Use of titanium dioxide as photo-catalyst in single basin single slope solar still

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ABSTRACT

Scarcity for water exists in many countries even though three fourth of the earth is covered by water. This is due to the rapid growth of industries and the immeasurable population of the world. Solar still is the efficient solution to solve water problem in areas of dry weather where there is scarcity of water and electricity. Solar still is a very simple solar device that is used for converting the available brackish water into potable water. This paper presents a new approach to enhance the chemical reaction and the productivity by the use of titanium dioxide as photo-catalyst. Using titanium dioxide, TiO_2 as photo-catalyst, the process was successfully degraded and reduces the organic pollutant and microorganisms in wastewater. It is non-toxicity, photo-chemically unwavering and highly reactive. Otherwise, the catalyst itself is inexpensive and commercially available in various crystalline forms. The daily productivity of single basin single slope solar still without the use of photo-catalysis was 615 ML/0.25M^2/day and with the use of photo-catalysis was 670 ML/0.25M^2/day

Keywords: photo-catalyst, Titanium dioxide ($TiO_{2)}$, Enhance Chemical reaction, water treatment, single basin single slope solar still

INTRODUCTION

Water is important for all life forms on earth-human, plants and animals. Water is one of the most plentiful resources on earth, covering three fourths of the planet's surface. About 97% of the earth's water is present as saltwater in oceans and the remaining 3% as fresh water in the form of ice, ground water, lakes, and rivers, which supply most human and animal needs. Less than 1% fresh water is within human reach. Nature itself provides most of the required fresh water, through hydrological cycle.

The vast population and express growth of industry lead a worldwide imbalance between supply and demand of fresh water. Most desalination plants such as reverse osmosis, membrane distillation, multistage and multiple effect distillation use fossil fuel as a source of energy. The above-mentioned treatment processes are available to supply clean potable water to rural and urban people. However, for the people living in remote areas, no device is available at inexpensive cost to supply drinking water.

In 1872, Swedish engineer C.Wilson designed the first conventional solar still for supplying fresh water to mining community in Northern Chile. The operation of solar still is similar to natural hydrological cycle that includes two processes, namely evaporation and condensation. A black painted basin filled by brackish water or waste water. Transparent cover is enclosed in a completely air tight area. Transparent cover passes incident solar irradiance and it is absorbed by the basin plate. Consequently basin water gets heated up and evaporates in the saturated conditions inside the still killing all pathogenic bacteria. Water vapors rises towards the cooler inner surface of the cover, where they condense to pure water, due to gravity and run down along the cover bottom surface, getting collected in a collecting tray. The still is easy to fabricate and does not require maintenance and skilled labors.

A different method used to increase the evaporation rate on passive solar still was reviewed by muthumanokar et al (MuthuManokar, et al., 2014). From the detailed; literature it is reported that there are number of methods used to increase the evaporation rate, among the number of methods, increase the chemical reaction in the basin water have eye-catching and simple technique among other treatment process. In this chapter already research work done to increase the evaporation rate by different methods are discussed.

Nijmeh et al. (Niimeh, et al., 2005) studied the effect of using various absorbing materials on the productivity of a single-basin solar still. The materials used to enhance the absorptivity of water for solar radiation include dissolved salts, violet dye, and charcoal. The salts were potassium permanganate and potassium dichromate. They found that the addition of potassium permanganate resulted in 26% raise of efficiency. The best result was obtained by using violet dye with a raise of about 29% efficiency.

Suresh et al. (sureshpatil, et al., 2006) used oxides like Cuo, pbo_2, Mno_2,metal sulphides like Pbs, Cus, Bi_2S_3 and Sb_2S_3 and dyes like Malachite Green, Fuschine and Alizarin Reds as photo catalysts to improve the rate of production. Among the materials that are used as photo catalysts they were found that oxides are better than sulphides and dyes.

Any semiconductors can be the catalyst of photo-catalysis. But, photo-catalysis on TiO_2 photo-catalyst has been given attention in wastewater treatment. It is because, the possible use under solar irradiation, the operation occurs under ambient conditions and lack of mass transfer limitations. TiO_2 reported as the best photo-catalyst due to the particle characteristics such as non-toxicity, high reactivity and photo-chemically stable. Otherwise, the catalyst itself is inexpensive and commercially available in various crystalline forms. Using titanium dioxide, TiO_2 as photo-catalyst, the process successfully degraded and reduced the organic pollutant and microorganisms in wastewater. TiO_2 is excellent for photo-catalytically breaking down organic compounds. For example, if one puts TiO_2 powder into a shallow pool of polluted water and allows it to be illuminated with sunlight, the water will gradually become purified (Akira, et al., 200)

MATEERIALS AND METHODS

Description of the solar still: Insingle slope solar still, the height of the lower vertical side of solar still was kept at 10cm. For a 30^0 inclination of the glass cover, the required height of the other vertical side was 43cm. The absorber area of basin and collector of solar still are 500 mm x 500 mm, and 500 mm x 590 mm respectively. Design diagram of single slope solar still is as shown in Fig. 1. The basin structure of the solar still was composed of Galvanized Iron sheet. The inner side of the basin was painted black to maximize the absorption of solar radiation. The bottom and sides of the still basin were well insulated with a thermo-cool layer of

0.05 m thickness. An ordinary clear window with a glass thickness of 0.004 m was used as the top cover of the solar still and inclined at an angle of 30º. The total experimental setup was arranged to face the southerly direction to receive the maximum solar radiation. A silicon rubber sealant was used as the seal between the glass cover and body of the solar still to prevent leakage at the seam. The distillate water condensed from the glass cover was collected in a distillation trough fitted on the lower side of the solar still. Plastic tubes are used to discharge the distilled water. Titanium-di- oxide was placed in the solar still basin it is shown in figure 2.

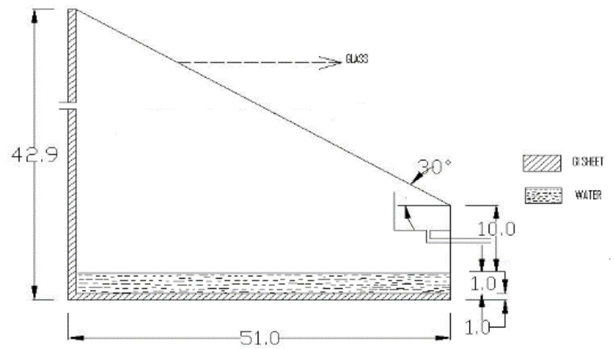

Figure.1. Schematic diagram of Single Slope Solar still

Figure. 2. Titanium dioxide in the solar still basin

Experimentation: The experiment was carried out at the Energy Park of National Engineering College, Kovilpatti[77^{0}52’N, 9^{0}11’E], Tamil Nadu, India. The experiments were conducted form morning 6 AM to evening 6 PM. The Solar radiation, wind velocity, ambient temperature, outside and inside glass surface temperatures, basin, basin water, vapor and distilled water temperature were recorded for 30min interval. Mass of distilled water collected was recorded, for one hour interval. Solar radiation is measured by using solar meter. Wind velocity is measured by using Anemometer. Thermocouples wires are fixed at basin, basin water, basin wall (vapor), distilled water, basin glass in and outside to measure the temperature by using digital temperature indicator. Collecting bottles are fixed at the end of drains to collect the distilled water. Measuring jars are used to measure productivity rate.

First conventional solar still was tested under naturally available solar radiation condition for one month and readings were taken for every 30min interval. The maximum productivity considered for comparison purpose. In the Second modification titanium-di-oxide was placed in still basin to enhance the chemical reaction in the solar still. Due to the superior properties of titanium-di-oxide it killed all harmful microorganisms and increases the chemical reaction in the presence of solar radiation.

Figure.3. Photographic view of conventional solar still and basin with titanium dioxide

RESULTS AND DISCUSSION

Using titanium dioxide, TiO_2 as photo-catalyst, it reduced the organic pollutant and microorganisms in wastewater. Photo catalysis is one of the most interesting ways to achieve clean and renewable energy. Photo catalytic water splitting was the simplicity of using a powder in water and sunlight to produce H_2 and O_2 from water and it was provided a clean, renewable energy, without producing any greenhouse gases and affecting the atmosphere.

The daily productivity of conventional solar still is 615ML/0.25M^2/day and the daily productivity of solar still with photo-catalysis reaction is 670ML/0.25M^2/day. When titanium dioxide is placed in basin there was 8.2% increase in productivity.

Fig. 4 shows the productivity of simple solar still and use of photo-catalysis in solar still. From the output it is clear that titanium dioxide successfully degraded and reduced organic pollutant in wastewater and increase in productivity. It increased the chemical reaction inside the still and splitting the water easily. In the presence of sunlight, TiO_2 was accelerating the natural decomposition of low-level organic compounds in aqueous solutions.

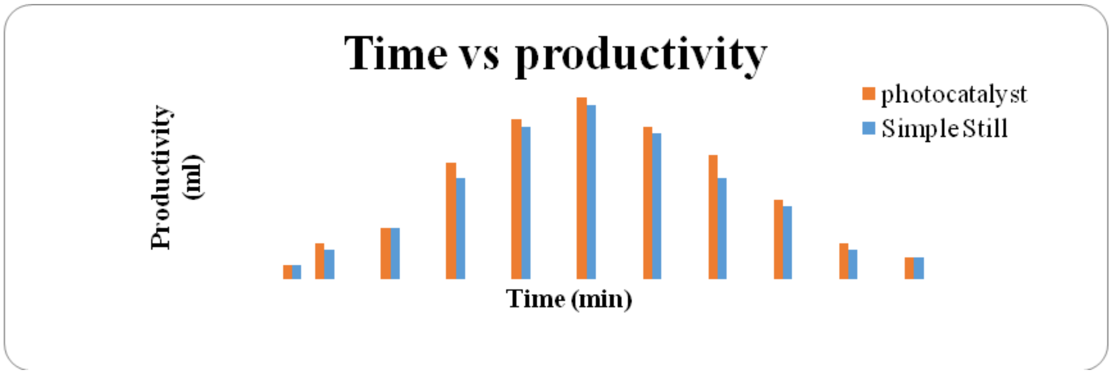

Figure.4.Variation of productivity for conventional and photo-catalysis solar still

REFERENCES

Akira Fujishima, Rao TN, Tryk DA, Titanium dioxide photocatalysis Journal of Photochemistry and Photobiology. C: Photochemistry Reviews, 1, 2000, 1–21.

MuthuManokar A, KalidasaMurugavel K, Esakkimuthu G, Different parameters affecting the rate of evaporation and condensation on passive solar still – A review. Renewable and Sustainable Energy Reviews, 38, 2014, 309–322.

Nijmeh S, Odeh S, Akash B, Experimental and theoretical study of a single-basin solar still in Jordan. Int. comm. Heat Mass Transfer, 32, 2005, 565–572.

Suresh Patel G, ShilpiBhatnagar, JitendraVardia, Ameta Suresh C, Use of photocatalysts in solar desalination. Desalination, 189, 2006, 287–291.