Introduction

The Mediterranean Sea is a semi-closed sea, surrounded by highly populated and industrialized areas that present a low capacity ofinterchange of waters with the Atlantic Ocean and other surrounding seas. For millenniums, it has been the scenery of human development, which has extensively influenced the coastal areas. More recently, the capacity of humans for modifying the environment has experienced an exponential enhancement. As expected, it has not escaped from this process, and currently, it offers several examples of dramatic anthropogenic impacts.

Mediterranean Sea considers among the most polluted marine habitats around the world. Its open water is generally good, but the coastal areas are subjected to environmental problems including, heavy metal, organic and microbial pollution as well as the land activities (urbanization, industry, and agriculture) which consider the main source for pollution (EEA, 1999 and EMECS, 2003).The pollution in the Mediterranean area had been extremely increased during the recent years due to increasing heavy industrial activities and great commercial harbours concentrated particularly in the northwest (major hot spots). The main industrial sectors around the Mediterranean comprise the chemical, petrochemical, metallurgy, waste treatment, paper production, paints, plastics, textiles industries (Abd-Alla, 1993; EMECS, 2003). UNEP (1996) has estimated that 650,000,000 tones of sewage, 129,000 tons of mineral oil, 60,000 tones of mercury, 3,800 tons of lead and 36,000 tones of phosphates are dumped into the Mediterranean each year.

The coastal zone of Egypt on the Mediterranean Sea extends from Rafah the east to Sallum to the west for over 1200 km. It hosts five large lakes; namely Bardawil, Manzala, Burullus, Edku and Maryut which represent about 25% in area of the total wetland of the Mediterranean. It also hosts a number of important residential and economic centers of the country including the cities of Alexandria, Port Said, Damietta, Rosetta and Matruh. Activities on the coastal zone include fishing, industrial activities, tourism, trading and agricultural activities in the delta region.

Alexandria is the second largest city in Egypt and one of the most important industrial centers, comprised 100 large factories and about 260 smaller ones (Abd-Alla, 1993) to cover about 40% of the nation's industry. It is also the main summer resort in Egypt; about 4 million citizen and two million summer visitors (Nasr, 1995). More than 180 x 10^6 m^3 of untreated sewage and waste water were discharged annually from large numbers of outlets into Alexandria coastal area through local-sewerage system (Abdel-Motai, 1991).

Abu Qir Bay is a shallow semi-circular basin lying 35 km east of Alexandria City. The bay has a shoreline of about 50 km long and the maximum depth of about 16 m. The surface area of the bay is about 360 km^2 and the water volume is 4.3 km^3 (Said *et al.*, 1995). It was considered as a fertile marine habitat when compared with the other Egyptian Mediterranean coastal waters. As in many coastal regions near major urban areas, the bay is used for variety of purposes; commercial fishing, shipping, recreational boating, swimming and as a repository for sewage effluents. During the last three decades, the bay is facing the problem of pollution which discharges into the bay from different sources; El-Tabia Pumping Station (TPS), the outlet of Lake Edku and the Rosetta mouth of the River Nile. The estimated amount of untreated sewage and industrial wastes from 22 different factories pumped to Abu

Qir Bay through TPS is of about 2 millions m^3/day. The exchange of water between Abu Qir Bay and Lake Edku occurring through El-Maadiya channel (about 100 m long, 20 m wide and 3 m deep) is controlled by the prevailing wind and the difference in water level between the bay and the lake. Actually, the amount of brackish water discharged from the lake to the bay is at a rate of about 3.3 million m^3/day (Report on pollution status of Abu Qir Bay, 1984).

The importance of Abu Qir in east of Alexandria and impact of variable sources of pollution thirst many researchers to study the biology and ecology of this region (Abdel-Moneim and Shata, 1993;El-Deek, 1995; Aboul-Naga*et al.*,2002; Youssef and Masoud, 2004; Abdallah *et al.*, 2006; Zakaria, 2007; Kholeif, 2008; Mahmoud *et al*., 2010 and El-Gohary *et al*., 2011) .

Marine environmental pollution is a complex topic of huge scientific importance. There are different pathways by which pollution can be introduced into the marine environment, contamination inputs include industrial and/or domestic effluents, chemicals released in conjunction with oil exploration or the decommissioning of oil platforms and chemicals originating from agricultural run-off, such as fertilizers and pesticides. Anti fouling agents leaching from ship paints (Tributyltin TBT) and other release from ships, including events such as accident involving oil tankers or ship carrying hazardous chemicals contribute to seas pollution (Kröger *et al*., 2002). There is always concern that damage could be done to marine life before the source of any problem is discovered. Direct pollution may occur through deliberate disposal from an accidental loss of substances at sea, while indirect pollution is resulted mainly from land based activities. This in accordance with GESAMP (1993), which estimated that at least 40% of all marine contaminants are coming from land sources.

On the same context, metals are natural components of seawater and sediments and as such as harmless to marine life, but they can build up to high concentrations from human activities as in mining and/or industrial effluents and then represent a risk to human consumer of sea food.

Molluscais a large assemblage of animals having diverse shapes, sizes, habits and occupy different habitats. According to their habitat preference, they can be classified into aquatic and land communities, and they are used as indicators to compare and contrast the differences between ecosystems (Zenetos, 1996). In the Mediterranean Sea, benthic molluscs have been used as descriptors of the sublittoral soft-bottom benthic communities in association with their ecological relevance to water quality variations from unpolluted to moderately and grossly polluted bays with the impact of hypoxia and sedimentation linked to river discharges (Zenetos, 1996). They also play important roles in the ecosystem structure and biodiversity maintenance,and some of it have been widely used in monitoring studies of various contaminants worldwide because of their economic and ecological importance.

Aim of the study:

The present study aims to study the effect of physico-chemical parameters,nutrient,heavy metal,some molluscs and water quality inAbu Qir Bay. As well as study impact the environmental conditions on the distribution, biodiversity and population dynamics of some molluscs in the investigated area.

Literature Review

1. Physico-chemical parameters

Gharib and Soliman (1998) determined physico-chemical properties of El-Mex Bay region which they concluded that the surface water showed the following characteristics: salinity (20.73-28.87‰), dissolved oxygen (0.79-7.1 mg/l).

Okbah and Tayel (1999) studied pH, salinity, DO of El-Mex Bay, Kayet Bay, Abu Qir Bay and Eastern Harbour; the annual range of surface water pH and salinity in the four studied coastal areas were (7.55-8.22) and (33.96-37.87‰), respectively. The surface DO values were fluctuated between 5.8 mg/l at El-Mex Bay and 8.23 mg/l at Abu Qir Bay.

Salinity, DO of the southeastern Mediterranean offshore waters of Egypt was investigated by (Fahmy, 2001) he showed the following results. Salinity (38.66-39.79‰), DO (4.4-5.22 mg/l).

Okbah and El-Gohary (2002) studied seasonal variations of some physico-chemical parametersof Lake Edku. They recorded that the relatively low pH values reflect the decreased productivity as a result of the polluted water discharged into the lake.

Abou-Taleb (2004) studied salinity and pH of Alexandria coast water and found that salinity was in the range of (18.77 – 40.80‰) and pHwas (7.63 – 8.90).

Masoud *et al.* (2005) determined some water characteristics of Alexandria hot spots and the obtained results showed a wide range of salinity (28-36‰), while dissolved oxygen were ranged between 1.21and 4.18 mg O_2/l.

El-Gohary *et al.* (2011) determined some physico-chemical parameters of Abu Qir Bay water during winter and summer seasons.

They recorded that the mean values of water temperature, pH, salinity, DO, BOD and COD were found in the range of 16.06-26.36 ^{o}C, 7.34-8.07, 35.1-38.66 ‰, 5.01-6.79 mg/l, 3.00-3.15 mg/l and 11.41 mg/l respectively.

2. Nutrients

The distribution of nutrient salts in the water and discharged water of the Western Harbour of Alexandria was reported (Nessim and Tadros 1986). Seasonal distribution pattern of nutrient contents were detected at different parts of the harbour. The P: N: Si average ratio where 1: 23: 27 in the water and 1: 29: 49 in the discharged water.

The distribution pattern of ammonia showed higher values > 14 µg/l in most polluted water such as Eastern Harbour, Abu Qir and El-Mex beaches water which derived from the domestic water discharge through different sewers located at these areas (Nessim, 1989).

Fahmy *et al.*(1996)were calculated the ratio of nutrient salts in the coastal Egyptian Mediterranean waters where the abundance of nitrogen species in the studied area was in the order (Organic-N > NH_4-N > NO_3-N > NO_2-N).

Nutrient salts of El-Mex Bay water were measured by Gharib and Soliman (1998). They recorded that the surface water showed that nitrate was in the range of (5.07-25.67 µM/l), nitrite (1.88-6.68 µM/l), dissolved phosphate (1.29-6.96 µM/l), and reactive silicate (11.40-14.28 µM/l).

Fahmy (2001)studiedthe nutrients concentrations of the southeastern Mediterranean offshore waters of Egypt and he showed that nitrate ranged from (0.20 to 5.73 µM/l), nitrite (0.03-0.12 µM/l), ammonia (0.26-0.71 µM/l), silicate (0.28-6.41 µM/l), total nitrogen (20.76-65.18 µM/l) and total phosphorus (0.33-28.98 µM/l).

Abou-Taleb (2004) studied nutrients in Alexandria coast water and obtained that ammonia was in the range of (1.0 – 10.23 µM/l) nitrite (0.11 – 2.02µM/l), nitrate (ND-13.99 µM/l), phosphate (ND -6.50 µM/l) and silicate (1.67 – 13.57 µM/l).

Mohamed *et al*. (2005) studied the impact of cooling water from the power plant at Abu Qir Bay on the surrounding area. They concluded that the outlet cooling water was complied with the environmental law 4/94 in all measured parameters except phosphate, ammonia and total hydrocarbons.

Shams El-Din and Dorgham (2007) carried out on the effect of nutrient salts on the distribution and biodiversity of the phytoplankton in Abu Qir Bay. They recorded that the phytoplankton count showed insignificant correlation with the nutrient salts resulting from the acute eutrophication and the increase of pollution stress in the bay.

3. Heavy metals

3.1. Heavy metals in water

Some heavy metals were occurred in El-Mex Bay water in the order: Fe > Mn > Zn > Cu > Pb > Cd (Aboul-Dahab, 1985).

The levels of Zn, Cu, Cd and Pb in sea water at the Western Harbour were observed by Tayel *et al*., (1997) and recordedconcentrations of38.48,3.41,4.19 and 1.08µg/l, respectively.

The concentrations of manganese, iron, cobalt, nickel and zinc ions in the Eastern Harbour and El-Mex Bay waters were determinated by Emara and Shriadah, (1991)the results showed that the concentrations of the metals in both areas were in the order: Zn > Fe > Mn > Ni > Co at the surface and near the bottom water.

The heavy metals concentrations (Cd, Pb and Fe) in Abu Qir Bay waters were varied in the ranges of 0.21 - 0.52, 1.9 - 6.11 and 1.09-1.28 µg/l respectively (Abdel-Moneim and Shata 1993).

The average concentrations of dissolved metals of lead, zinc and cadmium in Abu Qir Bay waters were 9.92, 53.32 and 1.55 µg/l, respectively (El-Deek, 1995).

The levels of heavy metals in Eastern Harbour and Abu Qir Bay waters were reported by El-Nady (1996)where Abu Qir Bay water showed the highest concentrations of most metals than those of Eastern Harbour.

The distribution of some metals in Abu Qir Bay, Eastern Harbour, El-Mex Bay and Mariut areas (Khaled, 1997) showed that the average concentrations of Zn were 53.55, 64.44 and 28.20 µg/l for Abu Qir, Eastern Harbour and El-Mex waters, respectively.

The behavior of dissolved metals during transport in El-Mex Bay estuary was reported by El-Rayis *et al*. (1998) where the considerable loss of most the metals including Fe and Mn from the discharged plume off El-Umum Drain outlet,high levels of some heavy metals were reported in the inshore waters of El-Mex Bay mainly near the drain outlet and low concentrations were reported in the offshore water. Heavy metals in suspended matter in El-Mex Bay gave mean concentrations of particulate zinc, copper, lead and cadmium as follows: 9.90, 2.42, 0.55 and 0.24µg/l, respectively.

The dynamics of Cd and Pb in Abu Qir Bay waters were studied, the average concentrations of dissolved Pd was 1.48 and dissolved Cd was 0.73µg/l(Ahdy, 1999).

Abou-Taleb (2004) Studied the concentrations of Cu, Zn, Cd, Co, Pb, Ni and Cr in Alexandria coast waters,which varied in the ranges of 0.2-15.83, 0.33- 40.62, ND-2.16, ND - 9.11, ND - 28.63, ND - 13.07 and ND-0.83 µg/l, respectively.

El-Moselhy *et al*. (2005) determined concentration of nine heavy metals (Cu, Zn, Cd, Pb, Ni, Cr, Co, Fe, and Mn) in water of Suez Canal. The results revealed that the northern part of the canal (at Port Said) recorded higher concentration for most metal than those in the other part along the canal.

Due to sewage water discharges, El-Rayis and Abdallah (2005) found increases in the levels of heavy metal concentration to many folds in the water of El-Mex Bay and Eastern Harbour of Alexandria coast during the last 15 years.

El-Moselhy *et al*. (2006) studied some heavy metals concentration (Cd, Pb, Cu, Cr, Co, Ni, Mn, Zn, and Fe) in water and sediments from the intertidal zone of Suez Bay. They stated that the distribution of the investigated metals showed similar pattern for water and sediments giving highest values at the stations affected directly by the different pollution sources.

Shakweer *et al.* (2006) determined heavy metals concentration (Zn, Cu, Ni, Mn, Fe, Pb and Cd) in Egyptian Mediterranean cost at different depths. The results revealed that the concentrations of heavy metals decreased gradually in the water samples collected far from the sources of drainage water.

Hamed and Emara (2006) detected the concentrations of heavy metals Cu, Zn, Pb, Cd, Cr and Fe in the sea water at Gulf of Suez,which were in the range of 3.37- 4.78, 18.83 - 21.46, 2.75- 3.16, 0.22 - 0.27, 0.99- 1.21 and 23.82 - 32.78 µg/l respectively.

Behavior of the heavy metals in El-Mex Bay was carried out by Abdallah (2008) which studied the distribution of heavy metals (Cd, Cr, Co, Cu, Zn, Pb, Mn and Fe) in water, suspended particulate matter and sediments.

YehiaandSebaee (2012) considered accumulation of heavy metals in water and sedimentsin Rosetta branch of the River Nile. The order of heavy metal accumulation in water was Fe > Pb > Cu > Zn > Cd, while in sediments was Fe > Zn > Cu > Pb > Cd.

El-Serehy*et al.*(2012) studied the concentrations of Fe, Mn, Zn, Cu, Pb and Cd in surface water in the Egyptian coastal waters along the Mediterranean Seain the water showed apparent seasonal variations of metals accumulation with maximum concentrations during summer and winter, respectively.

3.2.Heavy metals in sediments

Okbah *et al*. (1998) investigated some heavy metal concentrations (Cu, Cd, Fe, Pb, Zn and Cr) in the sediments of the coastal zone of Alexandria recorded high levels of all the studied metals.

El-Sammak and Aboul-Kassim (1999) studiedmetal pollution in the sediments of Alexandria coast from Abu Qir Bay till El-Agami, theywere observed that, the concentrations of Co, Ni and Zn were 50.24, 85.7 and 101.8µg/g.

Aboul-Naga (2000) determined heavy metals (Fe, Cu, Pb, Zn, Mn, Ni, Cd, Cr and Co) near shore sediments from Abu Qir Bay,the results of humic acids isolated from the sediments have been characterized by higher heavy metal levels than the proper sediment samples.

Kirdy *et al*. (2001) Chan *et al*. (2003) and Alquezar *et al*. (2006) pointed out that the presence of such toxic heavy metals in marine sediments makes it interact and enter inside food of many marine organisms.

Aboul-Nag *et al*. (2002) determined the partitioning of Pb, Ni and Cd between dilute acid leachable and residual fraction in the sediments of Abu Qir Bay.They observed highest concentrations were measured in the vicinity of points recognized as potential sources pollution.

Distribution of some metals (Ca, Mg, Fe, Mn, Co, Ni, Cu, Cr and Zn) in sediment samples collected from Alexandria coast showed that the concentrations were varied in the ranges of 53.56-371, 3.62-9.66, 0.47-0.668, 0.021-0.89, 0.004-0.031, ND-0.026 and 0.010-0.083 mg/g respectively (El-Said, 2005).

El-Moselhy and Abd El-Azim (2005) investigated heavy metals Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, V and Zn and grain size of sediments from the inshore and offshore areas of Suez Bay, red Sea, Egypt. Thy stated that most of the studied metals were gradually increased with decreasing the grain size of sediments and chiefly associated with the clay (and silt) forming mineral phases. This trend reflects combination effects of possible industrial pollution with the natural constituents of sediments.

Abd Allah and Abd Allah (2006) determined the concentration of Cd, Co, Cu, Zn, Mn and Fe in biota and sediment samples collected from the Eastern Harbor and El-Mex Bay in the Mediterranean Sea, Egypt.

Khalil *et al*. (2007) studied heavy metals in twelve samples collected from the surface sediments of Burullus lagoon and adjacent Mediterranean Sea. The obtained data indicated that the variations of the measured metals in sediments were varied depending on the locations, whereas the high levels were observed in the western area of the lagoon. The studied metals gave positive correlation with each other and organic carbon suggested that the distributions of these metals were associated with the organic matter accumulation.

Abdel Ghani*et al.* (2013) evaluated metal pollution in surface sediments of Abu Qir Bay and Eastern Harbour of Alexandria, Egypt. The enrichment factors revealed anthropogenic sources for Cd in Abu Qir Bay, as well as pollution load index indicated that most stations in both areas are polluted.

3.3. Heavy metals in some molluscs

Clarck (1986) demonstrated a relationship between sea water pollution and concentration of heavy metals inside the body of marine organisms.He found that every metal has a specific critical concentration for each living organism that has a role in the ecosystem.

Bourgoin (1990) used soft tissues of *Mytilus edulis* as indicators for marine metals pollutions, he used these shells for heavy metals analyses in biological monitoring programs, that indicated the shell can provided an index of Pb bioavailability which was strongly correlated with the tissue-Pb concentrations.

Heavy metals were studied in some bivalves species from Abu Qir Bay. As, *Mytilus* spp. was investigated by Abdel Moati (1991), and*Mactra corallin*a was studiedby EL-Rayis *et al.* (1997) and Ahdy (1999). *Donax trunculus* was greatly investigated in the bay (Khaled, 1997; Ahdy, 1999; Abdel Moati, 2002 and EL-Sikaily *et al.*, 2004).

Oliver *et al*. (2003) found high significant differences between concentration levels of Pb, Cu, Fe, Cd, Ni, Sn, Ag, Hg in water of different bays with different rates of pollution, and the concentration levels of these heavy metals in the some bivalves.

Liang *et al*. (2004) found that the Bivalve species *Crassostrea talienwanesis* possessed a much greater ability for bioaccumulation of

Cu and Zn while the Gastropod species *Rapana venosa* manifested the most bioaccumulation capacity of Cd.

Bonneris *et al*. (2005) measured Zn, Cu, and Cd concentration levels in the bivalve *poleandon gremdis* that live in 9 lakes in Canada which have different concentrations of the metals in their waters, and found that Cd concentration in these animals has significant differences with Cd concentration in the water of each site with no significant differences was in the case of Cu and Zn.

Beldi *et al*. (2006) studied seasonal variations in the concentrations of heavy metals (Cd, Cu, Pb and Zn) in *Donax truncculus*at two contaminated sites in the Gulf of Annaba. The statistical analysis revealed a significant effect of seasons for all metals measured, the highest values being recorded in winter for Zn and in summer for the other metals.

Shreadah *et al*. (2006a) determined concentration of metals (Zn, Cu, Cd, Pb and Hg) in *Donax* collected from the Egyptian Mediterranean coast. They reported that Zn and Cd were more accumulated in the bivalve'stissue than the other studied metals.

Maanan (2008) detected some of heavy metal in soft tissue of some marine molluscs from Moroccan coastal region (Cd: 7.2; Pb: 9.6; Hg: 0.6; Cu: 26; Cr: 8.8; Zn: 292; Mn: 20.8 and Ni: 32.8 mg/kg).He found that the relationship between metal concentration and season in each species showed very similar annual profiles with a peak observed around spring-summer, as well as different species showed different bioaccumulation of metals depending on study site and season.

4. Biological and ecological studies on some molluscs

Farag *et al*. (1999) studied taxonomical on the edible bivalve molluscs inhabiting the coastal zones of Alexandria, Egypt.

El-yami (2011) studied some molluscs in Jeddah area on Red sea Coast.He was found that Gastropods*Cerithium erythraeonese* has greater ability to accumulate heavy metal of Pb, Cr, and specially Cd than theBivalve*Tridacna maxima*, whoever, *Tridacna maxima* was stronger accumulator for Fe, Cu and Zn than *Cerithium erythraeonese*.

Mutlu and Ergev (2012) studied the mollusc'sspecies abundance with its seasonal variations. The highest species richness (6-16 species) was encountered between depths of 10 and 100 m in winter and spring, whereas the molluscan population increased in warm seasons due to the high abundance of *Corbula gibba* and *Nucula nitidosa*. Bivalves and gastropods were abundantly found at depths of 10-200 m, 10-25 m, and 75-100 m.

Diversity is more than just the number of species, and therefore the number of individuals (abundance) per each species is also important. Thus a diversity index must take into account not only the number of species but also the number of individuals per species by (DeVantier *et al*., 2000).

However, the diversity of marine animals at shallow-water habitats beings changed and correlated with several factors including habitat complexity, seasonal rhythms, depths, availability of food, migration and latitudinal trends and even by the availability of empty gastropod shells for hermit crabs (Reese, 1968 andJones *et al*., 1987).

The different patterns of the distribution of the intertidal fauna in relation to habitat diversity and the classification of environmental feature were developed in order to determine species richness (Hily and Jean 1997).

Species diversity, species richness, species composition, faunal density, and zonation pattern of the benthic macrofauna, as well as its relation to sediment characteristics at low, medium and high intertidal level had been studied in several works (Diamant *et al.,* 1986 and Corbisier, 1991). The low species diversity is thought to be due to largely to the stressful physical conditions which have restricting effects on the biota (Price, 1982).

Wells (1978) recorded an unexpectedly low diversity of gastropods in the lower intertidal zone of the Admiralty Gulf,this can be explained in terms of the beach structure as the rocks in the mid-tide region were large enough that they were not rolled by waves except during storms and provide an abundance of nooks and crannies for the snails to retreat into during immersion of low tide.

Dexter (1981) found that the intertidal sand beaches communities of the Red Sea were characterized by a large number of species and highest diversity indices (H`) rather than the Mediterranean sand beach communities.

Kumar (1981) studied the structure, composition and seasonal distribution of the macro benthic fauna at the mangrove ecosystem of Cohin Back. It was represented mainly by polychaetes, crustaceans and molluscs. Faunal diversity, species diversity, richness, evenness and macro faunal density was studied.

Hanafy and El-Azri (1997) demonstrated the major benthic organisms in the coral reefs of Sharm El- Sheikh including hard corals, soft corals, sponges, molluscs and hydroids. The distribution of these