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GENERAL BIOLOGY

Imbalance of Factors Providing Control of Unicellular Plankton Populations Exposed to Anthropogenic Impact

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Populations of unicellular plankton organisms in natural aquatic ecosystems are controlled by various factors (Table 1). The anthropogenic impact on aquatic ecosystems should be analyzed taking into account both direct effects on the plankton organisms themselves and indirect modification of plankton abundance.

The goal of this work was to analyze new experimental data on the effects of chemical pollution of aquatic medium on the abundance of unicellular plankton organisms.

The species of unicellular organisms and mollusks studied are shown in Tables 1–4. Marine mollusks were grown at the aquaculture farm of the Institute of Biology of Southern Seas, National Academy of Sciences of Ukraine. The culture *Pavlova lutheri* (Droop) Green 1975 (=*Monochrysis lutheri* Droop 1953) was obtained from the same source. Suspension of *Saccharomyces cerevisiae* (S.I. Lesaffre, 59703 Marcg-France) was used in some experiments. The freshwater mollusks *Unio tumidus* were collected in the Moskva River upstream the town of Zvenigorod. Changes in the abundance of unicellular plankton organisms were detected spectrophotometrically.

The efficiency of cell elimination from water (*ECE*) was calculated using the following equation:

$$ECE = [A/B] \times 100\%,$$

where A is the optical density of the cell suspension treated with the chemical agent studied (a surfactant, detergent, etc.), which is expected to inhibit water filtration by mollusks and cell elimination from water; B is the optical density in the control samples (water containing mollusks and unicellular organisms without the chemical agent tested). The rate of water filtration in the control was higher than in the experiment. As a result, the rates of cell elimination and decrease in the optical density of control water were higher than in the experiment.

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The effects of surfactants, surfactant-containing washing mixtures (SWMs), and other contaminants on phytoplankton and other plankton organisms [1] revealed that the phytoplankton abundance may be indirectly controlled by the surfactant-induced modification of filtrating consumers (e.g., mollusks [1, 2] and rotifers [3]), a contiguous link of the trophic chain of the ecosystem. Many researchers showed that, under certain experimental conditions, SWMs might cause a decrease in the phytoplankton cell count. On the other hand, the opposite effect of SWMs on phytoplankton cell count was reported in [4–6]. Examples of these effects are shown in Table 2.

Contamination with surfactant mixtures (SWMs and others) exerts a dual effect on phytoplankton [1]. On the one hand, biogenic components of SWMs may cause direct stimulation of phytoplankton (see, for example, row 2 in Table 2). On the other hand, the surfactant components of SWMs may inhibit the filtration activity of the phytoplankton consumers (see, for example, rows 5 and 6 in Table 2). Eventually, the effects of thee two type are summed giving rise to an increase in the phytoplankton cell count.

The activity of filtrators in natural ecosystems is an important factor of phytoplankton abundance control. Therefore, inhibition of filtration activity should be regarded as evidence for imbalance of factors of phytoplankton abundance control. The situation illustrated by Table 2 (row 2) is also typical of other phytoplankton species, including marine microscopic algae [6].

New experimental data obtained in this work show that surfactant-containing mixtures (mainly, phosphorus-containing surfactants) may reduce the elimination of unicellular organisms from water in the course of its filtration by mollusks (Table 3). The method of measurement of filtration activity based on detection of the efficiency of water filtration and resulting elimination of unicellular organisms from water was suggested in the preceding work [1]. For the sake of methodological convenience, a suspension of the *Saccharomyces cerevisiae* yeast cells was used in addition to phytoplankton cells [1]. The efficiency of water filtration and elimination of unicellular organisms (cells of phytoplankton and *S. cerevisiae*) by the mussel *Mytilus galloprovin-*

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Table 1. Factors of regulation of unicellular plankton abundance (some important examples)

Factors causing an increase in the unicellular plankton abundance	Factors causing a decrease in the unicellular plankton abundance
Biogenic agents (including P and N)	Elimination of cells from water by consumers (including filtrators)
Light (for autotrophic organisms)	Shading (for autotrophic organisms)
Temperature increase (to optimal level)	Algal viruses, bacteriophages
Presence of vitamins and some other organic substances in water	Presence of metabolites (including toxins) causing plankton growth inhibition; presence of pollutants in concentrations sufficient to exert negative effects on unicellular plankton

Table 2. Effect of surfactants and SWMs on phytoplankton organisms (examples)

No.	Effect on phytoplankton	Phytoplankton species	References
1	WM-induced inhibition of growth (and abundance)	*Euglena gracilis*	[1]
2	Growth stimulation in the presence of surfactant	*Synechocystis* sp. PCC 6803, *Synechococcus*, *Scenedesmus quadricauda*, and others	[4, 5, 6]
3	Decrease in abundance as a result of elimination of plankton cells from water by the freshwater mollusks Unio tumidus and rotifers	*S. quadricauda*, *Synechocystis* sp. PCC 6803, *Chlorella* sp.	[1, 3] and our unpublished data
4	Abundance decrease as a result of water filtration by the marine mollusks *Mytilus edulis*, *M. galloprovincialis*, and *Crassostrea gigas*	*Isochrysis galbana*, *M. lutheri*, *Dunaliella viridis*	[1, 2, 5]
5	Decrease in the efficiency of cell elimination from water caused by the TX-100-induced (5 mg/l) inhibition of the filtration activity of the freshwater mollusks *U. tumidus*	*S. quadricauda*, *Synechocystis* sp. PCC 6803	[1] and our unpublished data
6	Decrease in the efficiency of cell elimination from water as a result of inhibition of the filtration activity of the marine mollusks *Mytilus galloprovincialis* and *Crassostrea gigas* induced by surfactants and Avon Herbal Care (hair shampoo)	*M. lutheri*	[1] and our unpublished data

Table 3. Summary of some results on the effects of surfactant-containing mixtures on filtration and trophic activities of mollusks

No.	Preparation	Mollusk species	Maximum value of ECE (concentration of preparation, mg/l, is given in brackets)
1	Synthetic surfactant OMO	*Unio tumidus*	186.7 (50)
2	Synthetic surfactant Losk-Universal	*Mytilus galloprovincialis*	2460.0 (20)
3	Synthetic surfactant Losk-Universal	"	551.7 (7)
4	Synthetic surfactant Tide-Lemon	"	206.9 (50)
5	Synthetic surfactant IXI	"	276.4 (50)
6	Synthetic surfactant IXI	"	157.8 (10)
7	Synthetic surfactant Deni-Automat	*Crassostrea gigas*	10 800.0 (30)
8	Synthetic surfactant Lanza	"	261.7 (20)
9	Synthetic surfactant Vesna-Delikat	"	200.0 (1)

Note: The maximum values obtained in the corresponding experiment are shown. The duration of an experiment ranged from 25 to 100 min. The unicellular organisms used were: *S. cerevisiae* (experiments nos. 1, 5–8) and *Pavlova lutheri* (=*M. lutheri*) (experiments nos. 2–4).

cialis was comparatively assessed in special experiments. The rates of elimination of cells of the two types were close to one another (Table 4), the two processes taking place in parallel. These data and results of similar experiments suggest that the model system with *S. cerevisiae* can be used for studying the elimination of unicellular organisms from water by biological filtrators.

It should be noted that direct effects of surfactants on unicellular plankton organisms in some cases are very destructive. Certain species of phytoplankton are very sensitive to synthetic surfactants. For example, it was shown in our experiments that diatomic algae *Thalassiosira pseudonana* (Hustedt) Hasle et Heimdal are highly sensitive to Triton X-100 (TX-100), a noniononogenic detergent [1, 7].

The results of this study can be regarded as additional evidence in favor of earlier conclusions [1, 2, 8] that contaminants (e.g., surfactants and surfactant-containing mixtures) can inhibit the functional activity of hydrobionts (e.g., mollusks) required for self-purification of water [9, 10]. A system of criteria of ecological hazard of anthropogenic factors was proposed in the preceding work [11]. According to this system, the surfactant-induced effects considered above are definitely dangerous and undesirable.

The results obtained in this work show that certain pollutants might cause substantial imbalance of the factors controlling unicellular plankton populations. Direct and indirect (mediated by consumers) effects of certain surfactant-containing mixtures on unicellular plankton are summed with each other, giving rise to mutual amplification. This may cause a complete imbalance of the system and abundant development of unicellular plankton. Although the results considered in this work were obtained mainly in benthic filtrating consumers, similar conclusions were drawn from studies of planktonic filtrators [3, 12]. In some cases, the postulates put forward in this work may be applied to unicellular plankton of both marine and freshwater ecosystems, including ecosystems subjected to eutrophication.

Table 4. Elimination of unicellular organisms from water as a result of water filtration by *M. galloprovincialis*

Time, min	OD_{650}	
	S. cerevisiae	*Pavlova lutheri* (=*M. lutheri*)
2	–	0.120
9	0.337	–
20	–	0.015
21	0.112	–
24	–	0.004
26	0.110	–
34	–	0.006
35	0.078	–
62	–	0.000
63	0.035	–

Note: The initial concentration of *S. cerevisiae* was 267 mg/l (dry weight); *M. galloprovincialis*, 0.5 g (fresh weight with shells); age of mollusks, 2 months. Temperature, 27.0°C. Spectrophotometer, LOMO SF-26; optical path, 10 mm.

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REFERENCES

1. Ostroumov, S.A., *Biologicheskie effekty poverkhnostno-aktivnykh veshchestv v svyazi s antropogennymi vozdeistviyami na biosferu* (Biological Effects of Surfactants in View of Anthropogenic Impacts on the Biosphere), Moscow: MAKS, 2000.
2. Ostroumov, S.A., Donkin, P., and Staff, F., *Dokl. Akad. Nauk*, 1998, vol. 362, no. 4, pp. 574–576.
3. Kartasheva, N.V. and Ostroumov, S.A., in *Pishchevaya promyshlennost' na rubezhe tret'ego tysyacheletiya* (Food Industry on the Verge of the Third Millennium), Moscow, 2000, pp. 245–247.
4. Kolotilova, N.N. and Ostroumov, S.A., *Problemy ekologii i fiziologii mikroorganizmov* (Problems of Microbial Ecology and Physiology), Moscow: Dialog, 2000.
5. Ostroumov, S.A. and Kolotilova, N.N., *Vodnye ekosistemy i organizmy* (Water Ecosystems and Organisms), Moscow: MAKS, 2000, vol. 2.
6. Aizdaicher, N.A., Malynova, S.I., and Khristoforova, N.K., *Biol. Morya*, 1999, vol. 25, no. 3, pp. 234–238.
7. Fisher, N., Maertts-Uente, M., and Ostroumov, S.A., *Izv. Ross. Akad. Nauk, Ser. Biol.*, 1996, no. 1, pp. 91–95.
8. Ostroumov, S.A., Donkin, P., and Staff, F., *Vestn. Mosk. Gos. Univ., Ser. 16: Biol.*, 1997, no. 3, pp. 30–36.
9. Ostroumov, S.A., *Dokl. Akad. Nauk*, 2000, vol. 372, no. 2, pp. 279–282.
10. Ostroumov, S.A., *Dokl. Akad. Nauk*, 2000, vol. 374, no. 3, pp. 427–429.
11. Ostroumov, S.A., *Dokl. Akad. Nauk*, 2000, vol. 371, no. 6, pp. 844–846.
12. Ostroumov, S.A., *Dokl. Akad. Nauk*, 2000, vol. 375, no. 6, pp. 847–849.