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INFLUENCE OF COLOUR OF SUBSTRATUM ON THE MARINE FOULING COMMUNITIES AT THE EASTERN HARBOUR (ALEXANDRIA, EGYPT)

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ABSTRACT

The present work aims to study the effects of substratum's colour on the succession of marine fouling communities at the Eastern Harbour of Alexandria, Egypt. By using six different colours (White, yellow, light blue, red, dark green and black) of acrylic test panels (each 12.5x12.5 cm), the succession of marine fouling communities were estimated at various intervals during autumn 2005. During the first six days of immersion, there is a general increase in the total bacterial counts with increasing the time of immersion. In average the highest bacterial count was recorded on the Black plate and the lowest on the white plate. Some physico-chemical parameters (pH, dissolved oxygen, salinity, forms of dissolved inorganic nitrogen, reactive phosphate and reactive silicate) which may affect on and by the fouling communities are studied and the statistical correlations between them are calculated. Concerning the fouling communities, during short intervals (one week, two weeks, three weeks and one month), the minimum values of the measured parameters (total number of recorded fouling species, total density of fouling organisms and total biomass) were recorded on the colours white, yellow and light blue and the maximum values on the colours red, dark green and black. On three months duration, the minimal values of the measured parameters were recorded on Black plate and the maximal values on the colours yellow, dark green and yellow, respectively. The results indicate the importance of colour especially during the shorter periods of immersion. The factors that may be responsible for these variations are discussed.

1. INTRODUCTION

Recruitment of many sessile invertebrates is influenced by a variety of biological, chemical and physical factors (Meadows and Campbell, 1972; Crisp, 1984; Pawlik, 1992; Walters *et al*., 1997).

Concerning the physical characteristics of surfaces that promote or prevent the settlement of marine fouling, it has already been shown that most of the investigated sedentary animals settle preferentially on rough rather than on smooth surfaces (McGuinness and Underwood, 1986; McGuinness, 1989; Anderson and Underwood, 1994; Hills *et al*., 1999), on concave rather on plane surfaces (Le Tourneux and Bourget, 1988; Hills and Thomason, 1996, 1998; Walters and Wethey, 1996), on shaded rather than on illuminated surfaces (Visscher and Luce, 1928; Ryland, 1960; De Silva, 1968; Yule and Walker, 1984; Dahlem *et al*., 1984; Venugopalan, 1987) and on undersides rather than on the other sides of surfaces oriented at different angles (Barnes, 1956; Crisp, 1967; Ramadan, 1986).

In the Eastern Harbour of Alexandria Ghobashy (1976) studied the physical characteristics of the exposed surfaces and he obtained similar results.

Compared to other factors affecting the settlement and recruitment of fouling organisms, colour of substratum has received relatively little attention and few works have been done (e.g. Visscher and Luce, 1928; Nair, 1962; Ghobashy, 1976; Ramadan, 1986; James and Underwood, 1994). Generally, these authors indicated that the dark background is preferred by a larger number of organisms than lighter backgrounds.

According to Abdel-Salam (2004), the maximum settlement of fouling organisms in the Eastern Harbour of Alexandria occurred in autumn season, so the present work aims to study the effect of substratum colour on the succession of marine fouling communities at different exposure periods during the autumn season in the Eastern Harbour and the factors that may be responsible for this variation.

2. MATERIALS AND METHODS

2.1. THE SITE: THE EASTERN HARBOUR

This work was carried out in the Eastern Harbour of Alexandria, Egypt. This Harbour is a relatively semi-closed basin, situated at longitudes 29º 53´ to 29º 54´ 40" E and latitudes 31º 12´ to 31º 13´ N (Fig.1). It is sheltered from the sea by a break-water leaving two openings (Boughaz) through which the exchange of water between the Harbour and the open Mediterranean Sea takes place. The area of the Harbour is about 2.53×10^6 m^2, with a maximum depth of 11m. The average water depth of the bay is about 6.0 m and it receives many kinds of vessels especially fishing boats. Although it is supposed that the discharge of domestic sewage inside the Harbour was totally ceased since 1999, Labib (2002) mentioned that the Harbour due to water circulation is subjected to additional amount of municipal wastewater from the main sewer of Alexandria (Kayet Bey), located at its western vicinity.

2.2. METHODLOGY

2.2.1. Chemical analyses

Sub-surface water samples (in front the plates directly ~10cm) were collected using PVC Niskin Bottle (3 liters). Another sub-surface sample from a station (station A) far away from the plate site about 500 m was collected during the autumn season to compared results. They were kept in well–cleaned stoppered polyethylene bottles. Water temperature was measured using standard thermometer accurate to 0.1°C. pH and total dissolved solids were measured using pocket pH-meter (Orien model) accurate to 0.01. Salinity and electric conductivity were measured using induction Salino-meter Beckman.

Dissolved oxygen was measured by the Winkler method (Grasshoff, 1979). Ammonium ion concentrations were determined spectro-photometerically according to Grasshoff (1979). Nitrite, Nitrate, reactive phosphate and reactive silicate concentrations were determined on pre-filtered seawater samples (Whatman GF/C) following Grasshoff (1979) & Strickland and Parsons (1972). The concentration of Dissolved Inorganic Nitrogen (DIN as the sum of NH_4-N + NO_2-N + NO_3-N) was calculated. Water transparency was measured using Secchi Disk.

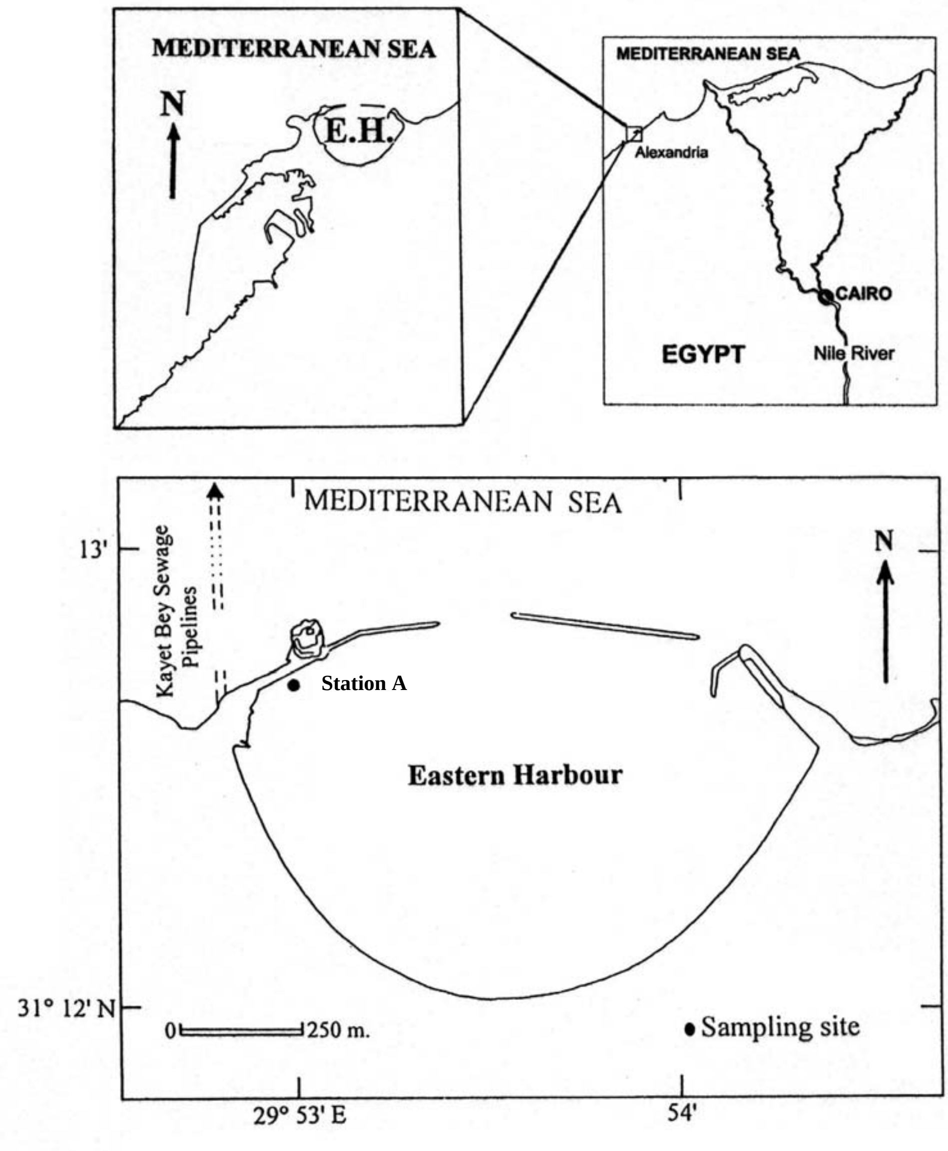

Fig.1. Location map of the Eastern Harbour (E.H.) of Alexandria and sampling site.

2.2.2. The bacterial count

A swap by a sterile cloned toothpick was taken per cm^2 in duplicates to determine the viable total bacterial counts from upon the six different colours of the acrylic test panels immersed in seawater. Each swap was washed in 1 ml sterilized seawater. A portion (100 µl) from each appropriately sample was pipetted to inoculate nutrient agar plates prepared with seawater. Then all plates were incubated at 30ºC for 24 hours after which the bacteria were counted. Nutrient agar medium (Peptone, 5; Yeast extract, 1; Beef extract, 2; Sodium chloride, 5 and agar 15g/L) was prepared with seawater.

2.2.3. The fouling communities

By using six different colours of acrylic test panels (each 12.5x12.5 cm), the succession of marine fouling communities were estimated at different intervals during autumn 2005. The experiment began on September, 20 and lasted to 21st of December. White, yellow, light blue, red, dark green and black were the available colours of the acrylic sheet which used in the experiment. The test panels were fixed to a wooden rack suspended vertically 0.5 m below water surface. The surface of the test panels facing seawater was roughened by using sand paper. It is worth to mention that the panels were suspended beside the jetty of the National Institute of Oceanography and Fisheries, Alexandria.

Seven sets of test panels were used; each set consists of the six different colours (duplicated). The first set was used to estimate the total bacterial count at six successive days. The other six sets were used to collect the marine fouling communities at six intervals (one week, two weeks, three weeks, one month, two months and three months). The fouling community was investigated to identify the foulers and associated organisms with the aid of a binocular zoom stereo-microscope (20X).

2.3. DATA ANALYSIS

A simple correlation coefficient (Pearson correlation) was used to treat some data of total fouling density and some environmental conditions measured during different periods of immersion, as well as, between some environmental conditions.

3. RESULTS

The present study was conducted in the Eastern Harbour of Alexandria where all the exposed panels were suspended vertically 0.5 m under water level and the transparency of water at the harbour ranged between 120 cm and 190 cm during different periods of panel immersion.

3.1. CHEMICAL PARAMETERS

Studying the chemistry of water surrounding the fouling on the test panels during different periods (one week, two weeks, three weeks, one month, two months and three months), showed that there is a remarkable variation of some chemical parameters (Figs. 2 and 3 and Table 1).

It is found that, approximately there is no variation in the pH measurements which ranged around the numerical normal seawater pH value (pH around 8) during different periods. There is a significant variation in the measurements of dissolved oxygen. The minimum value (5.46 mg/l) is measured during one month duration while the maximum value (12.74 mg/l) is recorded during the three months interval. The minimum value for salinity (33.25‰) is recorded after the first week which increased gradually to reach its maximum value (36.65‰) after two months.

Concerning the distribution of nitrogen forms, it is noted that the minimum ammonia concentration (3.02 µM) was recorded after two weeks and its maximum concentration (12.15µM) after two months. Since ammonia is the last form of reduction of inorganic nitrogen, consequently the same pattern was observed in the dissolved inorganic nitrogen (DIN) which has its minimum concentration after two weeks (6.03 µM) and its maximum value (21.68 µM) after two months. Nitrite concentrations show a little variation meanwhile, the distribution pattern of nitrate concentrations showed a gradual decrease with time (3.35 and 0.65 µM after one week and one month, respectively), It then increases suddenly after two months reaching (9.31 µM).

The distribution of phosphate showed low concentrations (< 1.00 µM) during the first month then it rises after two months to reach 2.93µM and still rising to reach (17.23 µM) after three months. The concentration of silicate was higher after short period of one week (11.69 µM) when compared to the other longer periods in which the silicate concentration varied between 4.39 and 6.50 µM.

Table (1): Concentrations of different parameters of sub-surface water samples in the investigated area during different periods.

periode	pH	Salinity	DO mg/l	NH_4 µM	NO_2 µM	NO_3 µM	DIN µM	PO_4 µM	SiO_4 µM
3 days	7.93	33.00	8.45	5.49	0.33	6.03	11.85	0.38	4.67
1st week	8.08	33.25	6.76	5.40	0.53	3.35	9.28	0.53	11.69
2nd week	8.43	35.20	10.14	3.02	0.63	2.39	6.03	0.29	4.62
3rd week	8.17	36.21	5.72	5.40	0.10	0.70	6.20	0.48	5.47
4th week	8.03	35.52	5.46	5.85	0.30	0.65	6.80	0.43	4.39
Two months	7.92	36.65	12.48	12.15	0.23	9.31	21.68	2.93	6.04
Three months	7.91	33.33	12.74	6.89	0.65	2.89	10.42	17.23	6.50
Station A	**8.14**	**38.73**	**7.90**	**3.92**	**0.27**	**5.40**	**9.59**	**0.55**	**3.13**

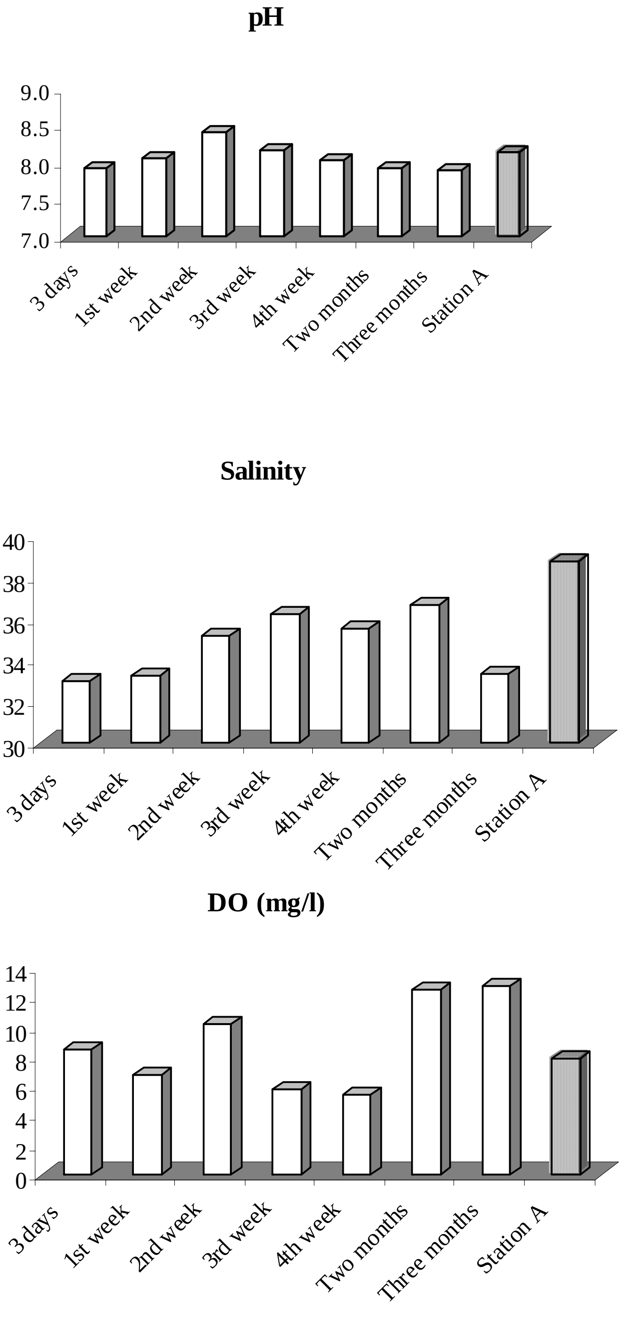

Fig. (2): Distribution of pH, salinity and DO of the investigated area during the different periods.

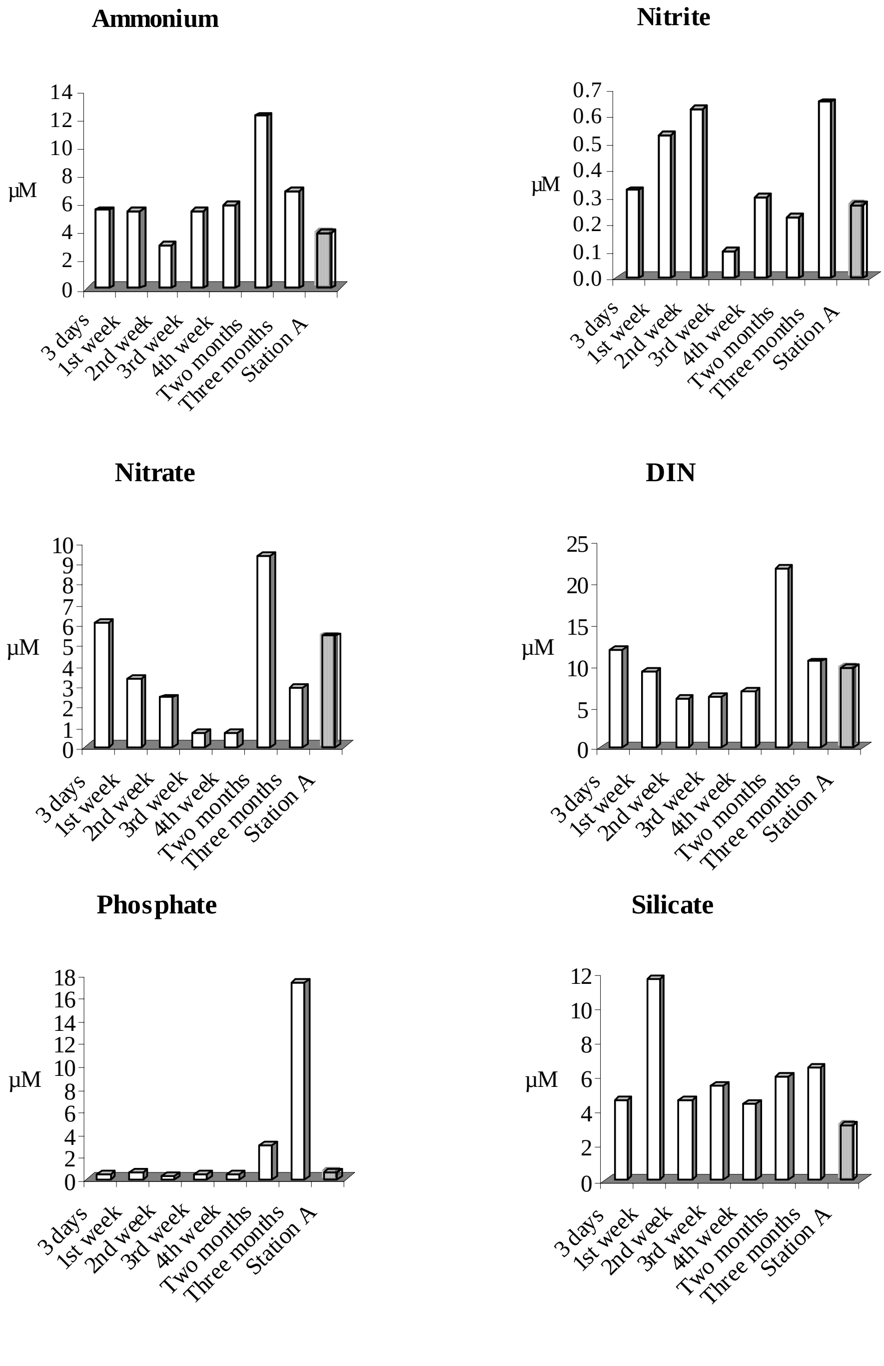

Fig. (3): Distribution of nitrogen forms, phosphate and silicate of the investigated area during different periods

3.2. BACTERIAL COUNTS

Table (2) shows the counts of total marine bacteria isolated from coloured acrylic plates immersed in the Eastern Harbour during the first six days The black plate sustained the highest count (8800 CFU/cm^2), followed by the dark green plate (6280 CFU/cm^2) after immersion in seawater for six successive days. On the other hand, the red plate harboured the lowest count (30 CFU/cm^2), followed by the yellow plate (40 CFU/cm^2) after one day of immersion.

Results of average counts of total marine bacteria isolated from the immersed coloured plates indicated that, there is a general increase in the bacterial counts with increasing time of immersion. The minimum count (117 CFU/cm^2) was recorded after one day of immersion while the maximum count (5150 CFU/cm^2) was recorded after six days. Meanwhile results of average counts of total marine bacteria isolated during the first six successive days showed that, the lowest count (1007 CFU/cm^2) was recorded on the white plate (fig.4). This count increased gradually from white to yellow, light blue, red, dark green and black which collected the highest count (2813 CFU/cm^2).

Table (2): Viable counts of total marine bacteria isolated from coloured acrylic plates immersed in the Eastern Harbour (CFU/cm^2).

Time (days)	Colour of plate					
	White	Yellow	Light Blue	Red	Dark Green	Black
1	80	40	50	30	100	400
2	150	1500	650	55	975	500
3	310	850	600	350	350	530
4	1500	1600	560	2425	605	650
5	2800	3200	4000	3600	4400	6000
6	1200	3500	5920	5200	6280	8800
Average	1007	1782	1963	1943	2118	2813

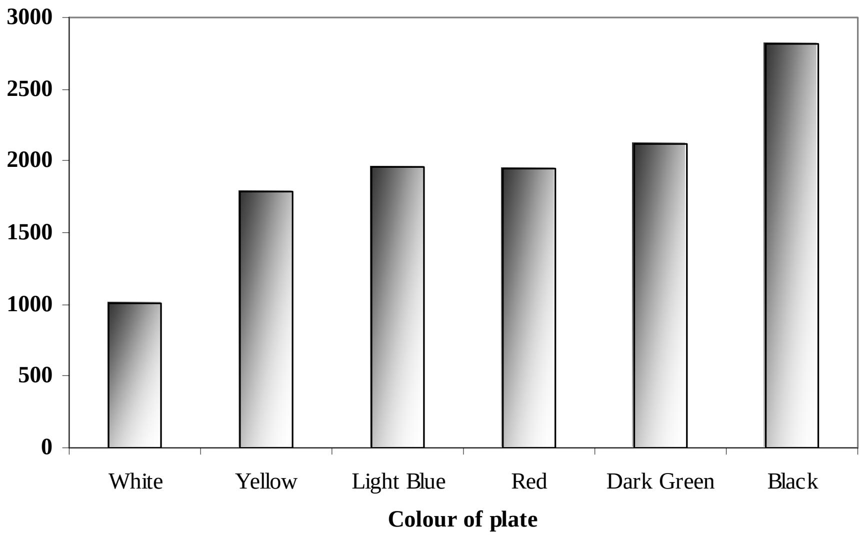

Fig. (4): Average of total marine bacteria isolated from coloured acrylic plates during different periods.

3.3. FOULING COMMUNITIES

Tables (3 and 4) demonstrate the composition of fouling communities, which varies according to the period of panel exposure. Moreover, the total fouling density and total biomass fluctuate from one colour to another, especially in shorter periods of exposure. These results can be summarized as follows:

3.3.1. One week

The fouling community is mainly composed of a thin mat of blue-green algae, the polychaete *Hydroides elegans*, an erect bryozoan species, a species of barnacle and few species of Amphipoda. The minimum total numbers of species, total density of fouling and total biomass were recorded on the white plate which collected 4 species, 2658 organisms and 1 gm. On the other hand, the maximum values of these parameters were recorded on the red plate which accumulated 6 species, 5463 organisms and 1.5 gm.

3.3.2. Two weeks

In addition to the previous fouling community, two macroalgal species namely *Ulva lactuca* and *Enteromorpha compressa* appeared on the plates during this period. More amphipod species were recorded. The white plate harboured the minimum total number of species, total density of fouling and total biomass which were 10 species, 2740 organisms and 12 gm, respectively. On the other hand, the maximum total numbers of species, total density of fouling and total biomass were again recorded on the red plate which collected 12 species, 6334 organisms and 24 gm, respectively.

3.3.3. Three weeks

During this period, the polychaete *Ctenodrilus* sp. and the tanaidacean species *Tanais dulongii* appeared on all the coloured plates, in addition to sporadic species of Isopoda and Pycnogonida. The minimum total numbers of species, total density of fouling and total biomass were recorded on the light blue plate. On the other hand, the maximum values of total number of species and total biomass were still observed on the red plate, meanwhile the maximum total density of fouling organisms was recorded on the black plate.

3.3.4. One month

During this period, there is no change in the community structure of fouling organisms except the appearance of the barnacle *Balanus eburneus* on all coloured plates. The minimum total density of fouling and total biomass (3535 organisms & 60 gm) were recorded on the white plate, while the lowest number of species (13 species) was recorded on the yellow plate. The maximum total number of species, total density of fouling and total biomass were observed on dark green, red and black plates, respectively.

3.3.5. Two months

The fouling community is the same as after one month duration, except the appearance of few individuals of ascidian species and the disappearance of one or both species of the macroalgae. The lowest number of species (11 species) was recorded on the dark green plate. The minimum total density and total biomass (5357 organisms & 120 gm) were recorded on the white plate, which in the same time harboured the highest total number of species (15 species). The maximum total density and total biomass (5932 organisms & 163 gm) were recorded on the red and light blue plates, respectively.

Table 3. Composition of fouling communities settled on coloured acrylic plates during one, two and three weeks at the Eastern Harbour.

Periods	One week						Two weeks						Three weeks					
Species \ Colour	White	Yellow	Light Blue	Red	Dark Green	Black	White	Yellow	Light Blue	Red	Dark Green	Black	White	Yellow	Light Blue	Red	Dark Green	Black
Ulva lactuca							±	+	±	++	+	±	++	+	+	+	++	++
Enteromorpha compressa							+	++	+	++	++	+	++	++	±	++	++	+
Obelia geniculata (%)				15														
Bugula neritina (colony)		4	4	15	8	7	12	11	9	29	19	58	40	55	58	40	59	90
Schizoporella sp. (%)												<1						
Hydroides eleganes	2650	3175	2750	5425	4100	5075	2575	3825	3600	6200	4445	3250	3350	3520	2230	4200	3940	4380
Ctenodrilus sp.													8	9	12	17	19	24
Balanus amphitrite	2	21	10	16	21	9	91	31	7	26	20	38	42	10	109	29	50	34
Balanus eburneus										3	1							5
Tanais dulongii													2	2	2	3	2	3
Cirolana bovina															1			
Paradella dianae								3	1							5		
Paracereis sculpata														6		1	4	4
Pycnogonida sp.													1			1		
Ericthonius brasiliensis	5	4	1	6	2	5	47	57	61	54	45	49	35	23	36	25	31	27
Elasmopus pectenicrus							3	10	7	7	6	5	34	59	33	49	39	59
Corophium acutum			1		1	2	5	5	8	4	7	7	13	13	15	12	11	13
Corophium sextonae							3	4	3	3	3	3	6	6	9	8	9	8
Podocerus variegatus		3						3	4	3	3	4	4	3		5	6	5
Stenothoe gallensis	1			1			4	5	5	5	2	8	14	21	17	17	18	34
Total number of species	4	5	5	6	5	5	10	12	12	12	12	12	14	14	13	16	14	15
Total density of fouling *	2658	3207	2766	5463	4132	5098	2740	3954	3705	6334	4551	3422	3549	3727	2522	4412	4188	4686
Total biomass (W.W.) in gm.	1	1	1	1.5	1.2	1.5	12	18	13	24	20	14	28	26	19	36	24	31

* For countable species only
% indicates area of panel occupied by a fouling species

± = Rare (< 5% of panel area)
+ = Present (5-19% of panel area)
++ = Common (20-50% of panel area)

Table 4. Composition of fouling communities settled on coloured acrylic plates during one, two and three months at the Eastern Harbour.

Periods	One month						Two months						Three months					
Species \ Colour	White	Yellow	Light Blue	Red	Dark Green	Black	White	Yellow	Light Blue	Red	Dark Green	Black	White	Yellow	Light Blue	Red	Dark Green	Black
Ulva lactuca	++	+	+	+	+	+	±	±	+	±			±	±	±	±		±
Enteromorpha compressa	±	±	±	±	±	±						±						
Sycon ciliata														1				
Bugula neritina (colony)	38	49	128	125	99	94	22	58	27	93	36	90	28	45	48	13	30	4
Amathia sp. (colony)													1			1		
Schizoporella sp. (%)			<1															
Hydroides elegenes	2890	4515	3945	4825	4100	4650	4925	5000	5050	5200	4850	4900	5150	5400	5200	5250	5500	4950
Ctenodrilus sp.	39	43	45	57	51	48	37	43	38	43	45	48	47	42	37	58	45	29
Ruditapes decussatus															1			
Balanus amphitrite	274	138	208	189	25	121	71	187	103	131	83	80	43	15	73	45	92	30
Balanus eburneus	17	8	10	12	3	17	4	8	16	10	6	8	2	2	4	5	5	3
Tanais dulongii	1				4													
Cirolana bovina			1	1			1	6	3				3	2	4	4	3	2
Paracereis sculpata	9	8	4	10	7	20	33	37	17	34	7	9	16	7	18	37	37	34
Spaeroma walkeri	1						1							1			2	
Sphaeroma serratum					1													
Ericthonius brasiliensis	91	94	122	92	49	74	67	82	103	84	78	73	115	105	105	95	205	95
Elasmopus pectenicrus	52	128	125	145	78	125	127	210	235	240	225	235	320	380	280	365	350	240
Corophium acutum	22	24	24	18	23	19	21	38	46	28	37	44	52	57	45	48	53	43
Corophium sextonae	14	13	18	13	12	12	11	29	28	14	19	23	19	22	17	29	21	21
Podocerus variegatus	7				4													
Stenothoe gallensis	80	84	100	148	48	122	36	39	43	52	29	34	89	130	95	97	120	90
Brachynotus sexdentatus					1													
Palaemon elegans										1								
Styela partita													17	7	13	6	15	17
Ciona intestinalis							1		3	2		2	6	13	12	27	22	12
Molgula sp.													1	3	2	1	2	3
Ascidia sp.																2	2	
Total number of species	16	13	15	14	17	13	15	13	14	14	11	13	17	18	17	18	17	16
Total density of fouling *	3535	5104	4730	5635	4505	5302	5357	5737	5712	5932	5415	5546	5909	6232	5954	6083	6504	5573
Total biomass (W.W.) in gm.	60	90	73	90	66	94	120	142	163	125	123	134	243	305	198	227	290	170

3.3.6. Three months

During this period, much more species and individuals of Ascidia are added to the fouling community of all coloured plates. The maximum total number of species (18 species) was recorded on both the yellow and red plates. The maximum total density of fouling and total biomass (6504 organisms & 305 gm) were observed on dark green and yellow plates, respectively. On the other hand, the minimum values for these parameters (16 species, 5573 organisms & 170 gm) were recorded on the black plate.

Table (5) summarizes the records of the minimum and maximum values of the measured parameters on different colours during different periods of immersion.

4. DISCUSSION

The accumulation of organisms on an exposed surface depends obviously on the species which are naturally present at a given site as well as on their ability to attach and grow on that surface (Hillman, 1977).

In the marine environment, competent larvae of sessile invertebrates are influenced by water flow and a variety of biological, chemical and physical cues (Walters *et al*., 1997). Specific chemicals in microbial biofilms serve as cues that attract the planktonic larvae to settle on a surface.

Although some biofilms play an important role in mediating settlement and metamorphosis of invertebrate larvae (Maki *et al*., 1989; Mitchell and Maki, 1988; Rodriguez *et al*., 1995), others may actually repel invertebrates from settlement on surfaces (Maki *et al*., 1990; 1992; Holmström *et al.*, 1992).

The growth of fouling organisms may affect the distribution of some environmental variables. Reduction of salinity during the all time of exposure means, consumption of different major ions of seawater (such as, sodium, potassium, calcium, magnesium, chloride,…) which leads to reducing in salinity (Table 1, Fig. 2). Ammonia is one of the major excretory products of fouling organisms inhabiting the sub-surface seawater (Gunasingh *et al*., 1997). So, it is reasonable to assume that the concentration of ammonia on longer periods increases (reach to 12.15 µM after two months).Consequently, increasing in nitrate content at the same period (9.31 µM) in a good oxygenated condition in the experimental site (DO concentration equals 12.48 mg/l after two months). The same pattern distribution was observed for dissolved inorganic nitrogen (Table 1 and Figs. 2, 3). The statistical analysis may confirm this conclusion, as high positive significant correlation coefficient between ammonia and nitrate was calculated ($r = 0.85$, $n = 6$, $p < 0.05$) and a positive correlation coefficient was observed between nitrate and DO ($r = 0.68$, $n = 6$, $p < 0.1$). Nitrite concentration does not show any noticeable variation as it is an intermediated form between ammonia and nitrate. The average concentrations of ammonia, nitrite and nitrate in Station A during autumn were 3.92, 0.27 and 5.40 µM, respectively. This may confirm that, the increasing of these nitrogen forms after long periods may be as a result of fouling growth and activities.

Inorganic reactive phosphate is an essential growth-controlling factor and a very important parameter to limit growth and reproduction of marine organisms (Abdel-Halim, 2004). During the period of the first month, it was observed that the phosphate content was lower (0.29 – 0.49 µM) than the normal seawater of station A (0.55 µM) during the same period of study. This may be attributed to the consumption of phosphate by fouling organisms in different activities (growth and reproduction). After the long periods of exposure (two and three months), the phosphate concentration increases suddenly reaching 17.23 µM after three months. This may be as a result of decay of some fouling organisms (Table 1 and Fig. 3).

A positive significant correlation ($r = 0.79$, $n = 6$, $p < 0.05$) was calculated between phosphate and the number of *Hydroides eleganes* (one of the principal fouling organisms).

In general, the concentration of silicate of water in the experimental site (4.39 – 11.69 µM) was higher than that of normal seawater of Station A (3.13µM). It is observed that, a decrease in the concentration of silicate with prolonged time of exposure which may be attributed to the consumption of silicate by the fouling organisms which have a calcareous shells (e.g. *Hydroides eleganes*, *Balanus amphitrite* and *Balanus eburneus* that correlated negatively with silicate r = -0.11, -0.56 and -0.45, respectively).

Regarding the fouling communities, during shorter intervals (one week, two weeks, three weeks & one month), there is a great variation in the total density of fouling organisms accumulated on different colours (Table 6), the maximum values being equal about twice the minimum values. This variation diminished on longer durations (two & three months) the maximum and the minimum values becoming about equal. Moreover, there are variations in the total number of fouling species and total biomass recorded on different colours during different periods of immersion.

During the short interval (one week), the minimum values of total number of species, total fouling density and total biomass were recorded on White colour with the lowest total bacterial count. While, the maximum was recorded on Red colour with relatively high total bacterial count. This can be attributed to the effect of bacteria count which is one of the main components of the biofilm. Maki *et al*. (1989) Mitchell and Maki (1988) Rodriguez *et al*. (1995) confirmed the importance of biofilms in mediating settlement and metamorphosis of invertebrate larvae.

Again, during slightly longer intervals (two weeks, three weeks and one month), the minimum values of total number of species, total fouling density and total biomass were recorded on White, yellow and light blue panels. On the other hand the maximum values of the measured parameters were recorded on the Red, dark green and black panels. With increasing time of exposure, there is a change in that the minimal values of the measured parameters are recorded on the first group of colours (lighter colours) and the maximal values on the second group of colours (darker colours). So during the two months interval the minimum values (total number of species, total fouling density and total biomass) are recorded on Dark Green, White and Green, respectively. On the other hand the maximum values are recorded on White, Red and Light Blue, respectively. After three months, the minimum values of the parameters are recorded on Black plate and the maximum values are observed on Yellow, Dark Green and Yellow plates, respectively. These results indicate the importance of substratum colour on shorter periods, but this importance declined on longer periods (two and three months) due to the disappearance of the colours under the fouling communities which cover the test panels.

It is well known that colours are seen due to decomposition of light into radiations of different wavelengths. The radiations or rays at low wavelength (475 µm) produce the sensation of a violet colour, those of a high wavelength (645 µm) produce that of the red colour, while the intermediate wavelengths produce blue, green, yellow and orange. A body which reflects all the rays of white light, without absorbing any, is the white. On the other hand, a body which absorbs all the rays of white light without reflecting any is the black. A coloured body absorbs all the rays and reflects only rays of its colour (Albers, 1975 and Brill, 1980).

It is important to mention that the settlement of fouling organisms is mainly affected by water temperature. The importance of temperature for the total settlement and biomass of fouling organisms was investigated by many authors (Wisely, 1959; Lepore and Gherardi, 1977; Montanaro and Tursi, 1983). Qiu and Qian (1999) revealed that high temperature resulted in increased survival and growth of embryos, larvae and adults of the barnacle *Balanus amphitrite amphitrite*. When light is absorbed, its energy is transformed into thermic energy (Nassau, 1983). So, it is expected that the thermic energy of the black colour will be the maximal because it absorbs all the rays of white light without reflecting any, followed by the red colour which absorbs all the rays and reflects only red coloured rays that have a very low energy. So, the micro temperatures of the red and black colours may be the optimum temperature for the attachment of larvae during shorter periods of immersion before the colours completely disappear after longer periods.

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Table (5): Records of the minimal & maximal values of the measured parameterson different colours during different periods of immersion at the Eastern Harbour.

	Minimal values of			Maximal values of		
	Total no. of species	Total fouling density	Total fouling biomass	Total no. of species	Total fouling density	Total fouling biomass
One week	White	White	White	Red	Red	Red
Two weeks	White	White	White	Red	Red	Red
Three weeks	Light Blue	Light Blue	Light Blue	Red	Black	Red
One month	Yellow	White	White	Dark Green	Red	Black
Two months	Dark Green	White	White	White	Red	Light Blue
Three months	Black	Black	Black	Yellow	Dark Green	Yellow

Table (6): Total fouling density settled on coloured acrylic plates during different periods of immersion at the Eastern Harbour.

Color / Periods	one week	two weeks	three weeks	one month	two months	three months	Average
White	2658	2740	3549	3535	5357	5909	3958.0
Yellow	3207	3954	3727	5104	5737	6232	4660.2
Light Blue	2766	3705	2522	4730	5712	5954	4231.5
Red	5463	6334	4412	5635	5932	6083	5643.2
Dark Green	4132	4551	4188	4505	5415	6504	4882.5
Black	5098	3422	4686	5302	5546	5573	4937.8

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