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Impact of Nile River outflow on Water Quality and Bacterial Diversity of Marine Water of the Egyptian Coast of the Mediterranean Sea

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Abstract

In comparison between the eastern and western coasts of the Mediterranean Sea of Egypt, water samples were collected seasonally from Port Fouad City and Damietta branch of the Nile River during four successive seasons. Water samples were tested for some physical and chemical parameters including: water turbidity, TSS and chlorophyll-a as well as the determination of water salinity, pH, concentrations of some nutrient salts and trace metals such as: Cl^-, Na^+, K^+, Mg^{+2}, Ca^{+2}, PO_4^{-3}, NO_3^-, SO_4^{-2}, Fe^{+3}, Cu^{+2}, Zn^{+2} and Mn^{+2}. Total bacterial counts of collected water samples were determined as well as biochemical identification of 17 bacterial genera. Results showed that the western coast of the Egyptian Mediterranean Sea recorded higher salinity values and higher concentrations of Cl^- ions than those recorded in the eastern coast represented in Port Fouad City. Water turbidity values showed strong positive significant correlations between Alexandria and Port Fouad as well as Port Fouad and the Nile River while non-significant correlations occurred between water turbidity of Alexandria site and the Nile River site.

Keywords: Nile River, Mediterranean Sea, bacteria, nutrient, trace metals.

Introduction

Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. Rather, it is variable in both time and space and requires routine monitoring to detect spatial patterns and changes over time [1]. There is a range of chemical, physical, and biological components that affect water quality and hundreds of variables could be examined and measured [1].

The Mediterranean Sea constitutes the largest area (2969000 km^2) and deepest average of depth (1460 m) enclosed Sea on Earth [2]. In the West, it is connected to the Atlantic Ocean via the Strait of Gibraltar, in the Northeast through the Dardanelles to the Black Sea and the Sea of Marmara, while the Suez Canal in the Southeast links the Mediterranean Sea to the Red Sea and the Indian Ocean [2].
The entire Mediterranean Sea is oligotrophic [3]. One major characteristic of the Mediterranean Sea is a strong West-East gradient regarding

surface nutrient concentrations with a sharp change at the transition between the two basins so that the eastern basin is ultra-oligotrophic whereas the western basin is oligotrophic [4].

The modified Atlantic water (MAW) outflows along the African coast off the Nile River, then around Cyprus [5]. Therefore the Nile River water spread over the sea surface and are deflected eastward along the coast toward the Levantine Sea [6].

The Egyptian Mediterranean coast lies at the South East sector of the Levantine sub-basin, from longitudes 25°30´ E to 34° E and extends northwards to latitude 33° N [6]. The salinity of the Mediterranean Sea is uniformly high throughout the basin, surface water averages about 38% except the extreme western parts, and the salinity can approach 40 % in the Eastern Mediterranean during the summer season; the salinity of seawater is made up of all the dissolved salts. Six major ions make up 99 % of the total dissolved salts in seawater; they are Na^{+}, Cl^{-}, and $SO4^{-2}$, Mg^{+2}, Ca^{+2} and K^{+} [6].

Nile River is one of the most known and important rivers in the world which its water outflows in the Mediterranean Sea, it is one of the world longest rivers and is the donor of life to Egypt and represents the principle freshwater resource that meets nearly all demands for drinking water and irrigation [7]. The Nile River outflows from south to north with 6,850 km long and over 35 degrees of latitude, its basin covers approximately 10 % of the African continent with an area of 3106 Km^{2} and spreads over 10 countries from Uganda in the south to Egypt in the north [8]. In Egypt, at the north of Cairo at Delta Barrage, the Nile River is branched into Damietta and Rosetta branches [9].

The aim of this study is to assess the impact of Nile River outflow on water quality and bacterial diversity of marine water of the Egyptian Coast of the Mediterranean Sea in Port Fouad City, Alexandria City and Damietta branch of the Nile River.

Materials and methods

Sampling sites

Marine water samples were collected from Port Fouad City with meridians of 31°14’56” north and latitudes of 32°19’39”east located at the Egyptian coast of the Mediterranean Sea and Alexandria City with meridians of 31°12’22” north and latitudes of 29°53’35” east located at the western Egyptian coast of the Mediterranean Sea.

While riverine water samples were collected from Damietta branch of the Nile River with meridians of 31°25’10.2’’ north and latitudes of 31°48’29’’ east.

Sampling

Composite surface water samples from Alexandria, Port Fouad and the Nile River sites were collected during the duration of four successive seasons of autumn 2014 to summer 2015. The water samples were collected in glass sterilized jars and transferred to the laboratory in ice box at 4°C further analysis.

Water quality analysis

Marine and riverine collected water samples were investigated for physically, chemically and bacteriologically properties.

Physical analysis

Physical analysis involved determination of water temperatures, water turbidity and TSS. Temperatures of water samples were measured in situ by submerging a graded -10:110 glass mercury thermometer in the water to more than 5 cm depth, turbidity of water samples were measured using Turbidimeter (LW-TN 3024) and results were recorded as NTU units. TSS concentrations were determined using method of Degen and Nussberge [10].

Chemical analysis

Chemical analysis of water samples involved determination of water salinity values, pH values, chlorophyll concentrations and concentrations of some nutrient salts and trace metals including: Cl^{-}, Na^{+}, K^{+}, Mg^{+2}, Ca^{+2}, PO_4^{-3}, NO_3^{-}, SO_4^{-2}, Fe^{+3}, Cu^{+2}, Zn^{+2} and Mn^{+2}.

Water salinity was measured using Master Refractometer ATAGO. While chlorophyll-a (Chl.a) concentrations were determined by filtration of a known volume of water, addition of $MgCO_3$, grounding the filter papers and extraction overnight in 90% acetone at 4°C, the concentrations were measured spectrophotometrically [11] using UNICO spectrophotometer. Cl^- concentrations were determined according to Mohr's titration method with the use of 0.1M of $AgNO_3$ solution and 5% di-potassium chromate indicator. Ca^{+2} and Mg^{+2} were determined using the titrimetric method of 0.01M EDTA- disodium salt solution in presence of Eriochrome Black T (EBT) and muroxide indicators [12]. Concentrations of SO_4^{-2} were determined according to the turbidity method which involves addition of $BaCl_2$ crystals to ensure fine and stable suspension of $BaSO_4$ at a pH of about 4.8 and the degree of the turbidity was measured spectrophotometrically at 490 nm [13] while concentrations of Na^+ and K^+ were determined using the flame photometric method [14]**.** Dissolved nitrates were determined spectrophotometrically using powdered cadmium to form a highly colored azo dye which was measured spectrophotometrically at 540 nm [15] while dissolved phosphates were determined using Murphy and Riley's molybdenum blue (MB) method [16] and concentrations were measured spectrophotometrically at 660–880 nm. Trace metals of Fe^{+3}, Cu^{+2}, Mn^{+2} and Zn^{+2} were determined using the atomic absorption method [17].

Total bacterial counts

Total bacterial counts of water samples were determined using acridine orange technique of 0.1 % w/v concentration and epifluorescence microscopy [18] Hobbie *et al.,* (1977). The total bacterial counts were determined according to the law of ($N = S_1$ a n /v S_2) [19] Whereas; N was the bacterial number, S_1 was the area of the filter in μm^2, a was the number of cells averaged of all fields, n was the index of breeding water samples ml, v was the volume of suspension that was filtered in ml, S_2 was the area of the microscopic field of view in μm^2.

Identification of bacterial genera

Bacterial isolates of marine and riverine water samples were morphologically and biochemically identified at the genus level according to characteristics stated in Bergey's Manual of Systematic Bacteriology [20-23].

Statistical analysis

SPSS 16.0 was used for the correlation tests.

Results and discussion

Physical results

The temperature range of Alexandria, Port Fouad and the Nile River water samples agreed with the seasonal variation of surface water temperature of the Levantine basin ranging between 14° C – 30 °C [24]**.** Water turbidity (Fig. 1) recorded the highest values during winter season which were 12.26, 17.45 and 10.54 NTU in water samples of Alexandria, Port Fouad and the Nile River, respectively. The highest values coincided with the turbulence of the coastal water, wind and wave action during winter season [25].

TSS results (Fig. 2) showed negative correlations (r = - 0.327) between water samples of Alexandria site and Port Fouad site whereas during autumn seasons, the highest concentrations of TSS were recorded in Port Fouad water samples and the lowest concentrations were recorded in Alexandria water samples.

The highest concentration of Chl.a might be attributed to higher concentrations of PO_4^{-3} and lower concentrations of NO_3^-, and the same findings were reported [26] as well as the higher levels of pH [27]. Similarly, TSS results showed a negative correlation (r = - 0.327) between the water samples of Alexandria site and Port Fouad site.

Alexandria water samples demonstrated the highest Chlorophyll-a concentrations (Fig. 3) during the warm seasons, in contrary; Port Fouad water samples demonstrated the highest concentrations during the cold seasons which agreed with previous studies [28]. Accordingly, values of Chl.a showed strong negative correlation (r = - 0.984) between readings of Alexandria and Port Fouad sites during the seasonal duration of autumn 2014 season to summer 2015 season. Negative correlations were recorded between results of TSS and chlorophyll-a in water samples of Port Fouad and the Nile River.

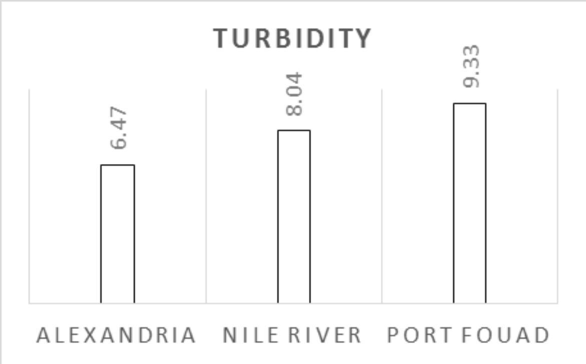

Fig. 1 Seasonal means of water turbidity in (NTU).

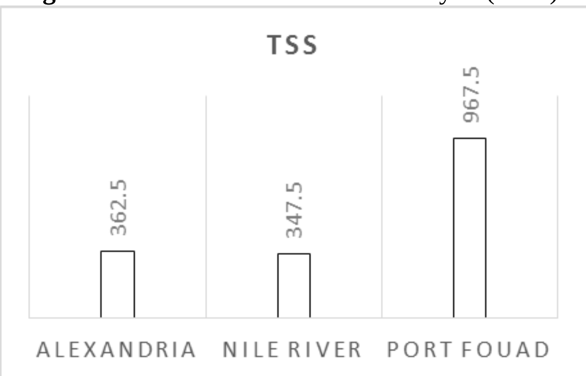

Fig. 2 Seasonal means of total suspended solids (TSS) in mg/l

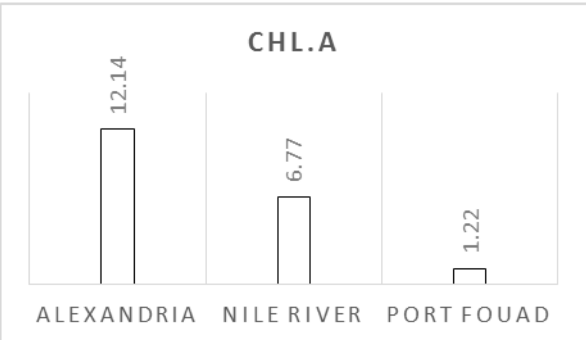

Fig. 3 Seasonal means of (Chl.a) (µg/l) in water samples of Alexandria, the Nile River and Port Fouad.

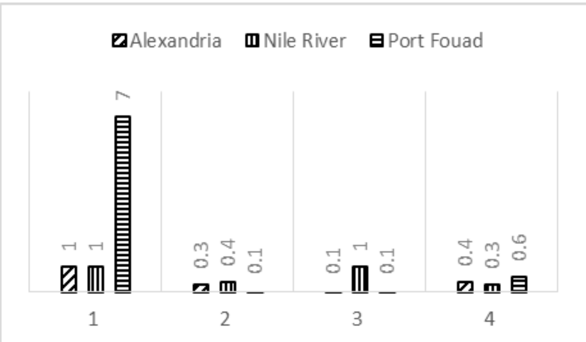

Fig. 4 Total bacterial counts of water samples in ($\times 10^8$ cell/ml) of Alexandria, Port Fouad and the Nile River sites during four successive seasons (1 - 4).

Chemical results

During the four successive seasons of the study, it was noticed that water samples of Alexandria site recorded higher salinity values than those recorded in water samples of Port Fouad site which might be attributed to the outflow of riverine water of the Nile River to the eastern Mediterranean coast of Egypt [8].

The seasonal mean of water salinity of Alexandria was 46.25% while in Port Fouad water samples was 38.75%. The results showed that autumn season recorded the lowest water salinity in Port Fouad water samples (table 1). The rise in salinity values in Port Fouad water samples during the three successive seasons of winter, spring and summer might be attributed to the circulation of the Suez Canal which is time dependent [29] whereas during winter to early summer water current flows from the Red Sea to the Mediterranean Sea [29]. Water salinity values of Alexandria water samples showed sharp increase during summer 2015 season than previous three seasons of the present study which was attributed to the low rainfall and high temperature and evaporation [30].

Water salinity values of the Nile River were the lowest amongst other sites where it was 17 % during autumn, winter and spring seasons while it was raised to 20 % during summer 2015 season.

Port Fouad site demonstrated the highest concentrations of $PO4^{-3}$ which was 0.825 mg/l during winter season while Alexandria site recorded the highest concentrations of NO_3^- which was 14.7 mg/l during summer season as indicated in (table 1). Nile River water samples recorded relatively closer concentrations of $PO4^{-3}$ to those recorded in Port Fouad water samples and higher concentrations of NO_3^-. The high concentrations of NO_3^- might be attributed to the oxidation of ammonia to nitrite and subsequently to nitrate during summer 2015 season [31] in water samples of Alexandria and Port Fouad while the low concentrations which were recorded during spring season were attributed to the uptake of nutrients by the phytoplankton [32]. The observed variation in the concentrations of $PO4^{-3}$ in water samples of Port Fouad and Alexandria sites might be attributed to its concentrations in the freshwater that mixes with the seawater [31]**.** Therefore, concentrations of PO_4^{-3} in water samples of Port Fouad and the Nile River sites were more closely related than those between Port Fouad and Alexandria sites. The lowest concentrations of PO_4^{-3} in the water

samples of Port Fouad and Alexandria sites during the warm seasons might be attributed to the uptake of nutrients by the phytoplankton [32].
pH values remained at the alkaline range of (7.53 – 8.59) during the four successive seasons of the present study and relatively close means in water samples of Alexandria, Port Fouad and the Nile River were recorded as 7.89, 8.11 and 7.95 respectively.
On the other hand, concentrations of Fe^{+3}, K^{+}, SO_4^{-2}, Na^{+}, Zn^{+2} and NO_3^{-} showed strong positive significant correlations between water samples of Alexandria site and Port Fouad site. Therefore, water samples of Port Fouad and Alexandria sites recorded higher and similar concentrations of Cl^{-}, Na^{+}, K^{+} and SO_4^{-2} than those recorded in water samples of the Nile River. Concentrations of these nutrient salts in marine water samples of both Port Fouad and Alexandria sites agreed with those concentrations mentioned in previous studies of seawater and the eastern Mediterranean Sea [33].
The lowest concentrations of K^{+} ion in the water samples of Alexandria, Port Fouad and the Nile River during the warm seasons might be attributed to the consumption of K^{+} by the phytoplankton, indicating the important role of K^{+} ion as an important limiting fertilizer for the growth of phytoplankton organisms in natural water systems at concentrations above 0.7 µmol/l [34].
Cl^{-} demonstrated the highest concentrations amongst other nutrient salts with seasonal means of 22048 mg/l, 21545 mg/l and 12266 mg/l respectively in water samples of Alexandria, Port Fouad and the Nile River. The highest concentrations were recorded during summer season in water samples of Alexandria and the Nile River which were 28809 mg/l and 17904 mg/l respectively, while in case of Port Fouad, it was during spring season and it was 24534 mg/l. Mg^{+2} demonstrated the second highest concentrations after Cl^{-} whereas the seasonal means of Alexandria, Port Fouad and the Nile River were 915.35 mg/l, 1131.1 mg/l and 660.75 mg/l respectively.
Calcium is considered as the most changeable major cation in marine environment since a noticeable portion of its content is used off by marine organisms especially during spring blooming period [6]. Therefore, much lower concentrations than Mg^{+2} were recorded in water samples of Alexandria, Port Fouad and the Nile River sites with seasonal means of 273.45 mg/l, 268.5 mg/l and 227.1 mg/l respectively.
The highest concentrations of $SO4^{-2}$ were mostly recorded during winter and spring seasons while autumn and summer seasons recorded relatively lower concentrations in water samples of Alexandria, Port Fouad and the Nile River sites whereas the seasonal means were 157.125 mg/l, 125.25 mg/l and 25.125 mg/l respectively. Winter and spring seasons recorded the highest concentrations of Na^{+} for Port Fouad and Alexandria sites while in case of the Nile River it was the autumn season. Na^{+} concentrations were much higher than K^{+} concentrations in all the water samples during the four successive seasons of the present study. The lowest concentrations of Na^{+} were during the autumn season while in case of the Nile River it was summer 2015 season. The seasonal means of Na^{+} concentrations in water samples of Alexandria, Port Fouad and the Nile River sites were 438.6 mg/l, 380.2 mg/l and 187.9 mg/l respectively.
Trace metals play important roles in the ocean, therefore iron recorded the highest concentrations over the other trace metals in the autumn season and the lowest concentrations were recorded during the spring season while the highest concentrations of copper were recorded during winter season, except for Port Fouad when the highest concentrations were recorded during the autumn season, and the lowest concentrations were recorded during summer season. Spring season recorded the highest concentrations of Zn^{+2} for both Alexandria and Port Fouad sites while in case of Nile River, the highest concentrations were recorded during winter season. Mn^{+2} mostly showed a higher concentrations than Cu^{+2} and Zn^{+2} and the highest concentrations were recorded during summer season except for Alexandria site where the highest concentration was recorded during the spring season.
The seasonal means of Fe^{+3}, Cu^{+2}, Zn^{+2} and Mn^{+2} ions in Alexandria were 0.655 ppm, 0.025 ppm, 0.3075 ppm and 0.407 ppm respectively. The seasonal iron concentrations ranged between 0 ppm during winter 2015 season to 2.4 ppm recorded during autumn season while the seasonal copper concentrations ranged between 0 ppm during autumn, spring and summer 2015 seasons to 0.1 ppm during winter season. Seasonal Zn^{+2} concentrations ranged between 0 ppm during autumn season to 0.6 ppm during spring season while the seasonal Mn^{+2} concentrations ranged between 0.12 ppm during autumn season to 0.9 ppm during spring season.

The seasonal mean of Fe^{+3}, Cu^{+2}, Zn^{+2} and Mn^{+2} at Port Fouad site were 0.6 ppm, 0.08 ppm, 0.247 ppm and 0.227 ppm respectively, while the seasonal concentrations of Fe^{+3} ranged between 0.0 ppm during spring season to 0.3 ppm during winter and summer 2015 seasons. The seasonal Cu^{+2} concentrations ranged between 0.0 ppm recorded during spring season to 0.2 ppm during autumn season while in case of Zn^{+2}, the seasonal concentrations ranged between 0 ppm during autumn season to 0.8 ppm during spring season. Mn^{+2} concentrations ranged between 0.11 ppm during autumn to 0.36 ppm during summer 2015 season.

The seasonal means of Fe^{+3}, Cu^{+2}, Zn^{+2} and Mn^{+2} in the Nile River were 0.502 ppm, 0.247 ppm, 0.118 ppm and 0.435 ppm respectively. The seasonal Fe^{+3} concentrations ranged between 0.05 ppm during spring season to 1.2 ppm during autumn season and the seasonal Cu^{+2} concentrations ranged between 0.11 ppm during summer 2015 season to 0.4 ppm during winter season. The seasonal Zn^{+2} concentrations ranged between 0.01 ppm during autumn season to 0.2 ppm during winter season while the seasonal Mn^{+2} concentrations ranged between 0.12 ppm during autumn season to 1.27 ppm as the highest concentration amongst other sites during summer 2015 season.

Statistical results showed that concentrations of Fe^{+3}, Mn^{+2} and Ca^{+2} showed strong positive significant correlations while on the other hand, the variations between marine and riverine water samples of Port Fouad and the Nile River sites were observed in results of Chlorophyll-a and TSS as well as concentrations of Na^{+}, Cl^{-}, Mg^{+2}, PO_4^{-3}, NO_3^{-} which showed negative non-significant correlations; the results of salinity and concentrations of K^{+} and Zn^{+2} showed weak non-significant correlations while Cu^{+2} showed no correlations at all. These remarkable variations in the concentrations of nutrient salts of Port Fouad and the Nile River water samples agreed to the variations mentioned in previous studies of seawater and riverine water [33] which are naturally found to occur between seawater and riverine water.

Table 1. Results of the seasonal chemical parameters of salinity (‰), pH, nutrient salts (mg/l) and trace metals (ppm) in water samples of Alexandria, the Nile River and Port Fouad.

Site	Alexandria				The Nile River				Port Fouad			
Season / parameter	Autumn	winter	spring	Summer	Autumn	winter	spring	Summer	Autumn	winter	spring	Summer
Salinity (‰)	45	45	45	50	17	17	17	20	35	40	40	40
pH	8.05	7.53	8.26	7.72	8.45	8.15	7.7	8.01	8.43	8.59	8.05	8.03
Cl^{-} (mg/l)	18613	23044	17726	28809	15422	7091	8650	17904	19144	22330	24534	20210
Na^{+} (mg/l)	297	639.2	479.4	338.4	236.9	161	226	128	7.5	573.4	545.2	394.8
K^{+} (mg/l)	9.4	10.7	5.9	7.4	6.4	4.3	4.7	3.3	14.3	15.1	9.2	9.9
Mg^{+2} (mg/l)	996	832.4	1320	513	800	510	450	883	1142	1689	702.4	991
Ca^{+2} (mg/l)	380	330	226.8	157	260	241	138	292.5	380	280.5	144.3	269.5
SO_4^{-2} (mg/l)	12.8	335.6	260.3	19.8	5.6	2.4	70.8	21.7	15.2	332.9	148.7	4.2
PO_4^{-3} (mg/l)	0.185	0.165	0.22	0.1	0.263	0.43	0.7	0.1	0.621	0.825	0.4	0.6
NO_3^{-} (mg/l)	4.78	5.24	2.04	14.7	6	6.4	4.8	4.08	3.54	3.6	0.8	4.9
Fe^{+3} (ppm)	2.4	0.0	0.1	0.12	1.2	0.6	0.05	0.16	1.8	0.3	0.0	0.3
Cu^{+2} (ppm)	0.0	0.1	0.0	0.0	0.2	0.4	0.28	0.11	0.2	0.1	0.0	0.02
Zn^{+2} (ppm)	0.0	0.4	0.6	0.23	0.01	0.2	0.12	0.14	0.0	0.1	0.8	0.09
Mn^{+2} (ppm)	0.12	0.18	0.9	0.43	0.12	0.15	0.2	1.27	0.11	0.24	0.2	0.36

Total bacterial counts

Examination of total bacterial counts under epifluorescent microscopy was used. According to Fig. 4, autumn season demonstrated the highest total bacterial counts of water samples of Alexandria, Port Fouad and the Nile River sites whereas the highest total bacterial counts were recorded in Port Fouad water which were 7×10^8 cell/ml while Alexandria and the Nile River recorded the same total bacterial counts of 1×10^8 cell/ml. Spring season demonstrated the lowest total bacterial counts in water samples of Alexandria and Port Fouad sites which recorded the same total bacterial counts as well which were 0.1×10^8 cell/ml. The seasonal means of total bacterial counts in water samples of Alexandria, Port Fouad and the Nile River sites were 0.4×10^8 cell/ml, 2×10^8 cell/ml and 0.7×10^8 cell/ml respectively.

Unexpectedly, total bacterial counts of both marine and riverine water samples of Alexandria, Port Fouad and the Nile River sites showed the same strong positive significant correlations ($p = 0.00$, $r = 0.99$) during the four successive seasons of the present study.

Identifications of bacterial genera

17 bacterial genera were identified morphologically and biochemically during the seasonal duration of autumn 2014 to summer 2015 whereas the identified bacterial genera varied being Gram positive and Gram negative, bacilli and cocci in shape, spore forming and non-spore forming as indicated in (table 2). They varied during the different seasons of the study whereas certain bacterial genera were isolated from all the water samples during the four successive seasons of the present study especially *Vibrio* sp. and *Escherichia* sp. while other genera were isolated occasionally during the four successive seasons.

Bacillus sp., *Corynebacterium* sp. and *Halobacillus* sp. were isolated from Port Fouad and the Nile River water samples during the same seasons as well as *Vibrio* sp. and *Escherichia* sp.

Cellulomonas sp. which is known for the degradation of cellulose was isolated on CMC agar media plates whereas positive results were observed by the formation of clear zones after 10 minutes of flooding the CMC media plates with Gram's iodine. *Escherichia* sp. was tested for lactose fermentation by isolation of pure bacterial cultures on MacConky agar media, positive results showed growth of creamy pink colonies after the incubation period.

Table 2. Some morphological and biochemical tests of some of the isolated bacteria.

Genera	Gram	Cat.	Oxd.	Glu.	Man.	Stac.	Arg.	Pig.	Mot.	Spr.
Escherichia sp.	-ve	+ve	-ve	+ve bub	+ve bub	-ve	-ve	W	+ve	-ve
Vibrio sp.	-ve	+ve	+ve	+ve bub	+ve bub	+ve	-ve	W	+ve	-ve
Aerococcus sp.	+ve	-ve	-ve	+ve	+ve	-ve	-ve	W	-ve	-ve
Lactococcus sp.	+ve	-ve	-ve	+ve	+ve	+ve	+ve	W	-ve	-ve
Micrococcus sp.	+ve	+ve	+ve	+ve	+ve	var	var	O	-ve	-ve
Planococcus sp.	+ve	+ve	+ve	-ve	+ve	-ve	-ve	Y	-ve	-ve
Staphylococcus sp.	+ve	+ve	-ve	+ve	+ve	+ve	+ve	W	-ve	-ve
Sporosarcina sp.	+ve	+ve	+ve	-ve	-ve	-ve	-ve	W	+ve	+ve
Bacillus sp.	+ve	+ve	+ve	+ve	-ve	var	-ve	W, Y	var	+ve
Cellulomonas sp.	+ve	+ve	+ve	+ve bub	+ve	+ve	-ve	W	var	-ve
Corynebacterium sp	+ve	+ve	-ve	+ve	+ve	var	-ve	W	-ve	-ve
Halobacillus sp.	+ve	+ve	+ve	+ve	+ve	+ve	+ve	Y, W	var	+ve
Kurthia sp.	+ve	+ve	-ve	-ve	-ve	-ve	-ve	W, O	-ve	-ve
Lactobacillus sp.	+ve	-ve	-ve	+ve	-ve	-ve	-ve	O	-ve	-ve
Listeria sp.	+ve	+ve	-ve	+ve	+ve	-ve	+ve	W	+ve	-ve
Microbacterium sp.	+ve	+ve	+ve	+ve	+ve	var	-ve	Y, O	+ve	-ve
Oceanobacillus sp.	+ve	+ve	+ve	+ve Oxi	-ve	-ve	-ve	W	+ve	+ve

Gram = Gram stain, Cat. = Catalase test, Oxd. = Oxidase test, Glu. = Glucose test, Man. = Mannitol test, Stac. = Starch hydrolysis test, Arg. = Arginine Hydrolysis test, Pig. = Pigmentation of bacterial colony, Mot. = Motility test, Spr. = Spore Formation, var. = variable results depending on the different species of the genus, bub = production of gas bubbles, Oxi = oxidation, Y = yellow, W = white and O = orange.

Conclusion

In conclusion, this study proved that there was an impact of the flowing Nile River water on the eastern Mediterranean Sea coast of Egypt according to the significant variations that were observed between the marine water samples which were collected from Alexandria city and Port Fouad city especially between the concentrations of certain nutrient salts including: Mg^{+2}, Ca^{+2}, PO_4^{-3} and NO_3^- as well as salinity values which were usually much higher in the water samples of Alexandria site than Port Fouad site. This variation between marine water samples has no logical reason except for the impact of the Nile River water on Port Fouad water which lowered the water salinity at this site.

The impact of the flowing Nile River water into the eastern Mediterranean Sea was confirmed by the significantly related results of water turbidity, pH levels and the relatively close concentration of NO_3^-, HCO_3^- and trace metals during the seasonal duration of autumn 2014 to summer 2015 in the water samples of Port Fouad and the Nile River sites when compared to those results of Alexandria site.

The variations in nutrient salt concentrations of Mg^{+2}, Ca^{+2}, Na^+ and K^+ between Port Fouad and the Nile River water samples were documented in previous studies of marine water and riverine water as well as the variations in bacterial genera.

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الملخص العربي

عنوان البحث: تأثير تدفق نهر النيل على جودة المياه والتنوع البكتيري للمياه البحرية لساحل البحر الأبيض المتوسط فى مصر

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تمت المقارنة بين السواحل الشرقية والغربية للبحر الأبيض المتوسط فى مصر عن طريق تجميع عينات مياه من مدينة بورفؤاد وفرع دمياط بنهر النيل خلال أربع مواسم متتالية حيث تم إختبار هذه العينات فيزيائيا وكيميائيا بالإضافة إلى تعيين الأعداد الكلية البكتيرية وتعريف 17 نوع من الأجناس البكتيرية التى ظهرت خلال المواسم المتتالية فى هذه العينات عن طريق التحاليل البيوكيميائية. وقد أظهرت النتائج أرتفاع ملوحة المياه وتركيز أيونات الكلور فى الساحل الغربى للبحر الأبيض المتوسط عن الساحل الشرقى و المتمثل فى مدينة بورفؤاد. أيضا عكارة المياه أظهرت وجود إرتباط قوى مؤثر معنويا بين عينات بورفؤاد والأسكندريه وكذلك بورفؤاد والنيل بينما أظهرت النتائج وجود إرتباط غير مؤثر معنويا بين عينات الأسكندرية ونهر النيل.