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Reducing Fossil Fuel Consumption by Incorporating Renewable Energy Sources in Wastewater Treatment Processes

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Abstract. Various types of aqueous solutions are disposed of in residential, institutional, commercial, and industrial buildings. The wastewater must be treated to remove pathogens (bacteria, viruses), nutrients (nitrogen, phosphorus), and other compounds in order to maintain public health and the environment. Accumulation of untreated sewage can result in a wide range of nuisances.
Most of Israel's wastewater is purified and used for irrigation every year, which amounts to 530 million cubic meters. Approximately 80 percent of wastewater recovered in Israel is recycled. By treating wastewater appropriately, agriculture, tourism, gardening, and industry can benefit. The presence of raw sewage in settlements with no sewage collection or transportation networks continues to pose a great threat even today.
There is a significant energy consumption associated with wastewater treatment processes. In this study, solar energy was attempted to be integrated as a renewable energy source.
With Renewable Energy Sources integrated into the process, costs will be reduced, and it will also be possible to establish decentralized facilities in areas without proper infrastructure for traditional treatment methods.

Key words. Renewable Energy, Solar Energy, Innovative, Wastewater treatment.

1. Introduction

Renewable energy refers to energy sources that are replenished naturally and can be used indefinitely. These include solar, wind, geothermal, hydro, and biopower. Industrial applications for renewable energy include using solar panels to power factories, using wind turbines to generate electricity for manufacturing facilities, and using biopower (such as biofuels) to fuel industrial vehicles and equipment. Additionally, many industries are starting to use renewable energy to offset their fossil fuel use and reduce their carbon footprint. Additional industrial applications of renewable energy include Solar thermal: Using solar energy to generate heat for industrial processes, such as drying, cooking, and sterilization.
Hydroelectric: Generating electricity from the movement of water, often used in the production of aluminium, paper, and textiles.
Geothermal: Using heat from the Earth to generate electricity, and also used in heating and cooling buildings.
Biomass: Using organic matter, such as wood, crops, and waste, to generate electricity and heat.
Tidal and wave energy: Generating electricity from the movement of ocean waves and tides, mainly used in coastal areas.
Biofuels: Using organic matter to create liquid fuels that can power industrial vehicles and equipment. Fuel cells: Using chemical reactions to generate electricity, mainly used in data centres, telecommunications, and manufacturing facilities. Overall, renewable energy can be integrated into many different industrial processes and can help reduce dependence on fossil fuels and decrease greenhouse gas emissions.

Residential, institutional, commercial, and industrial buildings dispose of wastewater composed of various types of aqueous solutions. To maintain public health and the environment, wastewater must be treated to remove pathogens (bacteria, viruses), nutrients (nitrogen, phosphorus), and other compounds. Various nuisances can result from the accumulation of untreated sewage.
Each year, Israel produces 530 million cubic meters of wastewater, most of which is purified and used for irrigation. Israel has the highest wastewater recovery rate in the world, at about 80 percent. Agricultural irrigation, tourism, gardening, and industry can then benefit from wastewater treated accordingly. Even today, raw sewage poses a great danger in settlements isolated from the rest of the world or places without sewage collection and transportation networks.
A significant amount of energy is consumed in wastewater treatment processes. An attempt was made in this study to integrate solar energy as a renewable energy source.
With solar energy integrated into the process, costs will be reduced, and it will also be possible to establish decentralized facilities in areas without proper infrastructure for traditional treatment methods.
Bacteria and organic load in wastewater appear to be decreasing according to the results obtained.

1.1. Wastewater Treatment

Wastewater treatment processes typically involve a combination of physical, chemical, and biological processes to remove pollutants and contaminants from wastewater. The specific processes used can vary depending on the quality of the incoming wastewater and the desired degree of treatment. Here are some of the common wastewater treatment processes: removal of large objects, and removal of small, heavy particles, such as sand and gravel. Suspended solids and organic matter are removed from wastewater using sedimentation tanks. Biological processes are used to remove organic matter and nutrients, such as nitrogen and phosphorus, from the wastewater and then treatment to remove remaining impurities, such as dissolved solids, nitrogen, and phosphorus. Wastewater treatment processes are designed to remove pollutants and contaminants from wastewater, using a combination of physical, chemical, and biological processes. The processes used depend on the quality of the incoming wastewater and the desired degree of treatment.

1.2. Renewable Energy

The Energy field is thriving. This is due to several factors: the world energy crisis, political trends that create a rise in oil prices, and other environmental topics. All of these have brought about the emergence of new and fascinating fields dealing with Energy [1]. Over the years, there has been an increase in demand for electrical power [2]. Such demands require fossil-fuel power stations to burn more fuel. This causes heavy air pollution, which is detrimental to the environment and our health. We are rapidly approaching the point of no return in terms of air pollution. Renewable energy and energy efficiency technologies are key to creating a clean energy future [3].

1.2.1 Solar Energy

Solar energy is clean energy. It produces no hazardous solid, liquid, or gaseous wastes. It does not create water or air pollution. Direct production of electricity using sunlight is accomplished using photovoltaic cells, also called solar cells. They have no moving parts and are “clean” energy. A major limitation is the cost, which greatly exceeds the cost of producing electricity using fossil fuels or nuclear power [3]. Thin film solar cells use layers of semiconductor materials only a few micrometres thick. Thin film technology has made it possible for solar cells to now double as rooftop shingles, roof tiles, building facades, or the glazing for skylights or atria. The solar cell version of items such as shingles offers the same protection and durability as ordinary asphalt shingles. Some solar cells are designed to operate with concentrated sunlight. These cells are built into concentrating collectors that use a lens to focus the sunlight onto the cells. This approach has both advantages and disadvantages compared with flat-plate PV arrays. The main idea is to use very little of the expensive semiconducting PV material while collecting as much sunlight as possible. But because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the country. Some concentrating collectors are designed to be mounted on simple tracking devices, but most require sophisticated tracking devices, which further limit their use to electric utilities, industries, and large buildings. The performance of a solar cell is measured in terms of its efficiency at turning sunlight into electricity [4]. Only sunlight of certain energies will work efficiently to create electricity, and much of it is reflected or absorbed by the material that makes up the cell. Because of this, a typical commercial solar cell has an efficiency of 15%-about one-sixth of the sunlight striking the cell generates electricity. Low efficiencies mean that larger arrays are needed, and that means higher costs. Improving solar cell efficiencies while holding down the cost per cell is an important goal of the PV industry [5-6].

Solar energy can be integrated into the wastewater treatment process in the following ways: Photovoltaic panels: Solar panels can be installed to generate electricity for the treatment plant's operation and energy needs. Solar drying: Solar energy can be used to dry and treat sludge, a byproduct of wastewater treatment. Solar pumping: Solar energy can power pumps used in the treatment process, reducing the need for traditional energy sources. Solar disinfection: UV rays from the sun can be harnessed to disinfect the treated water, reducing the need for chemical disinfectants. Solar-powered aeration: Solar energy can be used to power aeration systems, which improve the efficiency of biological wastewater treatment processes.

These are some of the ways that solar energy can be integrated into the wastewater treatment process, helping to reduce energy costs and make the treatment process more sustainable and environmentally friendly.

2. Local wastewater treatment system

A local wastewater treatment system, also known as a decentralized wastewater treatment system, is a system that treats wastewater from individual households, businesses, or small communities at or near the point of generation. In contrast to a centralized wastewater treatment system, where wastewater from a large area is collected and treated at a single location, local wastewater treatment systems treat wastewater locally, often on-site or nearby, before it is discharged into the environment. Local wastewater treatment systems come in various forms, such as septic systems, aerated wastewater treatment systems, and constructed wetlands. These systems use various treatment processes, such as sedimentation, biological treatment, and disinfection, to treat wastewater and remove pollutants before it is discharged. Decentralized wastewater treatment systems can provide several benefits, including reduced construction and maintenance costs, improved wastewater treatment efficiency, and reduced energy consumption and greenhouse gas emissions. However, proper design, installation, and maintenance of these systems are critical to ensure effective and reliable treatment of wastewater and the protection of public health and the environment.

In this study, the feasibility of small wastewater treatment systems that would be suitable for treating the wastewater of a single-family unit or a small cluster of family units, depending on the conditions of the area and the amount of wastewater produced, was designed and tested. The designed facilities were ordered from a local energy production system that could also be a prototype for wastewater treatment facilities for emergency use.

2.1. System structure

A small distributed wastewater treatment system was established under field conditions. The system was established in southern Israel, near the city of Keith Malachi. An area characterized by solar radiation, typical of Israel.

For energy production, 3 solar panels were placed towards the south measuring 0.63m on 0.41m and at an angle of 31°. The three solar panels are connected to the DC TO DC charge controller which receives the voltage generated from the solar panels and charges a battery of 24v batteries connected in parallel to each other. The batteries are connected to a voltage converter from 24v to 220v with a power of 600w. The voltage converter will provide alternating current for the pumps, lighting, and controller (Fig. 1). A GPRS-type GS828-H2 cellular controller will be installed to monitor and control the filtration system. This controller will transmit control data with the help of a cellular SIM to a server where the data will be saved and analyzed. The controller can receive analog and digital data on the system.

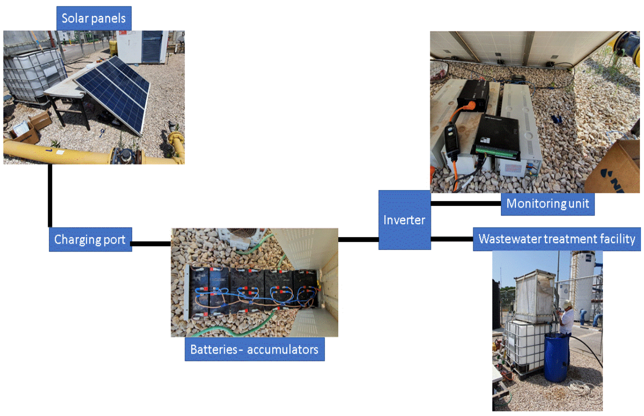

Fig. 1. System structure

3. Results

The energy consumption of a wastewater treatment facility can vary widely depending on several factors such as the size of the facility, the treatment processes used, and the degree of treatment required.

The energy consumption of a wastewater treatment facility is a significant expense, both in terms of cost and environmental impact. Therefore, efforts to improve energy efficiency and reduce energy consumption can have significant benefits for both the facility and the environment.

The energy consumption of this model typical wastewater treatment plant is 10 kWh per capita per year. This estimate includes the energy consumption required for various treatment processes such as aeration, pumping, and solids handling. Following the use of a solar system, the consumption of fossil energy decreased by about 40%-55%.

This decrease did not affect the quality of the effluent received at the facility.

The turbidity of wastewater is a measure of the number of suspended particles and solids in the water. In general, higher turbidity levels in wastewater indicate poorer water quality, suggesting that the water contains more pollutants and suspended solids.

Turbidity is often caused by suspended solids such as sediment, organic matter, and bacteria. These particles can make the water appear cloudy or murky and reduce the amount of light that can pass through the water.

In wastewater treatment, measuring the turbidity of influent (incoming) and effluent (outgoing) water can help determine the treatment process's effectiveness. For example, if the influent water has a high turbidity level, it may indicate that the treatment plant is not effectively removing suspended solids. Similarly, if the effluent water has a high turbidity level, it may indicate that the treatment plant is not removing pollutants effectively and releasing contaminated water back into the environment.

In order to evaluate the efficiency and effectiveness of the system, several parameters of the wastewater were measured. We continuously monitor the effluent temperature, Ph, and flow rate. The turbidity values of the wastewater were measured (Fig. 2).

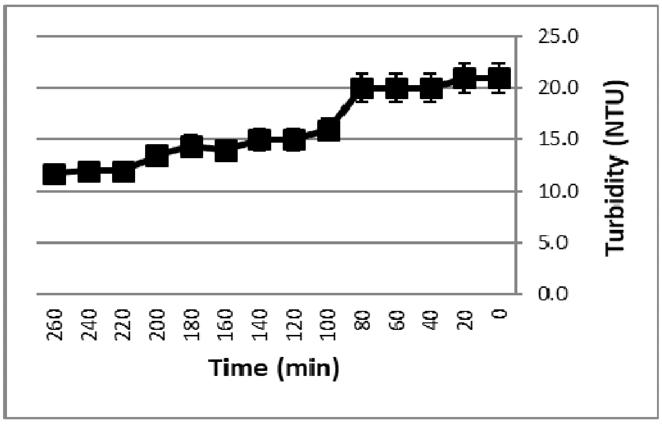

Fig. 2. Turbidity (NTU)

The turbidity of wastewater is an important indicator of its quality, as higher turbidity levels typically indicate a greater amount of suspended solids and pollutants present in the water. From Figure 2, it appears that the turbidity of the raw sewage, 21.5 NTU, this turbidity decreases somewhat in the first 80 minutes. After 100 minutes, the turbidity drops to 16 NTU and after another 160 minutes, 260 minutes from the start of the experiment, the turbidity drops to 12 NTU. The decrease in the turbidity of the wastewater implies an increase in its quality.

4. Conclusion

Reducing fossil energy consumption in wastewater treatment contributes to a more sustainable and environmentally friendly process in the following ways: Climate change: Reducing the use of fossil fuels, such as coal, oil, and natural gas, helps to reduce greenhouse gas emissions, which are major contributors to climate change. Energy independence: By reducing the use of non-renewable energy sources, the treatment process becomes less dependent on external sources of energy and more self-sufficient. Cost savings: Fossil fuels are becoming increasingly expensive, and reducing consumption can lead to lower energy costs for the treatment process. Improved air quality: Burning fossil fuels releases air pollutants that can negatively impact public health, so reducing consumption can improve air quality. By reducing fossil energy consumption in the wastewater treatment process, it becomes more sustainable and less reliant on non-renewable resources, leading to long-term benefits for the environment and communities. The use of renewable energy in energy-demanding processes contributes to sustainability and reduces dependence on non-renewable resources. By using renewable energy sources in energy-demanding processes, it is possible to reduce dependence on non-renewable resources, lower greenhouse gas emissions, and make the process more sustainable and environmentally friendly. We present, in this research, a way to treat wastewater, using renewable energy. These facilities can be used as small local facilities or treatment facilities in places with no energy supply or infrastructure. More processes are required to design the treatment process itself in order to obtain effluent suitable for use.

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