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Toxicology

# THE EFFECT OF DBS ON SURVIVAL OF JUVENILE PERCH (*Perca fluviatilis* L.) IN RELATION TO CERTAIN PHYSICAL FACTORS

# WPŁYW DETERGENTU DBS NA PRZEŻYWALNOŚĆ NARYBKU OKONIA (*Perca fluviatilis* L.) W ZALEŻNOŚCI OD NIEKTÓRYCH CZYNNIKÓW FIZYCZNYCH

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Survival of 5.8±1-cm long (l.t.) juvenile perch was studied as influenced by the DBS concentration of 5 mg/l SA in tanks of equal capacities and various surface areas as well as in tanks of the same capacities and surface areas with nettings placed at various depths. Survival time was found to be dependent on the free surface area of a tank, on depth, and on water movement. The results obtained indicate the necessity of taking into account, when determining toxic effects of detergent on aquatic organisms, surface area of a water body, its depth and aeration in addition to the detergent concentration.

## INTRODUCTION

In experimental studies on the effect of detergents on fishes, it is a common practice to report the detergent concentration (Trzebiatowski, 1973; Węgrzynowicz et al., 1975; Jurkowski, 1977). Although this is an easily-measured value and one facilitating comparisons of various water bodies, it does not seem to represent adequately the toxic properties of a detergent. Physico-chemical analyses of surfactants show their action to be

proportional to their concentration up to a certain level only, beyond which the further increase in the amount of the detergent added brings about no change in its effect. This phenomenon is widely applied in technology, e.g., in washing or in ore flotation. Furthermore, should detergents be released to natural water bodies of large areas, it is the water surface that will be mainly affected. Laboratory studies, however, ignore the importance of surface effect in spite of the existing techniques for measuring the so-called boundary (critical) concentration (Anastasiu and Jelescu, 1973; Niemiro, 1974), i.e., the concentration of a detergent, at which the water surface is covered by a monomolecular layer of the compound.

The present paper attempts to answer the question of the extent, to which the toxic effect of a detergent depends on the magnitude of the water-air interface and on such factors as depth and water movement.

## MATERIALS AND METHODS

Perch juveniles, the age of which was determined from body length (l.t.) equal to 5.8±1 cm (Jurkowski, 1976) were used for the tests. The fishes were transferred to a 200 l aquarium filled with sea water from the Puck Bay and aerated up to 8 mg $O_2$/l. After 48 hours, the fishes were placed in experimental and control 5-l containing freshly collected sea water of pH adjusted, by the addition of NaOH, to 8.2–8.5. The free surface areas of the tanks were 575.3 and 218.9 $cm^2$ in the first and second stage of the experiments, respectively. In some of the latter tanks, nettings were placed at the depth of 9 cm. 5 mg SA/l DBS (natrium dodecilbenzenesulphonate) were added to the tanks each time before the detergent effects was to be tested. Owing to the lack of possibility to maintain the stable temperature in the aquaria, all the experiments, the controls included, were run simultaneously. Keeping in mind the 24-hr survival in the control tanks, only one experimental series per day was run. Before the proper experiments could be commenced, the conditions of vertical mixing were established by pumping the air through 5-mm diameter polythene tubings. Oxygen content analysis before and after aeration, as measured using the fisherman's field kit showed that 15–20 air bubbles per minute sufficiently mixed the water without increasing its oxygen content. The experimental tanks used were cast entirely of natrium glass. Each experiment was run in 4–10 replicates, 1 fish each.

The statistical treatment of the results was based on Student's t test for small paired samples (Iwaniszewska, 1966).

## RESULTS AND DISCUSSION

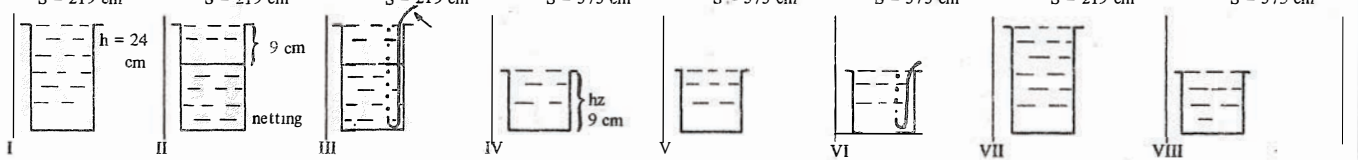
The analysis of fish survival time in the control tanks showed the 5 l tanks of various surface areas to have privided satisfactory living conditions as all the fishes survived 24 hrs and were released into the Bay thereafter. Thus the detergent and physical factors analysed, and not the stress exerted by the tanks used and physicochemical regime of the

Table 1

Fish survival time in experimental and control tanks

| Day of experiment | Water temperature (C°) | Survival time (minutes) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | x̄ | II | x̄ | III | x̄ | IV | x̄ | V | x̄ | VI | x̄ | VII | x̄ | VIII | x̄ |
| 1 | 20 | 280 | 245 | 255 | 219 | 195 | 209 | 135 | 143 | | | 150 | 156 | > 1440 | 1440 | > 1440 | 1440 |
| 2 | 20 | 210 | | 170 | | 165 | | 125 | | | | 110 | | > 1440 | | > 1440 | |
| 3 | 20 | 230 | | 195 | | 255 | | 135 | | | | 180 | | > 1440 | | > 1440 | |
| 4 | 20 | 260 | | 255 | | 220 | | 175 | | | | 185 | | > 1440 | | > 1440 | |
| 5 | 18 | | | 390 | | 275 | | 230 | | | | 200 | | > 1440 | | > 1440 | |
| 6 | 18 | | | 340 | 337 | 255 | 288 | 195 | | 185 | | 210 | | > 1440 | | > 1440 | 1440 |
| 7 | 18 | | | 380 | | 335 | | 280 | | 300 | | 230 | | > 1440 | | > 1440 | |
| 8 | 15 | | | 420 | | 360 | | 305 | 279 N=5 | 300 | 281 N=5 | 240 | | > 1440 | | > 1440 | |
| 9 | 15 | | | 420 | 420 | 360 | 380 | 315 | | 300 | | 275 | | > 1440 | 1440 | > 1440 | 1440 |
| 10 | 15 | | | 420 | | 420 | | 300 | | 320 | | 320 | | > 1440 | | > 1440 | |
| x̄ og. → | | 245 | N=4 | 314,5 | N =10 | 284 | N = 10 | 219,5 | N = 10 | 281 | N = 5 | 210 | N = 10 | > 1440 * | N =10 | > 1440 * | N = 10 |

Experimental design




I – 219-cm² 24-cm deep tank; water not mixed; detergent amount of 5 mg/l SA, II – 219-cm² 9-cm deep tank; water not mixed; detergent as above, III – 219-cm² 9-cm deep tank; water mixed; detergent as above, IV – 575-cm² 9-cm deep tank; water not mixed; detergent as above, V – 575-cm² 9-cm deep tank; re-used water from Tank IV, VI – 575-cm² 9-cm deep tank; water mixed; detergent amount of 5 mg/l SA, VII – 219-cm² 9-cm deep tank; water not mixed, no detergent added, VIII – 575-cm² 9-cm deep tank; water not mixed; no detergent added

* – a fish survived for a period considered sufficiently long when compared to the analogous experimental time

water, were assumed to be responsible for shortening the survival time of the experimental fishes.

As seen from Table 1, toxic effects of the detergent depend on water temperature. This phenomenon seems to be brough about by a decreased detergent solubility in colder water, and perhaps by a slowed-down metabolism of a fish since – as found for juvenile carp - a decline in water temperature from 20 to 15°C decreases the heart beat rate and locomotor activity by about 30 and 50%, respectively (Sigmund and Vogel, 1977).

Fish survival time analysis for the 575 $cm^2$ tanks showed the fishes to have survived an equal length of time in spite of the water being mixed in one of the tanks throughout the experimental period. On the other hand, fishes kept in those 219 $cm^2$ tanks with mixed water survived for a time shorter by about 30 min. ($P \geqslant 99\%$). In the 219 $cm^2$ 24 cm deep tanks the fishes lived by 26 minutes longer, on the average, ($P \geqslant 95\%$) than in a similar tank provided with a netting installed 9 cm below the water surface. These fishes kept in the 219 $cm^2$ 9 cm deep tanks (netting bottom) survived a period longer by about 95 minutes ($P \geqslant 99.90\%$) than those kept under anlogous conditions in the 575 $cm^2$ 9 cm deep tanks. In every experiment the fishes were given an unrestricted access to the water surface.

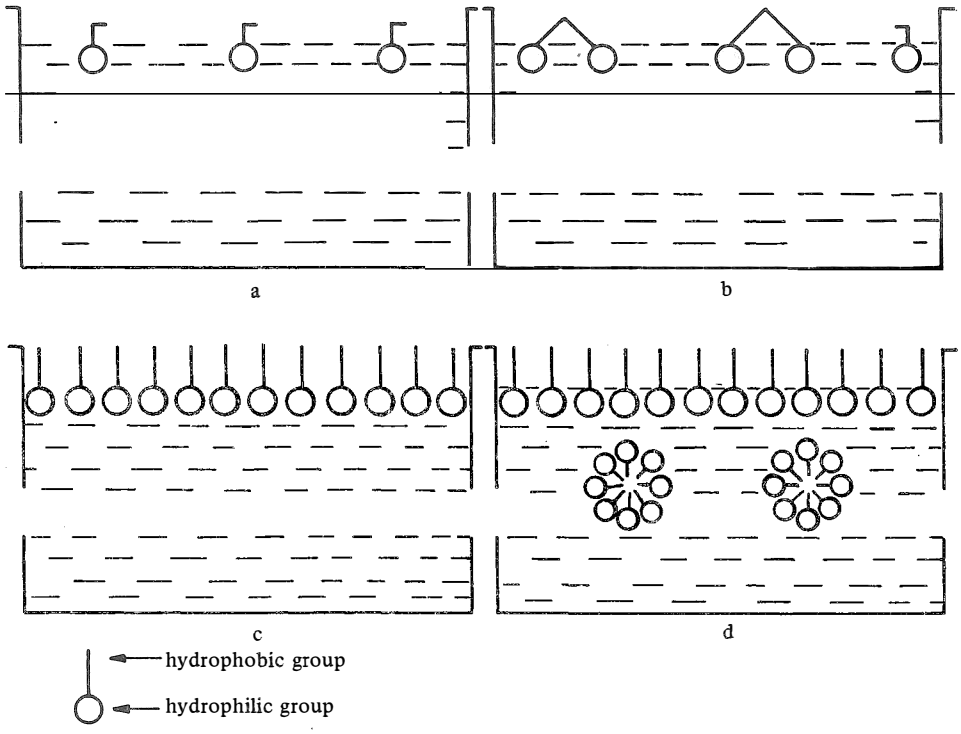
Survival time of a fish kept in a detergent-added water used beforehand for keeping another fish was basically the same as that for the preceding fish, no differences in oxygen content before and after the experiment being found using the field kit.

The results obtained generally show the survival time of fishes kept in detergent-added water to be dependent on the magnitude of water-air interface of a tank used in experiments, the time increasing with a distance from the water surface the fish was having. The toxic effect of the detergent, given the same detergent concentrations and fishes of the same age and species, seems to depend to a large extent on the free surface of a tank. As shown by the physico-chemical studies, detergent molecules shift to the water-air interface where they become appropriately orientated: their hydrophilic groups turn towards the water and hydrophobic ones towards the air (Fig. 1 a,b). This shift depends on the tank surface up to the moment of the maximum saturation defined as the so-called boundary concentration (Fig. 1 c). Having exceeded its boundary concentration, a surfactant forms colloidal spherical micelles (Fig. 1 d), hydrophobic groups fusing to decrease the surface contacting the phase they have no affinity to, water in our case (Anastasiu and Jelescu, 1973).

The detergent molecules' passage from the boundary phase into the solution and back depends mainly on temperature, surface area and mixing. Air-dispersing stones commonly in use (natural and artificial pumice) extend the water-air interface, which enhances the toxic action of a detergent through a suitable orientation of detergent molecules.

The studies presented show the spheric micelles to be less toxic than the monomolecular detergent since fish survival time was longer in tanks of a smaller surface area, thus with a larger layer of the spherical micelles.

The survival time vs. depth analysis shows the toxic effects to be inhomogenous throughout the water column, which is related to the detergent's shifting to the surface.




Comparisons of the oxygen contents in the water before and after the experiment and the survival time in the reused water imply that the toxic effect of the detergent in the first stage is not caused by oxygen deficiency, as it has been suggested (Trzebiatowski 1973).

The results obtained point out that, when determining the toxic effects of a detergent on aquatic organisms, tank surface area, depth, and aeration should be considered along with concentration of the compound studied.

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## WPŁYW DETERGENTU DBS NA PRZEŻYWALNOŚĆ NARYBKU OKONIA (*Perca fluviatilis* L.) W ZALEŻNOŚCI OD NIEKTÓRYCH CZYNNIKÓW FIZYCZNYCH

Streszczenie

Zbadano wpływ wolnej powierzchni w zbiornikach o tej samej objętości wody zawierającej detergent typu DBS w ilości 5 mg/l SA na czas przeżycia narybku okonia umieszczonego w tych zbiornikach. Stwierdzono, iż w akwariach o pow. 219 $cm^2$ ryby przeżywały dłużej średnio o 95 minut niż w zbiornikach o powierzchni 575 $cm^2$ (różnica z $P \geqslant 99{,}9\%$). Również mieszanie wody poprzez napowietrzanie skracało czas przeżycia ryb w detergencie w akwariach o powierzchni 219 $cm^2$ o około 30 minut (różnica z $P \geqslant 99\%$).

Umieszczenie ryb w odległości 24 cm od powierzchni wody zwiększało czas przeżycia w stosunku do ryb umieszczonych w odległości 9 cm o 26 minut (różnica z $P \geqslant 95\%$).

Z uzyskanych rezultatów wynika, iż działanie toksyczne detergentu jest najwyższe w warstwie przy powierzchni, a grubość tej warstwy zależy od stężenia detergentu i wolnej powierzchni zbiornika. W związku z powyższym przy określaniu toksycznego działania detergentu na organizmy wodne, oprócz stężenia detergentu w jednostce objętości, powinno się również uwzględniać powierzchnię zbiornika, jego głębokość, a także wpływ napowietrzania wody.

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## ВЛИЯНИЕ ДЕТЕРГЕНТА DBS НА ВЫЖИВАЕМОСТЬ МОЛОДИ ОКУНЯ (PERCA FLUVIATILIS L.) В ЗАВИСИМОСТИ ОТ НЕКОТОРЫХ ФИЗИЧЕСКИХ ФАКТОРОВ

Р е з ю м е

Исследовали влияние свободной поверхности в резервуарах с одинаковым объёмом воды, содержащей детергент типа DBS в количестве 5 мг/л SA на продолжительность жизни молоди окуня, находящегося в этих водоёмах. Установлено, что в аквариумах с поверхностью 219 $см^2$ рыбы жили в среднем на 95 минут дольше, чем в резервуарах с поверхностью 575 $см^2$ (разница с

$P \geqslant 99{,}9\%$). Аэрирование воды также сокращало продолжительность жизни рыб в детергентах, растворённых в экваримумах с поверхностью 219 $см^2$ приблизительно но 30 минут (разница с $P \geqslant 99\%$).

Размещение рыб на расстоянии 24 см от поверхности воды увеличивает продолжительность их жизни по сравнению с рыбами, находящимися на расстоянии 9 см от поверхности воды на 26 минут (разница с $P \geqslant 95\%$).

Из полученных данных следует, что токсическое действие детергентов является самым высоким в поверхностном слое воды, а толщина этого слоя зависит от концентрации детергента и свободной поверхности резеруара. В связи с вышесказанным при определении токсического действия детергента на водные организмы кроме концентрации детергента в единице объёма необходимо учитывать также поверхность резервуара, его глубину и влияние аэрирования воды.

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