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EFFICIENT USE OF MACROALGAE BIOMASS FOR HEAVY METAL REMEDIATION AND ENHANCE THE AGRICULTURE APPLICATIONS#

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Abstract

Macroalgae are the weed or primary plant. Heavy metals are dangerous for water, soil even for human animal and birds. Macroalgae is use full for remediate metals from toxic state to less toxic state or remove the metals from environment. The different mechanism is used for remediate the metal by macroalgae which is called Phycoremediation. From the ancient time algae were used in agriculture. Macroalgae are good fertilizer and also provide the easy nutrient uptake by plant. Macroalgae helps to enhance the growth of plant. Macroalgae activate the premature flowering and fruit in a various types of crop plants. This study is mainly focused on macroalgae and metal wastes. It shows good results, it improve and convert metal wastes into a useful input resource for the production of agricultural crops and increase their soil fertility.

Keywords: Macroalgae, Heavy metal, Agriculture, Phycoremediation

#General Article

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Introduction

A huge range of biological resources, mainly bacteria, algae, yeasts and fungi have rising for heavy metal removal and recovery from waste due to their superior presentation, low cost and great accessible capacity (Wang and Chen, 2009). Marine algae usually considered as cheap and existing resources and not compete with farming crops for soil or water so they are included in the group of renewable biological assets (Bulgariu and Bulgariu, 2020). There are two different classes of algae known as macroalgae and microalgae. These algae have same as photosynthetic organisms found in marine habitats. These are microscopic and have very amazing and interesting arrangements. Algae are divided in to six classes 1) Green algae, 2) Brown algae, 3) Dinoflagellates, 4) Diatoms, 5) Red algae and 6) Euglenoids (as shown in Picture1.1) discussed by Enamala et al., (2018).

Diversity of Macroalgae In India

Macroalgae consumption in the form of salads, soups and other food preparations is very common in Southeast Asian countries. Japan, China and Korea stand at the forefront of seaweed utilization in human food preparations, however, macroalgae are used for industrially essential phycocolloids such as agar, alginate and carrageen an. Where alginate are produced from wild stocks and carrageen an is obtained from cultivated Kappaphycusalvarezii (Doty)Doty ex P.C. Silva mentioned by (Ganesan et al., 2019).

According to the Central Salt and Marine Chemicals Research Institute (CSMCRI) the coast of Tamil Nadu has 97,400 tonnes wet wt. macroalgae, the coast of Andhra Pradesh contained 7500 tonnes wet wt. Of macroalgae and the Lakshadweep islands have 19,345 tonnes wet wt. of macroalgae. In India's total 366 species of macroalgae are available. More than 1600 km longest Gujarat coast is located in northwest India which has the Rann of Katch, the Saurashtra coast, Gulf of Katch, Gulf of Khambhat and the South Gujarat coast. Among these regions, the Gulf of Katch is a wealthy coastline with the Marine National Park and Marine Sanctuary that includes 42 islands, rocky intertidal regions and mangrove forests supporting rich macroalgae diversity. The Gulf of Khambhat is a delta region with minimal macroalgae diversity.

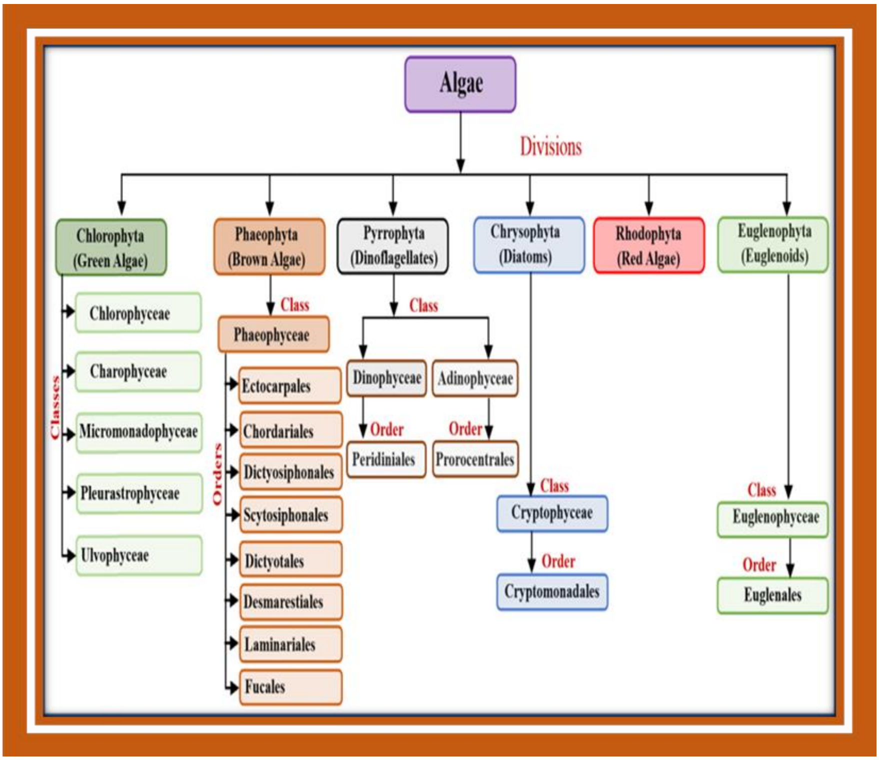
According to Jha et al., (2009) 198 species of macroalgae are available in Gujarat coastal line, in which three major groups of macroalgae are available such as Rhodophyta 109 species from 62 genera; Chlorophyta 54 species from 23 genera; Phaeophyceae 35 species from 16 genera. Total 130 species of macroalgae are found from the Gulf of Kachchh islands.

Anon (2012)noted the total of 282 macroalgae species were found from the Southeast Indian State of Tamil Nadu's coastline, among these, 80 species were Chlorophyta, 56 species were Phaeophyceae and 146 species were Rhodophyta. The genus Caulerpa was represented by the highest number of species (24) among the green algae, followed by Codium with seven species and Halimeda and Ulva with six species each. The genera Acrosiphonia, Anastomonas, Boergesenia, Dictyosphaeria, Neomreis, Microdictyon, Struvea, ValoniaandValoniopsis have a single species each. In brown algae, the genus Sargassum had the greatest number of species (15) followed by Dictyota with

10 species and Padina with seven species. The genera Turbinaria, Dictyopteris and Chnoospora had three species each and the genera Ectocarpus, Hormophysa, Hydroclathrus, Iyengaria, Rosenvingea and Zonaria were each represented by a single species. Among the red algae, the genus Gracilaria represented the highest number of species (20) while the genus Laurencia had 12 species. Other red algal genera found include seven species of Hypnea, six species of Grateloupia and several genera that were represented by a single species including: Asparagopsis, Bostrichia, Botryocladia, Chondrococcus, Chondrocanthus, Dasya, Dictyurus, Digenea, Enantiocladia, Griffithesia, Halichrysis, Helminthocladia, Neurymenia, Nitophyllum, Peyssonnelia, Tenaciphyllum and Wrangelia discussed by Ganesan et al., (2019).

Nourishment Metabolism Process in Algae

The metabolic mechanisms are same as photosynthetic organism's metabolic reaction. The most basic factor of the algae is nourishment uptake from the ambience through diverse biochemical and transportation reactions (Miazek et al., 2017). The carbon and nitrogen are most important elements in the photosynthetic metabolic mechanism. The major changes which occur during the metabolic reactions are the collection of the cells, volume, density, protein, chlorophyll, RNA, and vitamin noticed by the Enamala et al., (2018).



Picture: 1.1. Classification of algae *(Enamala et al., 2018)*

Sources of Heavy Metal in Environment

Heavy metals occur naturally in the soil environment from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace (<1000mg kg−1) and rarely toxic. Soil has being bio accumulated by most heavy metals like Fe, Pb, Ni, Cr, Cd etc resulting to serious disease infection to crops, animals and human beings. Soil pollution by heavy metals like cadmium, lead, chromium, copper and zinc are the matter which concern. Although heavy metals are naturally present in soil contamination and comes from local sources: mostly industry (non-ferrous industries, but also power plants and iron, steel and chemical industries) (Ekpete et al, 2013).

According to Dixit et al., (2015) natural created heavy metals are available in forms that are not easily effected plants. Heavy metals are naturally present in impenetrable forms, such as mineral, precipitated form which is in complex forms that are not freely absorbed by plant for accumulation. Naturally created heavy metals have a huge adsorption capability in soil but natural heavy metals not easily reaction in alive organisms. The naturally occurring heavy metals and soil have great bonding compared to anthropogenic sources. Comets, erosion, volcanic eruptions, and the weathering of minerals are the reasons for naturally occurrences of heavy metals in the atmosphere. Due to anthropogenic sources and the soluble and movable mechanical of heavy metals they have a high rate bioavailability. The alloy construction, atmospheric deposition, battery manufacture, bio solids, coating, explosive industrialized, offensive stacking of manufacturing solid waste, leather tanning, mining, pesticides, phosphate fertilizer, photographic materials, printing pigments, sewage irrigation, smelting, steel and electroplating manufacturing, textiles, and dyes and wood maintenance are the main anthropogenic activity that increases the heavy metal in environment discussed by Fulekar et al., (2009) . Resource of heavy metals, concentrations in soil and its properties, the amount of heavy metal uptake by plants, and the amount of assimilation by animals, are the reason for influence of the accumulation of metal ions in the food industries reported by Bolan et al., (2014). The geochemical rotation of heavy metals results in the construct of heavy metals in the atmosphere, that was the reason of risk to all forms of life and they are beyond permitted levels. The direction of access into the atmosphere normally comprise the climate of parent resources, the alteration of the geochemical sequence by man, soil intake, the relocation of mines and the release of high concentrations of metal waste by industries described by D'amore, et al., (2005).

According to Adler et al., (2007) mining has unconstructively impacted the environment and reason for demolition and an alteration of the ecology that includes a loss of biodiversity and an increase of contaminant in the surroundings. Mining and ore processing are major sources of heavy metal pollution in the soil. The improvement of ecological unit from mining actions could take quite a few decades. These actions created large capacity of accumulation and dump that often discarded without management. Dumped supply pollute water bodies during chemical run-off and particulates that build up in water resource, therefore generate a requirement to care for wastewaters and soil contaminated with heavy metals that releasing into the atmosphere occurs noticed by Ayangbenro and Babalola (2017).

Access Direction of Heavy Metal

Heavy metals are absorbed by plant, animal and human tissues via air inhalation, diet and manual handling. Motor vehicle emissions are a major source of airborne contaminants including arsenic, cadmium, cobalt, nickel, lead, antimony, vanadium, zinc, platinum, palladium and rhodium. Plants are absorbed heavy metals through the uptake of water; animals eat these plants; ingestion of plant- and animal-based foods are the largest sources of heavy metals in humans. (Mishra et al.,2019).

Phycoremediation for Heavy Metals

Using the plants for ecological remediation is extremely primeval and cannot be traced any particular supply. Phytoremediation is considered as an environmentally friendly technology. A variety of plant species have shown incompatible for metal accumulation. As plant-based information, the phytoextraction is naturally reliant on several plant qualities and also have ability to accumulate great quantities of biomass quickly and the capability to accumulate huge quantities of environmentally significant metals in the shoot tissue. The mechanism of metal uptake, translocation, role of rhizosphere in metal uptake, and possibility of using algae in phytoremediation were reviewed by Mahmood et al., (2015).

Algae are the primary producers in aquatic systems. The numerous reports have confirmed that algae can absorb nitrate, phosphorus, and heavy metals, and develop the quality of the water and soil (Li et al., 2015).The blue green algae were identified to remove heavy metals. Algal biosorbents retain high metal sorption competence at low levels of metals in aqueous solution (Ji et al., 2012).However, marine algae biomass areuse in the bioremediation processes for ecological and wastewater that become gradually more significant. It is prominent that the heavy metal contamination has severe downbeat cost for creature physical situation and also gave the negative impact on the atmosphere. So, the prospective utilize of algae to eliminate the substance of hazardous heavy metals from industrial effluents that are the major supply of green pollution. It has increased a universal concern by the evolution of ecological approach (Bulgariu, L., &Bulgariu, D. (2020). The bioremediation application is facing the great challenge; there are two trends for the improvement of the bioremediation process for metal removal. First trend is to employ hybrid skill for pollutants removal and second trend is to increase the commercial biosorbents immobilization knowledge for improving the biosorption (Wang and Chen, 2009).

Algae have renewable innate biomass and have paying attention of several investigators for used as a new investigative reagent to pre concentrate that adsorb the metal ions instantly like Cu, Cd, Pb, Cr, and Au. These types of natural organisms have been achieved very well for various type of application because they contain an identical cell size and a number of different metal binding sites on their cell walls. These sites consist of carboxyl groups from amino acids and polysaccharides and sulfhydral groups discussed by (Hamdy, 2000).Someinvestigations have been also shown the elimination efficiency using dead biomass of algae, involve that dead cells may absorb more metals than living cells (Ji et al., 2012).

Some algae show extraordinary potential to accumulate metal ions and this has opened up the option of their use in treatment of metalliferous waste (Mehta and Gaur 2005). Algae have frequently presented better metal ion elimination efficiency and profitable achievability than commercial ion-exchangers. For example, Sargassum natans and Ascophyllumnodosum outper formed ion exchange resins in sequestering Au2+ and Co2+, respectively, from solution. The efficiency of commercial resins often decreases at lower metal concentrations in wastewaters, whereas algal biosorbents retain high metal sorption efficiency even at very low levels of metals in the solution reported by Singh et al., 2007).

According to Ahluwalia and Goyal (2006) previous biosorption studies have been carried out with unicellular and using various algae as they have a large surface area for binding of metal ions. However, the high cost of harvesting microalgae from natural sources like fresh water and marine water or from cultivation ponds is a main difficulty in their industrial application. Therefore, large-sized algae are better suited for the purpose than unicellular algae. Macroalgae can efficiently remove heavy metal ions and radionuclides from aqueous solutions reported by Mehta and Gaur (2005). Using macroalgae for metal removal in areas away from the sea coast may be efficiently possible (Singh et al., 2007).

According to Ma et al., 2016 algae are autotrophic organisms and therefore need small amount of nutrients and generate huge biomass compared to other organisms. These algae have been used for heavy metal subtraction with a high sorption capability. Algae biomass is used for accumulation of heavy metal from polluted environment via adsorption or by integration into the cells. Phytoremediation is the use of various types of algae and cyanobacteria for the accumulation of heavy metals by removal or degradation of hazardous component discussed by Chabukdhara et al., (2017). Algae are consisting different chemical moieties on their outside such as hydroxyl, carboxyl, phosphate, and amide, that act as metal-binding sites reported by Igiri et al., (2018). Goher et al., (2016) noticed that dead cells of Chlorella vulgaris to remove cadmium, copper, chromium, iron and lead from aqueous solution under various conditions of pH, and contact time.

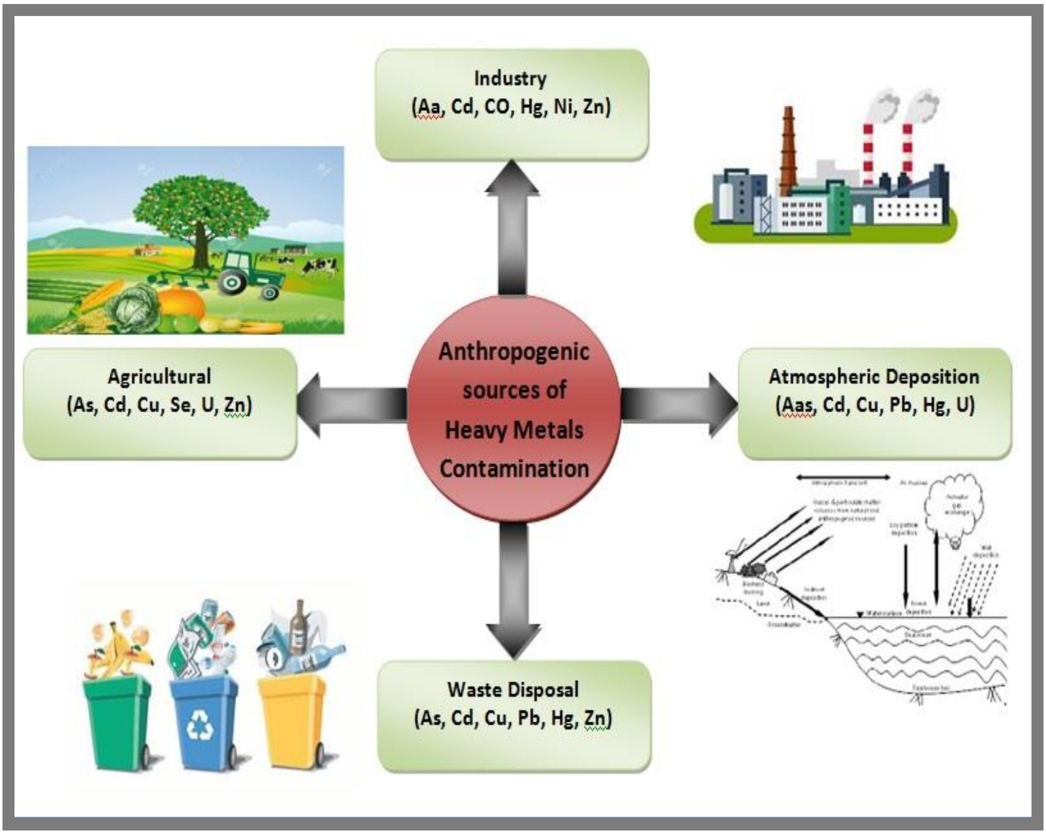
Mechanism of Phycoremediation

According to Lalhruaitluanga et al., 2010) explanation of mechanisms active in metal remediation is essential for successful development of the phenomenon and for biosorbents restoration in multiple re-useable cycles. The main metal accumulation mechanisms by algae are (1) Ion exchange between protons and heavy metal ions at the binding site (2) Heavy metals adsorption by physical forces, electrostatic interactions, chelation, complexation, and micro precipitation. Extracellular polysaccharides are the main components of algal cell walls responsible for metal accumulation. Sorption process can be classified in: (a) chemical sorption and (b) physical sorption.

The types of sorption mechanism are given by the magnitude of ΔH (enthalpy change) for the given sorption process calculated from sorption isotherm data obtained at different temperatures. Thermodynamically the heat of adsorption (ΔH), ranging from 0.5 to 5 kcal/mol (2.1–20.9 kJ/mol) gives physical adsorption mechanisms, and the value ranging from 5–100 kcal/mol (20.9–418.4 kJ/mol) gives chemical adsorption mechanisms discussed by Sati et al., (2016).

Macroalgae for Plant Growth

According to Jeannin et al., (1991) macroalgae merchandise encourages root growth and development. The root-growth-promoting activity was observed when the macroalgae were applied to the roots or as a foliar spray discussed by Finnie and van Staden, (1985) and also showed for tomato plants in which high concentrations repressed root growth but stimulatory effects were found at a lower concentration. Macroalgae in general are capable of affecting root progress by both recovering lateral root creation (Vernieri et al., 2005) and growing total volume of the root arrangement (Thompson, 2004). An enhanced root arrangement could be influenced by endogenous auxins as well as other compounds available in macroalgae extract. Macroalgae extracts develops the nutrient accumulation by roots (Sla`vik 2005) this developed systems that improved the water and nutrient efficiency and becomes the reason for improved general plant growth. Macroalgae and macroalgae stuff increase plant chlorophyll content reported by Mancuso et al., (2006). Even though they may have divers of minerals, biostimulants are not capable to supply all the nutrients essential to plant in mandatory amounts (Schmidt et al., 2003) though, their major advantage is to recover plant nutrient uptake by the roots and in the leaves (Khan et al., 2009).



Picture: 2. Source of heavy metal

Macroalgae Effect on Crop

Macroalgae activate the premature flowering and fruit in a number of crop plants (Arthur et al., 2003). For example, tomato seedlings treated with macroalgae set more flowers earlier than the control plants and this was not considered to be a stress response. According to Khan et al., (2009) as the onset and maturity of flowering and the number of flowers formed are linked to the growth stage of plants, macroalgae extracts possibly promote flowering by beginning of healthy plant growth. Product increases in macroalgae -treated plants are consideration to be associated with the hormonal material present in the extracts, especially cytokinins, that increases vegetative plant organs which associated with nutrient separating process and linked with nutrient mobilization (khan et al., 2009).
According to Mahmood et al., (2015) fruit ripening normally developed by transport of nutrient resources in the budding plant and the fruits have the capability to provide as strapping sinks for nutrients. Photosynthetic allocation could be changed by moving from roots, stem, and young leaves to the developing fruit and to be consumed in fruit growth. Fruit treated with macroalgae had high concentrations of cytokinins compared to natural fruit. Cytokinins have been occupied in nutrient enlistment in plant parts as well as reproductive organs. These reaction signify that macroalgae extracts are implicated either in improving the mobilization of cytokinins from the roots to the budding fruit, or by enhancing the quantity of endogenous fruit cytokinins reported by khan et al., (2009).
Advanced root and levels have also been found in macroalgae extract-treated plants. This enhance availability is result in a greater supply of cytokinins to the maturing fruit. The number of flowers and seeds per flower head increased 50% over the control (Van Staden et al., 1994). Application of maxi crop enhanced harvestable yield in lettuce, whereas an increase in the heart size of the florets and curd diameter was observed in cauliflower. Similarly, a substantial increase in yield was achieved in barley (Finnie, J. F., & Van Staden, J. (1985) and peppers after treatment with Kelpak. Foliar application of seaweed liquid extract enhanced bean yield by 24% discussed by Khan et al., (2009).

Conclusion

The key outcome of this study regarding macroalgae and metal wastes, we have tried a simple integrated approach to improve and convert metal wastes into a useful input resource for the production of agricultural crops and increase the soil fertility.

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