



Sediment characteristics and water quality in the two hyper-saline lagoons along the Red Sea coast of Saudi Arabia

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The two hyper-saline Shoaiba lagoons, Khawr ash Shaibah al Masdudah (northern lagoon) and Khawr ash Shaibah al Maftuhah (southern lagoon) have a unique environmental set-up because no rivers or wadis flow into the lagoons and therefore detrital material to the lagoons is lacking and most of the sediments are indigenous carbonates. The biogenic material is mostly derived from coral debris, coralline algae and molluscs abundant in gravel and sand size fractions. The evaporite deposits from the adjoining sabkhas are transported to the lagoon during tidal cycles. Carbonate is abundant in the form of aragonite and High Mg-calcite indicating carbonate to be recent and formed under shallow water conditions. In general, the sediments are the result of the mechanical breakdown of molluscs and coral reefs by either human activity or by coral boring marine organisms and physical processes such as tidal and wind generated currents. Strong currents dominate only the deeper part at the entrance of the lagoons that causes the winnowing of the finer sediments, and its transportation during flooding and ebbing. Shallow depths averaging 3 m, wind and tidal stirring are the main forces preventing the lagoons from developing stratification resulting in a well-mixed body of water. The shallow depth of the lagoons keep the turbidity levels higher, whereas salinity as high as 52 ‰ and water temperature as high as 38 °C helps in the formation of halite at the periphery. The cyclical inundation of sabkhas by a thin sheet of water during tidal cycles is important in understanding the ecological consequence. Mangrove stands in the lagoons act as a source of nutrients to the flora and fauna inhabiting the lagoons. The configurations of the mouth of the lagoons influence the tidal currents, including the sediment and water movement. The tidal current is enhanced as it enters the lagoons, in response to the funneling effect caused by the narrow channel. The current diffuses as the entrance widens. In the case of Khawr ash Shaibah al Masdudah the mouth is wide and it faces the open sea directly, whereas the mouth of Khawr ash Shaibah al Maftuhah, although narrower, the tidal current is only strong until the channel to the lagoon bends almost 90° where the tidal current dissipates, resulting in the restricted water and sediment movement in the lagoon. The coarser sediments are stained gray-black because of a reducing environment and formation of authigenic pyrite. Stagnant condition prevails inside the lagoons because of insufficient exchange of water with the open sea and lack of rainfall causes hyper-saline conditions. Higher salinity values were evident in the shallow waters, whereas oxygen saturation ranged between 77 % (southern lagoon) and 107 % (northern lagoon) which could be attributed to the complex nature of the southern lagoon. Reactive phosphate and nitrite concentrations in the surface waters were low and in many locations under the detection limit reflecting the oligotrophic behaviour of the Red Sea and limited supply of nutrients from adjacent areas. There is an abundant presence of trace metals especially in fine sediments that has the tendency to adsorb the metals more efficiently. There is an inverse correlation between heavy metals and carbonate content in the sediments, and much stronger particularly with Cr, V and Co. The Landsat ETM identifies two depth zones in the lagoons and shows the effects of the influence of flooding and ebbing on the sediment distribution and the extent of the water cover seasonally.