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THE USE OF BIOLOGICAL INDICATORS IN THE EVALUATION OF IASI WASTEWATER TREATMENT PLANT PERFORMANCES

BY

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Besides other environmental factors, water is of major importance both to human society and to biological diversity, currently in retrogression. The alarm signal is due not so much to the physical exhaustion of water as to its pollution. In this context, an increased exigency regarding the protection of the natural water system through prevention of pollution is imperious. Such exigency must be also transposed to the quality control of the process of waste water purification. It is well known the fact that treated waste waters - *effluents* of treatment stations - finally reach the natural water system - through *emissaries.* The purification process should be therefore rigorously controlled and made efficient. The current paper refers to the biological monitoring (through the use of protozoa as bio-indicators) of the quality of active sludge and of the effectiveness of the biological treatment process in the Wastewater Treatment Plant of the Iasi City. At the same time, we propose some ways to improve the biological purification process, with the objective of an advanced reduction of organic matter and ammonium in waste waters, so as to obtain an effluent with an advanced purification degree and therefore with a lower potential impact on environment.

Introduction

Water, that for a long time has been considered sufficient and whose existence has been given for granted, may become a limitation factor of the economic development in the future decades. The raising pressure is currently due to the extension of pollution, the exhaustion of some underground reserves, the lowering of subsoil water level and the decline of aquatic ecosystems. The danger is due not so much to the physical exhaustion of the water, but to its pollution, phenomenon primarily caused by the antropic impact. We refer both to pollution caused by industry, agriculture, domestic activities, and to the insufficient purification of waste waters, finally released into emissaries. Pollution of water basins has ever worse repercussions on hydrobionts and in many countries biodiversity is passing through a strong retrogression process. Many species have disappeared and many more are in danger of extinction. [1]

The juridical system that comes to support water protection in our country includes the Water Law 107/1996 and the Government Decree HG 188 of March 2002. The letter establishes the conditions for the release of waste waters into the aquatic

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environment and approves the NTPA 011, NTPA 002 and NTPA001 norms, based upon the European norms. At European level, mention should be made of the 1997 promoted Framework Directive whose environmental objective is to reach a "good" status for all underground and surface waters within 2010.

In this context, besides other measures, an increase in exigency is indispensable with regard to the quality of the waters released into emissaries by the wastewater treatment plants, exigency transposed into an increase of the effectiveness of the purification process, which requires a rigorous analytical physical-chemical and biological control.

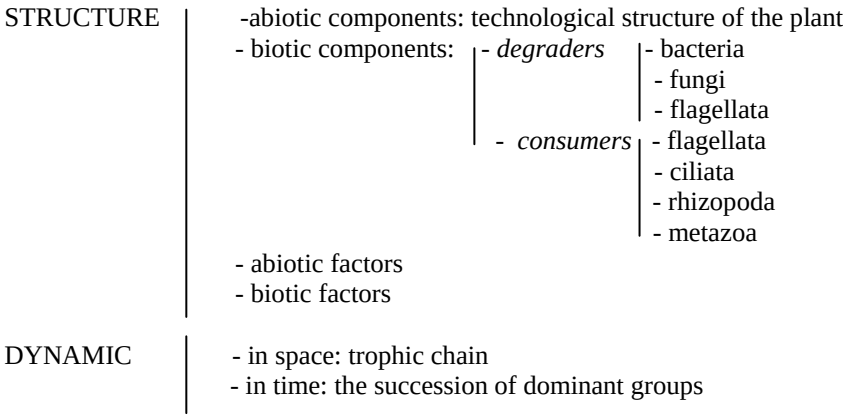
The current paper refers on one side to the biological control of the purification process with activated sludge and, on the other, to its use in the amelioration of the biological purification process. The study was carried out by the Wastewater Treatment Plant of Iasi.

The criteria to estimate the performance of the purification stations and of their purification effectiveness were mainly developed when the elimination of carbon compounds, respectively of organic matter, became a necessity. Nowadays, standards and norms in force are more exigent in as far as N and P are concerned, as they are the main nutrients that can lead to the appearance of the eutrophisation phenomenon in the receiving waters.

In the purification stations with activated sludge, aeration tanks represent ecosystems exposed to extreme conditions, characterized by a total dependency from the organic allochthonous substratum and by an intense rhythm of matter and energy going in and out. Like any biological system, the biocenosis from the treatment aero-tank with activated sludge has a structure based on components and factors and a dynamic in time and space [3] (fig.1).

In the biocenosis of active sludge a detrital network is established, where protozoa play a very important part. [3]. The substratum that assures the necessary food and energy is represented by organic substances, the dissolved oxygen and nutrients, respectively nitrogen and phosphorus salts from the wastewater. This allows the increase of primary degraders, most of them being heterotrophic bacteria and, to a lesser extent, fungi and flagellata. The next link, of the decomposers, represented by rhizopoda, ciliata, rotifera and nematoidea, develops depending on food availability. Thus, dispersed bacteria become food for the heterotrophic flagellata and bacterivorous ciliata, which, in turn, become prey for carnivorous organisms.

Fig.1



Although most of the ciliate species are able to resist in precarious environmental conditions, the special conditions in the active sludge limit their presence to a reduced number of species, in correlation with the organic loading of the active sludge and with the other dimensioning parameters. Thus, ciliata have become a performance indicator for the biological purification process. Generally, the identification of flagellata and ciliata, the quantitative analysis of their diffuseness as well as the proportion between dominant groups of organisms can provide us with information on the biological purification process in the bioreactors with activated sludge.

Materials and methods

This study was undertaken during the period January 1 - October 30, 2003, by daily monitoring the sludge from biological point of view. The monitoring included the identification of the species and the estimation of their diffuseness according to the Srämek-Husëk method. Based on the results obtained and computed for each month, the dominant groups of protozoa were established and, depending on their dominance an evaluation of the effectiveness of the purification process with active sludge was carried out. On the other hand, there was made a correlation with the following parameters

- the organic loading of the sludge (ION), expressed in kg BOD_5(5-day biochemical oxygen demand/kg MVS;
- biomass, expressed in volatile matter in suspension (MVS), mg/dm^3;
- efficiency of the elimination of organic matter (η_{BOD5}), %;
- efficiency of the elimination of ammonium (η_{NH4}), %.

Results and discussions

The protozoa species' role of immediate indicator can be observed by looking at the increase of the efficiency of the waste water purification process in the Wastewater Treatment Plant of Iasi.

Thus, in January, for an organic loading of the sludge ION=0.53 kg BOD_5/kg MVS, the dominant group of protozoa in the biocenosis of activated sludge was that of mobile ciliata, followed by fixed ones and by flagellata. This situation indicates a mediocre purification of the biodegradable organic matter (BOD_5) and of the ammoniacal nitrogen, signifying that the biomass quantity, the age of the sludge and the low temperatures were insufficient for the completion of a nitrification process. During the two following months the situation remained similar.

In April (fig.2), a high organic loading was recorded as well in the aeration tanks of the station. The efficiency of the purification of organic matter and ammonium remained low. In the biocoenosis of active sludge there was an increase of the number of mobile bacterivorous ciliata (40% among the individuals of the biocoenosis) and of fixed bacterivorous ciliata (30%), associated with values of I_{ON}>0.5. The dominant mobile species was *Aspidisca lyncaeus*, while the fixed one was *Vorticella convallaria*.

Noticing the lack of effectiveness of the active sludge for the reduction of the ammonium quantities (oxygen consuming substance that, once it arrives to the emissary, respectively the Bahlui River, leads to the lowering of the O_2 concentration and therefore has a negative impact on hydrobionts), we tried to increase the biomass quantity in the aeration tanks as well as the age of the sludge (as it is known that nitrification bacteria need a longer growing time).

Thus in August (fig. 3) we could notice that, for a biomass increase from 1452 to 1812mg/dm^3, there appeared modifications in the structure of the biocoenosis while the proportion between the main groups of organisms changed as well. The dominant group became Rhizopoda, represented by the species *Arcella vulgaris* (15-19 individuals / microscopic field); there appeared rotifera, organisms indicating a good oxygenation and an old age of the sludge. Among mobile ciliata, the best represented are the species *Aspidisca costata, Colpidium colpoda, Chilodonella cuculus,*, while among the fixed ones - *Vorticella convallaria* and *Epistylis digitalis*. The presence of this association in the active sludge indicates an increase in the effectiveness of the purification process. The efficiency of elimination of organic matter was of 84.9% - in comparison with 70.3% in April and 69.6% in January - while the efficiency of ammonium elimination was of 88,7% – in comparison with 22.7% in April and 22.5% in January.

A further increase of the biomass in the aeration tanks led to a decrease I_{ON} to 0.28 kg CBO_5/kg MVS/day in October and to an increase of the efficiency of the station in the elimination of ammonium – 96.8%. During that period, the *Arcella vulgaris* rhizopod, associated with an advanced nitrification process, had remained dominant in the biocoenosis of the activated sludge. The rest of organism groups were present in relatively equal proportions. The diversity was lower, as only 3 species of mobile ciliata and 4 species of fixed ciliata were identified. The presence of rotifera in a number of 3-4

individuals / microscopic field (10x) and of the gastrotrich *Chaetonotus sp.* – 1 individual / microscopic field (10x) is characteristic for an older age of the sludge, obtained through the increase of the biomass quantity in the aeration tank and diminishing of the excess active sludge.

Looking at the proportions of the main groups of organisms during the period January - October (fig.4), we can notice that, if in the first part of the year mobile ciliata, followed by fixed ones were dominant, starting with June rhizopoda, mainly tecate rhizopoda started to develop and than to be dominant, indicating a sufficient oxygenation of the active sludge and a good purification.

In parallel, looking at the variation of the main parameters registered in the effluent during the same period, it can be noticed that the lowest value of NH_4, BOD_5 and organic matter (COD-Cr) was recorded in August, corresponding to the peak of the development of tecate rhizopoda, respectively of the *Arcella vulgaris* species.

The graphic of the efficiency of the reduction of the organic charge and of ammoniacal nitrogen (fig. 5) shows that, starting with June, it began to raise, reaching its peak in August, and later it began to diminish very little.

Conclusions

The analysis of microfauna made during the study period on the activated sludge of Iasi Municipal Wastewater Treatment Plant, shows that the dominance of microfauna groups changes in relation to the environmental and operational condition of the plant.

A microfauna rich in small flagellates, free-swimming ciliates as: *Colpidium colpoda*, *Glaucoma scintilans* and peritrich ciliates: *Vorticella microstoma* and *Opercularia spp*. is associated with low values of MVS (1448-1459 mg/l), high values of sludge load (0.52-0.63 kg DBO_5/kg MVS/day), high final effluent DBO_5 and ammoniacal-N concentration as can be observed in the results recorded in January and May.

On the contrary, at low loading, high values of MVS (1890-2450 mg/l) and large sludge age the distribution between groups is more uniform, crawling and attached ciliates beeing more abundant. At low sludge loading (0.28-0.42 kg DBO_5/kg MVS/day) the in dominant ciliates species were: *Aspidisca costata*, *Chilodonella cucullus*, *Vorticella convalaria* and Epistylis digitalis.

A particular attention was addressed to relationship between microfauna and N–removal. During the summer period when higer temperatures, higer DO (dissolved oxygen) concentration in aeration tank and larger sludge age enable complete nitrification, testate amoebae was the dominant group, represented by *Arcella vulgaris*.

Observation on the activated sludge microfauna, identification of flagellates, free-swimming, crawling and attached ciliates and the identification of the dominant group of the microfauna allows diagnosis of the particular state of functionality of the plant.

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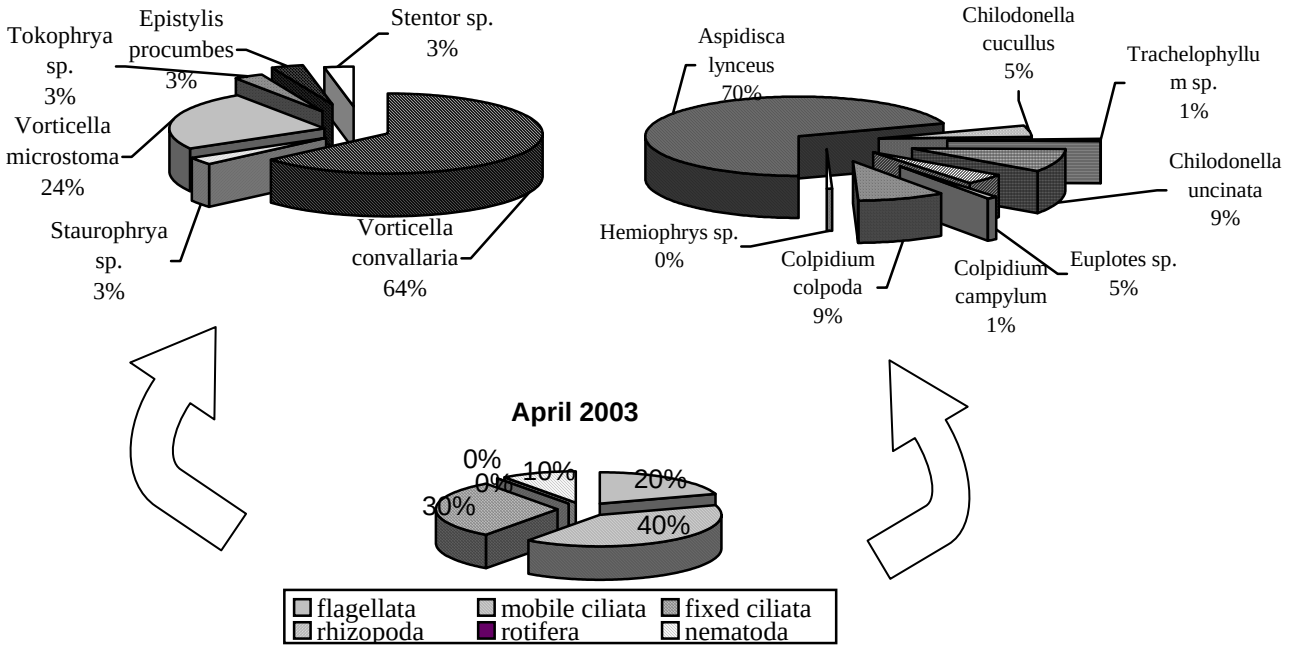

Fig. no. 2

ION =0.63 kg BOD_5/Kg MVS MVS = 1448 mg/dmc η_{BOD5}=70.3 % η_{NH4}= 22.7%

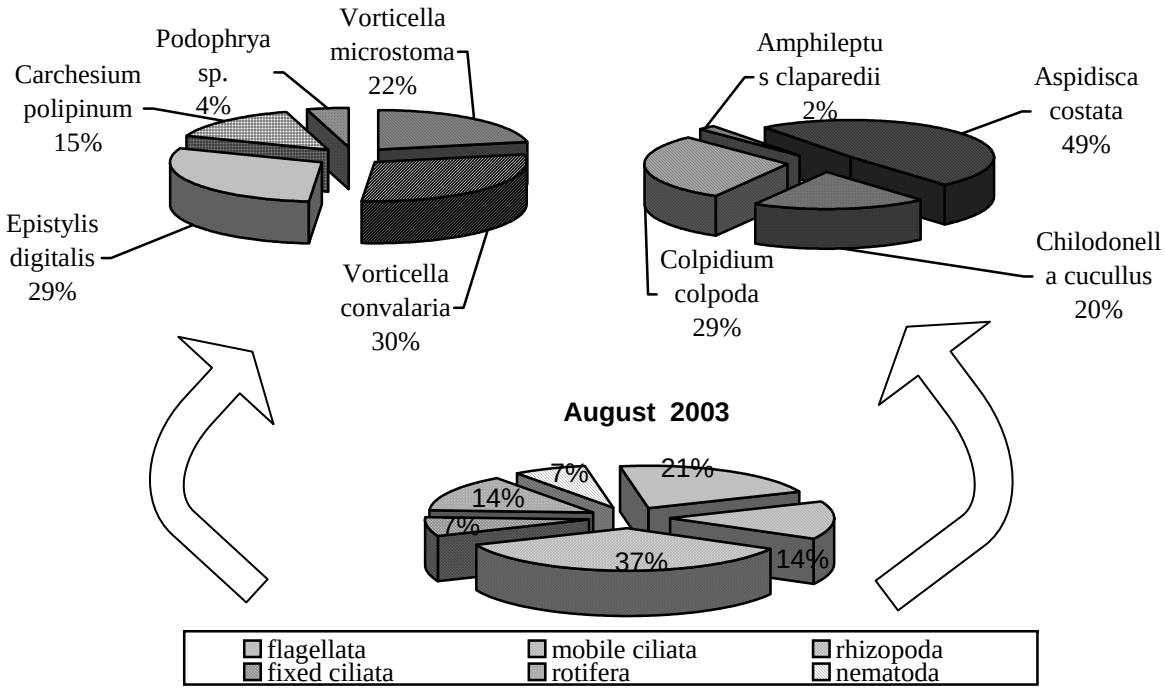

Fig. no. 3

ION =0.42 kg BOD_5/Kg MVS MVS = 1812 mg/dmc η_{BOD5}=84.9 % η_{NH4}= 88.7%

Fig. nr. 4 The proportion between the main group of organisms during the period January- October 2003

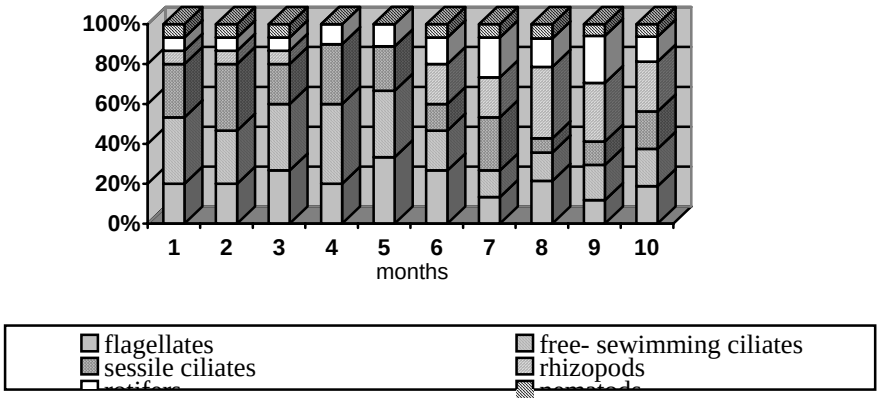

Fig. nr. 5 Efficiency in the reduction of organic matter and of ammoniacal nitrogen, year 2003