Granular activated carbon for the elimination of organic micropollutants form municipal wastewater

Municipal wastewater treatment plants (WWTPs) are a relevant source for organic micropollutants (OMPs) in surface water. Within this PhD thesis, lab-, pilot-, and full-scale filters with different granular activated carbons (GACs) and effluents of WWTPs were operated to investigate the elimination of OMPs (carbamezepine, diclofenac and sulfamethoxazole) using GAC.

The proportion of dissolved organic carbon (DOC) of three WWTPs of different size and discharge structure was analyzed using liquid chromatography - organic carbon detection (LC-OCD) and adsorption analysis according to SONTHEIMER. Rapid small scale column tests (RSSCTs) were carried out to test the suitability of different conventional characteristic numbers such as iodine number, methylene blue titer, Brunauer, Emmett and Teller (BET) surface to predict breakthrough curves of pilot scale tests. Pilot scale tests were operated to quantify the abrasion of various GAC due to air scour; and GAC-filters in lab- and full-scale were operated to determine the effect of the total suspended solids (TSSs), the empty bed contact time (EBCT) and the operation in parallel mode on bed volumes.

Using LC-OCD and adsorption analysis the study showed that the ratio of the fractions within the DOC of WWTP effluents is constant in first approximation. Knowing that the fractions with high adsorbability are most relevant for competitive adsorption with OMPs, WWTP effluents with high DOC concentrations lead to a faster exhaustion of GAC. Conventional characteristic numbers proved to be unsuitable to predict the adsorption capacity of GAC for the removal of OMPs from WWTP effluent. On the contrary, the density of GAC was identified as one possible parameter to describe the adsorption capacity of GAC. The study showed that RSSCTs can predict pilot scale GAC-filters breakthrough curves qualitatively concerning their shape and concerning the order of substances breaking through. The determination when a specific breakthrough criterion was reached (i. e. $c/c_0 = 0.2$) was not possible using RSSCTs. Furthermore, higher EBCT proved to be more relevant for the elimination of DOC the lower the quality of the GAC was. Air scour of pilot GAC-filters for 2 min/d (100 m/h) with six different GACs caused abrasion losses between 0.1 and 1.5 mass-%/a. These losses are negligible compared to losses during GAC reactivation of typically 10 %. For the DOC and the OMPs carbamezepine and diclofenac no relevant influence of the TSS in the filters influent on their elimination could be found. Duplicating the EBCT (~15 to 30 min) resulted in an extension of operating time between 57 and 114 % until the breakthrough criteria was reached. Operating six GAC-filters in parallel mode led to an extension in operating time of 82 % (mean) compared to a single GAC-filter.

The elimination of OMPs from WWTP effluents using parallel operated GAC-filters with a sufficient EBCT is advantageous. Whereas the operation of GAC-filters is usually easy, the abrasion of GAC due to backwash is negligible and the reduction of adsorption capacity due to high TSS concentration in the inlet was found to be irrelevant in this study. The selection and the quality control of activated carbon is still a challenge.

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