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Article

Water Desalination With Renewable Energy

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Abstract: Many countries suffer from a severe shortage of freshwater resources, leading to an increasing reliance on water-from-air (WFA) extraction technologies. Water is used for various purposes, including 10%–12% for direct human consumption, 70%–75% for irrigation, and 15% for industrial purposes. With the projected increase in water demand worldwide, alternative energy sources must be found. However, conventional desalination processes are energy-intensive and primarily fueled by fossil fuels, increasing carbon emissions. This article discusses the use of renewable energy sources, such as solar, wind, geothermal, and agricultural waste, in desalination system design, the purpose of energy expenditure, and the environmental impacts. It also addresses current issues and possible solutions in this field. According to our research, desalination and renewable energy together significantly lower carbon emissions while also improving the sustainability of water delivery systems. The study also emphasizes how crucial cutting-edge technologies like HESS and ML are to improving the effectiveness of desalination procedures based on renewable energy. The ultimate goal of this research is to encourage the worldwide use of desalination systems based on renewable energy sources and assist upcoming research and development initiatives.

Keywords: activated charcoal, barley, bacterial cane, adsorption.

1. Introduction

One of the biggest problems facing the world today is freshwater shortage, particularly in arid and semi-arid areas. One practical solution to this issue is desalination [1]. However, a significant barrier is the high energy costs associated with desalination [2]. Hence, the importance of integrating renewable energy with desalination technologies to achieve environmental and economic sustainability [3]. 10%–12% of water is utilized directly for human use, 70%–75% is used for irrigation, and 15% is used for industry. To solve the freshwater issue, more water sources must be discovered since the world's water consumption is predicted to rise. Desalination may be used to recover this water, making it a valuable water resource [4]. Due to population growth, the world's water consumption, which is currently 4,600 km3 per year, is predicted to rise to 5,500–6,000 km3 annually by 2050 [5]. The Falkenmark Index states that surface water resources are deemed very limited if they are fewer than 500 m3 per capita per year and scarce if they are between 500 and 1,000 m3 per capita annually [6]. Water shortages are already a problem in many MENA nations, and this issue has to be resolved [7]. A diverse approach is required to investigate the world of desalination systems driven by renewable energy, including the application of renewable energy for desalination in various geographical locations and technological contexts. The range of potentialities to be explored and researched is growing [8].

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Collectively, these initiatives advance knowledge of the opportunities, challenges, and advancements related to using renewable energy for desalination. This group endeavor seeks to explore the intricate relationship between water and energy resources and advance sustainable water supply solutions. This study, however, seeks to transcend current limitations in order to present a thorough assessment of the current status of desalination research and technical procedures, taking into consideration the wide range of renewable energy sources that support these advancements. The use of agricultural wastes, membrane distillation (MD), forward osmosis (FO), humidification-dehumidification (HDH), reverse osmosis (RO), and the possibility of synergistic hybridization between these technologies all of which rely on renewable energy sources are also important topics covered in this work. With the use of advancements in renewable energy, our effort aims to advance our common understanding and map the development of desalination techniques[9].

Common Desalination Technologies

Reverse Osmosis (RO) Desalination: The most widely used, operating under high pressure to separate salts. Multi-Stage Distillation (MSF) and Flash Evaporation (MED) Desalination: These rely on heat to evaporate the brine and then condense it. Activated carbon can also be used to remove impurities from agricultural waste.

Renewable Energy Sources Used in Desalination

Solar Energy: Can be used to operate RO systems to generate heat for distillation.

Wind Energy: Suitable for providing electricity in coastal locations.

Geothermal Energy: A reliable source of heat in volcanic regions.

Bioenergy and Wave Energy: Still in the research and development stages, they are promising.

Converting agricultural waste into activated carbon using solar energy or a thermal reactor powered by renewable energy.

Using Solar Energy in the Thermal Generation Process.

Solar energy is the most common use globally and has the highest potential for desalination using renewable energy, whether by thermal or electrical means. In the GCC region, solar energy is the fastest-growing technology, accounting for 98% of renewable energy. The primary solar energy technology is concentrated solar power (CSP). Concentrated solar power (CSP) systems collect and concentrate solar energy and direct normal radiation (DNI) to produce thermal energy, which is used to generate steam to power conventional thermal power systems that convert thermal energy into electrical energy [10]. The primary CSP technologies are the parabolic collector, the central solar tower, the linear Fresnel reflector, and the parabolic dish. CSP technologies can be integrated with existing thermal power plants, relying solely on solar fields to produce the thermal energy used in the desalination and adsorbent manufacturing process. This configuration also offers the advantage of generating renewable and dispatchable electricity while reducing the overall investment cost. CSP systems can also be integrated with thermal desalination units used to burn and dry adsorbents used in desalination experiments, resulting in reduced electrical energy consumption [11].

2. Materials and Methods

Equipment Used

Device Name and Type

Oven Burning: Carbolit, England

The sensitive balance of Sartorius BL210s

JENWAY pH Meter 3310

Shimadzu's FT-IR-8300 Infrared Spectrophotometer

Measurements

BS-11 Shaker Lab Companion

HP-3000 Magnetic Stirrer Lab Companion

Preparing the raw material

The raw material, consisting of sugarcane husks and barley husks, which are agricultural waste, was collected from the Samarra district of Salah al-Din Governorate, Al-Mu'tasim sub-district. Weighing and removing suspended impurities were performed. The material was placed in water at room temperature, then slightly raised in the sun. The suspended particles in the material were decomposed and dried. The material was then ground into a medium-sized powder. After that, the particles were washed on filter paper to remove impurities. After that, we dried them by putting them in a thermal oven set at 130°C for 30 minutes in order to eliminate any remaining moisture. The result was a soluble substance devoid of suspended contaminants. Activated charcoal was produced in the Physical Chemistry Laboratory of the College of Science at Tikrit University.

Charcoal carbonization, activation, and last cleaning

In a ceramic crucible, 40 milliliters of a 0.1% sodium hydroxide solution were combined with 40 grams of powdered dry charcoal. The result was a uniform paste. The crucible was mixed and then heated to 800°C for an hour in a kiln. The crucible was left outside the kiln after it had been burned. The final product was crushed after cooling. The prepared charcoal was converted into activated charcoal. By transferring samples to an infrared (IR) instrument, the activation process was verified. The active groups that developed during activation were noted, and each sample was examined both before and after activation. To verify the charcoal activation, samples of the manufactured charcoal were brought to an infrared device. The favorable results of the measurements performed using this apparatus validated the activation process with active groups on the charcoal. The charcoal following activation is seen in Figure 1 below.

Figure 1. shows activated charcoal.

Adsorption of inorganic elements using natural adsorbents.

Table 1 and Figure 2 display the percentage of adsorption and the chromium and cadmium concentrations before and after bagasse adsorption.

Table 1. Changes in Metal Ion Concentrations Before and After Adsorption

Element	Concentration before adsorption	Concentration after adsorption	Adsorption percentage
Cr	10ppm	3.1ppm	%69
Cd	10ppm	1.17ppm	%88.3

Adsorption of inorganic elements using natural adsorbents.

Table 2 and Figure 3 determines the percentage of adsorption and displays the concentrations of chromium and cadmium before and after adsorption using barley husk charcoal. The adsorption capacity of bagasse-based adsorbents for chromium and cadmium ions was measured and is presented in Table 1 and graphically depicted in Figure 2 and Figure 3. These results indicate the effectiveness of natural adsorbents in removing toxic heavy metals from aqueous solutions.

Table 2. Comparison of Adsorption Efficiency of Cr and Cd Ions from Aqueous Solutions

Element	Concentration before adsorption	Concentration after adsorption	Adsorption percentage
Cr	10ppm	2.1ppm	79%
Cd	10ppm	3.01ppm	69.9%

Figure 2 illustrates the calibration curve for chromium, depicting a linear relationship between concentration and absorbance. The regression equation y=0.0104x+0.0036y = 0.0104x + 0.0036y=0.0104x+0.0036 with a correlation coefficient R2=0.9985R^2 = 0.9985R2=0.9985 indicates high linearity and reliability for quantitative chromium analysis using spectrophotometric methods.

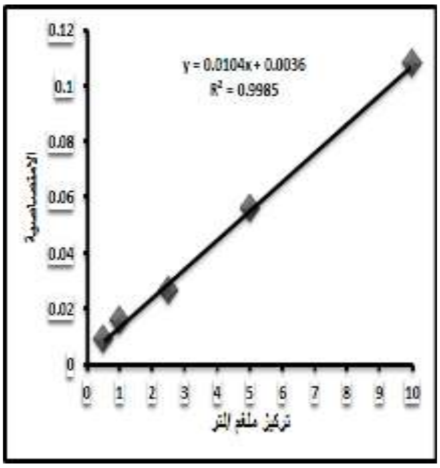

Figure 2: Chromium calibration curve.

Figure 3 presents the calibration curve for cadmium, demonstrating a strong linear correlation between absorbance and concentration. The regression equation y=0.1132x−0.0254y = 0.1132x - 0.0254y=0.1132x−0.0254 and high determination coefficient R2=0.999R^2 = 0.999R2=0.999 confirm the method's accuracy and suitability for quantitative cadmium analysis via spectrophotometry.

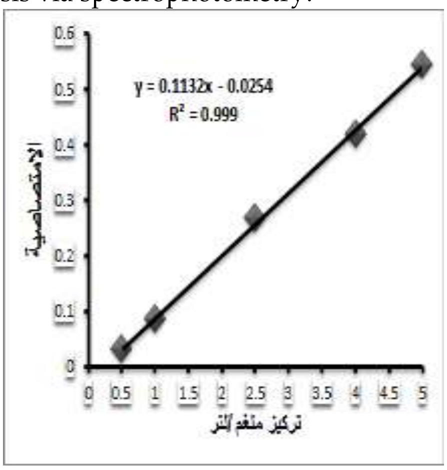

Figure 3: Calibration curve for cadmium

3. Results and Discussion

It is essential to develop new technologies and improve existing ones to address the issues associated with desalination in a more environmentally sustainable manner. These technologies must specifically address pollution, corrosion, and sedimentation. From an energy-supply perspective, it is essential to facilitate the transition from fossil fuels to alternative energy [12].

The widespread use of renewable energy sources is one possible way to stimulate this transition. Furthermore, converting agricultural wastes that are not useful for water into materials that can be used for water purification and desalination is a key issue in the field of water dechlorination . We used agricultural wastes, such as corn husks and pumpkin husks, as well as activated charcoal, which is used to purify water from impurities. Among the components, chromium and cadmium were tested, and these were then removed to a high degree, resulting in treatment rates ranging from 69% to 88% [13].

This percentage is theoretically limited to around 40% and can be increased by repeated adsorption of the same sample. Concentrated solar power technologies are integrated. These technologies rely solely on solar energy sources to produce thermal energy used to create adsorbents for water dehydration. This configuration is associated with a lower overall investment cost. For example, the source of adsorbents is agricultural waste, which, if not reused, could lead to environmental pollution [14].

Consequently, these waste materials have been reused and converted into materials that can be used for adsorbents, such as charcoal. After simple processing, charcoal has proven effective in removing contaminants from water, including chromium and cadmium, resulting in purified water. This addresses a significant problem [15].

4. Conclusion

Desalination techniques that use renewable energy are a viable and sustainable way to deliver water in the future. For these ideas to be widely adopted in the desalination industry more quickly, funding and regulatory backing are required. Numerous research have been carried out, with an emphasis on the removal of some unwanted contaminants from water by the use of renewable energy. The study's primary findings support the benefits of using agricultural wastes like barley and reed husks to remove contaminants and desalinate water, particularly wastewater. This approach offers a coordinated strategy to minimize the effects of water contamination on living things generally, increase the efficiency of desalination, and lessen environmental effects. The necessity of using sophisticated control techniques to forecast performance is also emphasized by this study. Based on energy management parameters and predictive control approaches, a pumping system can achieve optimal control, according to a number of recent research articles. This helps desalination facilities run as efficiently as possible.

Last but not least, integrating renewable energy sources with cutting-edge desalination technology is crucial to attaining sustainable water management.

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