Biological filtration of treated waste water by Daphnia: an alternative for technical filtration, or an addition?

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Abstract Several years of research on the island of Texel proofed that Daphnia magna are very well capable to remove faecal coli bacteria effectively from treated wastewater by biological filtration. The Daphnia population, mainly Daphnia magna, is maintained by activated sludge particles and loose bacteria from the treated waste water. Because of the filtration by Daphnia the ponds fed with treated waste water do no turn green by algae, as expected. A combined research project on mesocosm scale (m^3-scale) has been started on three sites (STP Horstermeer and STP Grou in the Netherlands, plus STP Empuriabrava in Spain) to study this phenomena. In Horstermeer the research aims mainly on comparing the biological filtration by Daphnia with technical filtration like sand filtration and membrane filtration. The experiments in Grou and Empuriabrava run parallel to full-scale Daphnia ponds.
Keywords algae, biological filtration, constructed wetland, *Daphnia*, disinfection, food chains, ponds, suspended solids, treated waste wastewater

INTRODUCTION

Daphnia research on Texel

A massive growth of Daphnia (mainly Daphnia magna, Strauss) has been observed in the 4.400 m^3 pond of the Everstekoog constructed wetland (Island of Texel, The Netherlands) that receives high quality effluent from a very low loaded activated sludge plant (Schreijer et al, 2000; Toet, 2003). This phenomena has been studied extensively on laboratory, mesocosms and semi-technical scale since 1998. The experiments showed that Daphnia in ponds are very effective in reducing the number of coliform bacteria within a hydraulic retention time of as low as 4 days, but only in a plug flow regime of ponds in series (Kampf et al, 1999, 2004).

Biological filtration of treated waste water by Daphnia

Based on literature and practical experiences (Jorgensen, 1983; Vermeij, 2003) it was expected that ponds fed with treated waste water turn green by unwanted growth of algae, influenced by light and temperature (figure 1).

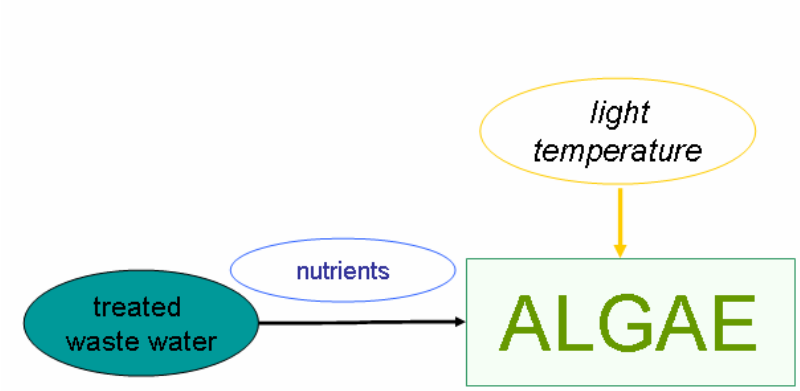

Figure 1: Expected: algae growth on treated waste water

The experiments on Texel indicated that the situation is more complex. The suspended solids in well treated wastewater sustain high number of *Cladocera* sp., in majority *Daphnia magna*. Sludge particles appear to be the main food source for Daphnia in the first ponds These Daphnia, are mainly indistinctive filter feeders. The intensive biological filtration process removes loose bacteria like faecal Coli effectively, but also prevent Algae to grow (Kampf, 1999, 2004). Contrary to the expectations the ponds stay clear with low algae numbers, because of the indistinctive feeding behaviour of the Daphnia. See Figure 2. Several experiments showed that Daphnia do appear automatically in the ponds, though bringing in Daphnia brings a stable system sooner. Snails (mainly *Lymnaea stagnalis*) are added to keep the walls of the mesocosms clean of attached algae, these snails appear also to eat on settled material from the waste water and on Daphnia faeces.

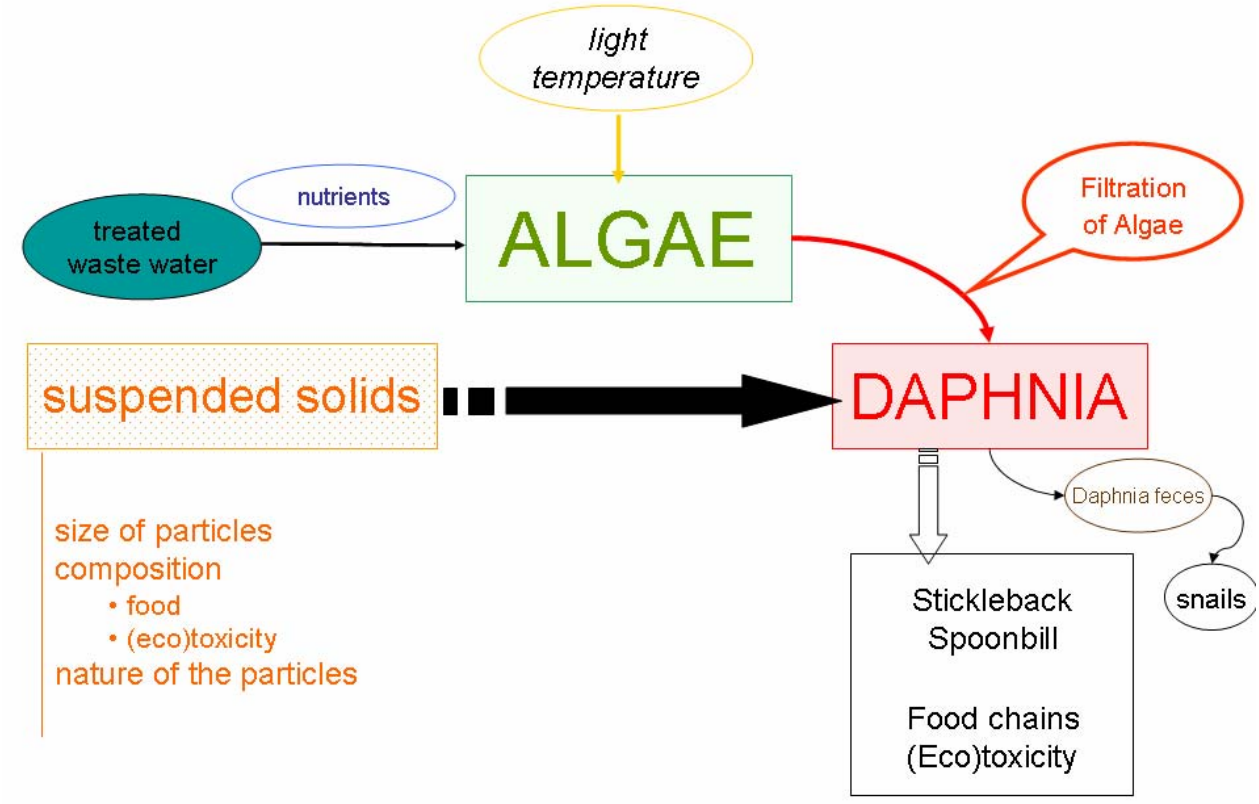

Figure 2: Hypothesis: Role of Daphnia, supported by snails in treated waste water ponds

MESOCOSM STUDIES IN HORSTERMEER, GROU AND EMPURIABRAVA

Filtration by Daphnia appears to be a good alternative for technical filtration processes, like sand filtration or membrane filtration. Therefore on three different sewage treatment plants (STP) in Europe (see Figure 3) a research project, project in mesocosms on m^3 scale has started:

1. *Horstermeer*: a rather high loaded activated sludge plant, 16 mesoscosms in 4 lines. Feed both effluent has filtrated effluent. Aimed on effect of technical filtration as pre-treatment, food web studies, effects of harvesting of Daphnia.
2. *Grou*: very low loaded activated sludge,8 mesoscosms in 2 lines. Parallel to the existing Daphnia ponds in the newly established constructed wetland Aqualân Grou. Aimed on disinfection
3. *Empuriabrava*: very low loaded activated sludge, 16 mesoscosms in 4 lines. Parallel to the existing Daphnia ponds in the constructed wetland. Aimed on food web studies, effects of harvesting of Daphnia, etc.

STP Horstermeer, The Nederlands

STP Grou

STP Empuriabrava, Costa Brava, Spain

Figure 3: The mesocosm studies in Horstermeer, Grou and Empuriabrava

The research project, that will last at least until the end of 2008, aims on understanding the process, obtaining knowledge for replication elsewhere and on assessing the place of such Daphnia ponds in "natural constructed wetlands "to produce a usable surface water" from treated waste water within the Waterharmonica concept to fulfil the new foreseen standards of the European Water Frame Work Directive.

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