Fabrication of a Humidification-Dehumidification Desalination System

Abstract:

The proposed research will investigate new methods for the production of freshwater with conventional desalination methods such as MSF, ME, VC and RO to cope with the scarcity of freshwater. The proposed approach will make use of a small-scale desalination system which will be operated by heat pump operated on solar energy and can prove as a reliable solution of this problem. This Humidification-Dehumidification Desalination (HDH) system will consist of a humidifier, dehumidifier, pumps and piping's which will contain heated air or water. This research will potentially pave a way to give idea that this approach could be predominantly adopted to meet water deficiency problem due to its diverse advantages in operation, system construction and maintenance as well as its reliability on green energy sources will make it an environment-friendly and cost-effective technique.

Literature Review:

The water scarcity problem has resulted in a rising need of developing an efficient and economical desalination technology for production of fresh water, especially in developing countries [1]. Furthermore, the surface water (lakes and rivers) pollution caused by agricultural and industrial wastes and the large-scale contamination from sewage water limits the fitness of many freshwater resources [2]. Humidification–dehumidification (HDH) technology is an advanced desalination technology that has already received significant attention of researchers in recent years from all over the world [3]. Specific practices have been done for coupling the humidification-dehumidification cycles with power, refrigeration and other desalination techniques with aim of increasing the performance of combined cycle and increasing the amount of freshwater produced, power and cooling effect [4]. However, Desalination is a capital-intensive technique and consumes substantial amount of energy, since it's currently driven by fossil fuels energy throughout the globe and it could be a source of large C footprint [5]. In this regard, shifting towards green energy resources for desalination technology is must for today's world as for as future perspective [5]. Keeping in view the aspect of energy production, environmental sociability and economics, solar energy driven HDH procedure is considered to be the most reliable and desired system for production of fresh water locally [6] [7] in an environment friendly manner [8] with considerable low maintenance cost [9] [10]. The basic principle of HDH technique is that evaporation and condensation of sea water vapor from the moist air takes place in the main unit at ambient pressure and at temperatures between 40° to 85°C [11].

Research Questions:

1. What could be limitations in conducting feasibility reports for installing of HDH desalination units by considering different regions of the world with different climatic conditions?
2. Other than solar energy what could be different types of renewable energy sources

taking into account for the simultaneous application of HDH desalination unit?

3. What are different environmental and physical factors which can affect or slow down the functioning of HDH unit?
4. What is the theoretical and practical limit of desalination of sea water or production of fresh water by a normal sized HDH unit functioning for a specific time limit keeping in view its cost-effectiveness and environment-friendly behavior?

Rationale:

Over the past few decades, different technologies and techniques are being introduced for the production of fresh water and treatment of contaminated water resources. These technologies being costly, involving too much capita, land and labor are also threat for the environment because they are cause of depletion of natural resources. HDH will prove to be a key technology for getting plenty of fresh water on low cost and without affecting environment. This research aims to provide the fresh water by desalination of seawater with humidifier-dehumidifier and membrane separation technique by depending completely on solar energy other than thermal and nuclear energy sources which are being used conventionally. This process is supposed to be natural process as water extracted from sea will be evaporated with the help of heat energy received from the sun.

If successful, this research will pave the way for the production of fresh water by desalination of seawater by using of simple and environment-friendly technologies as seawater is largest but undrinkable source of water on earth.

Connection to the current body of knowledge:

Kasaeian et al. [12] concluded that fresh water desalinized by solar HDH is an economical technique as competing with fossil fuel driven units but solar HDH units have low efficiency. On the other hand, HDH units based on fossil fuels energy emit significant amount of GHGs. Partial research efforts have already investigated environmental impacts of HDD devices in various climates but not enough research is conducted on comparison of environmental impacts of solar and fossil fuel driven HDH plants. On the other hand, Photovoltaic (PV) panels have shown some capable potential for supplying required electricity to the plant and producing even extra electricity increasing economic feasibility of the project. This could possibly be used for the desalination of seawater as an emerging technique in future on large scale.

Amin et al. [13] conducted a research on solar assisted heat pump desalination system using single stage Multi-Effect Desalination (MED) technique. Solar evaporator collector in the heat pump worked as a mean to collect renewable energy and in this evaporator collector the fluid ender goes in two-phase and temperature in maintained under ambient temperature. The typical production of this technique was 1 kg/h and flashing contributed 60-70% of overall steam generation. This system effectively harnessed solar energy and ambient heat therefor the system can also desalinate water at night although its efficiency will be low at night. This technique could be used for small-scale desalination setups such as at rural equatorial regions which have plenty of sunshine.

Kabeel et al. [14] proposed an experimental investigation of solar hybrid desalination unit which consisted of HDH and a single staged flashing evaporation unit while this work was carried out

on a solar desalination prototype. They concluded that solar water heater efficiency is affected by nano-particle volume fraction and productivity of the system increases with the increase in water temperature and air flow rate. They also proposed that humidifier efficiency is increased or decreased by change in water mass flow rate rather than change in air mass flow rate and reaches about 98%. Within the studied range, maximum productivity of their system reached about 41.8 kg/day keeping in view the test and operational conditions.

Expected outcomes:

The outcome of this research will lead to understanding the careful consumption of freshwater resources and to efficient and environment-friendly techniques of desalination of seawater in areas facing water scarcity with use of multiple energy resources giving importance to renewable resources like solar energy.

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