LAQUA a project for improving the aquatic environment in the Baltic region.

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Background

There is a growing concern among the public for the environmental impact created by municipal solid waste (MSW) landfills. Several reports the last couple of years have focused on adversed health effects on aquatic organisms living close to landfills that may have been caused by heavily polluted leachate water. The quality of leachate is complex and contains numerous types of soluble organic, inorganic and bacteriological constituents and suspended solids. If not controlled, it can seep through landfills to pollute ground and surface water. It is therefore essential to create local treatment plants at the landfill site to avoid polluted leachate to affect the environment either directly or as a part of the effluent stream from sewage plants.

It is essential for the improvement of the environment of the Baltic Sea area to create contacts between companies in the Baltic region with knowledge of environmental technology. In the long run it is important that Swedish companies take an active part of the design and construction of new local plants for treatment of heavily polluted waste water from sewage as well as from landfills. The LAQUA project is a good example showing know-how transfer from Sweden to the Baltic region in this area. Thus a pilot plant for local treatment of leachate from a solid waste municipal landfill has been constructed in Siauliai, Lithuania using knowledge obtained from pilot plant studies in Kristianstad.

The established network, a result of the LAQUA-project, has also led to exchange of students between Lithuania and Sweden. Several Lithuanian students taken part of the exchange program between Siauliai University and Kristianstad University and have also spent some time at Lund University. Their time was shared between work on the project and a course in environmental monitoring as a part of know-how transfer of environmental technology.

The Pilot plant

To construct well working full-scale treatment plants well controlled tests are needed in laboratory scale, as well as in pilot plant scale. The increasing fear of adverse health effects of pollutants on the environment has made it necessary to study the fate of these compounds after treatment. The goal is to construct treatment systems that satisfactory reduces organic pollutants to a safe level in recipients. This project has been focused on how to reduce the concentrations of organic pollutants. This approach is different from previous projects that mainly have studied how different treatment systems act upon nitrogen and heavy metals. Several local, small and medium sized enterprises have made substantial contributions to the development of the treatment systems evaluated in the pilot plant. A scheme of the pilot plant in Kristianstad is presented in figure 1. The tested methods have been relative simple natural based treatment (e.g. soil and plant system and willow), as well as more technical demanding ones such as ozone oxidation or degradation based on Fenton's reagent. The raw leachate water is pumped to a pre treatment step, aeration - and sedimentation, and then distributed to the different treatment methods:

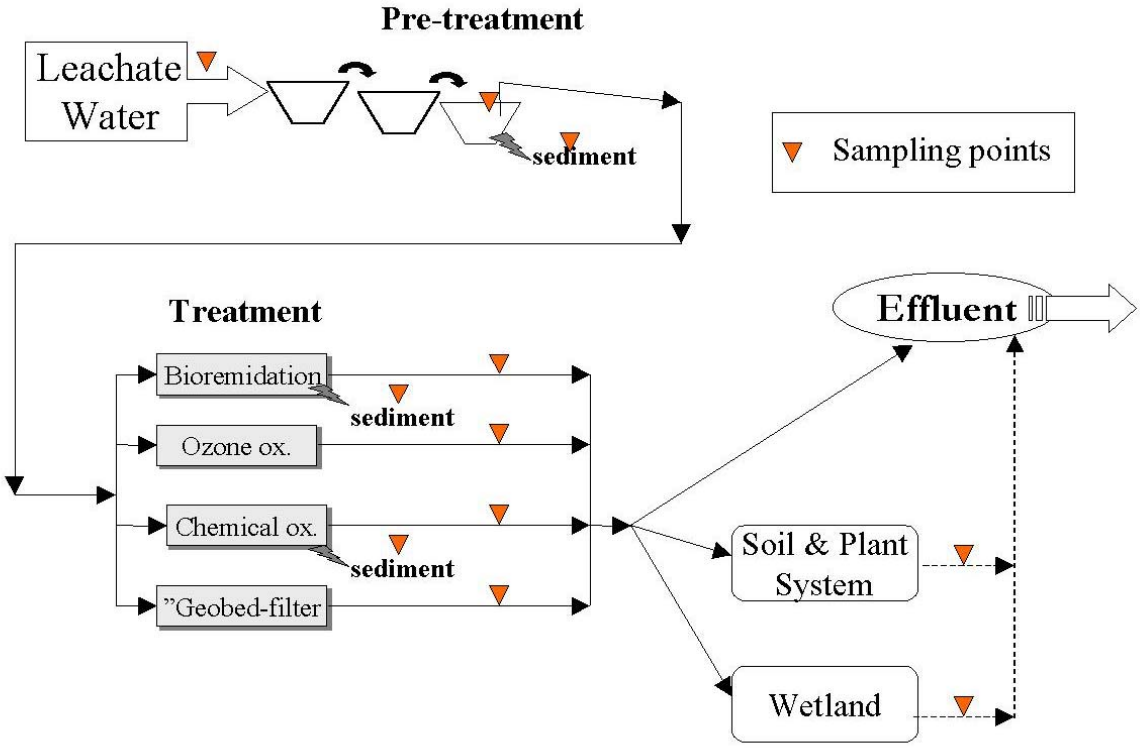

Figure The pilot plant in Kristianstad.

- **Bioremidation**, aerated tank with suspended carrier biofilm process.
- **Ozone oxidation**.
- **Chemical degradation** with Fenton's reagent.
- **Geobed-filter** with three different filters were tested, namely

    1. GeoO - Peat, leachate over-flushed.
    2. GeoCO - peat mixed with carbon containing ash, over-flushed.
    3. GeoU - Peat, leachate pressed in from under.

- **Wetland** with Phragmites growth
- **Soil and Plant system** with fast growing willow

The LAQUA-potocol

For accurate evaluation of the treatment methods it is crucial with accurate and precise analytical methods. Only then it is possible to design and construct proper treatment methods. In this project with emphazise on organic pollutants in leachate water the evaluation needs sophisticated analytical chemistry. Thus cooperation was established with the School of Engineering at Kristianstad University and the department of Analytical Chemistry at Lund University. Both departments have access to advanced analytical equipment and have great experience in environmental research. Leachate water from municipal solid waste landfills is a very complicated matrix and contains several hundreds of different chemical substances. In order to facilitate the evaluation process the LAQUA-protocol was established (figure 2). According to the protocol summary parameters such as for example pH, nitrogen, ammonium

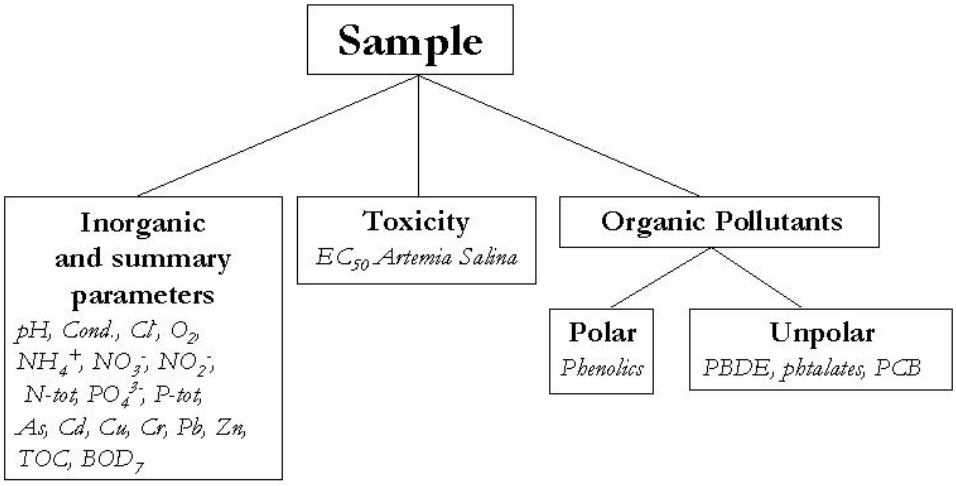

Figure 2 The LAQUA-protocol

and heavy metals were determined. The organic compounds were divided into two fractions and analysed with different methods according to their ability to be solved in water. The organic substances considered were phenolic substances, phthalates, PCBs and brominated flame retardants (PBDE). The toxicity of the leachate water was also tested before and after treatment using a small crustacean (*Artemia salina*). The organism was exposed to the leachate water and the toxic effect was measured as number of individuals immobilized.

Samples from the pilot plant were automatically collected before and after each treatment method by intermittent pumping into collection vessels several times a day. The samples were stored in refrigerator and samples were analyzed, according to the LAQUA protocol, once a week. This resulted in a good estimate of the average efficiency of each treatment method on a weekly basis.

Achieved results from the tests

The results obtained from the pilot-plant studies showed that different treatment methods were suitable, several of them giving high reducing effect. In figure 3 is shown an example of identified organic substances in the leachate. It is a polar chlorine containing phenol and a polybromated flame retardant belonging to the group of more unpolar substances. These substances varied in concentration between different treatment methods. The performed studies in pilot plant scale gave promising results as indicated in figure 4 and 5. In the figures the results are normalized in order to present the relative concentrations in percent after the individual treatment methods compared to the concentration in raw leachate set to 100%. Oxidation with ozone and Fenton´s reagent, reduced most of the investigated substances fairly well. However, also more natural based treatment methods showed good reduction towards the organic substances. The geobed filter with peat mixed with carbon containing ash was especially efficient. The toxicity after the different treatment steps was similar. However, a linear correlation was found between immobility and ammonia concentrations. Since none of the treatment methods efficiently removes ammonia, the ammonia concentrations at different occasions in the incoming leachate water therefore largely determines the biotest results.

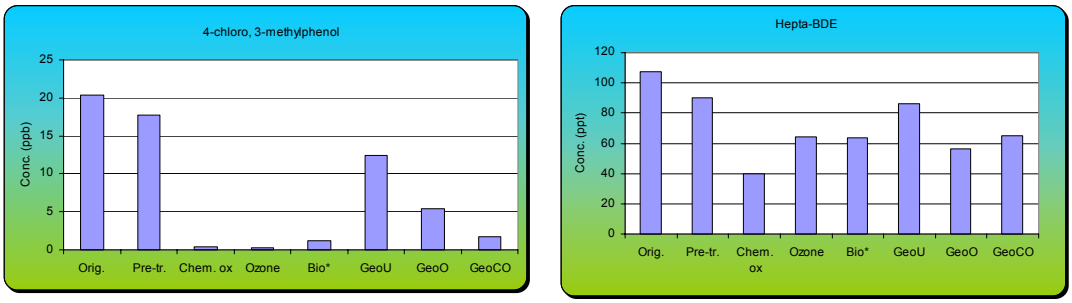

Figure3 Example of identified and quantified compounds

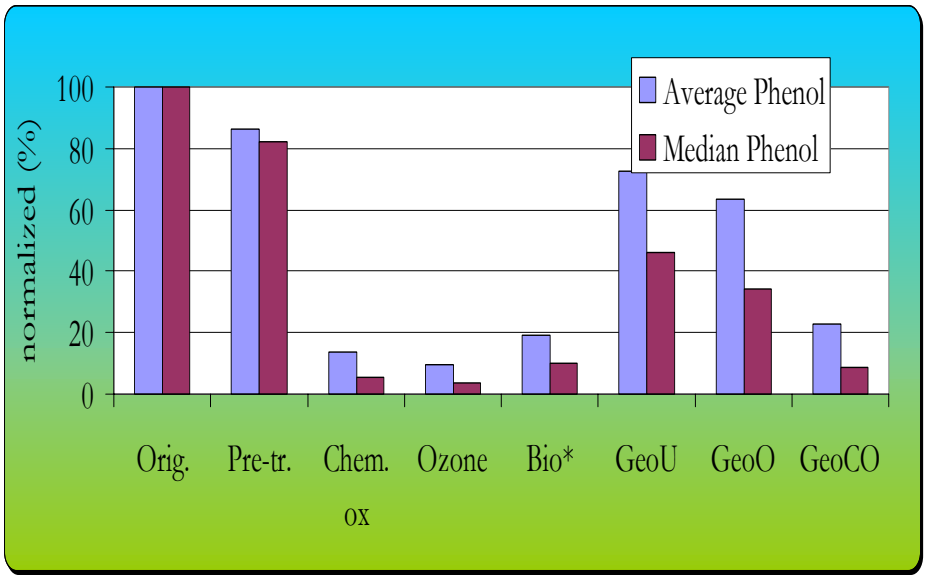

Figure 4 Normalized average and mean of the response of 9 different phenolic compounds after different sampling points

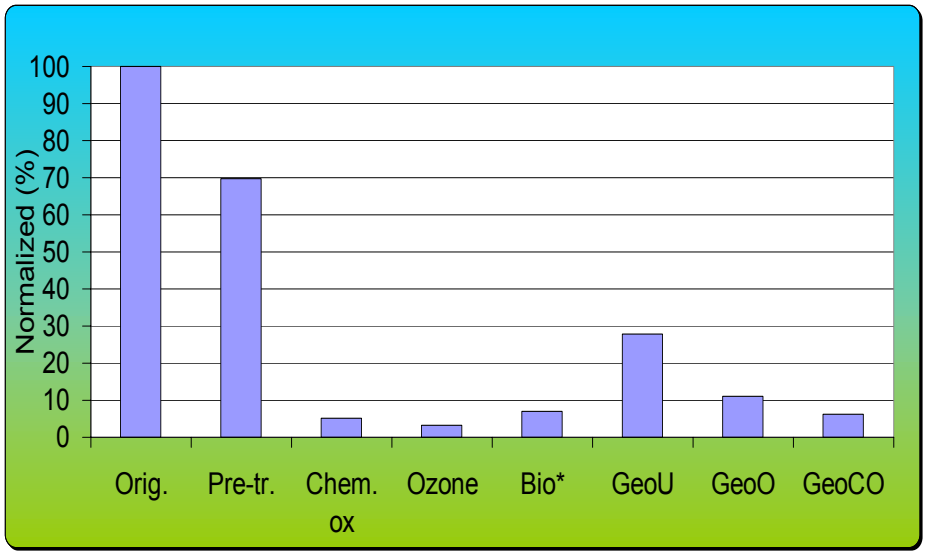

Figure 5 Normalized average and mean of the response of 6 different unpolar organic compounds after different sampling points.

Economy and future possibilities

The fact that geobed filter with peat and carbon containing ash, did not significantly differ from the more high-tech" treatments, as chemical oxidation, ozone oxidation and bio-reaction-tank, opens the possibilities of using such low cost treatment systems. This is promising with respect to the financial situation in e.g. Lithuania, the site for one of the partners in the project are located.

The newly built pilot plant in Siauliai is valuable as a demonstration facility, displaying the possibilities of local treatment of leachate from landfills. It can in the long run be an asset for the whole Baltic region for the future work in the area of environmental technology. It can also give opportunities for local enterprises to test treatment technology under relatively controlled conditions and with aid of competent personal. The pilot-plant in Siauliai is mainly constructed for testing natural based treatment method and as such suitable for the present technical and economical situation in the Baltic countries. Advantages with such methods are low energy consumption, low consumption of expensive chemicals and limited need of maintenance, and still capable of offering a sustainable treatment alternative.