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Halophytes: A Rapid, Inexpensive and Significant Way to Address Land, Water, Food, Energy and Climate

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Climate change, in spite of attempts at mitigation, is becoming much more serious. Wide spectrum major mitigation efforts are now necessary including removing CO_2 from the atmosphere, reducing fossil energy use and increasing the planet albedo. Halophytes, salt plants grown on deserts and wastelands using saline and seawater are uniquely suitable to rapidly and profitably, at the tremendous scale of the climate problem, using inexpensive land and water, remove CO_2 and produce major amounts of biofuels and food while returning up to 70% of the fresh water to direct human use. This article examines the extraordinary possibilities of halophytes to significantly mitigate the major societal issues involving land, water, food, energy and climate.

Keywords: Biofuels; CO_2 sequestration; drought alleviation; halophytes; saline water.

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1. INTRODUCTION

Climate Change is occurring quite rapidly, the identified major driver being combustion of fossil carbon fuels and resultant increase in atmospheric CO_2, along with the occurrence of positive climate feedbacks. Positive feedbacks include fossil methane and CO_2 released from the tundra and oceans as they warm, reduced ocean CO_2 uptake due to acidification, albedo change due to ice melting and increased atmospheric moisture content due to increased temperature/ evaporation. Impacts of climate change are increasingly serious and include temperature rise, increased storm severity, drought, health risks, sea level and poverty rise along with decreased species and food and negative infrastructure impacts [1]. There are ongoing efforts to mitigate climate change including a shift to ever less costly renewable energy and energy storage, energy conservation and shifting to electrics [2]. The scale of climate change is immense, it will take major change, at scale, to provide serious mitigation, and change, especially change that alters established econometrics aspects in a negative way, usually occurs slowly [3]. Renewable energy only began its' rapid growth when its' cost went below that of fossil carbon. Changes that are economically, financially positive occur more rapidly than those that are negative. There are concerns that the current mitigation efforts are not sufficient, sparking calls for CO_2 removal from the atmosphere and geoengineering. One approach to CO_2 removal is plant root sequestration. As we have cut down, cleared the forests such areas have become sources of CO_2, not sinks. To create useful or greater plant CO_2 sequestration requires large land areas and water. Unfortunately, the arable land and fresh water are taken up by food production, other activities. The purpose of this narrative is to proffer an alternative approach to at scale, rapidly and profitably address plant CO_2 sequestration via utilizing what we have a plethora of, saline, salt water and deserts, wastelands [4]. Saline, salt water is some 97% of the water and deserts and wastelands are some 40% of the land mass, so cheap water, cheap land and uniquely at the scale necessary to seriously mitigate climate change. The enabler for this is the alternate plant world, halophytes, or salt plants, plants that grow on deserts and wastelands with deep roots to sequester CO_2 [e.g. 5-14]. There is a plethora of halophytes, with many being food plants. Overall, they represent nearly every functionality, usefulness available in fresh water plants. Halophyte agriculture [AG] on deserts and wastelands using saline aquifers or pumped ocean/seawater would address far more than climate. It would bring much more land into cultivation, growing food with saline, seawater, releases much fresh water now used for current fresh water AG for direct human use, solves drought conditions, produces fresh water rain, provides massive amounts of biomass for biofuels and chemical feedstock including plastics replacing the major amounts of petroleum utilized for such, while sequestering some 18% of their CO_2 uptake in their deep desert roots. This would mitigate-to-solve, profitably and rapidly, with no new technology required, and uniquely at scale land, water, food, energy and climate. Would, could literally "green the planet" soon enough and at the requisite scale to effectively deal with climate, as well as seriously mitigate the issues with droughts, land, fresh water, food and energy.

2. HALOPHYTE CHARACTERISTICS AND UTILIZATION

Halophytes are land and aquatic plants that are salt tolerant, halo implies salt [e.g.10, 13,14]. These plants grow in, are nourished by saline and salt water and are present naturally in oceans/seas, salt marshes and deserts, wastelands. There are some 6,000 plus varieties of halophytes [15], largely mimicking fresh water plants in many respects with extant halophyte varieties suitable for food, fodder, biomass, energy, chemical feed stock, wood, CO_2 sequestration, land desalinization, ornamentals and wildlife habitat [9]. Over 28 countries are experimenting with halophytes, primarily for food and fodder. Halophytes can have yields equal to fresh water plants [15] and cover the plant spectrum of seeds, fruits, roots, tubers, grains, foliage, oils, berries, gums, protein and fats. Seawater contains some 80% of the nutrients' plants require, and trace minerals that humans require but which have been decreasing in arable land fresh water agriculture. Nitrogen can be taken from the air via nitrogen fixing bacteria. There are halophyte research institutes in the UAE and Pakistan, also growing interest in halophytes in China. The halophyte biomass can replace the some 50% of the petroleum produced that is used for chemical feedstock for plastics etc. Also, the many ocean dwelling halophytes including several edible seaweeds could be grown efficiently in such as the Gulf of Mexico utilizing the continent size nutrient stream from the Mississippi efflux. Halophyte research includes the goals of increased growth rates, reduced nutrition and saline water requirements, tailoring for specific conversion/ refining processes and approaches to avoid contamination of fresh water sources.

2.1 Food

Halophytes have long been utilized for food and fodder, Quinola being the usual contemporary foodstuff mentioned in connection with shifting from fresh water food agriculture to halophytes. Such a shift has been studied in a sizable literature [15–24] and their references are examples] and recently reemphasized by the increasing climate induced drought conditions and resultant concerns regarding sufficient future food supply. Recent estimates indicate that over 50% of the worlds' population will be fresh water deficient due to climate changes going forward. Growing halophytes for food using saline, seawater would make available the some 70% of the accessible fresh water that is used in agriculture for direct human use. There is a "salt penalty" [15], to grow halophytes of some 35% additional water to manage the salt, but saline, seawater is, can be inexpensive and is very plentiful. Due to the increasing salination of the aquifers some 25% to some estimate up to 50% [16] of irrigated land is salt affected [15], and over 800 million hectares of fresh water arable lands are salinated worldwide [17]. There is increasing interest in China wrt halophytes, with special emphasis upon salt tolerant rice and many other species and uses [16,18,19]. Jaradat from the International Center For Bio-saline Agriculture, Dubai in [20] explicates in detail the richness of the switch to halophytes for food, water and much else [feed, fiber, fodder and industrial crops] with economic yields of grains, oil seeds, vegetables, fodder, fuel, and fibers].

2.2 Water

Planet water resources are some 97.5% saline and 2.5% fresh. 68% of the fresh water is sequestered in glaciers, some 30% in ground water and much of the rest in permafrost and such as the great lakes and lake Baikal. The "available" fresh water [lakes, rivers, ground water] has been estimated as some .003% [25]. Climate change is causing increasing drought including in the U.S. southwest and East Africa and increasing desertification. As we have extracted water from aquifers for irrigation the aquifers have become more saline, salinating thus far some 25% to 50% of irrigated land. There are calls that [fresh] water scarcity is now the single greatest threat to human health, the environment and the global food supply. The response has been primarily a bevy of increasingly expensive measures to improve utilization of the .003% of the water that is available fresh water. The now ongoing cost reductions of renewable energy and energy storage approaches, along with the recent Japanese success concerning Low Energy Nuclear Reactions proffer ever less expensive desalinization for direct human use. However, projected desalinization costs for significant agricultural use are prohibitive thus far. Given the existence of major saline aquifers in many areas including wastelands and deserts, the prevalence of sunshine on deserts and wastelands, the number of deserts and wastelands with ocean, sea coasts, the ever-decreasing costs of solar PV and the use of halophyte biomass to produce low - cost plastic pipe, most of freshwater agriculture could rapidly, profitably shift to utilization of low cost, profitable saline/ seawater and halophytes. This would in the limit free up the some 70% of the available fresh water used for agriculture for direct human use and "solve" water, and food [26], while desalinating the land [27].

2.3 Land

Some 44% of the planets' land area is considered deserts, wastelands with major deserts in Australia, around the Arabian Sea and Persian Gulf, The Middle East, The Sahara, the Southwest U.S and the Atacama in South America. Saline agriculture on just a portion of the Sahara, using initially major saline aquifers such as the Nubian, would produce massive amounts of food and biomass for "clean" aircraft fuels etc. Massive amounts of biofuels can be produced without utilizing arable land and fresh water. Therefore, halophytes can solve land, water and food, soon, profitably, at low cost, with immense capacity that uniquely scales to climate impacts and more. Deserts, wastelands and saline, seawater, what we have a plethora of, are the last major and immensely unexploited planetary resources. Over a billion hectares worldwide are already salt affected and another billion overlay saline aquifers.

2.4 Energy

Deserts and wastelands are usually sunny areas, suitable for renewable energy utilization, especially using the ever less expensive and more efficient PV approach. Renewable energy is now less costly than fossil carbon derived energy and as a result is developing rapidly, as is the companion ever less expensive energy storage. There are studies of utilizing solar energy production on the Sahara to energize Europe. What are now marginal to less lands can be used to produce energy for pumping saline/ seawater, conducting halophyte agricultural activities, exporting energy and growing massive amounts of biomass for clean fuels, along with massive amounts of food. Halophyte biomass is literally green energy and chemicals [28–32].

2.5 Climate

Renewable energy as it and energy storage develop and reduce in cost are replacing fossil carbon fuels, reducing CO_2 emissions. However, this is apparently not fast enough to stave off serious climate effects and there are calls to remove the CO_2 from the atmosphere. Studies indicate that Halophytes can remove some 5 metric tons of CO_2/hectare [11] and in their roots sequester some .7 metric tons plus [33]. The immense capacity/ scale of halophyte agriculture [97% of the water, some 44% of the land] along with low cost, available technology, cheap land and water, profitability proffers the possibility of literally “greening the planet” to rapidly remove atmospheric CO_2. The Earth’s land mass is some 13 billion Ha. If Halophytes are planted on the 44% of the land mass which is wastelands and deserts, and irrigated with saline, seawater, they could sequester some 4 gigatons of carbon, which from ref. 34 is greater than the 3 gigaton yearly buildup. I.E., halophyte carbon sequestration could greatly mitigate climate change occurring via CO_2 increases in the atmosphere. The shift to renewables and storage could then reduce the atmospheric CO_2 by reducing the input to the atmosphere. Nothing else, no other climate mitigation approach operates at this scale and econometrics, given the increasing societal issues with climate change is what is needed [34].

3. IMPACTS OF HALOPHYTE AGRICULTURE

Halophyte Agriculture on waste lands and deserts using saline, seawater proffers low cost, near term, scaling to the climate problems and beyond, serious mitigations for land, water, food, energy and climate. Additional benefits include replacing some half of the petroleum that is used for petrochemical feed stock, plastics etc. Thus far in experimental plantings salt buildup has not occurred on the sandy soils, some ~35% of saline water above the amount usually used for comparison fresh water plants can be used to help flush the salt into the soil [15]. If it builds up there is a market for sea salts. Irrigation changes the local microclimate which at scale can affect regional weather [4]. Evaporation of saline, seawater irrigation would produce an unstable atmosphere and instigate fresh water rain downwind. On the Sahara this could conceivably produce rain in the middle east. Like renewable energy and other “disruptive” technologies saline/ seawater Halophyte Ag on wastelands is a major change, with impacts upon existing industries, corporations. In the case of renewable energy not much happened until the costs dropped below, are now much below, those of fossil carbon energy. Once that occurred the existing energy corporations, goaded by climate considerations, are changing their operations, following the profits. The vested commercial, industrial interests in the case of halophyte ag is the extant immense fresh water ag industry. Hopefully they will study the profit possibilities of Halophytes and goaded by the major developing issues with land, water, food as well as energy and climate decide to seriously consider this new solution space that uniquely scales to the increasingly societal issues cited. As these issues have become more worrisome the interest in Halophytes is increasing [35,36].

4. CONCLUSIONS

Society is rapidly running out of fresh water, arable land and food. We are despoiling the land and air with fossil carbon fuels, causing climate change. 44% of the land is wastelands, desert and 97% of the water is saline, seawater, which contains 80% of the nutrients to grow plants and trace minerals required by human nutrition. There are some 6,000 species of Halophyte plants, many are food plants, that grow using saline irrigation, halo means salt. Halophytes withdraw some 5 tons of CO_2 per Ha, on wastelands, for which there was little sequestration prior to Halophyte production. Therefore, this is NEW sequestration. At scale Halophyte sequestration could seriously address the yearly CO_2 increase in the atmosphere. Halophyte Agriculture using saline/ seawater irrigation to grow food could return the 70% of the fresh water now used for fresh water agriculture to direct human use. Halophytes/ deserts/ wastelands are perhaps the last major opportunity to exploit natural resources at the scale necessary to address climate. We are destroying the ecosystem rapidly, too many of us asking far too much of it. Indications are we will seriously utilize Halophytes as climate becomes sufficiently serious. Halophytes, wastelands/ deserts provide a cogent option to, uniquely at scale, soon, and profitably remove CO_2 from the atmosphere, produce massive amounts of biofuels and food without utilizing fresh water and arable land, seriously address the rapidly developing droughts and replace the some 50% of the petroleum utilized for chemical feedstock, providing significant mitigation.

COMPETING INTERESTS

Author has declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper

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