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Foraminifera as Evidence of the Existence of Mangrove Swamp in Southern Iraq

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Abstract

The current study aimed to prove and determine the area of the mangrove swamp in the Iraqi coast (southern Iraq), depending on the appearance of foraminifera, where these species are typical in their representation of the mangrove swamp environment. By examining the nature of the sediments in which the sandy silt sediments predominates over the presence of the silty and mudy sediments, it is expected that the rise of the sea level to a level beyond the presence of the mangrove swamp and the contribution of tectonic depression in the region may be the cause of the disappearance of the swamp. Dry climate conditions after mid-Holocene and its persistence to date may have a significant impact on the chances of a mangrove swamp emerging again.

Keywords: Mangrove swamp, Southern Iraq, Foraminifera, Northwestern Arabian Gulf, Southern Iraq

Introduction

Mangroves form a linkage between terrestrial and marine environments (Behling et al., 2001), found fundamentally in the intertidal zone (Naidoo, 2009) within tropical and subtropical zone (Zhou et al., 2010). Typically, the mangroves grow as thin or, rarely, thick forests along the shore-line, on near and off-shore islands and fringing tidal creeks and channels of various size (locally known as khors). They are also found around coastal lagoons communicating with the sea and where the effect of tides may be very weak and the salinity very low. Substrata are mostly composed of fine recent clay or silt sediments, but also of sand and peat (Marius & Lucas, 1991).

The influence of mangroves appears in reducing the currents velocities and increasing sedimentation of suspended material on the basis of prop roots (Woodroffe,1992 in PERSGA, thereby advances mangrove growth and expansion (Furukawa and Wolanski,1996) and this is especially important for protecting coasts from erosion. In addition to the mangroves represent one of the foremost ecosystems of the biosphere, wrapping about 161,000 km² and 60-75% of the shores in the tropics (Spalding et al., 1997).

The first appearance recording of mangroves in Arabian Gulf and Oman Sea was by Eratosthenes (194 to 276 BC), a geographer from Alexandria (Safiari, 2002 in Ghasemi et al., 2010). These mangroves are currently located along the coasts of Iran, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates and Oman (Saifullah, 1997; Zahed et al., 2010; Schneider, 2011; Al-Khayat & Balakrishna, 2014; Moore et al., 2015). In Iraq, there was no trace of the mangrove environment on its coast or in its surface deposits. The mangrove environment was first discovered in the coast of Iraq by Issa (2006) in the sediments of intertidal flats in Khor Al-

Zubair where she was found that this environment existed through appearances of the foraminifera species known for its presence in the mangrove environment. The tidal flats of Khor Al-Zubair are considered important tidal flats in the northwestern Arabian Gulf (Yaqoub, 2011). The study aims to reveal the presence of new sites proving the existence of mangrove swamps in southern Iraq.

Methods

Samples were collected during July 2017 from different locations and from depths ranging from 0.75 h to 1.25 m with a shovel close to the dendritic tributaries of Khor Al-Zubair tidal channel inland, southern Iraq (Fig. For particle size analysis, wet sieving on a 230 mesh sieve was used to separate sand from silt and clay, which was later used in the classical pipette method of Folk (1980). The proportion of sand, silt and clay was calculated to determine the sediment type according to the textural classification of Folk (1980). For the study of foraminifera, 100 grams of unit weight were taken from each sediment sample. All samples were washed on an ASTM 230 mesh sieve to remove fine particles of silt and clay, and then the residue remaining on the sieves was dried for examination under a binocular microscope to pick up the foraminifera and identify their species according to the most common classification Loeblich and Tappan, 1988.

Results and Discussion

The grain size distribution according to the texture classification of Folk (1980) shows three types of texture; sandy silt, silt and mud, where sandy silt deposits were the dominant and constituted about 50% of the total sediment samples, followed by silt which represents about 40% and the remaining clay 10% (Table 1).

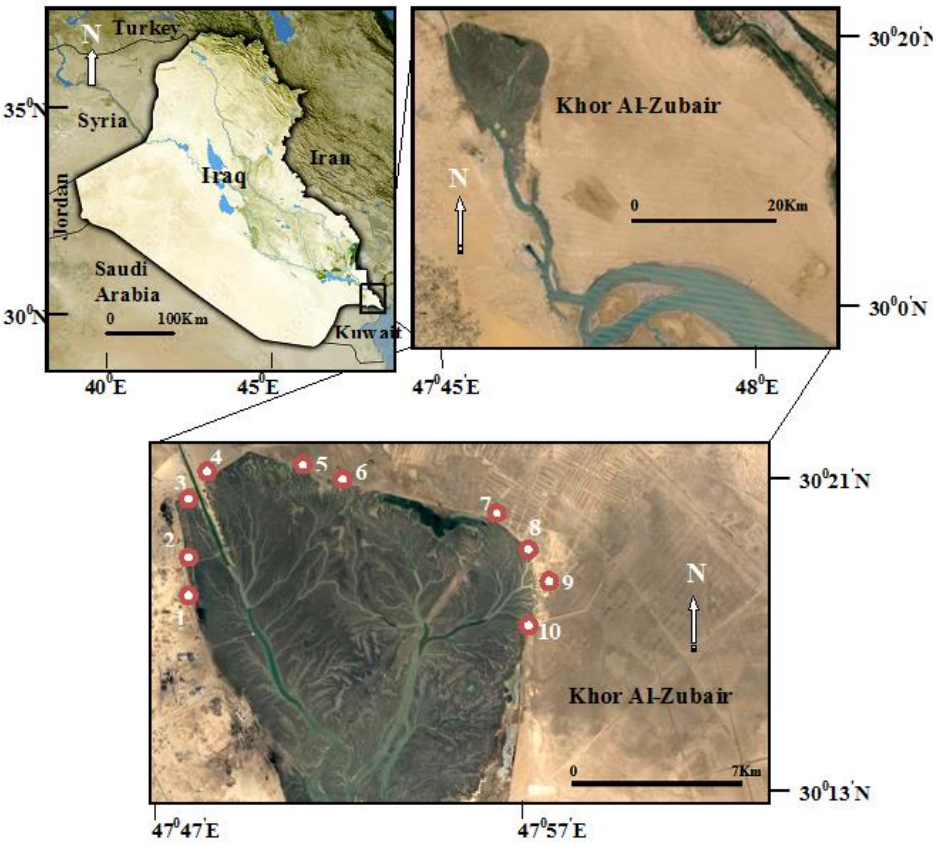

Figure 1. Map of the study area and sample sites

The foraminiferal species identified in the samples from Khor Al-Zubair (Figure. 2) are; *Trochammina inflata* (Montagu), 1808, *Quinqueloculina laevigata* (d'Orbigny), 1826, *Quinqueloculina seminulum* (Linné), 1758, *Rosalina globularis* (d'Orbigny), 1826, *Ammonia beccarii* (Linné), 1758, *Discorinopsis aguayoi* (Bermudez) 1935, *Elphidium advenum* (Cushman) 1922, *Elphidium excavatum* (Terquem), 1876, *Elphidium gunteri* (Cole), 1931.

Table 1. Percentage of sand, silt and clay in the study area sediment samples

Sample site	Sample depth (m)	Sand %	Silt %	Clay %	Sediment type
1	0.75-0.90	9	73	18	Silt
2	1.0-1.25	3	59	38	Mud
3	0.8-0.95	6	65	29	Silt
4	1.1-1.20	9	69	22	Silt
5	0.75-0.86	36	56	8	Sandy silt
6	0.95-1.15	38	53	9	Silt
7	0.75-95	40	57	3	Sandy silt
8	0.75-1.0	25	68	7	Sandy silt
9	0.80-96	25	70	5	Sandy silt
10	0.89-1.25	14	84	2	Sandy silt

Foraminifera as evidence of the existence of mangrove swamp in southern Iraq

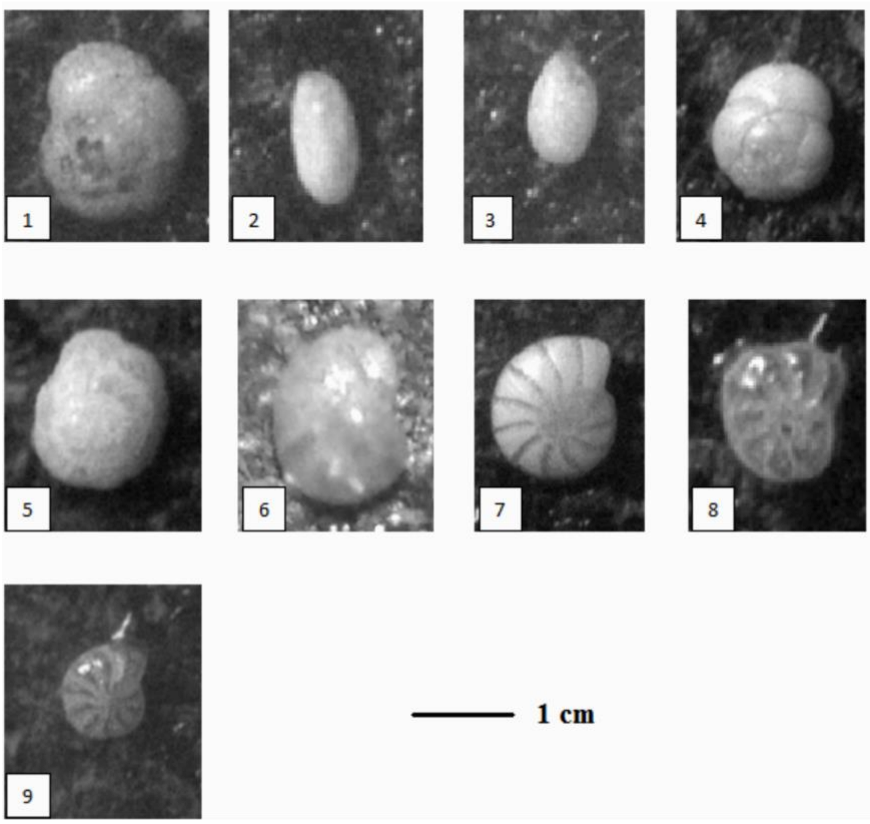

Figure 2. Foraminifera species. 1. Trochammina inflata (Montagu), 1808. 2. Quinqueloculina laevigata (d'Orbigny), 1826. 3. Quinqueloculina seminulum (Linné), 1758. 4. Rosalina globularis (d'Orbigny), 1826. 5. Ammonia beccarii (Linné), 1758. 6. Discorinopsis aguayoi (Bermudez) 1935. 7. Elphidium advenum (Cushman) 1922. 8 Elphidium excavatum (Terquem), 1876. 9. Elphidium gunteri (Cole), 1931. The scale bar is 100 µm.

Environmental evidence for the presence of foraminifera species

The foraminifera species (Figure 2) *Trochammina inflata*, *Quinqueloculina laevigata*, *Quinqueloculina seminulum*, *Rosalina globularis*, *Ammonia beccarii*, *Discorinopsis aguayoi*, *Elphidium advenum*, *Elphidium excavatum*, *Elphidium gunteri* showed a similar assemblage despite the different locations and depths of the sediments, which in itself is an environmental indicator. The assemblage of foraminifera species together was almost identical at all sites. What is striking is the environment of these species, which mostly reflect the mangrove swamp environment (Javaux & David, 2003).

However, the species *Trochammina inflata* and *Discorinopsis aguayoi* have a special ecological uniqueness in their presence in most of the world's mangrove swamps (Phleger, 1960; Goldtein, 1976; Steinker & Butcher, 1981). The genera *Trechammina* and Discorinopsis are characteristic of marine marsh environments where the water is shallow, rarely more than a few inches deep, or several feet deep due to the marsh's proximity to the tidal channel, as the tidal range rises to several feet, causing it to be completely covered by water. The salinity of the marsh depends greatly on its location in the freshwater stream, which means that a large change in salinity is expected, as the salinity of the marsh varies according to its exposure to any type of flooding, whether marine or freshwater, and even in the marsh itself, water (hypersaline) can appear in at least part of it (Phleger, 1960). The uniqueness of the species (*Discorinopsis aguayoi*) is determined by its belonging to the environment of the mangrove swamp (Javaux & David, 2003), The species has also been recorded in the Arabian Gulf, where it was found abundantly in Holocene lake sediments near Al-Mandafan in the Rub' al-Khali (Genari et al., 2011), and rarely in a saline lake in Tayma, northern Saudi Arabia, during the early to mid-Holocene (Bent et al., 2017).

Issa (2006) recorded the appearance of all types of foraminifera in her study of the sediments of the tidal flats of Khor Al-Zubair, and she proved the appearance of the facies of the mangrove swamp environment within them. Issa's study (2018) also recorded the appearance of the species *Discorinopsis aguayo*i for the first time in the Iraqi coast.

The current study clearly indicates the presence of a mangrove swamp environment in southern Iraq overlooking the Arabian Gulf (Iraqi coast), despite the absence of plants associated with the mangrove swamp environment. However, it is evidence of the presence of this environment or its effect on the Iraqi coast.

Discussion

Mangrove grows optimal on protected shore such as inlets, creeks, lagoons and estuaries where the environment with fine-grained mud and silty sediments containing high detritus matter of marine and terrestrial origin deposited by tidal and river currents. Over and above, mangrove requires best development a continuous freshwater influence from a permanent or seasonal river (Martens, 1996). All these situations are available in the Iraqi coast, but there is no record of the mangrove environment, as in the case of the Arabian Gulf mangroves recorded in the past and at present. This is probably due to the fact that the mangrove ecosystem is very sensitive to any changes of the environment because of its location (Godoy and De Lacerda, 2015). Mangroves respond to hazards that resulting from change in sea level which it is the most threat to mangrove environment (Nicholls & Cazenave 2010).

The detection of the mangrove environment in the Iraqi coast is determined in the silty sediments of intertidal flats in Khor Al-Zubair within the depth (0.3-1.1) meter where

Discorinopsis tropica (Issa, 2006), a species of foraminifera, was found to be particularly known for the mangrove swamp environment (Collins, 1958). With a note that it did not appear on the area surface any trace of the existence of a mangrove swamp environment (Issa, 2006). This is also the case in the present study, where no evidence of mangrove has been seen on the study area surface. But the presence of the species *Discorinopsis aguayoi* was the evidence that proves the presence of mangrove swamp (Javaux & David, 2003; Gennari et al., 2011), in addition to the foraminifera species assemblage that appeared in the study area, which has already referred to the mangrove environment (Phleger, 1960; Goldtein, 1976; Steinker & Butcher, 1981).

And through what has been mentioned it can be concluded that the sediments which contain these species in the present study must be during the early to mid-Holocene, specifically within 6000-5000 yr BP through the age of shells in Khor Al-Zubair defined by Plaziat and Younis (2005) at the age (5730±210) yr Hillier study (1995) further confirmed this by estimating the age of surface sediments in the region are not modern deposits at present or near time, but ancient sediments, the upper part of these sediments have been exposed to erosion.

After all these evidence that indicate the existence of mangrove swamps in the Iraqi coast, it is necessary to raise the following question:

Why mangrove swamp disappeared after the period mentioned earlier, and why is there no mangrove swamp environment currently on the Iraqi coast?

To answer, it is essential to know the factors that would affect the presence of the mangrove swamp , of which the most important is sea level rise, and mangrove swamp is extremely sensitive indicator of sea level, and are important proxy for sea-level reconstruction(Jones, 2014). This means that appearance of the mangrove swamp environment in southern Iraq was associated with the rising sea level that occurred during the early to mid-Holocene period, specifically during the middle of Holocene as is expected relative to the age of species. But this environment has not continued after rise sea level in the mid-Holocene or until in the present.

From examination of the sediments of the study area, the peat did not appear in any sediment sample, this indicates a high deposition in the intertidal zone at that time where mangrove swamp (Hait & Behling, 2009). It is self-evident that the sedimentation rate in this area increases with increasing concentration of suspended sediments (Chmura, 2009), therefore mangrove swamp exhibits more muddy sediments (Alfaro, 2010), and as the sea level rises, the thickness of these sediments will increase which leads to filling, draining and dredging of mangrove (Chmura, 2009). The explanation for this is: with predicted rates of sea level rise this rate of tidal flushing will necessarily increase and rates of organic accretion hence decrease, thus increasing the inability of mangrove to maintain itself within tidal limits (Bruun, 1962, Schwartz, 1967 in Ellison & Stoddart, 1991). In its sense the mangrove could not keep pace with rise in sea level and it consequently disappeared. Aqrawi (1995) have estimated sedimentation rates for the lacustrine/deltaic deposits of Lower Mesopotamia throughout the Holocene from 8400 yr BP until about 3000 yr BP between 1 and 1.8 mm/year, and this suggests that another factor must be involved in the disappearance of the mangrove swamp.

The most likely factor helped with sea level rise is the subsidence, this expectation comes from nature of Khor Al-Zubair which is likely to be a subsidence phenomenon (Lees & Falcon, 1952). Seawater intrusion was not capable of significant erosion events and the formation of an estuary or khor unless accompanied by tectonic depression of the area at the same time. In addition to that the tide alone cannot result in extensive erosion of the Khor Al-Zubair / Khor

Al-Sabbiyah Gulf region, confirming the belief that the tectonic subsidence has contributed strongly to vertical sculpture. The tectonic depression is still ongoing and the evidence for this is the extension of the active depression in the dendritic tidal channels system of Khor Al-Zubair (Sissakian et al., 2014). The contribution of tectonic subsidence to the degradation of the mangrove swamp environment comes from permitting marine waters to further penetrate the area during marine transgression and thus high tide becomes higher than the substrate elevation.

The previous interpretation is consistent with what is currently happening in the Arabian Gulf, where relative sea level rise to be 2.2 mm/yr taking into account subsidence rates of 0.7 mm/yr (Alothman et al., 2014 in Ward et al., 2016). It is therefore expected that up to 96% of coastal wetlands including mangroves swamps are likely to be lost from the region as a result of sea level rise (Blankespoor et al., 2014 in Ward et al., 2016).

In addition to the above, the climatic changes which started around 5000 years ago toward greater aridity and still prevail in the present-day setting (Aqrawi, 2001), it must have been an effect on the absence of a mangrove swamp after that period. The impact of climate change is clearly reflected in the exposure of the mangrove swamps of the Arabian Gulf to the threat of environmental change which may lead to the shrinking of their regions and disappearance, as a result of what the Gulf region is witnessing of increased temperatures and thus evaporation rates and related salt-stress (Ward et al., 2016).

Conclusion

Discorinopsis aguayoi, is typical form of the mangrove swamp environment. Depending on this presence in the study area, the mangrove environment was identified. Estimate the time period of these two species within the middle of Holocene (6000-5000 yr BP) was based on the appearance of a species similar to *Discorinopsis aguayoi* in Holocene lake sediments near Al-Mundafan in the Rub'al Khali. In addition to the expected age of shells in the Khor Al Zubair area

The disappearance of the mangrove swamp is believed to be the result of sea level rise to a level beyond the level of the mangrove swamp in the tidal zone, which has not allowed the mangrove to keep pace with the rise in sea level. The contribution of tectonic activity in the study area, which is the subsidence along with the rise in sea level in the disappearance of the mangrove swamp. The change in climate after the mid-Holocene to the drought and its continuation to the present may have had the effect in the lack of mangrove swamp in the Iraqi coast, especially after the decline of freshwater levels of rivers and rising temperatures and increasing salinity, which changes the nature of sediments and made it not prepared for the emergence of mangrove swamp again.

References

Alfaro, A. C. (2010). Effects of mangrove removal on benthic communities and sediment characteristics at Mangawhai Harbour, northern New Zealand. *ICES Journal of Marine Science*, *67*(6), 1087-1104. https://doi.org/10.1093/icesjms/fsq034

Al-Khayat, J., & Balakrishnan, P. (2014). Avicennia marina around Qatar: tree, seedling and pneumatophore densities in natural and planted mangroves using remote sensing. *International Journal of Sciences*.

Aqrawi, A. A. (1995). Correction of Holocene sedimentation rates for mechanical compaction: the Tigris-Euphrates Delta, Lower Mesopotamia. *Marine and petroleum geology*, *12*(4), 409-416. https://doi.org/10.1016/0264-8172(95)96903-4

Aqrawi, A. A. (2001). Stratigraphic signatures of climatic change during the Holocene evolution of the Tigris–Euphrates delta, lower Mesopotamia. *Global and Planetary Change*, *28*(1-4), 267-283. https://doi.org/10.1016/S0921-8181(00)00078-3

Behling, H., Cohen, M. C., & Lara, R. J. (2001). Studies on Holocene mangrove ecosystem dynamics of the Bragança Peninsula in north-eastern Pará, Brazil. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *167*(3-4), 225-242. https://doi.org/10.1016/S0031-0182(00)00239-X

Bermúdez, P. J. (1935). Foraminiferos de la costa norte de Cuba. *Memorias de la Sociedad Cubana de Historia Natural*, *9*, 129-224.

Chmura, G. L. (2009). Tidal salt marshes. *The management of natural coastal carbon sinks*, *5*.

Hait, A. K., & Behling, H. (2009). Holocene mangrove and coastal environmental changes in the western Ganga–Brahmaputra Delta, India. *Vegetation History and Archaeobotany*, *18*, 159-169. https://doi.org/10.1007/s00334-008-0203-5

Ellison, J. C., & Stoddart, D. R. (1991). Mangrove ecosystem collapse during predicted sea-level rise: Holocene analogues and implications. *Journal of Coastal research*, 151-165.

Folk, R. L. (1980). *Petrology of sedimentary rocks*. Hemphill publishing company.

Furukawa, K., & Wolanski, E. (1996). Sedimentation in mangrove forests. *Mangroves and salt marshes*, *1*, 3-10.

Gennari, G., Rosenberg, T., Spezzaferri, S., Berger, J. P., Fleitmann, D., Preusser, F., ... & Matter, A. (2011). Faunal evidence of a Holocene pluvial phase in southern Arabia with remarks on the morphological variability of Helenina anderseni. *The Journal of Foraminiferal Research*, *41*(3), 248-259. https://doi.org/10.2113/gsjfr.41.3.248

Ghasemi, S., Zakaria, M., Abdul-Hamid, H., Yusof, E., Danehkar, A., & Rajpar, M. N. (2010). A review of mangrove value and conservation strategy by local communities in Hormozgan province, Iran. *Journal of American Science*, *6*(10), 329-338.

Godoy, M. D., & Lacerda, L. D. D. (2015). Mangroves response to climate change: a review of recent findings on mangrove extension and distribution. *Anais da Academia Brasileira de Ciências*, *87*(2), 651-667.

Goldstein, S. T. (1976). *The distribution and ecology of benthic foraminifera in a South Florida mangrove environment* (Doctoral dissertation, University of Florida).

Issa, B. M. (2006). Sedimentological and palaeontological study of Tidal flats-Northwest of the Arabian Gulf. *Unpublished M. Sc. thesis, collage of science, University of Basrah*.

Issa, B. M. (2018). First Registration of Discorinopsis aguayoi Bermúdez and Discorinopsis vadescens Cushman and Todd from the Iraqi coast and their environmental implication. *Marsh Bulletin*, *13*(1).

Javaux, E. J., & Scott, D. B. (2003). Illustration of modern benthic foraminifera from Bermuda and remarks on distribution in other subtropical/tropical areas. *Palaeontologia electronica*, *6*(4), 29.

Jones, R. W. (2013). *Foraminifera and their applications*. Cambridge University Press.

Lees, G. M., & Falcon, N. L. (1952). The geographical history of the Mesopotamian plains. *The Geographical Journal*, *118*(1), 24-39.

Loeblich Jr, A. R., & Tappan, H. (2015). *Foraminiferal genera and their classification*. Springer.

Marius, C., & Lucas, J. (1991). Holocene mangrove swamps of West Africa sedimentology and soils. *Journal of African Earth Sciences (and the Middle East)*, *12*(1-2), 41-54. https://doi.org/10.1016/0899-5362(91)90056-5

Moore, G. E., Grizzle, R. E., Ward, K. M., & Alshihi, R. M. (2015). Distribution, pore-water chemistry, and stand characteristics of the mangroves of the United Arab Emirates. *Journal of Coastal Research*, *31*(4), 957-963. https://doi.org/10.2112/JCOASTRES-D-14-00142.1

Naidoo, G. (2009). Differential effects of nitrogen and phosphorus enrichment on growth of dwarf Avicennia marina mangroves. *Aquatic Botany*, *90*(2), 184-190. https://doi.org/10.1016/j.aquabot.2008.10.001

Hillier, S. (1995). Erosion, sedimentation and sedimentary origin of clays. In *Origin and Mineralogy of Clays: Clays and the Environment* (pp. 162-219). Berlin, Heidelberg: Springer Berlin Heidelberg.

Nicholls, R. J., & Cazenave, A. (2010). Sea-level rise and its impact on coastal zones. *science*, *328*(5985), 1517-1520. https://doi.org/10.1126/science.1185782

Phleger, F. B. (1960). Ecology and distribution of recent foraminifera. *(No Title)*.

Plaziat, J. C., & Younis, W. R. (2005). The modern environments of Molluscs in southern Mesopotamia, Iraq: A guide to paleogeographical reconstructions of Quaternary fluvial, palustrine and marine deposits. *Carnets de Géologie/Notebooks on Geology*, (A01), 1-18.

Saifullah, S. M. (1997). Mangrove ecosystem of Red sea coast (Saudi Arabia).

Schneider, P. (2011). The discovery of tropical mangroves in graeco-roman antiquity: Science and wonder. *J. Hakluyt Soc*, *3*, 1-16.

Sissakian, V., Shihab, A., Al-Ansari, N., & Knutsson, S. (2014). Al-Batin alluvial fan, southern Iraq. *Engineering*, *6*(11), 699-711. https://doi.org/10.4236/eng.2014.611069

Spalding, M., Blasco, E., & Field, C. (1997). World Mangrove Alias. *The International Society for Mangrove Ecosystems: Okinawa, Japan*.

Steiner, D. C., & Butcher, W. A. (1981). Foraminifera from mangrove shores, Bermuda. *Micron (1969)*, *12*(2), 223-224.

Ward, R. D., Friess, D. A., Day, R. H., & Mackenzie, R. A. (2016). Impacts of climate change on mangrove ecosystems: a region by region overview. *Ecosystem Health and sustainability*, *2*(4), e01211. https://doi.org/10.1002/ehs2.1211

Yacoub, S. Y. (2011). Geomorphology of the Mesopotamia plain. *Iraqi Bull. Geol. Min. Special Issue*, (4), 7-32.

Zahed, M. A., Rouhani, F., Mohajeri, S., Bateni, F., & Mohajeri, L. (2010). An overview of Iranian mangrove ecosystems, northern part of the Persian Gulf and Oman Sea. *Acta Ecologica Sinica*, *30*(4), 240-244. https://doi.org/10.1016/j.chnaes.2010.03.013

Zhou, Y. W., Zhao, B., Peng, Y. S., & Chen, G. Z. (2010). Influence of mangrove reforestation on heavy metal accumulation and speciation in intertidal sediments. *Marine Pollution Bulletin*, *60*(8), 1319-1324. https://doi.org/10.1016/j.marpolbul.2010.03.010