THE BIOLOGICAL WASTE WATER TREATMENT OF THE FUTURE

- Membrane-supported biological waste water treatment with high biomass concentrations as a cost-saving method of eliminating pathogens, organic pollutants and nutrients down to natural background concentrations of surface waters -

Wolfgang Dorau, Professor Dr.-Ing., Federal Environmental Agency, Institute for Water, Soil and Air Hygiene, Corrensplatz 1, D-14195 Berlin, Germany

The Problem:

Like other states, Germany is a densely populated area, especially in its industrial centres. In order to avoid waterborne epidemics like those which haunted Germany at the end of the last century it had to implement a strict management of its water resources. One of the basic rules in residential hygiene that was developed at that time demands that any contact of the population with inhygienic solid waste and waste water has to be prevented. Following that concept sewerage systems were built to an extent that today the waste water of more than 90 per cent of the German population is transported out of residential areas by hygienically safe underground sewers. Apart from few exceptions there is no other way than discharging waste water into surface waters. The unavoidable target conflict is evident. Because of the high population density surface waters have to be used simultaneously as recipients of waste water and recreational waters and for other hygienically sensitive purposes like drinking water production and irrigation. The conflict has become more critical through the wide use of chemicals in households and in industry.

As rainfall and the dilution capacity of waters do not increase with rising discharges and programmes to stop contamination of waters by chemicals, nutrients and pathogens enforce further reduction of pollution, the pressure on sewage plants to improve waste water treatment becomes obvious. It is evident that it is not enough just to have sewage plants but to have the right ones. Multiple use of waters demands that waste water treatment has to remove contaminants to far lower concentrations than standard sewage treatment is able to perform. We have to accept that pathogens survive and can be transported in surface waters over long times and distances, and that infections can be caused by very small numbers of viruses and parasites. To really stop eutrophication we have to accept that sewage treatment has to reduce nutrient concentrations down to the range of micrograms per litre. In order to avoid sublethal effects on the health of water organisms and humans as well we have to accept that sewage treatment has to remove organic substances far better than it does now. Sewage treatment can only comply with these demands if it is equipped with techniques that possess the necessary mechanical, physical and chemical elimination mechanisms.

An analysis shows that classical sewage treatment that restricts itself to the removal of solved substances by micro-organisms and of solids and pathogens by sedimentation cannot cope with the high demands on modern waste water treatment. The lack of elimination and control mechanisms is one of the main deficiencies. Classical sewage treatment is a process based on hope. Waste water contaminants are expected to be completely degraded by waste water micro-organisms, and sedimentation is expected to make all micro-organisms and other solids settle and to keep them in the sewage plant. It is the complete removal of contaminants that waste water "purification" is expected to manage. Purification means restoration of water as pure as it was before being contaminated. But the classical sewage plant is a hydraulically open system. If contaminants, waste water bacteria and pathogens are not behaving as they are expected to do nothing can stop them from leaving the plant and contaminating surface waters. Enlarging sewage plants results in only little improvement of effluent quality but significantly higher costs. It is especially the rises in costs that are no longer tolerated by the public. Classical sewage treatment has reached an impasse.

The Solution:

A closer look into the elimination mechanisms of the biological stage shows that the increase in degradation efficiency is blocked by sedimentation. The replacement of sedimentation by membrane filtration, e.g. by microfiltration, frees biological treatment of its chains. It will be shown, to which rise in performance biological treatment can be led and which prospects of cost reductions will follow if microfiltration is integrated into the biological treatment. The basic change in process design is the change from a hydraulically open system to a system with an impenetrable physical barrier to solids and to all kinds of waste water micro-organisms and pathogens. Chart no. 1 shows the principle of the membrane filtration process, chart no. 2 gives an idea of the drastic reduction in volume and the simplification of the biological process.

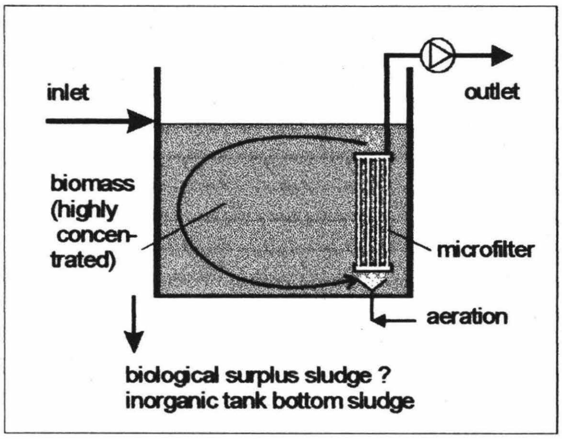

Chart no. 1 Membrane supported biological treatment with high biomass concentration

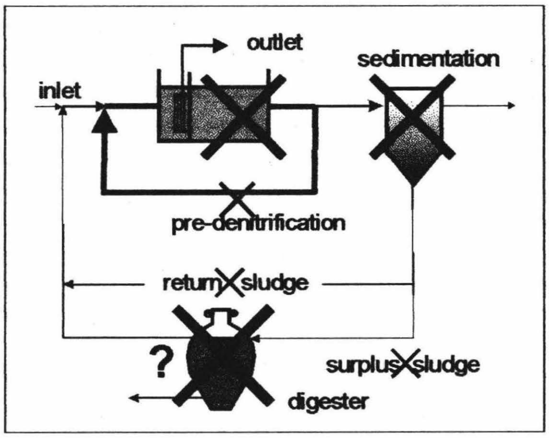

Chart no. 2: Reduction in treatment volume and simplification of the biochemical degradation process

The first striking improvement achieved by microfiltration is an effluent that is free of solids and micro-organisms (pathogen and non-pathogen). According to long-time test-runs of microfilters, pathogens of all sizes (viruses, bacteria, parasites) are retained practically completely. Apart from other improvements this water has lost its characteristic of being sewage, that means of containing faecal pathogens. A water free of particles and pathogens and with a very low concentration of organic residue is suited best for reclamation.

Reductions in tank volume are the second striking feature. Volume reduction and process simplification are not achieved at the cost of reductions in degradation efficiency. As there is no loss of biomass by incomplete sedimentation and no need to withdraw surplus biomass, the amount of biomass and biomass concentration can rise as long as microfilters are capable of managing higher concentrations. Higher biomass concentrations can be used to reduce the treatment volume correspondingly without losing biomass and degradation capacity. In this way rises in biomass concentration of 5 to 10 times can be reached (in comparison to classical sewage plants, depending on the organic load).

One of the most outstanding features is the alternative of operating the biological stage without having to withdraw any biological surplus sludge and of minimising the production of organic sludge to comparably small amounts. When this strategy is followed the production of surplus biomass automatically reaches a peak concentration at which organic carbon becomes the minimum factor for bacterial growth. This means that every biodegradable organic material is extracted from the water with the result that the concentration of organic compounds (COD, TOC) is reduced to its theoretically lowest concentration. The mode of operation is simplified to nothing more but aerating the biological reactor and operating the membrane filter (which both can be done automatically and by remote control). Biomass has an inborn tendency to take every opportunity to grow. Fluctuations of organic load will be automatically equalised biologically by either increasing growth or death of biomass.

The consequence of not withdrawing surplus sludge is the necessity of having to precipitate phosphorus by a separate step after microfiltration. The precipitation product is free of pathogens and a relatively clean product that can be recycled into phosphate production. Because of the high retention time of biomass and the raised temperature in the biological stage, nitrification is very stable. The treatment volume necessary for denitrification is reduced to the same degree as that of the biological stage (nitrification). Therefore pre-denitrification does not lead to space problems, even if a higher ratio of nitrified water is taken back to the denitrification tank or zone.

The membrane biology technique is a modular technique. Its basic principles can be applied in very small units as well as in large plants without any change in effluent quality. As its effluent is free of particles and micro-organisms and has a low content of organic compounds the membrane biology process offers ideal conditions for combination with other treatment processes if reclamation conditions or other requirements make this necessary. At the time membrane technique is developing rapidly. Increased filter efficiency will lead to low energy and maintenance demand and to low costs, so that membrane biology technique will become a most efficient tool to reduce the pollution of surface waters and to restore the hygienically safe usage of waters.

This development is of world-wide importance in the face of rising population figures and scarce water recourses, especially for the hygienically safe treatment and reclamation of water in future mega cities.