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THE ROLE OF MICROORGANISMS IN SELF-PURIFICATION FROM POLLUTION AND SELF-RESTORATION OF MARINE ENVIRONMENT OF THE BLACK SEA

Kovalyova N. V., Medinets V. I.
Odessa State University, Centre of Environmental Monitoring,
Dvoryanskaya St., 2, Odessa, 270026, Ukraine

Some data are given on the intensity of microbiological utilisation of the easily-oxidizable organic matter (OM) in the Black Sea coastal waters suffering moderate and intensive anthropogenic pressure. The rate of OM microbial destruction reaches its maximum values in the Danube region (1.8 g C/(m^3 day) and exceeds the intensity of this process in the background regions 30—60 times. The background regions are characterised by balance of production-destruction processes, but in the Danube region and near the coast of Odessa destruction processes exceed the photosynthesis intensity 2—4 times.

Key words: microorganisms, self-purification, marine envirinment.

Introduction

As it is known [2, 3, 4], microbial destruction of organic matter belongs to the most important ecological processes responsible for self-purification of marine ecosystems from pollution. Study of those processes gives us the possibility to assess the assimilative capacity and ecological reserves of marine ecosystem which will help to solve in future the problem of anthropogenic load regulation. In this connection the research into the speed of organic matter microbial destruction in the Black Sea coastal waters is of special significance.

Materials and methods

The studies were conducted in the near-Danube region (45°10' — 45°35' N, 29°45'-30°E), in Odessa economic & industrial zone, including Odessa Bay (46°20' — 46°30' N, 30°40' — 30°50' E) and the Odessa Bank (46°30' — 46°33' N, 31°10' — 31°30' E), in Karkilnitski Bay (45°30' — 46°00' N, 32°30' — 33°05' E) and Kalamitski Bay (44°38' — 45°10' N, 33°10' — 39°55' E) in Spring and Summer, 1994 and 1995. Bacterial destruction rate was determined using radiocarbon method [7]. Simultaneously with organic matter destruction rate determination we also determined the total bacteria number [6] and chlorophyll "A" content, from which the primary production was calculated [8, 10]. The hydrochemical and hydrological parameters were studied in accordance with the guidelines [9].

Results of the research and discussion

The rate of organic matter microbial utilisation in the studied areas of the sea in Spring, 1995 varied in wide spectrum (See Table), which is connected with big diversity of ecological conditions and the level of anthropogenic eutrophication.

The intensity of eutrophication processes may be judged from the content of phosphorus entering the NW Black Sea mainly with river discharge. The flow of phosphorus brought now by rivers into the NW Black Sea three times exceeds the same flow two decades ago, and this characterises the increase of anthropogenic pressure [5]. That is why we used the phosphorus content in marine water as an index of anthropogenic compound in the river discharge, which is one of the main factors of outer disturbance for coastal ecosystems in the NW Black Sea. Phosphorus concentrations registered in the NW shelf waters (6.5—672.0 mg/l) prove that the smallest anthropogenic pressure for nutrients was suffered by the ecosystems of Kalamitski Bay and Karkilnitski Bay (See Table). The average total phosphorus content in those regions did not exceed 15.5 and 22.4 mg/l correspondingly.

The speed of organic matter destruction in Kalamitski Bay and Karkilnitski Bay averaged to 21.9 and 51.1 mg C/(m^3day) correspondingly, which practically coincided with the intensity of phytoplankton primary production 32 and 50 mgC(m^3day).

So, in the mentioned parts of the shelf plankton communities were in equilibrium, which meant that there was practically no outer influence on the ecosystems of Kalamitski Bay and Karkilnitski Bay in the period of study. In connection with this, those parts of shelf were considered as background areas of microbiological indices for the other studied areas.

Table

Characteristics of the NW Black Sea Shelf Surface Waters in May, 1995

Region of Study	Bacterial destruction, mgC(m^3day)			Total phosphorus, μg/l			Chlorophyll "A", μg/l		
	min	max	mean	min	max	mean	min	max	mean
Kalamitski Bay	4	60	22	10.0	26.0	15.5	0	2.30	0.64
Karkinitski Bay	4	135	51	6.5	60.0	22.4	0.32	2.53	1.09
Odessa Bank	101	891	380	26.0	68.0	43.0	0	10.27	4.57
Odessa Bay	635	1041	800	31.0	66.0	51.0	7.59	19.93	15.33
Near-Danube region	1143	1809	1460	39.0	672.0	216.0	20.38	32.17	24.74

The highest anthropogenic pressure is suffered by the coastal waters of Odessa Region. There three big ports work, there is industry and municipal economy of the city with million population and, together with that, the discharges of the Dnieper and the Southern Bug from the Dnieper-Bug Liman, spreading along the coast westwards reach the coast near Odessa.

Considering the geographical position of the main pollution sources of the region, the research areas were situated in the Odessa Bay and on the Odessa Bank which is very close to the estuary of the Dnieper-Bug Liman.

In our opinion, the freshwater discharge from the Liman dominates over all other factors influencing functioning of the Odessa Bank ecosystem. In Spring, at the surface water temperature 12—13 °C and salinity 11.6—15.7‰ the total phosphorus content in the surface water of the Odessa Bank more than 2 times exceeded its content in the background areas. The organic matter utilisation rate appeared to be 7—17 times higher than in Kalamitski Bay and Karkilnitski Bay and averaged to 380 mgC/(m^3day). That value exceeded the intensity of primary production (173 mgC/(m^3day) , i. e. the rate of autochthonous organic matter formation. That is why we may assume that the high rate of organic matter destruction takes place due to accumulation of allochthonous organic matter brought by river discharge in the ecosystem. Our calculations showed that at the content of organic matter 4.68 mgC/l [1] in the fresh water of Dneper-Bug Liman, 940000 kg C enter the sea daily.

In Summer at the temperature of 18-25°C and salinity 10.9—13.2 ‰ the rate of organic matter destruction in the Odessa Bank increased twice and in June—August reached 730—800 mgC/(m^3day) correspondingly. Intensification of the processes was caused by the increase of water temperature on the one hand and by higher influence of river discharge on the other hand, the evidence of which was low salinity of water. In that situation the destruction rate exceeding the synthesis was even more pronounced than in Spring. In the surface waters organic matter was 4.5 times more utilised than produced by phytoplankton. Consequently, much organic matter enters the ecosystem from outside which leads to disturbance of natural production-destruction processes.

Odessa Bay, though 60 km far from Dneper-Bug Liman, during floods also suffers high influence of river discharge. The surface waters of Odessa Bay in May at the temperature 19.4—20.8 °C and salinity 7.9—10.6 ‰ contained 2-3 times more total phosphorus than the waters of Karkilnitski Bay and Kalamitski Bay. The main source of organic matter into the coastal zone of Odessa region is the industrial and domestic wastewaters discharge. From the city of Odessa (its coastline is about 40 km) about 700 000 $m^{3/}$day of wastewaters containing about 60 t C of organic matter are discharged. High content of easily assimilated organic matter in the coastal waters near Odessa as a rule goes together with microbiological pollution of marine environment [3, 2], enrichment with nutrients and consequent effects of eutrophication, which is testified by high concentration of bacteria (1.6—3.0 Mcells/ml) and chlorophyll “A” (2—20 mg/l) in the water.

At those conditions the bacterial destruction of organic matter in the surface water layer went intensively and made in May 800 mgC/(m^3day) and by the end of Summer grew up to 100 mgC/(m^3day). The intensity of destruction processes all the time exceeded the rate of organic matter production by phytoplankton. Maximum exceeding of the utilisation rate of organic matter in pelagic layer over the primary production was observed in August (8 times). Together with that, a significant amount of organic matter being the result of biosedimentation processes enters the bottom water layer and bottom sediments, where aerobic bacterial destruction processes go on and, as a rule, by the end of Summer all the dissolved oxygen is consumed for organic matter oxidation. Emerging of hypoxia phenomena in the bottom waters is an evidence of very high organic matter concentration in pelagic layer, the content of which exceeds the natural destructive potential of organic matter aerobic oxidation by bacterioplankton.

Among the studied areas the highest concentrations of total phosphorus were found in the estuarine zone of the Danube, they varied between 80 and 672 mg/l and on the average an order of magnitude exceeded its content in the background areas of the NW shelf. That agreed with the quantitative characteristics of bacterio- and phytoplankton development. In the Danube region the highest quantity of bacteria was registered

3.0—4.0 Mcells/ml and maximum concentration of chlorophyll "A" 20.4—32.2 mg/m^3, which corresponded to the phytoplankton production of 670—920 $mgC/(m^3 day)$. Those conditions contributed to the maximum increase of organic matter destruction microbiological processes. Average intensity of organic matter utilisation in the surface water layer made 1460 $mgC/(m^3$ day), which was 30—60 times higher than the rate in the background areas of the NW shelf. The absolute maximum of bacterial destruction, as well as of primary production, was registered at the maximum phosphorus concentration (672 mg/l), which is an evidence of the dominant influence of the Danube discharge of nutrients and organic matter on the intensity of anthropogenic eutrophication and, consequently, on the organic matter balance in the ecosystem.

Despite the high rate of microbiological processes, organic matter does not have enough time to mineralise in the pelagic layer and settle in the bottom, where at the end of Summer hypoxia and mortality of benthic organisms due to anoxia occurs [3]. This is the evidence that pollution of the coastal waters with OM exceeds natural destructive potential of OM aerobic oxidation by bacterioplankton.

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РОЛЬ МІКРООРГАНІЗМІВ В САМООЧИЩЕННІ ВІД ЗАБРУДНЕННЯ ТА САМОВІДНОВЛЕННІ МОРСЬКОГО СЕРЕДОВИЩА ЧОРНОГО МОРЯ

Ковальова Н. В., Медінець В. І.

Одеський державний університет, Центр моніторингу навколишнього середовища, вул. Дворянська, 2, Одеса, 270026, Україна

Резюме

Наведено дані про інтенсивність мікробної утилізації органічної речовини в прибережних водах Чорного моря під впливом постійної антропогенної діяльності. Значення мікробної деструкції легкоокислюваної органічної речовини досягає максимуму в Придунайському регіоні (1.8 $гС/(м^3$ на добу) і перевищує в 30—60 разів інтенсивність цих процесів у фонових районах. Фонові райони характеризуються балансом продуктивно-деструктивних процесів, а в Придунайському регіоні і біля Одеського узбережжя деструктивні процеси перевищують інтенсивність фотосинтезу в 2—4 рази.

Ключові слова: мікроорганізми, самоочищення, морське середовище.

РОЛЬ МИКРООРГАНИЗМОВ В САМООЧИЩЕНИИ ОТ ЗАГРЯЗНЕНИЯ И САМОВОССТАНОВЛЕНИИ МОРСКОЙ СРЕДЫ ЧЕРНОГО МОРЯ

Ковалева Н. В.,增 Мединец В. И.
Одесский государственный университет, Центр мониторинга окружающей среды,
ул. Дворянская, 2, Одесса, 270026, Украина

Резюме

Приведены данные об интенсивности микробной утилизации легкоокисляемого органического вещества в прибрежных водах Черного моря под влиянием постоянного антропогенного воздействия. Значение микробной деструкции легкоокисляемого органического вещества достигает максимума в Придунайском регионе (1.8 гС/(м^3 сут) и превышает интенсивность этих процессов в фоновых районах в 30—60 раз. Фоновые районы характеризуются балансом продукционно-деструкционных процессов, а в Придунайском регионе и у Одесского побережья деструкционные процессы превышают интенсивность фотосинтеза в 2—4 раза.

Ключевые слова: микроорганизмы, самоочищение, морская среда.