A REVIEW ON SOLAR POWERED WATER PURIFICATION

Prof. R. M. Dahekar[1], Ankit R. Farsole[2], Kundan S. Pusadkar[3], Manish D. Saini[4], Shubham S. Darwai[5], Suraj A. Hinge[6]

[1] *Asst. Professor, Mechanical Engineering Department, GWCET, Nagpur, Maharashtra, India*
[2,3,4,5,6] *UG Students, Mechanical Engineering Department, GWCET, Nagpur, Maharashtra, India*

ABSTRACT

Most of the peoples in developing countries are facing the problem of safe, clean and drinkable water. The peoples are generally depends on groundwater, lake water, bore well water as a raw for daily purpose use including drinking, washing, cleaning etc. The water obtained from the above sources contains bacteria, chemicals which causes different water borne dieses. There are different water purification technologies have been developed which are beneficial to us. So, in this paper we have reviewed solar based technology which is used for water purification in household or industrial areas. The cited literature shows that, there is much scope in water purification method by using solar energy and found useful in removing chemical and microbial bacterial infections.

Keyword: - *Water Purification, Solar Water Treatment, Design of Solar Based System, Biological Treatment*

1. INTRODUCTION

Solar water purification involves purifying water for drinking and household purposes through the usage of solar energy in many different ways. Using solar energy for water treatment has become more common as it is a usually low-technology solution that works to capture the heat and energy from the sun to make water cleaner and healthier for human use and consumption. Solar water treatment is particularly beneficial for rural communities, as they do not have other forms of water purification infrastructure and more importantly, electricity to run such structures. The most positive feature about solar water purification is that there is no requirement of fuel. It's precisely due to the lack of fuel that makes solar applications relatively superior than conventional sources of energy as it does not cause pollution (global warming, acid rain, ozone depletion) or health hazards associated with pollution. There are four main types of solar water treatment: solar water disinfection (SODIS), solar distillation, solar water pasteurization, and solar water treatment systems. Some of these technologies have been around for a very long time, but most are new adaptations to the concept of solar energy. These technologies are quite simple and easy to understand, usually require low financial input, and are proven effective.

2. LITERATURE RIEVEW ON SOLAR BASED SYSTEM

Phalak M., et al. (2017): The author had proposed a solar-powered reverse osmosis portable water purifier which can be very useful in situations of floods.
Md. Khan Z. H., et al. (2015): They developed a water purification and disinfection system by using solar energy. A compact water filter of five layers of filtrations was used for water purification as well as a solar collector was used in order to remove the rest pathogens, micro-organisms, some viruses and bacteria.
Edla P. J., et al. (2013): They provided a detailed review of different studies on the active solar distillation system in India. This paper discussed four different types of solar water purification methods such as; solar water disinfection, solar water distillation, solar water pasteurization and solar water purification.

Gowtham M., et al. (2012): In this research work, the performance of solar concentrated distiller with latent heat storage capacity is compared with solar concentrated distiller with trays on the basin. Paraffin wax is used as the latent heat storage material. Experiments are conducted for improving productivity and this is done by various

factors like heat storage capacity, exposure area and maintaining low depth. Hourly Productivity of the concentrated solar distiller is obtained for experimental duration 9AM to 5AM water was measured every hour by maintaining low depth**.** Analysis was made between two types of basins. Sponges were added to increase the exposure area by capillarity effect. It is observed that due to the presence of sponges, the water output is increased to 40.83% in latent heat storage distiller and 19% increase in tray basin type, while comparing with the plain basin type. Overall productivity was improved by a maximum of 48% by using various modifications**.**

Ozuomba J.O., et al. (2012): In this paper find a roof-type solar water distillation (RSWD) kit was fabricated and tested under actual environmental conditions of Urualla, an ancient town in the Eastern part of Nigeria. The system includes four major components; a rectangular wooden basin, an absorber surface, a glass roof and a condensate channel. The RSWD was able to generate $2.3m^3$ of distilled water within six days. Though the condensate was not large enough compared to human need as is peculiar to many solar stills, the efficiency can be enhanced by using large solar absorber surface and by any method that can increase radiant energy.

Mehta A.,et al. (2011): In this paper we observed that the increase in temperature and hence the evaporation is maximum in the period of 11:15 am to 1:30 pm. The maximum temperature achieved is 53^0C which is at 1:30 pm. then the temperature decreases. This experiment was to get pure water from the brackish water available. The brackish water we have supplied was 14litres and at the end of the experiment we got 1.5 litres. The experiment was carried out in winter season. The TDS level of purified water obtained is 81 PPM. So, the water obtained is potable. Theoretically, the experiment should fetch out 2.33litres. So, the efficiency of the system is 6%.

Kaushal A., et al. (2010): According to this there are many methods for desalination of brackish water in to potable water. Therefore, different types of solar stills are discussed for the production of pure water. A proper combination of cooling film parameters enhanced the still efficiency by 20%. In multi-effect diffusion model, the productivity decreases about 15% with an increase in diffusion gaps between partitions from 5 mm to 10 mm. So for specific requirement there is a requirement to select solar still very continuously based upon the local condition and operating conditions.

Sampathkumar K., et al. (2010): In this paper we noted that, under developed countries and developing countries face a huge water scarcity because of unplanned mechanism and pollution created by manmade activities. Water purification without affecting the ecosystem is the need of the hour. In this context, many conventional and non-conventional techniques have been developed for purification of saline water. Among these, solar distillation proves to be both economical and eco-friendly technique particularly in rural areas. Many active distillation systems have been developed to overcome the problem of lower distillate output in passive solarstills. This article provides a study on active solar distillation system over the years.

3. LITERATURE REVIEW ON BIOLOGICAL TREATMENT/MEMBRANE USED

Zaman et al. (2017): A simple and inexpensive water purification method was developed using a natural coagulant (Moringa seed powder) and antibacterial agents (scallop powder) followed by bio-sand filtration.

Nayara K. G, et al. (2017): They proposed electro dialysis (ED) over reverse osmosis (RO) for water purification in the urban area of India which outperforms RO and can achieve a recovery of 80%, producing 12 L/h of water at the desired salinity of 350 ppm from a feed salinity of 3000 ppm. The cost and size of the proposed system are also found to be comparable to existing in-home RO systems.

Jun Yin et al. (2016): The author prepared a thin-film nano composite (TFN) membrane containing grapheme oxide (GO) nano sheets for water filtration.

Bolisetty, S., and Mezzenga. R. (2016): They have proposed inexpensive hybrid membranes made from protein amyloid fibrils and activated porous carbon for wastewater treatment.

Deng et al. (2015): Shock electro dialysis (ED) can thoroughly filter micron-scale particles and aggregates of nanoparticles present in the drinking water. Shock ED can enable the disinfection of feed waters as well, by

combining these functionalities (filtration, separation, and disinfection) with deionization; shock ED has the potential to enable highly compact and efficient water purification systems.

Daniel S. Wendt (2015): He developed a model in which a switchable polarity solvent forward osmosis (SPS FO) system was used for water purification. A thermally driven process SPS FO may be more cost-effective than electrically driven processes, such as reverse osmosis (RO), even if more energy is required.

Caroline S.E. Sardella (2012): They had analyzed, the production rate of distillate water is estimated to be between 100 and 590 l/d per barked depending on the efficiency of the system. The water extracted from the drinking water tank is expected to be within the bacteriological and mineralogical advised quantities where no adverse health effects are observed. The distillate is expected to be partially re-mineralized during the mixing process with the harvested rain water. However, accurate monitoring and analysis of the water quality is advised during the pilot project. In this project using the water extracted from the drinking water tank is expected to be within the bacteriological and mineralogical advised quantities where no adverse health effects are observed. The distillate is expected to be partially re-mineralized during the mixing process with the harvested rain water. However, accurate monitoring and analysis of the water quality is advised during the pilot project low-cost technology with low-cost maintenance, it is possible to improve the quantity and quality of the available water.

Simonis (2012): He studied the manufacturing a low-cost ceramic water filter and filter system for the elimination of common pathogenic bacteria and suspended solids. A micro porous ceramic water filter in which clay was mixed with rice husk in a ration 2:1 by weight and a cylindrical shaped filter was manufactured by tradition oven drying and then burning in kiln at specified sintering temperature after being coated with silver nitrate solution for preventing the bacterial growth.

Chaturvedi (2012): He studied the removal of iron for safe drinking water. He used the methods of iron removal from drinking water such as electro coagulation; oxidation filtration, ion exchange, lime softening, adsorption by activated carbon, BIRM media, Anthracite, green sand, pebble and sand mixture, ultra-filtration etc. have been discussed.

Ganvir, et al. (2011): They studied the removal of fluoride from groundwater by aluminum hydroxide coated Rice husk ash. Activated aluminum hydroxide has been used for activating the RHA surface which forms a complex with fluoride ion in water and accelerates the process of removal. RHA was obtained by controlled burning of dry and crushed rice husk and treating with hydrochloric acid before activation.

Bordoloi, et al. (2007): They studied the removal of iron from water using the ash produced from banana residue. Ashes from different materials i.e., dry banana leaf, pseudo stem, rind, bamboo, rice husk were produced by controlled combustion. The mechanism of removal includes oxidation of iron at high pH or alkaline medium produced by potassium present in banana due to subsequent formation of potassium hydroxide. The study included analysis of chemical composition of banana ash and its efficiency in removal of iron from prefabricated water. Further it has been used in a low cost household water purification model in which after treated with ash, the water is being filtered with a cotton cloth and being used for drinking.

Takerlekkopoulou, et al. (2006): They studied in 2006 the physio-chemical and biological iron removal from potable water. He used the technique of trickling filter and constructed a model for it including the pilot-testing. The main mechanism was physio-chemical and biological oxidation of iron. The detailed chemical reaction and extent of each oxidation was studied. Experimentation was done with specified temperature, optimum feed iron concentration and volumetric flow rate. First order kinetics and Monod-type kinetics was observed in physiochemical and biological oxidations respectively.

Gupta (2006): He studied the non-conventional low-cost adsorbents for dye removal. He studied an extensive number of adsorbents for filtration and in the review; he showed the critical analysis of these materials, characteristics, advantages, limitations and mechanisms of adsorption. He used activated carbon of agricultural solid waste, industrial by product, clay and materials containing silica.

Choo, et al. (2005): They studied in 2005 the removal of iron and manganese in ultra filtration and also the process of membrane fouling. He also examined to remove the residual chlorine due to pre-chlorination which is opted as a

convenient option for safe drinking water. The membrane fouling was caused due to the oxidation of iron and manganese which was also visualized thoroughly at microscopic level and the steps for eradicating the degradation of membrane were proposed.

Wang, et al. in (2003): They studied the removal of heavy metal ions from aqueous solutions using various adsorbents with minimal cost. He used various low-cost adsorbents like Fe_2O_3, Fe_3O_4, FeS, Steel wool, Magnesium pallets, Copper pallets, Zinc pallets, Aluminum pallets, Iron pallets, Coal, GAC for removal of heavy metal ions like cobalt and zinc from ground water.

Tomotada (2001): He studied the Current bioremediation practice and perspective in 2001. In the method he used in-situ fluorescence hybridization (FISH), in situ PCR, and quantitative PCR for removal of contamination by bioremediation. In this method the detection and reorganization of bacteria and pathogens is very vivid and these are being directly related to the rate of degradation of contaminants.

William, et al. (1992): They studied the impact of dissolved organic carbon on the removal of iron during water treatment. He used the iron removal process by oxidation and coagulation method. Hemic and fulvic acids, tannic acid and oxalic acid were estimated in the organic content. Potassium permanganate, chlorine dioxide and free chlorine were used as oxidizing agent.

Hasan (1990): He studied the contact aeration for iron removal method. The iron removal process utilized the catalytic effect of ferric iron. Again, in this experiment it was theoretically demonstrated that by keeping high concentration of ferric iron, the volume of the aeration tank can be significantly reduced and it was according to the oxygenation rate equation. Ferric iron is very much effective in decreasing the reactor volumes at lower pH values. It is proposed to recycle the ferric sludge to maintain the high ferric iron concentrations in the reactor.

Catherine (1988): She studied the control of biological iron removal from drinking water using oxidation-reduction potential. In this study a pilot plant was used for treating raw water with pH 5.7 for biological removal of iron to produce drinking water. Here oxidation- reduction potential was used as a tool for evaluation and determination of relationship with dissolved oxygen and residual iron concentration in the infiltrate by using a biological filter.

4. LITERATURE REVIEW ON DESIGN OF SYSTEM

Kunduru, et al. (2017): Product design can be defined as a set of constitutive elements of a product that consumers perceive and organize as a multidimensional construct comprising the three dimensions of aesthetics, functionality, and symbolism.

Alsyouf, et al. (2015): To improve product design there are four steps such as; assess the current performance using Fishbone Diagram, Pareto chart, FTA, RBD, FMECA; identify the stakeholders needs through customer survey; establish target specification performing QFD and HOQ to translate the stakeholders' requirements into product technical specification (TS) and testing and final specifications using design of experiments through analysis of variance tool ANOVA.

John Ward (2003): In this paper designed black plastic sheet covered by a white glass window. The plastic is formed into an array of interconnected square cells which contain impure water output. There is no filter, no electronics no moving parts and cleaning is rarely needed. This solar water purifier has been designed, made and tested successfully. It will readily convert impure water such as bore, sea, brackish, urine, radioactive, arsenic contaminated, effluent etc. into pure drinking water with a TDS content of 1-2ppm. Insolation values of about 1000 W/m. result in output of about 9 l/m day at Adelaide, South Australia, Latitude 35 South. It is rugged, lightweight, portable and suitable for remote outback or third world countries.

5. CONCLUSION

From this complete literature review, it is found that numerous methods are developed for purification of water. These are matters to the demand of purified water, quality of water source and the difficult expense. Conventional, Reverse Osmosis systems are presently widespread domestically, but at the cost of sufficiently of waste water. Non-

conventional water cleansers like a solar still have unlimited potential, but their usage is insufficient due to minor output rate.

The humidification-dehumidification process is the most suitable option for fresh water invention and combined system for concurrently hot water production.The multi-effect purification method can be used for the bulk production of fresh water. The complete review reveals that there is a necessity to develop a hybrid system of water cleansing which can overcome the limits of all current water purification systems.

6. REFERENCES

[1] Phalak, M., Kurkure, P., Bhangale, N., Deshmukh, V., Patil, M., and Patil, M. H., Solar powered reverse osmosis water purifier, International Journal for Research in Engineering Application & Management (IJREAM), vol. 03, no. 01, 2017.

[2] M. Z. H. Khan, M. R. Al-Mamun, S. C. Majumder, and M. Kamruzzaman, "Water Purification and Disinfection by using Solar Energy: Towards Green Energy Challenge," Aceh Int. J. Sci. Technol., vol. 4, no. 3, pp. 99–106, (2015).

[3] Edla, P. J., Sonkar, N., Gupta, B., and Kumar, V., Solar water purifier for Indian villages – A review, International Journal of Engineering Research & Technology (IJERT), vol. 2, no. 6, 2013.

[4] M. S. Chander and M. Gowtham, "Concentrated Parabolic Solar Distiller integrated with latent heat storage material and mini solar pond," Int. J. Chem. Eng. Appl., vol. 2, no. 3, pp. 2–7, (2011).

[5] Zaman, S., Begum, A., Rabbani, K. S., and Bari, L., Low cost and sustainable surface water purification methods using Moringa seeds and scallop powder followed by bio-sand filtration, Water Science and Technology: Water Supply, vol. 17, no. 1, pp. 125-137, 2017.

[6] Nayar, K. G., Sundararaman, P., O'Connor, C. L., Schacherl, J., D., Heath, M. L., Gabriel, M. O., Shah, S. R., Wright, N. C., and Winter, A. G., Feasibility study of an electrodialysis system for in-home water desalination in urban India, Development Engineering 2, pp. 38-46, 2017.

[7] Yin, J., Zhu, G., and Deng, B., Graphene oxide (GO) enhanced polyamide (PA) thin-film nanocomposite (TFN) membrane for water purification, Desalination 379, pp. 93-101, 2016.

[8] Bolisetty, S., and Mezzenga. R., Amyloid–carbon hybrid membranes for universal water purification, Nature nanotechnology, vol. 11, no. 4, pp. 365, 2016.

[9] Deng, D., Aouad, W., Braff, W. A., Schlumpberger, S., Suss, M. E., and Bazant, M. Z., Water purification by shock electrodialysis: Deionization, filtration, separation, and disinfection, Desalination 357, pp. 77-83, 2015.

[10] Wendt, D. S., Orme, C. J., Mines, G. L., and Wilson, A. D., Energy requirements of the switchable polarity solvent forward osmosis (SPS-FO) water purification process, Desalination, 374, pp. 81-9.

[11[Kunduru, K. R., Nazarkovsky, M., Farah, S., Pawar, R. P., Basu, A., and Domb, A. J., Nanotechnology for water purification: applications of nanotechnology methods in wastewater treatment, Water Purification, pp. 33-74, 2017.

[12] Alsyouf, I., Alam, A. and Saidam, A., Implementing product design development methodology for assessing and improving the performance of products, International Journal on Interactive Design and Manufacturing (IJIDeM), Springer Paris, vol. 9, no. 3, pp. 225–234, 2015.

[13] Ward, J., A plastic solar water purifier with high output, Solar energy, 75(5), pp. 433-437, 2003.

[14]. Shannon, M. A., Bohn, P. W., Elimelech, M., Georgiadis, J. G., Mariñas, B. J., Mayes, A. M., 2008, "Science and Technology for Water Purification in the Coming Decades", Nature International Weekly Journal of Science, 452, pp.301-310.

[15] Duff, W. S., Clopper, A., Fagerston, K., Koski, A., Leak, A., Palenfo, R., Ruff, L., Simson,Z., Smith, B., and Ulrich, K., 2010, "A Passive Solar Water Purification System for Remote Areas of Afghanistan", 39th ASES National Solar Conference, 17, pp. 103-138.

[16] Kaushal, A., Varun, "Solar stills: A review", 2010, Renewable and Sustainable Energy Reviews, 14, pp. 446-453

[17] M. Gowtham, K. Richard Neiel, V. Nagarajan, P. Christhu Dass, and A. Thimothy Integrated Performance Analysis of Latent Heat Storage and Finned Type Solar Distiller IACSIT, International Journal of Engineering and Technology, Vol. 4, No. 5, October 2012

[18] Ozuomba J.O.1 , Edebeatu C.C.1, Opara M.F.2, Udoye M.C.3 and Okonkwo N.A.1 The Performance of a Solar Water Distillation Kit fabricated from Local materials Research Journal of Chemical Sciences ISSN 2231-606X Vol. 2(3), 64-67, March (2012).

[19] Carolina S.E. Sardella Evaluation of the implementation of the solar still principle on runoff water reservoirs in Budunbuto, Somalia. Thematic research MSc. Hydrology January 2012 AM_450129 12 ECTS. Solar still Distillation system, drinking water,

[20] Prof. Alpesh Mehta1, Arjun Vyas2, Nitin Bodar3, Dharmesh Lathiya4. Design of Solar Distillation System International Journal of Advanced Science and Technology Vol. 29, April 2011.solar still Distillation system, drinking water.

[21] Aayush Kaushal, Varun Solar stills: A review Renewable and Sustainable Energy Reviews 14 (2010) 446–453.

[22] K. Sampathkumara, T.V. Arjunanb, P. Pitchandia, P. Senthilkumarc. Active solar distillation a detailed review Renewable and Sustainable Energy Reviews 14 (2010) 1503–1526.

[23] John Ward a plastic solar water purifier with high output solar Energy 75 (2003) 433-437.