central space becomes markedly enlarged as a result of the upward and downward movement of the micromeres (plate 1 m), and the final shape is in the form of a large central space surrounded by a macromere crown and embracing inside the free micromeres. After that and onwards, 28 hours after spawning, cleavage begins to be irregular and the embryo Plate (1 n) appears as a crown of peripheral macromeres that surrounds irregularly arranged micromeres inside ; forming an embryo that consists of 66 blasntomeres (Naef, 1928). Irregular cleavage proceeds, and 36 hours after spawning *(plate 1 o)*, the developing ***Octopus vulgaris*** embryo now consists of 360 blastomeres with a considerably marked smaller central space. Forty hours after spawning the blastoderm stage is attained and defined by Naef (1928) to be ***stage I***, consisting of 1200 cells in which the central pore is markedly diminished and nearly closed *(plate 1 p)*.

Stage I - II , plate. I q 2 days after spawning:

It is an intermediate phase between both of the two ones in which endomesoderm formation starts. The blastodisc rim does not appear as a plane closed circle but as 12 slightly curved attached peripheries. This structure is in turn externally surrounded by a paler peripheral rim to which the yolk cells adhere.

Stage II, pate 1 r, 2½ days after spawning:

It is an advanced stage in endomesoderm formation.

Stage II-III, plate 1 s, 3 days after spawning:

Exhibits a transitory from between both.

Stage III, plate 1 t, 3 ½ days after spawning:

The animal gastrula, characterized by enlargement of the blastodisc size (Naef, 1928).

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DEVELOPMENT OF FOULING ORGANISMS ON FISHING NET MATERIALS IN RELATION TO THE ENVIRONMENTAL CONDITIONS AT THE EASTERN HARBOUR (ALEXANDRIA, EGYPT)

BY

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***Key Words:* Marine fouling, Alexandria, Mediterranean.**

ABSTRACT

The present investigation has been carried out for studying the settlement rates of fouling organisms on fishing net materials in the Egyptian Mediterranean water. Panels of mesh netting fabric were exposed vertically for various exposure periods at the Eastern Harbour of Alexandria for one year during 1995. The physical and chemical parameters of sea water in such area were recorded during the exposure time to indicate to what extent may these conditions affect the rate of settlement of the fouling organisms.

The intensity of fouling community on net fishing materials varied seasonally for both the short and long period of immersion. The calcareous tube worms settled with high rates during the winter season where the water temperature ranged between 16.6 °C and 18.3 °C. The bryozoan organisms which formed massive layer on the net panels accumulated with high rates in May where the temperature was 25.9 °C

Both the calcareous tube worms and the bryozoan organisms were removed off the panels under the natural conditions. This removal may be attributed to the short life span of these organisms.

It could be indicated also that the high transparncy and high concentrations of the phosphates and silicates increased the rate of settlement of the algal fouling organisms.

The mesh size, twine diameters and colours of net panels used in the present study showed insignificant effect on the development rate of fouling assemblages on the test panels.

INTRODUCTION

The constant immersion of mesh netting in seawater presents marine fouling problems not normally occurring in the realm of the fishing industry . Net used for hunting fish are usually cast for only a short time, and any settling organisms die on exposure when the net is recovered and stacked on board .

The choice of materials for structural work either in the intertidal, sub littoral, or surface floating zone of the sea is also critical in that the chosen material should be relatively resistant to marine fouling growths. Since these can impose an additional load on the structure. Alternatively the structure should be capable of being cleaned easily, but this however increases maintenance cost .

Fouling is meant the growth on submerged surfaces of plant or animal organisms which settle as spores or larvae and grow on these substrates until their adult forms. The number of fouling species known is in the range of 4000 to 5000. Sea grass and barnacles being the most common forms. The most serious ones are the shell fouling animal organisms including barnacles and calcareous tube worms which can accumulate in colonies of successive layers with different thickness (Crisp 1972).

In general, fouling organisms lie into two main groups, micro and macro fouling:

A) Micro fouling, is the earlier attack of any submerged surface in sea water forming the main constituent of slime film . It consists of the bacteria and protozoa. The presence of slime film is believed to influence subsequent attachments of larger fouling forms. Bray (1923) concluded that surfaces which accumulated the heaviest slime finally become the most fouled.

B) Macro fouling, this includes mainly , green and brown algae, calcareous tube worms, barnacles, ascidians and mollusca. The kinds of algae that cause fouling are drawn from all size ranks among the various species which in nature are found growing on rocky sea shores in the zones related to tide level and light penetration .

Climatic, geographical and topographical influences play a very considerable part in the incidence of fouling on submerged substances. In this concern El-Komi and El-Sherif (1992), pointed out that in usual a fluctuation takes place in the settling numbers of fouling organisms and their rate of growth is probably related to the environmental influences such as temperature, dissolved oxygen, organic matter and the degree of pollution.

The effect of hydrographic factors on fouling pattern could be indicated according to Iselin (1952) as follows:

The effect of temperature, current, salinity, pollution, silt and other suspended matter are considered to vary in their actions on the settlement rate of fouling assemblages on the submerged surfaces in sea water.

Fouling generally increase in warm water. Current affects the distribution of fouling organisms. Pollution may be harmful for these organisms. Silt and other suspended matter may produce substrate unsuited for the attachment of many forms.

Most of the studies on marine fouling organisms in the Eastern Harbour of Alexandria have been conducted on the settlement behaviour of fouling on test panels for various exposure periods (Ghobashy, 1976 and El Komi, 1991). Habal and Abo Samra (1991) investigated the effect of pollution on the abundance of fouling organisms. Halim *et al* (1980) have investigated the planktonic and benthic diatoms in relation to the pollution gradient inside the bay.

El Komi (1992), and Banoub (1960) have revealed the diverse of different biota of bacteria , diatoms and microscopic filamentous algae formed on microscopic slides.

The rate of settlement of fouling organisms on the submerged surface in relation to the ambient environmental conditions have been attempted by many authors in different areas of the world. Few of those authors used neting meshes as submerged materials for studying the tendency of the marine fouling organisms to settle on.

It is a matter of fact that the present study is considered as the first attempt to study the fouling settlement on the netting materials in the Egyptian water

The present work aims to demonstrate the rates of accumulation of the fouling organisms on some fishing materials having various mesh sizes, thicknesses and colours at the Eastern Harbour of Alexandria during the different seasons of the year . It is attempted also to correlate between these rates and some prevailing environmental conditions during the period of investigation

The Study area :

The Eastern Harbour of Alexandria is a relatively semi-closed basin sheltered from the sea by a breake - water leaving two openings (Boughaz) through which the exchange of water between the Harbour and the Mediterranean water takes place. The Harbour's area is about 2.53km^2 with an average depth of 6.0 m. Accordingly its water volume is estimated to be about 15.2 $\times 10^6$ m^3 (Zaghloul, 1988). This harbour receives many kinds of vessels especially fishing boats. A large amount of untreated sewage is discharged to the harbour, which amounts about 63000 m^3 / day (Said and Maiyza, 1987). This volume is about 2.3 times the volume of water in the Eastern Harbour. On the other hand , an occasional inflow of mixed waste water takes place through El.Boughaz from the main sewer of Alexandria located about 500 m. west of El.Boughaz in the open sea.

MATERIAL AND METHODS

The rate of fouling accumulation has been investigated on submerged test frames (20 $\times$ 30 cm.) of fishing netting materials and wood specimens (20 $\times$ 20 $\times$ 2 cm.) during the period from January to December 1995 at the Eastern Harbour of Alexandria. Sets of the frames were immersed regularly at the begining of winter , spring , summer and autumn and successively removed for examination at the end of each of these seasons. Another set of the frames (12 frames) were submerged at the beginning of January 1995 . Single frame of this set was monthly taken at the end of the successive months of this year .

These exposed frames and panels were fixed in an iron frame sized 150 × 100 cms. in two raws. The frame was suspended vertically at a depth of 2.0 m. below the sea surface under the jetty of the National Institute of Oceanography and Fisheries. The webbing used for studying the seasonal fluctuations of fouling rates on the test frames was manufactured from polyamide material having a mesh bar of 2.8cm. . The denier of the twines was Td 210/24 and its color was brown.

To investigate the effect of mesh size, twine diameter , and colour of net material on the rate of fouling accumulation on the fishing nets the following netting materials were used :

1. Netting material having mesh bar of 2.0cm.. Td 210/12 and white in colour (denoted as E group).
2. Netting material having mesh bar of 2.0cm. Td 210/12 and brown in colour (denoted as H group)
3. Netting material having mesh bar of 1.5cm. , Td 210/12 and brown in colour (denoted as I group).

The timber panels used in the present study were from " Pine" type having a thickness of 2.0 cm.

The principle fouling groups setting on the frames were examined, identified and photographed. The removed frames were hanged vertically in the open air for drying untill its weight becomes constant. The dry weight of the fouling organisms settling on each frame was then determine.

Water samples were collected monthly at a depth of 2.0 m. at the study area. These samples were used for the measurement of salinity, dissolved oxygen, pH, phosphates, silicates, nitrites and ammonia according to the procedure of Strikland and Parsons (1972). Water temperature and Secchi depth were monthly recorded at the area of investigation.

RESULTS AND DISCUSSION

A. Environmental conditions

The physical and chemical conditions that prevailed at the locality of investigation in the Eastern Harbour of Alexandria during the period from January to December 1995 are given in Table (1) and Fig. (1) It can be indicated from the data given table that :

1. The sea water temperature fluctuated from a minimum of 16.4°C in January to a maximum of 28.8°C in August. (Fig . 1).

Table (1) : Environmental conditions at the locality of investigation in the Eastern Harbour of Alexandria during 1995.

Month	Temp °C	Secchi depth (m.)	Salinity %o	PH	D.O. Ml/L	PO_4 µg at/L	Sio_4 µg at/L	NO_2 µg at/L	NH_3 µg at/L
Jan.	16.4	3.00	38.6	7.91	8.00	1.33	15.6	1.72	0.688
Feb.	16.6	3.20	37.9	8.12	7.30	0.93	9.64	1.41	-
Mar.	18.0	3.10	38.1	7.82	5.80	0.77	7.92	1.08	6.536
April	18.3	2.75	37.5	7.89	5.70	0.56	5.36	1.40	2.064
May	25.9	2.60	37.2	8.02	3.80	0.14	3.92	0.36	13.803
June	27.7	2.20	36.9	7.85	3.20	0.14	0.88	0.16	-
July	28.6	2.00	36.4	7.80	3.00	0.11	1.60	0.68	4.018
Aug.	28.8	2.20	36.5	8.18	2.60	0.28	3.12	0.10	-
Sept.	27.8	2.00	37.1	8.09	2.00	0.35	8.40	1.80	-
Oct.	24.5	2.10	37.5	8.15	9.80	0.30	3.12	1.92	5.719
Nov.	18.9	1.70	38.2	7.94	8.80	0.53	3.04	0.16	2.795
Dec.	17.8	2.00	38.8	8.05	10.30	1.16	6.64	1.16	-

As for the thermal and salinity distributions of the whole area of the Eastern Harbour, Zaghloul (1988), pointed out that the water of this area is strongly stratified during most of the time of the year. Dilute surface layer of mixed run off and a more saline bottom layer, the highest surface water temperature occured in July (30°C) and the lowest in January (14.5°C). The bottom water was slightly warmer (0.5°C) than the surface layer. Thermal stratification was rarely detected in this Harbour as showed by Zaghloul (1988) while the surface salinity of the Harbour water ranged from 28.2 - 31.2 %o and bottom water showed narrower range.

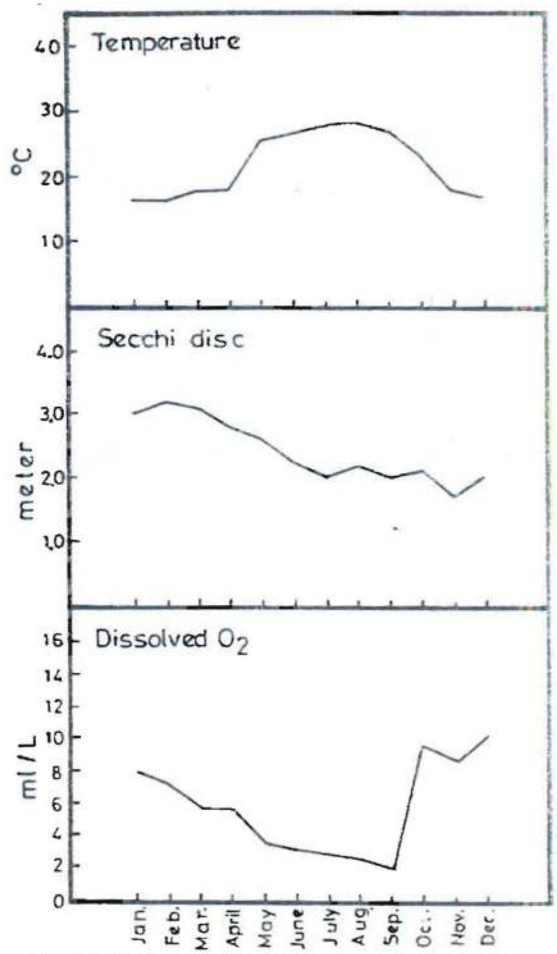

Fig.(1): Environmental parameters at the Eastern Harbour during 1995.

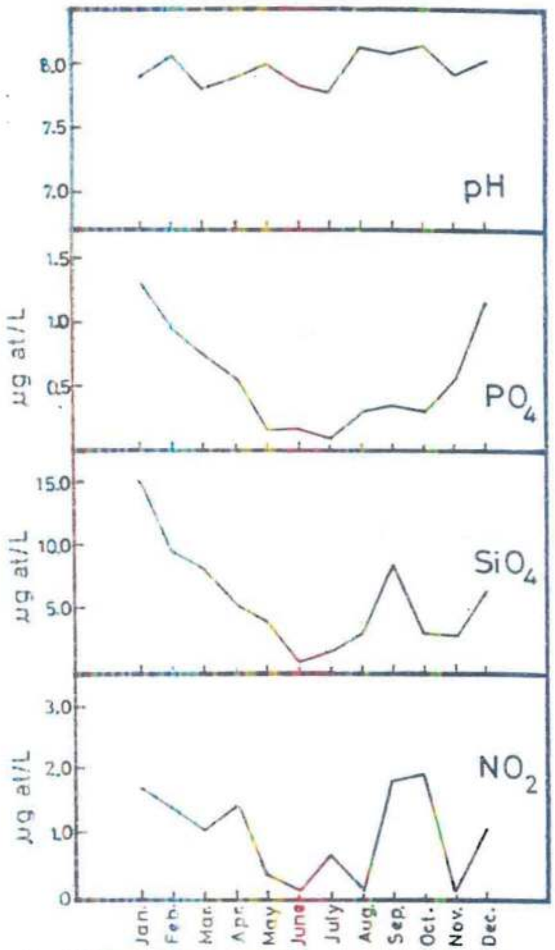

Fig.(1)(cont.): Environmental parmeters at the Eastern Harbour during 1995.

Maiyza and Said (1988), indicated that vertically thermal homogenity occurred in the E.H. in most time of the year. They attributed this homogenity to the wind action on a relativelly small, shallow water body nearly surrounded by land area .

Dowidar ***et al*** (1987), pointed out that the area of the E.H., as a part of SE Mediterranean represents a warm tropical or subtropical region. The average temperature is about 22. °C , with an amplitude of 11.9°C.

2. The transparency of the E.H. water was relatively high. The seechi depth at the investigated locality ranged from 1.7m. in November to 3.20 m. In February.

Dowidar ***et al*** (1987), found that at the Eastern habour the annual average of secchi disc visibility (2.65 ± 0.67 m.) is comparable or some times lower than found in other inshore areas .

Halim ***et al*** (1980), in their study on the transparency of the E.H. indicated that the relative light intensity or irradiance at the depth of Secchi disc disappearance is about 35% of surface illumination. They autors suggested also that the mean depth of 1% light intensity, i.e. lower limit of photic zone is about 4.32 times the Secchi disc depth .

3. The pH of the water at the investigated locality lied on the alkalline side ranging from 7.80 to 8.18. These values are comparable with those recorded for other Egyptian inshore waters.

4. The dissolved oxygen contents at the locality of investigation fluctuated between a minimum of 2.00 ml / L in September and a maximum of 10.30 ml/L in December. The high oxygen content can be attributed to the strong winds that prevail during these seasons .

However the study of dissolved oxygen content in the sea water is very important since it is considered as one of the important limiting factors for the life of aquatic organisms.

Redfield (1942) mentioned that the oxygen content can be considered as an indicator of organic loading, nutrient input and biological activity. The importance of oxygen to aquatic organisms is directly connected with their biological processes and indirectly with the oxidation of organic matter in water and sediments followed by regenerating the cycle of nutrients in the water.

As for the suitability of the E.H. water for the marine life in spite of the waste water disposal in this harbour. Dowidar *et al* (1987) pointed out that, except on rare occasions, the water of the E.H. was well oxygenated (annual average for water column 6.00 ± 1.81 mg O^2 / L corresponding to 87.2 ± 29 saturation). The surface layer is over saturated (105 %) while the bottom is unsaturated (69%) with oxygen. They pointed out also that concerning the D.O. requirements of warm water organisms, the surface water layer of the Harbour is still suitable for all marine life . The conditions in the bottom water is a border line suitable for some invertebrates and bacteria . It has been indicated also by Dowidar *et al* (1987) that the contineous increased disposal of raw sewage into the Harbour would result in the nearest future of converting the Harbour water into a place unsuitable for marine life.

5. The concentrations of silicates at the investigated locality of the E.H. Showed wide fluctuations ranging from 0.88 to 15.6 µ gm at /L as indicated in Table (1).

Three factors govern silicate fluctuations: The input of drainage water, the uptake by heavy diatom blooms and intermixing with sea water poor in silicate (Zaghloul, 1988). The high silicate concentration recorded in the present investigations can be attributed to the inflow of fresh water with higher silicate content and spreading on the surface water of the E.H.

6. The concentration of the surface phosphate in the locality investigated ranged between 0.11 to 1.33 µ gm at/L As it the case of the other nutrients in the marine environments, the bloom of phytoplankton rapidly takes up most of the available phosphates. On the other hand the inflow of fresh water plays a major role in increasing the concentrations of such nutritive salt at the surface layer of the water. The observed fluctuations in the concentrations of phosphates (Table 1) can be attributed to these two factors.

7. The concentrations of the nitrites ranged from 0.10 to 1.92 μ gm at /L. The lowest concentrations of nitrites were recorded during the summer months.

It can be concluded that the concentrations of various nutrient salts in the E.H. attained higher levels during the winter season if compared by their concentrations during the other seasons .

B- Seasonal accumulation of fouling populations :

It is a matter of fact that the settlement of fouling organisms on the exposed netting test frames in the present investigation at the E.H. of Alexandria depend mainly on the time of reproduction of populations of different marine organisms as well as the suitability of the ambient environmental conditions. The dependance of settlement of fouling organisms on the environmental factors was indicated by Iselin (1952). It has been pointed out also by El-Komi and El-sherif (1992) that the fluctutions which took place in the numbers and growth of the settling fouling organisms at the EH was propably related to the environmental conditions. Such settlement may be divided into three classes according to the period settling .

I. Annual fouling .

II. Seasonal fouling .

III. Monthly fouling .

I- Long term exposure test frames:

I-a. Fouling composition

The fouling developed on the submerged test frames for one year duration (1995) was monthly examined, recorded and photographed (plates 1,2 and 3).

It can be observed from the photos given in these plates that successions of the fouling differed in their species composition and amount throughout the year.

The succession of fouling organisms on the submerged surfaces (Fletcher and Chamberlain 1975), showed that the first settlers on such surface are bacteria and unicellular diatoms gradually replaced by colonial diatoms especially ***Navicula*** and in turn over grown by green Algae as ***Enteromorpha*** and brown algae as ***Ectocarpus*** sp .

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In our case the fouling complex on the exposed frames tended to be dominated by a rich growth of branched and unbranched algae as filaments of green, brown and red algae. The calcareous tube worms, erect bryozoan , and solitary ascidians formed massive accumulation on these frames.

Five species of algae were predominant on the test frames at the area investigated. These species were ***Ulva*** sp.. ***Cladophora*** sp , ***Chaetomorpha*** sp., ***Enteromorpha*** sp, and ***Ectocarpus*** sp.

The calcareous tube worms comprised massive settlement on the test frames after three months of exposure, while the bryozoan ***Bugula neritina*** added a major settlement after five months. Concerning the calcareous tube worms, El-Komi (1992) indicated that ***Hydroides elegans*** are numerically the major marine fouling groups reproduced during most of the time of the year in the Eastern Harbour of Alexandria . He pointed out also that ***Bugula neritina*** is the most a bundant bryozoan community.

It can be observed from plate (1) that the tube warms which comprised the major part in the setteled fouling organisms occured in February, March and April where the water temperature was relatively low (16.6°C to 18.3°C respectively).

This indicates that the prevailing environmental conditions especially water temperature that prevailcd during the late winter and early spring months favored the accumulations of tube warms on the test frammes during the period of immersion.

It is obvious also from plate (2) that the fouling bryozoan (***Bugula neritina***) which contributed a major catigory of the settling organisms on the test panels flourished at higher temperature (25.9°C) which was recorded during May 1995.

El-Komi (1992) in this work on the ecology of marine fouling organisms at the E.H. of Alexandria found that calcareous tube worms were numerically the most abundant animals which were attached in considerable amount forming dense material. He found also that such overcrowded accumulation of tube worms can be easily removed under the effect of the natural circumstances.

The removal of the dense settlement of calcareous tube worms and colonies of ***Bugula neritina*** was also demonstrated in the present investigation. It can be observed from the photos given in plate (1) that the dense fouling accumulation of which the calcareous tube worms and the bryozoan ***Bugula neritina*** contributed a considerable part, such accumulation was easily removed in the next month (Jane. 1995) under the natural environmental conditions (Fig. 4,5 and 6, plate 1 and Fig 1.2 plate 13) :

The removal of such dense fouling accumulation can be attributed to the comparatively short life span of both ***Hydroides elegans*** (as reported by Edmonson and Ingram, 1939, that the maximum size of H. norvegica. was 50 to 60mm in 3 or 4 months) and ***Bugula neritina*** (kitamura and Hirayama 1984) of about 3 months.

It is a worth mentioning in this paper that in spite of the accumulation of barnacles on the wooden frame used for the fixation of the netting materials these fouling organisms could not fined the optimum condition for settlement on the meshes of the webbing material.

The solitary and colonial ascidians formed a major part of the fouling organisms on the test frames during the early summer . These organisms were able to settle and form a massive layer on the frames that have been exposed for long periods. The figures given in plates (2) and (3) indicate that the frames which were exposed for a period of 8 months or more showed dense and massive settlement of the ascidians.

I.b. Fouling biomass:

The biomass of the fouling community on the test frames used in the present study are given as the dry weights in grams of the fouling organisms accumulated on the fishing net panels fixed to the exposed frames .Each panel of the netting material was 14 × 24 cm. in dimensions. Drying of these samples was carried out under the effect of sunlight.

Table (2) shows the initial weight of the netting panels, the weight of the accumulated organisms and the ratios between the weight of fouling organisms to the initial weight of the netting panels.

The commulative dry weights of the fouling organisms which settled on the test frames during 1995 are graphically represented in Fig. (2).

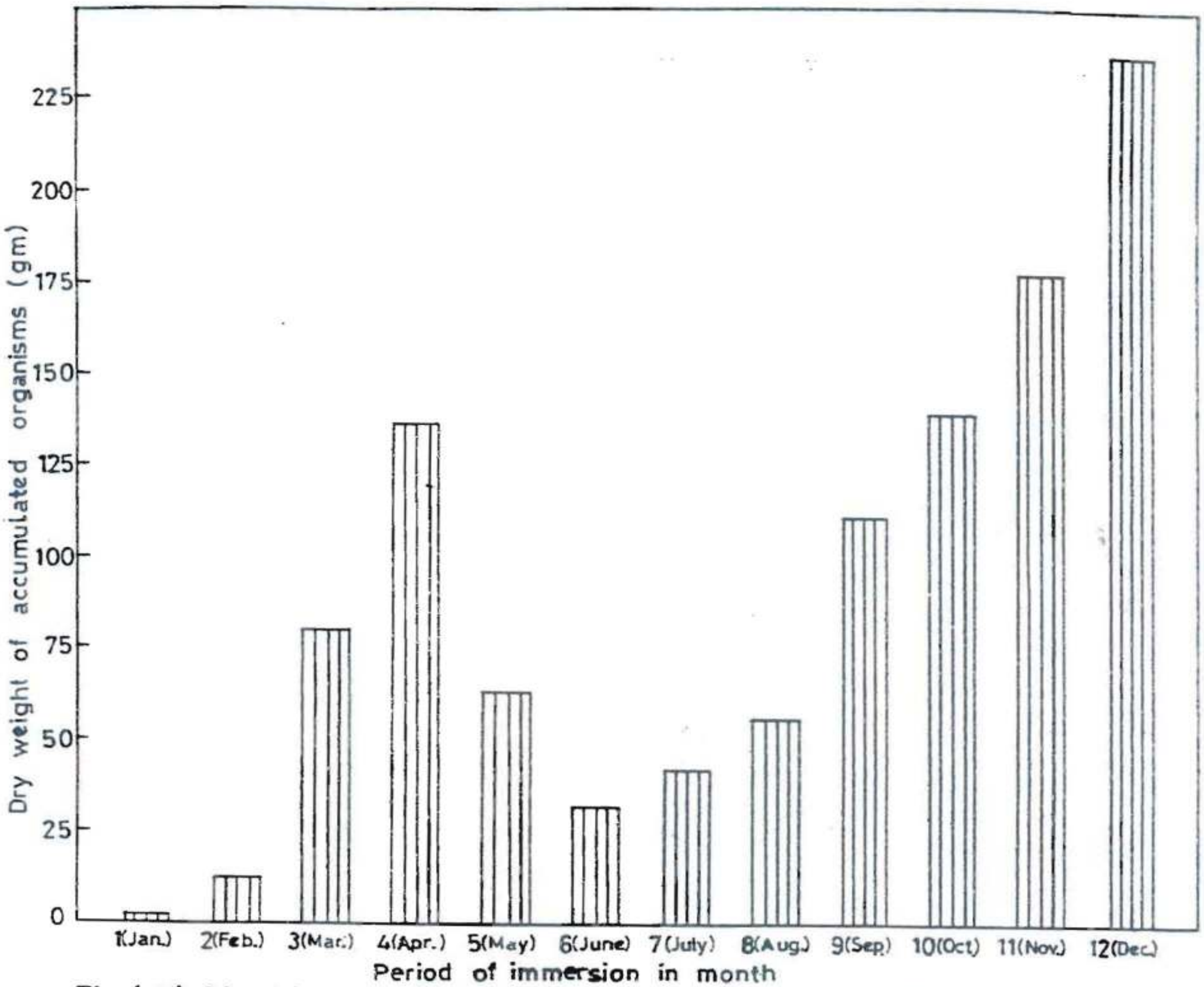

Fig.(2): Monthly weights of dry fouling organisms accumulated on fishing net specimens at the Eastern Harbour.

It can be indicated from the data given in table (2), that the weight of the accumulated organisms increased consequentlly from one month to the next during the period from January to April 1995. Such increase in weight has been resulted mainly from the commulative accumulation of the calcareous tube worms and bryozoan organisms during this period. The photos given in plates 1, and 2 show also that the fouling biomass on the test frames was steadly increasing and developing from one month to the next during this period .

Table (2) : The commulative monthly fouling biomass settled on netting materials at the Eastern Harbour of Alexandria during 1995.

Period of immersion in month	Month	Dry weight of sample (gm)	Dry weight of fouling organisms	Weight of fouling org. / Init. Wt. Of panel
		Initial weight = 4.410 gm		
1	January.	5.965	1.555	0.35
2	February	16.305	11.895	2.69
3	March.	85.000	80.590	18.27
4	April	141.000	136.590	30.97
5	May	68.000	63.590	14.50
6	June	35.700	31.290	7.09
7	July	49.000	44.590	10.11
8	Aug.	60.000	55.590	12.60
9	Sept.	114.400	109.990	24.94
10	Oct.	145.000	140.590	31.87
11	Nov.	182.000	177.590	40.26
12	Dec.	240.000	235.590	53.42

Such fouling biomass decreased greatly from136.59 gm / panel in April to 63.59 gm / panel in May and reached 31.59 gm / panel in June . This decrease was in fact due to the removal of the fouling organisms on the test frames. This removal could be attributed to the short life span of the fouling organisms.

In this concern El-Komi (1991) pointed out that the fouling settled on submerged test panels at the E.H. for long periods reached a saturation point after 3-6 successive months.

On the other hand it has been concluded afterwords by the same author (El-Komi, 1992) that the intensive accumulation of tube worms on the test panels at the E.H. has been removed under the effect of the natural conditions.

It has been pointed out also that the colonies of bryozoan organisms (***Bugula neritina***) settled in high density on the submerged surfaces reached a maximum height of about 10 cm with more than 20 bifurcations after an exposure time of about 3 months . After this period such organisms falled of the submerged surfaces (Kitamura and Hirayama, 1984).

After to June 1995 the fouling biomass started to increase steadly again to reach its maximum dry weight of 235.59 gm per panel in December. This means that the weight of the fishing net panels gained an extra weight of about 53 times its initial weight by the end of the exposure period.

It can be indicated from this discussion that the fouling biomass which resulted from the accumulation of calcareous tube worms and bryozoan organisms on the test panels were not able to remain settling for longer periods after reaching their maximum growth rates.

On the other hand the fouling biomass which resulted from the settlement of colonical acidians settled on the test frames for long periods resulting an increase in the fouling biomass from one month to the next.

The settlement of such ascidians on the mesh netting, imposed a severe additional increase in the weight of the tested net panels.

II. Short term exposure test frames

II-a. Fouling composition

The fouling development on the test frames has been seasonally investigated. Three frames were exposed at the beginning of winter, spring, summer and autumn in succession. The first frame of each group was removed after one month, the second was removed after two months and the third was removed by the end of each of these seasons.

Plates 4,5,6 and 7 show the fouling accumulation during these seasons respectively.

It can be indicated from these plates that :

Winter season :

The fouling organisms on the net samples were poor during the first month of winter Blockking rate of the meshes was negligable. During the second month (February). the accumulation rate of the fouling organisms increased.

The most abundant fouling organisms were macroscopic green algae and calcareous tube worms. The blocking rate of the meshes of the net samples increased during such month . Some meshes were completely obscured.

By the end of third month of winter the whole area of the frame was colonised by various species of green and brown algae as well as the bryozoan species ***Bulgula neritina. Ectocarpus*** sp. was the most abundant among the fouling organisms during this period . Complete blocking of the meshes of the net webbing can be observed (as obvious in plate 4) by the third month of winter.

The high rate of accumulation of the algal organisms on the test frames indicates that the environmental conditions prevailed in the E.H. during winter were favorable to the growth and therefore the accumulation of these organisms The high transparency of water (secchi depth ranged from 3.0 3.2 m.) as well as the high concentrations of nutrient salts (as shown in table 1) may have played important factors in increasing the algal development in this area .

Spring Season :

After one month of immersion during the spring season the netting twines of the test frames were lightly covered with a brown filmy growth of algae mainly ***Ectocarpus*** sp. After two months, in May 1995, the frames had become heavily fouled with different spices of algae as shown in plate (5). ***Ulva*** sp., ***Cladophra*** sp., ***Entermorpha*** sp. and ***Ectocarpus*** sp., were the most dominant fouling species during this season.

The acidians comprised also a major part of the fouling organisms accumulated on the test frames after two months of immersion in the spring.

During June 1995 most of the algae which settled during the previous two months were removed from the webbing of the test frames under the natural conditions. On the other hand, the acidians remained settling on such frames.

Summer season :

The fouling accumulation on the test frames during the summer season is shown in plate (6). It appears from the photographs given in this plate that the rate of fouling accumulation on the net webbing during the summer was very poor.

In this concern El-Komi (1991), pointed out that the growth of algae and the other fouling organisms on test panels exposed at the Eastern Harbour, during the summer season, was very little. This agrees to a good extent with the present observation that there was low rate of fouling accumulation on netting materials.

It may be a worth mentioning that in spite of the poor accumulation of fouling organisms on the net webbing during this season, a high rate of barnacles, calcareous tube worms and other species of the fouling organisms were settling on the woody frame which had been used for the fixation of the exposed net samples. This indicates that settlement of fouling organisms on net webbing different greatly in its rate and nature from that in the case of ordinary surfaces such as plastic or wood panels.

The low rate of fouling accumulation on the netting materials during the summer season can be attributed to the low growth rate and low abundance of the algal fouling organisms at the Eastern Harbour in summer. This agrees to a good extent with the results of El-Komi, 1991.

The growth of such funa may depend on the availability of optimum or high concentrations of the nutrient salts as well as the high transparency and light penetration through the sea water. It can be indicated from Table (1) that the concentrations of these salts attained decreased and minimum concentrations during the summer season. On the other hand, the secchi depth had it lowest values during this season. These two environmental factors may have played a very important role in decreasing the accumulation rate of the algal fouling organisms during the summer season.

Autumn Season :

The rate of accumulation of fouling organisms on the test frames was comparatively low during the autumn as can be indicated from plate 7. The frames which were removed after one or even two months of exposure showd a little accumulation of microscopic algae as well as few number of calcareous tube worms. The frames which were exposed for three months accumulated a moderate density of the fouling organisms. Such fouling organisms were composed mainly from brown algae and calcareous tube worms.

II- b. Fouling biomass on the test frames :

The dry weight of the accumulated fouling organisms on the test frames during the winter, spring, summer and autumn of 1995 are given in Table (3) and graphically represented in Fig . (3).

As shown in Table (3) the maximum fouling biomass accumulated on the test frames was in winter. The accumulated fouling biomass during the spring was moderate comprising 30.0 gm dry weight per a panel at the end of such season. Such biomass comprised about six times the initial weight of the net panel. The dry weight of the fouling organisms during the summer and autumn seasons were only 2.35 and 2.70 gm / panel. This indicates that the fouling biomass on the test frames had its minimum value during the summer season.

It can be concluded also that the recorded variation in the values of the fouling biomass during the different seasons of the year agree to a good extent with the observed variations in the photographs which reflected obvious differences in the intensity of the accumulated fouling organisms. Both of them contributed in qualifying the rates of accumulation of such organisms on the test frames.

C- Effect of mesh size and colour of netting material on the accumulation of fouling organisms :

It is attempted in the present paper to investigate the effect of twine diameter, mesh size and the colour of netting material on the rate of settlement of fouling organisms.

Plates 8,9 and 10 show the accumulated fouling organisms on net panels having different diameters, mesh sizes and colours after exposure period of one, two and there months during the winter of 1995. The two groups of net panels E.and H. had similar twine diameter and mesh size but differed in their colours. Their colours were white and brown respectively.

Table (3) : Seasonal changes in the dry weight of fouling organisms on netting materials at the Eastern Harbour of Alexandria during 1995.

Period of immersion	**Dry weight of panel gm.**	**Weight of. Organisms / Intital Wt. Of panel**	**weight of sample (Dry cond.) (gm)**	**Weight of. Organisms / Intital Wt. Of panel**
	Initial weight = 4.41 gm			
January.	5.965	0.35		
February.	16.305	2.70		
March.	85.500	18.39		
Winter			85.500	18.39
April	10.000	1.27		
May	18.300	3.15		
June	30.000	5.80		
Spring			30.000	5.80
July	6.000	0.36		
Aug.	10.800	1.45		
Sept.	14.800	2.35		
Summer			14.800	2.35
Oct.	6.600	0.50		
Nov.	8.400	0.90		
Dec.	16.300	2.70		
Autumn			16.300	2.70

The biomass of fouling organisms on group E. was 1.5, 10.5 and 65 gm/panel after one, two and there months in respective . Such biomasses on group H. were successively 1.7 , 11.5 and 60 gm during the three months.

It can be believed therefore that the colour of netting materials did not significantly affect the biomass of the fouling organisms during the period of exposure.

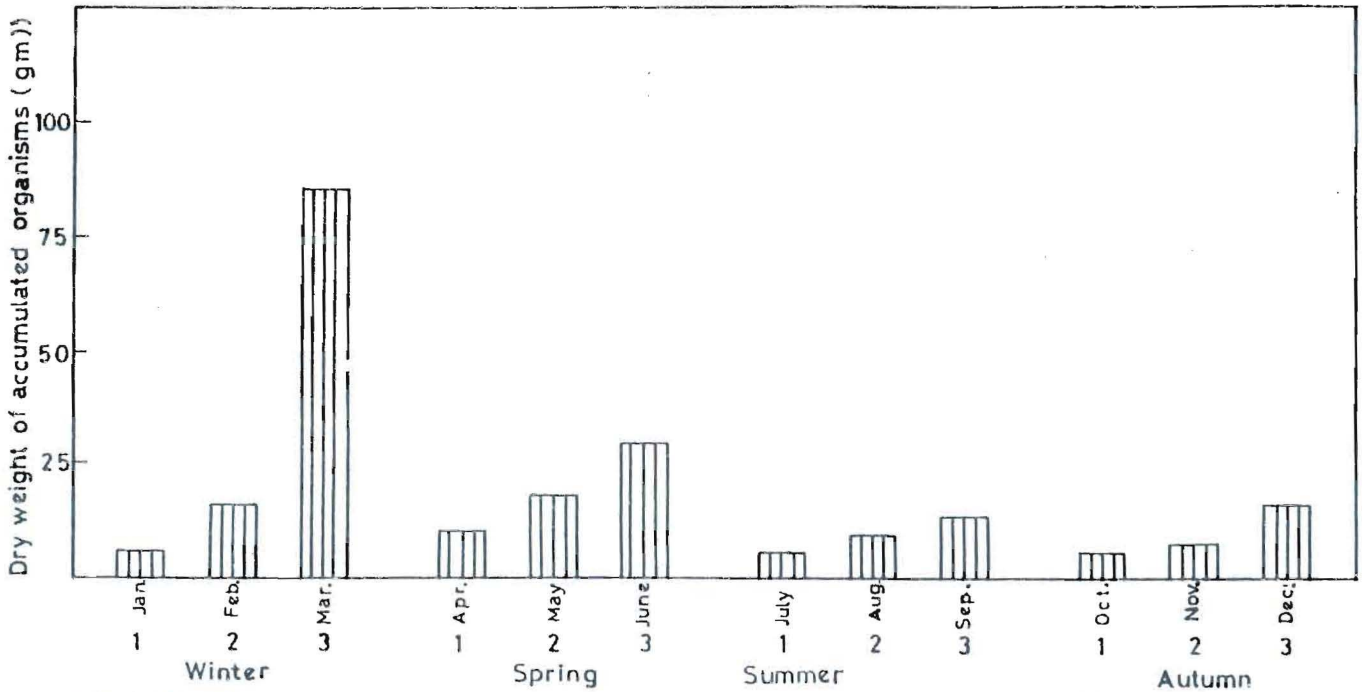

Fig.(3): The seasonal weights of dry fouling organisms accumulated on fishing net specimens at the Eastern Harbour.

On the other hand, the two groups H and I had the same twine diameter and colour but varied in mesh size . Group H had a mesh size of 2.0 gm while group I was 1.5 gm in mesh size. The fouling biomass on group I was 1.4 , 10.1 and 63.5 gm after one, two and three months of exposure in respective.

This means also that the variation in the mesh size of the tested netting panels did not greatly affect the accumulated biomass of fouling organisms on the tested panels.

However it can be believed that neither the mesh size, twine diameter nor the colour of the netting materials exposed at the E.H. during the winter of 1995 affected the biomass of the fouling organisms accumulated on such panels.

It can be recommended that further experiments must be carried out on a larger scale to investigate the effect of these three factors on the settlement of fouling organisms on the netting materials. In such a case it can be taken in consideration that treatment of the netting panels with some antifouling compounds must be attempted to investigate to what extent may these compounds be able to prevent or decrease the rate of settlement of the fouling organisms.

D- Comparison between settlement of fouling organisms on wood and netting panels (Short tern exposure)

Wood panels made from the pine type were used in the present investigation to demonstrate the rate of fouling accumulation on one of the most commonly used type of wood for building the fishing boats in Egypt.

These wood panels were exposed during the winter of 1995. Plate (11) shows the types and rate of fouling organisms which settled on such wood panels during January, February and March.

It can be demonstrated from the photos given in plate (11) that the main fouling organisms which settled after one month exposure were a rich growth of green and brown algae.

The rate of accumulation of fouling organisms on the wood panels after one month of exposure is much more higher than the rate of its accumulation on net panels after the same period of exposure.

After two months of exposure the rate of fouling community was comparatively high. The bryozoan organisms ***Bugula*** sp. Comprised a dense layer on the wood panel. Calcareous tube worms and ascidians comprised a major part of the fouling organisms.

During the third month of exposure, the bryozoan organisms falled off the panel, leaving a dense accumulation of the tube worms, ascidians and barnacles.

However, it is obvious that the rate of fouling accumulation on the wood panels was much more heavier than its rate of accumulation on the fishing net panels if exposed under the same conditions.

CONCLUSION

The results of the marine fouling observations at the Eastern Harbour are very useful and give a good indication of the relative marine fouling characteristics at the Mediterranean water of Egypt . This helps in the selection of the suitable materials for the enclosure and retention of the cultivated fish species if carried out in these areas. It is possible to summarise the present study in the following points :

1. The fouling complex on the exposed mesh metting panels tended to be dominated by a rich growth of branched and unbranched algae. The calcareous tube worms, bryozoan organisms, colonial and solitary ascidians formed massive accumulation on these test panels.

2. The calcareous tube worms which comprised a major part of the settled fouling organisms occurred during February, March and April where the water temperature was relatively low (16.6° - 18 3C°).

3. The bryozoan fouling organisms which added a considerable part of the fouling organisms flourished at higher temperature during May (25.9°C).

4. The dense fouling accumulation of which the calcareous tube worms and the bryzoan organisms contributed with a considerable part, was easily removed during June under the natural environmental conditions. Such removal can be attributed to the short life span of these organisms.

5. The solitary and colonial ascidians formed a major part of the fouling organisms, which started , its accumulation during the early weeks of the summer season . These organisms were able to form massive accumulation for long period which dominated for more than 8 months.

6. The accumulated biomass of the fouling organisms increased from January to April reaching 136.59 gm dry weight per panel. Such biomass decreased steadly during the next months to be 31.59 gm during June . Again it increased successively to reach a maximum weight of 235.59 gm in December.

7. The highest rate of settlement of the algal organisms was recorded during., winter season. The high transparency of water at the Eastern Harbour as well the high concentrations of the nutrient salts specially the phosphates and nitrates formed optimum and favourable environmental conditions for the growth and settlement of the algal organisms.

8. It was not possible to emphasize that neither the mesh size , twine diameter nor the colour of net panels could significantly affect the rate of fouling accumulation on the test panels. Further detailed experiments are required on larger scale to investigate to what extent may these factors affect the settlement of fouling organisms on met materials.

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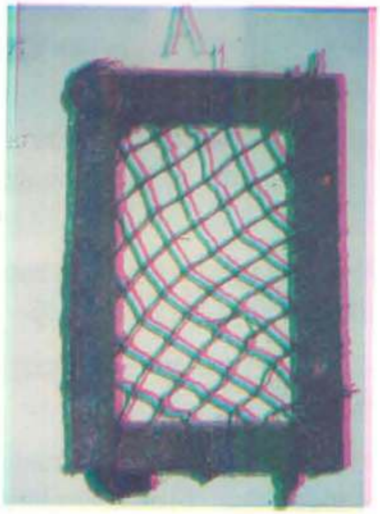

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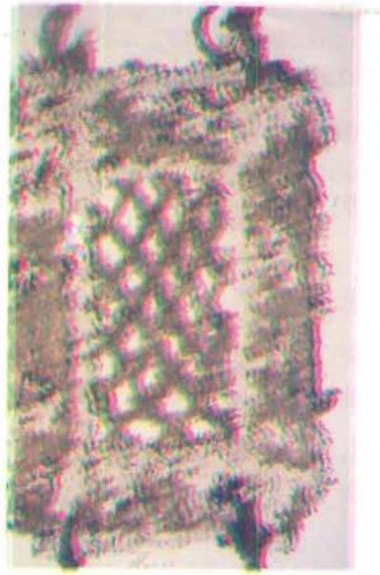


(2)

(3)

(4)

Plate (1): Fouling development on the test panels during the period from January to April 1995. Fig. 1,2,3 and 4 illustrate the accumulated organisms during January, February, March and April respectively.

(1)

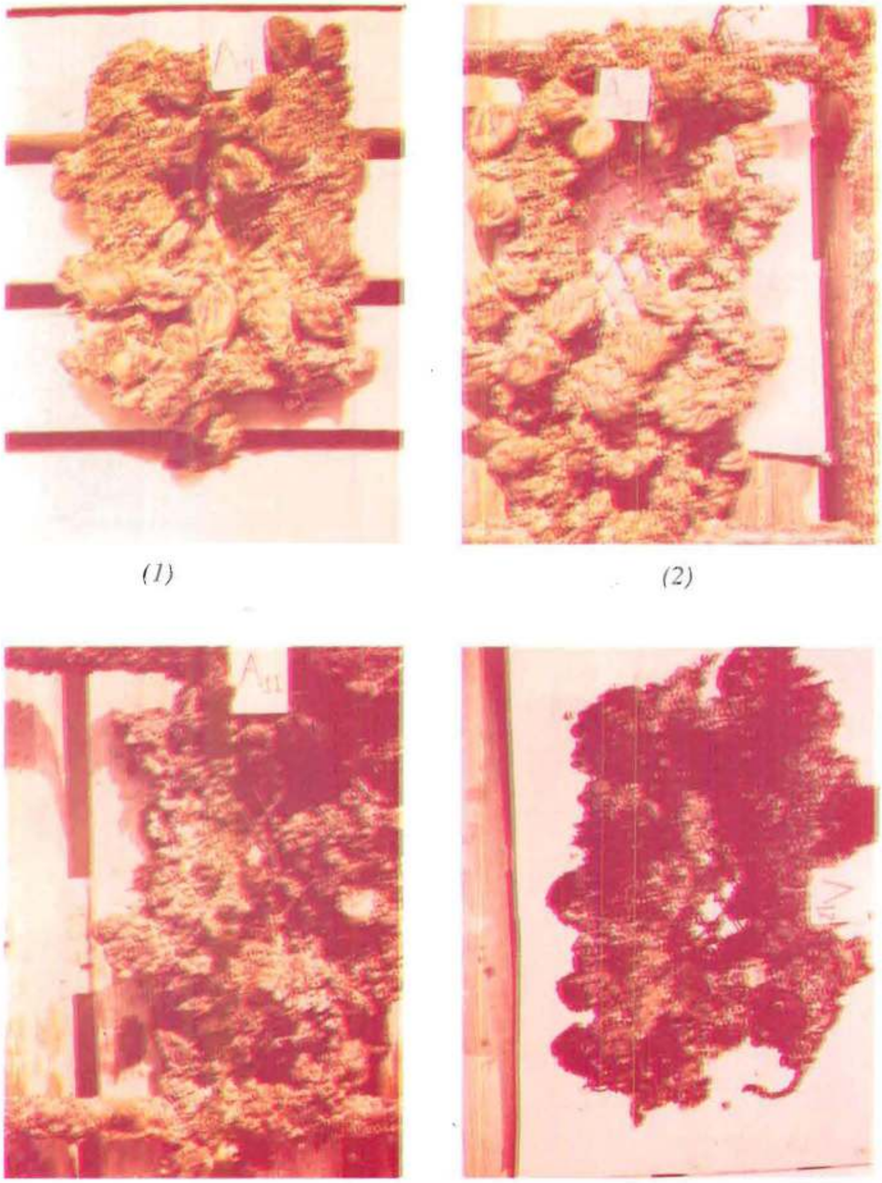
(2)

(3)

Plate (2)

(4)

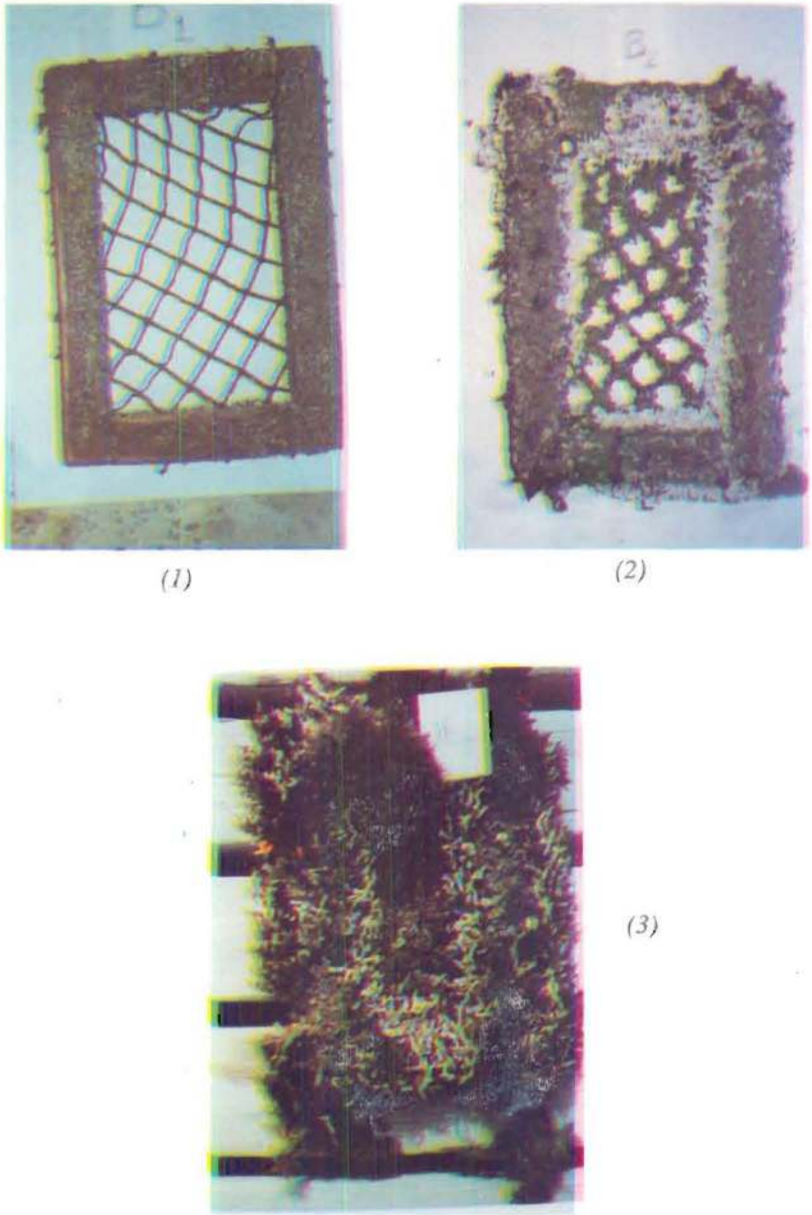
Plate (2): Fouling development during the period from May to August 1995. Fig. 1,2,3 and 4 in this plate indicate the commulative fouling development during May, June, July and August respectively.



(1) (2)

(3) Plate (2) (4)

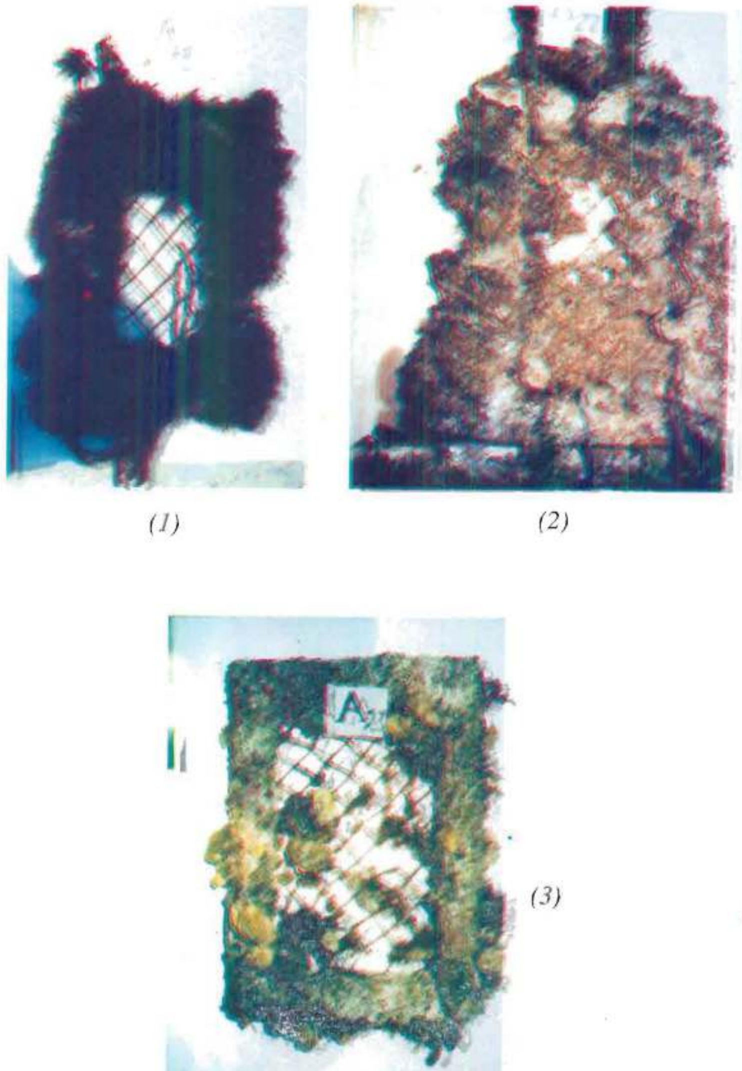
Plate (3): Fouling development on the test panels at the Eastern Harbour during the period from September to December 1995. Fig. 1,2,3 and 4 indicate the commulative development and December. October, November and December respectively.



(1) (2) (3)

Plate (4)

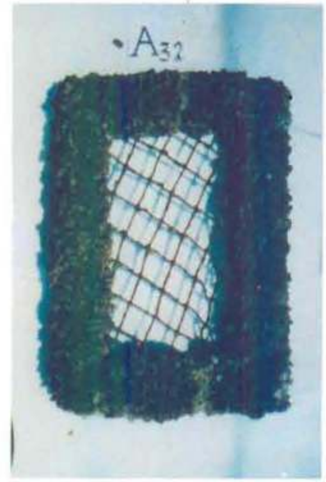
Plate (4): Commulative fouling development at the Eastern Harbour during, the winter of 1995. Fig. 1,2 and 3 ,of the plate show the com,m,ulative developm,ent during January, February and March respectively. Complete blocking of the meshes of net webbing can be observed by the third month of exposure.



Plate(5)

Plate (5): Commulative fouling development at the Eastern Harbour during the spring of 1995. Fig. 1.2 and 3 of the plate indicate the commulative fouling accumulation during April, May and June respectively. Removal of most of the fouling organisms can be observed during the third month of spring.

(1)



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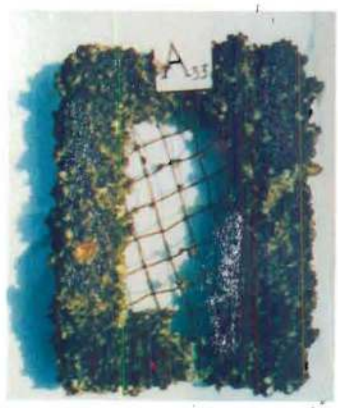


(3)

PLATE(6)

Plate (6): Commulative fouling development at the Eastern Harbour during the summer of 1995. Fig. 1,2 and 3 of this plate indicate the commulative fouling accumulations during July, August and September respectively. Low rate of fouling settlement can be shown during the summer.

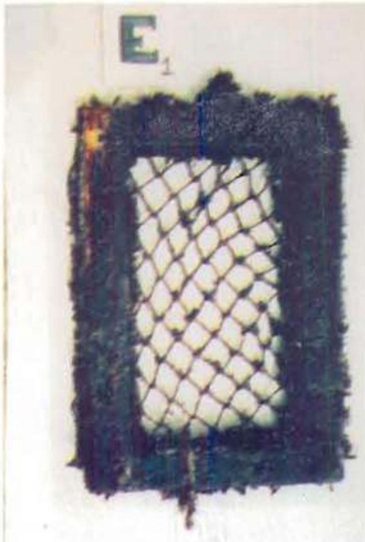
(1)

(2)

(3)

PLATE(7)

Plate (7): Commulative fouling development at the Eastern Harbour during the autumn of 1995 Fig. 1,2 and 3 of this plate indicate the commulative fouling accumulation during October, November and December in respective. Moderate fouling settlement of calcareous tube worms appeard during autumn.



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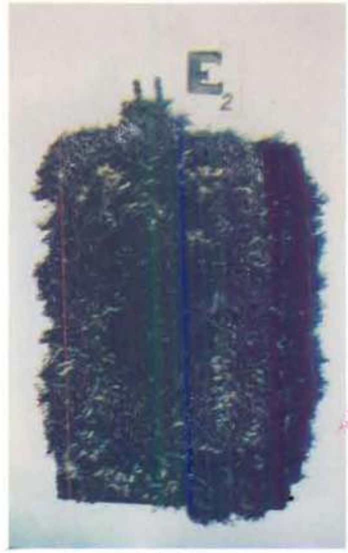

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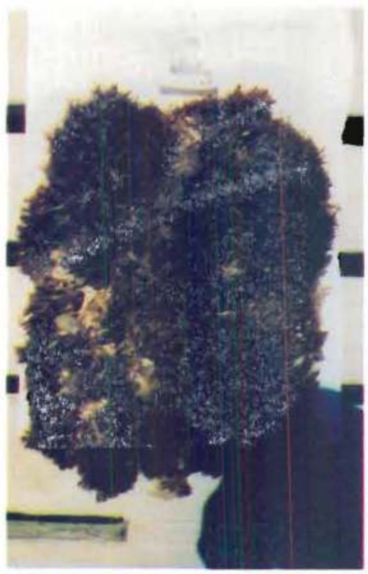
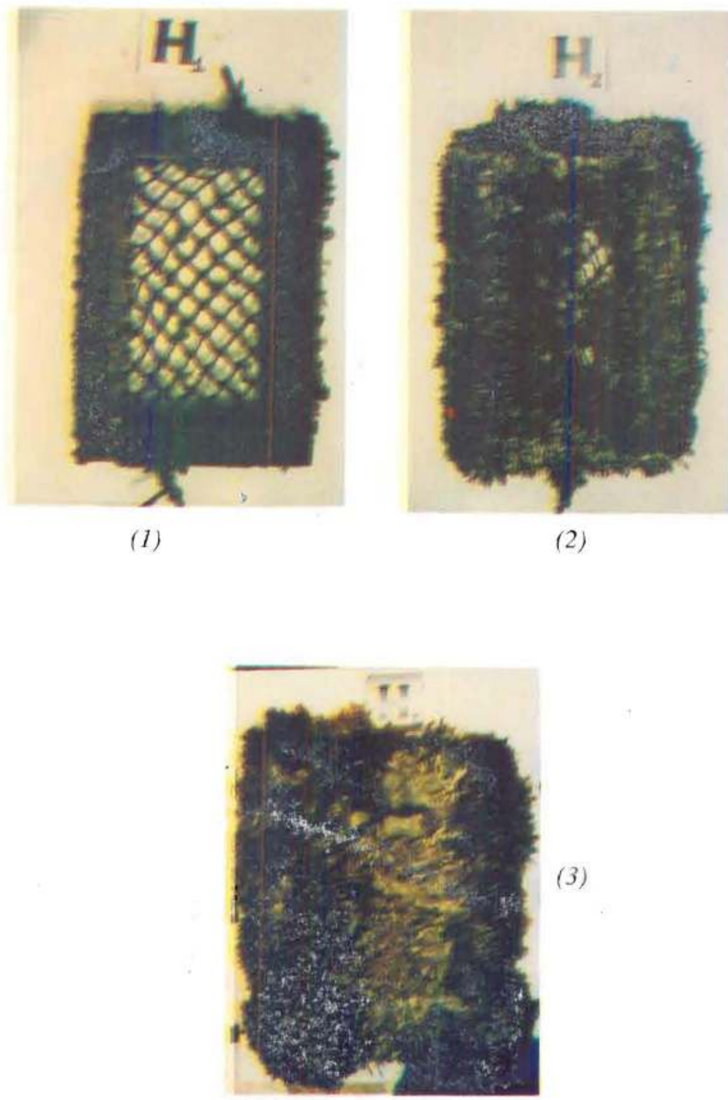


(3)

PLATE(8)

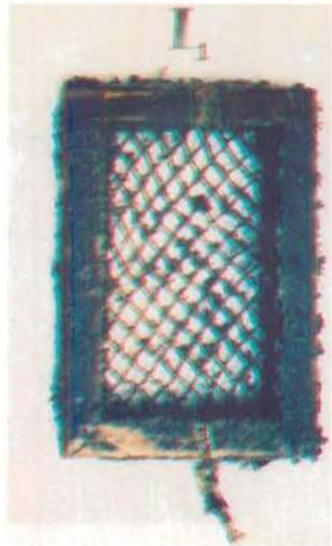
Plate (8): Fouling settlement on group (E) of netting panels having a mesh bar of 2.0 cm and white in colour, during the winter of 1995.



(1) (2) (3)

PLATE (9)

Plate (9): Fouling settlement on group (H) of netting panels having a mesh bar of 2.0 cm and brown in colour, during the winter of 1995.



(1)

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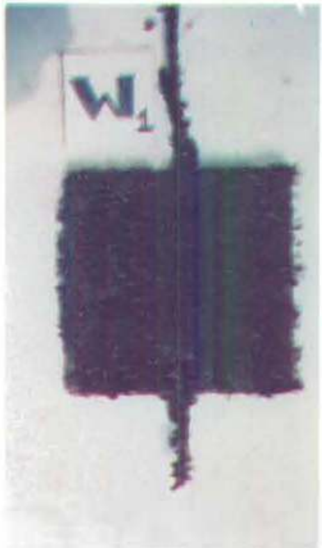
PLATE (9)

Plate (10): Fouling settlement on group (I) of netting material having a mesh size of 1.5 cm and brown in colour during the winter of 1995.



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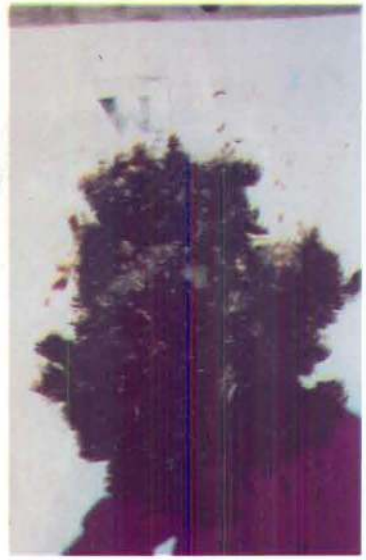

(2)

(3)

Plate (11)

Plate (11): Fouling accumulation on wood panels during the winter of 1995. Heavier rate of fouling development in comparison with that developed on net panels during the same period of exposure.

(1)

(2)

Plate (12): Commulative fouling development on a test panel after the exposure during the winter season. Heavy development can be observed in Fig. 2.

1

2

Plate (13): Heavy fouling accumulation on a group of panels exposed during the winter season can be observed in Fig. (1). Removal of such fouling development under the natural conditions can be observed in Fig. (2).