# Study on Potential Benefits of Halophyte, *Sesuvium Portulacastrum* (Linnaeus) Linnaeus, 1759

**Dr. Jaishinimol Bharghavan[a] Dr. Ebrahim Al Jamali[b], & Klaithem Ali Muhamed[c]**

[a, b, c], Marine Environment Research Centers Department,
Ministry of Climate Change & Environment, United Arab Emirates

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**Abstract:** Sesuvium portulacastrum is a cosmopolitan perennial coastal halophyte commonly found in coastal areas of the United Arab Emirates. Sea purslane has many reported benefits and is an excellent source of nutrients, vitamins, and minerals. An attempt has been made to study the potential benefits of this herbaceous plant that can be utilized in the United Arab Emirates. A pilot study has also been made to assess the salinity tolerance of this species and the growth of this plant in indoor and outdoor conditions.

**Keywords**: Sesuvium, halophyte, United Arab Emirates, salinity, tolerance

## INTRODUCTION

Sesuvium portulacastrum, commonly known as shoreline 'sea purslane' is a sprawling perennial and facultative halophytic herb dicotyledonous belonging to the family Aizoaceae that grows in sandy clay, coastal limestone and sandstone, tidal flats, and salt marshes areas throughout much of the world. It is native to all five continents and has naturalized in many places where it is not indigenous (Lonard and Judd 1997). Sesuvium portulacastrum naturally grows in wet sandy locations such as beaches, mangroves, dunes, salt flats, and marshes (Lokhande et al, 2013). It is seen to inhabit areas with annual rainfall as little as 50 to 150cm and can remain green in areas with long dry seasons. Sea purslane is an edible halophyte plant, that also helps protect fragile coastlines and dunes from erosion. Sea purslane is sold for food and medicinal purposes in markets around the world, especially in small local markets in the Caribbean, Asia, India, and Europe.

Sesuvium portulacastrum is a sprawling perennial herb up to 30cm high, with thick, smooth stems and smooth, fleshy, glossy green leaves that are linear or lanceolate, (10–70 mm long and 2–15 mm wide). Flowers are pink or purple with very small stalked black, smooth, and lustrous seeds and each fruit produce 50 or more seeds per capsule (Lonard and Judd 1997). Plants possess taproot systems, however, creeping nature produces adventitious roots from the nodal region. Shoots are trailing, succulent, and greenish pink or red in color and are diffusely branched with oppositely arranged simple, succulent leaves.

Sesuvium portulacastrum, a facultative halophyte and 'salt accumulator' grows well under severe salinity and low nutrient availability, the emerging data on the adaptability of the plant exposed to various abiotic factors reveal that Sesuvium portulacastrum maintains its growth by sequestration of saline ions and heavy metals into the vacuoles to maintain the osmotic balance between vacuole and cytoplasm (Venkatesalu and Chellapan1993a, b; Messedi et al. 2004).

Climate change is a significant challenge for agriculture and food security. Soil salinity is, together with drought, one of the major causes of the reduction of crop yields especially in arid and semiarid regions. The most effective strategy to address the problem should be based on the genetic improvement of crops. This requires a deep understanding of the mechanisms underlying salt tolerance. These halophytic plant species are morphologically, anatomically, and physiologically well-adapted to thrive and flourish in soils with high salt concentrations. Halophytes could represent the basis of sustainable 'saline agriculture', being commercially grown in salinized land and irrigated with brackish or saline water. Studies suggest that sea purslane is an excellent source of vitamins especially vitamin A, and minerals. Surprisingly studies indicate that It also to contains omega-3 fatty acids, more than any other leafy vegetable plant. Sea purslane has been reported to be a good source of protein and dietary fiber. Lastly, oil extracted from sea purslane leaves has also been reported to contain medicinal properties such as being an antimicrobial agent against some tested human pathogenic organisms. This edible

halophyte plant is native to coastal habitats of the United Arab Emirates, and the present paper illustrates a study by researchers from the Marine Environment Research Center, Ministry of Climate Change and Environment (MOCCAE) to review the benefits and potentials of farming sea purslane and an experimental study to assess the salinity tolerance of Sesuvium and growth of plant propagated stem cuttings.

## METHODOLOGY

### OBJECTIVES OF THE STUDY

•To review the ecological properties of *Sesuvium portulacastrum* plants from the United Arab Emirates coastal region and to enlist the potential uses of the plant.

•To assess the salinity tolerance of *Sesuvium portulacastrum* native to the United Arab Emirates by conducting experiments.

•Baseline assessment of the heavy metal concentrations in soil and plant collected from a natural coastal habitat in UAE.

Table 1. Scientific Classification

| | |
|---|---|
| **Kingdom** | Plantae |
| **Clade** | Angiosperms |
| **Order** | Caryophyllales |
| **Family** | Aizoaceae |
| **Genus** | *Sesuvium* |
| **Species** | *S. portulacastrum* |
| **Binomial name: *Sesuvium portulacastrum* (Linnaeus) Linnaeus, 1759** | |

Figure 1. *Sesuvium portulacastrum*

Fresh stems of *Sesuvium portulacastrum* were collected near the coastal mangrove area in Umm Al Quwain, UAE. The plant grows as a thick bed of vegetation in this area.

Figure 2. Vegetation of *Sesuvium portulacastrum* sample collection area


Figure 3. Map showing sample collection area – Umm Al Quwain (United Arab Emirates)

The transplants (shoots) of 30cm each were cut off as propagates and a duplicate (2 shoots of 30cm) was put to different salinity treatments and growth experiments. The experiments were conducted in indoor (lab) and outdoor conditions, carried out for a period of 6 months starting from June to December 2022 corresponding to air temperature range of $24^0$ to 40 $^0$C during these months The experiments were conducted growing plants in water with different salinities, (Table 2).

Figure 4. Stem cuttings of *Sesuvium portulacastrum*

Table 2: Showing Details of Salinity Treatment

| **Treatments (Salinity as ppt)** | **Source** | **Experiment Conditions (range)** |
|---|---|---|
| 0 | Tap water | **Indoor (controlled)**<br>**Temperature:** $23.5^0$ to $25^0$C<br>**Light:** 90 – 100 lumens<br>**Humidity :** 55% |
| 10 | Diluted sea water | |
| 20 | Diluted sea water | |
| 30 | Diluted sea water | |
| 40 | Sea water | **Out door***<br>**Temperature:** $16^0$ – $42^0$c<br>**Light:** sunlight<br>**Humidity: 55-67%**<br>*As per weather conditions |
| 60 | Evaporated sea water | |
| 75 | Evaporated sea water | |
| 100 | Evaporated sea water | |

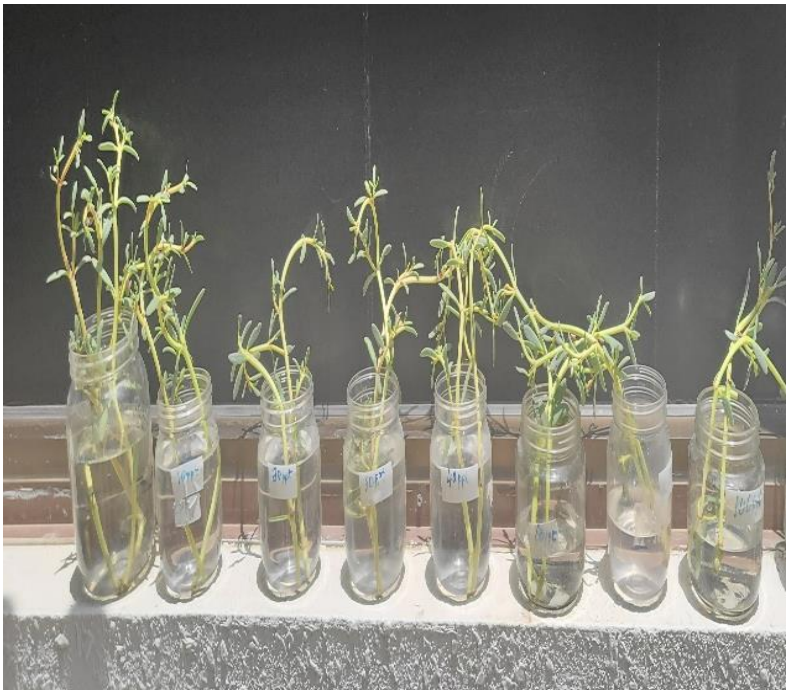


Figure 5. Outdoor Experimental Setup

Figure 6. Indoor Experimental Setup

## Results & Discussion

A detailed reference review indicated various significant uses and applications of *Sesuvium portulacastrum*

**Biomedical applications**

- Traditionally used as a remedy for fever, kidney disorders, and scurvy in some continents.
- The plant is used on the Senegal coast as a haemo-static and a decoction of it is considered to be the best-known antidote for stings of venomous fish
- *Sesuvium portulacastrum* is a potential source of 20E .20E and derivatives from plant sources is of great interest currently as anabolic preparations for body-builders and sportsmen.
- The secondary metabolites derived from the plant have great potential as a substitute for some synthetic raw materials in the food, perfumery, cosmetic, and pharmaceutical industries (Lis-Balchin and Deans 1997).
- The essential oil extracted from the leaves of *Sesuvium portulacastrum* revealed notable antibacterial activity against both gram-positive and gram-negative bacteria and displayed significant antifungal and antioxidant activity (Magawa et al.2006)

**Human consumption**

- Leaves and stems of sea purslane are rich in nutrients especially Ca, Fe, and carotene, consumed as vegetables by local peoples in the arid region.
- Mote Laboratory, Florida U.S has proved through pilot studies that hydroponic culture of this halophyte is viable option and an excellent source of vitamins and minerals (Kevan & Thomas, 2020)
- *Sesuvium portulacastrum* is utilized as a wild vegetable crop and occasionally cultivated as a vegetable for cooking purposes in India and South East Asia (Hammer2001)
- Pickled *Sesuvium portulacastrum is* eaten in the Philippines as atchara (sweet traditional pickles)
- It has excellent potential as a "salad" due to its salty taste and fleshy texture and can be used to complement vegetables in modern cuisine (Lokhande et al., 2013).

**Nutritional value**

Table 3: Nutritional Benefits of *Sesuvium portulacastrum*

| Element | Calories | Element | Calories |
|---|---|---|---|
| **Protein** | 10.2% | **Pantothenic acid** | 0.17mg |
| **Fiber** | 9.9% | **Folate** | 17.4mcg |
| **Carbohydrates** | 45.5% | **Magnesium** | 49.7 mg |
| **Fatty acids (PUFA)** | ~70% | **Vitamin K** | 164 mg |
| **Beta carotene** | 680mcg | **Vitamin B1** | 0.02 mg |
| **Calcium** | 23mg | **Vitamin B2** | 0.06 mg |
| **Phosphorous** | 33.4 mg | **Niacin** | 0.24mg |
| **Sodium** | 808 mg | | |

**Agricultural uses**

•*Sesuvium portulacastrum* is an important source of phytoecdysteroids, an insect molting hormone used in the sericulture industry
•This compost of halophytic plants is used as a fertilizer and was found to significantly improve the soil microflora such as bacteria, fungi and actinomycetes and soil enzyme activities (Balakrishnan et al. 2007)
•Phytoremediation- *Sesuvium portulacastrum* helps in low-cost clean-up technology offers a potential, economical and greener method of removing TDS, heavy metals etc. from wastewater discharged lands using a plant-soil system.

**Environmental significance**

•*Sesuvium portulacastrum* a useful species as a heavy metal pollution indicator (Lacerda 1982) and for predicting soil salinity (Tóth et al. 1997).
• *Sesuvium portulacastrum* can be used as a phytostabilizer in heavy-metal-contaminated coastal environments. Sesuvium can be an ideal candidate for plant-based removal of nitrogen (N) and phosphorus (P) from water bodies and an important method for the remediation of aquaculture wastewater (Zhang, 2022).

• *Sesuvium portulacastrum* has been reported as pioneer species for environmental protection such as sand dune fixation, saline soil stabilization, desalination, desert greenification, landscaping as well as an ornamental (Menzel and Leith1999)

• *Sesuvium portulacastrum* being a coastal plant inland plant and a mangrove associate has been shown to have nursing effects on mangroves. (McKee et al. 2007).

**Salinity tolerance experiments on survival of the plant at different salinities**

Halophytes, adapted to natural saline environments are able to survive and complete their life cycle in habitats with soil salinity equivalent or even higher, close to that of seawater. Halophytes are, therefore, ideal materials for basic studies of salt tolerance mechanisms in plants, at the physiological, biochemical, and molecular levels. An experiment was conducted Sesuvium portulacastrum collected from a coastal habitat, Umm Al Quwain in the United Arab Emirates to study the salinity tolerance (Graph1).

In indoor conditions Sesuvium portulacastrum cuttings could tolerate a salinity range between 0-40ppt for a period of 5 months and 60ppt for a period up to 4 months. The wilting of plants in indoor conditions after 5 months at a salinity of 40ppt was possibly due to the lack of sunlight or ambient light conditions. Results of the current experiment proved that in ambient indoor conditions, the plants can survive indefinitely in low salinities while at high salinity like 40- 60ppt for a considerable period (0-4 months' average), making the sea purslane a suitable candidate for indoor culture in saline, brackish or fresh water.

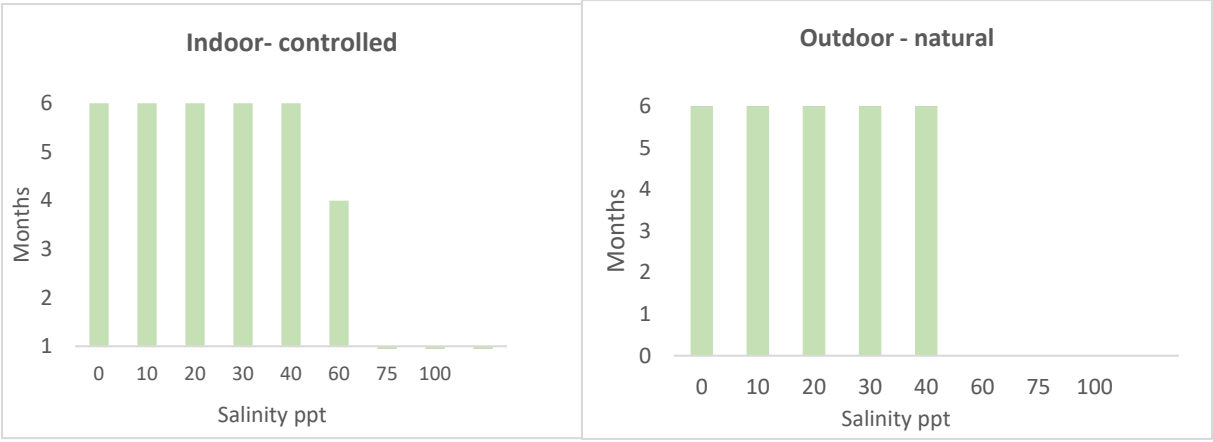
In outdoor conditions, the Sesuvium portulacastrum cuttings could tolerate salinity up to 40ppt at even extreme temperatures of 420C in summer. But the high salinity treatments 60ppt & above were not able to survive high temperatures in outdoor weather conditions. In outdoor conditions, Sesuvium portulacastrum cuttings tolerated a salinity up to 40ppt coupled with high temperature ranging up to 420C indicating the capability of the species to withstand extreme climatic conditions making it a species suitable for studies related to climate change and stress tolerance.

The salinity stress experiments conducted showed that Sesuvium portulacastrum growing in the United Arab Emirates can tolerate a salinity up to 40 ppt in both indoor and outdoor conditions for a long period of time. It was interesting to observe that in indoor controlled conditions the plants survived up to 4 months, indicating it as species suitable for short term indoor culture. The ambient light conditions could be possibly increase the survival period in indoor conditions

Table 4. Salinity Tolerance Experiment

| Salinity | **Months** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ppt | **Indoor** | | | | | | **Outdoor** | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** | **1** | **2** | **3** | **4** | **5** | **6** |
| 0 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |

Growing | Wilted




Graph1. Survival of *Sesuvium portulacastrum* Exposed to Different Salinities

## Growth of the plant at different salinities

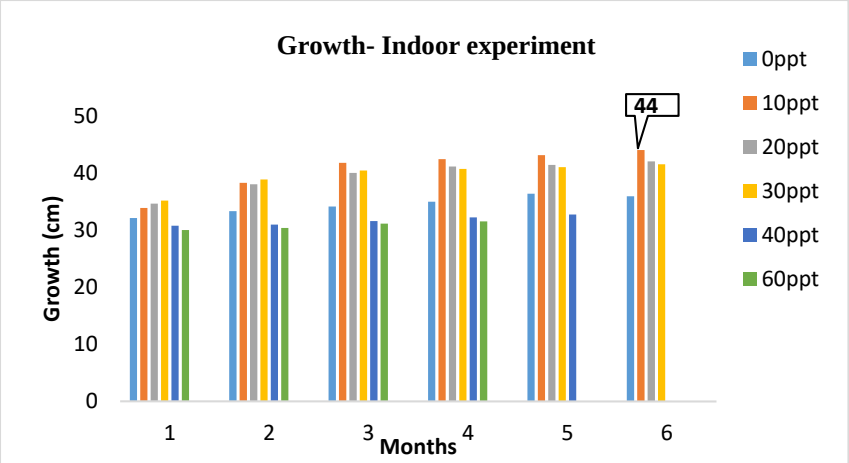
Halophytes show a diversity of growth responses to increasing salinity, from a dramatic stimulation to inhibition (Timothy & Timothy, 2008). The stem cuttings of length 30cm from *Sesuvium portulacastrum* grown in different salinities were assessed for the growth in indoor controlled and outdoor natural conditions. The growth was measured as length of the shoot in centimeters. The growth rate was also calculated.

In indoor conditions, maximum annual growth rate was in stem cuttings in salinity treatment of 10ppt (28) and lowest in salinity 60 ppt. After 6 months the length of shoot in treatment 10, 20 and 30 ppt showed good increase in length by 14cm,12cm and 11.5cm respectively, with salinity treatment 10ppt the showing maximum growth (Table 4).

Table5. Growth - Indoor (controlled) Conditions

| **Salinity (ppt)** | **Initial length (cm)** | Months | | | | | | Growth (cm) | Annual Growth rate |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | | |
| **0** | 30 | 32.1 | 33.3 | 34.1 | 34.95 | 35.9 | 36.3 | **6.3** | **12.6** |
| **10** | 30 | 33.85 | 38.25 | 41.75 | 42.4 | 43.1 | 44 | **14** | **28** |
| **20** | 30 | 34.6 | 38 | 40 | 41.1 | 41.4 | 42 | **12** | **24** |
| **30** | 30 | 35.15 | 38.85 | 40.4 | 40.7 | 41 | 41.5 | **11.5** | **23** |
| **40** | 30 | 30.75 | 30.95 | 31.55 | 32.2 | 32.7 | | **2.7** | **5.4** |
| **60** | 30 | 30 | 30.35 | 31.1 | 31.5 | | | **1.5** | **3** |
| **75** | 30 | | | | | | | | |
| **100** | 30 | | | | | | | | |

*Length measurements in centimeters (cm)



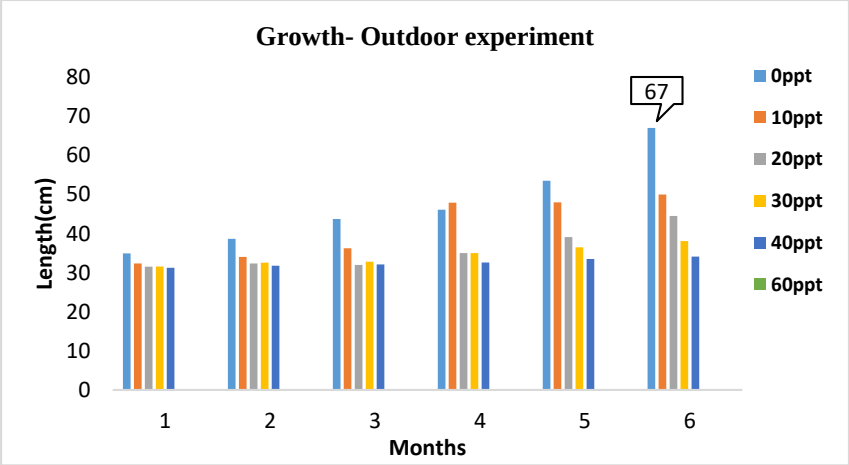

Graph2. Growth of *Sesuvium portulacastrum* Exposed to Different Salinities(indoor)

In outdoor conditions, it was interesting to note that the plant exhibited a high growth at 0ppt and very low at 40ppt. The growth rate also showed a similar trend. The high growth at 0 ppt, a growth rate of 74, compared to other salinity treatments showcases a fact that even at optimum conditions salinity could be limiting factor. This could be because *Sesuvium portulacastrum* is a monocotyledonous halophyte and these type of halophytes generally grow optimally in the absence of salt (Glenn et al., 1999). The growth of shoots at salinity treatments 0-30ppt was the best indicating a brackish habitat preference of the species.

Table5. Growth - Outdoor (natural) Conditions

| **Salinity (ppt)** | **Initial length (cm)** | Months | | | | | | **Growth (cm)** | Annual Growth rate |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | | |
| **0** | 30 | 34.95 | 38.65 | 43.75 | 46.1 | 53.5 | 67 | **37** | **74** |
| **10** | 30 | 32.35 | 34.05 | 36.25 | 47.9 | 48 | 50 | **20** | **40** |
| **20** | 30 | 31.55 | 32.35 | 32 | 35 | 39.1 | 44.5 | **14.5** | **29** |
| **30** | 30 | 31.6 | 32.55 | 32.8 | 35 | 36.5 | 38.1 | **8.1** | **16.2** |
| **40** | 30 | 31.25 | 31.8 | 32.1 | 32.6 | 33.5 | 34.1 | **4.1** | **8.2** |
| **60** | 30 | | | | | | | | |
| **75** | 30 | | | | | | | | |
| **100** | 30 | | | | | | | | |

*Length measurements in centimeters (cm)




Graph3. Growth of *Sesuvium portulacastrum* Exposed to Different Salinities(outdoor)

## Heavy metal absorption

Review of references showed that *Sesuvium portulacastrum* is a suitable species for phytoremediation. Samples of soil and plant (leaves) from was analyzed using ICPMS for important heavy metals Arsenic - As, Cadmium -Cd, Cobalt- Co, Chromium- Cr, Iron - Fe, Manganese-Mn, Molybdenum- Mo, Nickel- Ni, Lead- Pb, Titanium- Ti, Zinc- Zn to provide a baseline data. High iron and zinc content was noted in plants. The presence of heavy metals indicates that the plants effectively phyto remediate making it an important species to be cultivated for waste water treatment before discharge into the water bodies or soil.

The cadmium content of the soil and the plant was almost the same indicating good absorption of this heavy metal by the plants. Further research is necessary to understand these factors and mechanism.

Table 6. Results of Heavy Metal Analysis

| **Sample** | Arsenic As | Cadmium Cd | Cobalt Co | Chromium Cr | Iron Fe | Manganese Mn | Molybdenum Mo | Nickel Ni | Lead Pb | Titanium Ti | Zinc Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sea water** µg/L | 2.3 | 1.54 | 0.15 | 0 | 0 | 3.6 | 13.7 | 2.9 | 72.4 | 0 | 152.5 |
| **Sand** ug/kg | 3805 | 368.5 | 1415 | 57400 | $255*10^5$ | 114500 | 444.5 | 12850 | 35200 | 159000 | 7600 |
| **Plant S**ug/kg | 35.25 | 312.5 | 213 | 532 | 36450 | 4295 | 694 | 1450 | 3230 | 2530 | 9325 |

## Conclusions

### Possible areas of interest in United Arab Emirates

•Marine aquaponics system can be used to produce halophyte plants like *Sesuvium portulacastrum* together with fish (aquaculture). A pilot study to explore this potential can be envisaged.

•Being an edible plant with nutritional benefits, the edible potentials with new recipes should be explored.

•Apart from being a source of knowledge, *Sesuvium portulacastrum* being a halophyte can also provide biotechnological tools – salt-tolerance genes and salt-induced promoters – for the genetic improvement of salt tolerance of conventional crops. The genetic study of

this halophyte is a promising strategy to address the problem of soil salinization and climate change faced by food crops especially in arid region Gulf region.

•The organic compost made up of these fast-growing halophytic plants and as an easily available potential source of fertilizer in future for the development of sustainable agriculture.

•*Sesuvium portulacastrum* can be widely used environmental protection such as sand and rock fixation especially as coastal barriers, saline soil stabilization, soil desalination and desert greenification.

•Large-scale adoption of *Sesuvium portulacastrum*, as potential candidate, can be accorded as priority for rehabilitating contaminated soils, which can pave way for sustainable bio saline agriculture. Considering its nutritional composition, the plant can be used to complement as a vegetable.

•In addition, considering the nutritional content the potential of this plant as alternative source of fodder to domestic animals should be studied.

• Due to the extreme environmental conditions in the UAE, i.e., high temperatures and high salinity of the seawater of the Persian Gulf, it is possible that plants here may have unique compounds not found in other species or in higher concentrations found in other species. Research regarding the bio active compounds that can be extracted could be initiated in view of biomedical applications.

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**AUTHORS**

**Dr. Jaishinimol Bharghavan**, PhD, Marine Environment Research Centers Department,
Ministry of Climate Change & Environment, United Arab Emirates, jbharghavan@moccae.gov.ae
**Dr. Ebrahim Al Jamali**, Ph.D., Director, Marine Environment Research Centers Department,
Ministry of Climate Change & Environment, United Arab Emirates eaaljamali@moccae.gov.ae
**Ms. Klaithem Ali Muhamed**, Researcher, Marine Environment Research Centers Department,
Ministry of Climate Change & Environment, United Arab Emirates, kamohammed@moccae.gov.ae

**Correspondence Author:** Dr. Jaishinimol Bharghavan, PhD, Marine Environment Research Centers Department, Ministry of Climate Change & Environment, United Arab Emirates, jbharghavan@moccae.gov.ae