STUDIA UNIVERSITATIS BABEŞ-BOLYAI BIOLOGIA, LXI, 2, 2016 (p. 107-116)

# Physico-chemical properties of soils populated with wild halophytes in some Romanian areas

Kinga-Olga Réti[2], Kunigunda Macalik[1], Rahela Carpa[1], Erika Kis[1], Gyöngyi Székely [1,✉]

**SUMMARY.** Soil salinity is one of the most important abiotic stress factor which reduces crop productivity worldwide, limits plant survival rate and restricts the use of arable land. Romanian saline soil areas are located on the seaside of the Black Sea and in different inland regions of the country. Nine Romanian sampling sites were analyzed, several obligative and facultative halophytes were identified.The main objective of the present study is to determine physical and chemical properties (pH, conductivity, salinity, redox potential) of some soil samples of saline areas from the Transylvanian Basin in order to give a better understanding about further characterization of halophytes adaptation mechanisms.

**Key words**: conductivity, halophytes, pH, redox potential, salinity.

## Introduction

Soil salinity represents one of the most important abiotic stress factors which reduces the productivity of cultivated plants in the whole world, limits the growth and surviving rate of plants and restricts the use of tilled land. Soil salinization is one of the most serious problems of modern agriculture, because salts can also accumulate by irrigation. Soil salinity affects every aspect of plant growth and development, and is a major constraint of crop yield. Excess concentration of salt in soil has immediate effect on cell growth and associated metabolism (Munns and Tester, 2008; Muchatea *et al*., 2016). In general, plant root growth has been found to be reduced under salinity (Li *et al*., 2016; Farissi *et al*., 2013; Yan *et al*., 2016). Natural evaporation eliminates the pure water from the soil, substances concentrate, and thus salts can

[1] *Babeş-Bolyai University, Faculty of Biology and Geology, 5-7 Clinicilor Street, 400006, Cluj-Napoca, Romania*
[2] *Babeş-Bolyai University, Faculty of Environmental Science and Engineering, 30 Fântânele Street, 400294, Cluj-Napoca, Romania*
✉ ***Corresponding author: Gyöngyi Székely****, Babeş-Bolyai University, Faculty of Biology and Geology, 5-7 Clinicilor Street, 400006, Cluj-Napoca, Romania*
*Email: szekelygy@yahoo.com*

reach a damaging level, with adverse effects on the growth of plant species sensitive to salt. Plants face extreme salinity especially in the closeness of salt mines, salt lakes, sea shores and estuaries where sea water mixes fresh water. Natrium ($Na^{+}$) and chloride ($Cl^{-}$) ions are the most considerable components of soil and sea water, but other ions, like sulphate ($SO_4^{2-}$) and calcium ($Ca^{2+}$) also have an important role in salinity formation. In high-salt environments, plants initially suffer because of osmotic stress, reflecting water deficit, and subsequently experience ion-specific stress resulting from altered ion concentrations both in halophytes and glycophytes (Blumwald *et al*., 2000; Shabala and Mackay, 2011).

Some wild plant species, the so called halophytes, tolerate a large variation of soil salinity (Cadaret *et al*., 2016). These are capable to complete their life cycle in high salinity conditions, due to a series of anatomical and physiological adaptation mechanisms, developed in order to counter the ionic toxicity and water loss. Obligate halophytes vegetates on soils with high salts concentrations (> 0.5% NaCl), in order to accomplish their life cycle, they need high salt concentrations. Most of themes are succulent plants, this morphology being an adaptation to stress conditions (especially salt). Facultative halophytes do not need the salt presence by all means, but they tolerate it. These are found on the soils with lower salt concentration (<0.5% NaCl) or on the edge of saltings, where the salt concentration is lower.

Salt habitats develop on wide areas in two regions: on sea sides and inside continents, in zones with arid climate. Saline habitats vary in their salinity levels due to differences in topography, soil properties, and microclimate (Bazihizina *et al*., 2009; Kumar *et al*., 2016). The study is concentrated on continental saltings. Continental salt areas are speeded from East Mongolia, through Central Asia, Western Siberia and Transylvanian Plain up to Pannonian Plain. In West, from Carpathian Basin they are found only in isolated zones, on limited areas. Thus, the saltings in Romania are close to the Eastern limit of their range in Eurasia. These territories form in zones where due to the long warm and arid period in the summer a negative balance of phreatic water is formed. Thus, the water in the deep zones of the soil rises to surface, carrying the soluble salts in the soil. After the evaporation of water on the surface, the salts crystallize at soil level.

In the present study, physical and chemical properties of salty soils have been studied. We have also successfully screened the presence of the halophytes at the field level.

## Materials and methods

The study was carried out at nine salting zones from Transylvanian Plain (Fig. 1). In the autumn of 2015, soil samples were taken to determine physical and chemical properties of soil. from these zones. Observations were also made on the vegetation characteristic to these areas of saltings.

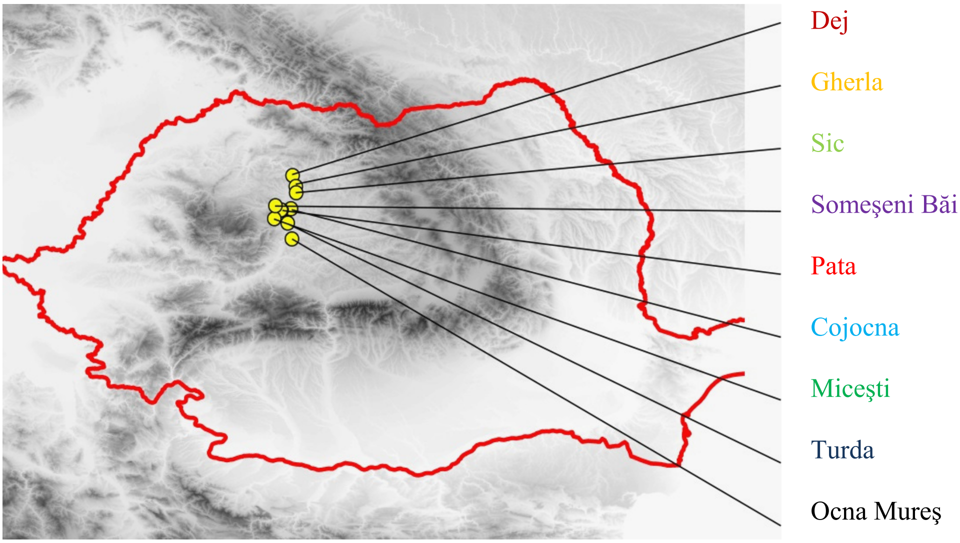


**Figure 1.** Soil sampling points

**Sampling and processing the soil samples.** The soil samples were taken form layers at different depths (0-10 cm, 10-20 cm, 20-30 cm), using a pedological bore made of inoxidable steel. Each soil sample weighted about 500 g. The samples were put in polyethylene bags, labeled, well sealed, and than taken to the Pedology Lab of the Faculty of Environmental Science and Engineering, Babeş-Bolyai University, Cluj-Napoca.

**Determinant parameters**: pH, electrical conductivity (EC), salinity, redox potential (ORP). For assessing the physico-chemical parameters, the soil samples were dried in open-air, at room temperature, for two weeks [US-EPA 3050B, ISO 11464] so that no parameter to be assessed is modified. After drying, the soil samples were sieved with a 2 mm sieve in order to remove the coarse material [ISO 11464].

pH, conductivity, salinity and redox potential were potentiometrically assayed in aqueous fraction (1:5) [ISO10390]. 40 g of soil were taken, prior dried in open-air (fraction < 2 mm), and put in an Erlenmeyer glass on top of which 200 ml of ultra pure water were added. The samples were stirred for two hours and that left to sedimentate for 30 min. After filtering the supernatant the mentioned parameters were analysed for each soil sample.

## Results and discussion

**Vegetation screening**. Out of obligate halophytes the following species were identified: *Salicornia europaea* (Sic, Pata, Cojocna, Turda, Tureni, Ocna Mureş), *Triglochin maritimum* (Pata, Turda, Tureni), *Aster tripolium* (Sic, Pata, Cojocna, Turda, Tureni, Someşeni, Ocna Mureş), *Plantago tenuiflora* (Sic, Pata, Someşeni, Ocna Sibiului, Cojocna), *Spergularia salina* (Ocna Mureş, Someşeni) and *Limonium gmellini* (Sic, Cojocna, Turda, Someşeni). Out of facultative halophytes *Artemisia pontica* (Sic, Pata), *Festuca pseudovina* (Sic, Pata, Cojocna) and *Achillea setacea* (Sic, Pata) were identified. Origin of the salt tolerance of halophytes has evolved through the accumulation of adaptive mutations leading to physiological and biochemical modifications required to thrive in high salinity (Bromham, 2014; Himabindu *et al*., 2016).

**Physico-chemical parameters.** By accumulating highly soluble compounds called osmoprotectants, which maintain osmotic pressure, most of halophytes can tolerate high-salt conditions (Guo *et al*., 2002). Nine salting zones were chosen for taking soil samples. The results of the measuring made on soil samples taken form saltings, far all the parameters, are showed in Table 1.

**Table 1.**

The values of the parameters analysed at soil samples

| Sample No | Sampling spot | Depth [cm] | pH | EC [µS/cm] | Salinity [‰] | ORP [mV] |
|---|---|---|---|---|---|---|
| 1 | Dej | 10-20 | 6.63 | 1709 | 0.8 | -7.1 |
| 2 | | 0-10 | 6.26 | 553 | 0.2 | +22.3 |
| 3 | Gherla | 10-20 | 6.86 | 2680 | 1.4 | +14.6 |
| 4 | | 0-10 | 7.24 | 1303 | 0.6 | -67.7 |
| 5 | Sic | 10-20 | 8.36 | 5010 | 2.7 | -21.5 |
| 6 | | 0-10 | 8.72 | 4700 | 2.5 | -116.0 |
| 7 | Cojocna | 10-20 | 7.70 | 3280 | 1.7 | -50.4 |
| 8 | | 0-10 | 6.98 | 2430 | 1.2 | -22.3 |
| 9 | Pata | 10-20 | 7.07 | 3900 | 2.1 | -21.5 |
| 10 | | 0-10 | 6.38 | 3520 | 1.8 | +14.8 |
| 11 | | 10-20 | 8.06 | 20800 | 12.4 | -71.4 |
| 12 | Turda | 10-20 | 7.78 | 6300 | 3.4 | -60.0 |
| 13 | | 0-10 | 6.89 | 6880 | 3.8 | -11.8 |
| 14 | Ocna Mureş | 10-20 | 8.39 | 1993 | 1.0 | -106.5 |
| 15 | | 0-10 | 8.71 | 1144 | 0.5 | -22.5 |
| 16 | Miceşti | 10-20 | 6.58 | 1602 | 0.8 | -1.6 |
| 17 | | 0-10 | 6.51 | 1304 | 0.6 | +13.4 |
| 18 | Someşeni Băi | 10-20 | 7.27 | 1674 | 0.8 | -11.9 |
| 19 | | 0-10 | 8.39 | 1090 | 0.5 | -107.1 |

**pH values influence soil characteristics.** The availability (mobility) of nutrients and pollutants is directly dependent of the pH value. Likewise, the soil organisms activity, degrading the organic substances, iron, manganese and aluminium discharge depend on pH. The soils pH falls into different reaction categories (Blaga *et al.,* 2008).

From the analyses done, the pH values indicate slight acid to moderate alkaline reactions, the values falling between 6.26 and 8.71. Out of all samples, 42 % samples are slight acid, 21% slight alkaline, 32% moderate alkaline and a single sample exhibits a neutral pH (Fig. 2).

The highest value, of 8.71, was recorded at Ocna Mureş, in the upper most 10 cm of soil, and than the pH slightly decreases with depth, reaching 8.39 in the layer of 10-20 cm (Fig. 2). Currently, the soils with pH higher than 7.2 are called saltings, because they contain in their structure high amount of salts.

The lowest pH was recorded at Dej, reaching values of 6.26 and 6.63 indicating a slight acid soil, which allow a better development of plants by higher nutrients mobility (Fig. 2). Plants rather support an acid soil, than an alkaline one.

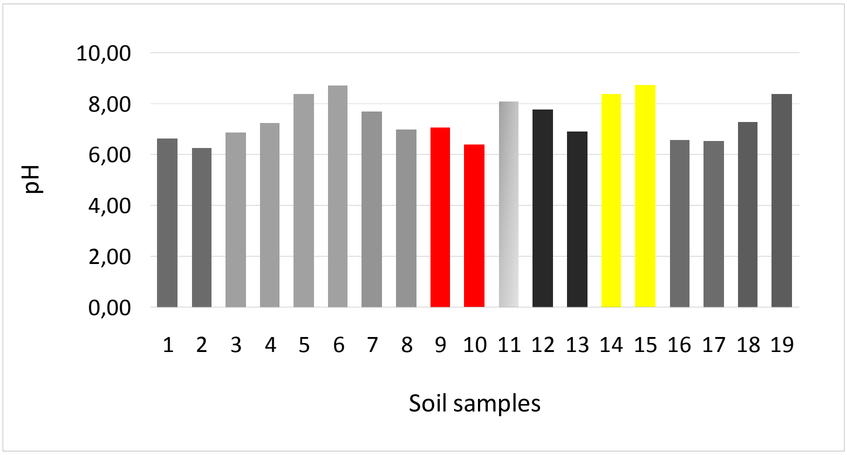


**Figure 2.** The values of the pH for soil samples

If we analyze the modification of pH value dependent on depth, two situations are differentiating: first, when pH decreasing along with depth, second, when it increases along with depth. As figure 2 shows, representing the samples taken from Dej, Cojocna, Pata, Turda, Tureni-Miceşti, the pH increases with depth, while in the other cases the situation reverses. These small modifications can influence the growth and development of plants in the studied areas. As a first indicator, pH can show us the presence of salts in higher concentrations in a soil, but, for a better highlight of this characteristic, the salinity was assessed.

**Salinity (S)** represents the accumulation of water soluble salts in soil. These salts include potassium ($K^+$), magnesium ($Mg^{2+}$), calcium ($Ca^{2+}$), chloride ($Cl^-$), sulphate ($SO_4^{2-}$), carbonate ($CO_3^{2-}$), bicarbonate ($HCO_3^-$) and sodium ($Na^+$). Salinization (primary) undertakes the accumulation of salts by natural processes due to a high salts content in the material from the origin soil or the underground waters (Krishnamoorthy *et al*., 2016). If there is a concentration of salts in soil, this will influence the water and nutrients regime, these being less accessible to plants. All the analyzed samples contain high concentrations of solute salts, showing that these soils are salty ones (Fig. 3).

The highest salt concentrations were recorded at Sic (2.7 ‰ and 2.5 ‰), Cojocna (1.7 ‰ and 1.2 ‰), Pata (2.1 ‰, 1.8 ‰ and 12.4 ‰) and Turda (3.4 ‰ and 3.8 ‰), values above 1 ‰. A very high concentration was recorded at Pata, where the value reached 12.4 ‰ (Fig. 3). It is indicated to follow the correlation between the concentration of salts and the development of vegetal associations, as well as the repetition of concentration analyses.

Except the soil samples taken from Turda, for all the other samples, higher salt concentrations were recorded in the 10-20 cm horizon, which can denote that the salts are originating from the geological sublayer, either by pedogenesis processes, either by phreatic layer.

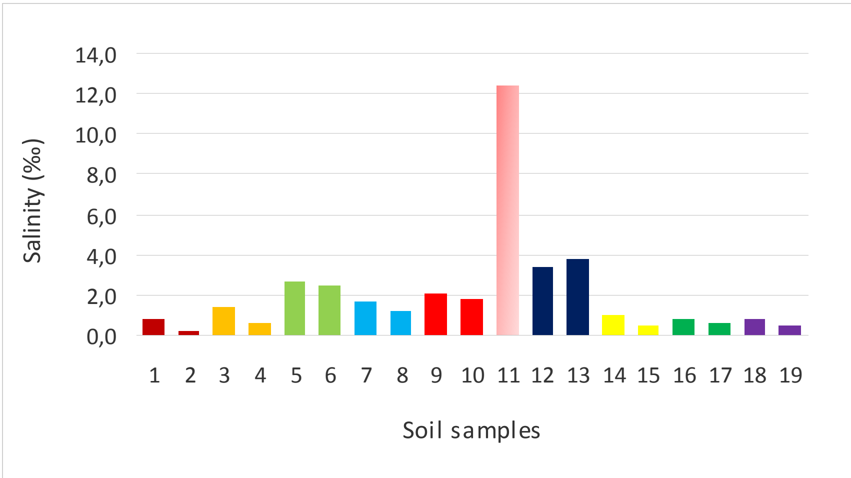


**Figure 3.** Salinity of soil samples

**Conductivity (EC).** Electric conductivity indicate the spatial distribution of different soil properties, with applications on the water course in soil, localization of zones with high salt content, determination of soil texture, identification of soil types, but also their quality. The field measurements of EC accumulate the product of static and dynamic factors: soil salinity, clay content and mineral composition of soil, water content (Wang *et al.,* 2012).

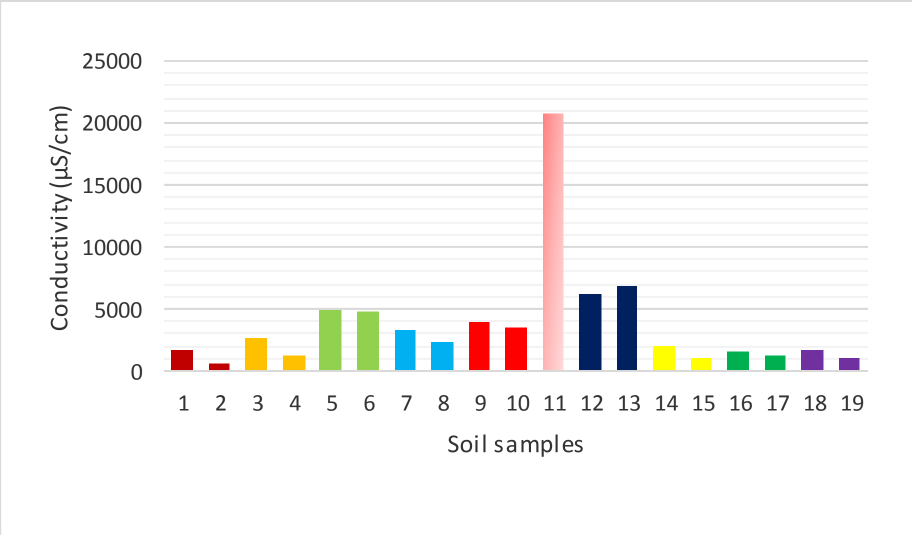


**Figure 4.** Soil samples conductivity

The clayish soils have the capacity to store water and they reach higher values of electric conductivity, while the sandier soils do not have this capacity and record lower electric conductivity values.

The highest conductivity was recorded at Pata, 20800 μS/cm, value which can be correlated with the high salinity of sample and will be also correlated with the clay content. The high conductivity was also recorded at the samples from Turda and Sic, values above 5000 μS/cm, which indicates the presence of dissolved soils and clay fractions, which has to be determined (Fig. 4).

**Oxidoreduction potential (ORP).** Oxidation Reduction Potential is a value measured in milivolts, its size indicates if a solution is oxidating or reducing. 79% of water samples show a negative ORP value and the rest of 21% represents positive values, meaning oxidant values. The samples with positive values were recorded from Dej (22.3 mV), Gherla (14.6 mV), Pata (14.8) and Tureni (13.4 mV) (Fig. 5).

A positive ORP value indicates that the solution can have negative effects on health of living organisms, because they do not possess the antioxidant capacity to neutralize the oxygen free radicals causing oxidative damages. A negative ORP value indicates that the environment is a strong antioxidant, absorbs free radicals, contributing to a better oxygenation of live organisms.

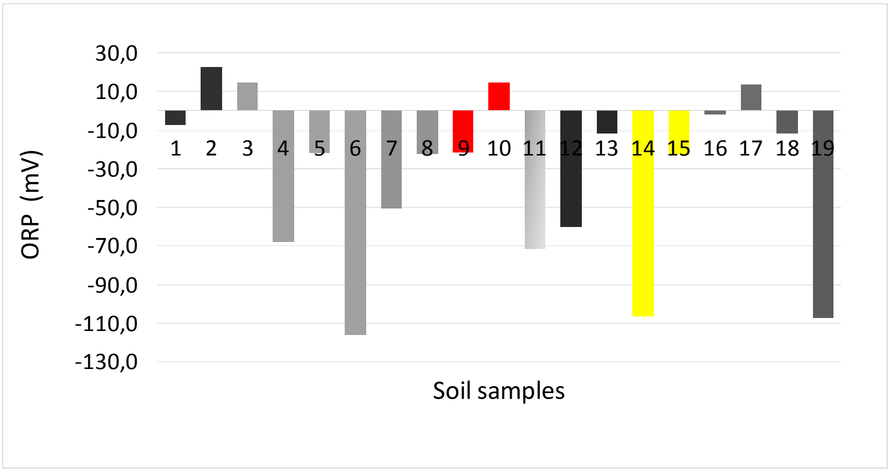


**Figure 5.** Oxidoreduction potential of soil samples

## Conclusions

Salinity is one of the most severe abiotic environmental factors at a global scale, with deleterious effect on plant growth and development. There were identified obligate and facultative halophytes which populates Romanian salty areas. All studied physico-chemical soil parameters (pH, ORP, conductivity, salinity) vary between a broad range, depending on the location of the studied area and depth. These parameters have a decisive influence on the plant populating the upper zone of the soil. All of the measured values proved to be specific for salty areas.

### Acknowledgements

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project number PN-II-RU-TE-2014-4-0831.

## REFERENCES

Bacchetta, G., Farris, E., Pontecorvo, C. (2012) A new method to set conservation priorities in biodiversity hotspots, *Plant Biosystems* **146**, 638-648

Bazihizina, N., Timothy, D., Edward, G. (2009) Response to non-uniformsalinity in the root zone of the halophyte *Atriplex nummularia*: growth, photosynthesis, water relations and tissue ion concentrations, *Annals of Botany* **104,** (4), 737–745.

Blaga, G., Filipov, F., Paullete, L., Rusu, I., Udrescu, S., Vasile, D. (2008) Pedologie. Ed. Mega Cluj Napoca, 450 p

Blumwald, E., Poole, R. J. (1985) Na(+)/H(+) antiport in isolated tonoplast vesicles from storage tissue of *Beta vulgaris*. *Plant Physiol*., **78**, 163–167

Bromham, L. (2014) Macroevolutionary patterns of salt tolerance in angiosperms. *Ann. Bot.,* 1–9

Cadaret, E. M., Nouwakpo, S. K., McGwire, K. C., Weltz, M. A., Blank, R. R. (2016) Experimental investigation of the effect of vegetation on soil, sediment erosion, and salt transport processes in the Upper Colorado River Basin Mancos Shale formation, Price, Utah, USA, *Catena*, **147**, 650–662

Ciocârlan, V. (2009) *Flora ilustrată a României. Pteridophyta et Spermatophyta*, Ceres, Bucureşti, pp. 225-226

Cristea, V. (2010) Conservarea *ex situ* prin culturi *in vitro* fotoautotrofe a taxonilor endemici şi cu diferite grade de periclitare aparţinând genului *Dianthus* din România, In: *Culturi in vitro fotoautotrofe la specii de Dianthus endemice şi periclitate din România*, Cristea, V., Todesco, Cluj-Napoca, pp 145-194

Farissi, M., Ghoulam, C., Bouizgaren, A. (2013) Changes in water deficit saturation and photosynthetic pigments of alfalfa populations under salinity and assessment of proline ole in salt tolerance. *Agric. Sci. Res. J.,* **3**, 29–35

Guo, Y. S., Wan-Ke, Z., Dong-Qing, Y., Bao-Xing, D., Jin-Song, Z., Shou-Yi, C. (2002) Overexpression of proline transporter gene isolated from halophyte confers salt tolerance in *Arabidopsis*. *Acta Bota. Sinica*, **44**, 956–962

Himabindu, Y., Chakradhar, T., Reddy, M. C., Kanygin, A., Redding, K. E., Chandrasekhar, T. (2016) Salt-tolerant genes from halophytes are potential key players of salt tolerance in glycophytes, *Environmental and Experimental Botany*, **124**, 39–63

Krishnamoorthy, R., Kim, K., Subramanian, P., Senthilkumar, M., Anandham, R., Sa, T. (2016) Arbuscular mycorrhizal fungi and associated bacteria isolated from salt-affected soil enhances the tolerance of maize to salinity in coastal reclamation soil, Agriculture, *Ecosystems and Environment*, **231**, 233–239

Kumar, A., Kumar, A., Lata, C., Kumar, S. (2016) Eco-physiological responses of *Aeluropus lagopoides* (grass halophyte) and *Suaeda nudiflora* (non-grass halophyte) under individual and interactive sodic and salt stress, *South African Journal of Botany*, **105**, 36–44

Li, X., Wan, S., Kang, Y., Chen, X., Chu, L. (2016) Chinese rose (*Rosa chinensis*) growth and ion accumulation underirrigation with waters of different salt contents. *Agric. Water Manag.*, **163**, 180–189

Muchatea, N. S., Nikalje, G. C., Rajurkar, N. S., Suprasanna, P, Nikamd, T. D. (2016) Physiological responses of the halophyte *Sesuvium portulacastrum* tosalt stress and their relevance for saline soil bio-reclamation, *Flora*, **224**, 96-105

Munns, R., Tester, M. (2008) Mechanisms of salinity tolerance. *Annu. Rev. Plant Biol*., **59**, 651–681

Shabala, S., Mackay, A. (2011) Ion transport in halophytes. *Adv. Bot. Res*. **57**, 151–199

Yan, K., Xu, H., Zhao, S., Shan, J., Chen, X. (2016) Saline soil desalination by honeysuckle (*Lonicera japonica* Thunb.) depends on salt resistance mechanism. *Ecol. Eng*., **88**, 226–231

Wang, D., Wang, H., Han, B., Wang, B., Gua, A., Zheng, D., Liu, C., Chang, L., Peng, M.,Wang, X. (2012) Sodium instead of potassium and chloride is an important macronutrient to improve leaf succulence and shoot development forhalophyte *Sesuvium portulacastrum*. *Plant Physiol. Biochem*., **51**, 53–62

*** (1996) US-EPA 3050B, Acid digestion of Sediments, Sludge and Soils
*** (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Official Journal of the European Communities, L327/72
*** (2005) ISO10390 Soil quality, Determination of pH
*** (2006) ISO 11464 Soil quality, Pretreatment of samples for physico-chemical analysis