International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 05 | May - 2021 ISSN: 2582-3930

Water Purification Using Solar Energy

Avanti Sarode
Tuhina Chatterjee
Aishwarya Rahamatkar
Juhi Gadekar
Banrisha Kurkalang
Ruchika Nandghaye
Roshani Ahir

8th semester, Electrical Engineering.
St. Vincent Palloti College of Engineering and Technology, Nagpur.

Abstract –

The aim of this work was to design a solar water treatment plant for household purpose. Water purification is the process of eradicating noxious chemicals, micro-organisms, suspended solids and gases from contaminated water. In this work we have reported an investigation of compact filter which is cost effective for developing countries and ease of maintenance. We have arranged a solar water disinfection system that improves the microbiological quality of drinking water at household level. We get 14 L pure water within 4 hours by using filtration method. In this system we can heat water up to 65°C. This simple solar hybrid system helps to remove turbidity as well as chemical and pathogenic contaminants from water sources in the most affordable, and expedient manner possibly.

Key words: Solar energy, Water filtration, Compact filter; Natural ingredients; Sustainable development.

Introduction-

The foremost important natural resource within the world is water and therefore the safe beverage availability may be a high priority issue for quality of life and human existence. In developing countries

water-borne disease results in many deaths and billions of illnesses annually.

Water disinfection is one among several interventions which will improve public health, especially if a part of a broad program that considers all disease transmissions routes and sustainable involves the community. Unfortunately, water resources are coming under increasing pressure thanks to increase, wastage

and over use. About 884 million people lack access to enhance water supplies is estimated by the planet Health Organization (WHO). It's microbiologically unsafe that a lot of more are forced to believe sources, result a better risk of waterborne disease transmission, including hepatitis, cholera and typhoid.The reuse of water has been doubled because the greatest challenge of the 21st century and, as such, great emphasis is being put into the event of latest technologies for the treatment of

wastewater for reuse. Generally, the methods used include physical processes like filtration, sedimentationand distillation, biological processes like slow sand filters or biologically active carbon, chemical processes like flocculation andchlorination and therefore the use of electromagnetic wave like ultraviolet. There are many parameters which may be wont to measure the standard of water, of which a standard one is turbidity, the aim being to live impurities within the water. In sense of physical, turbidity may be a reduction within the clarity of water thanks to the presence of colloidal particles or suspended, and commonly it's used as an indicator of the overall condition of water. Furthermore, turbidity has been used for several decades as an indicator of the efficiency of water filtration and coagulation processes, in order that it's a crucial operational parameter for this reason.Many physical and chemical features of raw water affect the water treatment process. Many inorganic and organic compounds in colloidal, suspended or solved form influence the flocculation process. Organic compounds, which are usually measured by a KMnO4 test, play an important role within the process. Furthermore, many inorganic compounds like the pH or the silicate of raw water also affect the method. The one among these is that the variation in water consumption, causing changes not only within each day but also within every week and even within a year. There are two main sorts of solar water pasteurization systems: continuous and batch flow. Batch systems usually contain an easy refillable vessel. It always takes a full day of sun for a batch system to treat water. During a continuous flow system water flows through a solar dish that heats the water to a desired temperature.

The Flat plate solar collectors are employed to pasteurize water. An adjustable thermostat valve is used to control the flow. The effect of the valve set point on the inactivation of microorganisms was studied. With a set point value of 75°C the collector treated about 50 L/m2-day. A flat plate solar water pasteurizer with an integral heat exchanger is designed. The system controlled flow with an automotive thermostat and heats the water to about 75°C. After a significant warm-up period the system is capable of treating up to 55 L/h-m2. When evacuated tube collectors are used about 10 L of water will be produced per kW h of solar radiation (2.8 L/MJ). Flat plate collectors produce about 3.5 L/kWh (0.97 L/MJ). Both systems heats water to about 95°C. This system is more important because of scarcity of pure drinking water in the remote areas and as a result around 2.2 million people die of basic hygiene-related diseases, like diarrhea, every year. The aim of this study is to style anaccessible and low-cost panel of hybrid technology for utilizing solar energy efficiently towards water purification and disinfection system, and to utilize waste materials for the purification system.

Materials and Methods

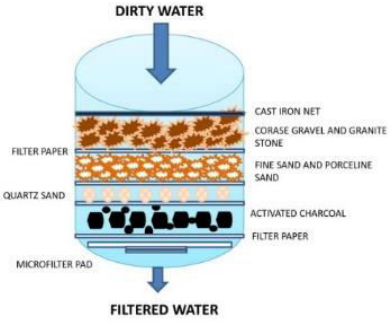
Mechanism of water purification and disinfection

The water purification and disinfection system aresplit into two steps. First is the compact filter preparation and the other is the solar collector preparation. In this system, the water is filtered by using solid process of filtration along with solar energy. At the startthe water is filtered by using the compact water filtration. Then the filtered water is reserved in an aluminum cylinder surrounding with the square or triangular glass structure, which is connected with the solar flat plate solar collector. The solar collector consists of aluminum cane which absorbs the solar heat energy and move through the aluminum cylindrical chamber. The collector is an air tight chamber in which glass is employed as surface cover. Then the reserve chamber obtains heat either directly from the sun or from the solarcollector so that there is significant effect on the disinfection of E. coli bacteria. The temperature is varied with the help of a thermostat up to a desired

value. This water is then moved further to the condenser where the heated water is cooled down for the purpose of drinking. The water which is condensed is considered as pure water. There are many parameters of measuring water purity are tested by different instruments after and before treatment.

Preparation of compact filter

Filtration is commonly the mechanical or physical operation which is used for the separation of solids from fluids (liquids or gases) by interposing a medium through which only the fluid can pass. The compact filter is consists of several layers i.e. cast iron net, coarse gravel and granite stones, fine sand and



porcelain sand, quartz sand, activated carbon, filter papers and micro filter pads.

Figure 1.Schematic diagram of compact water filter.

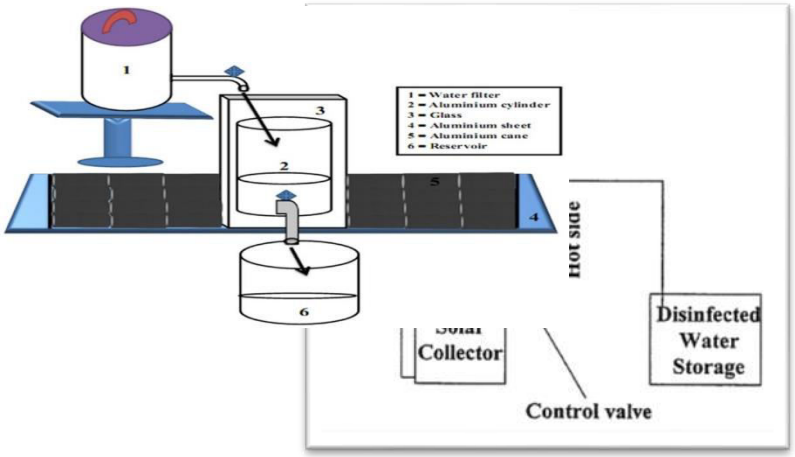
Preparation of solar collector

Solar water disinfection is a sort of portable water purification that employs solar energy to make biologically-contaminated (e.g., bacteria, viruses, protozoa) water suitable to drink. The filtered water is heat treated by solar energy in order to remove the rest pathogens, micro-organisms, some viruses and bacteria. The water is heated in an aluminum cylinder sheet containing 12-inchheight, 7-inch diameter and its capacity of containing approx. 5 liters of water. It is surrounded with the triangular or square box made of glass sheet containing 9 inch length, 9 inch wide and 13 inch height. The box is attached to the solar collector which consists of columns of painted black aluminum can, a frame to mount the columns and ventilation for the heat transportation. Here the water disinfection is donewith the help of the heat from the Sun up to

Figure 2. Schematic diagram of water purification and disinfection by solar energy

55-65 °C for a short period of time. The Figure 2 represents the proposed model of water purification and disinfection system. In the Figure 2, the number 1 indicates the compact water filter.

Block Diagram



Parameter's measurement

There are many parameters which can be used to measure the purity of water i.e. PH, Conductivity, Dissolved oxygen, Chemical oxygen demand (CODMn), Biological oxygen demand (BOD5), Color, Turbidity, Phosphate, Sulfate, Nitrite, Ammonia, Fecal coliform, Total hardness, Iron, Manganese and Arsenic. Quality of water depends on the above parameters.

Results and Discussion

Water purification is the mode of eliminating detrimental chemicals, biological poisons, suspended solids and gases from contaminated water. Drinking water purity standardsstates the quality parameters set for drinking water. Water can be contaminated by variousparameters suchas turbidity, dissolved oxygen, suspended solids, nitrates, phosphate, sulfate, ammonia, iron, manganese, arsenic etc. Such kinds of parameter will be present in a permissible level. These parameters stand for the water quality. The desirable level of PH, iron, manganese, hardness and lead are 6.5 to 8.5, 0.3, 0.1, 300 and 0.05 respectively (Water quality parameters and drinking water standards, IS: 10500-1991).The several researchers have been investigating that the various parameters determined before and after coagulation i.e., turbidity, PH, color, manganese, hardness, iron and Escherichia coli. This result in the removal of turbidity by 83.2%, PH showed minute variations through the coagulation, the hardness removal is down (0 to 15%), superior removal of iron (90.4 to 100%), manganese (93.1 to 100%) and the highest E. coli is 96.0% (Nkurunziza et al., 2009). In constructed wetland system, 69% of suspended solid (SS) is removed, 86% of biochemical oxygen demand (BOD), and 58% of total nitrogen (TN). Up to 82% of BOD and 27% of TN could be removed in this system (Lin et al., 2015).In the purification stage, with an inlet strength of 42.5 µS/cm and a nickel concentration of 10.0 mg/L, the outflow conductivity was 0.3– 1.0 µS/cm and the nickel concentration of the effluent was below the noting limit; in the regeneration stage, the average nickel concentration was over 80.0 mg/L, the average pH of the concentrate was 7.4 (Xiaolan et al., 2015).The inspection of pure water after treatment, the PH, iron, manganese, hardness and lead are 7.2, 0.02, 0.071, 200, -0.3162 respectively. All these water quality parameters are representing desirable values.

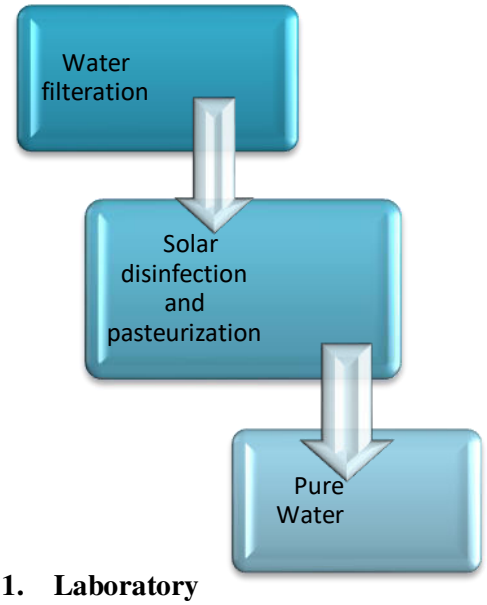


Table 1. Laboratory result of water purification and disinfection by using solar energy

Sr. No	Water Quality Parameters	Before Treatment	After Treatment
1	Ph	7.2	7.2
2	Turbidity	0.2 NTU	0.2 NTU
3	Dissolved Oxygen	5.9MG/L	4.8MG/L
4	BOD	18-19MG/	16.2MG/L
5	COD	5.1MG/L	4.8MG/L
6	Suspended Solids	Not visible	Not visible
7	Nitrate	0.8MG/L	0.075MG/L
8	Phosphate	0.72MG/L	0.60MG/L
9	Sulphate	1MG/L	0
10	Ammonia	0.01MG/L	0.02MG/L
11	Iron	0.03MG/L	0.02MG/L
12	Manganese	0.054MG/L	0.071MG/L
13	Arsenic	<LOQ	<LOQ
14	Hardness	240	200
15	Electrical Conductivity	372	306
16	Lead	-0.346	0.3162

Effect of time at sunny and cloudy days

For reduction of viruses, bacteria, protozoa and diarrheal disease incidence, the solar disinfection system is perfect. It is principally relied on the solar energy. Many researchers have been reported that the integrated storage-collector unit is a rectangular galvanized steel box with a complete storage capacity of 90 L and angle brackets is used to support the edges and forestall buckling and jute fibre was used for insulation. The performance of the solar collector is studied beneath numerous maximum daily solar intensities, starting from 1, 2 and 3 on a cloudy day, up to 695 W/m2 on a sunny day. In sunny days, the pure water within the reservoir is heated directly either of theabove sun energy or the below solar collector. Thesolar collector is an air tight chamber that gains huge amount of heat energy and flows through the water reservoir chamber. The water temperature moderately increases and the temperature reaches up to 49°C at the interval of 240 min. The intensity on sunny days is 700 W/m2. At this temperature, the viruses, bacteria, protozoa and diarrheal disease incidence don't seem to be alive and by this why they are removed. At cloudy days, due to excessive raining and violent blasts of wind blowing, less quantity of solar energy is absorbed. For that point, water temperature is relatively less than sunny days, because of lower intensity of the atmosphere. The intensity on cloudy days is 560 W/m2. Here the water temperature is also additionally increase and reaches up to 41°C at the interval of 240 min.

Effect of time in water flow rate

Time is vital in mass flow rate as it has low flow rate. After coagulation, flocculation and sedimentation flow rate increases. The water flow rate mostly depends on the layer of thickness of components in the compact water filter. The larger the thickness of the components, the lower the water flow rate. The separation system also affects the water flow rate. The investigation of solar disinfection unit is tested with both river water and partially processed water from two wastewater treatment plants. The result achieved that the 1 L of pure water in duration 30 minute (Laurie et al., 2004). We use cast iron net for separation of every layer. When time increases mass flow rate increases. We get pure water of about 14 L in duration of 240 min as an output. The Figure 4a shows that the output pure water with time.

Effect of solar intensity

When sun shines that time solar intensity increases over cloudy days. When environmental temperature is nearly 30°C that point solar intensity increases whether environmental temperature is at 28°C. The investigation of solar radiation during the three days, the maximum daily solar radiation is 176.3 W/m2 on the heavily overcast day, 961.8 W/m2 on the clear sky day and 633.4 W/m2 on the day with intermittent cloud cover (Ayompe and Duffy,

2013).The Figure 4b shows that the solar intensity is about 700 W/m2 at 12.31 pm and average solar intensity is 430 W/m2. When sun shines that time solar intensity is less increase than sunny days. When the environmental temperature is almost 28°C and that time solar intensity increases gradually.

Effect of time at vapor

When the water temperature is increases by using solar collector, some of water vapor are produced which is considered as pure water, because of no contamination of viruses, bacteria, protozoa and diarrheal disease incidence. It is largely depended on time variation and the temperature of the water. Higher the temperature of the water, the larger quantity of water vapor is separated. In this system, 16 mL water vapor is generated in duration 240 min.

Efficiency of the solar water purification and disinfection

At environment temperature 30°C

$Q = m\ Cp\ (Tf - Ti)$.....(1)

Where,

Q = Net useful heat gained by water,

m = Mass flow rate of the water (kg/sec),

Cp = Specific heat of water (kj/kg°C),

Tf = Maximum temperature attained by water (°C),

Ti = Initial temperature of water(°C), and

Efficiency,

$\eta = Q/[AC \times Hb \times Rb] \times 100$.....(2)

Where,

AC = Area of collector (m2),

Hb = Intensity of radiation (W/m2),

Rb = Tilt factor for beam radiation.

Advantages

- Chemical Free: Solar pasteurization does not use any chemicals like chlorine or leave any harmful by products.
- Taste & Odor Free: It does not add any chemical taste or odor to the water.
- Extremely Effective: It is an effective way to kill disease-causing microbes by.
- Requires very little energy: As it is solar dependent it is clean source of energy.
- Low Maintenance: Set and forget this type of system.

Conclusion

Experiments conducted with the simple and effective system presented in this paper shows that use of solar energy for water purificationusing pasteurization method is an attractive option to existing solar water filtration approaches. Studies have shown that it is effective in reducing diarrheal illness in children when implemented in field trials. However, the process does have limitations and several variables influence the effectiveness of the process such as solar intensity, temperature, turbidity, container shape, and sample volume. The properties of solar disinfection are therefore due to itssolar radiation component, or the synergistic effectsofsunlight and heat. Treatment of water with this optionresults in higher removal of bacteria and bacteriophages

than treatment of tap water with the other treatment options.

References

[1] Water Purification and Disinfection by using Solar Energy: Towards Green Energy Challenge Md. Z. H. Khan1*, Md. R. Al-Mamun1 , Suvash C. Majumder1 , Md. Kamruzzaman1 1Department

of Chemical Engineering, Jessore University of Science and Technology, Jessore 7408, Bangladesh

[2] https://sswm.info/sswm-solutions-bop-markets/affordable-wash-services-and-products/affordable-water-supply/solar-pasteurisation

[3] https://www.yellowlite.com/blog/post/what-is-a-hybrid-solar-panel-system-and-how-does-it-work

[4] https://dir.indiamart.com/impcat/thermostat-valves.html

[5]https://solarcooking.fandom.com/wiki/Water_pasteurization

[6] Research Gate

[7] What is a Hybrid Solar Panel System and How Does it Work? Academia.edu