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THE COASTAL ALTERATIONS DUE TO THE ARTIFICIAL LAGOONS, RED SEA "CASE STUDY"

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Key words: Hurghada, artificial lagoons, dredging, tidal habitats, coastal alteration.

ABSTRACT

Hurghada City shows progressive tourist development at the end of twentieth century. This development was required many additional facilities as; coastal constructions, recreational locations, artificial lagoons, jetties and marinas. The artificial lagoons were widely distributed along the Red Sea coast at Hurghada.

Many imperative reasons for the lagoons dredging as; navigation basins for safari and diving trips, buildings of boat landing wharf, mooring sites, water sports and recreational activities. Very rudimental methodologies were applied in the dredging operations including; the ordinary dredging by land use hydraulic mechanics and the dynamite explosives. The dredging operations were done without any considerations for the unfavorable oceanographic conditions during the executions as the winds, waves and currents that may increase the environmental risk.

Many negative impacts on the marine environment through the execution and the long-term exercising were recorded. During executions, the disposal solids were destructing the intertidal habitats and the coral communities along the dredged zones, altered the marine sediments by the excess infilling coarse and suspended materials and changing the water quality by increasing the turbidity and salinity.

Because of the artificial lagoons were not planned and executed correctly engineering and environmentally, the long-term uses show two main problems: bad water circulation and sidewalls erosion. The bad water circulation inside the lagoons increases the suspended particulate matter (SPM) precipitation with harmful benthos growing up. The sidewalls erosion increases day by day with decreasing the lagoonal depth that may require repeating the dredging operations to sterilize these lagoons.

The present study illustrates the resultant effects on the marine environment from the randomly designed and executed lagoons, and the practical methods to dilute these effects.

INTRODUCTION

The tidal flats of the Red Sea are composed from the submersible coralline terrace covered with mainly biogenic clastic sediments mixed somewhat with terrigenous sediments especially in the coastal areas and beaches. Along the shore, there is an almost continuous band of emergent reef terraces between 0.5 to 10km wide (El-Sayed, 1984). The shore area is skirted by a raised reefal terrace about 1.0m in height from the Quaternary coralline limestone. The intertidal zone has rocky fossil reef substratum covered with thin layer of soft biogenic deposits. These tidal flats are varying in width from few tens of meters to a few hundreds of meters (Mansour, 2000) and divided into four main parts; beach, intertidal, back-reef and fore-reef zones. Hurghada coastal area consists mainly of fringing coral reefs living over the coralline limestone terraces of the tidal flat. The northern part of the coastal zone of Hurghada locality is characterized by

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fringing reefs close to the coast, while the southern part is characterized by a series of stony islands such as; El-Fanadir Islands, Gifftun El Kabier, Gifftun El Saghier, Abu Minqar and Umm Gawish Islands (Dar, 2002).

The progressive coastal developments in Hurghada depending upon the tourist industry are prospering in the last three decades. Frihy *et al.* (2004) reported that the rapid and uncontrolled development of the Red Sea coast has resulted in a series of disturbances that are not friendly with the surrounding environment. These developments are demonstrated in many coastal constructions and dredging processes for creating artificial lagoons, jetties and blocky concrete obtrusive wharves inside the sea. The coastal constructions and dredging processes exacerbate the erosion and accretional problems or transfer the problems to the adjoining localities along the coast (Dar and Mohamad, 2003).

Dredging operations and the dredged disposal materials are considered an important source of the filling materials in the tidal flat areas (Barbosa and Almeida 2001). Dredging activity excavates the bottom substrate and suspended it as particulate sands, silts and clays in the water column. The suspended solids generated during these operations cause significant damage to the benthic communities, as the suspended solids can be carried by the prevailing water current over long distances and thus cause widespread damage to the marine organisms by smothering and forcing them to much of their energy to expel these particles producing high turbidity over and around the benthic organisms and causing damage for most of them (Nugues and Roberts 2003; Baun and Christensen 2004; Orpin *et al*. 2004). This sediment load interferes with filtering action of coral polyps and resident filter feeders and can completely suffocate the corals (Larcombe *et al*. 1995; Anthony 1999; Nawar *et al.* 2001; Blanchard and Feder 2003 and Thomas *et al*. 2003).

The tidal zones of the Red Sea contain numerous habitats, such as coral reefs, seagrass beds and mangroves, which support a highly rich, productive and diverse ecosystem. The continuous human stresses on the coastal areas by the unplanned projects depending upon unsuitable and rudimental methodologies, degrading and overexploitation of the natural resources have placed the sensitive ecosystems at a great risk.

The objectives of the present study are illustrating the direct and indirect impacts of the dredging processes, the worse situation of the present artificial lagoons and the coastal alterations that are constructing due to the newly changing in the natural coast continuity.

MATERIALS AND METHODS

The under-investigation lagoon is located in the seaward side of a tourist village southern of Hurghada (Fig. 1), in an artificially infilling zone. It was dredged in the tidal flat by extirpating the underlying submersible coral terrace using hydraulic and mechanical ordinary equipment. Twenty sediment samples were collected from: the infilling zone, sidewalls, lagoon basin and from the intertidal zone. The sediment samples were dried, dis-aggregated with fingers and sieved every one-phi (Ø) interval (Folk 1974 .(Seven different fractions were obtained including; gravel ($Ø_{-1}$), very coarse sand ($Ø_0$), coarse sand ($Ø_1$), medium sand ($Ø_2$), fine sand ($Ø_3$), very fine sand ($Ø_4$) and mud ($Ø_5$). The different fractions were categorized into three main groups; the coarsest fractions ($Ø_{-1}$+$Ø_0$ +$Ø_1$) medium fractions ($Ø_1$+$Ø_2$ +$Ø_3$) and the finest and particulate fractions ($Ø_4$+$Ø_5$)

Carbonate content (expressed as $CaCO_3$%) was determined by dissolution 1gm of each powdered sample with diluted glacial acetic acid (12%) for 4h (Basaham and El-Sayed 1998 and Dar 2002). Also, total organic matter (TOM) was determined as the ignition weight loss at 550°C (Flannery *et al*. 1982. Brenner and Binford 1988).

Ten seawater samples were collected using water sampler (PVC tube ≈ 3L). Seawater characteristics such as; salinity (‰), total dissolved salts (TDS), hydrogen ion concentration (pH) and dissolved oxygen (DO) were measured using Hydrolab Instrument (Surveyor 4, USA). The lagoon basin and inside the nearby seaward excavations were surveyed by snorkeling and SCUBA diving. The recorded benthos was identified according to; Ismail (1999), Sheppard and Sheppard (1991), Veron (2000) and Vine (1986).

RESULTS AND DISCUSSION

With the progressive development in the tourist industry, the artificial lagoons have become the distinguish character in most coastal resorts. There were widely used as private marinas, swimming pools, and in many places for recreational activities. These lagoons were dredged in the rocky tidal flats by very rudimental technologies without preliminary engineering and scientific studies for the base land nature, the oceanographic conditions and the applicable and the practicable designs.

Coral communities in the fringing reefs off Hurghada are the most exposed, varied and vigorously growing up (Behairy *et al.* 1992). Uncontrolled development has already caused substantial damage to inshore reefs imbalance in the hydrodynamic pattern of coastal sediments (Dewidar 2002). The depositional-hydrodynamic patterns in Hurghada have been altered as a result of blocking littoral currents by protruding constructions (Frihy *et al.* 2004). They also concluded that the fine grained sediments resulting from dredging activities badly affect the living coral nearby. Such dredging of coral reefs would have a negative effect on the stability of the beach and cause losses and damage for the recreation facilities. El-Gamily *et al.* (2001) divided the urban area of Hurghada into two categories; the natural expansion of the existing urban area and the unplanned landfilling throughout the shoreline. All types of living corals have affected seriously due to the extensive use of dynamite (Riegl and Luke 1998), anchoring, dredging and extensive diving.

The impacts during the lagoon execution

The dredging operations in the recreational lagoons, swimming pools and marina basins that executed along the coastal area of Hurghada were done using the ordinary crushing and uploading machinery in the tidal flat zones. These tidal areas are mostly covered with water layer not less than 0.5m in the low tide time, whereas, the tides in the Red Sea are ranging between 1.25m and 0.5m with a mean sea level up to 1.00m (UNEP 1997). As discussed by Lee (1970), the primary factor controlling release of constituents from sediments is the mixing or stirring processes. The stirring was done using machinery that crushes the limestone bottom and enables the rocky fritters to be brought to the surface at a significantly greater rate than typically occurs by diffusion. Therefore, the dredging activities and especially hydraulic dredging where the sediments are slurried in an approximate one part sediment to four parts water (20% by volume) tend to result in rapid release of constituents from sediments due to the change in liquid-solid ratio and from the mixing of the interstitial waters with the overlying water column used to slurry the sediments (Lee and Jones 1992). The impact of sediment disposal on benthic communities varies depending upon some factors such as the volume and sediment characteristics, water depth, the time of the year, the types of the inhabiting organisms, the amount of resulting suspended particulate matter (SPM), and the presence of toxic substances in the dredged materials (Harvey *et al.* 1998).

The physical impacts of dredging process and the dredged sediments range from burial of organisms due to the settling of the suspended or dumped sediment to physical abrasion or clogging of gills or other organs by suspended sediment. Dredging materials, especially the dredged suspended particulate matters can have adverse impacts on certain organism populations such as the coral reefs and the seagrass beds. The dredging activities increase the water column turbidity to the point where the amount of photosynthesis that can occur in the water is curtailed with the result that presence an overall impairment of the function of the ecosystem (Jones and Lee 1978). Subsequently, the surface sediment composition and the benthic community structure were changed drastically shortly after the open-sea deposition of dredged materials. The faunal response may be characterized as a decrease in the density of the less opportunistic families and a major increase in the density of families with the most opportunistic life-style (Harvey *et al.* 1998).

The present situation in the proposed lagoon

The proposed artificial lagoon (Fig. 2) suffers from many problems; increasing the shallowness rate with sidewalls fretting, turbid water, sediments with sludgy nature, very bad smelling and prevalence of some undesired and harmful benthos.

The coarsest portion ($Ø_{-1}$+$Ø_0$ +$Ø_1$) in the infilling zone recorded average percentage of about 64.04% mainly from silicate sands, the medium portion ($Ø_2$+$Ø_3$) is about 29.34% while the fine and particulate portion ($Ø_4$+$Ø_5$) only about 6.61%. Sidewalls samples of the investigated lagoon recorded average coarsest percentage of about 37.91%, the medium portion 52.78% and finest and particulate portion about 9.32%. The intertidal zone has averages of; 25.85%, 60.75% and 13.41% for the coarsest, medium and the finest and particulate portions respectively.

The portions distribution is completely reversed in the lagoonal basin, whereas the finest and particulate portion reach an average about 36.17% with obvious decreasing in the coarsest 24.01% and medium 39.82% portions (Fig. 3). The vital observation in the lagoonal basin is that the coarsest, the medium and a part of the finest and particulate portions were dropped from the dredged operations.

Also, the considerable occurrence of the finest and suspended particulate matter (SPM) in the lagoon basin illustrates the palpable sludgy nature of the sediments. It is clear that, the finest and suspended particulate matter in the lagoon basin have more than one source; the finest materials from dredging operations, wind smothers and the organic remains from the dead planktonic organisms. This is supported by the high organic matter, the low carbonate contents and the resultant bad odor of the sediments.

Carbonate percentage in the infilling zone recorded the lowest average 6.53%, the intertidal zone recorded the highest average percentage 40.27%, lagoon sidewalls 27.96% and the lagoon basin 33.41%. The total organic matter (TOM) shows the highest average in the lagoon basin 4.35%, followed by the intertidal zone 3.36%, while the infilling sediments recorded the lowest average content 1.78%. The relatively lower carbonate percentage in the tidal zone indicates the hazardous situation in the nearby areas of the lagoon.

The vertical sediment sequence (Fig. 4) illustrates that sludgy nature sediments with their high organic matter are concentrated in the lagoon basin rather than the other parts. The hydrogen sulfide is concentrated in these sludgy sediments and is fairly toxic to the aquatic life. It removes oxygen from the sediment column and therefore could deprive oxygen from organisms that are attempting to migrate to the surface of the sediment for a sufficient period to cause their death (Jones and Lee 1978).

The investigated lagoon has only one water inlet (Fig. 2) whereas, the water circulation and admixing is very difficult due to the lagoon shallowness and the water entrance restriction. The recorded salinity in the investigated lagoon is remarkably high. It varies between 41.25‰ and 41.66‰. Hanna *et al.* (1988) recorded that the seasonal variation of the average salinity in Hurghada ranged from 40.12‰ and 40.65‰. The increasing salinity is mainly attributed to the continuous agitating and sidewalls winnowing by the waves and the poor mixing with the open seawater. The pH value in the lagoon changes between 8.45 and 8.66, higher than that recorded by Hanna *et al.* (1988) and lower than that recorded by Dar and Mohamed (2003). The dissolved oxygen (DO) varies between 5.12 mg/l and 5.52mg/l, which is relatively lower than that values recorded by the other authors.

The recorded oceanographic parameters in the proposed lagoon (Table 2) deal to water characteristic alterations. These renewing conditions comprise intensive stress on the benthic communities and can easily change the community structure and the species dominance in/and nearby the lagoon. There is no considerable fauna or flora recorded inside the lagoon but only some feathery hydroids of species (*Cassiopea sp.* and *Cotylorhiza erythraea*), brittle sea stars (*Ophiocoma pica*) and sea urchins (*Echinometra mathaei, Diadema setosum* and *Tripneustes gratilla*) occupy the excavated parts of the sidewall terrace. In seaward of the water inlet, new hard coral recruits, young growing up species (*Acropora pharaonis, Stylophora pistillata, Porites sp., Goniopora sp.* and *Favia sp.*) and some bivalves (*Tridacna maxima*) with some snails were observed. The flora is represented by seagrass spots (*Thalssodendron ciliatum*) and macro-algae (*Lauranchia obtuse, Sargassum asperifolium* and *Hydroclathraus clathraus*) in the base of the water inlet.

As discussed in Dar and Mohamad (2003), the coastal areas are susceptible to the dynamic shoreline processes resulting in intensive erosion and accretion in the coastal areas due to the changing in the wave and wind induced current directions by the blocky concrete marine constructions, basin executions and the water path changing. They recorded that the erosional rate reaches to about 5m/year in a studied case.

The environmental balance of the sea coast is combined with both erosion in parts and accretion in the others. Man invasion to the marine ecosystem causes abrupt change in the erosion/accretion cycle. It is naturally that the resulting materials from the erosion process will deposit in the partially or completely protected tidal areas. The accretion processes are threatening and damaging the tidal habitats. Also they are accompanied with the dredging operations and the same destruction effects are expected in the nearby habitats.

CONCLUSIONS AND RECOMMENDATIONS

The unplanned designed and executed artificial lagoons represent worse situation and renewing coastal problem source. The artificial lagoons problems are concentrating in the sludgy with bad odor sediment nature, bad water circulation, shallowness increasing day by day and harmful faunal communities. All these problems require immediate and long-term solutions to improve these lagoons and dilute the worse situation.

New designs and sterilizations are important for one time that guaranteeing complete preventing for the problems recurrence and allowing the natural faunal assemblages growing up. Also the engineering and scientific solutions will help to protect the nearby habitats from destruction.

As mentioned in Michio *et al.* (2003), Dar (2002), El-Gamily *et al.* (2001) and UNEP (1997): the following recommendations are given to support the decision makers, engineers, planners, marine scientists and architects to protect the marine environment along the Red Sea with long-term of use without risk or degradation in the sensitive communities;

1-Redesigning all the artificial lagoons engineering and environmentally in order to improve their water circulation and prohibiting the repeating infilling, shallowness and particulate sediment accumulations.

2-Extensive monitoring programs using all the allowable facilities as the filed continuation for the benthos evaluation in the degraded zones are very important to measure the different changes in the impacted and altered coastal areas.
3-Remote sensing and satellite images are very powerful to delineate the erosion/accretion periods and displacements from location to another as a result of the coastal constructions, embankments and excavations for artificial lagoons.
4-Increase the punishments on the infringement cases and enforcement the environmental law 4/1994 are very necessary to decrease the impacts and dilute the chronic effects.
5-The effects of feeding and moving behaviors of sea cucumbers on the bottom are inhibitions of algal growth, detritus accumulation and reduction in number of benthos. Therefore, sea cucumbers have a potential effect on improvement of artificial lagoons and enclosed sea areas. Sea cucumber and benthos may recover the bottom conditions to previous conditions and also maintain it in oxidative condition.

Table 1: Minimum, maximum and average fraction distributions, carbonate percentage and total organic matter of the investigated lagoon.

	Coarse Fractions% (Ø-1+Ø0 +Ø1)	Medium Fractions% (Ø2+Ø3)	F. & P. Fractions% (Ø4+Ø5)	CO3%	TOM%
Infilling Sediments	21.30 - 78.48 ---------------- 64.04	15.86 - 70.83 ---------------- 29.34	5.24 - 8.53 ---------------- 6.61	5.12 - 8.45 ---------------- 6.53	1.45 - 1.95 ---------------- 1.78
Sidewalls	28.88 - 55.85 ---------------- 37.91	41.62 - 64.14 ---------------- 52.78	2.53 - 18.44 ---------------- 9.32	16.17 - 34.60 ---------------- 27.96	1.96 - 2.55 ---------------- 2.17
Lagoon Basin	15.39 - 42.33 ---------------- 24.01	31.04 - 44.66 ---------------- 39.82	16.69 - 53.37 ---------------- 36.17	23.10 - 40.70 ---------------- 33.41	2.75 - 6.00 ---------------- 4.53
Intertide	12.13 - 36.61 ---------------- 25.85	57.63 - 62.25 ---------------- 60.75	5.76 - 25.66 ---------------- 13.41	19.18 - 53.93 ---------------- 40.27	2.75 - 4.30 ---------------- 3.36

Table 2: Some oceanographic parameters measured in the seawater of the lagoon

Parameters	Range
S‰	**41.25 – 41.66‰**
pH	**8.45 – 8.66**
TDS	**40.14 – 40.88‰**
DO	**5.12 – 5.52 mg/l**
Turbidity	**1.22 – 11.56**

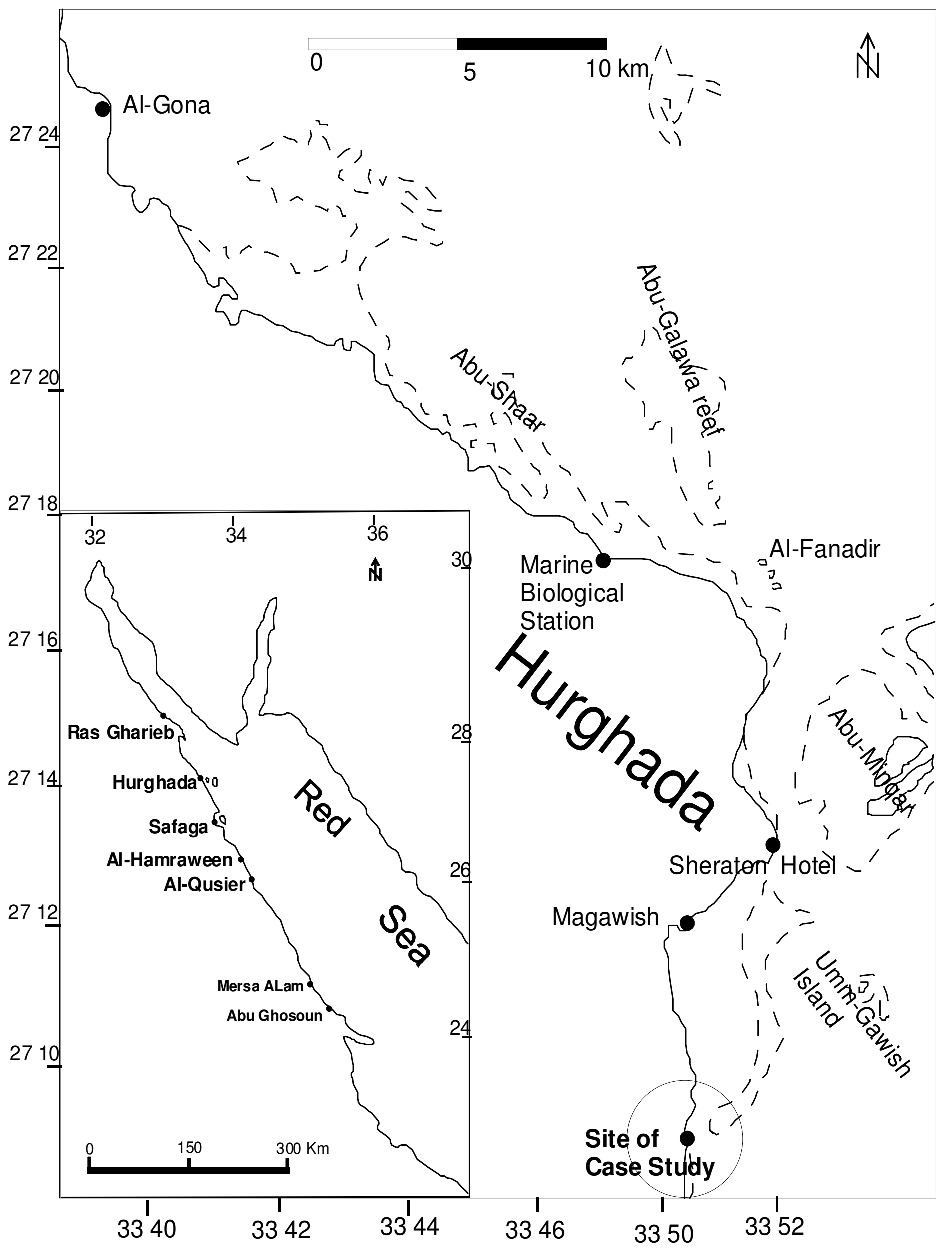

Fig. (1) Location map

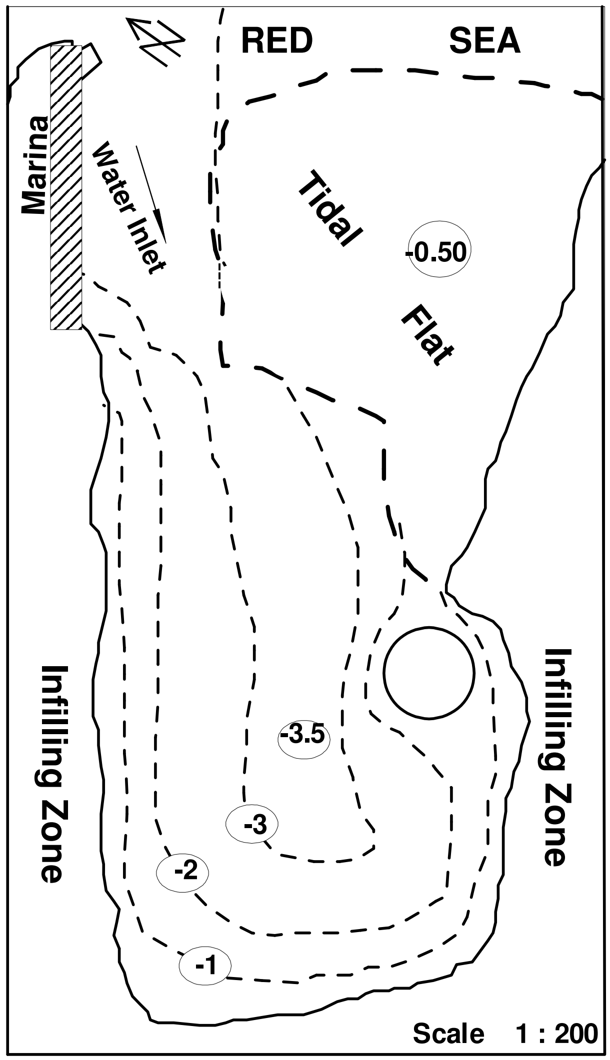

Fig. (2) Depth variations in the proposed lagoon.

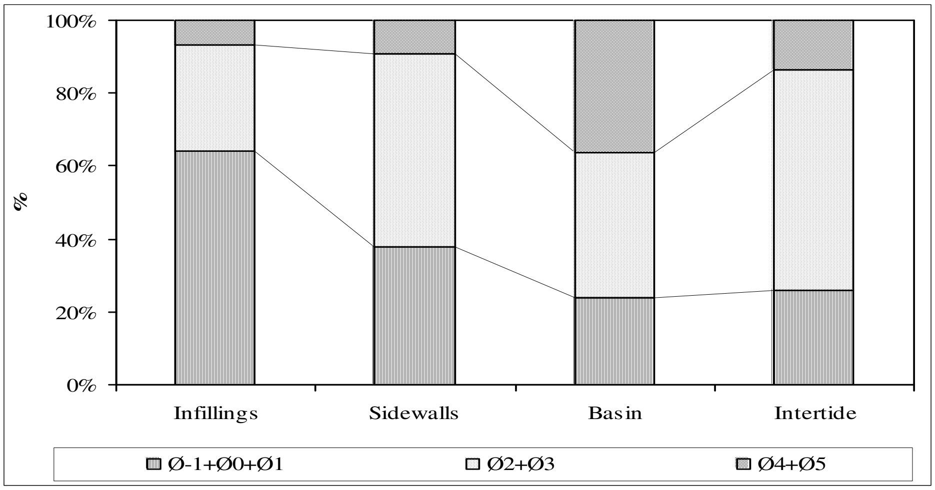

Fig. (3) Fraction distributions in the different zones of the investigated lagoon.

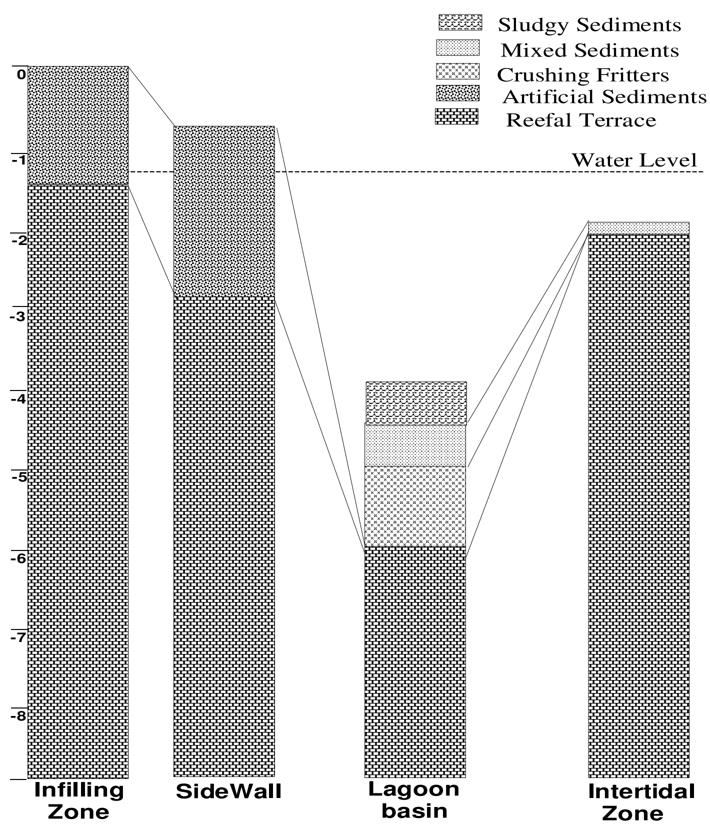

Fig. (4) Vertical sediment distributions for the different zones of the lagoon.

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