Measures for Purification of the Leachate from “Renseanlæg Damhusåen” into Copenhagen Waters, to meet the NPO-plan

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Measures to reduce the leaching of organic material and N-compounds from the land area at "Renseanlæg Damhusåen" are compared and discussed. Suggested measures are either total leachate collection followed by biological treatment, or selected leachate collection and treatment followed by distribution of "high-N" water for domestic use other than drinking. The latter solution will, if generally used, protect groundwater resources as well as marine life.

Background

The sewage plant "Renseanlæg Damhusåen" has been on the Copenhagen waterfront since 1930, giving primary treatment to a major part of the Copenhagen waste water. Today the effluent is forwarded to "Lynetten" for final treatment. Digested primary sludge from the sedimentation basins has been disposed of in sludge beds situated on the sewage plant area. Other parts of the area has been used for landfill. The main waste deposits over the years are shown in fig. 1.

Heavily coloured leachate from the area to the coastal waters caused in 1988 the environmental authorities to request that the leachate should be collected, and the contaminants should be identified, quantified and reduced, to meet the environmental standards.

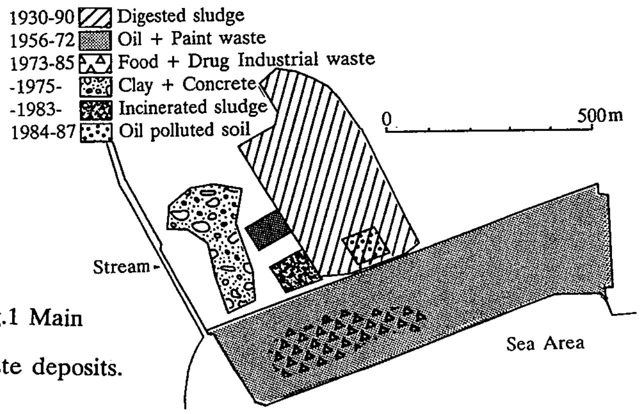

Fig.1 Main waste deposits.

The Danish NPO-plan of 1987, designed to protect the marine environment, has the following goals:

1. All waste water should be treated, to remove organics, N and P, before it is discharged to the ocean.
2. The N-load on the ocean from Denmark shall be reduced by 50% and the P-load by 80%.

The resulting demands on the danish sewage plants serving more than 5.000 person equivalents (PE) are as shown in table 1.

TABLE 1

Effluent demands on municipal sewage plants > 5000 PE

Nitrogen (N)	8 mg/l
Phosphorous (P)	1,5 mg/l
Organic mat.*)(COD)	25 mg/l

*)Demand is 15 mg/l BOD_5
This is ~ 25 mg/l COD

TABLE 2

Pollutants in leachate and ground water

N-compounds:	100-400 mg N/l
P-compounds:	0,4-2,3 mg P/l
Organics:	200-500 mg COD/l
Metals:	~ as drinking water.
Toxic compounds:	< LC_{50}.
Phenolic compounds:	< giving taste to fish.

The main results of analyses on groundwater and leachate are shown in table 2. Table 1 and 2 indicate that the heavy pollutants in the leachate and groundwater are *organic material*, here measured as chemical oxygen demand (COD) and *nitrogen compounds* (N). The metal content of the soil is high, but the pH of the soil is also high, thus metal leaching is avoided, so far, and the metals in the watersamples are generally close to drinking water standards.

Hydrogeological studies show, that the ground water in the area runs in 3-4 aquifers. The top aquifers give 10.000 m^3/year, the main bottom aquifer around 120.000 m^3/year. The aquifers seems to be cross connected in the north-west part of the area, leaching mainly to the stream and partly to the ocean, giving a groundwater flow and pollution pattern as illustrated in fig 2.

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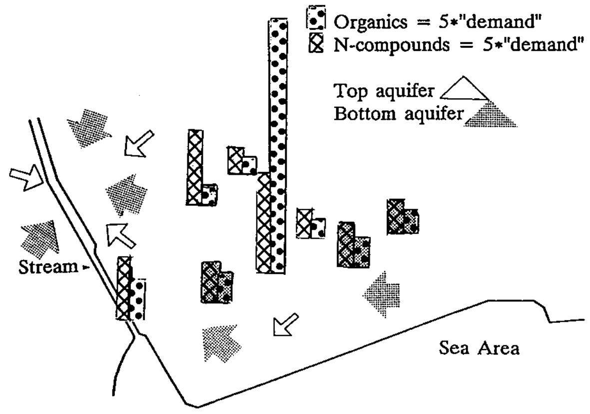

Fig.2 Ground water flow and pollution pattern.

Fig.3 Coastline along the Sound.

The waterfront is part of the coastline along the Sound (fig.3). Mass balances for the Sound for 1987 show that more than 30% of the N and about 15 % of the P discharge from Denmark come from streams and diffuse coastal leaching (Hovedstadsrådet 1990), while 75% of the N and 17% of the P from Sweden are diffuse discharges. Similar patterns, where a main part of the N-discharge comes from rivers and land areas, have been reported for neighbouring Kattegat and the Baltic (Rosenberg et al. 1990). Rosenberg points out that for Kattegat as a whole, a 50% reduction of N from local sources will result in about 20% reduction in the algal spring bloom (Rydberg et al 1989) and that this 50% reduction is the minimum requirement to subtantially improve the biological conditions in the Kattegat and Sound area, so that oxygen deficiancy can be avoided.

The fact that so much nitrogen comes from diffuse sources means, that the goal of the NPO-plan cannot be achieved by the new sewage plant demands alone. The diffuse loads will have to be reduced, and in particular the diffuse N-loads.

1. Suggested measures for *leachate collection and treatment*

Comparing tables 1 and 2 and fig. 2 it is obvious that the leachate and groundwater at "Renseanlæg Damhusåen" is N and COD polluted. A suggested measure is that all the water from both aquifers is collected in *drains along the stream and waterfront*, and then submitted to biological COD and N removal. This treatment will require aerobe and anaerobe basins, with a total volume of 550 m^3. The marginal cost will be around 1 million DKK or 25 million ¥, (Behrens & Østerby 1990).

The amount of drainwater which needs to be treated, if this measure is undertaken, amounts to 130.000 m^3/year, equivalent to 1.800 PE. Comparing with table 1 one might argue that this amount of water does not require treatment, being less than the given limit of 5.000 PE. The collected drainwater should however be regarded as part of the "Lynetten-Damhusåen" treatment plant, which serves about 2000.000 PE, so the argument lacks credability; once the drainwater is collected, it has to be treated to meet the demands of table 1. Launching of the collected drainwater into the effluent going to "Lynetten " is therefore considered. This will require the same tank capacity for COD and N removal, but the extra cost for a combined treatment there, might be slightly less than for the separate treatment.

A "Constructed Wetland" is an economical option. Comparing marginal cost of N-removal by variuos means (Fleischer et al. 1989), it is found that the cost for N-removal through wetlands is only a few per cent of the cost in municipal wastewater treatment plants. Requiered area will be about half of the oil/paint/food/drug polluted area closest to the coast in fig.1, and COD removal will be achieved at the same time (Behrens & Østerby 1990).

2. Suggested measure for *selected leachate treatment*

Fig.2 shows that the highest COD and N are in the top aquifer and in the middle of the indicated area. By *pumping in the top aquifer at the point of highest COD*, to an extent where the top aquifer flow is just reversed, it should be possible to collect the "very-high-COD", and at the same time reduce the neccessary amount of water, which has to be to treated, to a few per cent of the amount found necessary at pt.1 (above). In this smaller amount of water the main contaminant will be organic material, which is less expensive to remove in a sewage plant than nitrogen. This measure will therefore be the most economical, *provided* the N-leaching to the ocean can be prevented by other means.

3. Suggested measure for *utilizing "high-N" water*

The most **efficiant** N removal can be obtained if "high-N-low-COD" water is utilized. Fig.2 indicates that the "high-N" water runs in both aquifers, and comes partly from upland sources. Source-N tracing might lead to origins like forests, farming or crop production. The nitrogen now discharged to this part of the Copenhagen waters amounts to 5 tons N/year. This water could be distributed for crop production in water culture (Pettersen 1987). As long as high quality drinking water and commercial fertilizers are low cost and easily available for the same purpose, the benefit of this measure is not obvious to the crop producer.

Greater benefit can be obtained if the "high-N-low-COD " water is collected and *distributed for non-drinking purpose*. More than 80% of the drinking water normally distributed could be exchanged with lower quality water, for instance for flushing toilets, for laundry, car wash etc., and "high-N" water can take over these tasks. Collecting and distributing "high-N" water for domestic use other than drinking will serve the dual purpose of protecting the ocean and protect and save our groundwater rescources. The main part of the "non-drinking-water" will be disposed to the sewage system after use, which means that the "high-N" water will receive sewage plant treatment as indicated in table 1, before it finally reaches the ocean, and this gives better N-removal than the wetland solution (Schierup & Brix 1989).

Every year water wells in Denmark have to be closed due to high nitrate values. The common practice today is to close the "high-N" wells and make new ones, in unpolluted aquifers, which then are used untill the N-content again is too high. A better practice would be to *look for* aquifers which have *high N-values* and collect the main part of the domestic water there. If water is collected by "Separation pumping", (Andersen et al. 1989) it will in many cases be possible to draw "high-N" water from the top and "low-N" water from the bottom of the same well. The exploiting of our high quality drinking water resources will be reduced by the same amount which can be distributed of non-drinking-water.

Chosen measures

The results pictured in fig 2. has caused a better sludge treatment. The digested sludge is today properly dewatered by centrifugation, and the new sludge beds have drains from which any leachate can be collected and returned to the influent waste water. As an extra measure the sludge beds will be covered by heavy plastic under a layer of top soil where grass can grow.

A long term planning is to *eliminate* the disposal of digested sludge. The sludge cannot be spread on farmland because of its high Ni and Cr content. Pointsource tracing of the Ni+Cr polluters in Copenhagen opens the possibility for removing the metals for reuse. As the same analytical tool is used for many metals, this tracing will, if properly administred, lead to a general reduction of the sludge metal content. The sludge nutrients can be utilized on farmland, and the COD source is permanently stopped.

Measures for reducing the N-leaching has not yet been decided, and the demanded leachate collection not yet started. For the sake of our drinking water resources as well as the marine life, one can hope that the sewage plant and environmental authorities will promote a solution where "high-N" water is distributed for non-drinking-purpose.

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