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Effect of soda ash industry effluent on bioaccumulation of metals by seaweeds of coastal region of Gujarat, India

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Abstract

The bioaccumulation ability of five species of seaweeds to 15 metals was studied in the seawater polluted by the effluent of soda ash industry. The bioaccumulation of Al, Mn and Fe in these seaweeds increased continuously as distance increased from outfall. However, *Padina tetrastromatica* showed reverse trend. Quite a number of metals like Au, Co, Hg, Ni, Pb, Pt and Sn were not recorded from any species of seaweeds from all sampling stations. Cr was recorded in *Gracillaria acerosa* from control site only. Accumulation of Cu in *Gracilaria corticata* was maximum near effluent discharge point and least at control, whereas its accumulation in *P. tetrastromatica* was more at station with lower pollution (station-3) than higher polluted station (station-2). Seaweeds had different pattern of bioaccumulation to Cu and Ag under the influence of the effluent. The bioaccumulation of Cd in quite a number of species was in non-detectable range, however in case of red seaweed it was more under polluted condition and non-detectable in control. The biosequestering capacity of different seaweed to different metals and their suitability for bioremediation under the influence of effluent is discussed. Bioconcentration factor for different seaweed species from different distances from outfall has been computed and discussed.

The undiluted soda ash industry effluent is characterized by very high pH, density, settleable solids, total dissolved solids, ammonia and nitrate. The specific gravity, density, total suspended solids and total dissolved solids decreased continuously from undiluted effluent to seawater affected up to 1 km.

Keywords: Soda ash industry; Bioaccumulation; Seaweeds; Pollution

1. Introduction

Metals occur naturally, and several of them are essential components of global ecosystems [1]. They are present in the environment with a wide range of oxidation states and coordination numbers, and these differences are related to their toxicity. Metals such as Cu and Zn are essential to life, whereas others such as Pb and Hg are not known to perform a useful biochemical function [2]. Environmental pollution by metals became extensive as mining and industrial activities increased in the late 19 and early 20 century. These pollutants, ultimately derived from a growing number of diverse anthropogenic sources (industrial effluents and wastes, urban runoff, sewage treatment plants, boating activities, agricultural fungicide runoff, domestic garbage dumps and mining operations), have progressively affected more and more different ecosystems [1,3]. Heavy metals are usually present at low concentrations in oceanic surface waters and arrive there by atmospheric transport and upwelling. Higher levels occur in coastal waters because of river runoff. Close to urban centers, pollution is associated with sewage outlets, but levels are also elevated near extensive areas of industry [4–8]. Metal bioaccumulation by marine organisms has been the subject of considerable interest in recent years because of serious concern that high levels of metals may have detrimental effects on the marine organisms and may create problems in relation to their suitability as food for humans [9].

The soda ash industry near the study site manufactures soda ash by Solvay process [10]. It produces 40,300 tonnes of dense soda ash and 16,350 tonnes of sodium bicarbonate per annum; simultaneously it also generates 170,000 m^3 effluent per day.

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The original effluent is diluted with seawater (to meet the pollution control standards) before discharging into the coastal waters [11]. The diluted effluent is discharged 500 m away from the coastline through a sub marine pipeline. The different species of seaweeds grow luxuriantly in this effluent affected region.

Considerable reports from the different parts of the world are available on the bioaccumulation of quite a number of heavy metals by different seaweeds under diversely stressed natural conditions [12–23]. However, the literature search did not reveal any published literature on the impact of soda ash industry effluent on the heavy metal biosorption by seaweeds. However, impact of chlor-alkali industry effluent, an effluent closely related to soda ash industry effluent, on the heavy metal content of seaweeds has been studied [24]. Very scanty information even at international level is available on the bioaccumulation capacity of the seaweeds for the noble metals like Ag and Au [14,25]. However, the authors are not aware of any reports on the biosorption of Pt by seaweeds. Therefore, it was thought desirable to study the effect of soda ash industry effluent on the heavy metal sorption capacity/pattern by seaweed flora in in situ conditions. The Gujarat coast of India, where the present study has been carried out, has quite a number of large chlor-alkali industries including soda ash industry. The objective of the present study is to understand weather the soda ash industry effluent has changed the sequestering capacity and accumulation pattern of the different heavy metals by different seaweeds in comparison with unpolluted condition.

2. Materials and methods

2.1. Description of experimental site

The soda ash industry effluent outfall is situated at latitude 20°49′N and longitude 70°28′E. 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 (region which is exposed during low water tide) 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 stream side of the effluent discharge point (Figs. 1 and 2). Station-4 situated at latitude 20°43′N and 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 (as evidenced by seawater analysis, discussed later). 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 off 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. Even though the trace metal distribution in the coastal environment is to a great extent influenced by fresh water inflow, the areas of the current investigation do not show this effect. The seawater sam-

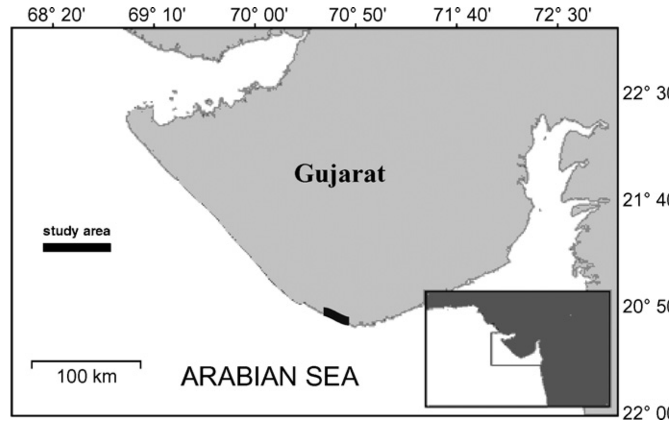

Fig. 1. Map showing study area.

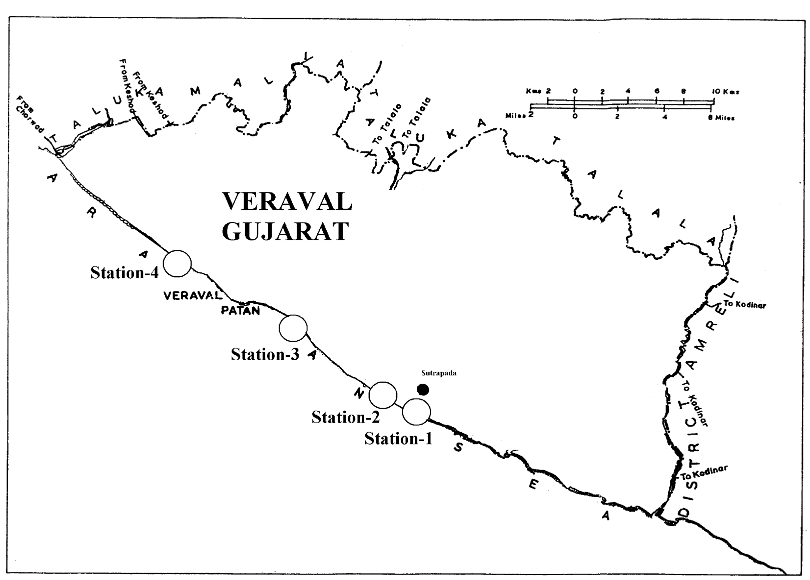

Fig. 2. Map showing effluent affected and control stations.