

NUTRIENT SALTS IN THE SURFACE MICROLAYER AND
SUBSURFACE LAYER OF KAŠTELA BAY WATERS

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ABSTRACT

This paper gives a values of the inorganic form of the main nutrient salts in the surface and subsurface layers of the Kaštela Bay waters (Central Adriatic). Analyses of all the dissolved nutrients show an enrichment in nutrients in the surface layer if compared with the subsurface water. Only silicon in the surface layer showed no significant enhancement with respect to silicon in subsurface layer.

RESUME

Dans ce travail, sont présentées les valeurs des formes inorganiques des principaux sels nutritifs, dans la couche superficielle ainsi que dans la "sub-surface" (eau située à 20 cm au-dessous de la surface), dans la Baie de Kastela. Les analyses de tous les sels dissous ont démontré l'enrichissement de la couche superficielle par rapport aux valeurs de la "subsurface". Seul le silicate réactif n'a pas démontré d'enrichissement considérable par rapport aux silicates de la "subsurface".

Even though it was long ago known that the chemical properties of the surface microlayer differ from the properties of the sea water mass in number of respects, this problem has been given special attention not earlier than for the last ten years.

Nutrient salts ($\text{PO}_4\text{-P}$, $\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$, $\text{NH}_4\text{-N}$, and $\text{SiO}_2\text{-Si}$) concentrations in the surface microlayer and subsurface layer

have been very little studied, even though these salts are the basic link in the nutrition chain of the biota in the sea. Mean values of our results on the studied nutrient salts in the surface microlayer and subsurface layer of the investigated area (Kaštela Bay) are given in the following tables:

Table 1. NUTRIENT SALTS IN SURFACE MICROLAYER (SL) IN $\mu\text{mol/l}$

	PO ₄ -P	P-total	NO ₃ -N	NO ₂ -N	NH ₃ -N	SiO ₂ -Si
\bar{x}	0,16 [±] 0,02	0,32 [±] 0,03	0,86 [±] 0,08	0,07 [±] 0,02	3,90 [±] 0,40	2,87 [±] 0,24
s	0,007	0,13	0,30	0,03	1,56	0,94
cv	0,48	0,41	0,35	0,52	0,40	0,32

Table 2. NUTRIENT SALTS IN SUBSURFACE LAYER (SSL) IN $\mu\text{mol/l}$

	PO ₄ -P	P-total	NO ₃ -N	NO ₂ -N	NH ₃ -N	SiO ₂ -Si
\bar{x}	0,12 [±] 0,06	0,18 [±] 0,01	0,32 [±] 0,08	0,07 [±] 0,01	2,30 [±] 0,53	2,95 [±] 0,04
s	0,24	0,05	0,32	0,04	2,04	1,72
cv	0,20	0,26	0,38	0,56	0,88	0,58

The increased concentrations of nutrients in the surface microlayer are expressed as the enrichment factor E_s according to Piotrowicz et al.

$$E_s = \frac{\text{conc. nutrients in microlayer}}{\text{conc. nutrients in subsurface}} - 1$$

Spatial distribution of nutrients in the surface microlayer and subsurface layer shows the obvious influence of the town outlets on the nutrient salts concentrations both in the surface microlayer and in the subsurface layer. The quantity of nutrients is reduced with the distance from the source of salts i.e. the source of town and industrial sewage waters.

Increased concentrations of PO₄-P (phosphate) in the surface microlayer, if compared to the subsurface layer, were recorded from all the stations of the investigated area. The highest

values of the enrichment factor were found at stations close to the shore. This may be accounted for by the already mentioned factors. In general, the majority of authors gave particular attention to the dissolved gass bubbles which rise up to the surface and enrich the surface microlayer by bursting. The enrichment factor of $\text{PO}_4\text{-P}$ in the surface microlayer ranges from 2,15 to 0,06 and its mean value is 0,33.

The $\text{N}_2\text{-}$ salts concentrations in surface microlayer are greater than those in the subsurface layer at almost all the stations. Even though the procedure of the enrichment has not yet been fully explained, Goering and Menzel (1965) these increased concentrations attribute to quick oxidation of $\text{NH}_3\text{-N}$ in $\text{NO}_2\text{-N}$ by bacterial nitrification, the photolysis of NO_3 to NO_2 and biological activity.

Unfortunately we could not say which one of these processes dominates. We found very small, even negligible factor of enrichment of $\text{NO}_2\text{-N}$ (nitrite) at almost all the stations. The greatest enrichment was found for $\text{NH}_3\text{-N}$ (ammonium) and $\text{NO}_3\text{-N}$ (nitrate), the maximum values of which are 2,61 and 0,32 respectively.

Williams (1967) states that the bacterial nitrification in situ is likely to be the primary cause of enrichment of $\text{NO}_3\text{-N}$ in the surface microlayer.

The concentrations of $\text{SiO}_2\text{-Si}$ in the surface microlayer are slightly higher than those in the subsurface layer. On one occasion there was even recorded the higher concentration of Si in subsurface layer (July 1980).

Somewhat more significant values of enrichment factor were recorded from the nearshore stations what could be accounted for by the influence of factors from the land, i.e. by the influence of fresh waters which carry considerable quantities of these salts into the sea.

References:

- Goering, J.J. and Menzel, D.W. (1965). Deep Sea Res 12; 839-843
 Piotrowicz, at al. (1972). J. Geophys. Res. 77, 5243-5254
 Williams, P.M. (1967). Deep Sea Res. 14, 191-800

Vukadin, I. and Huljić, V.

"Nutrient salts in the Surface microlayer and subsurface layer
 of Kaštela Bay waters"

Paper presented by I. Vukadin (Yugoslavia)

Discussion

M. Branica: Organic P has a very pronounced enrichment factor
 if you recalculate your results shown on page 4
 (Table 1) P-total - PO_4^{3-} (P)!

I. Vukadin: Yes, organic P has an enrichment factor about two
 and in my paper I have explained the reason that
 is most likely causing this effect.

N. Smodlaka: The slides show that there is no enrichment of
 nutrients in the surface layer. We did some re-
 search on the surface microlayer and found out
 the enrichment of phytoplankton biomass, bacteria,
 organic phosphorous, nitrogen of one order of
 magnitude. We found that phosphate was accumulated
 and that is probably caused by phosphate ad-
 sorption on particulate matter.

I. Vukadin: I have not seen anywhere your results and can
 not discuss this matter. From our results on
 Tables 1 and 2 you can see that there are en-
 richments of nutrients in the surface layer if
 compared with the subsurface water.

- Lj. Musani: Have you compared your results for nutrient salt concentration with some other polluted areas (industrial and sewage outfalls, e.g. close to Athens, etc.)?
- I. Vukadin: I compared our results with some data of the Ireland waters (Galway Bay) but unfortunately not with the results relating to the Athens area.
- J. Castelvi: C'est une suggestion pour l'interprétation: l'illumination en surface est très forte et peut-être elle donne une inhibition de l'activité photosynthétique. Cela produirait une non utilisation des nutriments et pas un enrichissement actif.
- I. Vukadin: Théoriquement il serait possible de donner une telle interprétation, mais malheureusement nous n'avons pas de données parallèles sur l'activité photosynthétique et l'illumination.
- A. Škrivanić: Circulation system in the Kaštela Bay is under predominant influence of local winds: SE (scirocco) and NE (bora). Concentration of nutrient salts in the surface microlayer had to be under strong influence of unpronounced drift circulation. To obtain realistic results, in my opinion you must perform sampling after both of the above mentioned meteorological conditions occurred. Please, are your results obtained in such a way?
- I. Vukadin: As I mentioned in the paper we collected our samples in the summer period (June and July 1979). Weather was really fine and the sea calm. Un-

fortunately, we did not take into consideration such conditions. I agree with you that scirocco and bora have an influence on the Kaštela Bay, but that influence is not so strong in summer.