Cladophora glomerata L. as indicator of chemical pollution in coastal areas of Farahabad Region, Iran

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ABSTRACT

Apart from key ecological role, some algal species have emerged as important indicators of chemical pollutants. Among such algal species, *Cladophora glomerata* L. which is a prevalent filamentous green alga found along the southern coast of Caspian Sea has emerged as important indicator of some metal pollution. The current study reports the analysis of *Cladophora* samples during summer of 2016 for selected metals and other nutrients. The antioxidant activity was also investigated in collected algal samples from various sampling points along the Caspian Sea with peak tourists' activity. The detection of heavy metals in *Cladophora glomerata* was found higher than normal background levels for studied metals (Cu, Zn, Mn and Fe). Such higher values of metals in this indicator species is alarming and shows a threat to recreational value of Coasts of Farah Abad region along Caspian Sea. It is urged that policy makers and stakeholders need to devise strategies to protect coastal areas of Caspian Sea so retain their recreational value and natural ecological phenomenon.

Keywords: *Cladophora glomerata*, bioindicator, Caspian Sea, Farahabad, metal pollution, tourism

Received: 20-01-2018
Approved: 10-03-2018

1. INTRODUCTION

Industrialization has enormously increased the level of pollutants and poisonous substances by untreated discharge into the oceans. Therefore metal contamination along with coastal regions is worldwide dilemma (Millward & Turner 2001). Major sources of marine water deterioration are sub marine volcanic eruptions, ocean floor erosions and metals leaching are natural processes that enhanced some essential and nonessential elements. Some trace elements like Copper, Magnesium, Zinc, Iron and manganese plays an important role in biological systems but its excessive amount also resulted in marine water toxicity (ATSDR, 1993; Millward & Turner 2001; Kalantari & Ebadi, 2006a; Kalantari & Ebadi, 2006b; Ebadi & Hisoriev, 2017b).

The introduction of various chemical pollutants like toxic metals, nitrates, phosphates and others have caused serious threats to the ambient environment and has resulted in the serious problems to natural ecological sustainability (Huang et al, 2009; Buchanan, Counter & Ortega, 2011). When such toxic metals come in contact with human skin in coastal areas, these metals may result in serious illnesses in human beings including respiratory, skin and central nervous system systems (ATSDR, 1995).

The coastal areas on Iran bordering Caspian Sea are popular tourist attraction where people come to enjoy beautiful beaches and swimming in clean waters. However, these coastal areas are being progressively polluted due to release of sewage waters carried by rivers which drain into coasts in most parts of the world (Ebadi & Hisoriev, 2017a).

For the assessment of metal toxicity, marine algae have been widely used as bio indicator of marine water contamination (Misheer, Kindness & Jonnalagadda, 2006: Chaudhuri et al. 2007). *Cladophora* is a genus that belongs to reticulated filamentous green algae, which exist in coastal regions along with logs, tough sides or submerged rocks through a holdfast. *Cladophora glomerata* has been investigated for accumulation and toxicity of zinc in River Roding, Essex, UK (McHardy & George, 1990). It has been observed that *C. glomerata* show high quantity of copper and manganese accumulation thus was referred as bio monitor and bio-accumulator of trace elements. Previously, *C. glomerata* shown promising results against accumulation of toxic metals like chromium (Cr), lead (Pb), and cadmium (Cd) from Farahabad Region of Caspian Sea – Iran (Ebadi & Hisoriev, 2017a).

The Objective of this present study aims to analyze metals, estimation of antioxidants, identifying the potential of *C. glomerata* against selected essential micronutrients (Mg,

Received: 20-01-2018
Approved: 10-03-2018

Cu, Mn, Zn and Fe) their uptake and accumulation from Farahabad Region of Caspian Sea – Iran.

2. METHODS

The algal samples were collected from 4 sampling points of Farahabad region (Mazandaran Province of Iran). Sampling, Preparation and drying procedures performed based on standard methods as described by Ebadi, Hisoriev & Aliev (2017). All samples collected from places under similar conditions during the spring of 2017. Stations 1-4 were selected for the sampling of algal species *Cladophora* near the coastal regions. Another point was selected for water sampling g where Tajan River drained into Caspian Sea (late 2016- early 2017). For algal collection, 10 g of each sample was collected in triplicates at each station and then mixed together to obtain a composite sample. In order to determine the heavy metal concentrations, all the collected samples digested with aqua regia (HNO3 67%:HCl 37% = 3:1). Acid mixture (HNO3 67%:H2SO498%:HCl 37%:HF 40% = 2:1:1:1) for 1 g dry weight of algal sample digestion was used (Misheer, Kindness & Jonnalagadda, 2006) to digest each sample. Mineralization of the samples was performed by using a Berghof MWS-2 microwave digester.

The total metal content of water and mud samples was determined by Flame Atomic Absorption Spectrometry (FAAS). Blank and standard solutions for calibration of devices were used as well. The determination of other nutrients was carried out according standard methods. Antioxidant activity was measured at the wavelength of 517 nm based on the capacity of damage of active radicals as described by Ebadi, Hisoriev & Aliev (2017) based on formula given below:

% of damage of active radicals = [absorb in control sample – absorb in test sample / absorb in control sample] * 100

3. RESULTS

Various metal concentrations at study stations were shown in Table 1. Each metal concentration had variations in the studied stations. The Cu concentration was in range of 13.6 to 15.8 ppm in collected algal samples. Although, these concentrations have no marked variations in the sampled areas, the prevalence order could be judged as: Station 1 >Station 3>Station 2>Station 4. These all concentration detected in *Cladophora* were higher than sea water standard concentration of seawater i.e. 0.09 ppm.

Received: 20-01-2018
Approved: 10-03-2018

The concentration of Zn in *Cladophora* also showed narrow range of variations in its content from various studied stations. The Zn concentrations varied in range of 14 to 16.8 ppm at various stations. The order of prevalence was Station 3>Station 1> Station 4> Station 2. The background level of Zn in sea water is 0.014 ppm, the higher amount of Zn in *Cladophora* is indicative of its potential to absorb and accumulate high Zn from polluted sea water. Regarding Mn, the range of concentrations detected in algal cells was 51 to 66 ppm. The order of prevalence of Mn in *Cladophora* from various stations was Station 4>Station 1>Station 3>Station 2 (Table 2). Such a high amounts of Mn in algal tissues might be due to high inputs of polluted water from draining Rivers in these coastal areas. The acceptable level of mn in coastal areas is 0.01 ppm. Hence, the accumulation of Mn in *Cladophora* is an indication of metal pollution in coastal waters.

Fe was another metal detected in *Cladophora* collected from various stations along coast of Farahabad region. Table 2 shows that the concentration of Fe was quite high and it ranged from 690 to 770 ppm in *Cladophora*. The prevalence order could be designated as Station 1>station 2>Station 4>Station 3. The normal limit for fe in seawaters is 0.02 ppm. Considering background Fe content, it was again alarming to note such a high Fe amounts in *Cladophora* from all studied stations.

The current study was conducted in coastal areas of Farahabad region, Iran on the bank of Caspian Sea. The region is main attraction of tourists due to its beautiful beaches and mild tropical temperatures. The introduction of municipals carried by Tajan River is creating pollution in this region. Such chemical pollution especially heavy metals would result in serious consequences especially spoiling beauty of coastal areas and bioaccumulation of metals in sea food. In Saudi Arabia, due to an increase in sea water pollution the concentration of some trace elements (Fe, Mn, Cu, Zn, Pb, Cd and Hg) was observed high in some common fish species, meat and meat products (Alturiqi & Albedair, 2012).

In some researchers reported that high levels of some heavy metals in the algae reflect both the high bioavailability of the metals in the study area and the capacity of the alga to accumulate the metals. Metal accumulation in algae is dependent on various factors including **(1)** metals concentrations in ambient water, **(2)** water conditions including pH, salinity, temperature, light, particulate matter and organic matter, **(3)** stage of development **(4)** variation in growth and **(5)** chemical composition of the algae (Chaudhuri et al., 2007).

Received: 20-01-2018
Approved: 10-03-2018

Various marine algal species like L. papillosa, T. hemprichii, J. adhaerens, G. crassa, S. tenerimum, G. cylindrica and H. musciformis were analyzed in coral environment for metals uptake of Fe, Mn, Zn, Cu, Co, Cr, Cd, Pb, and Ni thus concluded that bioaccumulation of essential elements was high in all species and was as follows Fe > Mn > Zn > Cu > Cr > Co > Pb > Cd (Gopinath et al., 2011). Besides other metals copper is an intermediate metal due to its narrow range of useful and toxic effects. It was observed that Cyanophyta, and Bacillariophyta biomass was effective for Fe, Zn, Cd, Pb, Cu, Ni, and Cr uptake and decontamination of water bodies (Elgailani & Elhassan, 2014a). It has further been analyzed that the trace metals i.e. Fe, Zn, Cd, Pb, Cu, Ni, and Cr uptake and accumulation was high in various algal species of the phyla Chlorophyta, Cyanophyta, Euglnophyta and Bacillariophyta which significantly enhance the decontamination of trace metals from water bodies (Elgailani & Elhassan, 2014b).

The biochemical composition of *Cladophora* cells has been presented in Table 2. No reference values are available in literature for *Cladophora*. Total N of *Cladophora* was in range of 3.5 to 4.7% at various stations. Likewise Total K was in range of 2.3 to 2.7% from various stations. The percentage of P in algal samples was in range of 0.08 to 0.18%. Mg ranged 0.26 to 0.49%. Regarding Ca, the amount varied from 1.2 to 2%. The antioxidant activity of *Cladophora* cells from various sampling stations has been shown in Fig. 1. It is evident that the accumulation of heavy metals resulted in oxidative stress. As a consequence, the antioxidant activities were evident (Ebadi, Hisoriev & Aliev, 2017). However, the level of antioxidant activities was variable. The maximum amount of activity was shown in cells from station 3. Although before studied showed that this species can be very proper and economic source for bio-energetic such as bio-oil (Ebadi & Hisoriev, 2017c; Ebadi & Hisoriev, 2018; Ebadi et al., 2018).

4. CONCLUSIONS

The detection of heavy metals in *Cladophora glomerata* was found higher than normal background levels for studied metals (Cu, Zn, Mn and Fe). Such higher values of metals in this indicator species is alarming and shows a threat to recreational value of Coasts of Farahabad region along Caspian Sea. The cells were showing high antioxidant activities due to metal accumulation. It is urged that policy makers and stakeholders need to devise strategies to protect coastal areas of Caspian Sea so retain their recreational value and natural ecological phenomenon.Precisar conclusiones.

Received: 20-01-2018
Approved: 10-03-2018

Table 1. Concentration of various metals in *Cladophora glomerata* collected from Farahabad region, Iran

Heavy metal	Cu (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)
Station 1	15±0.11	16±0.9	59±3	770±23
	15.5±0.09	14±1	51±4	690±32
	15.8±0.1	16.3±0.8	53±3	730±31
Station 2	14±0.8	15.2±0.9	55±4	743±21
	14.6±0.9	15.7±1	52±4	720±23
	14.8±0.12	15±2	54±3	733±21
Station 3	15.2±0.23	16.2±3	52±5	666±11
	15±0.7	16.4±2	51±6	678±21
	15±0.9	16.7±1	58±5	690±27
Station 4	13.9±0.21	16.8±0.99	61±6	710±21
	13.4±1	15.6±0.87	65±4	700±11
	14.6±2	15.3±1	66±6	690±14

Note that all the values presented were means of triplicates, ± indicates standard deviation

Table 2. Percentage values of various macronutrients in *Cladophora glomerata* collected from Farahabad region, Iran

	Total N %	Total K %	Total P %	Mg %	Ca %
Station 1	4.70±0.5	2.53±0.3	0.14±0.03	0.32±0.02	1.45±0.02
	4.30±0.6	2.33±0.2	0.13±0.02	0.29±0.02	1.33±0.02
	4.00±0.5	2.20±0.3	0.09±0.01	0.26±0.01	1.24±0.03
Station 2	4.20±0.4	2.60±0.4	0.15±0.01	0.32±0.01	1.55±0.02
	3.90±0.6	2.70±0.3	0.16±0.02	0.37±0.03	1.67±0.03
	3.70±0.5	2.50±0.2	0.13±0.02	0.39±0.02	1.59±0.01
Station 3	4.20±0.3	2.45±0.2	0.11±0.01	0.37±0.02	1.43±0.01
	4.50±0.4	2.40±0.3	0.12±0.01	0.44±0.03	1.62±0.02
	4.30±0.5	2.20±0.3	0.08±.001	0.47±0.04	1.54±0.02
Station 4	3.90±0.5	2.44±0.4	0.14±0.01	0.49±0.02	1.45±0.02
	3.50±0.4	2.40±0.3	0.16±0.02	0.42±0.03	1.89±0.03
	4.50±0.4	2.35±0.2	0.18±0.02	0.44±0.02	2.00±0.02

Note that all the values presented were means of triplicates, ± indicates standard deviation

Received: 20-01-2018
Approved: 10-03-2018

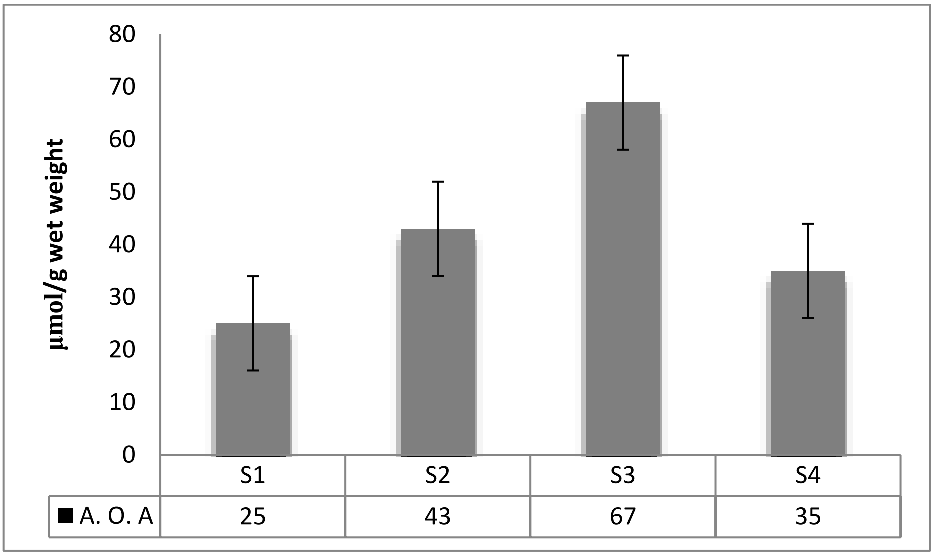

Figure 1. Measurement of Anti-oxidant activity (AOA) in *Cladophora glomerata* samples from different stations of Farahabad Region, Iran (Mean ± SE, $p < 0.05$)

5. ACKNOWLEDGMENTS

The authors greatly acknowledge Tavakkol laboratory staff (Sari City of Iran) who carried out metal analyses for the current study.

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Received: 20-01-2018
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Received: 20-01-2018
Approved: 10-03-2018