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Mineral composition in leaves of some halophytic species of 'Bhal' region in Gujarat

Suhas Jagdishbhai Vyas[1*] and Arvind Jatashankar Joshi[2]

[1]Department of Earth & Environmental Sciences, KSKV Kachchh University, Bhuj- 370 001. Kachchh, Gujarat – India; [2]Department of Life Science, Bhavnagar University, Bhavnagar-364002. Gujarat, India

Abstract

Gujarat has a long coastline of about 1,600 Km out of approximately 7,500 Km in the country. It has variety of flora and fauna in its biological diversity. Due to industrialization and modernization, the environmental conditions are being disturbed and disrupted. Coastal flora of 'Bhal' region have been studied in this present investigation. 'Bhal' region is a vast region spread in two districts (Bhavnagar and Ahmedabad) of the Gujarat. Leaves of dicots (*Suaeda nudiflora*, Moq., *Prosopis chilensis*, Stuntz. and *Salvadora persica*, Linn) and monocots (*Schoenoplectus maritimus*, Lye., *Sporobolus coromandellianus*, Link. and *Aeluropus lagopoides*, Trin**)** species which were found to be dominant in this region were analysed for mineral composition. Seasonal variations in mineral constituents was examined in leaves of dicot and monocot species. Statistical analysis was carried out within species and in different seasons.

Key Words: mineral composition, 'bhal' region, dicot, monocot, seasonal variation.
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Introduction

Researches on biological diversity and its values, uses, loss, conservation and management during last two decades has made a spectacular *nische* in the field of environmental science. Today's plant communities in the world are the result of long term interactions between vegetation and site factors including man-made impacts. Current species diversity reflects historical as well as environmental factors, which affect variations in species composition (Li and Krauchi, 2004).

Studies on coastal flora have assumed a new dimension in recent years because of their utility as human food (vegetables, salads, pickles); fodder (for camels, sheep, goats, wild life and fish); wood for building materials; bio-fuel, chemicals, landscaping and dune stabilization (Lieth and Moshenko, 1998). Additionally, halophytes also serve as (i) a model to study salt tolerance, (ii) a source for 'salt tolerant gene' and (iii) a source of crops themselves (Gallagher, 1985). Because of such scientific and economic potential, it is widely accepted now that large number of coastal plants can be used as cash crops (Lieth and Lohmann, 2000).

The present study was undertaken to study the coastal floral diversity in accumulation of salt concentration in 'Bhal' region of Gujarat, India.

Materials and methods

Leaves of 3 dicotyledonous species (*Suaeda nudiflora*, Moq., *Prosopis chilensis*, Stuntz. and *Salvadora persica*, Linn.) and 3 monocotyledonous (*Schoenoplectus maritimus*, Lye., *Sporobolus coromandellianus*, Link. and *Aeluropus lagopoides*, Trin) were collected from natural habitats in monsoon, winter and summer during the year 2003 – 2004. The material was thoroughly washed to remove dust, mud and salts and blotted to dryness. It was dried in the oven at 75-80^{o} C to a constant weight. Dry material so obtained, was ground to fine powder and preserved. The material was once more dried in oven, before using for analysis of mineral ions.

About 1 g plant material was taken into a silica crucible, incinerated and ashed in a muffle furnace at a temperature of 450-480^{o}C. To achieve complete oxidation of the organic matter, about 0.5 - 1 ml of concentrated nitric acid was added to the crucibles after cooling them to room temperature. The acid was evaporated on a water bath and the crucibles were again placed in the furnace for complete ashing.

After cooling at room temperature, 10 ml of 1:1 hydrochloric acid was added to the crucibles containing the ash and was evaporated on water bath. This was followed by addition of 20 ml distilled water and the extract was filtered through Whatman filter paper No. 44 with repeated washing and final volume of 250 ml was made by adding deionized water. The aqueous extract was further used for the estimation of sodium (Na^+) and potassium (K^+) by flame photometry, calcium (Ca^{2+}) and magnesium (Mg^{2+}) by EDTA titration and chloride (Cl^-) by argentometric method.

About 1 g dry material was boiled in 100 ml of deionised water on water bath for 30 minutes. After cooling, the extract was filtered, made up to 100 ml in volumetric flask and the filtrate was used for estimation of chloride by Argentometric method.

Results

It is widely accepted that coastal plants adjust osmotically to high salinity in natural conditions by accumulating varying amounts, mainly of Na^+, Cl^- and other inorganic ions and also possess different modes of salt avoidance. Attempts were made to determine whether temporal changes in this unique feature of salt accumulation can be related to behavior of diversified dicotyledonous and

*Corresponding author: vsuhas_13@yahoo.co.in

monocotyledonous coastal plant species. This section includes results of 48 samples of 6 plant species – 3 dicots and 3 monocots – collected during monsoon, winter and summer.

Dicotyledons

***Suaeda nudiflora*, Moq.**

Fig.1 represents the data of ion concentrations in succulent leaves of *S. nudiflora* growing at marshy locations. The ash content ranged between 43.02 to 45.03 % and Na^{+} (6.27 to 8.91 meq.g^{-1}) and Cl^{-} (8.15 to 12.52 meq.g^{-1}) constituted a major fraction of the salts. Likewise, Mg^{2+} varying between 0.78 to 0.88 meq.g^{-1} exceeded the amount of Ca^{2+} (0.48 to 0.55 meq.g^{-1}). The K^{+} content was noticed between 0.95 to 1.33 meq.g^{-1}.

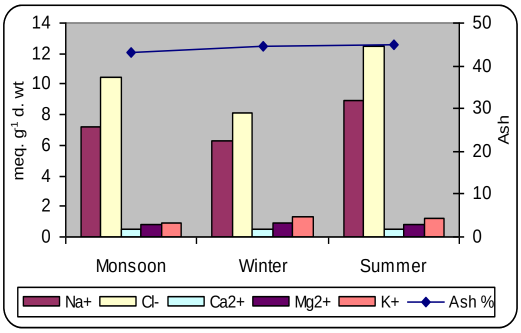
It was also observed that accumulation of all mineral ions and ash content reached to maxima in summer but maximum amounts of Mg^{2+} and K^{+} were noted in winter in this dicot species.

Salvadora persica, Linn.

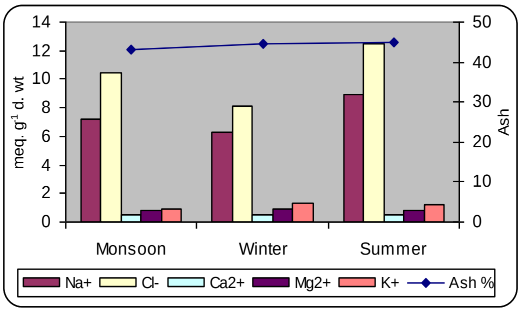
Amount of salts in leaves of another salt tolerant dicot *S. persica* fluctuated between 37.79 to 46.28 % (Fig. 2) and it was mainly constituted by Na^{+} (1.75 to 2.26 meq.g^{-1}) and Cl^{-} (2.10 to 3.5 meq.g^{-1}). Accumulation of Mg^{2+} varied between 0.81 to 2.35 meq.g^{-1} and that of Ca^{2+} ranged between 1.61 to 3.95 meq.g^{-1}. K^{+} content (1.0 to 1.87 meq.g^{-1}) was low in this dicot shrub.

Fig. 1 to 6: Seasonal variations in mineral constituents in leaves of different coastal floral of 'Bhal' region. Each value presents mean of 3 samples collected in each season.

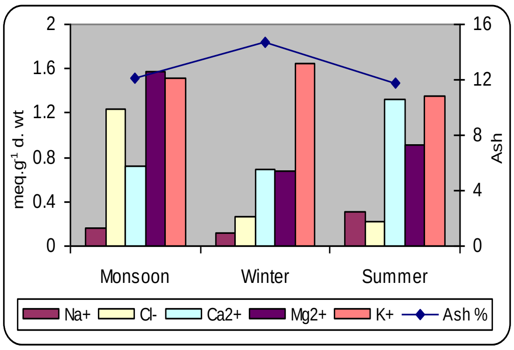
(1) *S. nudiflora*



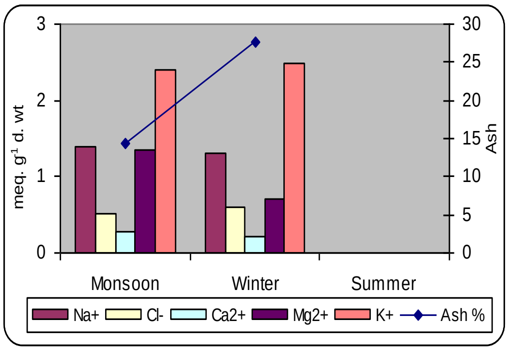
(2) *S. Persica*



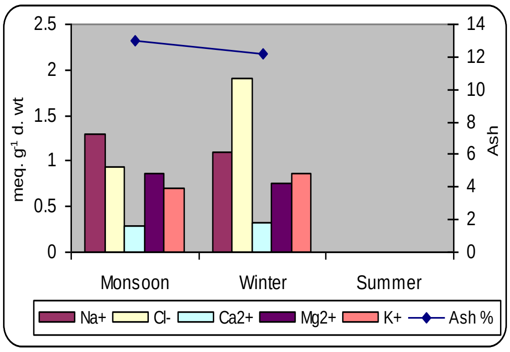
(3) *P. Chilensis*



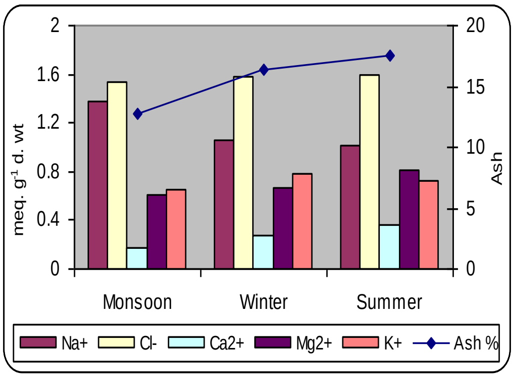
(4) *S. maritimus*



(5) *S. coromandellianus*



(6) *A. lagopoides*



Preliminary observations of the ash content and mineral ions of this species suggested that leaves of *S. persica* accumulated maximum amounts of Na^{+}, Cl^{-}, Mg^{2+} and K^{+} in monsoon and that of salt and Ca^{2+} in summer.

Prosopis chilensis, Stuntz.

These results further indicated that the ash content in leaves of *P. chilensis* was found between 11.8 to 14.71 % (Fig. 3). Amounts of Na^{+} and Cl^{-} ranged between 0.12 to 0.31 meq.g^{-1} and 0.22 to 1.23 meq.g^{-1}, respectively, whereas concentration of Mg^{2+} and Ca^{2+} was recorded between 0.68 to 1.58 meq.g^{-1} and 0.69 to 1.33 meq.g^{-1}. Amounts of K^+ (1.36 to 1.65 meq.g^{-1}) were low.

Since the salt content and concentrations of various ions showed maxima in different seasons, no consistent climatic effects were observed on mineral composition of leaves in *P. chilensis* having low shrubby habit.

Monocotyledons

Schoenoplectus maritimus, Lye.

Results of salt content and mineral ions in leaves of this freshwater species are represented in Fig. 4. As plants were totally dried in summer, findings of monsoon and winter were used for this study. Ash content in leaves of *S. maritimus* ranged between 14.41 to 27.68 %. However, Na^+ (1.30 to 1.39 meq.g^{-1}), Cl^- (0.51 to 0.59 meq.g^{-1}), Ca^{2+} (0.22 to 0.28 meq.g^{-1}), Mg^{2+} (0.7 to 1.35 meq.g^{-1}) and K^+ (2.41 to 2.49 meq.g^{-1}) were observed in a narrow range.

Primary observations showed that maximum amount of salt in leaves was recorded in winter, whereas differences between concentrations of mineral ions noted for 2 seasons were negligible for this aquatic plant.

Sporobolus coromandellianus, Link.

Plants of another, but moderately salt tolerant grass *S. coromandellianus*, also dried in habitat in summer. Fig.5 represents observations of ash content and mineral ions concentrations in leaves of this monocot species. Ash content (12.2 to 13.05 %) and accumulation of Na^+(1.11 to 1.3 meq.g^{-1}) and Cl^- (0.94 to 1.91 meq.g^{-1}) fluctuated in a narrow range during monsoon and winter. Mg^{2+} (0.87 to 0.75 meq.g^{-1}) was recorded with greater amounts than that of Ca^{2+} (0.29 to 0.32 meq.g^{-1}). The K^+ content ranging between 0.71 to 0.86 meq.g^{-1} was low.

As noted for previous species, seasonal variations in ash and ionic content were also observed in leaves of *S. coromandellianus*.

Aeluropus lagopoides, Trin.

Data of accumulation of salts and inorganic ions in leaves of *A. lagopoides* (Fig. 6) indicated 12.78 to 17.58 % ash content. Concentration of Na^+ (1.02 to 1.37 meq.g^{-1}) was less than that of Cl^- (1.53 to 1.59 meq.g^{-1}); while Mg^{2+} ranging between 0.61 to 0.81 meq.g^{-1} reflected greater quantity than that of Ca^{2+} (0.18 to 0.36 meq.g^{-1}). K^+ was recorded between 0.65 to 0.78 meq.g^{-1}.

Moreover, maximum values of ash content, Cl^-, Ca^{2+} and Mg^{2+} were recorded in summer. On the other hand, accumulation of Na^+ and K^+ reached to maxima in monsoon.

Statistical analysis

Additionally, attempts were made to determine whether two groups of plant species differed in accumulating mineral ions or not and whether temporal variations had any impact on their ionic composition.

2-way ANOVA (Table 1) for 3 dicotyledonous species reflected that their ash content (F= 62.62) and concentration of 2 major ions i.e., Na^+ (F=75.88) and Cl^- (F= 90.69) were highly significant ($P \leq 0.001$). The species also differed significantly in accumulating Ca2+ (F= 11.12; $P \leq 0.05$), but amounts of remaining 2 ions (Mg^{2+}, K^+) were not significant. The test further confirmed that temporal changes did not affect accumulation mineral ions in dicot species significantly.

Table.1. 2-way ANOVA assessing accumulation of mineral ions in 3 dicotyledonous species during 3 seasons.

Mineral ions	Species	Seasons
Ash%	65.62^{***}	0.66^{ns}
Na^+	75.38^{***}	1.27^{ns}
Cl^-	90.69^{***}	4.44^{ns}
Ca^{2+}	11.12^{*}	1.76^{ns}
Mg^{2+}	1.51^{ns}	2.74^{ns}
K^+	1.02^{ns}	0.92^{ns}

ns= non-significant; *= significant at $P \leq 0.05$; **= highly significant at $P \leq 0.01$ and ***= very highly significant at $P \leq 0.001$

Results of 2-way ANOVA (Table 65) further suggested that variations in ash content and quantities of ions in 3 monocot species were non-significant ($P \geq 0.05$). Likewise, their fluctuations, except that of Ca^{2+} (F= 17.02; $P \leq 0.05$), were not significantly affected by temporal changes during monsoon, winter and summer.

These important observations prompt a conclusion that monocot coastal plants do not differ in their mineral composition, but dicot species do exhibit differential behavior for this feature. Thus, functional diversity appears to exist for 2 groups of plants. Nevertheless, temporal variations had no impact on mineral ion concentrations in plants belonging to both the groups.

Table.2. 2-way ANOVA assessing accumulation of mineral ions in 3 monocotyledonous species during 3 seasons.

Mineral ions	Species	Seasons
Ash%	1.04^{ns}	4.16^{ns}
Na^+	0.33^{ns}	1.89^{ns}
Cl^-	4.62^{ns}	2.34^{ns}
Ca^{2+}	2.74^{ns}	17.02*
Mg^{2+}	0.23^{ns}	5.19^{ns}
K^+	2.16^{ns}	2.56^{ns}

ns= non-significant; *= significant at $P \leq 0.05$; **= highly significant at $P \leq 0.01$ and ***= very highly significant at $P \leq 0.001$

Discussion

Extensive efforts have been made on mineral accumulation and their ecophysiological role in coastal plants (Waisel, 1972; Flowers *et al*., 1977; Yeo, 1998; Xiong and Zhu,2002). Nevertheless, an approach of relating differential behavior of this feature by morphologically different coastal plants with their diversity is yet to be worked out.

Dicot plants

Findings of mineral composition of dicotyledonous species collected from 5 locations in 'Bhal' area (Figs. 1 to 3), showed that salt accumulation in this group fluctuated between 11.80 to 46.28 per cent. Previous studies (Chaudhri*et al*., 1964; Waisel, 1972; Waisel and Ovadia, 1972; Kabanov and Otegenov, 1973) indicated that the accumulation of salts in other dicots such as, *Suaeda monoica*, *S. fruticosa*, *Salicornia herbacea*, *Arthrocnemum* *indicum* ranged between 31 to 44 per cent. Similar ash content (43.02 to 45.03 per cent) in *S. nudiflora* was observed during this study. Joshi (1982) also noted a little greater quantity of salts reaching up to 55 and 57 per cent in *Suaeda nudiflora* and *Salicornia brachiata* growing in marshy habitats. According to Khot (2003), salt accumulation in dicot species i.e. *Haloxylon salicornicum*, *S. brachiata* and *Sesuvium portulacastrum* growing in the Marine National Park area, was noticed between 27 to 67.2 %.

Present investigation reflected a lower range of salts (11.80 to 14.79 %) in *Prosopis juliflora*. Earlier, Hinglajia (1997) recorded 4 to 20 per cent salts in the same species collected from saline locations. Reports on other dicot shrubs indicated that the salt content in *Atriplex griffithii* varied from 5 to 34 per cent (Anjaiah, 1987) and in *Salvadora persica* from 10 to 39 (Krishnakumar, 1986). Similar amounts of salts (37.79 to 46.28 %) was also observed in the last species during present study. Khot (2003) showed quite high range of salts (14.75 to 42 per cent) in non-succulent leaves and stems of halophytic shrub *S. fruticosa* .

It needs to be mentioned here that 2-way ANOVA for the present study clearly suggested that the salt accumulation capacity of the dicotyledonous species growing in 'Bhal' area varied significantly, but the process was not affected by temporal variations (Tables 1 & 2).

Monocot plants

Concentration of salts ranging between 12.20 to 27.68 per cent was observed in 3 monocotyledonous species viz., *Schoenoplectus maritimus, Sporobolus coromandallianus and Aeluropus lagopoides* during this investigation (Figs. 4 to 6). Results on other species of this group are indicative of lower values of salts in *H. mucronatum* (Khot, 2003), and in *Spartina patens* and *Distichlis spicata*(Undell*et al*., 1969). Nevertheless, 3 species of *Juncus* and *Spartina alterniflora* accumulated 4.5 to 13.8 per cent ash (Zahran and Abdel Wahid, 1982). Misra (1989) reported comparatively high salt content (6 to 20 per cent) in another grass *Sporobolus madraspatanus*. Results of this study certainly show greater amounts of salts in grasses collected from coastal habitats. They further support a conclusion that dicot species accumulated greater amounts of salts than that by monocot species.

It was also shown by the 2-way ANOVA (Table 2) that monocot species growing in this part of the country did not differ in accumulation of salts. Likewise, temporal variations had no effects on this important characteristic of the coastal plants.

Conclusion

Mineral analysis of 48 plant samples of 3 dicot and 3 monocot species indicated that Na^+ and Cl^- mainly contributed to the salt content in species, followed by Ca^{2+}, Mg^{2+} and K^+.2- way ANOVA further reflected that variations in the ash content, Na^+ and Cl^- were very highly significant in dicot species.Nevertheless, climatic changes did not affect mineral composition of dicot species.As suggested by 2-way ANOVA, 3 monocot species neither differ in accumulating mineral ions nor the process was affected by temporal variations.Foregoing observations suggested that functional diversity in accumulating mineral ions exists in dicot and monocot plants growing in coastal areas.

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