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Effect of soda ash industry effluent on protein content of two green seaweeds

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Abstract

The aim of the present study is to check the effect of soda ash industry effluent on the protein content of the seaweed *Ulva faciata* and *Chaetomorpha antennina*. Study shows that the effluent has positive effect on the protein content of the alga and thus these species can be used to reduce the effect of soda ash industry pollution because the rise of up to 35% of protein level is found in these species of alga due to uptake of polluted water. Thus, these seaweeds can be cultivated on a large scale in the effluent affected region and thus clean the environment while getting the proteinous food as by product.

Keywords: Marine algae; Seaweed; Protein; Pollution; Soda ash

1. Introduction

Algae are classified as unicellular microalgae and macroalgae, which are macroscopic plants of marine benthoses [1]. Macroalgae, also known as seaweed, are distinguished according to the nature of their pigments: brown seaweed (phaeophyta), red seaweed (rhodophyta) and green seaweed (chlorophyta). In Asian countries, several species of seaweed are used as human food, to provide nutrition and a peculiar taste. Fresh dried seaweed is extensively consumed, especially by people living in coastal areas. They are of nutritional interest as they are low calorie foods but rich in vitamins, minerals and dietary fibre [2–4]. Currently, human consumption of green algae (5%), brown algae (66.5%) and red algae (33%) is high in Asia, mainly Japan, China and Korea [5]. However, demand for seaweed as food has, now also increased in North America, South America and Europe [6]. The different species consumed have great nutritional value as they are source of proteins, carbohydrates, minerals and vitamins. Seaweeds are also called sea vegetables because of their high nutritive value. Seaweeds are traditionally used for human and animal nutrition. Their protein contents differ according to the species and seasonal conditions. In some green seaweeds, such as the species belonging to the genus *Ulva*, the protein content can be between 10 and 26% (dry weight) of the plant. For instance, the species *Ulva pertusa*, which is frequently consumed under the name of "ao-nori" by Japanese people, has a high protein level, between 20 and 26% (dry weight) [7].

Gujarat has the longest available seacoast in India and the substratum is rocky in many parts of Gujarat, which provides the suitable environment for algal growth. Out of more than 300 species found along the coast the *Ulva faciata* Delile and *Chaetomorpha antennina* (Bory) Kuetz are the major seaweeds found along the coast of Gujarat and they are available almost for a year. There are four soda ash industries, manufacturing washing soda, are also there along the coast of Gujarat. The soda ash industry near the study site manufactures soda ash by Solvay process [8]. It produces 40,300 t of dense soda ash and 16,350 t of sodium bicarbonate per annum; simultaneously, it also generates 170,000 m^3 effluent per day. The original effluent is diluted with seawater (to meet the pollution control standards) before discharging into the coastal water. The diluted effluent is discharged 500 m away from the coastline through a sub marine pipeline [9]. If algae are cultivated in this region, then it will not only clean the environment but also give proteinous food as a byproduct.

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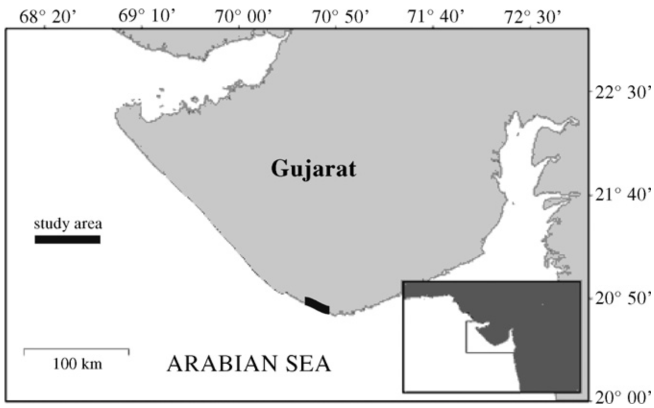

Fig. 1. Map showing study area.

The aim of present study is to examine weather the effluent of the soda ash industry has beneficial effect on the protein content of the seaweeds *U. faciata* and *C. antennina*?

2. Materials and methods

2.1. Description of experimental site

The soda ash industry effluent outfall is situated at Latitude 20° 49′N, Longitude 70° 28′E (Fig. 1). There is no source of pollutant other than soda ash industry near present study area. The first sampling station for seaweed was in the intertidal belt just in front of effluent outfall. The second, third and fourth stations were also situated in the intertidal belt of the coast at 1, 5 and 15 km away, respectively, in the down streamside of the effluent discharge point (Fig. 2). Station 4 situated at Latitude 20° 43′N, Longitude 70° 47′E and unpolluted by the effluent was considered as control. The effect of the said effluent decreases as we go down stream because of dilution due to sea current [10]. Therefore, the control station was chosen almost 15 km away from the point, where the actual effluent is discharged through submarine outfall by the factory. There is no fresh water inflow at these stations and the tide pattern is semidiurnal. In fact, southwest region of Arabian Sea, where the experiment has been conducted, experiences biannual reversion of water movements due to prevailing monsoons. All the stations have hydrography of completely open reef. The seaweeds grow luxuriantly at almost all the stations. The complete details regarding experimental site along with map has been published by us recently [10].

2.2. Sampling procedures, pretreatments and protein analysis

The plants of *U. faciata* and *C. antennina* (fresh weight 2 kg each) of same age and good health were collected randomly from the intertidal belt of each station. The age of the plant was determined by their size, and therefore, the plants of the same size were collected. This is because the protein content of the plant may vary with the age. The older plants always have higher protein content than the younger one. Therefore, to avoid the variation due to age effect the plant of the same age has been chosen from all the sampling station. Each sample of seaweed was washed thoroughly three times with filtered seawater to remove dirt and other attached material and then they were rapidly rinsed in deionized water to remove adhere seawater. The samples were brought to the shore laboratory and spread on clean polythene sheet under shade and left for drying. The plants and animal epiphytes and other material attached to the plants were physically hand picked before drying. The dried material was packed in polythene bags and they were dried in air forced oven at 60 °C till constant weight. These samples were pulverized and sieved through 60 μM mesh sieve. One hundred grams pulverized samples were again dried at 60 °C and stored in desiccators

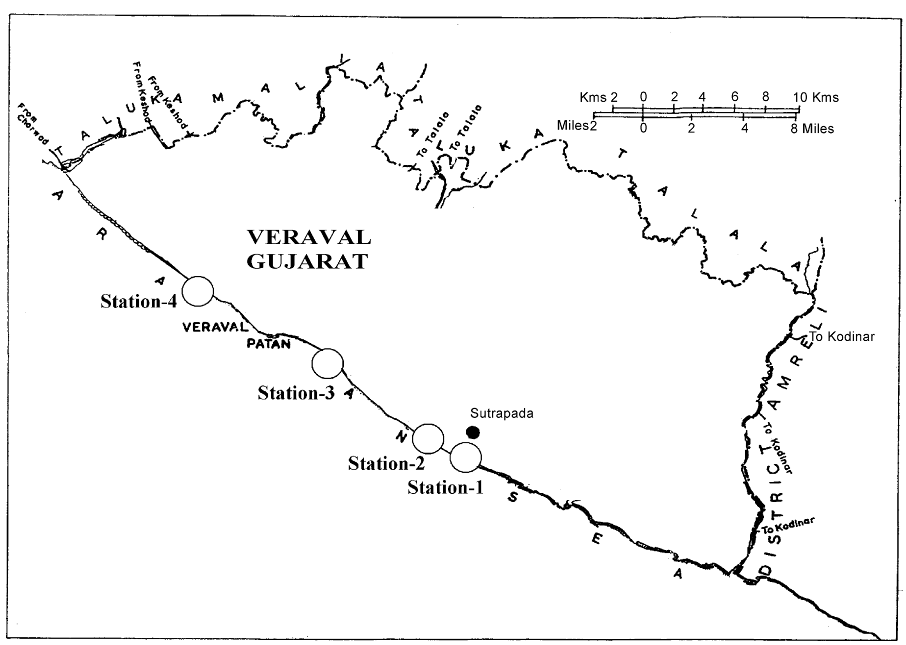

Fig. 2. Map showing effluent affected and control stations.

Table 1
Protein content in samples of seaweeds

Station/seaweed	*U. fasciata*	*C. antennina*
Station 1	18.55 ± 0.13 (35.90)	18.20 ± 0.27 (30.00)[a]
Station 2	16.40 ± 0.22 (20.15)	–
Station 3	15.40 ± 0.15 (12.82)	14.0 ± 0.13
Station 4	13.65 ± 0.19	–

'–' indicate there is no seaweed sample was available. Values in parenthesis indicate % increase in the protein content in comparison to control/least-polluted site.

[a] There was no *Chaetomorpha* available at control, therefore, this rise was calculated in comparison to least polluted site (Station 3) which is almost 5 km away from the effluent discharge point.

for protein analysis. About 1 g (dry wt.) of the pulverized sample from this was taken for protein analysis. Nitrogen content was determined using a micro-Kjeldahl method [11]. A conversion factor of 6.25 was used to calculate protein content. All determinations were performed in triplicate. All the data were expressed in terms of mean ± standard deviation and range. In addition, data concerning content of proteins were analyzed by one-way ANOVA by Microsoft Excel Software (version 9.0.2720).

3. Results and discussion

The protein content in the seaweed samples of *U. faciata* and *C. antennina* collected from each station are given in Table 1.

It is inferred from these data that the protein content of the seaweed increases as the distance from the outfall of soda ash industry decreases. This means that the protein content in the sample collected near effluent discharge point is more while in those collected from control is less. In general, there is a rise of 10–35% in the protein content is found due to the effect of said effluent ($p < 0.05$). The effluent, which is characterized by very high pH (11.25), density (1.1007 kg L^{-1}), Settable solids (0.201 kg L^{-1}), total dissolved solids (0.163 kg L^{-1}) and nutrients like ammonia (562.22 μmol L^{-1}) and nitrate (187.50 μmol L^{-1}) (the detail analysis of effluent and effluent affected seawater is presented in our recent paper see ref. [10]), has beneficial effect on the protein content of these seaweeds [8,10] and thus the nitrogen availability will be more in the effluent affected seawater. There is no other source of other anthropogenic pollution near the experimental site and thus it is believed that the increases in the protein level in these algae is due to the bioaccumulation of the inorganic nitrogenous species present in the effluent. Moreover, the other environmental factor, such as salinity does not affect the protein level [12]. The results are in accordance with the other independent study [13], which positively correlates the protein levels of algae *Gracilaria cervicornis* and *Sargassum vulgare* with the nitrogen content of the seawater. Furthermore, the mean of protein content (ca. 18.5%) recorded was higher than the concentrations found in higher plants [14]. Thus, these algae, especially *U. fasciata* can be cultivated on the large scale at the site affected by pollution due to soda ash industry effluent and the edible seaweed with high protein content can be obtained as a byproduct.

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