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Determination and discrimination in characteristics of coastal habitats in some parts of 'Bhal' region

Suhas J. Vyas[1,*], **A. J. Joshi**[2]

[1]Department of Earth & Environmental Science, K.S.K.V. Kachchh University, Bhuj- Kachchh, India

[2]Department of Life Science, Bhavnagar University, Bhavnagar, India

*E-mail address: vsuhas_13@yahoo.co.in

ABSTRACT

Gujarat has a coast line of approximately 1700 Km, varying in different habitat conditions. The state has two gulfs viz., gulf of Khambhat and gulf of Kachchh. Edaphic conditions of different habitats in 'Bhal' region of Gujarat state which falls in two districts viz. Ahmedabad and Bhavnagar district of Gujarat state. The coastal vegetation depends on the edaphic conditions of the region. The coastal flora of the 'Bhal' region belonging to Bhavnagar district has species like *Suaeda nudiflora*, *Prosopis chilensis*, *Dichanthium annulatum*, etc. The 'Bhal' region has marshy, wetland and semi-arid habitat. The present study investigates different physico-chemical parameters like Electrical Conductivity, pH and Sodium Adsorption Ratio, as well as mineral ion Sodium, Potassium, Calcium, Magnessium and Chloride concentration in the soil of 'Bhal' region.

***Keywords*:** 'Bhal' region; soil habitat; marshy; freshwater; semi-arid; mineral ions

1. INTRODUCTION

'Bhal' region is situated on the south-west border of Saurashtra, spreading in 2 revenue districts of Bhavnagar and Ahmedabad on the left border of the Gulf of Khambhat (Cambay). The term 'Bhal' in Sanskrit language means a forehead and as the hairs do not grow on the forehead, the natives here believe, plant species find difficult to grow in this area. In fact, it is an ecologically complex coastal belt having length of approximately 100 km and breadth of 25 km and low mean sea level; it receives an average annual rainfall about 650 to 700 mm and includes moderately big mouths of the rivers Sabarmati, Bhogavo and Bhadar and smaller ones of Keri, Ghelo and Kalubhar rivers. This region can be classified as a ~ 15 kms wide coastal wetland comprising of marshy areas towards the Gulf of Khambhat and of freshwater bodies in a landward margin of ~ 10 kms, which remains flooded during monsoon. Because of this diversified edaphic conditions, the flora represents a combination of salt tolerant halophytes growing in marshy area, less salt tolerant species and aquatic plants occurring in inland areas.

This investigation differentiates habitats of 'Bhal' region near gulf of Khambhat. Coastal wetlands represent interesting localities, which are influenced by tidal waters and freshwaters of the rivers. Freshwater condition is more prominent during the monsoon because of precipitation. Such habitats support plant communities adapted to varying degree

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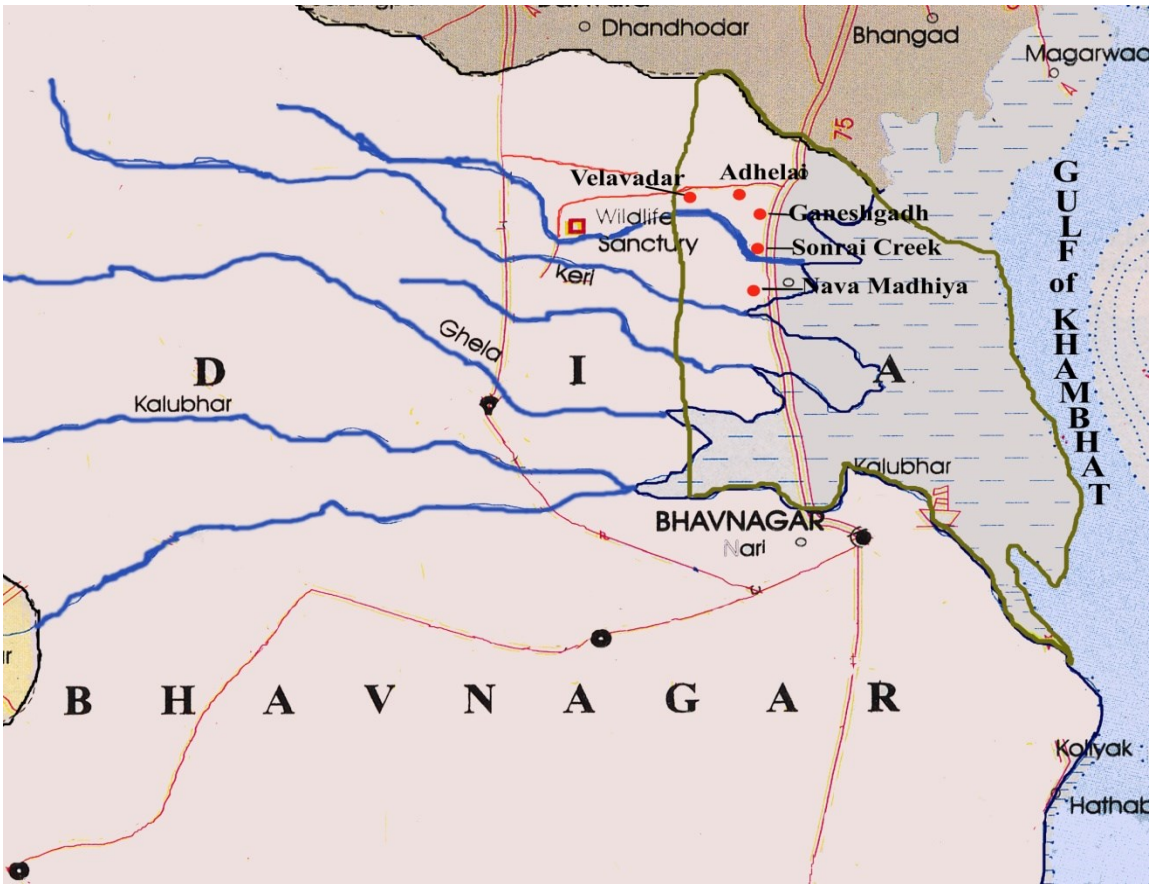
of salt tolerance, much remains to be done on biodiversity and phytosociology of such specialize group of plants. The present study shows the characteristics of soil conditions of different habitats found in this part of the country near the gulf.

2. MATERIALS & METHODS

Soil samples (0-15 cm) collected from each twin belt transect supporting halophytes, were sun dried, powdered and passed through 20-mesh sieve before analysis.

100 g of soil sample was taken in a conical flask and 200 ml of distilled water was added to prepare (1:2) soil : water suspension (Chopra and Kanwar, 1991). The suspension was thoroughly shaken and kept overnight. The solution was filtered and the filtrate was made up to 250 ml for further analysis. Electrical conductivity of 1:2 extracts was measured on EC meter (model WTW LF 530, 1983, West Germany), and pH on pH meter (Elico, model LI-120). Flame Photometer (Elico, model-128) was used for the estimation of sodium (Na^+) and potassium (K^+). Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were estimated by EDTA (ethylene diamine tetra acetic acid) method (Vogel, 1978). Chloride (Cl^-) was estimated by argentometric method (APHA, 2005).

Study area:



3. RESULTS

Coastal habitats feature a combination of chemical transformations and chemical transport not shared by many other ecosystems. Results of physico-chemical analysis of 5 locations supporting 6 plant species at marshy, freshwater and dry inland saline habitats are presented in this section. Soil samples were collected in month of September (monsoon); December (winter) and May (summer). Results of these samples were considered for seasonal variations. Ionic concentrations are expressed in terms of meq. in (1:2) soil : water extracts of 100 g soil throughout this study.

Location 1. Nava Madhiya

This habitat remains flooded either by mixed waters during monsoon or by high tidal waters during the rest of the year. Only one succulent species *Suaeda nudiflora* Moq. grew here. Electrical conductivity (salinity) of soil samples collected from the 3 twin belt transects laid down during three seasons at this location fluctuated from 25.427 to 57.267 $dS \cdot m^{-1}$ (Table 1), whereas pH and SAR varied between 7.00 to 7.94 and 11.91 to 15.08, respectively. Amount of Cl^- (24.037 to 173.943 $meq \cdot g^{-100}$) was greater than that of Na^+, which ranged between 9.533 to 30.437 $meq \cdot g^{-100}$. These results also showed greater concentrations of Mg^{2+} (0.703 to 9.513 $meq \cdot g^{-100}$) than that of Ca^{2+} (0.5 to 4.15 $meq \cdot g^{-100}$). K^+ was found in low concentration (0.37 to 2.827 $meq \cdot g^{-100}$).

These results primarily indicated high values of salinity (EC), pH and SAR during summer. Likewise, the data of inorganic ions clearly reflected their greater concentrations in summer than either in monsoon or winter. Thus, this habitat was exposed to subtropical climatic variations.

Fig. 1. Ions in soil at Navamadiya location.

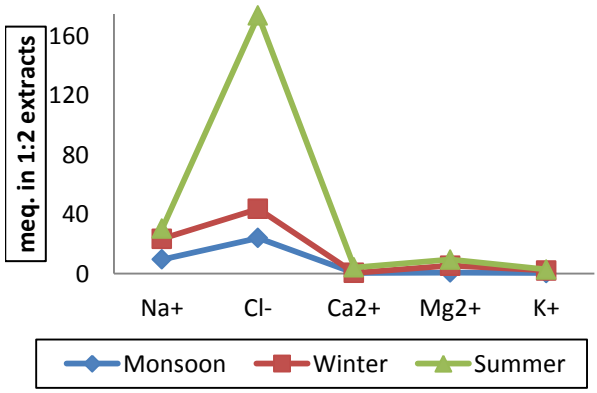


Table 1. Physico-chemical parameters at Navamadahiya location.

	EC ($dS \cdot m^{-1}$)	pH	SAR
Monsoon	25.427	7.237	12.15
Winter	36.637	7.007	15.08
Summer	57.267	7.94	11.91

Location 2. Sonrai Creek

Sonrai creek is a marshy location, wherein one succulent *S. nudiflora* and one non-succulent *Aeluropus lagopoides*, Trin. halophytic species occurred. Analysis of soil samples collected from 3 twin belt transects laid down at this location indicated the electrical conductivity varying between 18.72 to 42.51 $dS \cdot m^{-1}$ (Table 2). pH fluctuated from 7.04 to 7.80 and SAR from 8.74 to 18.96. These findings suggested dominance of Na^+ and Cl^- ranging between 5.92 to 37.67 $meq \cdot g^{-100}$ and 14.23 to 89.90 $meq \cdot g^{-100}$, respectively (Fig. 2).

Ca^{2+} and Mg^{2+} varied between 0.49 to 3.277 meq·g^{-100}. Concentrations of K^{+} were observed between 0.363 to 3.05 meq·g^{-100}. These results collectively reflected maximum values of EC, pH and SAR and all inorganic ions either in winter or summer at location 2.

Fig. 2. Ions in soil at sonrai creek location.

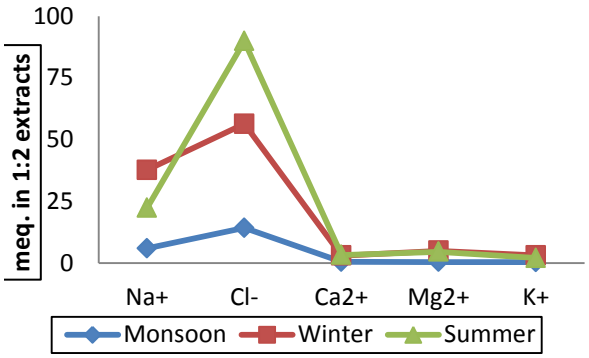


Table 2. Physico-chemical parameters at sonrai creek location.

	EC (dS·m^{-1})	pH	SAR
Monsoon	18.72	7.337	8.743
Winter	42.51	7.043	18.963
Summer	40.233	7.807	11.33

Location 3. Ganeshgadh

Ganeshgadh is a freshwater location supporting typical plant species such as, *Dichanthium annulatum*, (Forssk.) stapf., *Panicum colonum*, L. and *Schoenoplectus maritimus*, Lye. Salinity in this habitat was quite low (0.87 to 2.64 dS·m^{-1}) during different seasons and soil pH fluctuated from 7.76 to 8.29 (Table 3).

SAR values were noticed between 0.99 to 1.33. Ionic concentration was also remarkably low and it showed greater amounts of Cl^{-} (0.34 to 2.4 meq·g^{-100}) than that of Na^{+} (0.35 to 0.71 meq. g^{-100}) (Fig. 3). The Mg^{2+} content varying between 0.17 to 0.36 meq. g^{-100} was greater than that of Ca^{2+} (0.18 to 0.20 meq·g^{-100}). Low amounts of K^{+} (0.02 to 0.07 meq·g^{-100}) were noted. These findings primarily suggested marginal seasonal variations in physico-chemical characteristics and ionic content of a freshwater habitat.

Fig. 3. Ions in soil at ganesh gadh location.

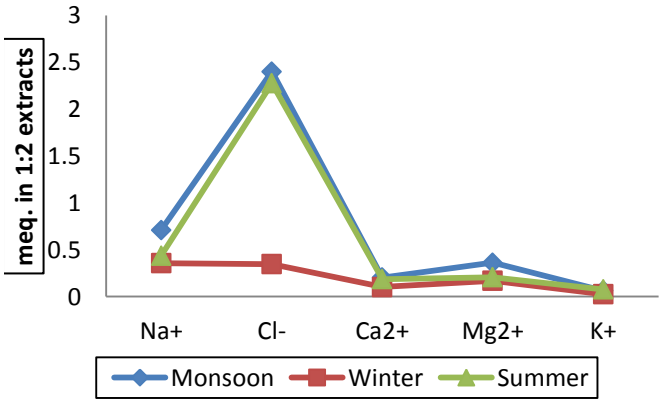


Table 3. Physico-chemical parameters at ganesh gadh location.

	EC (dS·m^{-1})	pH	SAR
Monsoon	0.877	7.76	1.17
Winter	2.64	7.63	1.337
Summer	1.013	8.29	0.997

Location 4. Adhelai

Adhelai represents a typical inland dry saline habitat. A succulent halophyte *S. nudiflora*, a less salt tolerant grass *D. annulatum* and a moderately salt tolerant shrub *Prosopis chilensis*, Stuntz. occupied this locality in 'Bhal' region.

Soil salinity fluctuated from 10.35 to 68.15 $dS \cdot m^{-1}$ in different seasons (Table 4). pH and SAR varied from 7.40 to 7.73 and 2.74 to 4.50, respectively.

Ionic composition showed greater values of Na^{+} (3.57 to 12.2 $meq \cdot g^{-100}$) than that of Cl^{-} (6.99 to 212.74 $meq \cdot g^{-100}$) (Fig. 4).

Ca^{2+} and Mg^{2+} varied between 2.00 to 2.99 $meq \cdot g^{-100}$ and 2.27 to 6.57 $meq \cdot g^{-100}$. Low concentration of K^{+} (0.44 to 0.82 $meq \cdot g^{-100}$) was observed here. Excluding the Ca^{2+} content and a couple of other exceptions, maximum values of all the soil characteristics were recorded in summer.

Fig. 4. Ions in soil at Adhelai location.

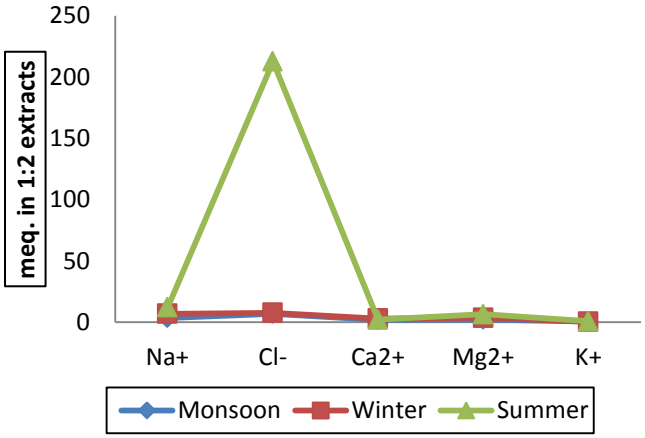


Table 4. Physico-chemical parameters at Adhelai location.

	EC ($dS \cdot m^{-1}$)	pH	SAR
Monsoon	19.533	7.403	2.74
Winter	10.357	7.45	4.503
Summer	68.15	7.733	6

Location 5. Velavadar

As mentioned previously, this location is situated near Black Buck National Park and is mainly occupied by a grass *Sporobolus coromandellianus*, Link., *Schoenoplectus maritimus*, Lye. and *Echinops echinatus*, Roxb.

Analysis of soil samples collected from 3 belt transects laid down at this location indicated the electrical conductivity between 27.38 to 40.53 $dS \cdot m^{-1}$ (Table 5). pH was observed between 6.95 to 7.45 and SAR from 8.87 to 12.48. These findings further reflected dominance of Na^{+} and $Cl \cdot$ ranging between 6.10 to 22.56 $meq \cdot g^{-100}$ and 15.89 to 37.58 $meq \cdot g^{-100}$, respectively (Fig. 5). Ca^{2+} and Mg^{2+} varied between 0.29 to 7.24 $meq \cdot g^{-100}$, while concentration of K^{+} fluctuated between 0.42 to 1.01 $meq \cdot g^{-100}$.

These results collectively reflected maximum values of EC, pH, SAR and all inorganic ions either in monsoon or summer.

Fig. 5. Ions in soil at velavadar location.

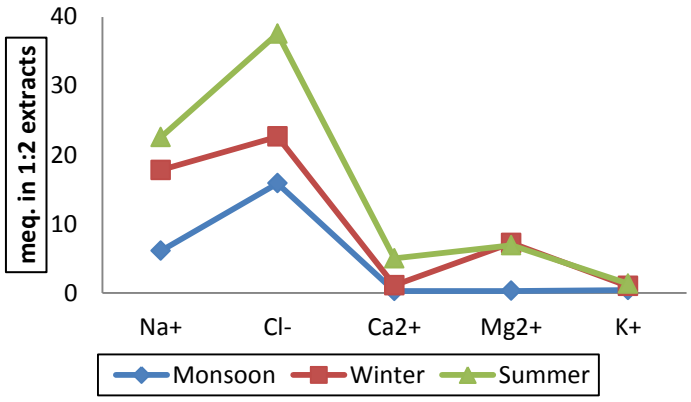


Table 5. Physico-chemical parameters at velavadar location.

	EC ($dS \cdot m^{-1}$)	pH	SAR
Monsoon	40.533	6.953	12.48
Winter	27.383	7.193	8.887
Summer	28.6	7.457	9.467

4. DISCUSSION

Although information on mangrove habitats is available in some publications (Blasco, 1975; Rao and Meher-Homji, 1985; Selvam *et al*., 1991; Dagar *et al*., 1993; Rao and Suresh, 2001), only few studies have been made on coastal habitats supporting remaining groups of plants mentioned in foregoing para. Earlier reports (Joshi and Iyengar, 1982; Kanzaria *et al*., 1982; and Hinglajia, 1997) include detailed analysis of coastal soils collected from some coastal localities.

Salinity

Findings of present study indicated that EC of (1:2) extracts of soil collected from 4 marshy or inland saline locations fluctuated between 10.35 to 68.15 $dS \cdot m^{-1}$ (Tables 1 to 3 & 5). Joshi (1982) and Rogel *et al*. (1997, 2001, 2001a) reported 10 to 216 $dS \cdot m^{-1}$ salinity in the saturated extracts of soils supporting succulent halophytic vegetation, whereas Rao and Aggarwal (1964) recorded that total soluble salts in habitats of *Suaeda nudiflora* and *Sesuvium portulacastrum* were found between 2.04 to 3.4 per cent. Similarly, in his reviews, Dagar (1995, 1998) noted that pure patches of the same species grew on soils with 25.2 to 72.6 $dS \cdot m^{-1}$ EC_e in inland areas of Rajasthan and Gujarat. Likewise, higher levels of salinity have also been observed for habitats of other shrubby halophytes (Joshi *et al*., 1993; Joshi and Hinglajia, 2000).

On the other hand, remarkably low salinity (0.87 to 2.64 $dS \cdot m^{-1}$) was noted for a freshwater site (Tables 3). It may be mentioned here that some of the coastal habitats supporting strand species *Halopyrum mucronatum* or even salt tolerant species like *Suaeda fruticosa* had such low levels of salinity (Khot, 2003).

pH

pH affects the physical conditions of soils, the nutrient availability to the plants and thereby growth of plants (Waisel, 1972; Chopra and Kanwar, 1980). Present investigation analyzing 45 soil samples showed that pH in natural habitats supporting aquatic, moderately salt tolerant and halophytic plant communities in 'Bhal' region varied from 6.95 to 8.29 (Tables 1 to 5). Earlier Joshi and Iyengar (1982) found *Suaeda nudiflora* and *Salicornia*

brachiata growing on marshy soils with 7.4 to 8.3 pH. Other halophytic species, too, are known to grow in similar conditions of soil pH in different parts of the world (Sagar Kumar, 1987 and Rogel *et al*., 1997, 2001). *A. lagopoides* and *S. nudiflora*, too, grew in similar soil pH condition in 'Bhal' wetland.

Some reports examining relationship between soil pH and the zonations of halophytes indicated distribution or zonations of halophytes were not related to pH of natural habitats (Misra, 1989). However, Keith (1958) casually noted soil pH, as an important factor determining the distribution of halophytes.

It may be mentioned here that the present study showed that pH in marshy, freshwater and grassland habitats significantly differed in monsoon, winter and summer but no such effects were observed for 2 remaining habitats (Table 1 & 3). These two important observations prompt a conclusion that coastal habitats subjected to similar climatic conditions may have different levels of pH possibly because of their geographical situation.

SAR

SAR values for 4 saline locations ranged between 2.74 to 18.96 and for a freshwater habitat between 0.99 to 1.33 (Tables 1 to 15). According to Waisel (1972), Na^+ brings about alterations in physicochemical properties of soils, when sodium adsorption ratio is 15 or more. Such interference was not observed for habitats in 'Bhal' area.

Ionic Compositions

Variations in ionic composition of soils suggested that Na^+ and Cl^- were major constituents and their concentrations varied from 3.57 to 37.67 $meq \cdot g^{-100}$ in saline habitats and between 0.35 to 0.71 $meq \cdot g^{-100}$ in a freshwater habitat (Figs. 1 to 5). It was further observed that concentrations of Cl^- were greater than that of Na^+ in all habitats. Rogel *et al*. (1997, 2001), too, noted similar trend for Na^+ and Cl^- in habitats supporting *Arthrocnemum macrostachyum* and *Sarcocornia fruticosa*. Studies on coastal habitats in Gujarat having succulent and shrubby halophytes and strand species report such characteristic (Joshi and Iyenger, 1982; Joshi and Bhoite, 1988; Joshi and Hinglajia, 2000).

Observation on divalent cation reflected greater quantity of Mg^{2+} (0.32 to 9.51 $meq \cdot g^{-100}$) than that of Ca^{2+} (0.29 to 4.25 $meq \cdot g^{-100}$) in habitats in 'Bhal' region.

Similar trend was observed for freshwater habitats, although concentrations of these two divalent cations were less than those recorded for other habitats. These findings are inconfirmatory with other reports on coastal locations occupied by divalent groups of coastal flora (Khot, 2003).

It may be added here that the Mg^{2+} content in 4 habitats fluctuated significantly (Table 1 to 5) but no such trend was observed for Ca^{2+}. Likewise, a variation recorded for these 2 divalent cations were statistically non-significant. Saline and grassland habitats in 'Bhal' contain K^+ fluctuating between 0.36 to 3.05 $meq \cdot g^{-100}$ whereas, its concentration in freshwater location (0.02 to 0.07 $meq \cdot g^{-100}$) was comparatively low (Figs. 16 to 30).

5. CONCLUSIONS

'Bhal' ecoregion, which is ~100 km long and ~25 km wide, is situated on the left border of Gulf of Khambhat in Gujarat. Average annual rainfall (~ 650 mm); low temperature in winter (~ 100 C) and high in summer (~ 430 C); tidal inundation and freshwater flows in

rivers make 'Bhal' as a unique coastal ecoregion. 5 locations in 'Bhal' area falling in the revenue district of Bhavnagar were selected for present investigation. Collection of soil samples were carried out in 3 seasons namely monsoon, winter and summer. Coastal vegetation of 'Bhal' region included 3 major groups of plants, namely highly salt tolerant halophytes, moderately salt tolerant species and aquatic plants. Analysis of 45 soil samples collected during 3 seasons from the selected locations indicated high values of electrical conductivity (salinity) and near neutral to alkaline pH. Noticeable high concentrations of Na^+ and Cl^- followed by that Ca^{2+}, Mg^{2+} and K^+ were observed in habitats. Salinity and amounts of mineral ions in freshwater habitat were remarkably low.

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