

Degradation of pulp and paper-mill effluent by thermophilic micro-organisms using batch systems

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Abstract

Paper manufacturers produce large quantities of wastewater, which can have deleterious effects on the receiving waters; therefore there is a need to find a treatment process which can minimize these effects considerably. A suitable aerobic biological treatment process that can be used with great success involves the use of thermophilic micro-organisms. This technology has many advantages, which include rapid biodegradation rates, low sludge yields, and excellent process stability. Batch studies were conducted on two types of activated sludge (pulp-mill sludge and sewage sludge) at 40°C, 50°C and 60°C to determine the feasibility of thermophilic degradation of bleach pulp-mill effluent in terms of increasing aeration, biomass concentration and nutrient addition. Preliminary batch studies had confirmed the feasibility of thermophilic degradation, as COD removal achieved with the pulp-mill sludge was 55.2%, 37.6% and 31.4% at 40°C, 50°C and 60°C after 5d, respectively while the COD removal with sewage sludge was 50.2%, 37.3% and 27% under the same conditions. Degradation was further improved, using the same inocula in subsequent experiments and this confirmed that an acclimatization period is required, prior to degrading the bleach pulp-mill effluent. Thermophilic degradation of pulp-mill effluent occurs at temperatures of up to 60°C; however, once final degradation is obtained, it decreases significantly as temperature increases.

Keywords: thermophilic micro-organisms, pulp and paper mill effluent, degradation, batch systems

Introduction

There has been considerable concern about the effect of chlorinated organic matter in pulp-mill effluents on the environment. Some members of this family are known to be toxic, mutagenic, persistent, and bioaccumulating, and are thought to cause numerous harmful disturbances in biological systems. The paper manufacturer generates significant quantities of wastewater, as high as 60 m³/t of paper produced. The raw wastewaters from paper and board mills can be potentially very polluting. Indeed, a recent survey within the UK industry has found that their chemical oxygen demand (COD) can be as high as 11 000 mg/l Thompson et al. (2001).

The paper and board industry is actively investigating closed water systems in the production line resulting in the so-called zero discharge paper-mills. Operation of these zero-discharge mills was shown to be possible in the board industry but requires an in-line treatment system to prevent bad odours in the end-products (Vogelaar et al., 2000). A sequenced anaerobic-aerobic treatment system was considered to be the most cost-effective option for in-line treatment of process water from a paper-mill using recycled wastepaper as a raw material. A disadvantage of their set-up is the required cooling of the process water to mesophilic conditions prior to biological treatment and subsequent heating afterwards (LaPara and Alleman, 1999).

The first investigation of thermophilic aerobic biological treatment, focusing on high-temperature board-mill wastewater was conducted in 1953. Biological oxygen demand (BOD) removal at thermophilic temperatures was slightly less than analogous mesophilic reactors after 24 h. Although the initial degradation rates were highest at 50°C, poor bacterial settling limited final effluent BOD quality. The addition of a coagulant

(alum) increased BOD removal (LaPara and Alleman, 1999) by thermophilic systems to 95%.

Pulp and paper industries commonly discharge a waste stream that is relatively hot (50°C) compared to other industrial wastewaters. Different investigators have attempted to treat pulp and paper wastewaters at the thermophilic temperature at which they are discharged in an attempt to reduce energy costs for treatment. Rudolfs and Amberg (1953) investigated the biological treatment for white water discharged from the board mills at temperatures up to 50°C. BOD removal in excess of 90% was possible only with the addition of chemical coagulant (alum). Gehm (1956) successfully treated kraft-mill influent for three months at temperatures from 50°C to 53°C and a pH of 9.5 to 9.8. Compared with treatment at low temperatures (30°C to 38°C), similar BOD removals were observed. Dissolved oxygen concentration was non-detectable, but apparently had no adverse effect on process performance. Settling characteristics were "excellent" with sustainable mixed liquor solids concentration up to 3 000 mg/l. Carpenter et al. (1968) compared the aerobic treatment of pulp and paper wastewater at temperatures of 26°C, 37°C, 42°C, 47°C and 52°C. Effluent BOD increased at higher temperatures from a maximum removal percentage of 80.5% (37°C) to a low of 37% (52°C). A low sludge volume index (SVI) was measured at thermophilic temperatures (47°C and 52°C) indicative of dispersed microbial growth.

Pertulla et al. (1991) treated sulphite mill condensates containing acetate and ammonia at 65°C in packed-bed bioreactors, attempting to save energy by decreasing cooling requirements before treatment and reheating prior recycling the treated effluent. Extensive growth was observed, even to the point of clogging an activated carbon packing media. Overall, acetate removal was similar to that of mesophilic processes. Rintala and Lepisto (1993) treated bleached kraft-mill effluent by both anaerobic-aerobic and aerobic bench-scale processes at 55°C. Both systems studied provided levels of COD and adsorbable organic halogen (AOX) removal similar to analogous mesophilic systems.

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