RENEWABLE ENERGY BASED DESALINATION TO ADDRESS WATER SCARCITY IN COASTAL AREAS OF KOZHIKODE

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ABSTRACT
A survey was conducted in coastal areas Beypore, Vellayil, West Hill, Puthiyappa, Koyilandy, Payyoli, and Chambal via social media platforms like Facebook, WhatsApp, and Instagram. The questionnaire contains questions about the water scarcity faced in coastal areas and also about the possible way to solve this issue. About 90% of the people informed that their area experiences a variation of rainfall pattern and also have saline intrusion in their wells. People who have taken the survey recommended that the desalination process may solve the water scarcity in coastal areas. Based on the survey. The paper reviews various desalination technologies using non-conventional sources such as solar, wind, and geothermal energy that can be implemented in coastal areas of Kozhikode to solve the problem of water scarcity.

1.0 INTRODUCTION

1.1 Availability of Drinking Water in Coastal Areas of Kozhikode

With wells and other water resources drying up due to the depletion of groundwater levels, the coastal villages of the Kozhikode district face severe water shortages. Many families are facing severe shortages of drinking water, as the supply of drinking water through the Kerala Water Authority (KWA) pipelines is also interrupted at times. The lack of preparatory action by local self-government bodies and KWA to start water supplies using tanker trucks is also causing inconvenience to many families living along the coastline. Drinking water shortages are severe in the areas of Beypore, Vellayil, West Hill, Puthiyappa, Koyilandy, Payyoli, and Chombal along the coast of Kozhikode. A lot of wells have dried up. Saltwater intrusion into well water is another major issue along the coast. Many wells in the Payyoli and Thikkodi areas have become unusable due to salinity. Thus there is a need for drinking water in coastal areas of Kozhikode. (The Times of India, 2019)

1.2 Saline Water Intrusion in Wells

Saltwater intrusion is the upstream movement of brackish or saline water that causes salt and other seawater-derived ions to rise above natural background levels (Herbert et al., 2015). The increase in global sea level has the potential to affect tidal freshwater wetlands by modifying their hydroperiod and pushing the salt upstream so that these systems are exposed to more saline waters. These are most common in coastal areas. Similarly, decreases in river discharge caused by changes in watershed precipitation and/or anthropogenic activities (e.g. dam construction) that reduce river flow can lead to increased salinity in the freshwater. Future changes in salinity in a given freshwater wetland will depend on the position of the wetland on the current salinity gradient, sea-level rise rates, and changes in river discharge. Both rising sea levels and the discharge of rivers are affected by global warming (Burkett et al., 2001). Thus there is a need for desalination of saltwater to acquire pure drinking water.

1.3 Renewable Energy (RE) Usage for Desalination.

An enormous amount of energy is needed for the desalination process, which helps to overcome the problem of water scarcity. Currently, this energy is mainly derived from the combustion of fossil fuels, which are depleting day by day and are unsafe for the environment as they emit carbon dioxide (CO_2), a greenhouse gas. By incorporating and exploiting various renewable energy (RE) sources, energy sustainability can be improved with current desalination technologies. In remote regions, a desalination system based on RE is the best option for desalination where electricity supply is not stable. Various non-conventional energy sources, such as solar, wind, wave, and tidal energy, can be used to produce electrical energy for desalination power plants. Desalination using biomass and geothermal energy is still at the stage of development. Geothermal desalination requires less maintenance and output than the RO method. This is because, throughout the year, the temperature of the ground remains constant below a certain depth (Kalogirou SA et al., 2005). A plant that uses RO technology to burn fossil fuels produces 2.79 kg of CO_2, 3.38 g of nitrogen oxides, 3.25 g of sulfur oxides, and 0.93 g of non-methane volatile organic compounds per m3 of water. However, a plant that uses wind energy as fuel produces 0.11 kg of CO2, 0.42 g of nitrogen oxides, 1.80–2 g of sulfur oxides, and 0.08–0.07 g of non-methane volatile organic oxides. A plant that uses photovoltaic energy as a fuel produces 0.34–0.90 kg of CO2, 1–2.10 g of nitrogen oxides, 4.73–16.15 g of sulfur oxides, and 0.36–0.72 g of non-methane volatile organic compounds per m3 of water. A plant that uses hydro energy as fuel produces 0.082 kg of CO2, 0.24 g of nitrogen oxides, 1.68 g of sulfur oxides, and 0.05 g of non-methane volatile organic compounds per m3 of water. In the future, the desalination industry will depend on renewable energy sources due to the limited and continuous depletion of fossil fuels and their associated negative environmental impacts (Raluy RG and Serra L,2005).

2.0 RESEARCH METHODOLOGIES

A detailed questionnaire consisting of about 6 important questions were sent to people living in coastal areas Beypore, Vellayil, West Hill, Puthiyappa, Koyilandy, Payyoli, and Chambal via social media platforms like Facebook, WhatsApp, and Instagram. The questionnaire was in the format of a google form in which the individuals can either fill their responses or write a short description. The survey was taken among 200 people from the above-mentioned areas.

2.1 Study Questions

The following questions were asked to the people in Coastal areas.

1. Are you experiencing water shortages in your residential areas?
2. What is the major reason you believe is the cause of water scarcity?
3. What quantity of water is required by you daily?
4. Is rainfall pattern varying in your area?
5. Is there saline intrusion in your wells?
6. Can you suggest any method that may solve the water scarcity in coastal areas?

3.0 RESEARCH ANALYSIS

A survey was taken among the people of Beypore, Vellayil, West Hill, Puthiyappa, Koyilandy, Payyoli, and Chambal in the Kozhikode district of Kerala on the availability of fresh drinking water in these coastal areas. The majority of the people who completed the survey agreed on the fact that they face acute water scarcity. About 45% of the people believe that water scarcity is due to change in climatic conditions, 50% believe that depletion of natural resources is the cause for it, 5% of the people marked the reason unknown. Average daily consumption of water was most commonly marked around 4 liters per person. About 90% of the people informed that their area experiences a variation of rainfall pattern and also have saline intrusion in their wells. They also recommended desalination as an apt solution for solving the drinking water problem in coastal areas.

4.0 LITERATURE REVIEW

4.1 Review of Desalination Technologies.

Indirect desalination systems

In the desalination sector, solar illumination is used to convert energy to heat and transfer it to fluid so that it can flow through a concentrated or non-concentrated collector. A brief description of various types of collectors, such as flat plate collectors, evacuated tube collectors, and concentrated collectors, is provided in the study conducted by Kalogirou SA, which explains the optical, thermal and thermodynamic analysis of the collectors, along with various applications such as water heating, space heating, desalination, solar furnace, refrigeration, and others. The recent developments in seawater desalination using various renewable energy sources such as thermal solar energy, solar photovoltaic energy, wind power, biomass, geothermal, and ocean energy are presented in the study conducted by Garcia-Rodriguez L.

Solar photovoltaic (PV) with RO desalination technology

In the urban areas where water scarcity is more and electrical grid connection is not available, PV coupled RO technology is a promising desalination unit (Garg MC, Joshi H, 2015). To get fresh-water from the RO process, it is reported that there is a requirement of 1 t of oil/year to produce 1 m3 of pure water/day (Garcia-Rodriguez L,2002). For a PV-RO desalination plant with a capacity of 120–12 m3/day, the cost of water from the system is INR 583.36–2119.97/m3 (Al-Karaghouli A, Renne D, 2010). According to published reports, the cost of water from PV-RO brackish water desalination unit with a water capacity of 250 m3/day is IN5 529.99/m3 (Garg MC, Joshi H, 2015). PV-RO can be used for both sea and brackish water desalination systems and in recent years the technology has attained much attention at a small scale level. The energy requirement for the desalination process to get fresh water from brackish water is very less when compared to the seawater desalination technique. This is because the brackish water has less osmotic pressure than fresh-water and hence the requirement of the number of PV panels for incident solar illumination is less in brackish-water PV-RO units than seawater PV-RO units. Hence the total cost of water from brackish-water PV-RO unit is lesser than seawater PV-RO unit (Garcia-Rodriguez L,2002). However, for the smooth operation of RO units, lots of chemicals and machine parts are essential, which need capital investment. Further, skilled labor is essential to maintain the pumps and for the pre-treatment of membranes to avoid fouling. Despite these disadvantages, from the technical point of view, the PVRO is a commercially available matured technology (Abdallah S, Abu-Hilal M, 2008)

Solar photovoltaic (PV) with ED/Electrodialysis reversal (EDR) desalination technology

ED combined with PV is an attractive technology as it requires only direct current (DC) power for the electrodes, DC/AC power for low-pressure pumps, and is suitable for various climatic conditions. The EDR is similar to the ED technique, except that the electrode periodically reverses its polarity with time, thereby changing the current flow. Both ED and EDR methods are used in brackish water desalination with TDS up to 5000 ppm and this technique is not feasible for concentrations above 5000 ppm. For feed water with salinity ranges between 1500 and 3500 ppm, the total energy required for an ED unit is between 1.50–4 kWh/m3. The cost of water from the PV-ED desalination unit ranges from INR 1169 to 423/m3. For PV-EDR plants with a capacity of less than 100 m3/day, the energy consumption is 3–4 kWh/m3. However, although the brackish water recovery rate is high, the technology is subject to both technical and economic constraints due to higher capital costs, cost membranes, short membrane life, and excessive energy consumption (Garg MC, Joshi H, 2015).

Geothermal desalination

Geothermal energy originates in the core of the Earth, which is almost like that. 4000 miles below the surface of the earth. Main sources of this kind of energy. They are hydrothermal, geo pressurized brine, hot dry rocks, and magma. Geothermal desalination involves the use of high-temperature geothermal fluids for the production of freshwater from the subsurface. This method is reliable and provides a stable supply of geothermal energy (Heat) throughout the day, ensuring the stability of the geothermal system Desalination as water produced by this technique is of high quality. Studies on desalination using geothermal energy began in the early 1970s by the Office of Reclamation of the United States of America (USA) Department (Isaka M.,2012.)Best efforts have been made to provide a brief review of the various geothermal projects from 1979 to 2012 (Awerbuch L, Lindemuth TE,1976). Literature(Michelle LSZ and Palmer A, 2013) reports that geothermal-RO desalination is a cost-effective technology in GCC countries by varying the quality of the water supply and the operating life of the geothermal desalination system. Queensland geothermal energy center of excellence has estimated that a geothermal plant having 1000–1,00,000 m3/day capacity can produce water at a rate of INR 53.36–106.73/m3. Kimilos and Milos Islands, Greece, had a pilot project on a geothermal desalination unit coupled with a MED unit with a freshwater production capacity of 80 m3/h and a power generator capacity of 470 kW. Almost 7% of geothermal energy is used to generate electricity from the plant. However, the geothermal desalination units are subject to certain limitations as the resource is only available at certain locations where the transport of geothermal or desalination water adds capital costs and operational complexity.
(Loutatidou S, Arafat HA, 2015)

Wind desalination

Areas with high potential for wind energy, such as islands and higher altitude zones, can be used to derive wind energy for the desalination process to produce fresh water. The main problem of wind energy is its unpredictable and intermittent nature. The hybrid combination of wind and any other RE technology can therefore be used for the production of freshwater (Subramani A and Badruzzaman M, 2010). The location of the source is also dependent and the storage of wind energy using batteries increases the cost of capital (Dehmas DA and Kherba N, 2010). Integrating wind energy with desalination processes began in the early 1980s. A case study was conducted in (Kalogirou SA, 2005)on the RO Seawater Wind Power Plant and the RETScreen Clean Energy Management (RETScreen) software used to find out the environmental benefits of the region. The annual energy production of the 10 MW plant is 17,673 MWh and at local conditions is 16,800 MWh. A wind-based desalination unit coupled with RO technology has been operating on the Greek island since 2007 with a capacity of 3360 m3/day. The cost of the water sold by the company to the municipality was INR 147.67/m3. The wind desalination unit coupled to the MED and MVC systems was analyzed where the MED system was powered by solar collectors and the MVC energy was derived from the wind turbines. The cost of water from a facility with a capacity of 100 m3/h was INR 48.25/m3. A wind-energy desalination is a reasonable option when coupled with other RE technologies to overcome the country's anticipated future energy and water scarcity problems. (Ma Q, Lu H, 2011)

Wave power desalination

Wave powered desalination is an economically viable solution for areas with high energy waves. Based on the wave energy converter used, wave-powered desalination units can be categorized into two desalination technologies, RO and VC. Wave-powered desalination units are mainly based on both direct and indirect methods. The indirect method generates electricity from the tide and uses this energy to power the desalination plant. Direct method couples wave-powered units with

MVC or RO technology (Fernández-López C and Viedma A, 2007). The first wave desalination unit was developed and tested by researchers at Delaware University in the Caribbean in 1982. The unit is small consisting of a wave pump and RO unit with a capacity of 2 m3/day (Folley M and Peñate Suarez, 2008). India commissioned the first wave of indirect desalination Unit at Vizhinjam, a natural port located near the international shipping routes of Thiruvananthapuram, Kerala, India, in 2004. This unit derives energy from the RO plant with a capacity of 10 m3/day to meet the water needs of the fishing community in the locality (Davies PA., 2005). The literature analyzes an autonomous wave-powered desalination plant where the cost of water is INR 51.17/m3, which is similar to that of a standard desalination unit. The advantage of using wave desalination units is that the system does not have to convert pressurized water to electricity and back to water. The plant has a lot of technological barriers and, most importantly, has high investment costs(Folley M and Whittaker T, 2009). Besides, energy storage devices are required to deliver regular power output due to high tide and low tide, special structural engineering architecture is also required for offshore plants to withstand high energy waves. This technology can be applied to remote areas where access to water and electricity is remote and negligible. More research and development is needed to combine RE technologies with desalination units to help reduce water scarcity (López I and Andreu J, 2013).

5.0 CONCLUSION AND RECOMMENDATION

An inquiry into the availability of fresh drinking water in these coastal areas was conducted among the people of Beypore, Vellayil, West Hill, Puthiyappa, Koyilandy, Payyoli, and Chambal in the Kerala district of Kozhikode. The majority of the people who completed the survey agreed that they were short of acute water scarcity. Approximately 45 percent of people believe that water scarcity is due to climate change, 50 percent believe that depletion of natural resources is the cause, and 5 percent of people do not the actual reason. The average daily water consumption was mostly about 900 liters per household. Roughly 90% of the citizens accepted that the rainfall patterns vary and that saline contamination is also present in their wells. They also advise that desalination in coastal areas is a viable solution for solving the issue of drinking water. In this paper, various desalination technologies using renewable energy as a power source are reviewed. Taking full advantage of India's geographical position the renewable energy sources available to us are solar, geothermal, wind, and other sources of energy. The primary energy source for combining with desalination should be wave technology and Solar-powered desalination systems with low carbon emissions and are ideal for salt and brackish locations where waters are supplied with ample sunshine. Most geothermal energy sources for desalination are concentrated on the northern side of India and the southern part of India is surrounded by oceans and can be economically unsustainable. So such a desalination plant that uses geothermal energy cannot be set up in Kozhikode coastal areas. Desalination using wind energy is an intelligent technology as most of the southern states have huge wind potential. Finally, there is a huge potential of tidal wave energy coupled with desalination as India has a sprawling coastline measuring 7517 km. In India, groundwater recharge and exploitation are the most relevant reasons for water shortage expected in the decades to come. Renewable energy sources, including solar, wind, and tidal waves with technology for desalination can solve this situation and are also atmosphere friendly and viable. Almost 6 Lakh liters of water is required by the people of above mentioned areas in a daily basis. This can be achieved by implementing desalination plants working on renewable energies in these areas. Respective Government authorities should encourage community based organizations to establish decentralized water supply using desalination plants, and must providy subsidy and load through banks for their establishments. For a developing country like India, renewable energy is driven desalination technology is a suitable competitive alternative for generating freshwater to meet the future freshwater requirement.

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