Recent developments in carbon pollution abatement

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Biologically aerated filters are compact treatment processes, which combine filtration and aerobic/anoxic/anaerobic treatment using fixed-film biodegradation. They consist of an immersed biological filter operating either in downflow or upflow hydraulic condition. They are used to remove TSS, COD, BOD$_5$, NH$_4$-N and NO$_3$-N, either as a secondary or tertiary stage. Their filtering properties can also be used to remove phosphorus. The filter medium is periodically backwashed to remove suspended solids retained during the filtering interval and excess biomass produced within the filter bed.

The development of biologically aerated filters (BAFs) has spanned the last 20 years. This article presents the latest innovation in the application of BAFs for carbonaceous pollution abatement.

Nitrogen abatement using an upflow BAF

Conventional activated sludge treatment degrades the nitrogen through the biological activity in the activated sludge. This technology is well known and mastered. Its main drawbacks are the large footprint required for treatment and lack of elasticity of the treatment toward concentrations above the design loading.

The BAF technology is a hybrid technology that builds on the benefits of both conventional activated sludge biological treatment and of fixed-film biotreatment and subsequent filtration. This is achieved through an upflow BAF using a floating polystyrene media comprised of individual spherical beads.

The beads are approximately the same size, according to uniformity specification. The diameter of the beads originally used for nitrogen abatement is 3.6 mm, which provides a large specific area (>1,200 m$^2$/m$^3$ or 400 ft$^2$/ft$^3$) for biomass attachment and retention of suspended solids. With these small beads, the biofilm surface area and subsequent volumetric loading capacities and removal efficiency are very high.

There are close to 150 references for this technology around the world (US, France, Germany, England, Italy, Spain, etc.) for nitrogen removal in municipal wastewater applications. The first two Canadian Biostyr$^\text{®}$ biofiltration units are currently in construction (Kingston WWTP in Ontario and Boisbriand WWTP in Québec).

Kingston upflow biofiltration unit

In 2008, the Kingston Ravensview WPCP will commission its new biofiltration facility. Wastewater treated by the Biostyr system will first undergo primary treatment, including a 12 to 15 mm screening, and primary clarification. The biofilters are designed to achieve BOD and TSS removal, as well as partial nitrification of the incoming nitrogenous compounds.

The main design parameters of the system are described in Table 1 and the effluent requirements are shown in Table 2.

In order to achieve these goals, a set of 11 Biostyr cells, each using a surface of 147 m$^2$ was provided. The height of each filter bed is 3.5 m. One cell is considered to be out of operation at all times, meaning one cell could be in a permanent stand-by mode. When one of the remaining 10 filters is in backwash mode, the system is thus operating at N - 2 filters, so nine filters are in filtration mode.

Carbon pollution removal using an upflow BAF

Over the last five years, further research and development of this technology has led to its use as a cost-effective solution for compact wastewater plants for carbonaceous pollution. Due to the high solids and BOD content of the primary effluent, upflow BAFs for carbon removal do require a larger floating media to maintain a low head loss and to store the increased sludge production.

Consequently, the diameter of the floating media has been increased for carbon abatement applications. Moreover, the media should be small enough to ensure the filtration effect of the media bed. The floating media diameter is, therefore, selected for each project, optimizing each specific situation.

Also, in order to reduce the solids and BOD load reaching the BAF, chemically enhanced primary treatment (CEPT) often precedes the biofiltration step. Indeed, effective primary treatment is needed to meet the effluent guarantee without over-sizing the BAF units. The purpose of the clarifier is to remove as much particulate matter as possible to keep the volumetric TSS load below 2.0 kg/m$^3$/d. This loading value typically ensures a backwash interval above 24 hours when the COD
load does not exceed 7 kg/m³/d.

The CEPT most often used with this type of upflow BAF is a lamella plate settler (Multiflo®) or a ballasted flocculation process (Actiflo®), the latter providing the most compact primary treatment solution.

As in other BAF applications, backwashes are performed on a daily basis to remove excess biomass and filtered TSS. Counter-current flushes, separated by air scour sequences, are applied to expand and clean the filter bed media. The procedure lasts approximately 20 minutes.

Backwash water rinse velocity varies according to the media size. Waste backwash is temporarily stored in a surge tank or mud well. From there, the waste backwash is either treated separately or blended with the raw water before entering the primary clarifier units.

Several plants in France and other countries have already been upgraded to meet new, more stringent carbon discharge limits. Based on the combination of CEPT and BAF, these new plants achieve carbon removal down to 25 mg/L both for BOD and TSS.

Givors Wastewater Treatment Plant

The Givors wastewater treatment plant in the south of France has a 90,000 population equivalent. To achieve this, the WWTP required the installation of five units of 42 m² of footprint. Figures 2 and 3 show the BOD₅ and TSS concentrations from the plant during the first five months of operation in 2005.

The BOD₅ and TSS discharge limits were maintained even though there were large variations in the influent BOD and TSS. The upflow BAF process treats the effluent of a CEPT, using lamella plates to minimize the footprint of the plant.

Conclusions

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Figure 2. BOD\textsubscript{5} concentration during the first five months of the BAF installation

Figure 3. TSS concentration during the first five months of the BAF installation

Efforts have made it possible to extend the range of operation of the first generation of upflow BAFs to now include carbon pollution abatement.

The first full-scale installations using this novel application have been successfully built and commissioned in Europe. Several plants in France and other countries have already been upgraded to meet new, more stringent carbon discharge limits. Based on the combination of chemically enhanced primary treatment and biologically aerated filters, these new plants achieve carbon removal down to 25 mg/L for both BOD\textsubscript{5} and TSS.

As existing municipal WWTPs are upgraded and smaller communities design their new WWTPs, the combination of CEPT and BAF technology will prove a cost-effective and efficient method of reaching the more stringent discharge limits.

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