Environment Protection Engineering

Vol. 5 1979 No. 1

JANINA PUDO*

COMMUNITIES OF ORGANISMS IN AN AERATED SEWAGE POND OPERATING IN THE SECONDARY AND TERTIARY TREATMENT

Plankton and microbenthon were studied in an aerated sewage pond operating in the secondary and tertiary treatment, to which mixed municipal and textile industry wastewater was fed. Different retention times were applied. Essential differences were found in the formation of communities of organisms depending on the character of the wastewater supplied. However, the wastewater retention time was not noticed to have any distinct influence on the development of individual groups of flora and fauna. In the research period only one algae species (*Scenedesmus quadricauda*) formed water blooms.

1. OBJECTIVES

In parallel to technological investigations into the course and effectiveness of mixed (domestic and industrial) wastewater treatment processes in areated ponds at Andrychów, the development of communities of organisms accompanying the treatment was also traced. The aim of the biological investigations was to show how communities of organisms are formed when the ponds operate in the secondary and tertiary treatment and whether they can illustrate the progress in wastewater treatment.

The subject of the research was one of the two experimental sewage ponds which constitute an element of the pilot biological treatment plant [1], to which municipal and textile wastewater from the Andrychów Cotton plant are fed, in the proportion 1 : 1. The ponds were aerated with compressed air through perforated pipes installed at the bottom at a depth of 1.7 m. The compressed air was supplied to the ponds in a continuous manner. The research involved pond No. 1, the bottom of which was padded with an asphalt rug, and the active volume was 47 m^3.

2. SCOPE OF RESEARCH AND METHOD

The research was carried out in two stages. The first stage was conducted during March and April 1974 when the pond received mechanically-treated wastewater and the second

* Institute of Meteorology and Water Management, Kraków Branch, Poland.

stage from August to September of the same year when biologically-treated (activated sludge) wastewater was fed to the pond. In the first case the wastewater was retained for 6 and 9 days, in the second for 6 and 3 days. Physico-chemical control of the process was carried out every few days. The team of chemists at the IMWM Branch in Cracow performed these analyses. As a result of treatment in the first stage 59.8% BOD_5 removal was obtained after 6 days, 70.1% after 9 days and in the second stage 42.0% after 6 days, 37.0% after 3 days [3]. The average values of physico-chemical indicators of influent and effluent wastewater for successive stages are presented in tab. 1.

Table 1

Average values of physico-chemical indicators of sewage flowing in and out the pond during two stages of research

Name		Stage I		Stage II	
		secondary influent	treatment effluent	tertiary influent	treatment effluent
Dissolved oxygen mg/dm³	O_2	1.7	2.2	2.3	7.1
BOD_5 mg/dm³	O_2	239.5	82.7	19.05	16.2
Dichr. COD mg/dm³	O_2	381.5	233.7	105.1	91.05
Permang. COD mg/dm³	O_2	99.4	59.4	24.15	26.3
Suspended solids mg/dm³		98.0	66.5	37.5	50.0
Alkalinity h		14.4	14.3	120	120
Putrescibility mval/dm³		8.76	7.93	9.9	8.7
Colour (Pt) mg/dm³	Pt	140.0	131.2	40.5	36.0
pH		7.6	7.5	8.1	8.5
Chloridae mg/dm³	Cl	76.6	65.9	—	—
Ammonia nitrogen mg/dm³	N	2.74	2.27	0.00	0.00
Nitrite nitrogen mg/dm³	N	1.04	0.35	0.13	1.11
Nitrate nitrogen mg/dm³	N	1.23	0.61	1.44	2.30

Biological investigations of the pond comprised a determination of plankton and microbethon, both from a qualitative and quantitative point of view. Plankton samples were obtained by centrifuging the unstrained water. The numbers of organisms counted under the microscope are given in relation to 1 cm³. Microbenthon samples were collected by means of a pipette, and observed directly under a microscope. The number of organisms was evaluated according to a six-degree scale of assessment. The investigations were carried out on living material.

In the stages discussed previously six research series were performed altogether.

3. DISCUSSION OF RESULTS

a) First stage of research — a pond working in the secondary treatment. In the first stage of research when mechanically-treated wastewater was fed to the pond, the composition of organisms both in plankton and in microbenthon included mainly bacteria

Table 2

Plankton and microbenthons in aerated sewage pond at Andrychów. Average values for individual stages of research

Effluent after treatment:	Mechanical		Biological	
Name	Plankton in 1 cm^3 of water	Microbenthon, six degree scale of assessment	Plankton in 1 cm^3 of water	Microbenthon, six degree scale of assessment
1	2	3	4	5
Zoogloea	44	4	2	+
Spirillum sp.	1200	4	2	+
Sphaerotilus natans Kütz.	136	3	26	2
Oscillatoria Limosa Ag.	—	—	5	1
— *sp.*	—	—	1	1
Cyanophyta n.d.	1	+	2	1
Euglena acus Ehr.	2	—	—	—
— *proxima Dang.*	2	—	—	—
— *sp.*	1	+	1	—
Phacus caudatus Hübner	—	—	8	—
— *sp.*	1	—	2	+
Trachelomonas volvocina Ehr.	4	—	25	+
— *sp.*	2	—	4	+
Melosira italica (Ehr.) Kütz.	—	—	4	—
Cyclotella sp.	—	—	—	+
Ceratoneis arcus (Ehr.) Kütz.	—	—	—	+
Synedra ulna (Nitzech) Erh.	1	—	6	+
— *sp.*	—	—	4	—
Cocconeis pediculus Ehr.	—	—	—	+
Achnanthes minutissima Kütz.	—	—	8	+
— *Linearis (W. Sm.) Grun.*	—	—	18	+
— *spp.*	1	+	10	+
Navicula cryptocephala Kütz.	4	—	8	1
— — *var. intermedia Grun.*	4	+	2	—
— *viridila Kütz.*	2	+	26	2
— *dicephala (Ehr.) W. Sm.*	20	2	24	1
— *sp.*	3	—	6	+
Gomphonema parvulum (Kütz.) Grun.	2	—	26	2
— *lanceolatum Ehr.*	—	—	—	+
— *sp.*	—	—	2	+
Hantzschia amphioxys (Ehr.) Grun.	—	1	—	+
Nitzschia stagnorum Rabh.	—	+	4	+
— *dissipata Kütz. Grun.*	—	+	18	1

1	2	3	4	5
— *palea (Kütz.) W. Sm.*	14	2	10	1
— *sigmoidea (Ehr.) W. Sm.*	—	—	—	+
— *spp.*	4	—	10	1
Surirella ovata Kütz.	—	—	—	+
— *sp.*	—	—	2	+
Chlamydomonas sp.	130	2	—	—
Chlorella sp.	60	2	—	—
Tetrastrum sp.	—	—	2	+
Micrastinium pusillum Fres.	—	—	4	+
Scenedesmus acuminatus (lag.) Chod.	—	—	90	2
— *obliquus (Turp.) Kütz.*	—	—	20	2
— *quadricauda (Turp.) Bréb.*	—	—	4100	5
— *ovalternus Chod.*	—	—	36	1
— *intemedius var. bicaudatus Hortob.*	—	—	16	+
— *opoliensis P. Richt*	—	—	4	—
Scenedesmus sp.	—	—	4	+
Gloeocystis planctonica Lemm.	—	—	2	—
Ankistrodesmus falcatus Ralfs.	2	—	6	+
Chlorococcales n.d.	—	—	2	+
Stigeoclonium sp.	—	—	—	1
Zooflagellata n.d.	235	4	35	2
Amoeba limax Duj.	20	+	2	+
— *sp.*	—	1	1	+
Lionotus sp.	—	2	—	+
Paramaecium caudatum Ehr	2	+	2	—
— *sp.*	2	—	—	—
Glaucoma scintillans Ehr.	24	—	—	—
Colpidium campylum Bres.	36	2	8	+
— *colpoda Stein.*	2	1	—	—
Cyclidium sp.	8	1	22	2
Halteria sp.	1	—	4	+
Oxytricha fallax Stein	—	1	—	—
Euplotes sp.	—	—	—	+
Opercularia coarctata Cl. L.	20	2	—	—
Vorticella microstoma Ehr.	28	2	—	—
Ciliata n.d.	20	2	2	+
Podophrys fixa O.F.M.	—	+	—	+
Nematodes n.d.	2	+	1	+
Rotaria rotatoria Pal.	—	+	1	+
Brachionus calyciflorus Pal	—	—	1	—
— *sp.*	—	—	1	+
Rotatoria n.d.	—	—	2	1
Nauplius	—	—	1	+

and protoza and only a small number of algae. So it was close to the composition of activated sludge in good operation [3]. In plankton the bacteria group, apart from zoogleal concentrations in large numbers and bacteria of the *Spirillum* type, was also represented by the species *Sphaerotilus natans* which was less numerous. Protoza had representatives among colourless *Flagellata*, *Rhisopoda* and *Ciliata*. Colourless *Flagellata* and then *Ciliata*, of which the species *Colpidium compylum* was noted most often developed in the greatest numbers. The next in decreasing order places were occupied by: *Glaucoma scintillans*, *Vorticella microstoma* and *Opercularia coarctata*. The accompanying group was algae which had representatives among blue-green algae, euglenins, diatoms, volvocales and green algae. Green algae and strictly speaking two kinds, *Chlamydomonas* and *Chlorella*, occurred in relatively large numbers. The number of *Chlamydomonas* specimens in the pond was above 100 per 1 cm^3, and *Chlorella* somewhat less (tab. 2). At the same time diatoms were observed in small numbers. Of these the species *Navicula dicephala* and *Nitzschia palea* were relatively most often encountered. These are not, however, proper plankton species — they were noted in greater numbers in microbenthon where they found suitable conditions for development. Of the higher animal organisms *Nematodes* and *Rotifers* occurred sporadically. In the communities of microbenthon similar qualitative and quantitative composition to that of plankton was found. The reason for this was the shallowness of the pond and artificial aeration. Due to a general mixing and re-mixing of organisms typical benthonic species were found in the water. The communities of microbenthon were somewhat richer in the representatives of bacteria and the ciliata group. In the first stage of research no essential differences were found in the composition of species and number of organisms in relation to the retention time of sewage in the pond.

b) Second stage of research — a pond operating in the tertiary treatment. In the second stage of research, i.e. in the period when biologically-treated waste was fed to the pond, the analyses showed the presence of groups of organisms similar to those distinguished for the previous period, but supplemented with representatives of crustaceans.

However despite such an arrangement, great changes were found as regard the development and domination of individual species.

At this time the decided dominants were algae (fig. 1). Green algae were noted in the greatest numbers, particularly of the *Scenedesmus genus*. The number of individuals of species. *S. quadricauda* grew gradually to over 5000 per 1 cm^3 of water in September and October. An accompanying species was *S. acuminatus*. Of other algae the somewhat more numerous development of diatoms, euglenins and blue-green algae, as compared with the first stage was observed in this period. The leading species for diatoms was still *Navicula dicephala* and in October *Gomphonema parvulum* additionally began to develop. Of the euglenins the species *Trachelomonas volvocina* was relatively most often noted, of blue-gree algae *Oscillatoria limosa* (tab. 2). In the research of the second stage a general regression of bacteria and protozoa was found. In particular the number of colourless flagellates was reduced. Ciliata were most often represented by the genera *Cyclidium* and *Colpidium*. Nematodes occurred sporadically and rotifers although not numerous were

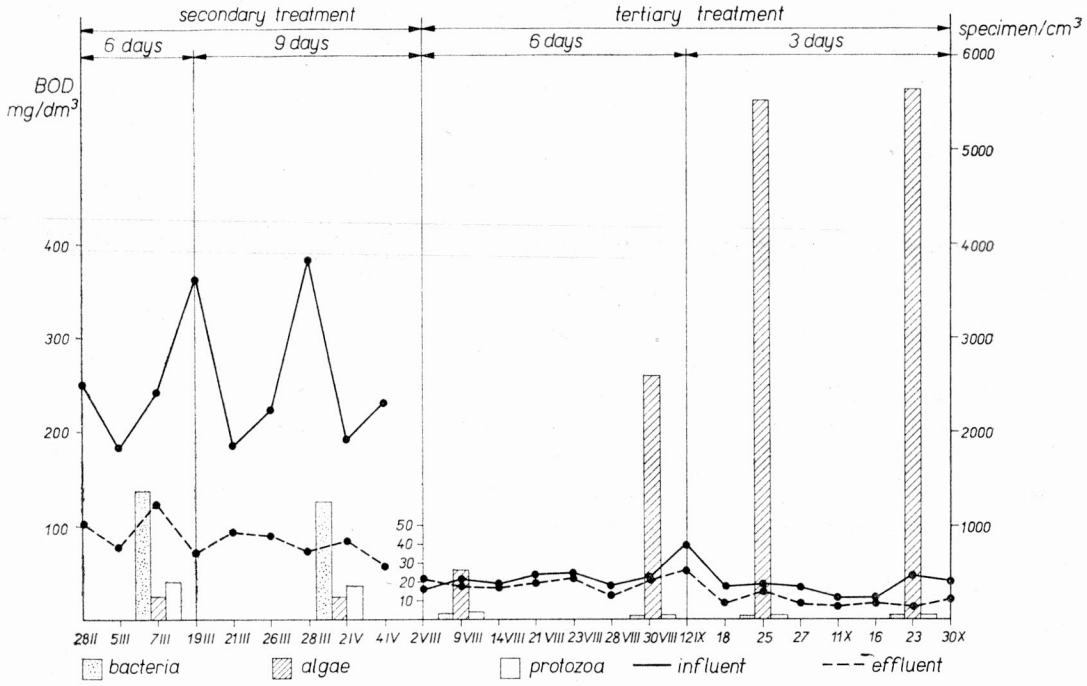

Fig. 1. Groups of organisms in research periods with respect to BOD_5 content

Rys. 1. Grupy organizmów w okresach badawczych na tle zawartości BZT_5

met more often than in the first stage. At this time crustaceans began to appear. In communities of microbenthon only small changes were found in the qualitative and quantitative composition of organisms (somewhat richer cliliata fauna) in comparison with plankton. The reasons for this have been described previously. Nor in this period any differentiation was found in species or in individuals in relation to the sewage retention time.

4. GENERAL COMMENTS

When comparing the composition of organisms in the first and second stage of research it has been found that in both cases there is a decided predominance of plants over animals, both in plankton and microbenthon. The percentage portion of individual groups of organisms in the pond varied with the kind of operation (secondary or tertiary treatment), as is shown in fig. 2. The composition of the species noted was poor. This is characteristic of sewage ponds where usually, particularly in phytoplankton a small number of species, but abundant in individuals is observed [4]. In the present research, however, a relatively low number (max, 6000 per 1 cm^3) of phytoplankton individuals per unit of water was

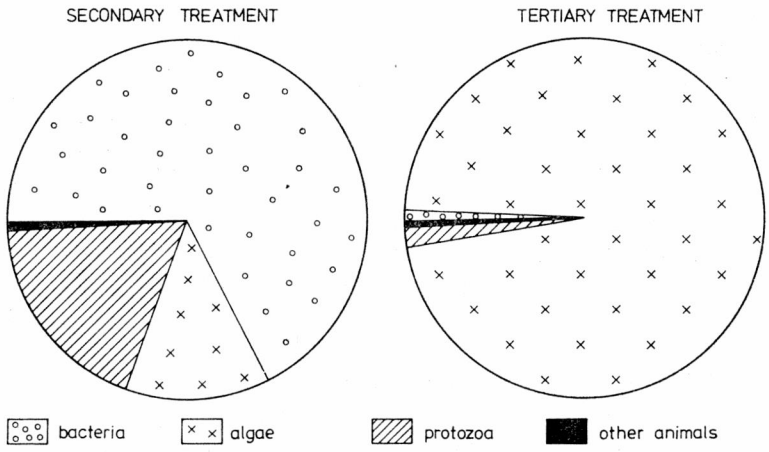

Fig. 2. Percentage participation of basic groups of organisms in secondary and tertiary treatment

Rys. 2. Procentowy udział zasadniczych grup organizmów w II i III stopniu oczyszczania

found. The reason for this was probably the low content of nutrients in the pond. It is accepted that e.g. green algae blooms occur in the presence of nitrogen salts above 5 mg/ /dm^{3}N [5]. In this case the nitrate concentration in the influent in the secondary treatment, oscillated from trace to 5.0 mg/dm^3 (average 1.23 mg/dm^3) and in the tertiary from trace to 4.5 mg/dm^3 (average 1.44 mg/dm^3). Several organisms were observed which developed in fairly large numbers but only one species dominated which gave the water an intense green colour. This was the alga *Scenedesmus quadricauda*, which during the second stage of research occurred in numbers above 5000 specimens per 1 cm^3 of water. This is a figure which makes it possible to speak already of the bloom of this species. According to STARMACH [5] water-blooms can practically be observed when the number of algae cells in 1 cm^3 of water approaches 1000. Water-blooms of the *Scenedesmus quadricauda* species in sewage ponds are known and given in the literature [6, 7] and more than once the number of cells reaches several million in 1 cm^3 of water. The alga *Chlamydomonas* which occurred in fairly large numbers in the first stage of research without forming blooms is also characteristic of sewage ponds and is usually noted in papers concerning this type of research [8, 9, 10] as one of the first green organisms to appear in the treatment process. This is because it achieves optimum development in an environment rich in organic compounds.

5. CONCLUSIONS

— Essential differences were found in the formation of communities of organisms in an aerated sewage pond in accordance with the character of the waste supplied, however, sewage retention time was not seen to have any distinct influence on the development of individual flora and fauna groups.

— When the pond was supplied with mechanically-treated wastewater the composition of organisms included mainly bacteria and protozoa. Algae were only accompanying organisms.

— When the pond was supplied with biologically-treated wastewater the dominant organisms were algae (mainly of the *Scenedesmus genus*) and other groups occurred in smaller numbers.

— Only slight differences were found in the qualitative and quantitative composition of plankton and microbenthon. The reason for this was probably artificial aeration and the shallowness of the pond. Therefore in control investigations of this type of pond it is sufficient to refer to plankton.

REFERENCES

[1] Bożko L., Kalisz L., Suchecka T., *Stawy biologiczne jako trzeci stopień oczyszczania ścieków*, Gaz, Woda i Techn. Sanit. 1966, No. 6, pp. 201–202.

[2] Godzik S., Kotulski B., Szczygieł P., *Badania nad oczyszczaniem ścieków Zakładów Chemicznych „Oświęcim" metodą stawów ściekowych*, Gaz, Woda i Techn. Sanit. 1963, No. 1, pp. 19–29.

[3] Hawkes H. A., *The ecology of wastewater treatment*, Pergamon Press, Oxford—London 1963.

[4] Jackson H. W., *Plankton in water supplies and stabilization ponds*, Water and Pollution Control, 1966, No. 104.

[5] Juszczak J., *Oczyszczalnia ścieków dla miasta Andrychowa*, BPBK, Vol. 1 (type script), Kraków 1970.

[6] Kalisz L., *Stawy glonowe jako zabezpieczenie przed eutrofizacją*, Gaz, Woda i Techn. Sanit. 1975, No. 9, pp. 285–287.

[7] Kalisz L., Suchecka T., *Znaczenie pewnych organizmów w procesie oczyszczania ścieków w stawach biologicznych*, Gaz, Woda i Techn. Sanit. 1966, No. 7, pp. 236–237.

[8] Kyselowa K., *Plankton stawów zasilanych ściekami cukrowniczymi*, Acta Hydrobiol., Vol. 15 (1973), No. 1, pp. 51–88.

[9] Michalcewicz-Mączka M., Pudo J., *Efektywność i parametry oczyszczania ścieków mieszanych: bytowo-gospodarczych i przemysłowych w stawie napowietrzanym II i III stopnia na stacji pilotowej w Andrychowie*. IMGW, Kraków 1974 (maszynopis).

[10] Starmach K., *Wody śródlądowe, zarys hydrobiologii*, Uniw. Jagiell., Kraków 1973.

ZBIOROWISKA ORGANIZMÓW W NAPOWIETRZANYM STAWIE ŚCIEKOWYM DZIAŁAJĄCYM W II i III STOPNIU OCZYSZCZANIA

Badania dotyczyły składu jakościowego i ilościowego planktonu i mikrobentosu w napowietrzanym stawie ściekowym pracującym w II i III stopniu oczyszczania, przy różnym czasie przetrzymania ścieków. Prace prowadzono w Andrychowie na oczyszczalni pilotowej, do której dopływały ścieki miejskie i z przemysłu włókienniczego, mieszane w stosunku 1:1. W pierwszym etapie badań, kiedy doprowadzono do stawu ścieki po oczyszczaniu mechanicznym, skład organizmów obejmował głównie bakterie i pierwotniaki, a grupą towarzyszące były glony. Natomiast w drugim etapie, przy doprowadzaniu do stawu ścieków po oczyszczaniu biologicznym, (osad czynny) organizmami dominującymi były glony, głównie z rodzaju *Scenedesmus*, a inne grupy wystąpiły w małej ilości. Zakwit tworzył w tym czasie tylko jeden gatunek *Scenedesmus quadricauda*. W obu etapach badań nie zauważono wyraźnego wpływu czasu przetrzymania ścieków na rozwój poszczególnych grup flory i fauny.

W wyniku oczyszczania uzyskano w pierwszym etapie usuwanie BZT_5 po 6 dobach przetrzymania — 59,8%, po 9 dobach — 70,1%, a w drugim etapie po 3 dobach — 37,0%, po 6 dobach — 42,0%.

DIE ANSAMMLUNG VON MIKROORGANISMEN IN BELÜFTETEN ABWASSERTEICHEN DER 2. UND 3. REINIGUNGSSTUFE

Getestet wurde die qualitative und quantitative Zusammensetzung des Planktons und des Mikrobentos in belüfteten Abwasserteichen der 2. und 3. Reinigungsstufe bei verschiedenen Verweilzeiten der Abwässer in der Anlage. Die Versuche wurden in einer Pilotanlage in Andrychów geführt. Das Mischabwasser setzte sich zu je 50% aus Kommunal-Abwasser und dem Abwasser eines Textilbetriebes zusammen.

Während der ersten Versuchsreihe, in welcher den Teichen nur mechanisch vorgereinigtes Abwasser zugeführt wurde, waren in dieser vorwiegend Bakterien und Protozoen nachzuweisen; Algen waren nur Begleitorganismen.

In der zweiten Versuchsreihe floß den Teichen ein mit Belebtschlamm biologisch gereinigtes Abwasser zu, daher dominierten Algen, hauptsächlich *Scenedesmus*. Andere Algenarten waren in entsprechend kleineren Mengen vertreten. Massenhaft lag nur *Scenedesmus quadricanda* vor, die auch für eine Blüte verantwortlich war.

In beiden Versuchsperioden konnte kein deutlicher Einfluß der Verweilzeit auf die Entwicklung der Flora und Fauna beobachtet werden.

Die Reinigungswirkung der Teichanlage (gemessen als BSB_5-Abbau) war entsprechend:

in der ersten Versuchsreihe: nach 6 d Verweilzeit 59,8%,
nach 9 d Verweilzeit 70,1%;
in der zweiten Versuchsreihe: nach 3 d Verweilzeit 37,0%,
nach 6 d Verweilzeit 42,0%.

СООБЩЕСТВО ОРГАНИЗМОВ В АЭРИРОВАННОМ ПРУДУ, ДЕЙСТВУЮЩЕМ ВО II И III СТЕПЕНЯХ ОЧИСТКИ

Исследования касались качественного и количественного состава организмов планктона и микробентоса в аэруруемом сточном пруду, действующем во II и III степенях очистки при разном времени продержки водостоков. Работы проводились в Андрыхуве на очистной станции, к которой подводились смешанные по пропорции 1:1 стоки: городские и промышленные от текстильного завода. На первом этапе исследований, когда в пруд поступали стоки после механической очистки, состав организмов озватывал, главным образом, бактерии и простейшие, а сопровождающей группой были водоросли. Зато на втором этапе при подаче в пруд стоков после биологической очистки (активный осадок) преобладали водоросли, прежде всего из вида *Scenedesmus*, другие группы появились в малом количестве. Зацвет составлял в это время только один вид *S. quadricauda*. На обоих этапах отчетливое влияние времени продержки стоков на развитие отдельных групп флоры и фауны не было отмечено.

В результате очистки получено в первом этапе удаление после 6 суток продержки — 59,8%, после 9 суток — 70,1%, а на втором этапе после 3 суток — 37,0% ,после 6 суток — 42,0%.