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PATTERN AND KINETICS OF NITRATE AND AMMONIA UPTAKE IN COASTAL MEDITERRANEAN WATERS IN FRONT OF ALEXANDRIA.

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ABSTRACT

Uptake of nitrate and ammonia in coastal Mediterranean waters in front of Alexandria was affected mainly by the nitrogen input from land sources. Nutrient uptake could be described by Michaelis-Menten model in areas of nitrogen content less than 5 ug at N/l and chlorophyll "a" concentration higher than 15 ug/l. Half saturation constant Km for nitrate uptake ranged from 2.8 to 27.2 ug at/l while that for ammonia ranged from 3.7 to 63.9 ug at/l. Variations of Km values were found to depend on the areas characterized by high nutrient concentrations, the rate of nutrient uptake v remained coastant, while in areas of low nutrient v increased steeply by increasing the ambient concentration of substrate S. The effect of light on nutrients uptake was discussed.

INTRODUCTION

Incorporation of nitrogen into the first trophic level via phytoplankton utilization of nitrate and ammonia is the first and the most important dynamical step in the nitrogen cycle. Measurements of nutrient uptake velocity are very important to people concerned with marine productivity and also for researchers dealing with marine pollution and eutrophication (Lean and White, 1983; Mahmoud, 1985 and others). It is evident that under steady state conditions, specific uptake and specific growth rates must be equal.

Light and nutrient concentrations are considered to be the principal environmental factors affecting nutrient uptake (Dugdale and Goering, 1967; Eppley et al., 1969 and Toetz, 1976).

The present work aims to follow the effect of environmental conditions, mainly, nitrogen input from land sources and light, on uptake rate of nitrate and ammonia in coastal marine environments.

MATERIALS AND METHODS

Surface water samples were collected from 3 areas: El-Mex Bay, Kayet Bey and El-Agamy (Fig. 1). In situ expriments were conducted according to the procedure of Eppley et al. (1969). Each water sample was divided into a series of one liter aliquots. Five aliquots from that series were enriched with various amounts of nitrate (2.5, 5, 10, 20, 30 uM) and five others with various amounts of ammonia (5, 10, 20, 30, 40 uM). A water volume from each aliquot was transferred to a corresponding incubating bottle of 300 ml. The bottles were then incubated in situ. Care was taken not to expose the water samples to direct sunlight. In addition and prior to enrichment, seawater samples were immediately analyzed for nitrate and ammonia. After 4 hours incubation, the water in the incubation bottles were analyzed for nitrate and ammonia. The uptake rate was taken to be the difference between the initial and final concentrations. Nitrate, ammonia and chlorophyll "a" were determined according to Strickland and Parsons (1968).

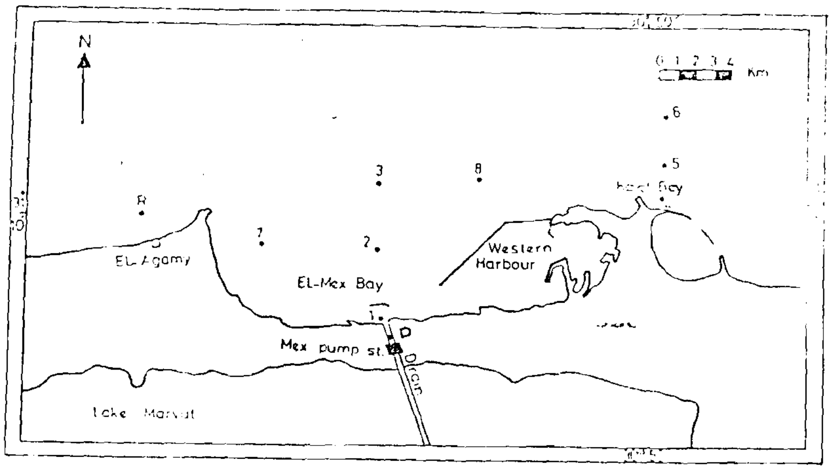

Fig. 1

Area of investigation.

RESULTS AND DISCUSSION

It is clearly noticed (Table 1) that the highest rates of nutrients uptake were measured at El-Mex Bay, thus reflecting the effect of brackish water effeluents (salinity 10 $‰$) on the coastal area. The lowest uptake rates, on the other hand, were found at El-Agamy, as it is far from land effect (salinity 38 $‰$). Kayet Bey area (salinity 10-38 $‰$) represents the intermediate case. In general, lowest rates of nutrients uptake were measured in winter, while the highest rates (specially for ammonia uptake) were measured during summer, thus reflecting optimum conditions of temperature and light for plankton to assimilate nutrients during summer.

Table 1.

Variations of nitrate and ammonia uptake rate by natural phytoplanktonic populations in El-Agamy, El-Mex and Kayet Bey.

Season	Nitrate		Ammonia		Chlorophyll "a"
	Conc. uM/l	Uptake rate u M/l	Conc. uM/l	uptake rate u M/l	ug/l
El-Agamy :					
Winter	2.00	0.002	4.32	0.08	1.73
Summer	2.04	0.008	2.31	0.14	5.13
Autumn	0.40	0.010	2.72	0.04	11.43
Kayet Bey :					
Winter	1.62	0.140	21.34	0.07	2.63
Summer	0.91	0.160	41.47	0.06	11.27
Autumn	0.37	0.050	3.25	0.01	16.07
El- Mex :					
Winter	0.69	0.240	27.83	0.31	14.44
Summer	6.26	0.090	8.15	0.46	24.29
Autumn	27.01	0.030	19.93	0.10	12.20

Diəl Variations and the Effect of Light:

Some experiments were conducted to follow diel changes of nutrients uptake, which by, parallel dark and light vessels were used during day light for sample incubation. Rates of ammonia uptake in dark and light bottles during the day time (8h-13h) are shown in Fig. 2. It is noticed that in light bottles uptake values were slightly higher than 1.4 ug at NH_4-N l^{-1} h^{-1}. In the dark bottles, on the other hand, uptake values were slightly lower than 1.4 ug at NH_4-N l^{-1} h^{-1}, with no significant changes from the light ones.

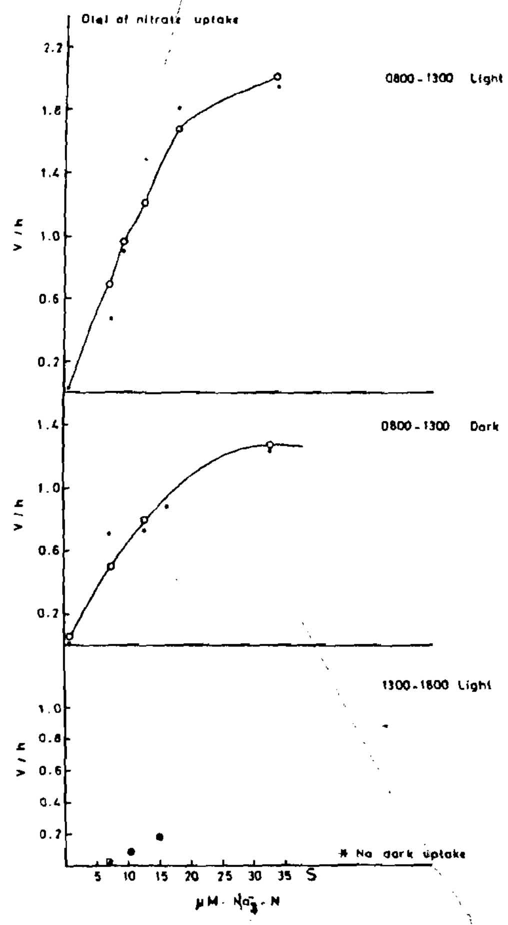

Fig. 2

Light and dark uptake of nitrate and ammonia.

Rates of nitrate uptake are shown in Fig. 2. During the period, 8h-13h, nitrate uptake reached 2 ug at NO_3-N l^{-1} h^{-1} in light bottles, while it did not exceed 1 ug at NO_3-N l^{-1} h^{-1} in the dark ones. During the period, 13h-18h, there was no dark uptake of nitrate, while light uptake rates were lower than the corresponding values measured during forenoon period, i.e. less than 1 ug at NO_3-N l^{-1} h^{-1}. No uptake of nitrate was succeded to be measured during night. The present experiment indicates, in general, that light is clearly involved in nitrate uptake, while it is not involved in ammonia uptake. This pattern of diel changes in nutrient uptake is in good agreement with results obtained in fresh water environments by MacIsaac and Dugdale (1969) and Toetz (1976). No data, but the present, are available on diel variations of nutrients uptake in marine environments.

Kinetics of Nitrate and Ammonia Uptake:

It was suggested by many authors (Eppley et al.,1969; Toetz, 1971 and others) that nutrient uptake by phytoplankton can be a function of its concentration in the water and can be modeled by Michaelis-Menten expression $v = V_max. S/K_m + S$, where v is the uptake velocity, S is the ambient concentration of substrate, $V_m$ax. is the maximum uptake velocity attained at saturating levels of S, and K_m is the half saturation constant; it is equal to S when $v = 1/2\ V_m$. Eppley et al. (1969) showed that a hyperbola results when nutrient uptake velocity v is plotted against substrate concentration S. In the present study, many in situ experiments were conducted to determine k_m and V_{max} for nitrate and ammonia uptake at three locations; El-Agamy, El-Mex Bay and Kayet Bey. K_m values were calculated by least-square fit of S/v on S. In this transformation K is the negative intercept on the X axis and V_{max} is the inverse of the slope of the regression line. S/v against S plot was used in preference to other transformations because it gave the best spread of the experiment points. Normal smooth hyperbolae, fitting Michaelis-Menten model could be obtained (Figs. 3 & 4), mostly, in locations characterized by low concentration of nutrients (less than 5 ug at N l^{-1}), and high concentration of chlorophyll "a" (15 ug/l). Toetz et al. (1977) found that nitrate uptake was highest when the concentration of chlorophyll "a" was 8-19 ug/l and the concentration of inorganic nitrogen was low. These cases reflect normal conditions of light and nutrient concentrations for phytoplankton activity. It is noticed from Fig. 3 and 4 that half saturation constant K_m for nitrate uptake, ranged from 2.8 to 27.2 ug at/l, while that for ammonia ranged from 3.7 to 63.9 ug at/l.

The inhibition effects of high values of initial concentration on the nutrient uptake have got, recently, a very great consideration. Many authors (Conway, 1974, Dugdale and MacIssac, 1971 and others) could predict the limiting nutrient in certain environment by plotting v against S. Dugdale (1976) stated that points along the plateau of the hyperbolae represent concentrations of S which do not limit uptake, while points along the steeply rising slope my be interpreted to mean that S is limiting.

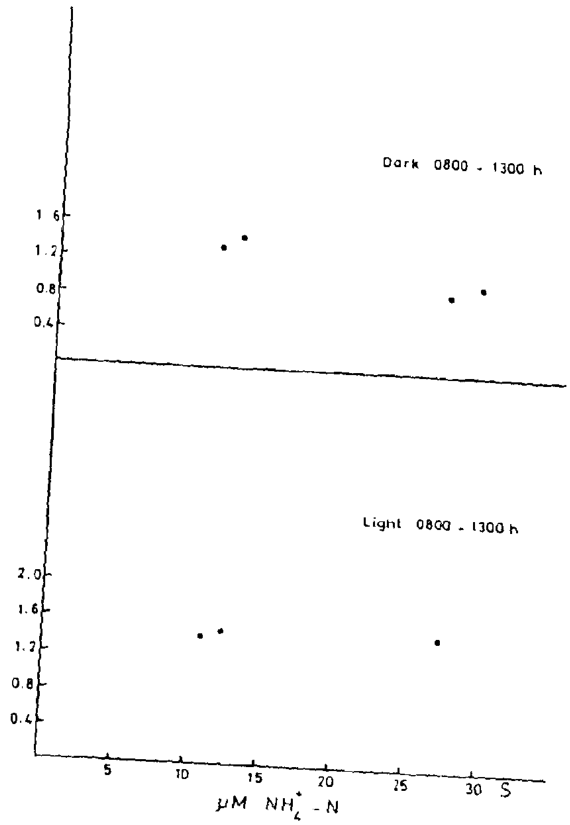

Fig. 3

Hyperbolae for nitrate uptake in the different areas.

Thus, at El-Mex Bay and Kayet Bey, nitrogen is not limiting for primary productivity, as its intial concentrations are very high comparing to points along the plateau of the obtained hyperbolae. At El-Agany (pure seawater, far from land effect), on the other hand, nitrogen could be a limiting nutrient.

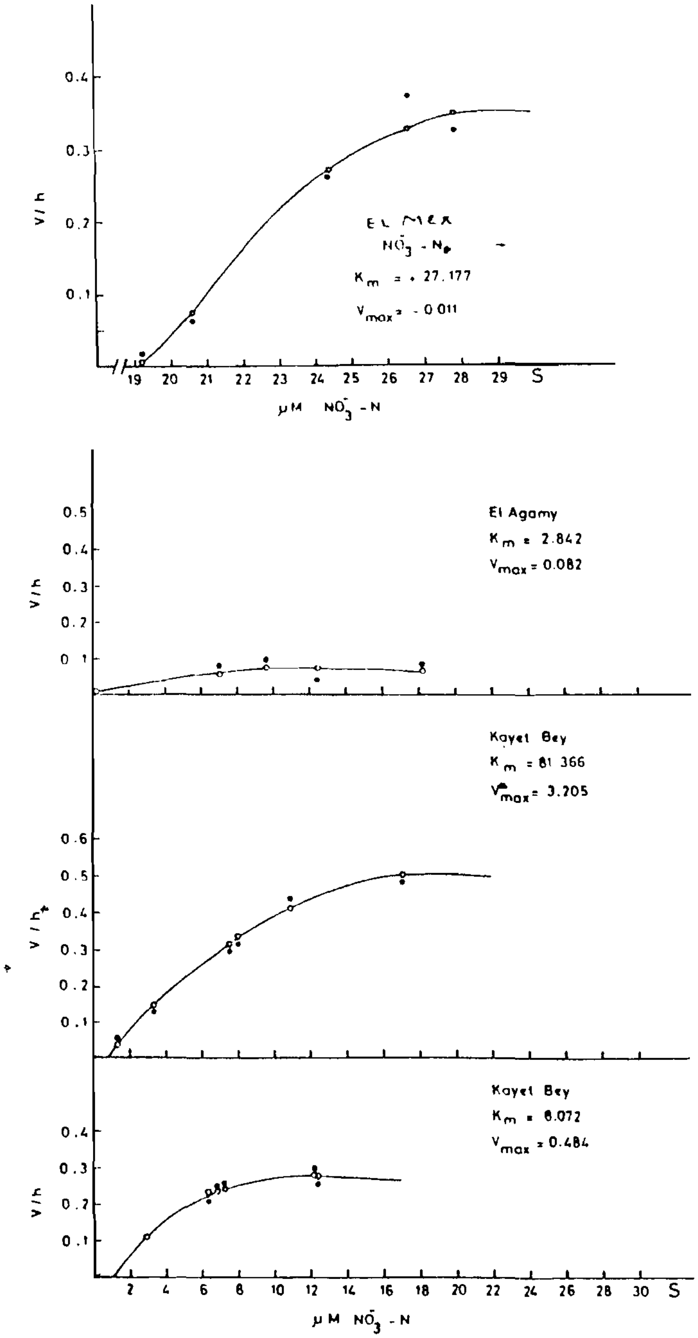

Fig. 4

Hyperbolae for ammonia uptake in the different areas.

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