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Research Article

Detecting Marine Environmental Pollution by Biological Beacons and GIS program

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Abstract: A survey of detailed quantitative assessment of the vulnerability of El Mex Bay along Alexandria Mediterranean Coast to the impacts of physical-chemical pollution is presented. GIS tools are used together with many environmental parameters to assess the vulnerability of the most economical and industrial resources along the coast. The coastal bay of El Mex is an important ecological and economical resource whose physical characteristics and location make it particularly vulnerable to the effect of climate changes and pollutants. The ecological study of many planktonic groups such as rotifer assemblages indicated that some rotifers have the ability to exist in polluted waters and are considered as pollution bio-indicators, like *Brachionus species and Polyarthra* species, several other species considered a mark to certain type of pollution (water acidity, water quality….) as cleared in this work. El- Mex Bay during the present study involved several types of pollution bio-indicator organisms and it is water contained high chlorophyll concentrations, thus confirming their classification as highly eutrophic and polluted waters and have great impact on the surroundings aquatic system and biological resources.

Keywords: Vulnerability; Climate change; El Mex Bay; Rotifer; Physical-chemical pollution

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Introduction

Plankton, because of their rapid response to ecosystem variability, their non-exploitation as commercial species and their amplification of subtle changes through non-linear processes, have been suggested to be indicators of climate variability (Taylor et al., 2002; Perry et al., 2004; Hays et al., 2005). Notably, the use of long-term plankton time-series can be a key tool to detect those changes (Perry et al., 2004; Alheit and Bakun, 2010; Mackas and Beaugrand, 2010).

The Mediterranean Sea (MS) is the largest quasi-enclosed sea on the Earth, its surface being similar to that of the largest semi-enclosed (e.g., the Gulf of Mexico) and open (e.g., the Caribbean Sea) marginal seas of the extant ocean (Meybeck et al., 2007). The MS' size, location, morphology, and external forcing allow for a rich and complex physical dynamics that includes: i) unique thermohaline features, ii) distinctive multilayer circulation, iii) topographic gyres, and iv) meso-and sub-mesoscale activity. Nutrients and chlorophyll-a pools rank the basin as oligotrophic to ultraoligotrophic (Krom et al., 1991; Antoine et al., 1995). Oligotrophy seems to be mainly due to the very low concentration of inorganic phosphorus, which is assumed to limit primary production (Berland et al., 1980; Thingstad and Rassoulzadegan, 1995, 1999; Thingstad et al., 2005). Additional features of the MS are i) the decreasing west-east gradient in chl a concentration, as shown by color remote sensing (D'Ortenzio and Ribera d'Alcal´a, 2009; Barale et al., 2008) as well as by in situ data (Turley et al., 2000; Christaki et al., 2001), ii) a high diversity compared to its surface and volume (Bianchi and Morri, 2000), and iii) a relatively high number of bioprovinces (Longhurst, 2006), with boundary definition mostly based on the distribution of the benthos and the nekton (Bianchi, 2007). The MS is also a site of intense anthropic activity dating back to at least 5000 years BP, the impact of which on the marine environment has still to be clearly assessed and quantified. All these peculiar and contrasting characteristics should likely be reflected in the structure and dynamics of plankton communities.

Due to the several complains including the fishermen complains about the fishery decreasing in this area also, the vessels owners about the increasing of corrosion and the surrounding construction on the other hand, there are several problems on the public health of the bay surrounding peoples and declining the water quality of the bay including its odor and colour, the present work aims to examine the spatial and temporal variability in diversity of plankton and their relation to the environmental conditions changes. Also, Using GIS (ARCMAP 10) to produce maps illustrating the organism's abundance and the prevailing environmental conditions. Determine which planktonic organisms can be used as bio-indicators on the prevailing environmental conditions. Finally, Planning prediction and recommendations to prevent the risks that threatening the environment.

Methodology

Study area

El-Mex Bay is located west of Alexandria City, Egypt at longitude 29º45' and 29º54' E and latitude 31º07' and 31º15' N, It extends for about 15 Km from Agami headland to the west to the Western Harbor to the east **(Figure 1)**. The bay has a mean depth of 10 m. Its surface area is about 19.4 Km^2, and its volume 190.3×10^6 m^3 (Said et al., 1991). The shoreline of El-Mex Bay is rocky with narrow sandy beaches. It receives a heavy load of wastewater (7×10^9 m^3/year) both directly from industrial outfalls (El- Umoum Drain) and indirectly from Lake Mariut via El- Mex Pumping Station (Mahmoud et al., 2009). El- Umoum Drain is mainly agricultural water. Lake Mariut also receives wastewater from the four sources in its eastern section, consisting of domestic, industrial and agricultural wastes; this liquid wastes discharged to the harbor via El-Mex Pumping Station.

El-Mex Bay is located under stress condition due to the discharge of untreated domestic, industrial and agricultural effluents, beside the effect of ships movements from and to the harbors. Therefore, the condition at this bay is eutrophic and completely different from the open sea water. These are expected

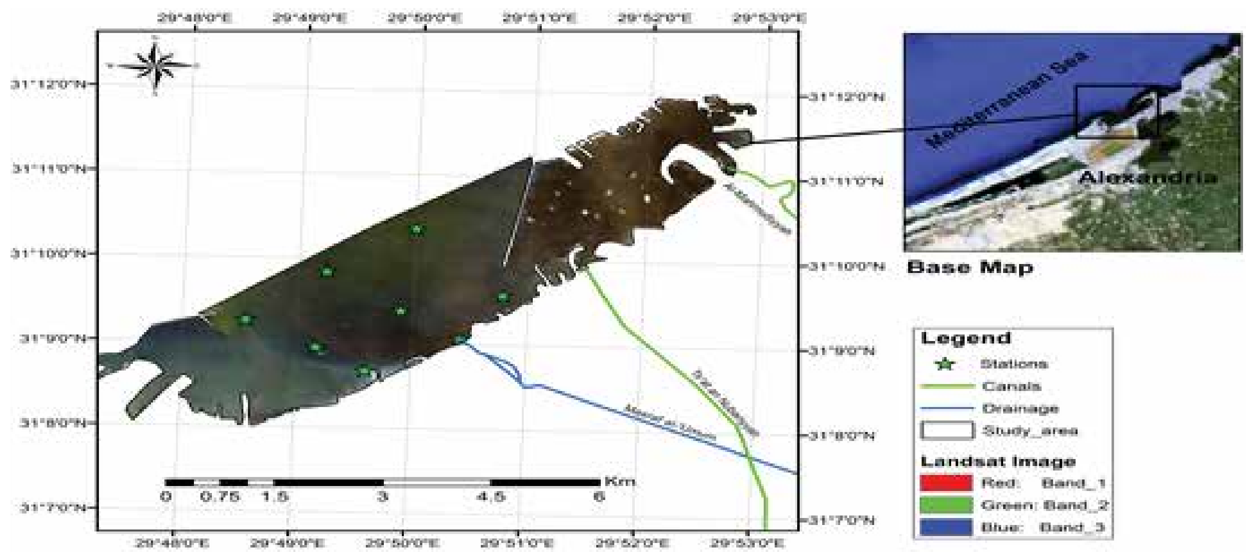

Figure 1: Satellite image and Base map of El-Mex Bay and the different connected drainages that discharged into this bay.

to continue and added to the climatic influence of increasing temperature and rising sea level in the future.

As a consequence of rapid population growth, industrial development, untreated or poorly treated industrial waste, domestic sewage, and agricultural runoff have moved to and from Mariut Lake south of the city and then released into the sea. This lake has also received a significant loading of agricultural runoff through canals and drains. El-Mex Bay subjected to severe environmental conditions.

Sampling

Samples were collected seasonally during a complete year cycle (from autumn 2011 to autumn 2012) at the selected stations. The stations will be selected to cover all possible climatic and environmental characteristics of the different parts of the study area. Eight stations were chosen in the El-Mex Bay for the present study, the locations of the sampling stations are shown in **Figure 1**. Samples were collected vertically by using standard plankton net (55 lm mesh size), lowered near the bottom and then pushed up to the water surface. The collected fauna which retained in the net were then transferred into small glass bottles and preserved in 5% neutralized formalin solution, and the sample volume was then adjusted to 100 ml. The samples were examined under a binocular research microscope.

The identification was undertaken to species levels. For the estimation of standing crop, sub samples of 5 ml were transferred to a counting chamber (Bogorov chamber) using a plunger pipette. This operation was performed three times, and the average of the three counts was taken. Rotifera were counted to species level, and the standing crop was calculated and estimated as organisms per cubic meter according to the following formula equation 1 (Santhanam and Srinivasan, 1994):

$$N=n\ (v / V)*1000$$

Where; N: Total number of zooplankton per cubic meter. n: Average number of zooplankton in 1 ml of the sample. v: Volume of zooplankton concentrate (ml). V: Volume of total water filtered (L).

Additionally, at each station, water temperature was measured directly by usual thermometers, graduated to 0.1ºC, the pH values of the water samples were measured in the field by using a pocket digital pH meter (Oyster, inspected 82738, Extech instruments, Germany) and the salinity of water samples were measured by using Salino-meter by electrode (range 0-199.9 µm, 2-19.99 ms) model (Oyster, inspected 82738, Extech instruments, Germany). The phytoplankton biomass (Chlorophyll-a) was measured according to procedures described by Strickland and Parsons (1972) where sample filtered using Whatman GF/F filters (pore size 0.45 µm) then Chlorophyll- a is extracted by 90% acetone and measured at wavelengths (630, 645, and 665) this was done by using Spectrophotometer.

Photography of zooplankton species was done by using microscopic camera that replacement one eyepiece of binuclear microscope and connected to the computer.

Every single species was separated on glass slide with glycerin droplet and examine under binuclear microscope, some species that need anatomy for identifying their fifth legs “p5” such as copepods and the identification of the different species of zooplankton species was carried out according to Sars 1911 and 1918 (Copepoda), Rose 1933 (Mediterranean copepods), Tregouboff and Rose 1957 (Mediterranean plankton), Pontin 1978 (Freshwater plankton), Guerguess 1979, Hutchinson 1967 (Plankton as a general), Marshall 1969, Bick 1972, Paulmier 1997, Jörgensen 1924 (Protozoa), Gurney 1931, 1932, 1933 and Hardig and Smith 1960 (freshwater Copepoda), Wilson and Yeatman 1959, Edmondson 1959, Gurney, 1927 (Copepoda and Cladocera), Berzins 1960, Berzins and Pejler 1989 (Rotifera), Sars 1926 (Ostracoda) and Sars 1927, (Entomostraca).

Results and Discussion

There were 205 different zooplankton forms collected from El-Mex Bay belonging to 13 groups. Protozoa was the most diversified group 69 species and formed 34% of total zooplankton groups, followed by Copepoda, which was represented by 50 species in order to copepodite stages and nauplii that constituted 25%. Rotifera ranked the third diversified group formed 20 % and represented by 38 species besides their eggs and immature forms, Chordata represented by 9 forms while, Cnidaria, Mollusca and other Arthropoda represented by 6 forms for each one of them, Cypredina, Cladocera, and Annelida were represented by 12 forms, four to every single group. Two cirripedian forms and two Chaetognatha were recorded and finally one Porifera **(Figure 2)**. Some zooplankton species among the collected samples considered good bio-indicators on the prevailing environmental conditions.

The ecological study of rotifer assemblages in different world regions indicated that some rotifers have the ability to exist in polluted waters and are considered as pollution bio-indicators, like *Brachionus species and Polyarthra species* (Klimowicz, 1961, Aboul Ezz et al.,1996, Abo-Taleb, 2010 and Abdel Aziz, et al., 2011), or serve as indicators of trophic nature of the environment (Arora, 1966). The presence of *Brachionus species, Keratella cochlearis and Filinia* species in any water body is an indicator of eutrophy (Pejler, 1957) while *Filinia longiseta* was considered among pollution indicators (El-Bassat, 1995). All the species mentioned above were found in El- Mex Bay during the present study, thus confirming their classification as highly eutrophic and polluted waters.

In this investigation there was a notice that, the presence of eutrophication problem was always synchronistic with the presence of high numbers of the genus *Brachionus* and at low concentrations of phytoplankton (represented by chlorophyll-a) the average counts of this organism were shrunk as mention in the following **Table 1 and Figure 3**.

The genus *Keratella cochlearis* flourished at station I during autumn 2011 and winter 2012 (93 and 46 organisms/m^3), this station receives an enormous amount of agriculture and urban drain from El-Umoum Drain carried with high concentrations

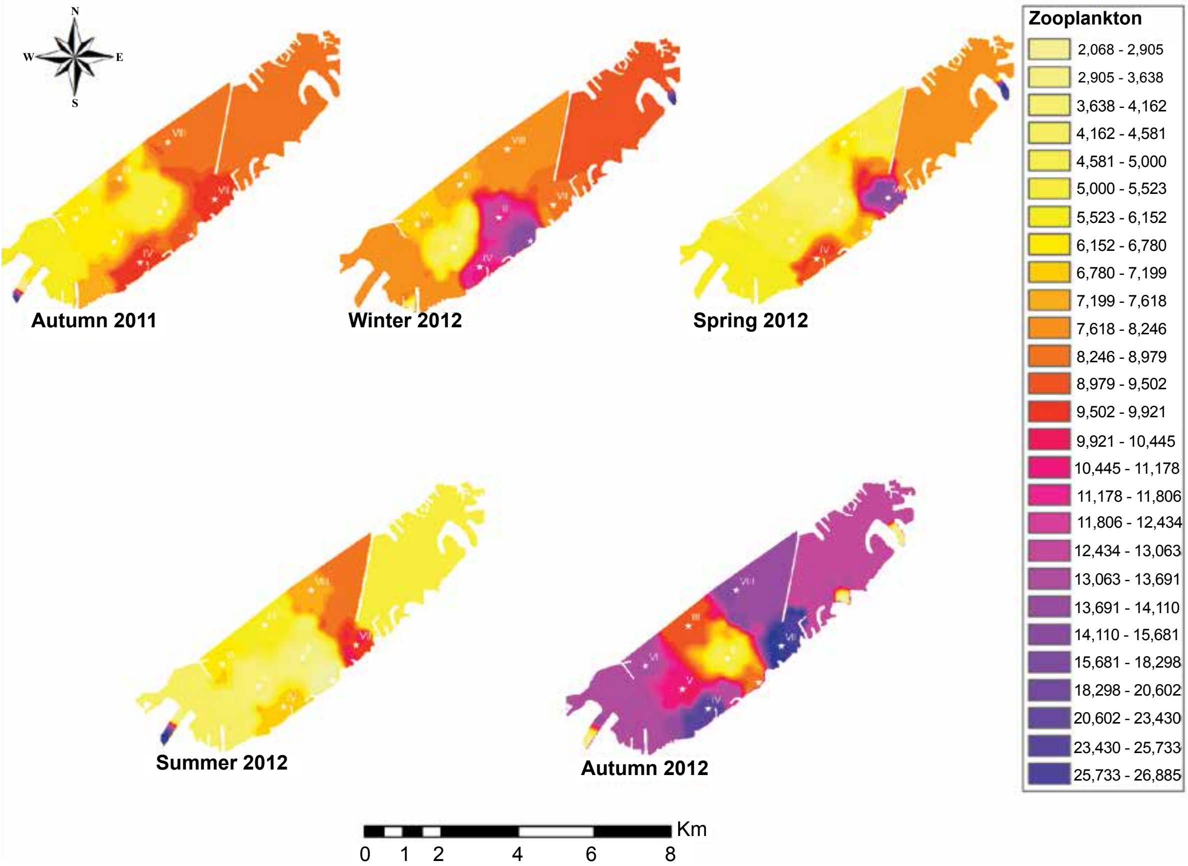

Figure 2: Temporal variations of zooplankton abundance at El-Mex Bay.

Table 1: The relation between Chlorophyll-*a* concentrations and average *Brachionus* counts.

	Autumn (2011)	Winter (2012)	Spring (2012)	Summer (2012)	Autumn (2012)
Chlorophyll-a	7.50	9.06	8.82	34.38	29.92
Average *Brachionus* counts oganisms/m^3	128	88	40	132	664

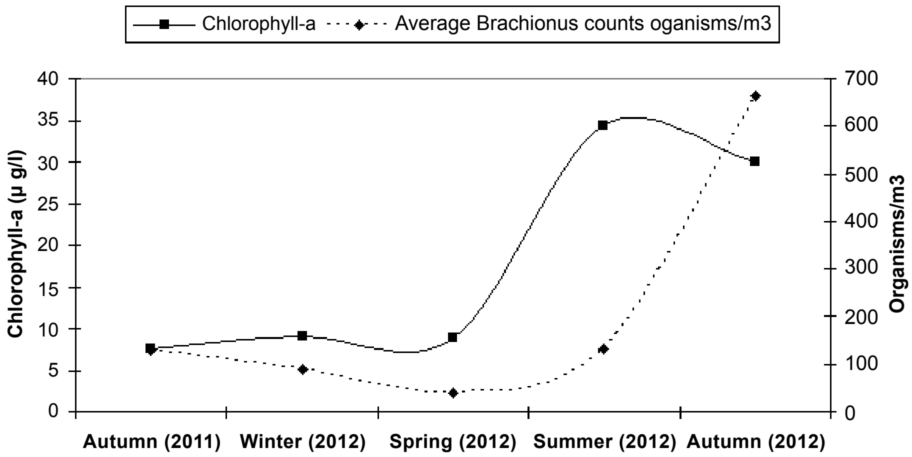

Figure 3: The relation between Chlorophyll-*a* concentrations (µg/l) and average *Brachionus* counts.

of nutrient salts provided suitable conditions that enhanced the growth of phytoplankton biomass and prevailing eutrophic conditions, this confirmed by the high values of chlorophyll-a that recorded at this stations during this two seasons (36.9 and 25.7 µg/l).

Filinia longiseta recorded in the bay at two seasons, the first was the winter at station I in front of El-Umoum Drain, station VII at the gate of Western Harbor with total numbers were 93 and 85 organisms/m^3 respectively, these two station showed the minimum salinity values during the whole sites and investigation period (6.2

and 7.8‰) and too dangerous acidic condition prevailing (pH 4.5 and 5.6) while the second season was the spring, this organism was also encountered at stations VII with total counts were 85 organisms/m^3 during this season, the pH value at this station was slightly acidic (7.1). This confirms that these organisms can use as indicators of the presence of fresh water source (either sewage drainage or others) in any marine ecosystem.

Water temperature changing problem

The water temperature showed the classical seasonal fluctuations Known to the Egypt's Mediterranean Coast (15-34ºC). The maximum value was reported in summer 2012 (32°C) and the smallest one in winter 2012 (14.2ºC) represented in **Figure 4**.

In temperate regions generally, the temperature rising causes diversity of organisms to be lesser **(Figures 5 and 6)**, except some groups which correlated directly with temperature increasing, the most common group in this case is rotifers which considered an indicator to pollution of marine environment and enhanced with temperature increasing as illustrated in **Table 2 and Figures 7-9)**. In this study there was an only exception noticed during the winter season because the effect of another variable, salinity, which decreased in this season enhanced the rotifers growth which considered at the almost freshwater organisms, this was combined with the increasing of the drainage from El-Umoum Drain and the fresh water from runoff.

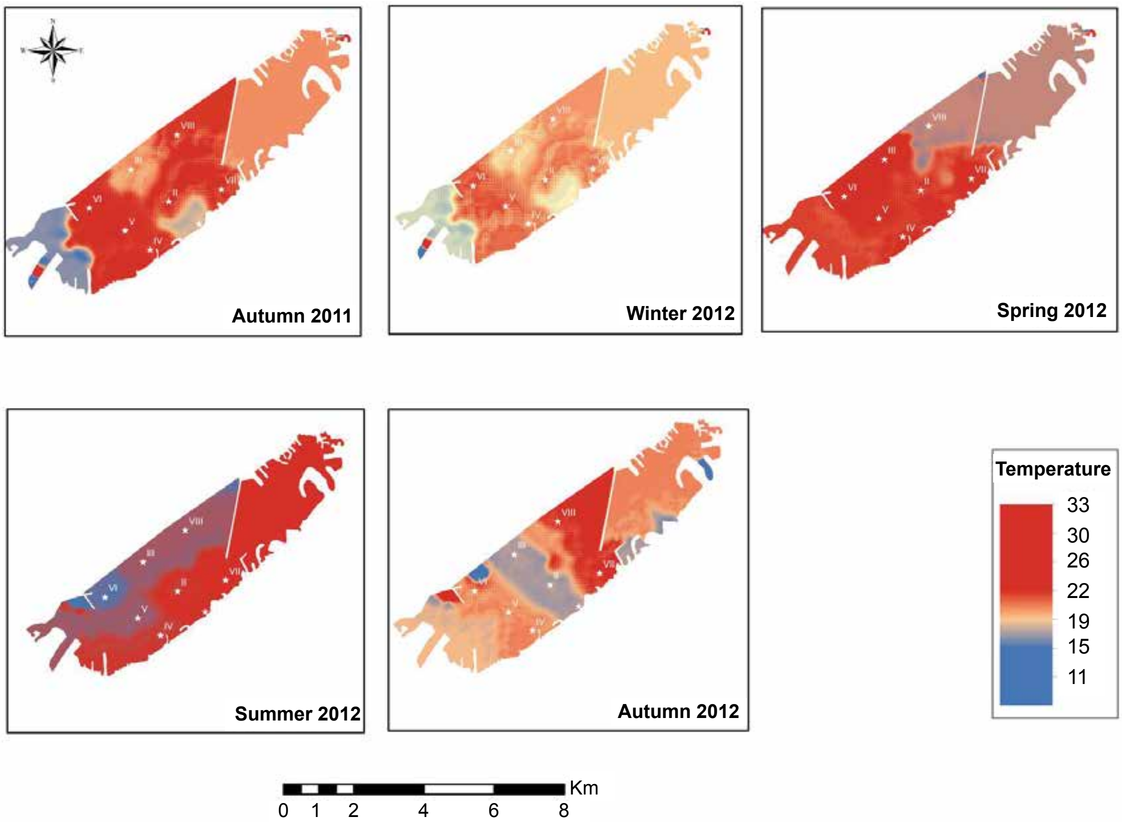

Figure 4: Seasonality changing in water temperature (°C) at different study areas.

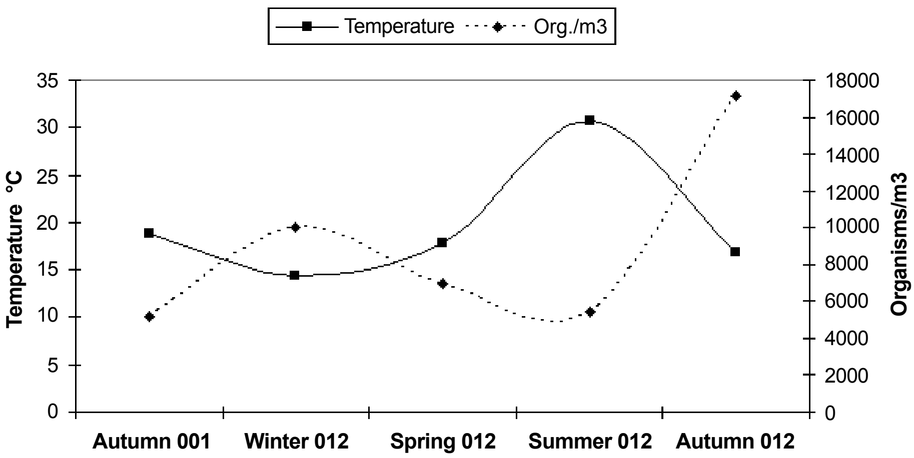

Figure 5: The seasonal variations of recorded water temperature (°C) along El- Mex Bay stations.

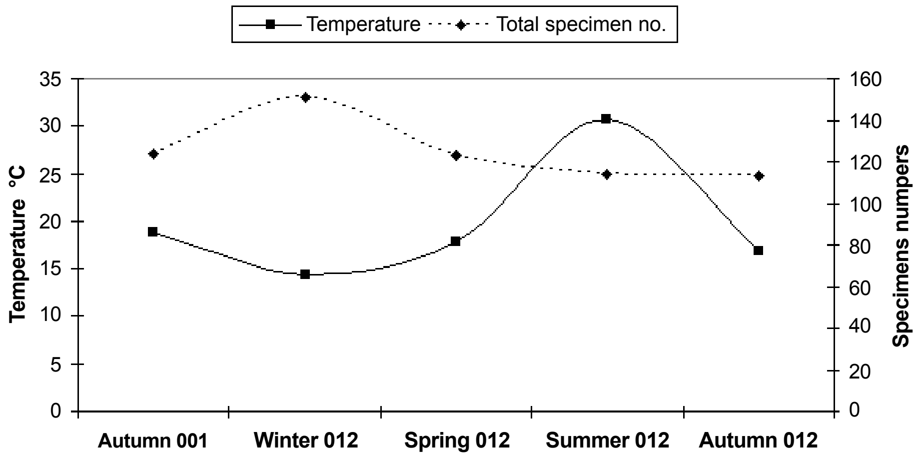

Figure 6: The relation between temperature (°C) and zooplankton diversity.

Table 2: The seasonal variations of temperature (ºC), salinity, zooplankton density, zooplankton diversity and roifer.

Average	Autumn 2011	Winter 2012	Spring 2012	Summer 2012	Autumn 2012
Temperature	18.75	14.39	17.89	30.68	16.88
Salinity	22.1	10.8	25.3	25.2	28.5
Total Org./m³	5180	10011	6971	5401	17111
Total specimen no.	124	151	123	114	113
Rotifera Org./m³	434	1421	734	1445	1353
Rotifer species No.	19	34	17	21	13

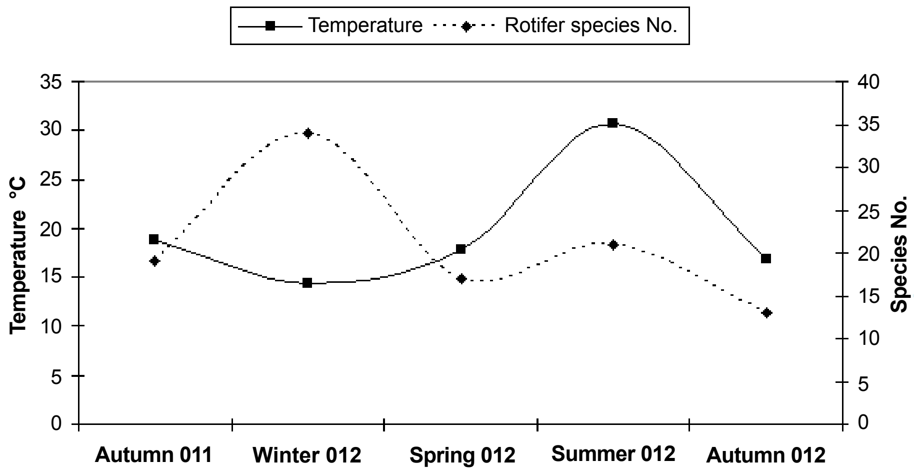

Figure 7: The relation between temperature values (°C) and rotifer diversity.

Bio-indicators of water quality

Protozoa occupied the 2nd order of abundance among zooplankton groups in El-Mex Bay contribution 15.6% of the total zooplankton counts (averaged 1440 organisms/m^3), predominated by ciliates. Protozoa are characterized by many specific structural and functional features, present an important ecological assemblage in aquatic ecosystem and play a crucial role in the function of microbial food webs in addition to their role as indicators of water quality (Xuet et al., 2008).

Ciliated Protozoa are considered as bio-indicators. The absence of these organisms indicates the presence of toxic substances, such as phenols, cyanides, and heavy metals. The presence of these organisms indicates oxygen deficiency, system overload, and putrefaction. An increased number of several different bacteria, the presence of Cyanophyta, Zooflagellate, and Ciliata, is an indication of water overloaded with organic matter, i.e. an indication of polysaprobic processes and oxygen deficiency (Németh-Katona, 2008). Some Protozoan species are considered as indicator of the pollution with sewage pathogens such as the genera *Euplotes, Centropyxis and Difflugia.*

Salinity changes bio-indicators

In the present study the maximum chlorophyll- a concentrations was recorded at station (I) 52.65 µg/l. The high concentration of Chl-a content recorded in the water is coincided with low salinity, high temperature and high values of nutrient salts, which reflects such eutrophication condition caused by drainage effluents **(Figure 10)**.

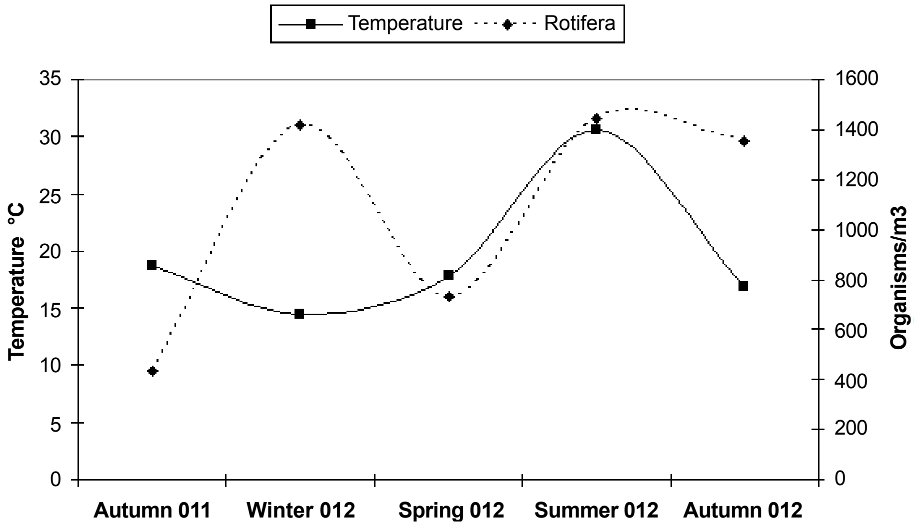

Figure 8: The relation between temperature (°C) and total rotifer counts (organisms/m^3) at different stations during the study period.

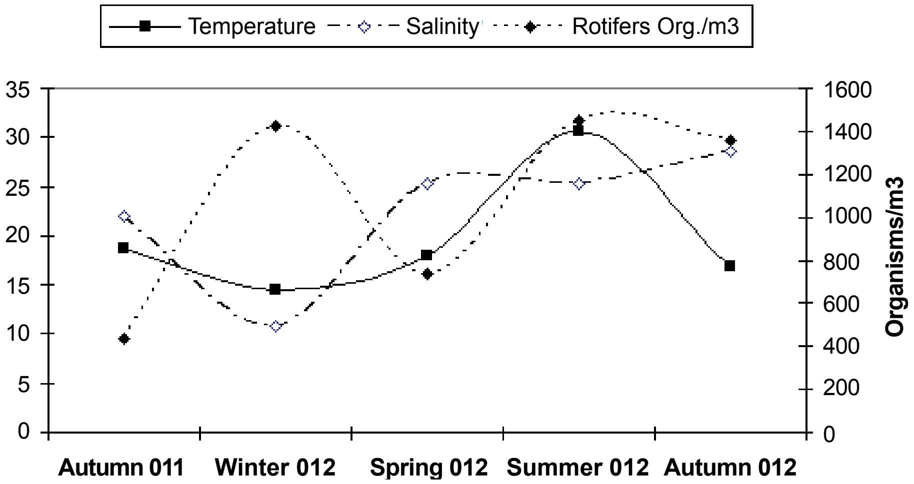

Figure 9: The seasonal variations of temperature (°C), salinity and total rotifer counts (organisms/m^3) relationship.

Protozoa community in El-Mex Bay is pronouncedly affected by the dispersion pattern of discharged waters. The water masses in the bay showed different communities, relative to the salinity differences. Higher values were particularly observed during winter 2012 (2272 organisms/m^3) while autumn 2011 displayed lower densities (519 organisms/m^3). Protozoa reached the maximum density at station VII during spring 2012 (5860 organisms/m^3) due to the predominance of *Centropyxis aculeate, Difflugia oblonga, Favella azorica, Tintinnopsis beroidea, T. campanula, T. cylindrical, and T. lobiancoi* were important contributors to the *tintinnids* population at most stations in different seasons.

Station VII located in front of the Western Harbor gate at the bay side, the domination of protozoa at this location reflect the effect of the western current direction inside the bay which moving the water from Al-Umoum Drain passing by station I and right direction into station VII, this was coincident with the well-known fact that, Western Harbor receive the drainage from two sources (Al-Mahmodeia and El-Nobareia canals) including industrial, domestic and agriculture wastes with high amounts of nutrient salts which enhanced the flourishing of protozoa and other pathogens this water passed directly from the western harbor into the open Mediterranean water through El-Mex Bay, the first affected site is VII that located at the connection between the harbor gate and the bay.

All copepod organisms observed in El-Mex waters are eurythermic and euryhaline forms living under a range of water temperature between 14.39-30.68ºC and water salinity between 10.82-28.53%.

Water acidification problem and Pteropods as bio-indicators

The absence of pteropod organisms from any marine water system considered a strong signal on water acidification. The results indicated that pteropods organisms correlated positively with pH values recorded their highest counts (Average 44 organisms/m^3) at the highest measured pH at the investigation period (7.76) **(Figures 11, 12 and Table 3)**, the prevailing acidic conditions in the bay stand as a barrier to abundance, diversity and dispersal of this organisms which recorded in lower densities and diversity (two species only, *Creseis aciculate* and *Limacina inflate*) coincident with lower values of water pH were with

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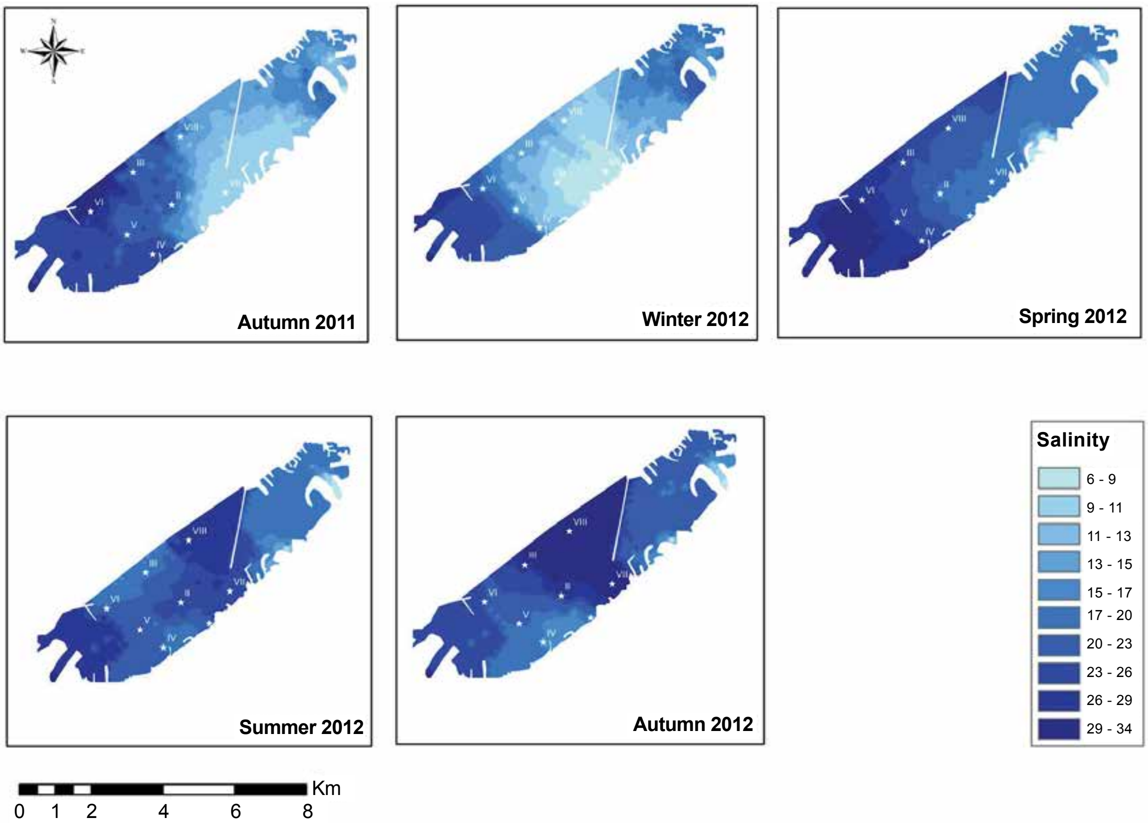

Figure 10: Seasonally changings of salinity at different stations.

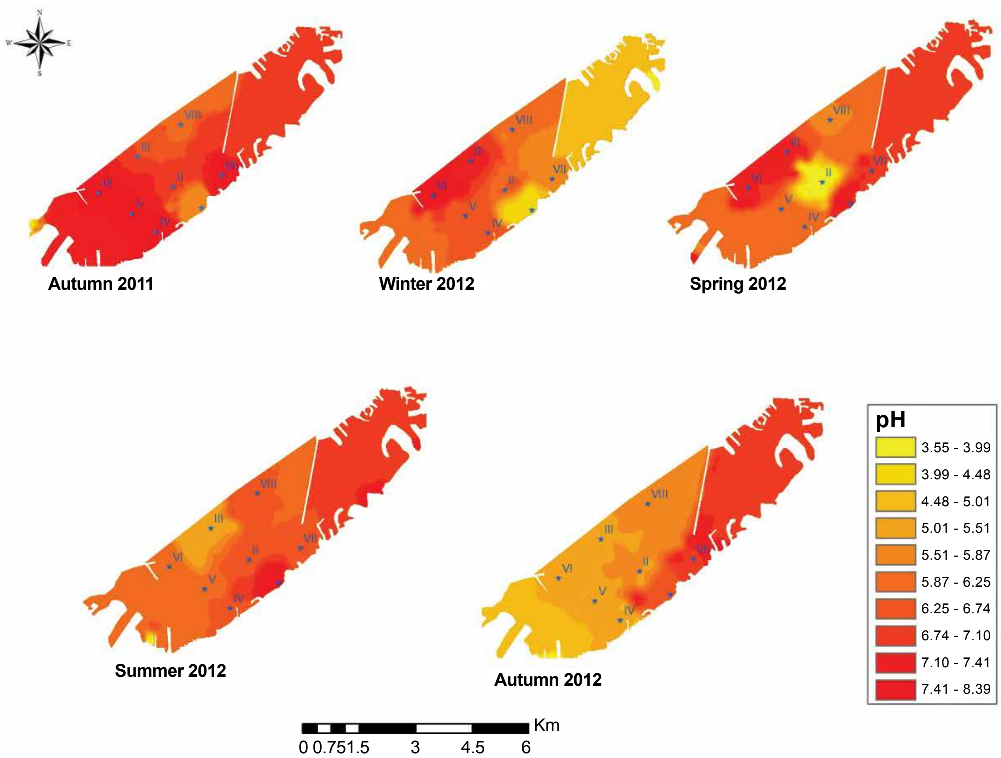

Figure 11: Changing of pH values at the bay during the study period.

decreasing in pteropods numbers this was a result of the fact that, Pteropods are likely to be the plankton organism highly sensitive to environmental condition change in pH (Russell, 1935), because the composition of their shells which mainly of aragonite, will be subject to the increased dissolution under more acidic conditions.

Pteropods would not be able to adapt quickly enough to live

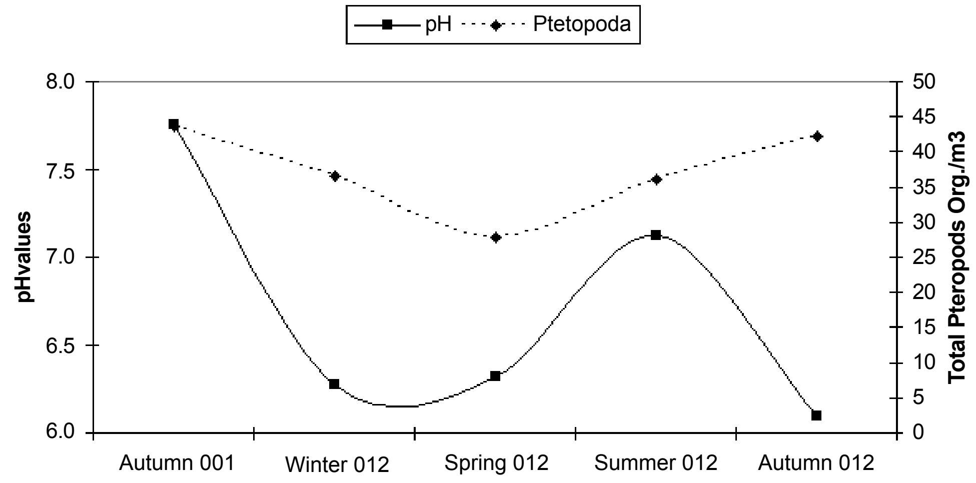

Figure 12: Seasonal variations of pH and Pteropods total counts.

Table 3: The seasonal variations of pH and Pteropoda species.

Pteropoda species Total counts	Autumn 2011	Winter 2012	Spring 2012	Summer 2012	Autumn 2012
Creseis acicula	44	9	12	18	41
Limacina inflata	0	28	16	18	1
Sum.	44	37	28	36	42
pH	7.76	6.28	6.32	7.12	6.09

in under wet conditions. Pteropods, with their aragonite shells, are highly vulnerable, while coccolithophorids, foraminifera and some crustaceans, with their calcite shells and lithe, are less vulnerable. Pteropods are likely to decline and may eventually disappear in response to ocean acidification (Orr et al*.,* 2005). The direct effect of ocean acidification on calcifying zooplankton will be to partially dissolve their shells, increasing shell maintenance costs and reducing growth. Foraminifera contribute a significant proportion of the sediments are highly affected Hallegraeff, (1984). pH decreasing in the bay was a consequence of growing heavy industries such as chemicals, textile, tanneries, industrial dyes, ink, petroleum refining, metal processing industries (Aboul Ezz et al., 2014 and Hendy et al., 2015).

Declining pH may also alter the growth rates of photosynthetic organisms in the bays and harbors the Mediterranean Sea. In particular, changes in pH will affect nutrient uptake kinetics, altering rates of growth and photosynthesis. Changes may also occur in phytoplankton cell composition **(Table 4 and Figure 13)**, which could affect their nutritional value for higher trophic levels (McKinnon et al*.,* 2007).

Eutrophication problem and its bio-indicators

The zooplankton abundance is primarily controlled by fluctuations in the physical environment and nutrient concentrations, which cause high seasonality among samples. Due to pollution and eutrophication, many species were favored while rare species became extinct. It is clear that for a better understanding of the ecosystem of El-Mex Bay, long-term monitoring data on the relevant physico-chemical and biological components and on the quality and quantity of zooplankton is essential.

The sensitivity of rotifer and other zooplankton species to some physical and chemical conditions allow them as bio-indicators of aquatic ecosystem. Being rather tolerant to different environmental conditions, many rotifer species are good indicators of water quality and can be used for the ecological monitoring of water bodies.

With increasing phytoplankton biomass, the abundance of phytoplankton cause herbivorous zooplankton species to increase (Shiganova et al., 1998). Due to pollution and eutrophication the copepod *Acartia clausi was favored, while rare species became extinct (*Isinibilir et al*.,* 2008). Zhenbin et al*.,* 2008 reported that zooplankton community structure changed from eutrophic-indicator genera (*Brachionus, Polyarthra and Keratella)* **(Figure 14)** to genera more characteristic of oligotrophic conditions (*Tintinnopsis and Acanthocyclops)*. The results indicated this idea as shown in the following **(Figures 15, 16 and Table 4)**, rotifer species flourishing in eutrophic conditions with high chlorophyll values; on the other hand *Tintinnopsis* species **(Tables 5, 6** and **Figure 14)** flourishing at low concentrations of primary productivity and oligotrophic conditions, this appeared in the reverse correlation between *Tintinnopsis* counts and chlorophyll-a concentrations.

Nematodes represented by 0.7% of the total zooplankton with an average of 65 organisms/m^3. Németh-Katona (2008) considered that the presence of nematodes is an indication of the final stage of contamination with sewage, the absolute putrefaction of water: hydrogen sulfide indicator.

Ciliated Protozoa are considered as bio-indicators. The absence of these organisms indicates the presence of toxic substances, such as phenols, cyanids, and heavy metals. The presence of these

Table 4: The relation between seasonal variations of pH and Chlorophyll-a (µg/l).

	Autumn 2011	Winter 2012	Spring 2012	Summer 2012	Autumn 2012
Chlorophyll-a (µg/l)	7.50	9.06	8.82	34.38	29.92
pH	7.76	6.28	6.32	7.12	6.09

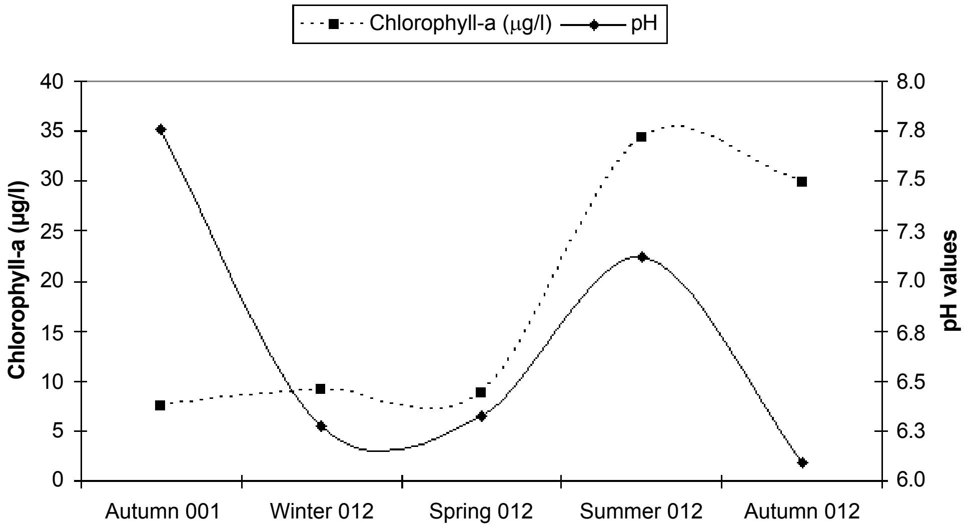

Figure 13: The relationship between pH seasonality and Chlorophyll-a (µg/l).

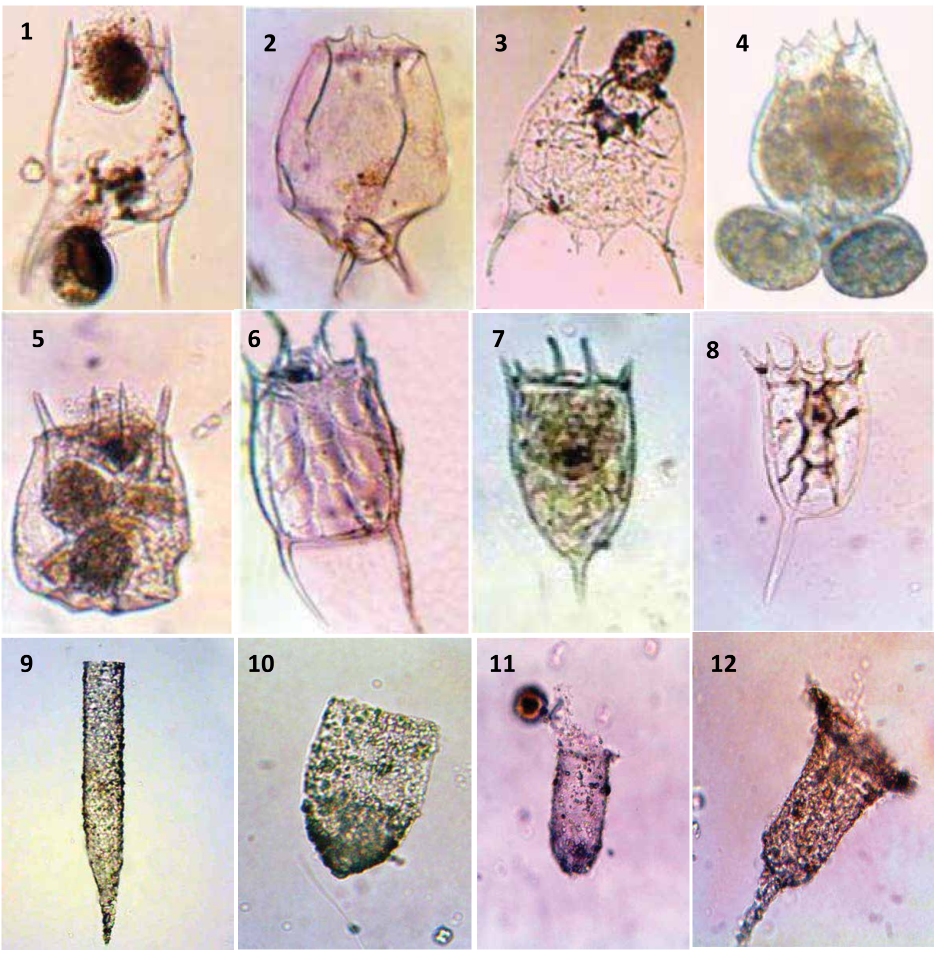

Figure 14: Some rotifers and ciliates species (1) *Brachionus calyciflorus*, (2) *Brachionus caudatus*, (3) *Brachionus quadridentatus*, (4) *Brachionus urceolaris*, (5) *Brachionus budapestinensis,* (6) *Keratella quadrata,* (7) *Keratella cochlearis*, (8) *Keratella tropica*, (9) *Tinnopsis radix* (10) *Tintinnopsis acuminate,* (11) *Tintinnopsis beroidea* and (12) *Tintinnopsis campanula.*

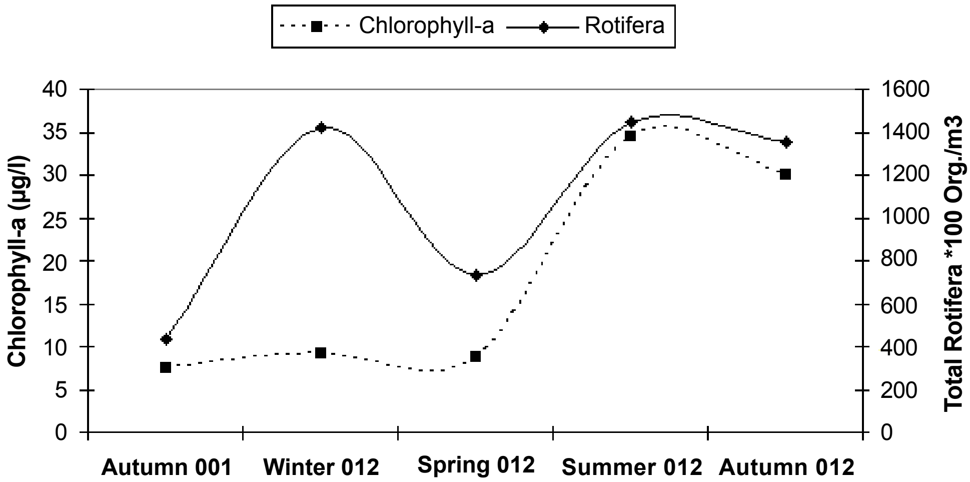

Figure 15: The relation between Chlorophyll-a (µg/l) concentrations and rotifer.

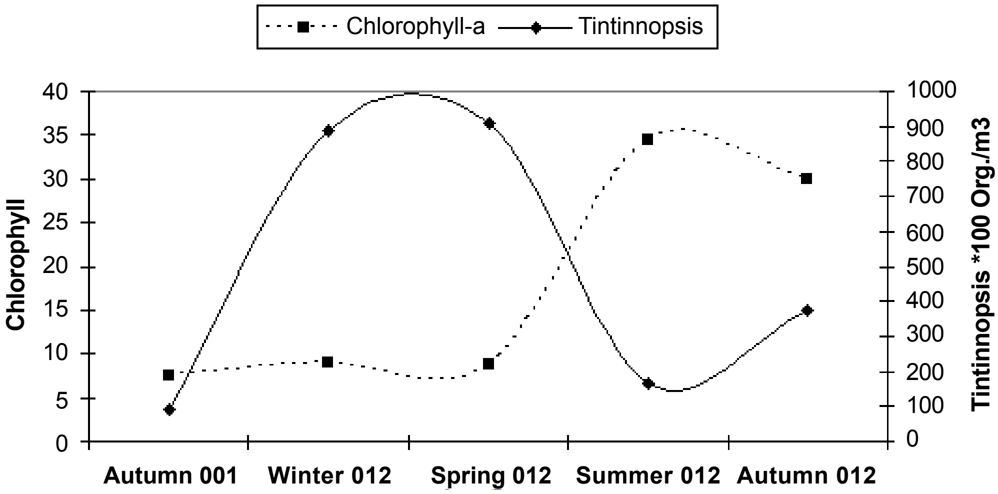

Figure 16: The relation between Chlorophyll-a (µg/l) concentrations and Tintinnopsis.

Table 5: The relation between seasonal variations of Chlorophyll-a (µg/l), rotifer and Tintinnopsis.

	Autumn 2011	Winter 2012	Spring 2012	Summer 2012	Autumn 2012
Chlorophyll-a (µg/l)	7.50	9.06	8.82	34.38	29.92
Rotifera organisms/m^3	434	1421	734	1445	1353
***Tintinnopsis* organisms/m^3**	91	887	911	166	377

organisms indicates oxygen deficiency, system overload, and putrefaction. An increased number of several different bacteria, the presence of Cyanophyta, Zooflagellata, and Ciliata, is an indication of water overloaded with organic matter, i.e. an indication of polysaprobic processes and oxygen deficiency (Németh-Katona, 2008). Some Protozoan species **(Figure 17)** are considered as an indicator of the pollution with sewage pathogens such as the genera *Euplotes*, *Centropyxis* and *Difflugia*. These freshwater protozoan species that encountered in this study confirmed the contamination of the by sewage, this agree with (Froneman, 2004) who mentioned that The presence of protozoan freshwater species in marine coastal areas are considered a biomarkers on the presence of freshwater discharge into these areas, and according to types of this species can determine the source of water discharged neither rivers, lakes, drainage or sewage.

Role of ballast water in species transmission

Some species known to be characterize the clear open deep water like *Archiriscus hertwigi* and *Myxosphaera coerulea*, **(Figure 18)** these two species were encountered at the bay during this study and didn't record before from the shallow water of Egyptian Mediterranean Coast. After investigations, there is only one reason supposed to discuss this phenomenon, it is the mechanical transmission through the ballast water. It is well known fact that, El-Mex Bay lied between two of the biggest harbors at the Egyptian coasts, many ships transport some heavy industrials like metals includes irons products and others, these vessels discharge the ballast water directly into the bay before there entrance to the harbors including many invading organisms from different regions and origins. Ballast water is considered one of the primary transport vectors for the transfer in order to

Table 6: List of bio-indicator zooplankton species.

Phylum: Amoebozoa	
Centropyxis aculeate (Ehrenberg, 1832) Stein, 1859	**Phylum: Nematoda**
Difflugia oblonga Ehrenberg, 1832	Free living nematodes
Phylum: Arthropoda	**Phylum: Rotifera**
Acartia (Acartiura) clause Giesbrecht, 1889	*Brachionus budapestinensis* Daday, 1885
Acanthocyclops Kiefer, 1927	*Brachionus calyciflorus* Pallas, 1766
Phylum: Ciliophora	*Brachionus caudatus* Barrois and Daday, 1894
Euplotes O.F. Müller, 1786	*Brachionus quadridentatus* Hermann, 1783
Favella azorica (Cleve, 1900) Jörgensen, 1924	*Brachionus urceolaris* Müller, 1773
Tintinnopsis acuminate Daday, 1887	*Filinia longiseta* Ehrenberg, 1834
Tintinnopsis beroidea Stein, 1867	*Keratella cochlearis* Gosse, 1851
Tintinnopsis campanula Ehrenberg, 1840	*Keratella quadrata* Müller, 1786
Tintinnopsis cylindrical Daday, 1887	*Keratella tropica* Apstein, 1907
Tintinnopsis lobiancoi Daday, 1887	*Polyarthra* Ehrenberg, 1834
Tinnopsis radix Imhof, 1886	**Phylum: Sarcomastigophora**
Phylum: Mollusca	*Archiriscus hertwigi* Haeckel 1887
Creseis aciculate (Rang, 1828)	*Myxosphaera coerulea* Schneider, 1858
Limacina inflate d'Orbigny, 1834	

Figure 17: (1 and 2) *Euplotes* sp. (3) *Centropyxis aculeate* (4) *C. ecornis* (5) *Difflogia urceolata.*

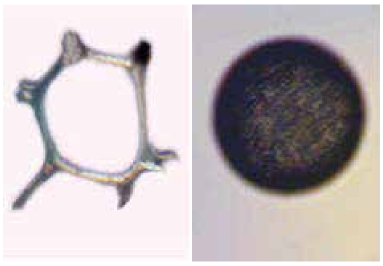

Figure 18: (1) *Archiriscus hertwigi* and (2) *Myxosphaera coerulea*.

the introduction of non-indigenous zooplankton (DiBacco et al., 2012). It may also be a result of the prevailing northeastern current at the Egyptian Mediterranean Coast that can bring the open water organisms into the shallow areas.

Environmental management

- It is necessery to enhance the using of bio-indication concept for monitoring the water characteristics and quality in different aquatic habitats due to their consequences on the other organisms of different food webs that will have impacts on the fisheries.
- Prevent the drainage of the acidic water that have bad effects on the coastal zones like; corrosin, erosion of the coast and also the destoration of the aquatic resources including molluscan shells that interact with acids.
- Improvement of the physical and chemical properties of the water that drained into the coastal areas and ports from different land based sources including factories cooling water, urban and agriclutural drainage.
- Construction of periodic database contiuning checklist of fauna found in ports and bays to follow the invasive species that transformed by the ballast water and their effects on theie interaction with the natives and their effects on the local environment.

Conclusion and Recommendations

El-Mex Bay is located under stress condition due to the discharge of untreated domestic, industrial and agricultural effluents, beside the effect of ships movements from and to the harbors. Therefore, the condition at this bay is eutrophic and completely different from the open sea water. These are expected to continue and added to climatic influence of increasing temperature and rising sea level in the future.

Rotifer and other zooplankton species sensitivity to some physical and chemical conditions allow using them as bio-indicators of aquatic ecosystem saprobility. Being rather tolerant to different environmental conditions, many rotifer and ciliate species are good indicators of water quality and can be used for the ecological monitoring of water bodies.

If we found indications on the presence of any water problems that mentioned, we can gain a prediction on the consequences risks that will happen to the aquatic environment and the natural resources, so we must give a recommendation to the policy makers to prevent such risks. Author think this is one of the main objects of this manuscript.

It is recommended that the integrated coastal zone management approach (ICZM) is a necessary tool for long-term sustainable development of the coastal area in Egypt. The severe land-use interference and the large population involved and conflicting requirements for development make it necessary to use decision-support systems based on GIS for future development and planning of these areas.

Short-term adaptation measures are also necessary for the frame of the no regrets policy. These involve beach nourishment, upgrading awareness and building institutional capability in ICZM.

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