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Removing Non-Biodegradable Toxic Ions via Bio-Oxidation Analysis in Anzali Lagoon: A Usage of Seaweed in Biodiversity

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Abstract: Seaweed has been considered a treatment with the possibility of saving the environment in Anzali Lagoon in Iran due to its eco-potential, accessibility, and anti-toxic metal ion. Mostly, transition metals are toxic to human organs. Due to these problems and concerns, this study exhibits suitable adsorption materials for several native materials. Using the seaweeds of Anzali Lagoon in Iran for treatment has shown prominent results compared with other materials. The adsorption of transition metals by dead seaweed biomass offers a comparative advantage over other natural adsorption materials. This work describes the situation of heavy metals on the environment and why dead seaweed biomass is considered for remediation, among other materials. This work provides general ways to remove dissolved metals and toxic ions from Anzali Lagoon. Each of the various stages of operations of this lagoon will be discussed with their role in the metals removal process. The described treatment is general for metals and ion oxides removal. Some variations will exist among different systems. In layman's terms, these methods are intended to provide a suitable understanding of the precipitation process for toxic water treatment application. This investigation also provides a general method on how to remove dissolved metals (third and fourth-row elements of Mendeleyev tables) from toxic waters for discharge into sanitary systems.

Keywords: Anzali lagoon, seaweed, metallic cation chelation, toxic oxide ions.

1. Introduction

Water resources are affected by climate change, human activities, and forest fires. Climate change in temperature and precipitation changes water resources effects. Since the use of water and its saving in its sources are very necessary, Wetlands from mangroves to subarctic ecosystems have affected humans in whole of world history and are also much more important. Due to the importance of wetlands, which are a very critical ecosystem, A symposium in 1971 was accomplished in Ramsar (Caspian Sea side city in Iran), and related rules for wetlands were registered, which is known as Ramsar Convention [1]. It is named based on an environmental conference in Ramsar, a city in the North of Iran, where the convention was signed due to the contracting parties at the meeting of the contracting parties (COP). COP is the policy-making organ of the convention, which adopts decisions to administer the convention's work and improve the strategies [2]. Based on this convention, Wetlands that are about 6% of the earth can be classified as mangroves, wetlands, rivers, lakes, floodplains, flooded forests, and also coral reefs.

Some wetlands are transitional wetlands among aquatic and terrestrial ecosystems that are separated into two categories: permanent and temporal flooded. In addition, these classifications can also be defined through Wetland's physical, chemical, and sediment situation. Unfortunately, more than half of the wetlands in Europe, North & South America, Australia, and New Zealand were destroyed under agricultural area, deforestation, and freshwater reduction during the twentieth century [3, 4]. In spite of wetlands exhibiting various advantages in protecting nature, due to urbanization, economic priority, technology, industrialization, and urban population, more wastes were discharged into nature, and wetlands have been destroyed. The evaluation of wetlands from the viewpoint of multidisciplinary sciences approaches such as chemical environment, forest fires, erosion, climatology, biology, biochemistry, and statistical analysis can be provided useful information. Wetlands provide valuable economic by themselves. The reasons for wetland loss and destruction are excessive use, land degradation, urbanization, pollution, climate change, decreased biotic diversity, forest fires, and invasive species. Wetlands in the environment of cities provide significant climate filtration and cleaning [5]. Therefore, it is necessary to consider natural equilibrium and geochemical cycles as wetland ecosystem modulators, and the assessment of water cleaning is controlled based on biological and physical chemistry parameters. In this work, the physical parameters such as NMR, IR, and UV visible, and the chemical parameters such as the reaction between heavy metals and transition metals with several effective molecules of seaweed in (third and fourth-row elements of Mendeleyev tables) have been considered. Water assessment must be developed based on biology, hydrology, and water chemistry. In further evaluating geographic information, jungle climatology, forest and wood economy, and remote sensing data are needed to detect the climate change in the wetlands zones [6-9]. Therefore, wetland surveys have possessed multidisciplinary scientific approaches such as chemistry, biochemistry, physics, climatology, and forest fires.

1.1. Anzali Lagoon and its importance.

The total Anzali Lagoons are located from 37°22′ to 37°36′ in the east and 49°18′ to 49°36′ in the North on the southwest of the Caspian Sea close to Bandar- Anzali city in the Gilan province. Several environmental problems exist around these beautiful wetlands, including agricultural waste such as fertilizers, pesticides, and herbicides, especially from rice fields, as well as polluted rivers consisting of the 10 biggest rivers and industrial wastewater, including 30 main polluted factories, cause huge pollution in this zoon. This lagoon spans an area of 125 square kilometers and is the largest natural habitat of animals in Iran. Anzali Lagoon has a unique position among other Iran Lagoons in terms of rainfall due to its special location. Anzali Lagoon was registered in 1975 in the list of international lagoons of the Ramsar Convention. BirdLife International Organization declared this lagoon as an important shelter for birds. Anzali Lagoon is the first registered international lagoon in Iran. Since Anzali Lagoon is a registered international lagoon, it is currently included in the Montreal List.

Being on this list means the lagoon is being dried and needs attention. Anzali Lagoon has the highest amount of rainfall in the winter and level of humidity (about 80 to 85%) in the summer. Its lowest air temperature is close to zero or zero in winter, and its highest temperature is between 33 to 36 ^{0}C in midsummer. Various amphibian and fish species lay eggs in Anzali

Lagoon, and it is also a refuge for local and migrant birds, some of which are at risk of extinction. This lagoon has more than one hundred bird species, 50 kinds of fish, and various plants. Lagoons in the world attract attention with their rich flora and fauna. Like all wetlands, Anzali Lagoon is home to various plant species such as water lily, lotus, and many other flowers. Anzali Wetland is also home to several kinds of birds like herons, egrets, western marsh harriers, purple swamp hens, pygmy cormorant, white-tailed eagle, ducks, geese, and swans at specific times (Figure 1).

Figure 1. Anzali Lagoon in Iran.

As mentioned, the Anzali lagoon has an important function as a habitat for various plants and bird species. It is known that the ecosystem of the Anzali lagoon is threatened by large amounts of Chemical Oxygen Demand, excess Nitrogen, and a high amount of Phosphorus.

1.2. The effect of Gilan forest destruction on Anzali Lagoon.

The Alborz mountain range is the highest mountain range in the Middle East which captures, by relief precipitation and dew point mists, much of the evaporation of the southern Caspian Sea. The Caspian "Hyrcanian mixed forests" zone, in the world's temperate broadleaf and mixed forests biome, are an area of lush lowland forests covering about 60.000 square kilometers adjoining the shores of the Caspian Sea of Iran. The forest is named after the ancient region of Hyrcania. These ecosystems are located on the coast along the Caspian Sea and the northern slopes of the Alborz Mountains, including 5 provinces, North Khorasan and Golestan (421.000 hectares (1.041.000 hectares), Mazandaran, Gilan, and Ardabil. The total wood production from these forests is around 269.000 cubic meters. The Golestan National Park and Shastkolateh forest watershed are in Golestan, Mazandaran is estimated at 965.000 hectares. 487.000 hectares are used commercially from these forests, and 184.000 hectares are protected. The climate in lower places is subtropical, at mid-altitude, oceanic, and in the mountains, humid continental. Summer is a humid but dry season. The natural forest vegetation is deciduous broadleaved forest, so the main feature of the region is the lack of conifers. The

Caspian Sea coastal plains were once covered by *Quercus castaneifolia*, *Buxus sempervirens*, Black Alder, Caucasian Alder, Caspian Poplar (*Populus caspica*), and Caucasian Wingnut, but these forests have been almost entirely converted to urban and agricultural land and destroyed destruction on Anzali lagoon. The diversity of the species in the Caspian Hyrcanian forests is a reason for a priority for species conservation. Unfortunately, habitats are threatened by conversion into tea, vegetables, and fruits; unsustainable forest management creates an unstable situation in the climate both of Anzali lagoon and Alborz Mountain. Rivers from the Alborz mountain ranges are important for the Anzali lagoon, which is the eutrophic Wetland. Approximately 50% of the total toxic heavy metals and organic pollution load flowed from the Pirbazar River into the Wetland. Therefore metal contamination treatments via chemical and physical analyzing purification are important that is the subject of this work.

1.3. Toxicity of heavy metals.

Heavy metals in nature are detrimental due to their high toxicity. Whether produced from human metabolism or the environment, most themes make the dangerous, persistent, and non-biodegradable of these ions [10, 11]. These ions of transition metals cause various human, plant, and animal health problems, such as the human brain and lung damage or cancer [12, 13]. Seaweed or marine algae helps lead bio-adsorption metals and remove heavy metals [14]. Seaweed consists of several compounds, including xanthophyll, chlorophyll, carotenoids, vitamins, fatty acids, amino acids, antioxidants, alkaloids, polyphenols, and polysaccharides with the same structures of alginate, carrageenan, proteoglycans, galactosyl glycerol, laminarin, Rhamnan sulfate, and fucoidan [15]. The alginate structure in the seaweed makes it an effective compound for metal ion removal. Both alginate and fucoidan structures have a high sorption potential, which can be related to polysaccharides in the cell membrane [14, 16]. Usually, seaweed is the most effective bio-sorption plant for removing metal ions with a unique potential with high metal ion uptake capability, making it an ideal bio-sorption material compared with other materials [15, 17]. This manuscript analysis the toxic ions of those mentioned metals with dead seaweed of Anzali lagoon that has been taken from Iran.

1.4. Heavy metal and toxic ion oxides in Contamination in Anzali lagoon.

Anzali lagoon is completely affected by various heavy and transition metals that seriously make its ecosystem dangerous [18, 19]. Most rivers, and lagoons, are polluted via erosion by metal corrosion and sediment, which are the reason which makes the environment polluted [20, 21]. The non-biodegradable mechanisms of heavy metals have led to bioaccumulation via the food chain and environmental pollution [22]. The metalloids by mass over 6 g cm^{-3} can be regarded as trace elements due to their lower environmental concentrations. Human activities and natural phenomena such as mining, agriculture, volcanic, earthquakes, and industrial activities are the major reasons for environmental contamination [23-25]. These ions of metals, either by inhalation or ingestion, pose teratogens, cancer, and internal disorders [26, 27]. Elements such as Cd, Cr, Pb, and Hg, are the most toxic transition metals. Activated oxygen atom with oxidation is an important key in the toxic removing problem of those mentioned metal ions [27]. Zn, Cu, Mo, and several other metals have also been evaluated due to their assistance in biochemical reactions [28]. Table 1 shows the internationally accepted thresholds of metal ion concentrations in drinking water.

Table 1. Accepted thresholds of toxic thresholds of toxic metal ions in Anzali water.

Metals	WHO[29]	USEPA[30]	EU (Standard)[31]	EE-China [32]	DWI-UK[33]
Lead (Pb)	0.01	0.015	0.005	0.010	0.01
Zinc (Zn)	-	5.0	-	0.05	-
Uranium	0.03	0.03	0.03	-	-
Copper (Cu)	2.0	1.0	2.000	1.000	2.0
Cadmium	0.003	0.005	0.005	0.005	0.005
Mercury (Hg)	0.006	0.002	0.001	0.00005	0.001
Arsenic (As)	0.01	0.010	0.01	0.050	0.01
Chromium (Cr)	0.05	0.100	0.025	0.050	0.05

Transition metals pollution negatively affects the environment due to volcanic mountains, forest fires, biomaterial items, and the damage to the rock. Figure 2 exhibit the main items for transition metals due to the natural groups for these toxic metal ions [34, 35].

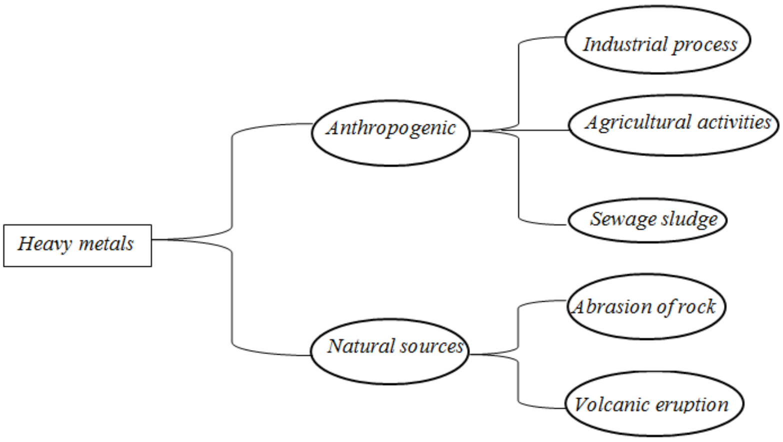


Figure 2. Categories of heavy metal sources.

Biodiversity such as flora and fauna are damaged by polluted water and saved in their systems, tissues, and organs. In addition, as a result of large forest fires, which are effective in large areas, significant pollution may occur in water resources. Therefore humans are exposed to hazardous biochemical problems following the ingestion of contaminated plants and animals (Figure 3).

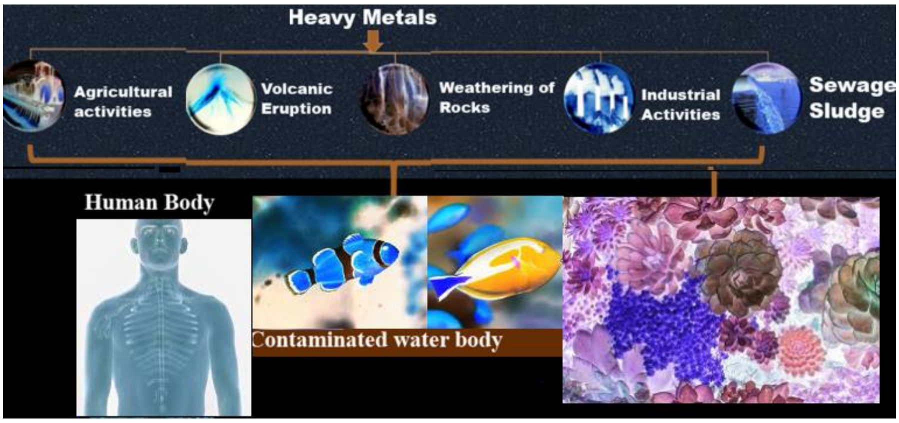


Figure 3. Heavy metal contamination in water.

The seaweed plant has no root; instead, it has holdfasts attached to the bottom of the sea and consists of Haptera and is controlled by several stalks [36]. Some of these stalks are filled with gas, and others are empty. These are known as pneumatocysts, while the whole structure of the seaweed is known as Thallus. Seaweeds have leaves called blades, which help in photosynthesis and are listed into three main categories based on their color Brown (Phaeophyceae), Red (Rhodophyceae), and Green (Chlorophyceae) [37].

The Phaeophyta with brown color has several physical bodies in filament shape that includes chlorophyll, which aids in photosynthesis [38]. Rhodophyta or red one has chlorophyll in which phycoerythrin pigments are responsible for the red appearance. Physically, red seaweed plants are shorter than brown [39]. Hlorophyte or green has chlorophyll without pigment and is smaller than red and brown seaweeds [5, 40-42], Table 2.

The cell walls of brown seaweeds are composed of cellulose, alginic acid, and polysaccharides, with alginates and sulfate being the dominant active groups [7]. The cell wall of red algae contains cellulose, but their biosorption capabilities can largely be attributed to sulfated polysaccharides made up of galactans. Recently, seaweed has been found to be more useful than other plant materials for toxic material sorption [43]. The non-biodegradability, carcinogenicity, and toxicity of heavy metals and ions make them harmful, and treatment of these heavy metals is essential [44]. Sorption has been found to be a stable and effective method for treating heavy metals in aqueous solutions using natural biomass [45]. Therefore, seaweed has known as the best plant for ion removal. The biosorption approach is one of the easy and effective methods for removing heavy metals [46].

Table 2. Characteristics of Seaweed of Anzali Lagoon.

Common Name (Phylum)	Colour	Size	Pigments	Cell Walls
(Phaeophyta)	Brown algae	50 cm - 10 m	Chlorophyll, Fucoxanthin, xanthophylls	Cellulose, Alginate, Fucoidan
(Rhodophyta)	Red algae	40 cm – 2.5 m	Chlorophyll, Phycocyanin,	Cellulose, Xylans, Galactans
(Chlorophyta)	Green algae	10 - 500 μm	Chlorophyll and several xanthophylls	Cellulose β-xylans, β- mannans

Finally, deleting heavy metals using seaweed presents an easier, cheaper way of removing heavy metals from aqueous solutions than the other methods. Different mechanisms have been done in heavy metal removal and ion exchange has been considered the main model among the list of mechanisms [47, 48]. The cell membrane of the seaweed has polysaccharides and proteins that serve as a binding portion to metal ions [49]. In this study, several physical and chemical properties of chemisorption of seaweed surfaces such as IR, NMR, UV absorption spectroscopy of binding groups for metal ions and their affinities of the metal with the functional group, the chemical state of these sites, the number of functional groups in the seaweed, and the coordination number of the metal ion have been calculated [50]. The metal biosorption ability of seaweed varies because of the heterogeneity of their respective cell wall composition. For instance, brown, green, and red seaweed have high affinities for Pb, Cu, and Co, respectively [7]. Physical or chemical phenomena can enhance heavy metal uptake by algae, and the cell membrane is suitable for any additional binding sites for biosorption [7, 51]. The most usual chemical compounds for algae treatment are glutaraldehyde, $CaCl_2$, H-CHO, NaOH, and HCl. Treatment with $CaCl_2$ increases calcium binding with alginate, which plays a major role in ion exchange [52]. The crosslinking bond between OH and NH_2 groups is strengthened via formaldehyde and glutaraldehyde [53]. The electrostatic interactions of metal ion cations are increased through NaOH while simultaneously providing optimal conditions for ion exchange.

2. Materials and Methods

2.1. UV absorption spectroscopy.

Carotenoids have diverse natural pigments produced by plants, algae, and photosynthetic bacteria [54]. These strong, colorful molecules are the reason for the red, yellow, orange, and brown colors of many plants of vegetables and fruits. The principal molecular structure of carotenoids includes a polyisoprenoid carbon chain with a series of conjugated double bonds placed in the molecule's center. This manner lets effective delocalization of electrons along the entire length of the polyene chain and provides carotenoids their pigmentation, light-harvesting potential during photosynthesis, and chemical reactivity. Another structural state of carotenoids is the existence of cyclic end groups [1]. Cryptoxanthin, α & β-carotene, lutein, zeaxanthin, and lycopene are the most important usual dietary carotenoids [54].

UV spectroscopy is one of the important methods for determining impurities in organic molecules that can be compared with that of standard raw material. The impurities can be detected by measuring the absorbance at a specific wavelength. On the other hand, UV spectroscopy is useful in the structure elucidation of organic molecules, the presence or absence of unsaturation, and the presence of hetero atoms. UV absorption spectroscopy can be used to determine compounds that absorb UV radiation [55] quantitatively. This determination is based on Beer's law which is as:

$$A = \log I_0 / I_t = \log 1/ T = -\log T = abc = \varepsilon bc$$

where ε is extinction coefficient, c is concentration, and b is the cell length used in UV spectrophotometer. Also, UV absorption spectroscopy can characterize those types of compounds that absorb UV radiation. Identification is made by comparing the absorption spectrum with the spectra of known compounds. The UV radiation is passed through the reaction cell, and the absorbance changes can be observed. This spectroscopy can be used in quantitative analysis of pharmaceutical substances because many drugs are in the form of raw material or formulation. They can be assayed by making a suitable drug solution in a solvent and measuring the absorbance at a specific wavelength. In this study, UV-Vis absorption spectra of chlorophyll, xanthophyll (Figure 4-a, 4-b), and a mixture of chlorophyll and xanthophyll in seaweed have been accomplished (Figure 5).

The result of temperature relation and also the stable structures of these compounds were also investigated. Xanthophylls compounds were found to be more stable compared with chlorophylls groups, which is attributed to the potential of xanthophyll to dissipate ultra-energy via reversible conformational changes for removing the toxic oxides in the water of the Anzali Lagoon.

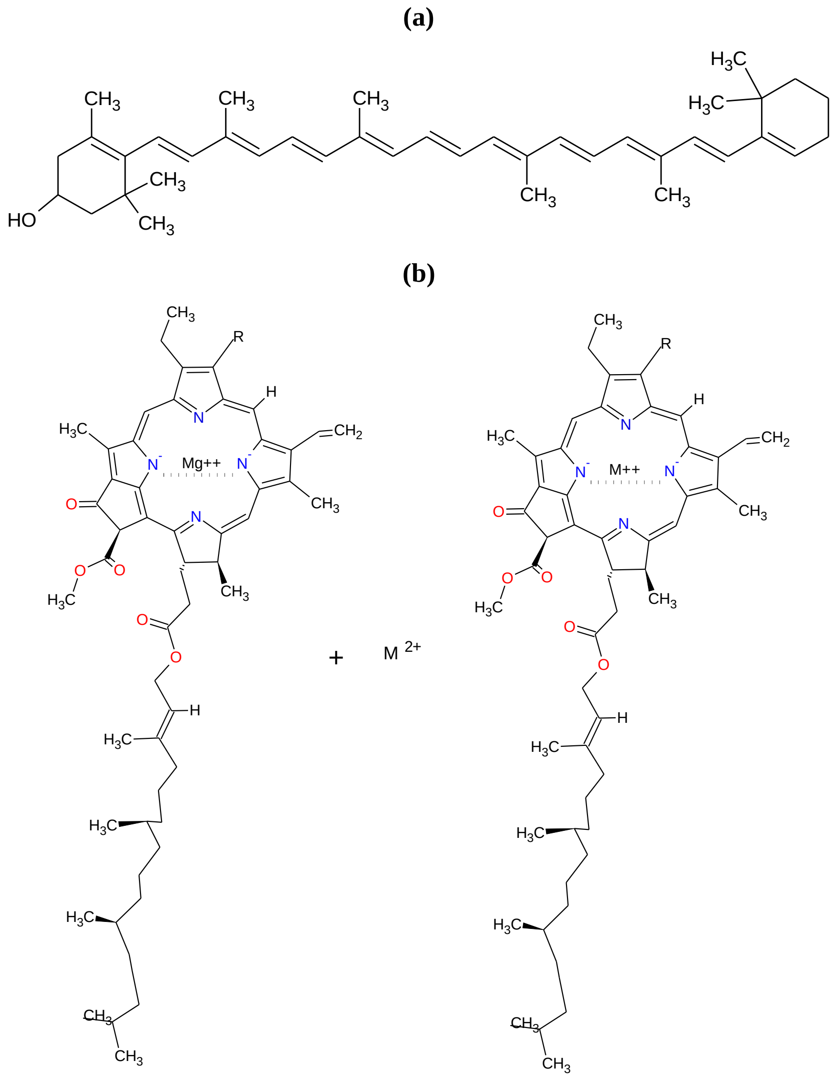


Figure 4. The structure of (**a)** xanthophyll and (**b)** two kinds of chlorophyll with R =CH_3 (Chlorophyll a) or R=CHO (Chlorophyll b).

The maximum absorption has been observed in the wavelength between 350-460 nm for xanthophyll, 350-470 nm for chlorophyll, and the mixture of both compounds in the wavelength between 400-500 nm (strong adsorption), 500-600 nm (weak adsorption) through the different active sites in these structures. Light transmittance in UV-VIS spectroscopy was applied to quantify the fillers' dispersion in all nanofibers.

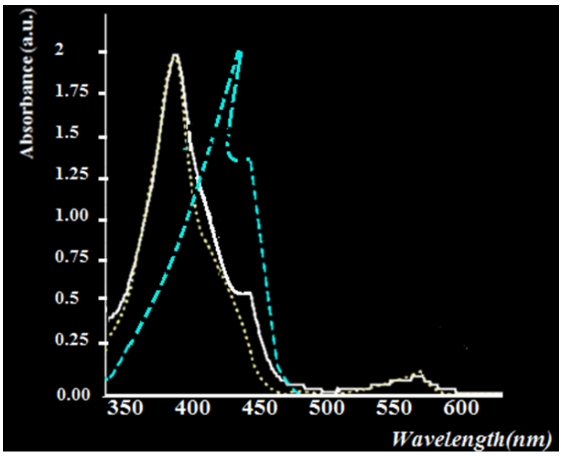


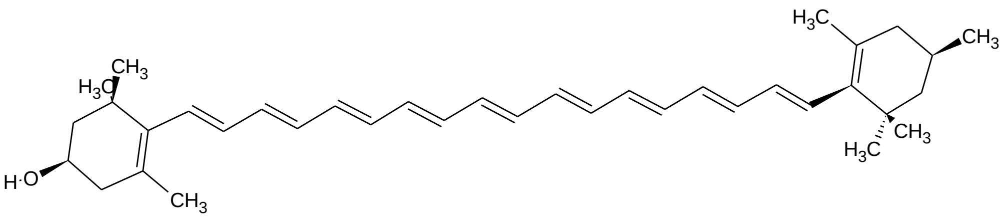
Figure 5. UV-Vis absorption spectra of xanthophyll(dashed line), chlorophyll(blue), and mixture(white) seaweed.

Tests were accomplished for xanthophyll and chlorophyll on wet systems. Several dimensions were tested, and the optical transmittance curves for wet samples were plotted. The effect of water absorption on the mechanical behavior of these compounds was formulated after placing the specimens in water for further discussion, and the theoretical data was compared with the same compounds in the dry condition. The temperature role was important for accelerating the effects of water aging.

2.2. Near-infrared (NIR) and excited Fourier transform (FTIR).

NIR excited Fourier transform Raman spectroscopy has been applied for *in situ* analysis of carotenoids in living plant samples. The seaweed has been mapped using a Raman mapping technique to illustrate the heterogeneous distribution of lutein and zeaxanthin carotenoids (Figure 6-a,6-b).

(a)



(b)

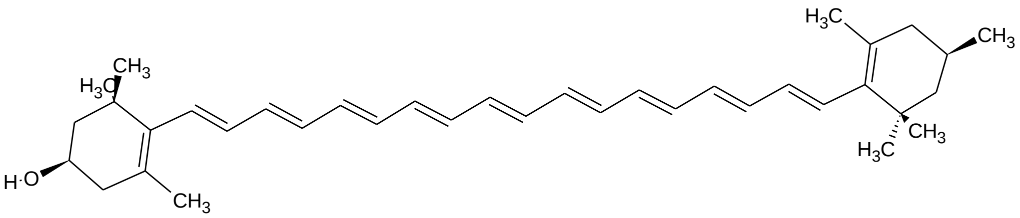


Figure 6. The structure of (**a**) lutein and (**b**) zeaxanthin.

NIR-FT-Raman spectroscopy has been shown to be a very useful technique for the nondestructive analysis of carotenoids in various living plant tissues (Figure 7).

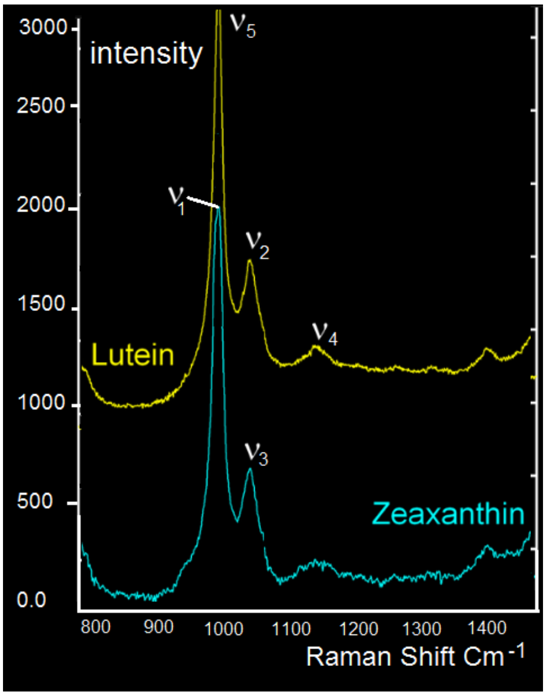


Figure 7. Raman spectra in the 800–1400 cm^{-1} for zeaxanthin (blue) and lutein (yellow)

2.3. FTIR analysis.

The spectra of Mid-infrared between 4000-600 cm^{-1} to 1 cm^{-1} data limitations were achieved using a spectral resolution of about 4 cm^{-1} on the Perkin-Elmer Spectrum 2000 FTIR spectrometer (Perkin-Elmer Corp., Norwalk, CT) that was supplied through an ATR collection Specac MKII GoldenGate (Specac Inc., Smyrna, GA) and was cited for the interaction angle was 45°. The spectrophotometer was installed by a wire coil conducted at1350 K with infrared light cause, a DTGS detector, and a potassium bromide beam splitter. The samples for saving and preparing and data collection for acquiring were accomplished at 25 °C. Data collection of acquiring was performed over several days, and The samples were selected randomly. A part of the powder sample was mixed and then placed on the ATR diamond surface.

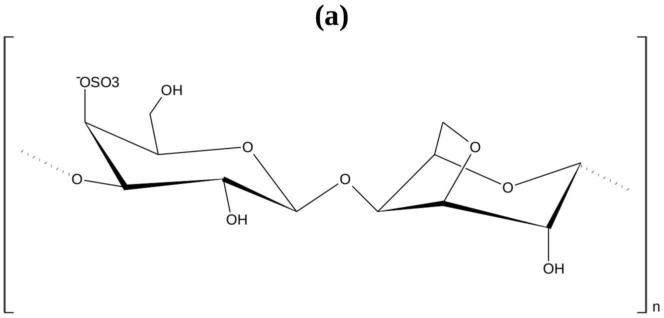
Therefore, it was considered a pressure of 11000 psi for the sample using a pressure clamp instrument. So, it was gathered four repetitive spectra of each sample on four various parts of the sample. The average of sixteen scans was indicated in front of the background by every spectrum, which was gathered with the vacant ATR accessory based on similar situations at the start of every day through analysis. Then, the ATR surface among the samples has completely become neat with water and alcohol. The total performing task of spectra acquiring took 5 minutes because there was no essential thermal equilibration for each sample. The analysis of existing data was done by Spectrum Quant+ version 4.51.02 (Perkin-Elmer Corp.). First, the reflectance spectra were converted into absorbance, and second standardized on the maximum absorbance peak, which was between 1024 cm^{-1} and 1035 cm^{-1}, before employing for calibration of validation or development.

3. Results and discussion

3.1. FTIR analyses.

Figures 8-10, consisting of the FTIR spectra of kappa and iota carrageenan indicate that the principal spectral divergence based on specific absorption bands in 2520 cm-1 for the ester sulfate structure and 1550 cm-1 for the 3,6-anhydrogalactose, 1150 cm-1 for the galactose-4-sulfate, and 1050 cm-1 for the 3.6-anhydrogalactose- 2-sulfate. PCA (a principal component analysis) was accomplished with the recorded spectra of the 52 samples. This PCA's first nine PC's (principal components) exhibited 99.4% of spectral variation. Therefore, due to this PCA, the spectral residual F ratio for every spectrum was measured, which represents the ratio of the variation of the residuals among the estimated spectrum and its computed spectrum, which was regenerated from the chosen elements, and the residual spectral variation of all of the spectra.

(a)



(b)

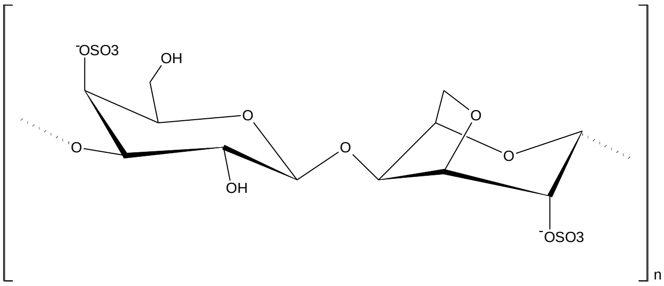


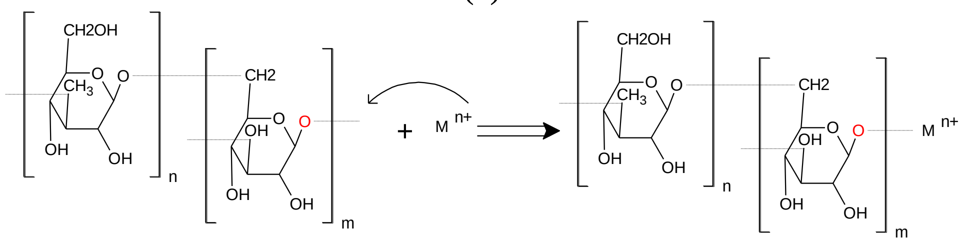
Figure 8. Basic structures of (**a**) kappa and (**b**) iota carrageenan repeating units.

A considerable amount remarks that the residual spectrum includes characteristics that the PCA did not create. So, in these situations, forecasting the consequences should have behaved with careful attention, and the characteristics in the residual spectrum must be explored.

3.2. Metallic chelation of seaweed compounds.

As a result, the seaweed consist of a variety of compounds such as xanthophylls, chlorophyll, carotenoids, vitamins, fatty acids, amino acids as well as antioxidants (including alkaloids and polyphenols), and polysaccharides (including alginate, carrageenan, proteoglycans, galactosyl glycerol, laminarin, Rhamnan sulfate, and fucoidan) can be removed based on metallic chelation in order with one and two valances mechanism as follows. The chelation of laminarin and 2-(α-D-galactosyl) glycerol (Figure 9-a, 9-b & 10) with metallic ions such as Na^+ K^+ Mg^{2+} Sn^{2+} has been studied in this investigation by forming relatively stable complexes in the weak acidified medium with a different pH range.

(**a**)



β- 1,3 β-1,6 β- 1,3 β-1,6

(b)

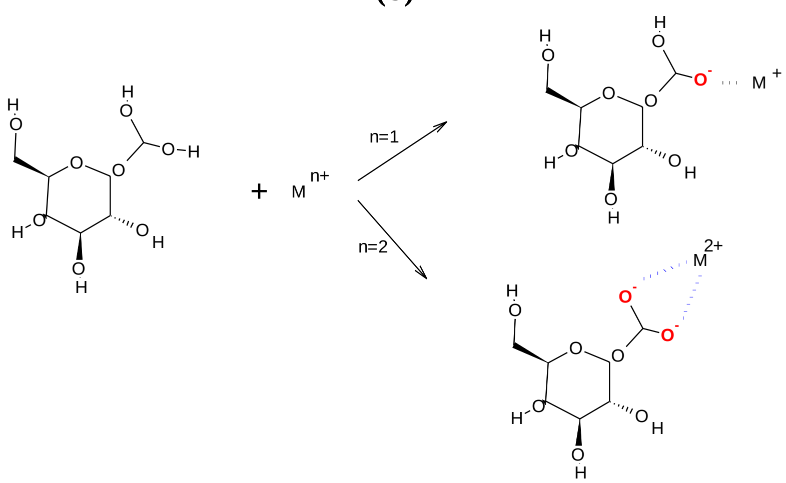


Figure 9. Chelation mechanism of **a)** laminarin and **b)** 2-(α-D-galactosyl)glycerol ($C_9H_{18}O_8$) for removing toxic cation metals.

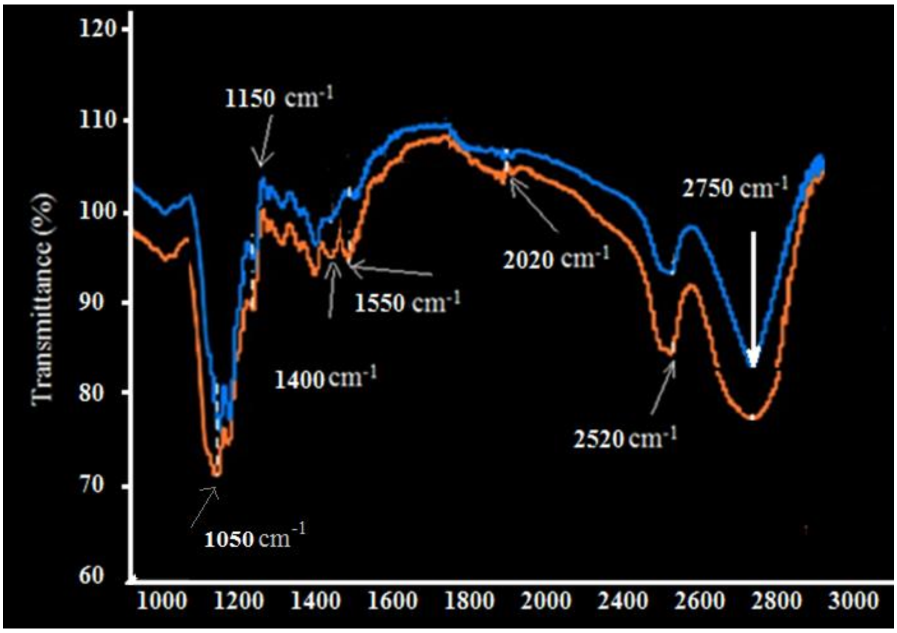


Figure 10. FT-IR of kappa-carrageenan spectra of purified laminarin gained from seaweed

3.3. NMR analysis of seaweed compounds in Anzali Lagoon.

A sulfated polysaccharide from *seaweed* was extracted through anion exchange and gel filtration column chromatographies. Polysaccharides consisted of a large amount of l-rhamnose with a small amount of d-glucose, and it was considered a Rhamnan sulfate (RS).

To evaluate the ability of a rhamnan sulfate [56] as a possibility of a food additive or not, it has been investigated the rheological properties of the polymer isolated from *Monostroma nitidum* applied to a rheogoniometer.

Soft gelation was prepared at a concentration of 4.0%, and the elastic modulus was fixed by the temperature at 50 °C, then reduced with further growth in temperature. However, a small reduction in elastic modulus has been remarked with the increase of urea (4.0 M) . Growth in the elastic modulus has been seen in a 0.05 M NaOH solution, and soft gelation happened. The elastic modulus rested largely during the temperature growth, even at 90 °C. The soft gelation also happens when Rhamnan sulfate has been solved in a Tris buffer (pH 8.0) solution (Figure 11-a, b).

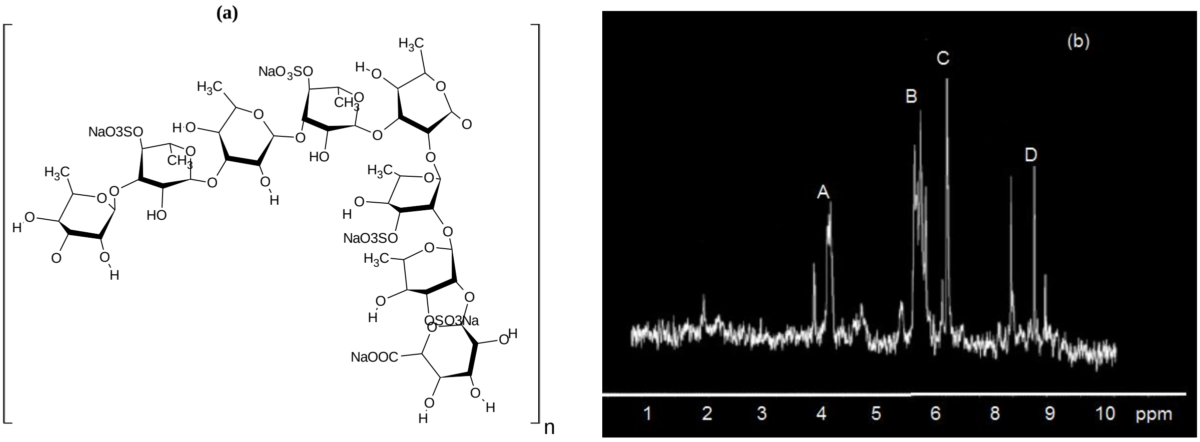


Figure 11. (a) Structure of rhamnan sulfate from Monostroma nitidum (green seaweed). **(b)** ^{1}H NMR .

The ^{1}H NMR spectrum of Rhamnan sulfate (Figure 11-a&b) has shown four anomeric proton signals at 4.99 ppm, 5.07 ppm, 5.22 ppm, and 5.37 ppm with relative integrals of

1.05:0.97:1.00:0.20, which were attached to α-L-rhamnopyranose. The labels of A, B, C, and D in (Figure 11-b) have indicated the signals at 4.99 ppm and 5.07 ppm for H-1 of 1,3-linked α-L-rhamnopyranose, 5.22 ppm has been determined to be the H-1 of 1,2-linked α-L-rhamnopyranose, and 5.37 ppm was determined to the H-1 of 1,2-linked-3-sulfated α-L-rhamnopyranose. Moreover, the signal at 1.33 ppm belongs to the proton of the CH_3 group of the rhamnose unit [57-59]. In ^{13}C NMR, it has been estimated that in the anomeric area of the ^{13}C NMR spectrum of Rhamnan sulfate, the main anomeric carbon resonances of α-L-rhamnopyranose exist at 102-104 ppm. The signals at 70–80 ppm have been determined to be C-2–C-5 of the glycosidic rings. The signal at 18.23 ppm belongs to the C-6, and the α-anomeric configuration of rhamnopyranose residues has been reduced from the H-5 signal at 3.79 ppm and the C-5 signal at 70.82 ppm [60]. Also, the NMR analysis has been applied for fucoidan seaweed compounds, famous for copious and diverse biological functions like antivirus, anticancer, anti-bacteria, and adjustment of immunity. Fucoidan, one of the principal ingredients of water extracts of brown seaweeds, has been indicated with intense anticancer, antivirus, and antipathogen adhesion functions for removing toxic oxide ions [61-95].

4. Conclusions

Studying existing coastal lagoons in the Middle East, such as the Anzali Lagoon in Iran, is important because of this region's climate change and ecology. Eutrophication of waters due to human activities is a significant cause of their poor quality. The relationship between the climate of the Caspian Sea and morphological factors varies depending on the quality of the environment and traditional and current uses. Conservation of the site requires appropriate management of water quality. The exchange of lagoon water with seawater is important, including freshwater inlets that preserve biodiversity and quality contributions to inland waters. The Anzali lagoon is completely affected by various heavy and transition metals that seriously affect its ecosystem and make it dangerous. Non-biodegradable mechanisms of heavy metals lead to bioaccumulation through the food chain and environmental pollution—water quality for people and all other living important to living things. Especially aquatic life is even more important for not only toxic environmental wastes or pollutants are involved in the deterioration of water quality, but also deterioration in water quality after forest fires [66]. Water quality can be affected after a forest fire; consequently, fish and some aquatic organisms are affected.

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Conflicts of Interest

The authors declare no conflict of interest.

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