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].

H. Tyagi (✉) · A. Goyal
Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi, India
e-mail: tyagiben@gmail.com

R. Al Khaddar et al. (eds.), *Advances in Energy and Environment*, Lecture Notes in Civil Engineering 142, https://doi.org/10.1007/978-981-33-6695-4_2

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

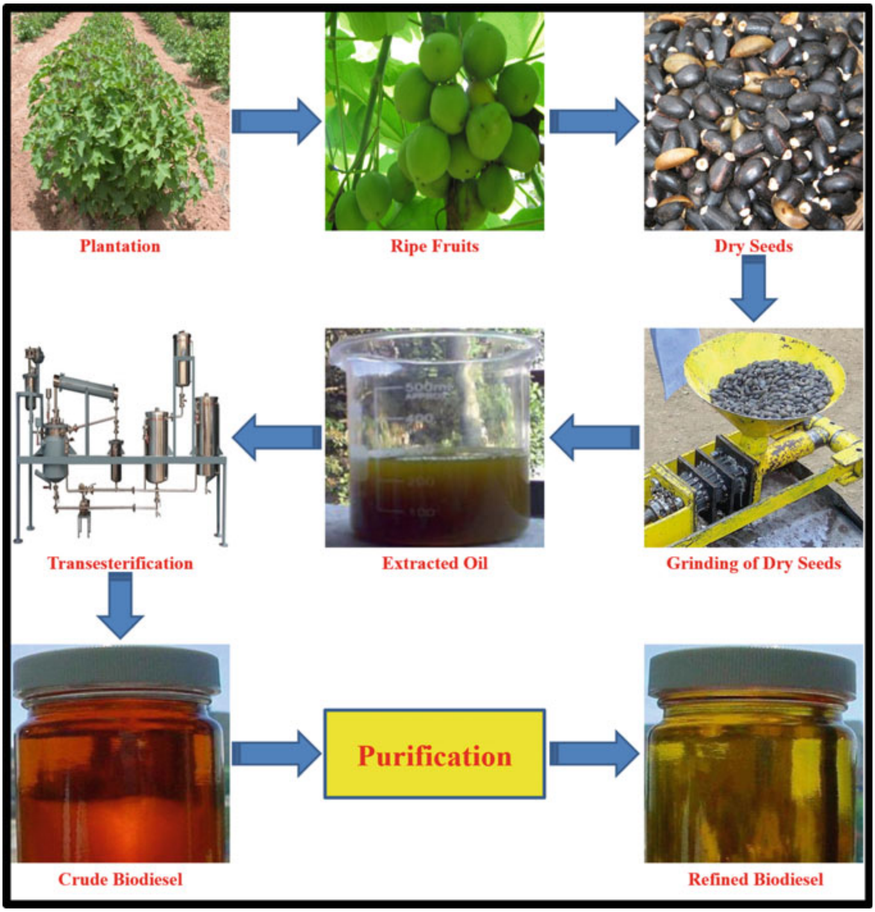

Fig. 1 Typical biodiesel production process

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.

References

1. Karnataka State Remote Sensing Applications Centre. Wasteland Atlas. Government of Karnataka, India. https://karunadu.karnataka.gov.in/ksrsac/atlas-wasteland.html
2. Department of Land Resources and National Remote Sensing Centre (2019) Wasteland Atlas of India-2019. Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi and National Remote Sensing Centre, Indian Space Research Organisation, Department of Space, Government of India, Hyderabad
3. Central Soil Salinity Research Institute (2015) Vision 2050. Central Soil Salinity Research Institute, Indian Council of Agricultural Research, Ministry of Agriculture and Farmers Welfare, Government of India, Karnal
4. Department of Land Resources and National Remote Sensing Centre (2011) Wasteland Atlas of India-2011. Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi and National Remote Sensing Centre, Indian Space Research Organisation, Department of Space, Government of India, Hyderabad
5. Dagar JC, Singh AK, Arunachalam A (2014) Agroforestry systems in India: livelihood security & ecosystem services. Springer, India
6. Goyal A, Tyagi H (2017) Spatial mapping of salinity affected lands. In: Proceedings of the international conference on remote sensing and GIS for applications in geosciences. Aligarh Muslim University, Aligarh, p 25
7. Indian Council of Agricultural Research (2010) Degraded and Wastelands of India. Indian Council of Agricultural Research Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi
8. Shivay YS (2011) Saline and alkali soils and their management for effective utilization. Kurukshetra J 60:8–12

9. Verheye W (2009) Soils of arid and semi-arid areas. Land use land cover and soil sciences. EOLSS Publishers, Oxford
10. Kumar A (2004) A text book of environmental science. APH Publishing, New Delhi
11. Bhattacharya AK (2007) Drainage. https://nsdl.niscair.res.in/jspui/bitstream/123456789/543/1/Drainage%20-%20FORMATTED.pdf
12. Department of Environment and Resource Management (2011) Salinity management handbook. Department of Environment and Resource Management, The State of Queensland, Brisbane. https://publications.qld.gov.au/storage/f/2013-12-19T04%3A10%3A23.754Z/salinity-management-handbook.pdf
13. Abrol IP, Yadav JSP, Massoud FI (1988) Salt-affected soils and their management. FAO Soils Bulletin 39, Food and Agriculture Organization of the United Nations
14. Chalker-Scott L (2007) Impact of mulches on landscape plants and the environment-a review. J Environ Horticul 25:239–249
15. Hodges SC (2010) Soil fertility basics. Soil science extension, North Carolina State University. https://www2.mans.edu.eg/projects/heepf/ilppp/cources/12/pdf%20course/38/Nutrient%20Management%20for%20CCA.pdf
16. Sharma BK, Kaur H (1994) Soil and noise pollution. Krishna Prakashan Mandir, Meerut
17. Ladeiro B (2012) Saline agriculture in the 21st century: using salt contaminated resources to cope food requirements. J Bot
18. Ashraf MY, Awan AR, Mahmood K (2012) Rehabilitation of saline ecosystems through cultivation of salt tolerant plants. Pak J Bot 44:69–75
19. Biswas A, Biswas A (2014) Comprehensive approaches in rehabilitating salt affected soils: a review on Indian perspective. Open Trans Geosci 1:13–24
20. Hasanuzzaman M, Nahar K, Alam MM, Bhowmik PC, Hossain MA, Rahman MM, Prasad MNV, Ozturk M, Fujita M (2014) Potential use of halophytes to remediate saline soils. BioMed Res Int
21. Thapliyal A, Malik A, Teixeira da Silva JA (2006) Application of fly ash in reclamation of wastelands through plantations and floriculture. Floricul Ornamen Plant Biotechnol 288–297
22. Niu G, Rodriguez D, Mendoza M, Jifon J, Ganjegunte G (2012) Responses of Jatropha curcas to salt and drought stresses. Int J Agronomy
23. Dagar JC, Minhas P (2016) Agroforestry for the management of waterlogged saline soils and poor-quality waters. Springer, India
24. Sharma SK, Dagar JC, Singh GB (2010) Biosafor-biosaline (agro) forestry: remediation of saline wasteland through production of renewable energy, biomaterials and fodder. Central Soil Salinity Research Institute, Indian Council of Agricultural Research, Ministry of Agriculture and Farmers Welfare, Government of India, Karnal
25. Sarin A (2012) Biodiesel: production and properties. Royal Society of Chemistry Publishing, Cambridge
26. Ahamed MS, Dash SK, Kumar A, Lingfa P (2020) A critical review on the production of biodiesel from Jatropha, Karanja and castor feedstocks. In: Ghosh S, Sen R, Chanakya H, Pariatamby A (eds) Bioresource utilization and bioprocess. Springer, Singapore
27. Pradhan RC (2010) Centre design and development of low cost post harvest equipments for Jatropha. Ph.D. Thesis, Centre for Rural Development and Technology, Indian Institute of Technology Delhi, New Delhi
28. Muralidharan M, Mathew P, Thariyan S, Subrahmanyam JP, Subbarao PMV (2004) Use of pongamia biodiesel in CI engines for rural application. In: Proceedings of the 3rd international conference on automotive and fuel technology. Allied Publishers, New Delhi, pp 199–204
29. Kesari V, Das A, Rangan L (2010) Physico-chemical characterization and antimicrobial activity from seed oil of *Pongamia pinnata*, a potential biofuel crop. Bio Mass and Bioenergy. 34:108–115
30. Eipeson WS, Manjunatha JR, Srinivas P, Kanya TS (2010) Extraction and recovery of karanjin: a value addition to karanja (*Pongamia pinnata*) seed oil. Ind Crops Prod 32:118–122
31. Mukta N, Sreevalli Y (2010) Propagation techniques, evaluation and improvement of the biodiesel plant. Ind Crops Prod 31:1–12

32. Mishra SN (2014) Design of resource use: case of Jatropha based biodiesel in India. J Rural Develop 33:1–13
33. Biofuel in India. https://en.wikipedia.org/wiki/Biofuel_in_India
34. De Fraiture C, Giordano M, Liao Y (2008) Biofuels and implications for agricultural water use: blue impacts of green energy. Water Policy 10:67–81
35. Gopakumar L (2020) Jatropha cultivation in South India—policy implications. In: Mauerhofer V, Rupo D, Tarquinio L (eds) Sustainability and law. Springer, Cham