

ACTA ADRIATICA
INSTITUT ZA OCEANOGRFIJU I RIBARSTVO — SPLIT
SFR JUGOSLAVIJA

Vol. XIX, No. 6

**NUTRIENT SALTS AS A POSSIBLE INDICATOR OF URBAN
POLLUTION OF THE ADRIATIC COASTAL WATERS**

HRANJIVE SOLI KAO INDIKATOR ZAGAĐENJA U PRIOBALNIM
VODAMA JADRANSKOG MORA

MILJENKO BULJAN, LAMBE STOJANOSKI and ILIJA VUKADIN

SPLIT 1979

NUTRIENT SALTS AS A POSSIBLE INDICATOR OF URBAN POLLUTION OF THE ADRIATIC COASTAL WATERS

HRANJIVE SOLI KAO INDIKATOR ZAGAĐENJA U PRIOBALNIM
VODAMA JADRANSKOG MORA

M. Buljan, L. Stojanoski i I. Vukadin

Institute of Oceanography and Fisheries, Split

INTRODUCTION

The object of this study is to determine whether the effect of fast development of coastal urban agglomerations on the chemical composition of the sea adjacent to them may be noticed.

Nutrient salts distribution has therefore been surveyed in some parts of the Adriatic. We used our own data and the data collected by several other Adriatic laboratories.

METHODS

Material we used in this study includes:

a) the data from three Stations, (6, 9 and 10) in the vicinity of the town of Split (the Bay of Kaštela and Split Channel) collected during 1972 and 1973, and UNDP data (unpublished).

b) the data from seven stations in and out of the Krka River Estuary (Buljan, Stojanoski, Vukadin, 1976) collected during 1973 and 1974.

c) the data from the northern Adriatic collected by m/s VILA VELEBITA (Gilmartin et al., 1972) during 1972.

d) the data from the northern Adriatic collected by Scaccini-Ciccatelli (1976) along the Italian coast from 1965—1966.

DISCUSSION

*The influence of the town of Split on the seawater of the Bay of
Kaštela and Brač Channel*

This area was surveyed between July 1972 and October 1973. The survey included following stations: P 6 (Station 25), 3,5 Nm distant from the town outfalls, P 9 (Split cargo port) 1,0 Nm distant from the town outfalls (in

Spinut), and P 10 (Split passenger port) 0,3 Nm distant from the town outfalls (Fig. 1).

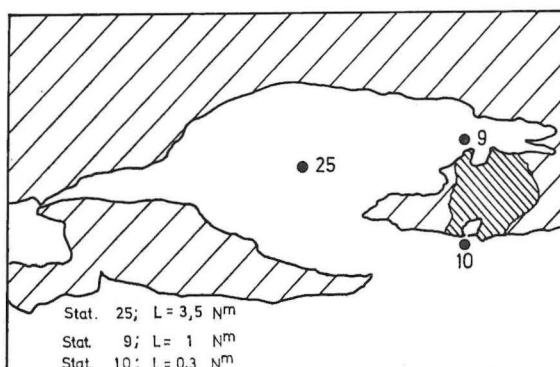


Fig. 1. Split area. Stations 25 and 9 are in the Bay of Kaštela and station 10 off the city harbor

From the data presented in the Tab. 1 one can infer that distance of a station from town outfalls affects a series of chemical parametres. Thus the greater this distance the lower is the concentration of nutrient salts. Ammonia salts behave like other nutrients although in somewhat different way (Tab. 2).

Table 1. Influence of the town Split to nutrient enrichment of the adjacent sea

Stations	25	9	10
L in Nm	3.5	1.0	0.3
PO ₄ -P μg-at/l	0.097	0.102	0.108
tot-P "	0.168	0.205	0.203
NO ₃ -N "	1.10	1.21	1.24
NO ₂ -N "	0.060	0.050	0.045
NH ₃ -N "	0.98	3.21	1.06
SiO ₃ -Si "	7.93	8.38	8.52
Si/Cl x 10 ⁻⁵	1.05	1.09	1.12
BOD ₅ mg/l	1.10	1.70	3.28

N-NO₂ also behaves in opposite manner. This may be accounted for by that time (or spatial) distance, is needed for NH₄⁺ to be converted into N-NO₂.

Table 2. Increase (in %) of nutrients at stations closer to town port of Split related to the most offshore stat. 25

Stations	25	9	10
L in N ^m	3.5	1.0	0.3
PO ₄ -P $\mu\text{g at/l}$	1	5.2%	11.2%
tot-P "	"	22.0%	21.0%
NO ₃ -N "	"	10.0%	12.8%
NO ₂ -N "	"	-8.3%	-25.0%
NH ₃ -N "	"	228.0%	8.2%
SiO ₃ -Si "	"	5.7%	7.4%
Si/Cl	"	3.8%	6.7%
BOD ₅	"	54.5%	189.0%

The data for BOD₅ are also given in the Tables. Their distribution is similar to that to nutrients, i.e. their offshore level is lower than the inshore one.

The influence of the town of Šibenik on the Krka River Estuary

The distribution of free phosphate, measured during February 1974, is significant since it is indicative of pollution. From the Fig. 2 it is apparent that the greatest quantities of this salt were recorded from all the levels in the sea between the Stations P-1 and P-8, i.e. close to the town of Šibenik.

Means of phosphate contents recorded from the outer station were within the 0.047—0.057 $\mu\text{g-at P/l}$ and of those recorded from the stations in the Estuary were: 0.072 (P-1), 0.164 (P-2), 0.205 (P-3), 0.106 (P-8), 0.052 (P-10), and 0.024 (P-14) $\mu\text{g-at P/l}$. Considerable increase in the level of phosphate in the sea near the town of Šibenik is clearly shown in the figure of longitudinal cross-section (Fig. 2). The same situation extends at deeper layers as far as Prokljan Lake. The increased level of phosphate may be indicative of two things: first, that the town affects the chemical composition of the sea and, second, that there is present a compensatory current which transports the bottom sea water up the river.

This phosphate of urban origin positively affects the organic production in the Estuary, which then influences the oxygen complex dynamics (O₂ ml/l, O₂‰, Fig. 3). As indicated by the numerical data, the influence of the town on the chemistry of seawater is still positive. The town of Šibenik fertilizes the adjacent sea of the Estuary and through the Estuary the open sea is enriched. There is still no indication that dystrophic conditions may become established.

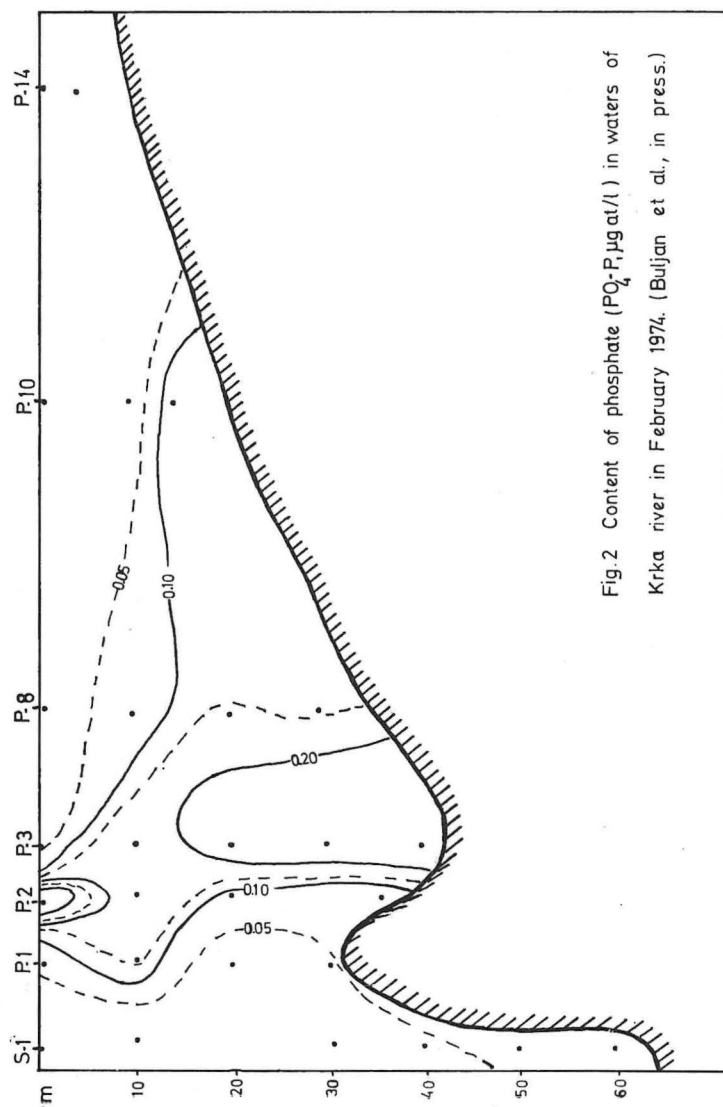
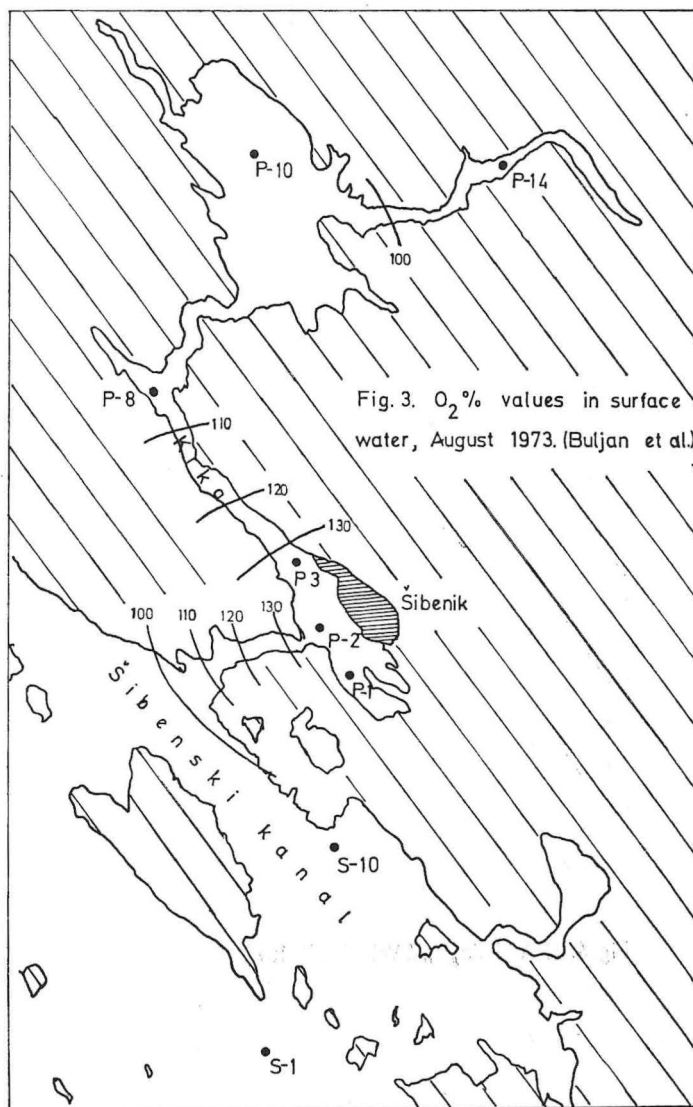


Fig.2 Content of phosphate ($\text{PO}_4\text{-P}$, $\mu\text{g at/l}$) in waters of Krka river in February 1974. (Buljan et al., in press.)



Northern Adriatic

Out of the material collected during the cruise of m/s VILA VELEBITA (Gilmartin et al., 1972) we took the data which indicate that nutrients content in the sea is affected by the presence of large coastal towns. The level of influence is lower if the distance of the station from the coast is larger (Fig. 4). Numerical data for five nutrients are given in Tab. 3.

The data were collected from a) Stations 1 and 2 which are 33 Nm far from Trieste and Venice respectively.

b) Stations 19 and 20 placed 72 Nm far from Trieste and 81 Nm from Venice respectively.

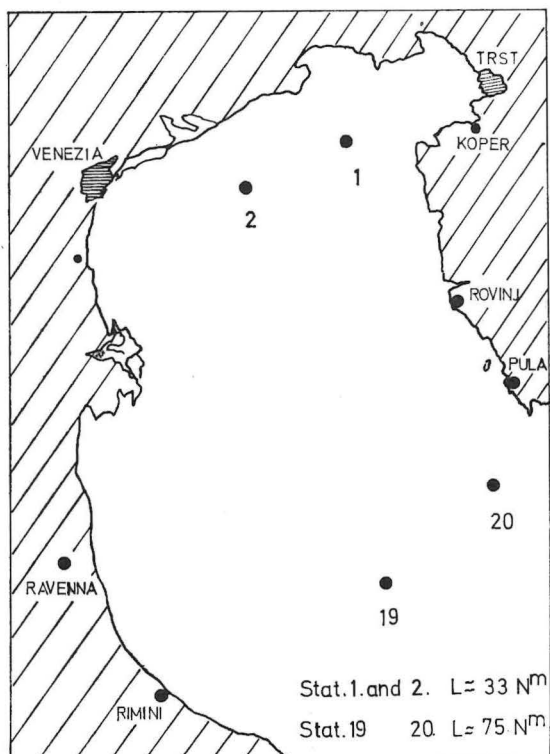


Fig. 4. N-Adriatic, „V. Velebita " 1972

Table 3. Content of nutrient salts at stations in Northern Adriatic (mg-at/t)

Stations	Date	PO_4-P	NO_3-N	NO_2-N	NH_3-N	SiO_2-Si	L in Nm
19 and 20	III 1972.	0,01	0,16	0,03	0,07	2,20	75
1 and 2	"	0,04	0,24	0,04	2,80	4,60	33
Increase in %	"	400%	50%	33%	3900%	109%	
19 and 20	IX 1972.	0,00	0,53	0,10	1,20	2,30	75
1 and 2	"	0,03	1,08	0,17	1,90	2,40	33
Increase in %	"	∞	103%	70%	58%	4%	

It is evident that these two large urban agglomerations affect the winter as well as summer level of nutrients in the *open sea*. This influence is intensified in winter (see in Tab. 3 for how many percentages is this effect stronger at stations closer to the port).

Particularly intensive influence of large urban agglomerations (Trieste, Venice) on nutrient enrichment at adjacent sea is evident. It is reduced with the distance of the station from urban agglomerations.

The influence of smaller towns (Split) is less intensive. Thus the regularity of decrease of this influence with distance of the station is lesser (e. g. for NH_4 , NO_2 , P-tot).

Western Adriatic

In order to study the influence of urban pollution on the open sea we have partly made use of the data of M. Scaccini-Cicatelli (1967). The data were collected from the seventeen miles wide coastal area, extending from Po Estuary to Ancona (Fig. 5).

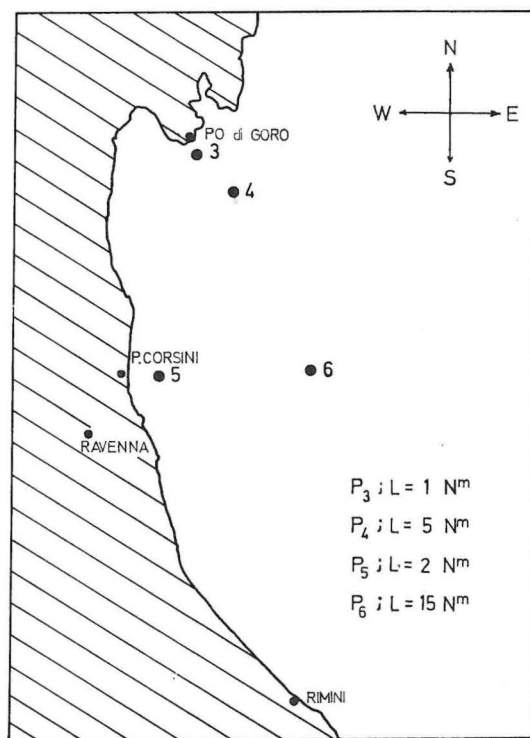


Fig. 5. N-W Adriatic coast

The stations near Fano (and Pesaro) and Po di Goro Estuary may be impaired. One station is closer to the port, for Fano Station 7 (2 Nm) and for Po Di Goro Station 3 (1 Nm), the other station is more distant, for Fano Station 8 (8 Nm) and for Po di Goro Station 4 (4 Nm). (Distance is given within brackets). There is not much difference between the influence of each of these two agglomerations on the belonging stations. The stations are not polarized what is probably due to the fact that Fano is a rather small town and there is no larger town at the Po di Goro Estuary (Fig. 6).

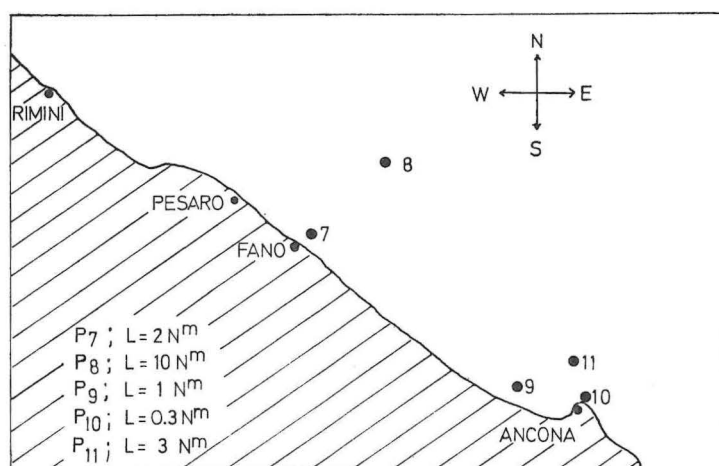


Fig. 6. West Adriatic coast

Quite a different situation may be found near Porto Corsini (Ravenna) and Ancona. There are two stations near Porto Corsini, a closer one Station 5 (2 Nm) and a more distant one Station 6 (13 Nm). The quantities of $\text{PO}_4\text{-P}$ and $\text{NH}_3\text{-N}$ in the summer and of $\text{PO}_4\text{-P}$, $\text{NO}_2\text{-N}$ and $\text{NO}_3\text{-N}$ in the winter are larger at Station 5 than at Station 6. Stations 9 and 10 are closer to Ancona (1 Nm) than it is Station 11 (5 Nm). They show a tendency towards polarization with respect to nutrients content. $\text{PO}_4\text{-P}$, $\text{NH}_3\text{-N}$, $\text{NO}_2\text{-N}$, and $\text{NO}_3\text{-N}$ are accumulated at closer stations in winter and also in summer all of them with the exception of nitrate.

We may say that here also the increase in nutrients is due to town sewage waters.

More irregularities were encountered here. They may be the results of the influence of the River Po.

SUMMARY

Four Adriatic areas have been described and the evidence is given that the coastal industrial towns discharge into the sea large quantities of the sewage. This material is distributed thus that the level of pollution is higher in waters of the stations which are closer to the coast than at those placed more offshore. The higher or lower degree of pollution of the sea is represented in this paper by the higher or lower level of phosphate or nitrogen compounds in the sea.

It has been shown that even though the stations are at the same or similar distance from the coast they are not polarized if there is not any larger town on the coast.

REFERENCES

- Buljan, M., L. Stojanoski i I. Vukadin; 1976. The chemical properties of the waters in the Krka River Estuary (the Central Eastern Adriatic) with particular reference to water pollution. *Rapp. proc. int. Mer Medit.* 23, 7, p. p. 47—48.
- Gilmartin, M., S. Kveder, D. Degobbis, N. Revelante & Smodlaka, 1972. Hydrographic data collected during approximately bi-weekly cruises in Northern Adriatic. July—December 1972. *Thalassia Jugoslavica* 8 (1) 149—213.
- Scaccini-Cicatelli, M. 1967. Distribuzione Stagionale dei sali nutritivi in una zona dell'alto e medio Adriatico. *Bollet. di Pesca, piscicoltura e idrobiologia*. Anno XLIII, Vol. XXII (n. s.), Fasc. 1, pag 49—82, Roma.

HRANJIVE SOLI KAO INDIKATOR ZAGAĐENJA U PRIOBALNIM VODAMA JADRANSKOG MORA

M. Buljan, L. Stojanoski i I. Vukadin

Institut za oceanografiju i ribarstvo, Split

KRATAK SADRŽAJ

Zadatak rada je da utvrdi može li se zamjetiti kod današnjeg razvoja gradskih aglomeracija, utjecaj gradova i njihovih efluenata na kemijski sastav morske vode bližeg područja.

Mi smo u tu svrhu ispitivali ponašanje sadržaja hranjivih soli u moru nekih dijelova Jadrana, iz vlastitih podataka kao i iz onih sabranih od drugih jadranskih oceanografskih zavoda.

Utvrđeno je da neke veće gradske aglomeracije (Trst, Venecija, Ankona) vrše jače obogaćenje mora hranjivim solima na bližim postajama a u manjoj mjeri na udaljenim postajama. Količine hranjivih soli uzete su u ovom radu kao mjera zagađivanja mora.

U koliko se ne radi o većem gradu (Split, Fano, Po di Goro) more ne pokazuje polarizacije s obzirom na gomilanje hranjivih soli.

U zatvorenim sredinama (estuar rijeke Krke) i manja gradska aglomeracija (Šibenik) može polarizirati morsku sredinu.