Abstract

The behaviour of copper and zinc in wastewater treatment systems has been studied in a municipal sewage plant operating with carbon oxidation, nitrification/denitrification and chemical removal of phosphorous. Using activated sludge differing in origin and composition as biosorbing agent the biosorption of heavy metals was characterised comparatively. The mechanisms of accumulation were described and the role of exo-polysaccharids for copper biosorption has been studied.

A total mass balance of copper and zinc was achieved for the municipal sewage plant Emden-Larrelt including all internal fluxes. The recovery rates for the whole system were between 90 % (Cu) and 106 % (Zn). Beside typical zinc loads in the influent (343 µg/l) the copper loading (249 µg/l) was unusual high for German wastewater. 86 % (Cu) rsp. 96 % (Zn) of the incoming metals were removed within the residual sewage sludge, 4 % (Cu) rsp. 10 % (Zn) remaining in the effluent and were discharged in the river Ems. The removal of heavy metals was depending on metal species and operating unit. For primary sedimentation the removal of zinc predominated, for the activated sludge process the removal of copper prevailed. In the anaerobic treatment there was an equal removal efficiency of both metals. The removal efficiency of the activated sludge was tremendously high (bioconcentrationfactor (BCF) 14,000 l/kg (Zn) rsp. 45,000 l/kg (Cu)) due to the high sludge age of the aerobic treatment.

Short-term adsorption of cadmium and copper by activated sludges differing in origin and composition resulted in maximum adsorption capacities between 0.33 and 1.38 mol/kg dw. corresponding to a maximum metal uptake between 3.7 - 8,8 % (w/w dw.). The accumulation optimas were achieved by BCF-maxima of 15,800 l/kg rsp. 27,7000 l/kg and effluent concentrations up to 2.1 mg/l. Adsorption capacity and behaviour were determined by specific sludge characteristics. A laboratory sludge showed a 2.2-fold higher accumulation capacity than the municipal sludge, which is in good correspondence to the 2.4-fold higher content of exopolysaccharids. There was an excellent agreement between the cadmium adsorption by the municipal sludge and the equation of Freundlich. However, the accumulation of cadmium and copper by laboratory sludge could neither be described by the models of Langmuir, BET nor by the equation of Freundlich sufficiently. Copper was mainly bound to exopolysaccharids of the activated sludge by cation exchange and complexation, again varying with specific sludge characteristics.

The comparison of sequential extractions for copper spiked sludges of different origin indicated a sludge specific loading of binding sites, resulting in different amounts of phase-specific bounded copper. In laboratory sludge copper was predominantly bound as exchangeable fraction (up to 80 %), while in municipal sludge there was a shift to more stable binding forms. At lower concentrations copper was predominately bound as exchangeable cations and also to the fraction of weak acid groups, followed by fractions bound to strong acid and to sulfidic groups. For highly copper contaminated sludges a tendency of binding to sites with low binding strength especially the ex-changeable cations was observed.