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A Study on the Efficiency of Solar Water Purifier and Subsequently its Application

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Abstract—*Water and air are the two engulf fluids that we need and consume the most during a lifetime. Preservation of water from pollution, Harvesting of water and Treatment of Water are prime objectives of the engineers around the world through cost-effective and energy efficient techniques to meet the increasing demand of water at an alarming rate every year. Fresh water constitutes only 2.7% of total world's water and also after being on three-fourth of the total earth's land. With high increase in population and pollution together it becomes a very difficult to encounter such needs of life. The reason also renders around the fact that the sources of water on earth is constant while population is not. Therefore solar-powered purification is one of the technologies which allows to obtain the same result, by using the renewable solar source, an important energy saving process as compared to conventional refrigeration technique. This study is an investigation into the methods of solar purification of water that can be adopted for the purpose of purification of used water for its reusing.*

Introduction

This paper is an investigation into an efficient solar powered purification system for treatment of water, basically to reuse the water (specifically bathing and washing clothes) in those parts of India where scarcity of water is general phenomenon due to low level of ground water and also for the places where, there are less number of sources of natural water like Gujarat and Rajasthan. Except that in many places of India there are a abandoned sources of sea water but due to the presence of sea salt it can't be used for bathing and other daily works. These can compete with electrical or conventional energy based purification system. It also follows sustainable development by using renewable energy as main source and thereby conserving the conventional energy resources.

Water and air are the two engulf fluids that we need and consume the most during a lifetime. Preservation of water from pollution, Harvesting of water and Treatment of Water are prime objectives of the engineers in allaround the world with cost-effective and energy efficient techniques to meet the increasing demand of water at an alarming rate every year. Fresh water constitutes only 2.7% of total world's water and also after being on three-fourth of the total earth's land. With high increase in population and pollution together it becomes a very difficult to encounter such needs of life. The reason also renders around the fact that the sources of water on earth is constant while population is not. Therefore solar-powered purification is one of the technologies which allows to obtain the same result, by using the renewable solar source, an important energy saving process as compared to conventional purification technique. This study is an investigation into the methods of solar purification of water that can be adopted for the purpose of purification of used water for its reusing.

We are from Rajasthan. We are studying in a great institution there. The state is full of culture, colour, peaceful public. But all this glory goes fade every year in the season of summer. There is a huge source of water in the underground, where the college is situated, but the water level goes extremely down in summer. From 2011 to 2016 the source of water has blessed us. But this year the water level is so down that it can't be find after digging a boring of 27 ft. We have three water boring from where the reservoirs of volume 8000lit. is being filled daily two times. The usage of water (Lit/head) goes increasing in summer automatically. Among the three boring two have already dried. The one and only boring supplies water till the year. So it's not so surprising that the only boring will dry till next year. It is not possible to bring water supply from the main city. So we have decided to reuse the water by purifying it.

There are two types of foul water exerted from a residential building. One is from latrine room and the other is from Bathroom. The water is exerted from latrine room will not use again even we will purify it due to some anxiety disorder. But we can reuse the water which is already used only for bathing purpose. The water came initially in a sanitary chamber. From there we separate a part of water. Now we have to remove its hardness.

Step: 1:- Removal of hardness of water

Hardness

So now we have to discuss the hardness of water. Simply hardness can be defined as the present of amount of dissolved magnesium and calcium in a sample of water. Hard water is high in dissolved minerals, both calcium and magnesium.

Hard water is not so effective for bathing and washing clothes because hard water has calcium and magnesium present in this. In other hand soap has organic acid. This organic acid reacts with the calcium and magnesium presents in hard water and form calcium and magnesium salt. Due to this when we applied soap in hard water it produces soap scum but no lather. So the soap is less effective in hard water. A nominal hardness can be allowed for the water to be used. Water systems using groundwater as a source are concerned with water hardness, since as water moves through soil and rock it dissolves small amounts of naturally-occurring minerals and carries them into the groundwater supply. Water is a greatsolvent for calcium and magnesium, so if the minerals are present in the soil around a water-supply well, the hard water may be delivered to residents.

Measure of hardness

Hardness is caused by compounds of calcium and magnesium. A general measurements are fixed to consider the water as soft moderately hard or very hard. Depending upon this hardness we have to reduce with suitable process.

General guidelines for classification of waters are:

Calcium carbonate (milligrams per litre)	Type of water
0 to 60	Soft
61 to 120	moderately hard
121 to 180	very hard.

Process to get rid of from hardness

There are some processes to get rid of from hardness of water or reducing the hardness of water like:

- Chemical Process of Boiling Hard Water
- Adding Slaked Lime (Clark's Process)
- Adding Washing Soda
- Calgon Process
- Ion Exchange Process
- Using Ion Exchange Resins

Among these, three processes are very suitable and feasible to apply. Boiling of hard water , Adding slaked lime and by adding Calgon complex we can reduce the hardness of water.

Chemical process of boiling hard water

We can boil water to remove temporary hardness. Temporary hardness in water can be easily removed by boiling. With boiling, calcium/magnesium bicarbonate decomposes to givecalcium/magnesium carbonate, which is insoluble in water. Therefore, it precipitates out.

These boiling can be done by solar heater. This is also energy conservation process.

$$Ca(HCO_3)_2 \xrightarrow{\text{boiling}} \underset{\text{insoluble calcium carbonate}}{CaCO_3\downarrow} + H_2O + CO_2$$

Adding Slaked Lime

In Clark's process, slaked lime, $Ca(OH)_2$ is added to temporary hard water. Insoluble calcium carbonate precipitate out and no longer produce hardness.

$$\underset{\text{slaked lime}}{Ca(HCO_3)_2 + Ca(OH)_2} \longrightarrow \underset{\text{insoluble calcium carbonate}}{2CaCO_3} + 2H_2O$$

Calgon process

Calgon is a trade name of a complex salt, sodium hexametaphosphate $(NaPO_3)_6$. It is used for softening hard water. Calgon ionizes to give a complex anion:

$$(NaPO_3)_6 \text{ or } Na_2(Na_4P_6O_{18}) \longrightarrow 2Na^+ + \underset{\text{complex anion}}{Na_4P_6O_{18}^{2-}}$$

The addition of Calgon to hard water causes the calcium and magnesium ions of hard water to displace sodium ions from the anion of Calgon.

$$\underset{\text{from hard water}}{Ca^{2+}} + \underset{\text{anion of calgon}}{Na_4P_6O_{18}^{2-}} \longrightarrow 2Na^+ + \underset{\text{goes into solution}}{CaNa_2P_6O_{18}^{2-}}$$

This results in the removal of calcium and magnesium ions from hard water in the form of a complex with Calgon. The water is softened and sodium ions are released into water.

Indian Scenario towards solar energy.

India has recently signed up with INDCs(Intended Nationally Determined Contribution) reflect each country's ambition for reducing emissions, taking into account its domestic circumstances and capabilities under Paris Agreement in 2016.

Thus it is necessary to reduce the carbon credits as Indian Govt said to reduce carbon credit by 2% by 2020.

Step:2 :- Purification done by UltraViolet ray

Solar Water Purify:

Now we have to purify the reduced hard water by Ultra Violet ray. Because the Ultra Violet Ray is the best because it has the property to destroy harmful pathogen. Removal of hardness process reduces the hardness of water. But the water body is not bacteria free. So we have to disinfect the water body. Chlorine is the material by which we can disinfect the water body but we do not go with chemical treatment. We will like to go with Ultra Violet Ray passing. Ultraviolet water purification is the most effective method for disinfecting bacteria from the water. Ultraviolet (UV) rays penetrate harmful pathogens in the water and destroy illness-causing microorganisms by attacking their genetic core (DNA). This is

extremely efficient in eliminating their ability to reproduce. Disinfecting our water with Ultraviolet light is exceptionably simple, effective and environmentally safe. UV systems destroy 99.99% of harmful microorganisms without adding chemicals or changing your water's taste or odor. UV water purification is usually used with other forms of filtration such as reverse osmosis systems or carbon block filters.

UV Purification is most effective way than Chemical Disinfectant:

UV systems are an effective means of water disinfection for residential point of entry use to help disinfect the entire residential area. UV systems are highly recommended to the human being who may suspect any E.coli, cryptosporidium, giardia or any other types of bacteria and viruses in the water. It is not advised to use chlorine or other chemicals to disinfect water body. Because the use of chlorine for disinfection of water creates toxic byproduct. It is important to avoid drinking any water that is potentially contaminated from bacteria to protect ourself from any water-borne bacterial diseases.

The ultraviolet spectrum includes wavelengths from 2000 to 3900 Angstrom units (Å). One unit is one ten billionth of a meter. The 2000 to 3900 Å range may be divided into three segments:

Long-wave ultraviolet - The wavelength range is 3250 to 3900 Å. These rays occur naturally in sunlight. They have little germicidal value.

Middle-wave ultraviolet - The wavelength range is 2950 to 3250 Å, also found in sunlight. Middle-wave UV is best known for its sun-tanning effect; it provides some germicidal action, with sufficient exposure.

Short-wave ultraviolet - The wavelength range is 2000 to 2950 Å. This segment possesses by far the greatest germicidal effectiveness of all ultraviolet wavelengths. It is employed extensively to destroy bacteria, virus, mold, spores, etc., both air- and water-borne.

Short-wave ultraviolet does not occur naturally at the earth's surfaces, because the atmosphere screens out sunlight radiation below 2950 Å. In order to take practical advantage of the germ-killing potential of short-wave ultraviolet, it is necessary to produce this form of energy through the conversion of electrical energy. The conversion of electrical energy to short-wave radiant ultraviolet is accomplished in a mercury vapor lamp.

Mercury Vapor or Germicidal Lamps:

The low-pressure variety of mercury vapor lamp, which can be referred to as a germicidal lamp, provides the most cost-effective and efficient source of short-wave ultraviolet energy. Germicidal lamps are made of special quartz glass that will allow 70 to 90 percent of the short ultraviolet rays to pass. Ordinary glass is not transparent to wavelengths below 3200 Å. The low pressure mercury vapor lamp emits radiation that is predominately at 2537 Å. This is in the region of maximum germicidal effectiveness.

The germicidal lamp works on the following principle: An electric arc is struck through an inert gas carrier, in a sealed special glass tube. Heat from the arc causes vaporization of the small amount of mercury contained in the sealed tube. The mercury, when vaporized, becomes ionized and in the electric arc gives off UV radiation.

Required Germicidal Energy:

Bacteria withstand considerably more ultraviolet irradiation in water than in dry air. E.coli, for example, (common in the water of unprotected catchment systems), requires more UV exposure for their destruction in water than in dry air. In either case, the germicidal radiation must strike a microorganism to destroy it. This requires that the water be clear enough to allow transmission of an adequate quantity of UV energy. The degree of microbial destruction is a function of both the time and intensity of the radiation to which a given microorganism is exposed. A short exposure time at high intensity is as effective as a long exposure time at low intensity, provided the product of the time and intensity remains the same.

Solar Purification Applications:

1. Tap water filtration for consumption.
2. Contaminated water filtration
3. Used water filtration for reuse
4. General filtration of water

Conclusion

Traditional water filtration uses different kinds of cycles like UV filtration, anode and cathode rod filtration which was the basic design of water filter, there after comes heating of water for killing micro organisms bacteria and other harmful germs that causes disease or harm to human body.

Typically for the cycles stated above can be done by the use of electricity or chemical water purifier indicator but in this of model the equipment requires just the solar energy and a battery to store the produced electricity for the future use thus increasing the efficiency of the model and saving electricity as compared to traditional filters thus this is an amazing technique to save electricity and use the renewable of energy for the filtration of water.This Project is our ongoing and final year project. We are working on this and goes to almost complete by May, 2018.

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