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ARTIFICIAL WETLANDS AS TERTIARY TREATMENT SYSTEMS

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Introduction

The IJsselmeerpolders Development Authority is charged with the development of newly reclaimed land in The Netherlands. A considerable part of it has been or is to be developed to recreational areas, where wastewater is produced from many sources and at a season-dependent rate. In this situation local treatment in artificial wetlands instead of relatively expensive centralized, conventional treatment was preferred. On the basis of experimentally derived design criteria about fifteen purification fields (either infiltration or horizontal flow-through type; refs. 1 and 2) have been put in operation throughout the polders.
In order to assess any capacity of wetland systems for polishing secondary municipal wastewater effluent, experiments have been carried out using laboratory and half-scale systems. Some experience with full-scale systems is now also available.

Experimental and full-scale systems

Infiltration tests were performed for two years using planted and unplanted sand filter and clay filter columns. The purification results (see table) showed that fairly high reduction values for nitrogen, phosphorus and coliform bacteria can be achieved, if the hydraulic loading does not exceed 0.02 m per day. Furthermore, it appeared that all filters can be regenerated when allowed to dry sufficiently long (up to several months).
On the basis of the column test results, four half-scale infiltration fields with and without a sand layer on top of the original clay soil have been laid out. Both types of fields were charged discontinuously with secondary effluent from the Lelystad municipal Caroussel type treatment plant, either at 0.15 - 0.20 m per week or at 0.7 m per month. No significant difference in removal efficiency for any parameter was observed between the four fields. The mean concentrations are presented in the table. Zinc and copper were removed for 40 and 20%, respectively.
The former provisional wastewater treatment facility of the new town of Almere consisted of a contact-stabilization activated sludge system, alternately discharging on four clay soil infiltration fields. Removal efficiency dropped only slightly when severe overloading conditions for the activated sludge system developped, which caused horizontal flow purification being added to the infiltration process.

Treatment in a virtually horizontal direction is applied on the effluent from the Elburg municipal trickling filter plant. Here a reed-planted, 14 hectare clay soil wetland was designed to work primarily as an alternative for chemical methods of phosphorus removal and disinfection. Suboptimal conditions existed during the first test period with regard to the development of the reedplants (too high water depth/stem length ratio) and the attached microflora (too high NH_4/C ratio of the influent). A poor nitrogen elimination efficiency resulted probably from these factors. A moderate phosphorus removal (see table) and a substantial reduction in coliform bacteria were observed. Lead and zinc removal was considerable at 73 and 85%, respectively. The field has been reconstructed and recently put in operation again; the first analyses indicate a start-up of the purification process.

In general, maintenance of horizontal flow-through fields is relatively simple and the purification process is not easily affected by loading fluctuations or overloading. Infiltration fields need more careful maintenance, whereas overloading conditions should be avoided.

The construction costs of wetland systems with a vertical or horizontal flow direction are approximately Dfl. 50 - 65 and Dfl. 30 per population equivalent (p.e., calculated for the original raw wastewater) respectively. The annual costs amount Dfl. 5 - 7 and Dfl. 4.50 per p.e., respectively. Costs of tertiary treatment by chemical methods are comparable with regard to investment and high for annual operation (ca. Dfl 40 and Dfl. 10 per p.e., respectively).

A bulrush-planted horizontal flow-through field for treatment of the Zeewolde village purification plant effluent is now under construction.

Conclusions

- Artificial wetlands are capable to polish recreational and municipal wastewater without the addition of chemicals (therefore no secondary pollution) and virtually without energy consumption.
- The present effluent quality is generally far better than the minimum quality to be met according to discharge regulations. It does not yet meet standards as laid down in eutrophication abatement programs nor swimming-water standards. However, laboratory scale experimental results indicate that further elimination is possible.
- Construction costs for artificial wetlands are comparable with those for tertiary treatment facilities employing chemical methods; annual costs are considerably lower for wetlands, especially for horizontal flow-through purification fields.

References

1. J. de Jong et al.: "The purification of sewage with the aid of ponds containing bulrushes or reeds in The Netherlands". R.IJ.P.-Rapport 1977 - 7 bbw.
2. R.W. Greiner & J. de Jong: "The use of marsh plants for the treatment of wastewater in areas designated for recreation and tourism". Flevobericht no. 225 (1984).

Table. Pollutant elimination data for various tertiary treatment systems

System	P-tot (gP/m^3) influent	P-tot (gP/m^3) effluent	N-kj (g/m^3) influent	N-kj (g/m^3) effluent	coliforms (MPN/ml) influent	coliforms (MPN/ml) effluent
Columns (1):						
filter 1	15.4	0.9	10.8	1.2	3 620	145
filter 2	15.4	4.6	10.8	1.0	3 620	18
filter 3	15.4	9.7	10.8	0.4	3 620	25
Lelystad field(2)	16.3	7.8	3.0	1.5	300	50
Almere field(3)	8.9	6.0	23	13	81 000	8100
Elburg field(4)	3.1	1.7	38	33	6 240	23

Table (contd.).

System	COD (g/m^3) influent	COD (g/m^3) effluent	BOD (g/m^3) influent	BOD (g/m^3) effluent
Columns(1):				
filter 1	47.2	32.1		
filter 2	47.2	26.0		
filter 3	47.2	27.4		
Lelystad field(2)			4.6	2.6
Almere field(3)	73	41	15	4
Elburg field(4)	71	50	15	7

(1) Open air infiltration columns, planted with Festuca arundinacea. Column length 0.6 m. Mean loading 0.021 m/d. Filter 1: clay (35% lutum); filter 2: fine sand (U=224); filter 3: coarse sand (U=64)

(2) Experimental infiltration field, planted with Festuca arundinacea. Drain depth 0.8 m. Mean loading 0.025 m/d.

(3) Temporary infiltration field, unplanted. Drain depth 0.8 m. Mean loading 0.037 m/d.

(4) Horizontal flow-through field, planted with Phragmites communis. Mean loading 0.15 m/d at 1.0 m water depth (optimum water depth has now been established as 0.5 m, corresponding to 0.08 m/d loading).