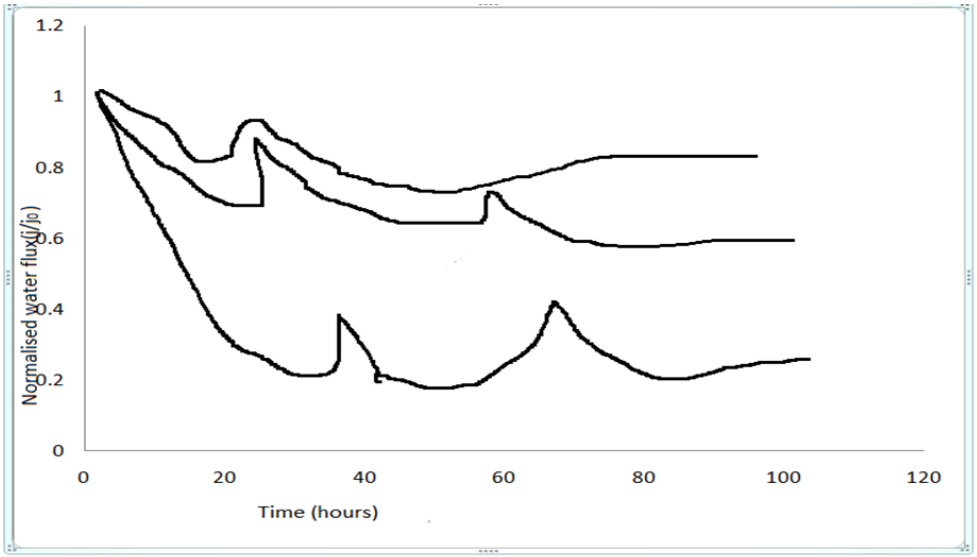

Fig. 12 Time versus normalized water flux

The tests performed on the output water and input water from the solar energy and enhanced reverse osmosis based mobile hybrid water purifier are tabulated. The drinking water is the output from the system.

TABLE. 1 Tests conducted

S.no	***Parameters***	***Input water***	***Drinking water***
1	TDS measurement	700(ppm)	100(ppm)
2	Hardness measurement	55	20
3	pH measurement	65	7.2
4	Turbidity	1(NTU)	0.7(NTU)
5	DO	1.7(ppm)	1.5(ppm)

Table 1 shows that the TDS measurement of input water is 700ppm where s that of drinking water is 100ppm. The hardness measurement of input water is 55 and that of drinking water is 20. The pH measurement of drinking water is 7.2 which is same as that of fresh water and the same of input water is 65. The turbidity of drinking water is .1 NTU and dissolved oxygen in drinking water is 1.5ppm.

TABLE. 2 Underground water input samples

Test	**Sample1**	**Sample2**	**Sample3**	**Sample4**
TDS(ppm)	1200	2000	4500	7500
Conductivity(ns)	2.5	4.9	6.1	9.3
pH	6.2	6.1	5.9	6.3
Arsenic	Nil	Nil	Nil	Nil

Table 2 shows the tests conducted on underground water samples and table 3 shows the tests conducted in purified water of different areas. Four samples of underground water from four different areas were collected and tested.

TABLE. 3 Purified water samples

Test	**Sample1**	**Sample2**	**Sample3**	**Sample4**
TDS(ppm)	100	100	100	100
Conductivity(ns)	0.3	0.32	0.4	0.35
pH	7	7.2	7.3	7.1
Arsenic	Nil	Nil	Nil	Nil

The same samples were again tested after the purification. From that it is concluded that the total dissolved solids of purified water is very much less than that of input water. The pH of drinking water is same as that of fresh water that we drink.

IV. CONCLUSION

The objective of this project is to test and implement a solar energy and enhanced reverse osmosis based mobile hybrid water purification unit which is very efficient and cost effective. The quality of water before and water purification was tested and came to a conclusion that this system can enhance the quality of

water to a great extent. The pH of the purified water is absolutely same as that of fresh water. The use of enhanced reverse osmosis can improve the permeability by 30 percentages than the normal RO membrane and has long membrane life and fouling resistant. The solar tracker implemented can track more sunlight and hence more power can be received. The tracking system has enough qualitative betterment than conventional system. Hence this system is very efficient, simple, cost effective and never compromise the quality of water.

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