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Examining Solar Energy's Potential for Use in Water Processes

Mr. Rajkishor Singh, Mr. Anil Kumar Joshi, Mr. Jitendra Kumar Singh Jadon
Shobhit Institute of Engineering and Technology (Deemed to be University), Meerut
Email id - rajkishore@shobhituniversity.ac.in, anil.joshi@shobhituniversity.ac.in, jitendra@shobhituniversity.ac.in,

ABSTRACT: Water shortages are anticipated to increase significantly as a result of an impending energy crisis brought on by the end of the oil era. Water difficulties are also anticipated to lead to increasing energy concerns, owing to the tight connection between water and energy issues. Environmental concerns, such as global warming, will almost certainly add to the pressure. In this scenario, renewable energies are rapidly increasing their contribution to the global mix, with solar energy clearly having the greatest potential, and given the worldwide coincidence that where there is water stress and/or scarcity, there is also good solar radiation levels, it seems clear that appropriate technologies must be developed to allow the use of solar energy to simulate water stress and/or scarcity. Solar desalination, solar detoxification, and solar disinfection are the three major solar energy applications for water processes described in this article.

KEYWORDS: Solar Energy, Solar Desalination, Solar Photo Catalysis, Solar Disinfection, Water Processes

INTRODUCTION

Power and water availability are generally acknowledged as the two most pressing problems that humanity will confront and address this century. While it is obvious that oil will lose its dominance in the next decades, it is unclear what energy source will take its place. Simultaneously, water shortage, which is currently a major worldwide issue, will become severe in the first half of this century. Energy and water issues are perhaps the most difficult to address scientifically of all the contemporary environmental issues [1]. Using an average of 1200 billion barrels and a current (rapidly rising) consumption rate of roughly 88 million barrels per day (approximately 32 billion barrels per year), the time period is obviously less than 40 years. Alternative primary energy sources are likewise difficult to come by. Nuclear power faces significant public opposition in many areas of the globe, as well as limited long-term fissionable uranium supplies and security concerns (possible weapon manufacturing) in many nations. Coal produces a lot of CO2 and has a lot of negative consequences for climate change[2]. If the energy outlook is concerning, the issues associated with water scarcity are much more so. With over 6700 million people on the planet today, approximately 600 million people are already suffering chronic water shortages, over 1 billion people lack access to clean drinking water, and unsafe water and inadequate sanitation are responsible for 80% of all illnesses in the developing world. As virtually all flowing surface water is already in use in many areas of the globe, and over-exploitation of groundwater resources will certainly grow, water tables in groundwater sources accessible to approximately one third of the world's population are dropping, in some instances by 1–3 m each year[3]. If current trends continue, by 2025, two out of every three people on the planet would be living in water-stressed regions, with the greatest effects occurring in dry developing nations, where average water availability per person will be just around 15% of what it was in 1950. Water provision for such huge people is therefore one of humanity's biggest problems today[4]. Water shortages are anticipated to increase significantly in the event of a future energy crisis. Water shortages, on the other hand, are anticipated to lead to increasing energy issues and exacerbate their effects due to

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the tight connection between water and energy. Environmental considerations, such as global warming, will undoubtedly add to the pressure[5]. The ramifications of this study are grave, since the water issue cannot be successfully handled without taking into account the implications for energy and projected human population increase. Within a few decades, not only will huge quantities of previously inaccessible water be required, but the energy required to generate it will also be scarce. As a result, there is no way to achieve a sustainable water and energy future without a significant contribution from renewables in general, and particularly solar energy, which has the greatest potential of all renewable energies[6]. This potential is clearly shown in the graph below, which depicts the projected theoretical, technical, and economic potential of various renewable energy resources, with a total technical capacity of about 85 TW. In 2005, the total primary energy consumption (11,435 MTOE) was equal to 15.18 TW, as previously stated. Global energy consumption is expected to be 25–30 TW in 2050, rising to 40–50 TW by 2100. Only solar energy has the potential to vastly exceed this figure until the possible advent of fusion energy in the far future (60 TW of technically feasible estimated potential). As a result, given that solar energy has the greatest potential of all renewables, and given the global coincidence that areas with water stress and/or shortage also have high amounts of solar radiation, the conclusion seems obvious. Appropriate technology must be developed to allow solar energy to be used to help address both energy and water issues at the same time[7]. The major solar water treatment applications, which are still being researched and developed scientifically and technologically. The latest United Nations Human Development Report 2006 warns that a rising shortage of fresh water per inhabitant in developing nations would lead to an unprecedented catastrophe in the future years. According to the report, the average global water supply per inhabitant would drop by one-third over the next twenty years, owing mostly to rising global population, pollution, and climate change. In the worst-case scenario, seven billion people in 60 nations would suffer a water scarcity in the second part of this century. Depending on variables like as the global population growth rate and the adoption of suitable remedial measures, this shortage would impact two billion people in 48 nations in the best-case scenario[7]. The answers to the issue of water scarcity range from required savings in all consumer sectors to the development of surface groundwater treatment methods and waste water reuse. There are, however, certain places on the globe very dry or remote that need outside assistance to grow. Desalination, particularly saltwater desalination, is suggested as one of the primary solutions to the issue in this instance. Because more than 70% of the world's population lives within a 70-kilometer radius of the oceans, desalination is often not only a viable but also the only practicable and practical choice[8]. The installed desalination capacity of the globe in 2003 was 37.75 hm3/day. Seawater accounts for 64% of this, with 10,350 plants capable of producing more than 100 m3/day[9]. Today, total desalinated water production meets the needs of about 100 million people. In many parts of the globe, such as the Persian Gulf, the Mediterranean Sea, and the Caribbean, seawater desalination has proven to be the sole option, and it is also a significant source of fresh water in many other places[10].

DISCUSSION

Despite recent improvements in energy efficiency, saltwater desalination continues to be a large consumer of fossil fuels. Furthermore, the bulk of these locations have abundant solar energy, and when considering the energy situation, the solar-driven desalination alternative not only appears reasonable but, in the medium term, absolutely essential. It is also obvious that more scientific and

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technical advancements are required to make them commercially viable. Indirect solar desalination, which involves connecting a conventional distillation plant to a solar collector field that provides the thermal energy needed for multi-stage flash (MSF) or multi-effect distillation, is the best choice for big desalinated water output volumes (MED). In the 1960s, conventional MSF facilities drove out MED systems due to cost and perceived efficiency, and only modest MED plants were constructed. However, interest in multi-effect distillation has resurfaced in the past decade, and the MED process is now competing with the MSF technique on both a technical and economic level. The ‘‘Enhanced Zero Discharge Seawater Desalination utilizing Hybrid Solar Method" project (AQUASOL) was recently completed, with the goal of creating a more cost-effective and energy-efficient MED solar desalination technology. The AQUASOL project was a continuation of earlier sun desalination research at the Plataforma Solar de Almera, which had been extensively published in a number of previous publications. The project centered on the development of certain technological elements that are anticipated to significantly enhance the current technical and economic efficiency of solar MED systems, lowering water production costs. Central receivers, parabolic troughs, parabolic dishes, and linear Fresnel systems are the four main kinds of solar power production being pushed worldwide for MW scale solar power generation utilizing Concentrating Solar Power (CSP) technology. They're all based on glass mirrors that monitor the sun's location in real time to achieve the appropriate concentration ratio. A tube specifically constructed to minimize heat loss absorbs the concentrated sunlight. In a conventional power cycle, a heat transfer fluid (e.g., oil) flows through the absorber tube and transmits the heat to a power cycle, where high-pressure, high-temperature steam is produced to spin a turbine. Direct steam generation has recently been utilized to generate electricity. For generating electricity and producing fresh water from saltwater, a variety of basic conventional co-generation power-desalting plant (CPDP) configurations are available: I MSF units that use steam derived from steam turbines or boilers; (ii) low-temperature multi-effect boiling (MED) units that use steam extracted from a turbine; and (iii) seawater RO desalting units that use energy from a steam power plant or a combined gas/steam power cycle. Most power plants in Gulf nations are co-generation power desalination facilities, which combine the three traditional desalination methods (MSF, MED, and RO) at various degrees. Many variables, including the necessary power to water ratio, the cost of fuel energy charged to the desalting process, electricity sales, construction expenses, and local regulations, would influence which system is preferred. Hybrid desalination systems, which combine both thermal and membrane desalination processes with power generating systems, have been touted as a cost-effective alternative to conventional dual-purpose evaporation facilities in recent years. Flexible operation, cheap construction cost, reduced specific energy consumption, high plant availability, and improved power and water matching are all characteristics of hybrid (membrane/thermal/power) configurations. Solar power-water co-generation facilities are therefore a highly appealing idea, since they have the ability to address both power and water issues in many arid and semi-arid regions of the globe. Combined gas and steam turbine cycles are the most efficient power generation technology for dual-purpose power and water facilities, while MED is the most efficient thermal desalination technique. As a result, combining a solar field with a combined cycle power plant in an integrated solar combined cycle power plant (ISCC) is a viable method to lower the cost of solar production by taking use of shared infrastructure and the steam turbine's economies of scale. While the solar to fossil production ratio in an ISCC is low, the absolute solar energy produced (in kWh) for a given additional investment is greater than in a solar Rankine cycle power plant. Although this configuration, in which a MED unit replaces a traditional water cooling system for turbine exhaust steam condensation, is one of the first basic CSP + D plant designs, it is not always the best, because the water produced does not always compensate for the reduction in electricity production. As a result, alternative options (such as combining combined cycles and heat pumps) are more appealing than the current one. The potential of a power plant is enormous, and much more so thermodynamically, and depending on the configuration chosen, completely reasonable. CSP is now a reality in places like Spain, and by 2025, it may cover 14% of MENA (Middle East and North African) nations' energy consumption. With a 57 percent share of the market by 2050, it may become the region's dominant power source.An anticipated cost of 8 to 15 cents per kilowatt-hour More R&D and demonstration would be required, but the sharp increase in oil prices, which is already pushing to lower the cost of conventional electricity and energy-intensive desalination systems, is a significant impetus behind such efforts, since CSP technology is a highly promising solution to the issue. The concentrated solar thermal collector array needed by these methods to desalinate 1 billion m3/year would be about 10 km x 10 km, or about 10 m3 of desalinated water per square meter of collector surface. The role of sunlight in the removal of synthetic chemicals from the environment has been well documented in recent papers, and "Advanced Oxidation Processes" (AOPs) have emerged as important hazardous water pollution treatment techniques, with an increasing number of technically and economically feasible applications. AOPs are often used to address severe water pollution and/or toxicity that cannot be handled naturally. All AOPs are based on the production of strong oxidant radicals, and ‘‘Photocatalytic Oxidation Processes" (PCOs), as well as other radical-promoting processes like plasma, electron-beam, and so on, are generally classified among the AOPs. The primary benefit of PCOs over other AOPs is their ability to use solar energy in the form of solar photons (e.g., in solar detoxification), which increases the environmental impact of deterioration. To far, heterogeneous TiO2 with persulfate enhancement and homogeneous Photo-Fenton have been the most extensively researched and developed PCO methods for sun purification of water effluents. Both methods utilize the most energetic portion of the solar spectrum, near ultraviolet/visible light, to activate a photo catalyst in the presence of oxygen, resulting in a highly powerful oxidation reaction. This produces hydroxyl radicals (OH), which attack any organic molecule in the media, eventually breaking bonds and converting them to carbon dioxide and water. The procedure works for complicated combinations of organic pollutants as well. Hazardous pollutants such phenols, agrochemical wastes, halogenated hydrocarbons, industrial pharmaceutical biocides, wood preservation waste, hazardous metal ions, cyanides, and aqueous weapons waste are only a few examples. Treatment of contaminated groundwater, seaport tank terminals, landfill cleanup, and other uses are also of interest. Batch operations are common in solar photocatalytic treatment facilities. To ensure that the organic destruction process takes occur in the best feasible circumstances, polluted water must first be pre-treated. The catalyst is then added, and the mixture is circulated through the chemical reactor (solar collector field) in batches until the pollutants have been degraded. Some potentially helpful chemical oxidants may be added to improve process efficiency depending on the type of the pollutants to be treated. After the procedure is finished, post-treatment operations must modify the water's chemistry to dischargeable levels. Post-treatment may be simplified to a simple pH adjustment and catalyst recovery when industrial wastewater is followed by biological treatment. The solar photocatalytic treatment plant's proposed design was created to treat wastewater from recycled pesticide bottles. The water used to clean the pesticide bottles is treated in batches until the TOC content reaches 80%. The water is then moved to the post-treatment (iron precipitation,

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sedimentation, and recuperation) stage, where it is either reused for bottle cleaning or released for irrigation after passing through an activated carbon filter to guarantee water purity. The recycled water is fed back into the system to cleanse the shredded plastic until the TOC reaches 100 mg L—1. Water may be reused up to ten times in this closed cycle before being discharged. About 95% of the pollutants are mineralized, while the remaining 5% is removed using a granulated activated carbon filter. In 150 m2 of CPC solar reactors, the solar photo-catalytic treatment plant is equipped with a completely automated control treatment circuit that is constantly exposed to sunshine. The water is transported to the catalyst separation tank after the required destruction has been reached, and the treatment circuit is refilled with fresh wastewater to be treated, repeating the process. All operational processes and sequences are controlled by a programmable logic controller. Initial market studies indicate that this amazing environmental technology has a wide range of applications, with pesticide treatment being one of the most promising. systems with the bare minimum of operating and upkeep needs The availability of sunlight is used to determine the degree of water treatment. The partial oxidation of hazardous chemicals by AOPs has been found to significantly enhance wastewater biodegradability, accounting for around 75% of the total volume. Despite the fact that AOPs for wastewater treatment have been shown to be very efficient, their operation is still rather costly (tens of s/m3). As a result, the combination of a solar AOP as a preliminary treatment, followed by a low-cost bio treatment, seems to be a cost-effective alternative. One of the most predictable causes of early mortality in the world is poor-quality drinking water or insufficient treatment. This is due to the fact that water is one of the most common carriers of disease. Polluted drinking water, according to the World Health Organization, is responsible for approximately five million fatalities per year globally and is a deadly childhood risk factor. Every 8 seconds, a kid dies from an illness caused by water contamination. And this isn't only an issue in poor nations. Even in OCDE nations, outbreaks of these illnesses are common. Chlorination, in which diluted chlorine or gas effectively fights viruses and bacteria, is the most widely used disinfection technique. These techniques, on the other hand, produce extremely hazardous by-products including trihalomethanes and other carcinogenic chemicals.

The bactericidal action of solar radiation in 1877, and it uses the ultraviolet region of the solar spectrum, which is restricted to wavelengths above 290 nm. The solar height determines the instantaneous sun irradiation at a particular place, which may vary by a factor of 2–100. UV light makes up less than ten percent of all solar energy that reaches the Earth's surface, and only a tiny portion of it is effective for water disinfection. Despite this, much has been written on using just sun radiation to cure water polluted by organic chemicals and bacteria. It has been shown to kill a significant number of organic and pathogenic organisms while avoiding the harmful by-products associated with traditional methods. Due to light dispersion, the rate of bacterial decontamination by solar radiation is related to radiation intensity and temperature, but inversely proportional to water depth. The quantity of radiation absorbed is determined by the wavelength range. For example, the decrease is less than 5% m—1 depth between 200 and 400 nm, while it may be up to 40% m—1 at longer wavelengths. The wavelengths in the near UV-A spectrum (320–400 nm) are the most damaging to microbial life, while the spectral range from 400 to 490 nm is the least hazardous. Similarly, variations in bacterial inactivation rates between 12 and 40 8C are insignificant, but as the temperature rises to 50 8C, the bactericidal action is enhanced twice, most likely owing to the synergetic impact of radiation and temperature. Sunlight is absorbed by photosensitizers in the water, which subsequently react with oxygen to produce highly reactive oxygen molecules like hydrogen peroxide and superoxide dismutase, which disinfect the water. Although SODIS has only been tested for a few viruses, its efficacy against numerous viral, protozoan, and helminthic diseases found in Sub-Saharan Africa and poor nations in general is unknown. Another use of solar energy that has the potential to be significant.

CONCLUSION

The twentieth century saw unparalleled progress in human history, with significant advances in all fields of science and technology. Those advances, however, were not free, and the price paid in certain instances, and from some perspectives, was enormous. The human population has quadrupled in the past 100 years (from 1.6 billion people in 1900 to over 6 billion at present). However, over the same time period, water use increased by nine times and energy consumption increased by sixteen times, both with significant environmental and natural resource deterioration. Water, energy, and the oxygen we breathe are the three components that make life and civilization possible (obviously, linked). At this time, there is broad agreement on the negative effect that over-exploitation of resources is having on our planet's delicate environment, straining (if not already beyond) the planet's capacity for sustainability. As a result, this development, which has been and continues to be plainly unsustainable, must become ecologically friendly, with sustainable development defined as that which meets current needs without jeopardizing the requirements of future generations. The following three key components are deemed required to break the present worrisome vicious cycle of necessary growth and limited resources: (a) fresh ideas that the majority of people can use; (b) more effective and ecologically friendly innovative technology; and (c) political demand and policies to put them into action. In this context, renewable energies in general, and solar energy in particular, which has the greatest potential of all renewables, are called upon to play a critical role in achieving the objective of sustainable development. Associated technologies have the potential to offer not just electricity and water, but also economic growth and jobs in many Sunbelt regions throughout the globe. Although costs are currently greater than those of other traditional technologies, a concerted worldwide effort in research, development, and demonstration may quickly close the gap. Other reasons that have influenced the development of all of these solar energy technologies related to water processes and applications include rising oil prices and environmental concerns.

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