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Opinion

Marine World: Agricultural and Biotechnological Approach to Use the Un-used

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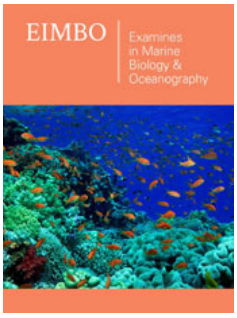

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Introduction

It almost seems unreal to visualize earth as a watery body while observing from a land surface. Factually, approximately 71 percent of the earth's surface is covered with water. The existence of water is everywhere, in air, rivers, lakes, icecaps and glaciers, ground soil, aquifers including all organisms. Among all these, the oceans alone accounts for about 96.5 percent of earth's water (Figure 1). The remaining 29 percent of earth's land area is inclusive of the barren land, cultivable land, urbanised land, forests and deserts. So, one can guess the minimal percentage of land available for agriculture purpose to feed the ever-growing population needs. Several research groups, scientific bodies and marine biologists are now focusing on utilizing the water body resources as a means to establish a solution to meet the above stated issue. Beside the scarcity of limited food, drinking water is as equal a problem for the existing population and shall worsen even more in the coming years. Therefore, the vast marine world consisting of oceanic water and the organisms living within is now being targeted for the mitigation of problems associated with space, agriculture, fresh drinking water, food and nutrition. Identification of beneficial and edible water-growing organisms especially within the plant kingdom with enhanced nutrient content as well as possessing the property of purifying/desalinating the sea water is a recent trend upcoming with a variety of interesting and promising approach. The opinion stated here shall focus on some of these facts and highlight few concerns with a specific objective to develop strategies that can have multidirectional aspects and/or outcomes but serve as sole idea of utilizing the marine world in the benefit of fulfilling the growing needs of the population.

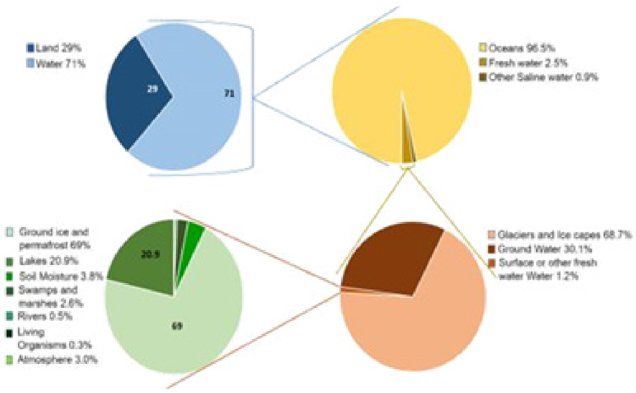

Figure 1: Depiction of the water content on earth and further categorization on the basis of distribution of fresh water present in the air, soil and ground. All numbers are rounded percentage values.
Data source: Chapter by Igor Shiklomanov. World fresh water resources. In Peter H. Gleick (ed), 1993, Water in crisis: A guide to the world's fresh water resources.

Selection of Beneficial Marine Microbes for Multidirectional Approach

Filamentous cyanobacterium, *Spirulina* is used as a safe functional food. It naturally grows in fresh water as well as in sea water and commercially is produced in outdoor water bodies under controlled conditions. There are several potential health benefits of Spirulina mainly because of the various bioactive proteinaceous components like sulphated polysaccharides, phycocyanin and γ-linolenic acid. Additionally, the presence of various essential amino acids and fatty acids, high iron content, vitamins, carbohydrates and pigments make it a superfood [1]. Similarly, the very diverse ocean phytoplanktons, for example diatoms are multifaceted organisms with immense contribution to the primary productivity in marine ecosystem, carbon fixation, ocean silica cycle, iron and nitrogen cycle, bioindicators and filters for controlling and purifying contaminated water [2]. Apart from this, diatoms like *Cyclotella cryptica, Cylindrotheca fusiformis, Skeletonema costatum, Phaeodactylum tricornutum*, and *Thalassiosira pseudonana* are known to absorb high quantities of heavy metals [3-5]. In parallel, diatoms have been identified as sources of bioactive metabolic compounds having many uses in the food industry. For example, diatoms have been used as feedstock in aquaculture [6] and lately in human health and food supplements [7] also, diatoms have been explored in the nanotechnology sector to produce living nano-scale structures [8]. Development of such specialised organisms that are adapted to grow in saline water for improved nutrient content, for production of drugs and for water purification purposes would be potential solution for various sectors and aim to mitigate the problems of land and water scarcity. Besides such water species can be replaced by other land plants and solve the space required by utilising the unused saline water.

Sea Water Farming

Coastal regions experience severe lack of freshwater, and agricultural activities is minimised due to undesirable soil conditions. Biosaline agriculture may be considered to address such adversities by using sea water for plant irrigation especially in arid and semi-arid areas. While in fertile agricultural areas, utilization of diluted sea water as a source of minerals for the production of fruits and vegetable crops, as well as for developing pastures, lawns and flowers would be very effective. On the contrary, sea and ocean saline water used in agriculture may result in plant toxicity due to excessive uptake of salts such as sodium. Water stress conditions can reduce the uptake of essential nutrients, especially potassium and also may worsen the soil surface. Mitigation to such loses have bought few projects around the world at several locations for sustainable seawater farming by applying different techniques for example: in Mexico, Eritrea, UAE and Australia [9]. Identification and cultivation of edible plant species deficient in beneficial salts and minerals that are abundantly found in saline water will help the use of water bodies as farms and produce food supplements for livestock. But then measures where precise check-in should be implemented since plants do have the property of accumulating certain other components like heavy metals and excessive salts that may harm the feeding organisms. One of the remedy for this is co-culturing fish and/or other microorganisms together that can be indicators of toxicity level of the water in use.

Desalination of Water

Desalination can be a sustainable way to reuse salt water, but with efforts to reduce its harmful environmental impact. In addition, the process is energy-intensive, complicated and costly. Although desalination technology sounds promising as it makes use of the abundant unusable sea water and converts it into freshwater to facilitate the water starved regions. Therefore, more energy efficient technologies addressing ways to reduce the harmful environmental impact of the left out salty waste water along with efforts to cut short the power energy used within, are required. A solution to this is utilizing the diverse marine vegetation as stated above as a better natural idea of purifying saline water. Selective species with manipulated genomes that are able to grow efficiently, purify the salted water with additional benefit to human health and food industry.

Biotechnological Approach to Mitigate the Problems of Utilizing the Source-Full and Unused Marine World

Biochemical and molecular advanced techniques including extraction and purification systems, genome editing technologies, transformation methods with additional support from the huge information of the genomes in the public domain with bioinformatics software tools to enable utilizing that data has revolutionised the area of gene manipulations to obtain improved organisms with desired characterised, traits and yield. The CRISPR/Cas9 system is a successful and efficient system proven in a number of eukaryotic organisms, recently also in microalgae and diatoms [10-12]. Identification of significant genes responsible for transport and nutrient uptake, genes of metabolic pathways involved in synthesis of essential compounds and their storage as well as genes for the growth and development of the species under water and or salinity stress conditions by critically analysing the regulatory mechanisms should help design precise strategies to develop the species with multiple improved traits/qualities to utilise the marine water, purify it as well as and also benefit the population in terms of healthcare and food supply. Diatoms for example are quite easy to modify by molecular genetic transformation and allow easy incorporation of foreign genes into their genome by random integration and is a well-established system [13].

Summary Key Points and Conclusion out of this Opinion

a) The purification of saline (ocean/sea) water through desalination by efficient energy conservation methods that have less environmental impact and/or adopt the more natural way of purifying salt water into fresh drinking water by promoting the growth of marine vegetation adaptable to the water conditions in saline water.

b) Selective marine vegetation (micro algae, phytoplanktons) with improved traits can be achieved by incorporating molecular transformation methods using the most advanced techniques and genome sequence data available in the public domain datasets.

c) Sea/water farming techniques could be designed to develop efficient farming on the unutilized water bodies and flourish better and useful varieties of plants able to grow on the saline water.

d) Production of better improved varieties of edible marine phytoplanktons, algae with enhanced nutrition quality and absorption of heavy metals. These shall serve the needs of the growing population in terms of food and healthcare supplements.

e) Utilization of the saline water bodies and the water itself to improve selective plant wild varieties that are deficient in salts abundantly found in the sea water, such varieties can be used as feed for livestock and other animals.

The opinion set here broadly aims to build and develop cost effective multifactorial designs and strategies that can utilize the oceanic and sea water as a farming space and also purify the saline water manageable enough for agriculture and drinking. The usage of seawater in agriculture sector should produce useful crops with higher yields and justify the expense of pumping irrigated water from the sea and researchers should aim to develop agronomic techniques for growing seawater- irrigated crops in a sustainable manner without any damage to the environment. This also encourage to develop new and improved existing marine vegetation that could grow well and provide solutions in terms of food, healthcare supplements to humans and livestock. This could be done by the use of molecular biology tools like genome editing by CRISPR/Cas and transformation techniques by utilizing the immense information present in public platform and identifying the most significant genes responsible to achieve the desired traits**.**

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