Doklady Biological Sciences, Vol. 385, 2002, pp. 377–379. Translated from Doklady Akademii Nauk, Vol. 385, No. 4, 2002, pp. 571–573.

GENERAL BIOLOGY

Identification of a New Type of Ecological Hazard of Chemicals: Inhibition of Processes of Ecological Remediation

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Presented by Academician V.N. Bol'shakov February 27, 2002

Received March 13, 2002

Some approaches to solving the problem of environmental pollution are based on bioremediation and phytoremediation of contaminated aquatic ecosystems. Many ecological processes causing self-purification of water in ecosystems were reviewed in the preceding works [1, 2]. The aggregate of these processes constitutes a system of remediation (self-purification). To a certain extent, the importance of the processes of ecological remediation in natural ecosystems is comparable with that of the processes of repair, which take place at the molecular genetic level. Indeed, the processes of the two types facilitate stabilization of biological systems. The aggregate of natural processes of ecological remediation includes water filtration by hydrobionts, activity of microbial destructors of pollutants, and other phenomena [1, 2].

There are many publications on the identification, analysis, and classification of dangerous anthropogenic impacts on organisms, populations, ecosystems, and the biosphere [3–11].

The goal of this work was to identify and characterize essential elements of a new type of ecological hazard of chemical pollution of water, which includes inhibition of important processes of ecological remediation of ecosystems (water filtration by hydrobionts). The first steps in this direction were made in [1, 7, 8].

The effects of some synthetic washing mixtures (SWMs) on the filtration activity of various bivalve mollusks were studied in this work to provide a deeper insight into the mechanisms of anthropogenic impact of mixed chemical preparations.

Experiments were performed using mollusks (oysters), *Crassostrea gigas* Thunberg, and a cell suspension of *Saccharomyces cerevisiae* [7]. Mollusks were obtained from the Department of Mariculture, Institute of Biology of Southern Seas, National Academy of Sciences of Ukraine. The experimental procedure was described in more detail in [7]. The SWM Lanza-Automat was tested. This washing mixture includes surfactants, water softeners, enzymes, optical bleach powder, and odorants. Lanza-Automat is produced by Benckiser.

Mollusks were incubated in water at 23.4°C. The optical density (OD) of the cell suspension was simultaneously measured in three variants (A, B, and C). Two variants (B and C) were control. The cells of *S. cerevisiae* were uptaken from water by mollusks during biological filtration. This caused a decrease in OD of the suspension of algae in the experimental tank containing mussels. The initial concentration of the *S. cerevisiae* cells added to all tanks (A, B, and C) was the same (100 mg dry weight per l). The volume of seawater (from the Bay of Sevastopol, the Black Sea) in each tank was 500 ml. Mollusks were placed in tanks A and B (ten specimens in each). The overall wet weight of oysters (with shell) in tanks A and B was 52.6 and 49.0 g, respectively. The mean weight of one specimen in tanks A and B was 5.26 and 4.9 g, respectively. Tank A contained mollusks, cells of *S. cerevisiae*, and SWM (20 mg/l). Tank B contained mollusks and a suspension of the *S. cerevisiae* cells but did not contain SWM. Tank C contained only the suspension of *S. cerevisiae* without oysters and SWM. Optical density was measured at 550 nm (optical path length, 10 mm) using an SF-26 LOMO spectrophotometer. Spectrophotometric readings were rounded off to the second decimal place.

During the experiment, the process of water filtration by oysters caused a decrease in the value of OD in variant A (in the presence of SWM) from 0.27 to 0.15 (Table 1). Under otherwise identical conditions in variant B (with mollusks but without SWM; control 1), there was a decrease in the value of OD from 0.18 to 0.08. Therefore, the rate of medium turbidity decrease in the presence of SWM in the incubation medium was significantly lower than in control 1 (variant B). In the absence of mollusks (variant C), the optical density of the cell suspension remained almost invariable during the experiment (variant C (control 2) in Table 1).

The value of the effect on elimination efficiency (EEE) was calculated to obtain quantitative estimates of the extent of influence of chemicals on the rate of filtration and elimination of particles from water [7]. The value of EEE depended on the experiment duration and

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0012-4966/02/0708-0377$27.00 © 2002 MAIK "Nauka/Interperiodica"

Table 1. Effect of SWM on OD_{550} changes in *S. cerevisiae* suspension during filtration by *Crassostrea gigas*

Period of measurement, nos.	Time interval from the beginning of incubation, min	Experiment (+SWM), variant A	Control 1 (with oysters without SWM), variant B	Control 2 (without oysters without LWS), variant C	EEE (A/B), %
1	4	0.27	0.18	0.290	150
2	11	0.24	0.11	0.29	218
3	19	0.21	0.08	0.29	262.5
4	35	0.15	0.080	0.27	187.5

Note: The SWM Lanza-Automat (20 mg/l) was used.

Table 2. Chemical substances capable of affecting the organisms involved in water purification

Species (filter-feeder)	Chemical substance (xenobiotic)	Biological effect	Reference
Mytilus edulis	Potassium bichromate	Inhibition of elimination of *S. cerevisiae* suspension from water	Ostroumov (unpublished data)
Crassostrea gigas	SWM1 (L)	The same	See Table 1
Dreissena polymorpha	Trimethylstannate chloride (TMSC)	Decrease in the rate of elimination of kaolin particles from water and water clarification	A.V. Mitin, 1984, cited from [7]
Unio tumidus	Triton X-100, SWM OMO	Inhibition of elimination of single-cell plankton from water	[7]
M. edulis	Pesticides	Inhibition of water filtration	Donkin *et al*., 1997, cited from [7]
M. edulis	SDS	Decrease in the rate of elimination of the *Isochrystis galbana* cells from water	Ostroumov *et al*., 1997, cited from [7]
M. edulis	Triton X-100	The same	Ostroumov *et al*., 1998, cited from [7]
C. gigas	SDS	Decrease in the rate of water filtration	[7, 8]
C. gigas	TDTMA	Decrease in the rates of water filtration and elimination of *S. cerevisiae* suspension from water	[7, 8]
M. galloprovincialis, C. gigas	LWM1 (E)	Decrease in the rate of water filtration	[7]
M. galloprovincialis, C. gigas	LWM2 (F)	The same	[7]
M. galloprovincialis	SWM2 (I)	″	[7]
M. galloprovincialis	AHC	″	[6, 7]
M. galloprovincialis × *M. edulis* (hybrid organisms)	Cationic surfactant TDTMA	Inhibition of elimination of the *I. galbana* cells from water	Widdows and Ostroumov (unpublished data)
Ephemeroptera	25-6-Alcoholethoxylate	Decrease in the population of larvae in model ecosystem after 8 weeks of incubation in the presence of concentration of 36–760 μg/l	[12]
Brachionus calyciflorus	TDTMA	Decrease in the rates of water filtration and elimination of the algal cells *Nannochloropsis limnetica* from water	Walz, Rusche, and Ostroumov (unpublished data)
Cladocera	Fungicide Carbendazim	Decrease in the population of Cladocera, increase in the population of phytoplankton cells, and increase in the concentration of chlorophyll *a* in the microcosm after incubation in the presence of concentration of 100–1000 μg/l	[13]

Note: (TDTMA) tetradecylcetyltrimethylammonium bromide, (SDS) sodium dodecylsulfate, (SWM1 (L)) Lanza-Automat, (SWM2 (I)) IXI Bio-Plus (Cussons), (LWM1 (E)) dish washing liquid E (Cussons International, Ltd.), (LWM2 (F)) dish washing liquid Fairy (Procter & Gamble, Ltd.), (AHC) Avon Hair Care. The data given in table are far from complete inventory of polluting agents and species of filter-feeders inhibited by pollutants.

ranged from 150 (4 min) to more than 200% (11 and 19 min). Therefore, it was shown that SWM significantly inhibited the processes of water filtration. As a result, there was more than twofold difference between the optical densities of filtered suspensions in control 1 and the variant with exposure to SWM for 11–19 min.

The results of this work are consistent with my previous findings that water filtration by mollusks is also inhibited by some other SWMs and individual surfactants (Table 2) [6–8]. These results show that there is an additional aspect of potential ecological hazard of SWMs.

There is additional evidence that pollutants may upset the processes important for purification of aquatic ecosystems and water quality maintenance at a high level. Some of them are given in Table 2.

It is important to note that representatives of large taxonomic groups (both benthon and plankton organisms) are listed in Table 2 as biological species capable of water purification. It also follows from Table 2 that the range of chemical substances exerting negative biological effects of this type is rather large and includes both organic and inorganic pollutants. Additional examples of chemical substances inducing similar effects on zooplankton [14] and the freshwater mollusk *Unio tumidus* [15] were described in the literature.

In summary, it should be noted that new experimental data on bivalve mollusks obtained in this study provide the opportunity to identify a new type of ecological hazard caused by water pollution. This hazard is associated with the fact that chemical pollution of water causes inhibition of the physiological activity of hydrobionts, thereby inhibiting the ecological processes mediated by the hydrobionts. These ecological processes contribute significantly to water purification and the related remediation of aquatic ecosystems (their ecological repair).

I am planning to consider similar ecological hazard of factors connected with the anthropogenic impact of chemical compounds on organisms involved in ecological processes resulting in water purification and remediation of aquatic ecosystems.

ACKNOWLEDGMENTS

I am grateful to V.D. Fedorov, V.V. Malakhov, E.A. Kriksunov, and other researchers at Moscow State University and Russian Academy of Sciences for stimulating discussion and valuable criticism. I am grateful to G.E. Shul'man, G.A. Finenko, Z.A. Romanova, A.V. Pirkova, V.I. Kholodov, A.Ya. Stolbov, A.A. Soldatov, and other colleagues from the Institute of Biology of Southern Seas, National Academy of Sciences of Ukraine, for assistance, the samples of mollusks, and the help in work. My thanks to P. Donkin, J. Widdows, N. Walz, Renate Rusche, N.N. Kolotilova, and N.V. Kartasheva for assistance in some experiments and valuable comment.

This study was supported by the Open Society Foundation (project RSS).

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