S.S.Phuse, R.S.Shelke/ International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue4, July-August 2012, pp.2014-2018

Water Purification System For Remote Areas Using Photovoltaics

S.S.Phuse [a] R.S.Shelke[b]

[a*] Student, IV Semester M.Tech (Heat Power Engineering)
[b] Assistant Professor, Mechanical Engineering Department,
G. H. Raisoni College of Engineering, Nagpur-440016, India

Abstract

Water purification is the process of removing undesirable chemicals ,biological contaminants ,suspended solids and gases from contaminated water .Propose water purification system for remote areas focus on providing a pure drinking water at low cost with high reliability to the rural families. It involves the research, design and manufacture of water purification system using renewable energy . It consist of a combination of solar pasteurization, reverse osmosis (RO) and ultraviolet (UV) lamp sterilizer system with power supplied by photovoltaic (PV) modules. It is an effective method to deactivate bacteria ,viruses and protozoan in contaminated water .This method can be made portable ,cost effective ,user compliant and energy efficient enough to meet the drinking water needs .Experimentation is carried out for testing six different water samples. Water samples selected are tap water, well water, river water, lake water, muddy water and colour water. All the water samples are analyzed and tested in a laboratory for different parameters and found within the standard range .This paper will be helpful for those who are working in the area of water purification system and their use in remote areas.

Keywords: ***Reverse osmosis system, photovoltaic, solar pasteurization.***

1. Introduction

Water is the most common liquid on the earth .Pure drinking water is necessary for human survival .The water supply for drinking water is either ground water or surface water.The water from each source contains sediments and other solids .Part of the treatment process requires removal of sediments and other solids .Many different processes are used to obtain the finished product of clean drinking water. In remote villages in India, there is lack of developed infrastructure due to poor economic situations. These remote areas do not have pure drinking water, electrical power, communication, sanitation and hence these issues are important. In small villages in India, water is drawn from the nearby river or lake for drinking, cooking and cleaning .It is necessary to provide pure drinking water at low cost with high reliability. To Accomplish this objective impurities such as sediments must be removed and bacteria must be killed along with other microorganisms. Additionally the water must be stored in safe containers so that any recontamination from bacterial growth must be restricted. From the literature it is found that an average person must consume 4 liters of water to survive.

Also according to UN World Water Development Report in 2009, it has been estimated that two billion people are affected by water shortages in over forty countries, and 1.1 billion do not have sufficient drinking water. There is a great and urgent need to supply environmentally sound technology for the provision of drinking water for rural areas.

The objectives of this work are :-

a) To provide water purification system working on renewable energy and reduce the use of fossil energy.
b) To provide pure drinking water at low cost to the rural areas.
c) To make the system energy efficient.
d) To make the system portable and user friendly.

2.EXPERIMENTAL SET-UP & PROCEDURE

2.1 Experimental Set-up

Fig. 2.1 shows the schematic of experimental set up.The experimental set-up consist of a solar photovoltaic panel of 20 watt for 12 volt DC mini solar system. The number of cells in this panel are 36 and the maximum power output from the panel is 20 Watt and 17.3 volts . It consist of three filters i.e. first filter which is pre carbon filter . Pre carbon filter absorbs and eliminate any chlorides and organic chemicals from water. Second filter eliminates various foreign bodies that come from service water pipes such as bits of rust. The third filter is the reverse osmosis pump membrane filter , once the water passes through the RO pump it passes through this membrane filter.

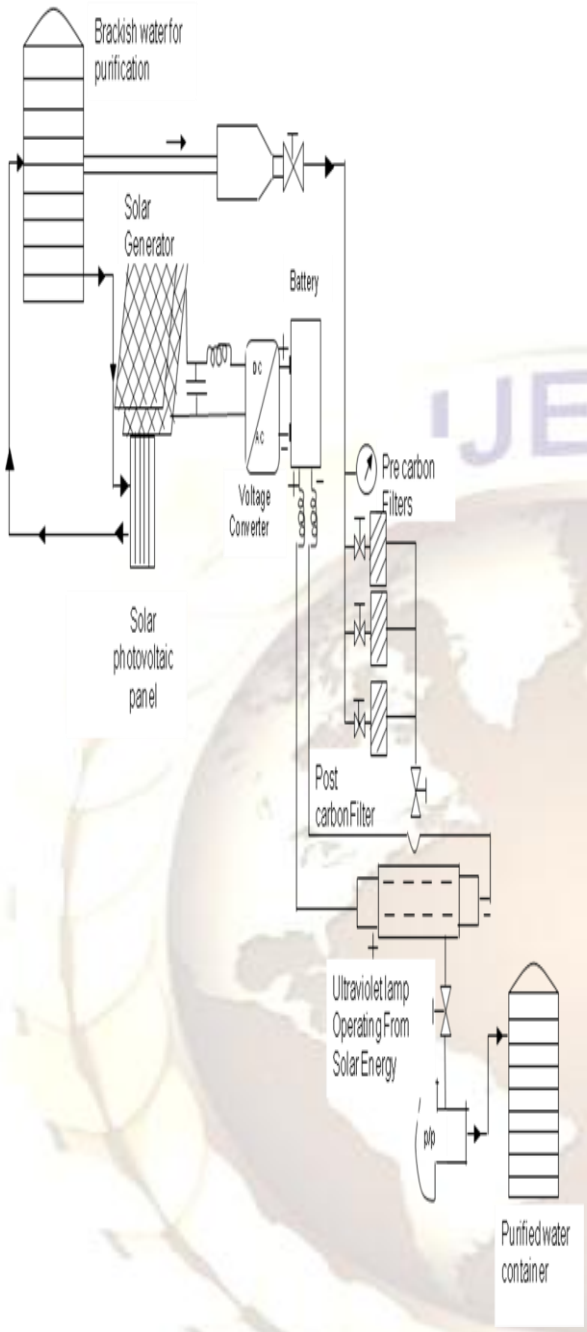

Fig. 2.1Block Diagram of experimental set up.

The solar charge controller consist of voltage converter . It is used to regulate the power going from the solar panel into the batteries .The rated solar input is 4.5 Amps , the regulation voltage is 14.1 volts . The reverse current leakage is less than 10 mA.

The experimental set up has a Reverse osmosis booster pump . The model number is HT-75 , normal flow rate through this pump is 1.0 lit/min and the minimum voltage required for its operation is 12 volts DC. The ultraviolet tube which is used for this experiment is of 9 watt capacity . Sheet metal tanks are installed in the experimental set up of 27 litres capacity.

Procedure

The set up is placed on a flat surface. Photovoltaic panel along with the along with the set up can be placed separately in the sunlight for battery charging purpose. Water and electrical connections are checked properly for any leakages .The water to be purified should be filled in the top plastic tank .As the water starts flowing from the pipe the purging of all the three filters are done for avoiding air lock. Impure water first passes through the pre carbon filter, this filter effectively removes chlorine sediments and volatile organic compounds from impure water. Once the water comes out from the pre carbon filter it goes inside the sediment filter where the hard water gets soften into soft water. This sediment filter adsorbs the mineral sediments which makes the hard water into soft water and does not allow the minerals to get deposited inside the reverse osmosis pump. The water then passes through the reverse osmosis pump where it gets pressurized to 12.5 bar and passes through the reverse osmosis semi permeable membrane where water soluble organics are removed .The water then passes through the ultraviolet lamp sterilizer where most of coli form ,viruses and protozoa are destroyed .Total load on the system is 19 watts ,total watt hour rating is 57 watt hours. Actual output of PV panel is 19 watt and power used at the end is 15.40 watt .Energy produced by one 20 watt panel in a day is 61.6 watt- hour .Hence the number of PV panels required for this experimental set can be calculated as the energy produced by one 20 watt panel in a day divide by total watt hour rating and it comes to 1.08 . Therefore one panel is required for charging a battery of 12 volts and 12.5 amps for its operation for 3 hours.

3. RESULTS AND DISCUSSIONS:-

Table 3.1 Observations for purification of Six water samples .

S.N.	Parameter	Requirement	Tap	Well	River	Muddy	Lake	Color
1.	Coliform Count	Less Than 10	5	8	7	7.5	7	7
2.	Colour	5hazen Unit	<1	<1	<1	<1	<1	<1
3.	Odour	Agreeable	Ok	Ok	Ok	Ok	Ok	Ok
4.	Taste	Agreeable	Ok	Ok	Ok	Ok	Ok	Ok
5.	Turbidity	5 Ntu	3.2	3	4	4	3.2	5
6.	Ph Value	6.5 To 8.5	8.3	7	7.1	7.2	8.3	7.5
7.	Total Hardness	300	130	150	210	180	150	230
8.	Iron	.3 Ppm	0.20	0.30	0.40	0.30	0.20	0.40
9.	Chlorides	250ppm	30	30	60	40	30	60
10.	Resi.Free.Cl	0.2 Ppm	Nil	Nil	NIL	NIL	NIL	NIL
11.	TDS	500 Ppm	270	290	340	290	240	340
12.	Calcium	75 Ppm	30	45	70	45	30	70
13.	COPPER	0.05 PPM	NIL	NIL	NIL	NIL	NIL	NIL
14.	MANGANESE	0.1PPM	NIL	NIL	NIL	NIL	NIL	Nil
15.	SULPHATE	200 PPM	15	45	110	45	15	110
16.	NITRATE	45 PPM	20	30	35	30	25	35
17.	ZINC	5 PPM	NIL	NIL	NIL	NIL	NIL	Nil
18.	ALKALINITY	200 PPM	40	50	160	50	60	160
19.	ALUMINIUM	0.03PPM	NIL	NIL	NIL	NIL	NIL	NIL
20.	BORON	1PPM	NIL	NIL	NIL	NIL	NIL	NIL

Table 3.1 shows the different parameters and required standard values of water for different six samples . The testing and analysis of six different samples from different sources are carried out. Above 20 parameter are tested for all six samples in order to confirm the water as the drinking water.

Six water samples selected from different sources of water are tap, well ,river ,muddy ,lake and colour water .It is found that for lake water the coli form count before purification was 10 and after purification is 7 which gives satisfactory result of ultraviolet tube operation. Colour, odur and taste of purified water sample is satisfactory after purification . Turbidity before was 8 and after purification was 3.2 which shows satisfactory functioning of sediment filter . Ph value before was 9.6 and after was 7.3 which is well within the range . Total hardness count before purification is 290 and after purification is 150 which gives desirable result .The total dissolved solids before purification was 440 and after purification is 240 which shows satisfactory performance of pre carbon filters . Copper ,manganese ,zinc ,aluminum boron and chlorine are absent in water before and after purification . Calcium ,nitrate is also within limits . Similar types of results were obtained for other five samples. Based on above observation for lake water, the following graphs are plotted to observe the performance of the experimental test rig.

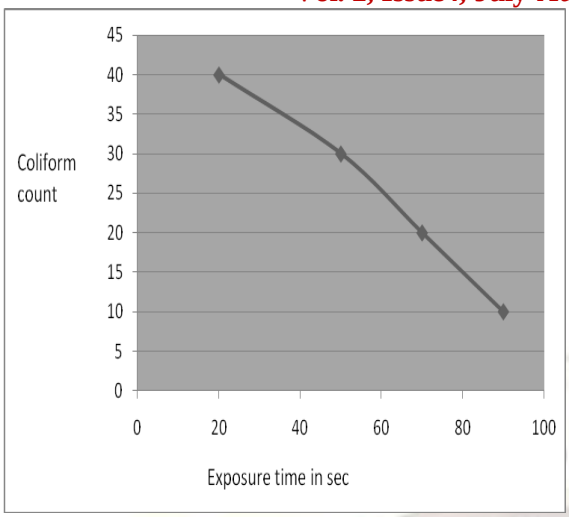

Fig.3.1 Graph of coli form count vs exposure time in sec

Fig. 3.1 shows the variation of coliform count with exposure time in seconds .From the graph it is observed that as the exposure time for lake water increases as it is exposed to ultraviolet light the coliform count goes on decreasing which is important for good water purification.

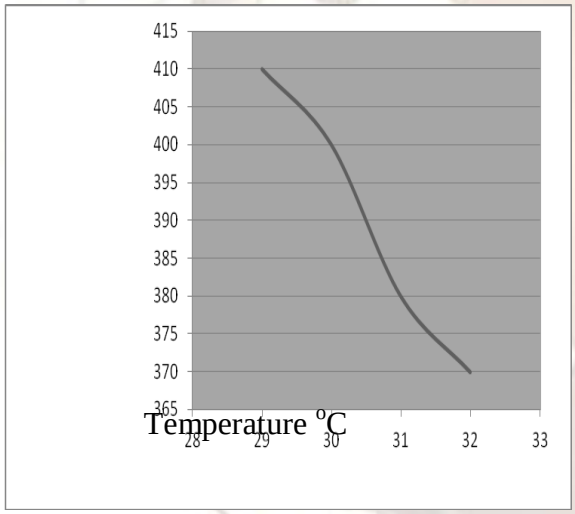

Fig.3.2 Graph of Total hardness vs ambient temperature

Fig. 3.2 shows the variation of total hardness count with temperature . From the graph it is observed that as the the ambient temperature goes on increasing the total hardness count for lake water goes on decreasing which is due to the pretreatment filters used for purification processes.

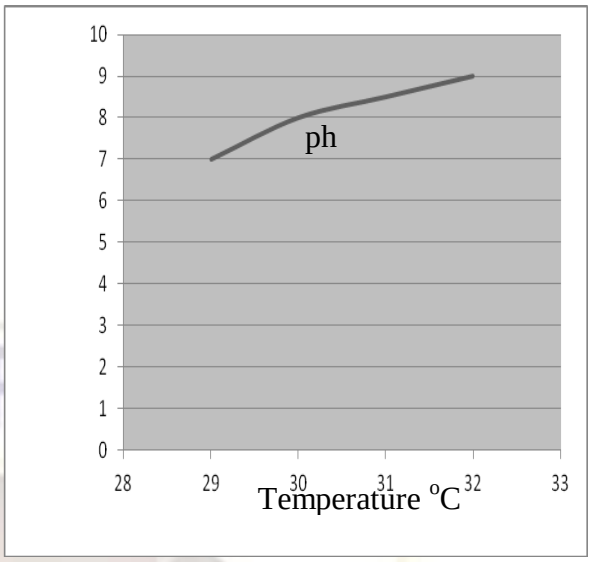

Fig.3.3 Graph of PH vs ambient temperature

Fig. 3.3 shows the variation of Ph value with temperature for lake water .From the graph, it is observed that as the the ambient temperature goes on increasing the Ph value for lake water also increases which is good for water purification processes.

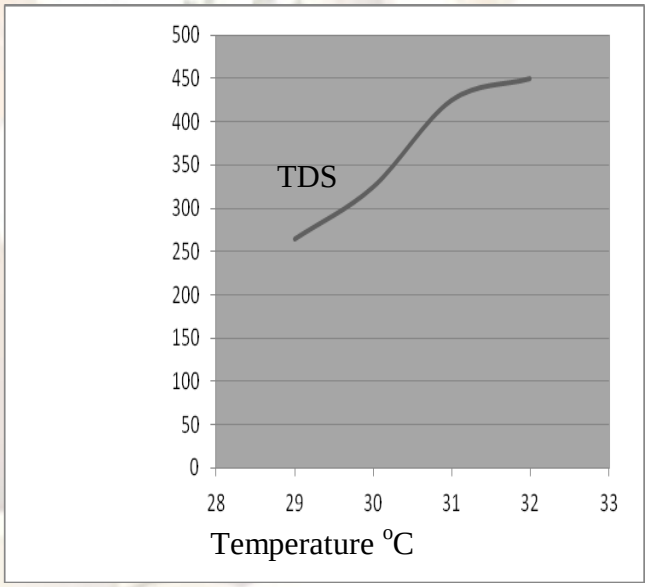

Fig.3.4 Graph of TDS vs ambient temperature

Fig. 3.4 shows the variation of total dissolved solids (TDS) with the temperature .From the graph it is observed that as the the ambient temperature goes on increasing the total dissolved solids goes on increasing for lake water which is good for colour water purification processes.

4.CONCLUSION:-

Propose test rig is portable, cost effective, user compliant and energy efficient enough to meet a persons drinking water needs in rural areas. The coupling of renewable energy and water purification technologies are presented with reference to more

comprehensive studies and showed the significance of small-scale battery operated water purification system using ultraviolet sterilization and photovoltaic's . The quality of the other components and the control strategy adopted proves to be effective. The reverse osmosis (RO) rig itself promises to be highly efficient, due to the Clark pump. The Ultraviolet lamp (UV) sterilization is very effective for stopping the bacterial growth. UV exposure is an efficacious method to deactivate pathogens such as bacteria, viruses, and protozoan in drinking water. The hardware is not over-complicated and will be straightforward to use and maintain. The system requires no fuel and is non-polluting. The predicted total cost of drinking water is just Rs.90 per m^3,which makes the system very competitive with other small-scale brackish water purification systems. This technology is suitable for systems to obtain pure drinking water for rural areas .

References:

[1] James Hart ,Matthew Macdonald, Shaun, Montminy John duffy. " Hybrid purification using UV rays and solar photovoltaic's" National solar energy conference of the American solar energy society (Lowell) ,vol 13,pp 78-89, 2003.

[2] Rob Susanto Lee ,Yu zhao,V.Nayar " Design of hybrid power system with reverse osmosis desalination plant for Maldives" Trans. ASME journal of hybrid energy systems vol 51,pp 65-78,1993.

[3] J.Belhadj,M.Turki,X.Roboam " Control strategy of an autonomous desalination unit fed by PV – wind hybrid system without battery storage" Journal of electrical system ,vol 42 , pp 1-12, 2008.

[4] Dilder Ahmed Taufiq " A case study on application of solar pv on rural development in Bangladesh"Journal of rural and community development vol 3,pp 93-103,2008

[5] M.Thomson "Batteryless photovoltaic reverse osmosis desalination system" Trans. International Journal of unconventional energy systems , Vol-22 , pp 103-104, 2001.

[6] Marcos.S.Miranda ,David Infield " A Wind – Powered seawater reverse osmosis system without batteries" Journal on Elsevier Science B.V.,center for renewable energy systems technology desalination vol 153,pp 9-16 , 2002.

[7] Jacob Kornev " Electric Discharge Treatment of water containing organic substances" roceedings of the seventh Korea Russia International Symposium vol , pp 181 -184,2003.

[8] D.Vaju,C.Festila ,G.Vlad "Drinking water quality improvement by physical methods,using middle frequency inverters" , in proceedings of the 34th international scientific symposium of the military equipment and technologies research agency ,vol2 , pp 317-322 , 2003 .

[9] Takeo.S.Saitoh, Hamdy H. El –Ghetany " Exposure time as a disinfecting index in asolar water disinfecting system" 7th International Energy conference Energex ,vol 21 ,pp 133-154 , 1998.

[10] Cozy Ban ,Kazunao Sato,Makoto Hirayama "Advance water purification system for Sun-Half micron devices" IEEE conference paper from International symposium of semiconductor manufacturing , vol7,pp 291-292 , 1995.