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Research area: General aims

Environmental technology // Water

Key words:

Paper mill effluents, limit value, monitoring, duckweed growth inhibition test

TITLE:

Assessing the aqua-toxicological impact of paper mill wastewaters by means of the Lemna test, and identifying the causes of increased D_w values

Background/Problem area

At the request of the Federal Ministry for the Environment, the working group (WG) for the revision of Annex 28 Waste Water Ordinance looked for a test assessing the aquatic toxicity that could be included in the new Annex 28. In a project funded by the German Federal Environment Agency, 20 wastewater samples from 13 paper mills were subjected to the following tests: fish egg, daphnia, luminescent bacteria, algae, Lemna and umu tests. Data collected by the agency were examined as well. Based on these investigations, the duckweed growth inhibition test (Lemna test, results expressed as dilution factor D_w) was recommended for inclusion as a requirement in Annex 28 on the grounds of its adequate sensitivity and minimum cross-sensitivity.

D_w values were inconspicuous in the majority of samples, amounting to 1 or 2. However, there were isolated cases with measured D_w values of up to 8, and values of up to 24 were found in more recent data of the agency. These increased values occurred exclusively in paper recycling mills. Their exact causes or further attendant circumstances could not be clarified so far. Against this background, the WG for the revision of Annex 28 is currently unable to define a minimum requirement for the Lemna test to be included in the revised Annex 28. A specified limit value, however, is absolutely necessary for directly discharging paper mills to safely comply with the requirements of the Waste Water Ordinance.

Objectives/Research results

The main goal of this project is to identify the causes and influences of increased D_w values in biologically treated paper mill effluents. Moreover, the variation ranges of D_w were to be determined to propose a scientifically based, practically viable requirement for the new parameter to be included in the revised Annex 28.

A total of 15 paper mills were selected for a multiple Lemna test screening of fully biologically treated effluent samples, comprising 6 recovered paper (rp) mills with deinking line, 7 rp mills without deinking line and 2 virgin fibre processing mills. Two or three mills showing higher D_w values in their effluents will be investigated in detail, by detailed studies of either the effluent treatment plant and/or the papermaking process.

Approximately 100 effluent samples – biologically non-treated, anaerobic pre-treated and biologically fully treated – from 15 paper mills were subjected to the Lemna test. Biologically non-treated and anaerobic pre-treated samples were taken in six paper mills. All non-treated samples (effluent pre-clarifier) exhibit D_w values between 6 and 24, except one sample with 48 and one with ≤ 2. This partly increased Lemna toxicity in biologically non-treated effluents is decreased down to D_w = 6 or ≤ 2 in all anaerobic pre-treated samples. So, anaerobic treatment leads to a significant reduction of Lemna toxicity. The nutrient dosing before anaerobic treatment do not influence the test results of anaerobic treated samples, because the concentration of N and P in the samples is much lower compared to the nutrient solution which is applied during the test procedure.

The final effluent samples of all 7 rp mills without deinking, of 3 rp mills with deinking and of the 2 virgin fibre processing mills show no Lemna toxicity, which is represented by D_w values of 6 or ≤ 2. Growth inhibition was detected in final effluent samples of 3 rp mills with deinking which produce graphic papers. Besides low D_w values of ≤ 2 and 6 higher values of 12, 24 or even > 48 were detected in a few samples. Due to the comprehensive screening of 15 paper mills the origin of higher D_w values could be pinpointed to the 2nd biological treatment stage, which is a activated sludge process in all 3 mills. Two of them were selected for detailed investigation, which means a round-a-clock sampling over 3 to 4 days (40 to 50 samples in each mill) at all treatment stages which was completed by investigation of additives (e. g. defoamers, flocculation agents etc.). The results of the detailed investigation will be subjected to a comparison of operating and design parameters together with corresponding data of mill with no increased D_w in final effluents. If data base is sufficient, a multiple correlation analysis will be performed to identify the causes.

Application/Economic benefits

The inclusion of an aqua-toxicological parameter in Annex 28 of the Waste Water Ordinance is a novelty for the paper, paperboard and board manufacturing industry. It is therefore all the more important to define and stipulate a target value for D_w that can be complied with by means of state-of-the-art technology. This will ensure the safe compliance of directly discharging paper mills with the minimum requirements of the Ordinance. In view of the all-pervasive economic pressure on the paper sector, it is imperative to avoid any costs incurred by the non-compliance with limit values, e.g. penalties for multiple transgressions according to the four-out-of-five rule.

Period of time: 01.05.2012 – 31.08.2014

Remarks

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