Cultivation of Gray Mangroves *Avicennia marina* (Forssk) Vierh. in the Iraqi Coast

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Abstract

The ecosystems of the Iraqi marine coasts are notoriously poor in vegetation and highly vulnerable to coastal erosion. The current study aims at finding out the possibility of cultivating the Iraqi coasts with mangrove *Avicennia marina*. Two sites were chosen to conduct the experiment, the first in the Khor Al-Zubair oil port, and the second in the Al-Faw Grand port. The experiment was carried out by planting 50 seedlings in each site, in order to study the possibility of acclimatization of gray mangrove plants in these environments. Experimental measurements of vegetative growth indicators, total chlorophyll content, and survival rates were taken during the study period. The results demonstrated a normal growth of plants in the Khor Al-Zubair oil port site, as it recorded an average height of seedlings amounted to 93.8 cm during the study period at a daily rate of 0.256 $cm.day^{-1}$. total Chlorophyll content increased from 43.68-52.10 $\mu g.cm^{-2}$, while achieving survival rates of 78% at the end of the experiment. Compared to the site of the Al-Faw Grand port, it achieved medium vegetative growth during the first six months of the experiment, after that the plants began to deteriorate, and thus to the destruction of all seedlings after 12 months of the experiment's life. This failure is primarily attributed to high wave energy /extreme soil compaction /open sea exposure. These findings suggest that sheltered coastal environments like Khor Al-Zubair are viable candidates for mangrove restoration in Iraq, whereas open coastlines require prior artificial wave-breaker protection.

Keywords: Iraqi Coast, *Avicennia marina*, Mangroves, Khor Al-Zubair oil port, Al-Faw Grand port.

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Introduction

Mangroves comprise a specialized group of arborescent halophytes or salt-tolerant plants that occupy tidal habitats within coastal and estuarine regions. This group of plants is uniquely adapted to thrive under conditions of constant salinity stress, as well as continuous sediment saturation (Tomlinson, 1986). Mangrove ecosystems play an important role in estuarine physical activity, as they trap suspended sediments, which reducing water turbidity, help to stabilize the shoreline and impede erosion by attenuating wave energy. Beyond their geomorphological functions, these ecosystems possess immense ecological value by supporting high biodiversity., providing breeding and nursery habitats for a range of different terrestrial and marine species, including bacteria, fungi, algae, invertebrates (such as gastropods and shellfish), and vertebrates (such as fish, birds, and mammals). (Morrisey *et al.,* 2007).

Since these plants are identified in intertidal zones, the growth and productivity of mangroves are greatly affected by salt stress adaptations, as many nutrients are required to protect the plant from stress and growth processes with the harmful presence of NaCl. Photosynthesis and plant growth in mangroves are also affected by temperature, water freshness, nutrient availability, and salinity stress (Alongi, 2009; Day *et al.,* 2012). Besides, mangroves are matchlessly adapted to grow under salinity stress. In sake of growth retention under conditions of high salinity in the sediment, mangroves accumulate salts in the leaves. While this adaptation stimulates plants to overcome osmotic differences to absorb water, it negatively affects enzymatic activity. Mangroves grown in extremely saline conditions have been displayed to exhibit lower levels of photosynthesis (Lovelock and Feller, 2003). The distribution of mangroves is also affected by climates (Alongi, 2008), such as temperature (Duke, 1992) and precipitation (Saenger and Snedaker, 1993). Temperature and precipitation promote mangrove survival, but the temperature has a greater influence than precipitation on the global distribution of these ecosystems (Numbere and Camilo, 2017).

Mangrove ecosystems are also nutrient-limited, and mangroves can survive in Oligotrophic environments (Day *et al*., 2012). Among the most important mineral nutrients for all forms of life are nitrogen and phosphorus ions, (Campbell *et al*., 2016). Nitrogen is important for the formation of proteins and facilitates enzymatic activity, while phosphorus is essential for energy transfer and storage in cells in the form of adenosine triphosphate (ATP). Moreover, both of these elements are present in DNA (deoxyribonucleic acid). In addition, the length of the Iraqi sea coasts does not exceed 64 km, compared with the Kuwaiti coasts extending to more than 500 km, while the Iranian coasts reach more than 2000 km (Al-Mahmood *et al*., 2018). Despite the shortness of this coast, it is the only external waterfront for Iraq overlooking the seas, which is a significant economic and strategic part. These coasts suffer from many problems, whether natural or human, such as increased sedimentation rates that cause shallow depths along the coast, high marine water salinity, soil erosion, and erosion processes as a result of high wave energy and lack of vegetation, consequently impeding maritime navigation and a declining marine biodiversity (Al-Mahmood, 2006). The present study focuses on investigating the feasibility of planting mangroves in Iraqi coastal repeated to multiply vegetation cover, preserve coastal soil from erosion, create a suitable repeated for marine life, and increase biodiversity. This paper sheds light on identifying the obstacles that limit the growth and spread of these trees within local marine habitats. By monitoring experimental plots across distinct hydrological regimes, this study evaluates the specific environmental determinants affecting mangrove growth, as well as the capacity of these plants to adapt to regional climate variations.

Materials and Methods

Study site

Two sites were chosen to conduct the field experiment to find out the possibility of cultivating the gray mangrove plant *Avicennia marina* on the Iraqi coasts. The first (St1) is located at the Khor Al-Zubair oil port with the Khor Al-Zubair of Al-Zubair district in the southwest of Basrah Governorate (30° 12' 12.00" N, 47° 52' 34.51" E). This site represents a relatively sheltered, low-energy estuarine environment. The second site (St2): is located near the eastern breakwater of the Al-Faw Grand port at the southernmost tip of the Basrah Governorate (29° 54' 20.65" N, 48° 30' 1.96" E). This site characteristically represents a highly exposed coastline subject to open marine dynamics, (Figure 1).

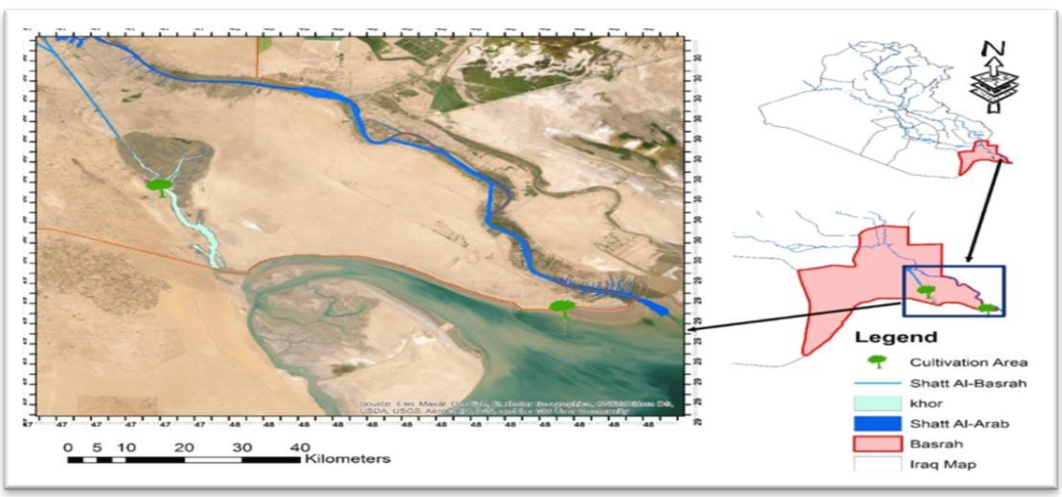

Figure 1. Geographic location of the two experimental study sites along the Iraqi coast: Site 1 (St1) located at the sheltered Khor Al-Zubair oil port, and Site 2 (St2) located near the eastern breakwater at the open-sea Al-Faw Grand port, Basrah Governorate, Iraq.

Khor Al-Zubair oil port (St1) is located 150 km north of the Arabian Gulf, and 60 km from the center of Basra Governorate, southern Iraq (Dakheel *et al.*, 2022). Khor Al-Zubair is an extension of the waters of the Arabian Gulf in the lower reaches of Mesopotamia. The length of the Khor Al-Zubair channel is about 40 km, and its width ranges from 1 to 2 km in the case of the highest flood tide, and the depths of the navigational channel range between 10 to 20 m, and that the surface area covered with water is 60 km^2 in the case of flood tides, and the average tidal range in Khor Al-Zubair is 3.2 m, which generates high-velocity tidal currents during the flood and ebb phases (Al-Ramadan, 1988; Al-Taei *et al.*, 2012). The lower (southern) end is connected to Khor Abdullah, and the topography of Khor Al-Zubair looks like a spindle with graduated ends at the northern and southern ends. The northern end receives an average freshwater influx of 100-200 m^3/s throughout the tidal cycle (OMD, 2008).

The nature of the tide in the Khor Al-Zubair channel is similar to the nature of the tide in the northwestern Arabian Gulf region, which is classified as a mixed semi-diurnal tide, but they are unequal in amount (Al-Ramadhan, 1988; Al-Mukhtar *et al.*, 1992). The tidal zone covered in the study area is of a muddy, alluvial nature with a small percentage of sand and extends about 150 meters towards the water until the lowest point of the tides. The salinity of the water ranges between 32.65 - 43.42 ppt. The vegetation consists of a single halophytic species, *Salicornia europaea* (syn. *S. herbacea*) which is an ascending annual herb with branches up to 30 cm in height, typically thriving in clayey soils and salt marshes (Al-Mayah *et al.*, 2016), with a wide distribution of Mudskipper fish, and the presence of pits due to several types of crabs (Ali *et al.*, 2021). A number of birds are also spread, such as *Calidris spp.*, some species of gulls *Larus spp.*, *Numenius araquata*, *Phylloscopus trochilus*, *Recurvirostra avosetta*, sea crow, *Phalacrocorax carbo*, and other migratory and domestic birds (Muhammad and Ali, 2021). The second site (St2) is situated near the eastern breakwater of the Al-Faw Grand Port, located at the southernmost extremity of Iraq, opening directly into the Arabian Gulf at the entrance of Khor Abdullah. The tidal zone extends with its alluvial mudflats to the extending seaward up to 1000 m toward the lowest astronomical tide. Salt concentrations in this region range between 37.86-43.73 ppt. It lacks vegetation, as there is no species of plant, and burrows of mudskippers and small brachyuran crabs are widely spread in this area, as well as several species including the great cormorant (*Phalacrocorax carbo*), various gulls (*Larus spp.*), and the gull-billed tern (*Gelochelidon nilotica*), among other migratory and resident water birds (Mohammad and Ali, 2021).

Experimental design

At each designated study site, a total of 50 healthy, uniform seedlings of the gray mangrove (*Avicennia marina*) were planted. The transplantation layout followed a randomized grid design consisting of five parallel lines extending perpendicular to the waterline toward the low-tide mark. Each line contained 10 seedlings, with a standardized inter-plant and inter-row spacing of 3 meters to prevent resource competition and ensure uniform environmental exposure.

Field measurements

First, the average temperature and relative humidity data were recorded in the two study sites, where a US-made (Hobo MX2301A Temperature/RH Data Logger) device designed for this purpose was used, where the data is transferred using a mobile phone based on the HOBO mobile application. Ambient air temperature and relative humidity (RH) were continuously recorded using a HOBO MX2301A Temperature/RH Data Logger (Onset Computer Corp., Bourne, MA, USA), with data retrieved wirelessly via the HOBO connect mobile application. Soil samples were also collected from both sites to determine the physical and chemical properties and texture of the soil. The measured parameters (height plant, total number of leaves per plant, total leaf area of the plant, number of lateral branches, total leaf content of chlorophyll and fresh weight and percentage of dry matter) from March 2020 to March 2021 for both sites. The survival rate of the cultivated seedlings was determined at the conclusion of the experiment. Third, the plant height was recorded using a measuring tape from the soil surface to the upper end of the plant, where five morphologically uniform, randomly selected plants in each site for each season was recorded. Accompanied with recording the average number of total leaves of the selected plants in each site. The surface area of three mature leaves of each plant taken at each site was measured using ImageJ software, according to the method used by (Stawarczyk and Stawarczyk, 2015). The number of lateral branche for each selected plant was calculated in each site during the study period. Lastly, the total leaf chlorophyll content was measured non-destructively on intact leaves utilizing an atLEAF CHL PLUS Chlorophyll Meter (FT Green LLC, Wilmington, DE, USA).

Statistical analysis

Five plants were randomly designated as independent biological replicates per treatment combination. All gathered data were subjected to Analysis of Variance (ANOVA) using the GenStat statistical software was conducted according to the Randomized Complete Block Design and with a Factorial Experiment consisting of two factors, the location and measurement periods P0 at the time of planting, P1 after six months, and P2 after 12 months of planting, with five replicates for each treatment namely 30 seedling The statistical analysis included the use of the program (GenStat 23rd Edition)to observe the Least Significant Difference (LSD) between the means of the Treatment means were compared and evaluated using the Least Significant Difference (LSD) test at a significance level of $p > 0.05$.

Results

Effect of planting site on plant growth indicators and survival rates

As illustrated in Figure 2, the Analysis of Variance (ANOVA) revealed highly significant differences between the two distinct study locations indicators of vegetative growth of the plant (height plant (cm), total leaves number (leaf. plant^{-1}), total leaf area of the plant (cm^{2}.plant^{-1}), and the number of side branches of the plant (branch.plant^{-1}), and total leaf chlorophyll content (µg.cm^{-2}) in the two study sites and for all measurement periods (P0 at the time of planting, P1 after six months, and P2 after 12 months of planting.

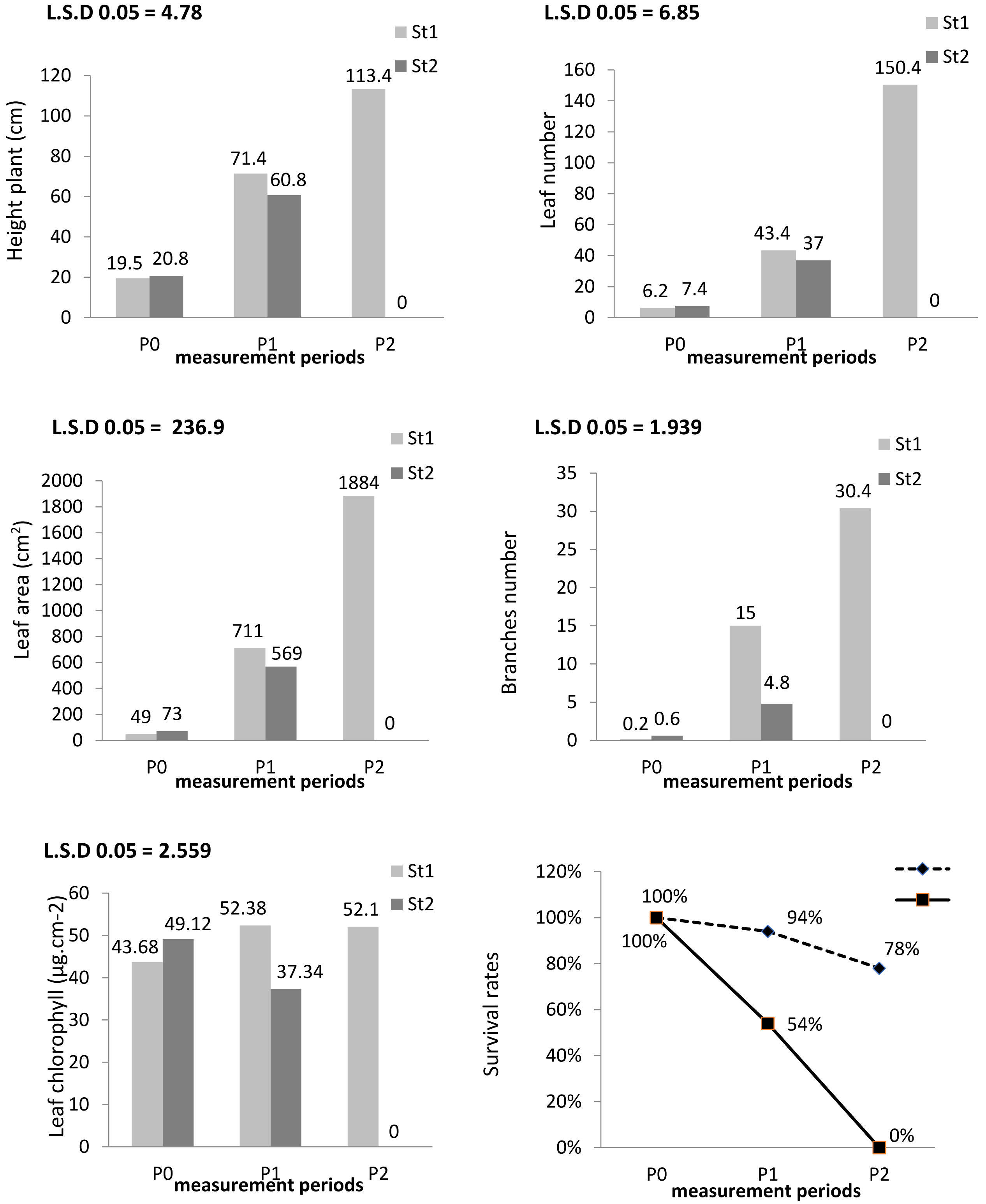

Figure 2. Effect of planting location, measurement periods and their interactions on the growth indicators of the gray mangrove plant *Avicennia marina* cultivated at Khor Al-Zubair oil port (St1) and Al-Faw Grand port (St2).

The results in the above fig exhibited a significant effect on the average effect of the site on the total plant height, as St1 achieved the highest average height, which 68.1 cm, compared to St2, which was 27.2 cm. The highest rate of plant height was 113.4 cm at St1 at P2 period, complete mortality or 100% mortality rate of all plants at St2 after the same period. The highest mean effect of measurement periods for both sites, at P2 was 66.1 cm.

As for the effect of the site on the number of leaves in the plant (leaf. plant^{-1}), the St1 showed a significant effect, with an average of 66.7 (leaf.plant^{-1}) compared to St2, which amounted to 14.8 (leaf.plant^{-1}). The average of the overlap effect on the number of leaves displayed a significant effect, as the highest value was 150.4 leaves.plant^{-1} in a period P2, in which the highest mean of the effect of the periods was 75.2 (leaf.plant^{-1}) in the same period, which demonstrated a significant difference from the rest of the averages.

The experimental data also a significant difference in total leaf area of the plant (cm^2.plant^{-1}) for the average effect of the site, which amounted to 882 and 214 cm^2.plant^{-1} in St1 and St2, respectively. The highest average overlap was in St1, which was 1884 cm^2.plant^{-1} at P2 period, with an effect rate of 942 cm^2.plant^{-1} for the same period.

The results of measuring the number of lateral branches of the plant (branch.plant^{-1}) also disclosed that there is a significant effect, as the average effect of the site was 15.2 and 1.8 (branch.plant^{-1}) at both sites, respectively, with an interaction effect of 30.4 branches.plant^{-1} at P2 period, in which the highest effect rate was recorded for the measurement periods, amounting to 15.2 (branch.plant^{-1}) compared to P0 and P1, which amounted to 0.4 and 9.9 (branch.plant^{-1}) respectively.

As for the total content of chlorophyll (μg.cm^{-2}), it had a significant effect, as it revealed the highest values in St1 in the P1 and P2, which amounted to 52.38 and 52.1 μg.cm^{-2}, respectively, and in St2 at P0 was 49.12 (μg.cm^{-2}), which did not show significant differences between them compared to other interventions. The highest average effect of the site was in St1, which was 49.39 μg.cm^{-2} compared to St2, which amounted to 28.82 μg.cm^{-2}. The average effect of the periods did not show a significant difference between P0 and P1 periods, which amounted to 46.4 and 44.86 (μg.cm^{-2}) respectively, compared to P2 period 26.05 (μg.cm^{-2}), which presented a significant difference from the previous two periods.

The survival rates were calculated for the seedlings planted for P0, P1 and P2 periods for both sites. As St1 site exhibited superior seedling establishment and survival. compared to St2 site in the two periods P1 and P2. The survival rates in the first site were 94% and 87%, while on the second site they reached 54% and 0%, respectively. Seedlings at St2 experienced severe degradation, with survival rates dropping precipitously to 54% at P1, culminating in a 100% mortality rate (0% survival) by the end of the 12-month experimental period (P2).

Table 1, shows the air and water temperatures (°C), relative humidity (%) for the air, and salinity (ppt) for the water in the two study areas, during the study period (March 2020 – March 2021).

Table 1: Microclimatic and hydrological parameters monitored at the two experimental study sites (St1 and St2) in Basrah Governorate, southern Iraq, during the study period (March 2020 – March 2021).

Sites	Khor Al-Zubair oil port	Al-Faw Grand port
Air temperatures °C	4.33 – 44.31	6.73 – 45.61
Water temperature °C	13.03 – 36.25	14.94 – 36.66
Relative humidity %	15.83 – 97.49	17.33 – 100
Salinity ppt	32.65 – 43.42	34.19 – 44.04

Discussion

The quantitative dataset illustrated in Figure 2 showed the vegetative growth indicators, total content of chlorophyll pigment, and the average survival rates of gray mangrove (*Avicennia marina*) cultivated in the two locations of Khor Al-Zubair oil port (St1) and Al-Faw Grand port (St2). The results proved the success of cultivating these plants at St1 site. The vegetative growth indicators (total height of the plant, total number of leaves, total leaf area, number of lateral branches, and survival rates) in addition to the total content of chlorophyll during the study period, which continue for 12 months, were best compared with St2 site, in which all plants perished after the passage of the same period. During the P1period in this site, the vegetable growth indicators increased significantly, while the average survival rates recorded 54% compared to the site St1, which recorded 94% during the same period, while the total content of chlorophyll in the leaves decreased significantly in the seedlings of the St2 site during the first six months of cultivation. The survival rate of the seedlings grown in the site St2 was (100% mortality) after 12 months of the planting, compared to the seedlings grown in the site St1, which amounted to 78% in the same period. This result is in accordance with a study conducted by Bhat *et al*., (2004) for the cultivation of mangrove trees of *A. marina* in five sites in the State of Kuwait, as it indicated survival rates of 71.0-81.2% in the Doha site, while it reached 16.1-78.0% in other sites. In a study carried out by Erftemeijer *et al*. in 2020, it was clear that the survival rate of mangrove seedlings of *A. marina* in an experiment conducted to cultivate this species in the Mubarraz region near Abu Dhabi in the United Arab Emirates on the Arabian Gulf amounted to 26-32%. In another experiment conducted by Erftemeijer *et al*. (2017) for the cultivation of four species of mangrove plants in Port Hedland, Western Australia, the gray mangrove *A. marina* recorded the highest survival rate among other cultivated species, amounting to 46%. Clark and Allaway (1993) reported an overall survival rate of 20% in a three-year study of gray mangrove seedlings *A. marina* cultivated in the mangrove forests of southeastern Australia. The mortality rate for mangrove seedlings was 10% for *Avicennia officinalis* and 40% for *Rhizophora mucronata* in a mangrove planting experiment in Thailand (Thampanya *et al*., 2002). The survival rates observed during the current study reflect the geomorphological and hydrological conditions in the two planting sites, which can be studied when choosing the appropriate planting site.

The results brought to light that the possibility of planting gray mangrove *A. marina* on the coasts of Khor Al-Zubair, even under harsh climatic conditions, and the reason may be attributed to the low currents in this location, unlike the Al-Faw Grand port site, which directly exposed to the open marine environment. as the cultivation of these trees requires coasts that are protected from currents and high waves when they are established, because these seedlings are insufficient root anchorage when planted and need a period of growth in order to be established in the soil to face these currents. Once they are stable, they provide effective protection for the coasts from erosion (Mazda *et al*., 1997; Li *et al*., 2015). To overcome this problem, a more modern approach was used in mangrove planting campaigns in the United Arab Emirates by digging channels parallel to the coast with earthen berms towards the open sea, which provides a protective barrier between the planting site of mangrove seedlings in these channels and the open sea, attenuating high-energy wave action, that causes uprooting of the cultivated seedlings, in addition to that, channels providing optimal tidal flushing of the seedlings with water, thus preventing the accumulation of salts on the soil surface (Erftemeijer *et al*., 2020). The study of water requirements (tides) for mangroves is considered one of the keys to success in managing mangrove forests in terms of planting and rehabilitating them all over the world (Lewis III, 2005). As one of the important reasons for the early failure in the initial establishment of mangrove forests is the lack of a correct estimate of the rate of tidal coverage of the sites where the mangrove forests are to be established. (Erftemeijer *et al*., 2020), it is possible that the planting site in the Al-Faw Grand port was unsuccessful because the cultivation of seedlings is located at an inappropriate tidal elevation insufficient inundation frequency and drainage cycles by tides. Also, hydrodynamics (waves) and sediment dynamics influence the successful establishment of mangrove forests (Balk *et al*., 2011; Winterwerp *et al*., 2013). The failure of the Al-Faw Grand port site compared to the success of the Khor Al-Zubair oil port site may be attributed to these reasons. The good growth of mangrove seedlings in the Khor Al-Zubair oil site may be due to the abundance of nutrients as a result of the anthropogenic nutrient inputs and the arrival of quantities of fresh water to this site (Al-Habshi *et al*., 2007), compared to the Al-Faw Grand port site, in which the salt concentrations are high as a result of high evaporation and lack of fresh water discharges that reach this region, which causes soil salinization during the neap tide cycle. This is identical with the results of (Hubbard, 1994; LeProvost- Dames and Moore 1997), in addition to the lack of nutrients reaching this region, along with the high waves cause the planted seedlings to be uprooted early.

The soil texture and the amount of pore water in the soil also play an important role in maintaining the salinity levels around the root system close to the salinity of seawater, as the high percentage of clay reduces the drainage capacity of the soil and thus increases the waterlogging capacity. Under dry climatic conditions, the interstitial water evaporates quickly, leaving behind salt in the surface layers. Excessive salinity in the surface and subsurface layers in the long term negatively affects the growth and development of the pneumatophore, which is necessary to supply the roots with oxygen (Bhat *et al*., 2004). Embabi (1993) also showed that *A. marina* do not live in soils that accumulate high levels of salts or form a surface salt crust on them, while soils with high levels of medium and coarse sand in the subsurface layers reduce salinity levels and increases the growth of pneumatophore and improves the supply of oxygen to the root system. Ogino (1993) also illustrated the fact that the mangrove ecosystem is an interaction between soil, seawater, and vegetation and suggested that soil-related factors may be more important in determining mangrove growth. Clough (1998) also reported that mangrove forests in Australia grow in different soils in terms of texture, from coarse sandy soils to soils with silt, heavy clay, and peat, which have salt concentrations close to the salinity of tidal waters. Hutchings and Saenger (1987); Ogino (1993); and Saenger (1996) emphasized the importance of soil factors and their interaction with the surrounding environment and the physical and chemical factors of seawater in the successful establishment, abundance, and growth of newly planted mangrove seedlings. The results confirm that soil-related factors play a major role in the establishment and growth of gray mangrove seedlings in the early stages, so these factors can be used along with other site characteristics to determine suitable sites for establishing new mangrove farms along the Iraqi coast .

Unlike many other regions around the world in which mangroves have been successfully implemented or replanted, the climatic and environmental conditions in the two study sites on the Iraqi coasts are hyper-arid and high-stress climate with air temperatures, water temperature, relative humidity, salinity and very low precipitation (Table 1), which can only be tolerated by the hardest-tolerant species of mangroves, *A. marina* (despite the lower growth indicators than normal rates). In view of these harsh conditions, the successful establishment and relatively high survival rates of the mangrove farm in the Khor Al-Zubair oil port site, is a pivotal milestone for coastal zone management.

Conclusion

The results of vegetative growth indicators, total chlorophyll content, and survival rates in this study showed that cultivating and establishing *Avicennia marina* mangrove farms on the Iraqi coasts is possible in sites that are hydrodynamically sheltered coastal zones even under harsh environmental conditions such as temperature variations, salinity, and low relative humidity, and a decrease in precipitation rates.

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استزراع اشجار القرم الرمادي *Avicennia marina* (Forssk.) Vierh في الساحل العراقية

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المستخلص

تتصف النظم البيئية للسواحل البحرية العراقية بفقرها الشديد للنباتات وتعرضها الكبير للتآكل الساحلي. تهدف هذه الدراسة إلى استكشاف إمكانية زراعة أشجار القرم الرمادي (*Avicennia marina*) على السواحل العراقية. تم اختيار موقعين للتجربة: الأول في ميناء خور الزبير النفطي، والثاني في ميناء الفاو الكبير. أُجريت التجربة بزراعة 50 شتلة في كل موقع، لدراسة إمكانية تأقلم أشجار القرم الرمادي في هذه البيئات. وتم قياس مؤشرات النمو الخضري، ومحتوى الكلوروفيل الكلي، ومعدلات البقاء على قيد الحياة خلال فترة الدراسة. أظهرت النتائج نمواً طبيعياً للنباتات في موقع ميناء خور الزبير النفطي، حيث بلغ متوسط ارتفاع الشتلات 93.8 سم خلال فترة الدراسة بمعدل نمو يومي قدره 0.256 سم. ارتفع إجمالي محتوى الكلوروفيل من 43.68 إلى 52.10 ميكروغرام/سم^2، مع بلوغ معدلات بقاء النباتات 78% في نهاية التجربة. وبالمقارنة مع موقع ميناء الفاو الكبير، اذ حققت هذه الشتلات في هذه المنطقة نمواً خضرياً متوسطًا خلال الأشهر الستة الأولى من التجربة؛ بعد ذلك، بدأت النباتات بالتدهور، مما أدى إلى هلاك جميع الشتلات بعد مرور 12 شهرًا من بدء التجربة. يُعزى هذا الفشل بشكل أساسي إلى طاقة الأمواج العالية، وانضغاط التربة الشديد، والتعرض للبحر المفتوح. تشير هذه النتائج إلى أن البيئات الساحلية المحمية، مثل خور الزبير، تُعدّ خيارًا مناسبًا لإعادة تأهيل أشجار المانغروف في العراق، بينما تتطلب السواحل المفتوحة حماية مسبقة باستخدام حواجز الأمواج الاصطناعية.

الكلمات المفتاحية: السواحل العراقية، *Avicennia marina*، القرم الرمادي، ميناء خور الزبير النفطي، ميناء الفاو الكبير.