Lecture Notes in Civil Engineering

Rafid Al Khaddar
N. D. Kaushika
S. K. Singh
R. K. Tomar *Editors*

Advances in Energy and Environment

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Editors

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Preface

The present global objective in civil engineering is to meet the ever-growing demand to handle rising population, various energy–environmental concerns and safety of structures and its inhabitants. The 3rd International Conference on "Trends and Recent Advancement in Civil Engineering" (TRACE) was hosted by Department of Civil Engineering during 20th and 21st August 2020 at Amity University, Uttar Pradesh, Noida, India.

TRACE 2020 focused on advances and rapid evolution of various areas in civil engineering. The conference witnessed participation and presentation of research papers (topical reviews and original articles) from academia, industry expert and researchers from R&D centres from India and abroad. The conference proceedings was classified into three titles:

- Advances in Energy and Environment
- Advances in Geotechnics and Structural Engineering
- Advances in Water Resources and Transportation Engineering

The title *Advances in Energy and Environment* covers papers on contemporary renewable energy and environmental technologies which include water purification, water distribution network, use of solar energy for electricity production, waste management, greening of buildings and air quality analysis. In all twenty-three papers have been selected for publication. It is believed that this collection will be useful to fairly wide spectrum of audience like researchers, application engineers and industry managers.

Liverpool, UK — Rafid Al Khaddar
New Delhi, India — N. D. Kaushika
New Delhi, India — S. K. Singh
Noida, India — R. K. Tomar

Acknowledgements

The conference was organized to fulfil the vision of honourable Dr. Ashok K. Chauhan, Founder President of Ritnand Balved Education Foundation (RBEF), and under the able leadership of honourable Dr. Atul Chauhan, Chancellor, Amity University, Uttar Pradesh, Noida, India. I am also thankful to Honorable Vice Chancellor, Dr. Balvinder Shukla for giving us platform and all the support required for successful conduct and our Jt. HOI's for guiding us by providing vital inputs. I am honored to organize this prestigious conference which connected world's foremost industries with top most academia.

I express my sincerest thanks to all the lead speakers and authors for their original research papers contribution. I also express thanks to all the reviewers for their cooperation in the review process. I am happy to express my deep sense of gratitude to our publication sponsor Springer Nature for publishing the conference proceedings.

I express my gratitude towards all our sponsors: Academic Partners: Liverpool John Moores University, UK; Tribhuvan University, Nepal and Rowan University, USA; Industry Partner: J K Cement Ltd., Defense Infrastructure Planning and Management (DIPM) Council of India; Knowledge Partners: Institution of Civil Engineers, India; Bentley Systems India Pvt. Ltd., Women in Science & Engineering (WISE), India and Indian Geotechnical Society (IGS), Delhi.

Finally, I compliment my team for their hard work and enthusiasm to make TRACE 2020 a success story. I am confident that TRACE 2020 will allow exciting and meaningful conversations, partnerships and collaborations in construction technology and infrastructure growth.

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About the Editors

Dr. Rafid Al Khaddar has extensive experience in Water and Environmental Engineering, with special expertise in wastewater treatment methods. He graduated from the University of Basra, Iraq, as a civil engineer, and obtained his Masters and Ph.D. in Civil Engineering Hydraulics from the University of Strathclyde, Glasgow, UK. He is currently Professor and Head of the Department of Civil Engineering at Liverpool John Moores University where he manages 27 staff and 900 students, who are enrolled in various courses such as HNC, B.Eng., M.Eng., M.Sc. and Ph.D. The Department runs fully accredited degrees by the Institution of Civil Engineers in the UK, and he led a number of these accreditations. He has maintained a very strong link with the UK Water and Environmental industry in order to stay involved with any new developments in the aforementioned fields. He was President of the Chartered Institution of Water and Environmental Management (CIWEM) in 2015–2016. He is also Fellow of the Institution and Honorary Vice President of the Institution. He has developed a number of collaborative programmes with International Universities with the University of Babylon (Iraq), International College for Business and Technology (Sri Lanka) and Oryx Global University (Qatar). He has published over 170 publications in peer-reviewed journals and international conferences. He has managed to attract over £1.5 Million in research and consultancy funding since the year 2000.

Dr. N. D. Kaushika, Formerly Professor, Centre for Energy Studies, Indian Institute of Technology Delhi, and subsequently Director of reputed engineering institutions in Delhi and National Capital Region, is a specialist in renewable energy and environment. He is a recipient of the Hariom Prerit S. S. Bhatnagar Research Endowment Award for research in energy conservation in 1987. Currently, he is Visiting Research Professor at the Institute of Technological Engineering and Research of SOA University, Bhubaneswar, India. He is an author of five books and has contributed articles in several reputed journals and book chapters in several books by international publishers.

Dr. S. K. Singh is Professor and Dean, at Delhi Technological University (DTU), Delhi. He has obtained his Ph.D. from BITS, Pilani, and M.Tech. from IIT (BHU), Varanasi, and B.E. from Gorakhpur University having first division with distinction throughout. He is engaged in teaching, research, administration and consultancy for the last 31 years and is presently Professor of Civil and Environmental Engineering for the last 20 years at DTU, Delhi. He is also Independent Director, WAPCOS Limited (A Mini Ratna-I PSU, GOI). He has guided 12 Ph.D.s, about 65 M.Tech. theses and more than 150 UG Projects. He has participated in various national and international conferences, published more than 214 research papers in national and international journals of repute and authored 04 books. He has provided technical assistance as Member to groups of experts, set up for determining polluting industries in NCT of Delhi; examining proposals for establishing degree/diploma level technical institutions in NCT of Delhi; evaluation of projects for the Department of Science and Technology (DST), Ministry of Environment and Forest, GOI; Member of Board of Governors, CSMRS, Ministry of Water Resources, GOI; Chairman, Departmental Promotion Committee, IASRI (ICAR) New Delhi; Member, University Court, University of Delhi; Expert Member, Equivalence Committee, UPSC, New Delhi; Advisor, Selection Committee for recruitment at UPSC, New Delhi; Technical Expert for various committees of MoEFCC, GOI; Expert Member, DST, GOI; Member, Expert Committee, CAPART, Ministry of Rural Development, Government of India. He has received felicitations and awards by professional bodies such as APJ Abdul Kalam Award 2016, Rashtriya Shiksha Gaurav Puraskar 2014; International Felicitation and WEC-IIEE-IAEWP Environmental Award; Rashtriya Samman Puraskar 2005; Excellent Services Award; Clean Up The Earth Award; Eminent Personality Award.

Dr. R. K. Tomar received his Ph.D. from the Indian Institute of Technology (IIT) Delhi and is currently, Head of the Department of Civil Engineering, Amity School of Engineering and Technology, Amity University, India. His research interests include artificial intelligence applications in buildings and sustainable built environment. He has a combined experience of 30 years in industry and academia in various capacities. He has published several research articles in international peer-reviewed journals. He is also guiding students for Ph.D. in the field of Energy and Built Environment.

Proposed Modification of Solar Still Using PCM for Purification of Ground Water

Harsha Yadav, Apurv Yadav, and Asha Anish Madhavan

Abstract The advent of industrialization increased the problems of water scarcity and groundwater degradation. Solar stills are robust devices to produce fresh water from contaminated. The low productivity of these devices limits their widespread commercial usage. This drawback could be enhanced by the utilization of phase change nanocomposite materials. This paper proposes a design for the modification of solar still by using both nanocomposites and solar photovoltaic energy. The integration of both these approaches will enhance the effectiveness of the process and will increase the productivity of solar stills.

Keywords Groundwater · Solar still · Heat storage · Phase change materials · Nanoparticles

1 Introduction

Overexploitation of groundwater due to industrial development leads to its degradation and increases its salinity [1]. This reduces the already depleting freshwater present in the land. Potable water scarcity is one of the greatest challenges around the world, because of the increasing water demand and the decreasing availability of pure natural water resources [2]. Many commercial water purifying plants are used that run on the energy supplied by diesel or electricity generated from fossil fuels [3]. This also leads to an increase in pollution and global warming. Hence more and more renewable energy-based techniques are considered [4]. Biodiesels are also being considered to power purification systems and new biodiesels are being explored [5, 6]. The most promising method for the purification of water is the use of solar stills [7]. Since long solar distillation has been considered as an economical and an easy to implement method for brackish water treatment [8]. Around 2.3 MJ/kg

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amount of energy is required for the evaporation of water [9]. Although it is more strenuous than reverse osmosis, it is advantageous that it does not need energy in terms of electrical power but as heat; dense medium distillation can be also conducted and it is almost no maintenance device [10]. In practical application, solar distillation is much cheaper than reverse osmosis.

2 Solar Stills

A solar still is an insulated container of water covered by a transparent glass from the top. The glass is slanted generally at an angle equal to the latitude location [11]. The sunlight enters this container through the glass and heats the water. The water evaporated and the vapors condense on the inner side of the glass surface and then the droplets trickle down to a collector tray. The contaminants are left behind at the bottom of the container. All types of solar stills follow the common basic working principle. A fundamental schematic of solar still is shown in Fig. 1.

The efficiency of the solar still, η, is given by

$$\eta = I_{\text{utilized}} / I_{\text{incident}} \tag{1}$$

where I_{utilized} is the ratio of the amount of solar radiation utilized for evaporation and.

I_{incident} is the total amount of radiation incident on the still.

The approximate daily output (l/day) from solar still can be found by

$$P = \eta I_G A / 2.3 \tag{2}$$

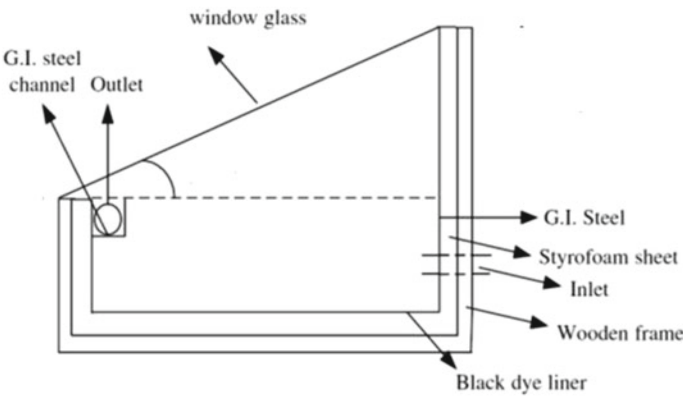

Fig. 1 Single basin solar still printed with permission from Elsevier [12]

where P is the daily output, A is the aperture area of the solar still in m^2, and I_G denotes the global solar irradiation in MJ/m^2 [13]. Although it is a robust, simple, and reliable device, and it has low productivity. Therefore, many researchers have focused on limiting this drawback [14, 15]. The output of a solar still can be increased by increasing its operating hours. The most promising method is the use of phase change materials (PCM) as absorbers in solar still.

3 Phase Change Materials Integrated Solar Stills

The most effective method of improving productivity was found out to be storing of sun's heat energy during the day and its release at night when there is no sun. Phase change materials (PCM) are energy storage materials that possess the properties of isothermal heat storage and retrieval [16]. Radhawan [17] incorporated a PCM absorber layer in a stepped solar still. A uniform still temperature and daily efficiency of 57% were obtained. El-Sebaii et al. [18] did a similar experiment in a simple solar still investigate its performance. The still operation continued during the night also and high efficiency of 85.2% was attained. PCM was found to be effective in both the systems. As the difference in temperature between the basin water and tilted glass cover is increased, it led to higher heat transfer rates. Also, a substantial amount of the heat is accumulated by the PCM in comparison to the heat rejection to surroundings in case of simple still. During the night, PCM is hotter in comparison to the basin water; therefore, the flow of heat takes place from PCM to water, consequently evaporating the water. This increases the nocturnal productivity of the still. PCM integration in a solar still is shown in Fig. 2.

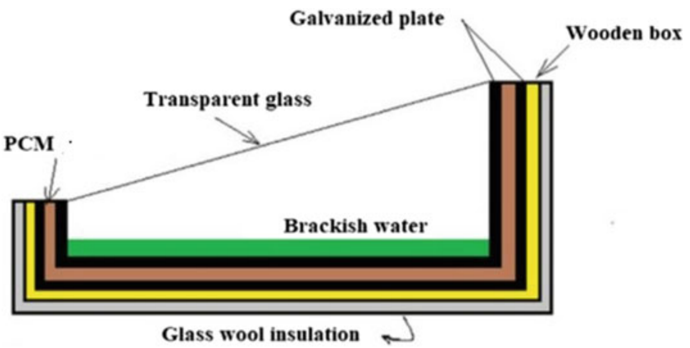

Fig. 2 Solar still with PCM integration printed with permission from Elsevier [19]

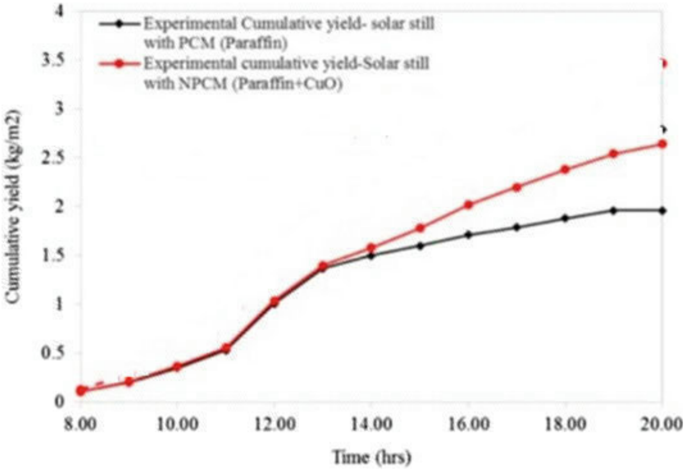

Fig. 3 Increased productivity of solar still by nanoparticle enhanced PCM printed with permission from Elsevier [25]

4 Nanoparticle Enhanced Phase Change Materials

However, the application of PCM does not provide the desired results at night due to their poor thermal conductivity. This limitation could be eliminated by the inclusion of nanoparticles in PCM [20]. Adding highly conductive nanoparticles in PCM increases the effective thermal conductivity of composites and paves a way for higher heat transfer rates [21–23]. The addition of alumina nanoparticles in the absorber PCM of a dual-slope solar still increased its productivity by 12% [24]. Rufuss et al. [25] discovered that the impregnating copper oxide nanoparticles in paraffin PCM used as an absorber layer in a solar still improves the still productivity by 35%. The performance of the solar still with and without nanoparticles in PCM is shown in Fig. 3.

Carbon-based nanomaterials have proven to be more effective in PCM as apart from high thermal conductivity they possess an additional perk of low density [26, 27].

5 Proposed Design

Hot inlet water supply is beneficial for the productivity of solar still [28]. Many integrations have been used with the solar stills to heat the water before it enters the still [29]. Groundwater can be pumped to the solar still with the help of solar panels. The rise in solar panel temperature decreases its efficiency; therefore, its cooling will increase its output [30]. This work proposes the integration of a modified solar

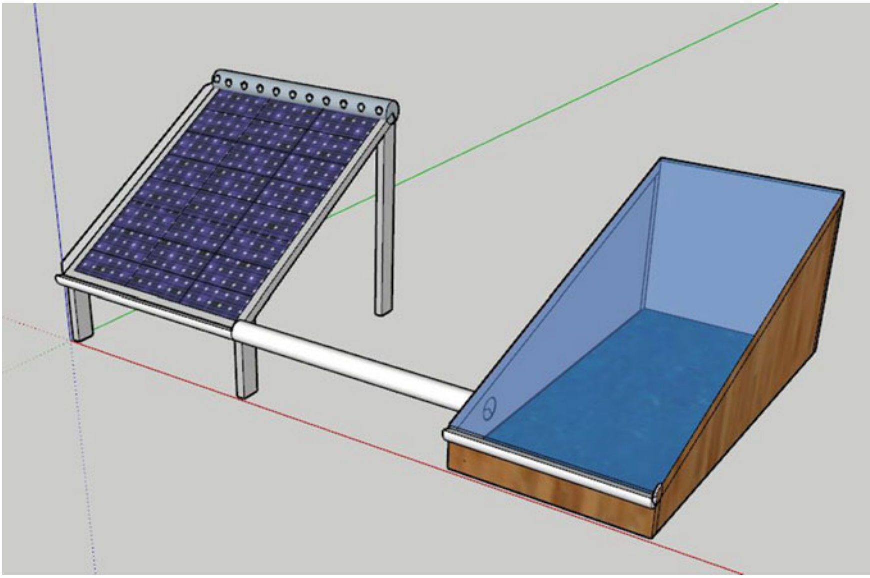

Fig. 4 Proposed solar panel integrated solar still design

panel with the solar stills as presented in Fig. 4. The design involves the installation of cooling pipes akin to a solar thermal collector at the back of the panel. These pipes will receive the cooling water from the groundwater which will be pumped with the help of a DC pump powered by the panel itself. The water running through the metal pipes in contact with the panel will absorb heat from the panel and reduce the excess temperature. This heated water will enter the solar still and get collected in the basin. Due to the high water temperature, the evaporation rate will be higher than the normal setup.

Also, a paraffin PCM layer enhanced with carbon-based nanoparticle will be fitted at the bottom of the basin to act as an energy storage layer. In nocturnal hours, the operation of the solar panel will cease and water can no longer receive heat from sunlight. However, the heating of water will continue due to stored heat in the PCM as discussed in the previous section.

6 Conclusion

The salinity of groundwater is a global issue that renders it unfit for human consumption. Solar still is a method of purification of water but pumping water into it requires electrical power. Also, the productivity of solar still is very low. This work proposes a modification in the design of a solar still for the purification of groundwater. The supply of groundwater and purification will be powered by solar photovoltaic and solar thermal energy, respectively. This system will be self-sufficient and the setup can be installed in remote or rural areas. Further modification and validation through the experimental setup will increase in prospects of this design.

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An Approach for Reclamation of Salinity Affected Lands for Bio-energy Production

Himanshu Tyagi and Anupriya Goyal

Abstract Vast arable tracts are suffering from soil alkalinity/salinity. Such marginal lands need to be rehabilitated through eco-friendly and socio-economically viable technologies. The approach being presented here suggests rejuvenation of such wastelands through plantation of salt-resistant trees like Jatropha and Pongamia pinnata which are also known for being a biodiesel source. This model is not only effective in recovering salty soils but can go a long way in making villages bioenergy hub.

Keywords Wasteland · Soil salinity · Biodiesel · Jatropha · Pongamia pinnata

1 Introduction

Due to finite land resources, land and energy security is of utmost importance. But with ever-increasing human needs, the supply of land and land-linked products is far lagging behind their disproportionate demand [1]. In population-rich nations like India, this shortfall has resulted in over exploitation of land resources and continuous decline in per capita cultivable land due to formation of numerous patches of degraded lands affected by desertification, erosion, salinity, water logging, etc. [2].

For instance, approximately 6309.10 km^2 area in India is affected from varying degrees of salt problems attributable to climate change and anthropogenic influences [2]. As can be observed from Table 1, these wastelands are spread predominantly over Indian states/union territories of Andhra Pradesh, Bihar, Daman and Diu, Gujarat, Haryana, Jammu and Kashmir, Karnataka, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, and West Bengal [2].

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Table 1 Salinity-affected states/union territories of India

State/union territory	Area affected by strong/medium salinity/alkalinity (In sq. km)
Andhra Pradesh	1150.03
Bihar	1.33
Daman and Diu	3.13
Gujarat	763.52
Haryana	65.62
Jammu and Kashmir	181.34
Karnataka	398.36
Maharashtra	52.41
Odisha	26.27
Punjab	20.66
Rajasthan	799.01
Tamil Nadu	279.78
Telangana	434.99
Uttar Pradesh	2129.61
West Bengal	3.04
Total	**6309.10**

Source Wasteland Atlas of India—2019

2 Soil Salinity and Its Origins

The salinity-affected lands have surplus soluble salts and high exchangeable Sodium [3]. Such lands have predominance of sodium carbonates and bicarbonates [4]. Alkaline soils can be identified through white or grayish-white salt efflorescence in dry seasons [5]. These soils appear in different shades of white tone with fine to coarse texture on false color composite satellite images [6]. Prosopis juliflora, Acacia nilotica, Capparis aphylla, Cynodon dactylon, etc., are indicator plants for these areas [6]. Based on the physio-chemical properties and the salt characteristics, salinity-affected soils are categorized as saline, sodic and saline–sodic [7].

Soil salinity primarily happens due to capillary movement of water through the soil profile during extreme climatic conditions, leaving a coating of accumulated salts on the surface. Chemical weathering of rocks results in release of dissolvable salts that get deposited in the lower soil layers via downward movement of soil water [8]. But these salts again move up to the soil surface when the water evaporates. This way salts also get deposited in the root zone during water table fluctuations. Further, scanty rainfall and high temperature of arid regions do not allow leaching of soluble weathered products [9]. Additionally, excessive irrigation through poor quality water and use of basic fertilizers like sodium nitrate may also develop soil salinity [10].

3 Adverse Effects of Salinity

Salt-affected marginal lands do not give decent crop yields and experience water stagnation due to poor drainage [11]. Salinity also affects the water quality and makes soil erosion prone due to weak vegetation [12]. It also results in sedimentation issues and spoils infrastructure.

4 Management of Salt-Affected Areas

Saline wastelands can only be revitalized by removal of salts from the root zone. Adequate leaching requirement in irrigation efficiency can prevent soil from turning saline. Artificial drainage may be provided in places where use of leaching is limited. Drip and sprinkler irrigation systems can also be engaged to dilute the salt content by high soil moisture [13]. Furthermore, application of organic mulch slows surface evaporation and may decrease salt movement by evaporative water [14]. Though very tedious, scraping off highly saline patches can also be employed.

Because of high pH in saline soils, many plant nutrients are fixed up in unavailable forms. So, manure application can remove this deficiency of organic matter and improve soil fertility. If saline salt contains a little amount of sodium, gypsum is needed to displace sodium [15]. Further, molasses can be applied on the affected soils as on fermentation it produces organic acids that can reduce alkalinity [16]. The use of some acidifying fertilizers can also help in reducing the salt toxicity.

In addition to the above-mentioned remedial measures, plantation of salt-resistance crops may also help in rehabilitating the salty soils [17–20]. Trees like Jatropha, Pongamia pinnata, Arjun, Palash, and certain types of babool (Australian babool, babool, vilayati babool) are known for being tolerant to the saline conditions [21–23].

5 Suggested Model

In fast-developing countries which have limited fossil resources, it is imperative to explore new avenues of sustainable energy for uninterrupted progress of the nation. Recovered wastelands possess enormous potential for supporting energy needs, especially in rural areas [24, 25]. Therefore, in this communication, a case is being made to revive saline wastelands through cultivation of established salt-resistant trees like Jatropha and Pongamia pinnata which can double up as a biofuel source too. The adoption of this innovative technology will not only bring wastelands back to their productive capabilities, but will also support agro-forestry and energy needs.

Ahamed et al. [26] reviewed biodiesel production from abundantly available non-edible oils of Jatropha, Karanja, and Castor and found biodiesel to be an ideal substitute for diesel as it does not necessitate engine adjustment. Both Jatropha and Pongamia pinnata are native to subtropical environments and can grow on different soil types within temperature range of 5–50 °C [26, 27]. Mature trees can endure water logging and slight frost too. They have a height of about 15–25 m and yield of around 20–25 kg [27, 28]. The derived oil has good calorific value, and even the deoiled cake and residual fruit shells possess decent energy [29–31]. Besides, they have a relatively short gestation period years and long economic life [27, 28]. Typical process of biodiesel production can be seen in Fig. 1.

The governments in India are sentient of the fiscal prospects of the wastelands. For instance, while there is still ambiguity about biodiesel production in most of the states, states like Chhattisgarh, Madhya Pradesh, Rajasthan, and Uttarakhand are leading by an example in endorsing Jatropha biofuel by leasing marginal lands to businesses for trivial amounts and have also setup biofuel development authorities

Fig. 1 Typical biodiesel production process

to encourage biofuel plantation [32]. In 2006, Chhattisgarh Biofuel Development Authority (CBDA) planted 160 million saplings throughout the state in its endeavor to become bioenergy self-sufficient and since 2010 generates a revenue of INR 40 billion/year by selling Jatropha seeds [33].

6 Conclusion

It can be said that the idea being recommended through this paper possesses enormous potential for supporting energy needs and can resolve multitude of concerns like joblessness and exodus of rural denizens by empowering villagers to lead a monetary self-reliant and dignified life. In a country like India where the government has a vision to grow 7.5 million tonnes biofuel per year and consequently generate jobs for 5 million people [34], the proposed approach can be a revolutionary measure if implemented after rigorous scientific studies and solid policy backup [35]. The principal advantage of this technique lies in the fact that biodiesel generation does not compete with food production as these proposed trees can be grown on lands which were rendered useless. Therefore, this model is not only sustainable in recovering salty soils but can go a long way in making rural areas a bioenergy hub.

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Optimal Design of Water Distribution Network by Reliability Considerations

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Abstract Water distribution networks (WDNs) are quite complex systems in such a manner that it is not easy to obtain the most reliable and efficient systems due to the complexity of algorithms generated using linear programming. Many studies dealt in the past with the objective of least cost design where reliability was quantified as a constraint. This study provides a multiobjective approach for assessing the performance and reliability of an urban residential area Surjamal Vihar, New Delhi. The schematic network is constructed using commercial software Bentley WaterGEMS V8i, which is also used to simulate the results. Linear programming algorithm approach is used to analyze the network for the design, considering the reliability of the network. Results are discussed at the end of the study suggesting certain modifications in the network design to achieve optimization of the distribution system, including constraints related to hydraulic feasibility, satisfaction of nodal demands, and requirement of nodal pressures.

Keywords Urban water supply · Water distribution networks (WDNs) · Optimization · Reliability

1 Introduction

A water distribution system is a vital part of the modern urban infrastructure. With global rise in population and raised living standards, there is a constant demand for the development and modification of such systems [1–4]. Transients in a water

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