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SURVEY ON THE OCCURRENCE OF FILAMENTOUS ORGANISMS IN MUNICIPAL WASTEWATER TREATMENT PLANTS RELATED TO THEIR OPERATING CONDITIONS

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INTRODUCTION

A common problem associated with biological treatment plants is the excessive growth of filamentous organisms in the activated mass which causes a deterioration in the settleability of the mixed liquor with a reduction in plant treatment efficiency, and a nuisance presence of foams on aeration tanks or secondary settler surfaces. An important aspect in the control of filaments depends on understanding the specific conditions that provide an advantage to a particular filamentous microorganism. Consequently, their identification is an important part of any bulking and foaming study.

Withthisaima field survey has been conducted at about 40 full-scale municipal treatment plants in Italy (Latium region in particular), of different sizes. Attention is given to the correlation between the presence of particular types of filamentous microorganisms and process parameters such as organic loading (F/M ratio), dissolved oxygen (DO) concentration in aeration tanks, influent characteristics (such as readily biodegradable COD fraction), biological reactors type and aeration system. The observations were undertaken in parallel with measurements of the Sludge Volume Index (SVI), in order to verify a correlation between the presence of filamentous microorganisms and the sludge settleability characteristics.

MATERIALS AND METHODS

The microscopic investigation of the activated sludge was carried out by collecting small amounts of mixed liquor from the aeration tanks and of foams, if present, and testing them as soon as possible. The identification procedure includes, at first, a phase contrast microscopic observation of the wet mount sludge sample, and a following examination of the stained sample, according to the procedures included in the manuals of Eikelboom & van Buijsen (1981), and Jenkins et al. (1984).

Tests in order to measure the oxygen utilization rate (OUR., mg O_2/1/h) were undertaken in situ on batches of activated sludges collected at the head end of the aeration basin where feed sewage and recycle sludge enter. The specific OUR (SPOUR), calculated as OUR/VSS ratio (mg O_2/gVSS/h), was then determined in order to obtain biomass activity information comparable with that of other activated sludges coming from different treatment plants.

Analyses of mixed liquor suspended solids and their volatile fractions (MLSS and MLVSS), together with influent Chemical Oxygen Demand (COD) were carried out according to the procedures outlined in Standard Methods (A.P.H.A., 1985). For some sewage treatment plants, the determination of the

readily biodegradable portion of influent wastewater COD was performed according to the aerobic batch reactor method (Ekama et al., 1986), while for most wastewaters the physical - chemical method was used (Mamais et al., 1993).

RESULTS AND DISCUSSION

Samples collected at 39 wastewater treatment plants have been microscopically examined in order to point out the severity of the biological phenomena of bulking and foaming, the types of filamentous microorganisms present and their impact on the biological floc structure.

The results about the abundance of filamentous microorganisms, rated on a scale from 0 (none) to 6 (excessive) according to the scoring system defined in detail in Jenkins et al. (1984), are reported in Fig. 1. For some plants, the microscopic observations have been undertaken both in winter and in summer,not finding appreciable differences due to the changed temperature.

Fig. 1 shows that most of the activated sludges examined fall within the abundance category 4 (46%) and 5 (30%) ("very common" presence and "abundant" presence of filaments, respectively) with consequent poor settling characteristics. In this regard, we must notice that the parameter SVI, commonly adopted for assessing the settleability of activated sludges, was not significant, so proving the criticisms attracted by this parameter (Ekama & Marais, 1984). As a matter of fact the MLSS concentration has a considerable influence on the SVI measurement, since high values of the former imply low values of the latter; however, even adopting the alternative test by diluted sludge (DSVI), no significant advantage could be obtained. Practically, from the 30 minute settled sludge volumes, the settlement difficulties of the sludges were manifest, almost suggesting a higher significance of this measure, at least under the same concentrations.

The identification of filamentous microorganisms, responsible for bulking and for foam occurrence on the aeration basin and settler surfaces, represents one of the major aims of the present experimental survey. The results obtained for the dominant microorganisms(scored "very common" or greater) and for the secondary (belonging to the immediately lower categories) are reported in Fig. 2, in which the occurrence of each filamentous organism, expressed as percentage of the microscopic observations undertaken (100 in all) are also given. The latter correspond, for some of the treatment plants considered, to different samples collected at intervals during a long period of time.

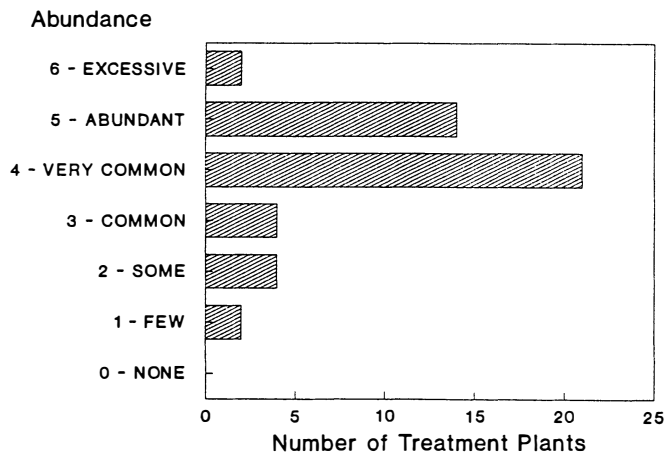

Fig. 1. Abundance rating of filamentous organisms as a whole, for the treatment plants considered (some examined both in winter and in summer)

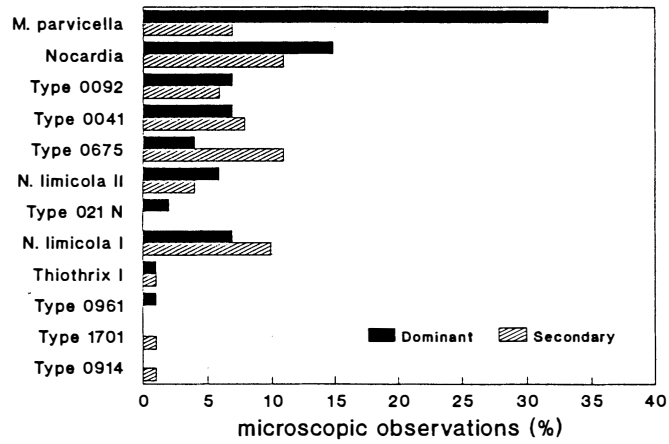

Fig. 2. Percentage of bulking sludges where each filamentous organism was observed as dominant and/or secondary

From the survey carried out in the region investigated, it is possible to state that at least five types among the dominant filamentous microorganisms, mainly responsible for the bulking events observed (*Microthrix parvicella* (32%), *Nocardia spp.* (15%), *type 0092* (7%), *type 0041* (7%), *type 0675* (4%)), belong to the low F/M filaments group. Such a result is in agreement with the organic loading rates of the plants investigated which, for the most part, operate at low F/M values (Fig. 3).

During the survey low DO concentrations in the biological reactors of most of the plants examined were observed, probably caused by a non-homogeneous or insufficient aeration which could also produce zones with DO near to 0. Nevertheless, microorganisms such as *Haliscomenobacter hydrossis* and *Type 1701*, which are low DO filaments, occur as secondary filaments with very low percentages, i.e. cases of bulking associated with low DO concentrations were not revealed by the survey. These microorganisms, even if observed frequently, are never dominant in the systems, meaning that the low F/M ratio always represents the critical condition for bulking. In this regard, the measurements of the specific oxygen uptake rate (SPOUR) have been related to the F/M, confirming the corresponding low metabolic activity of the sludge (5-20 mgO/gVSS/h) at low organic loading rates (Palm et al., 1980).

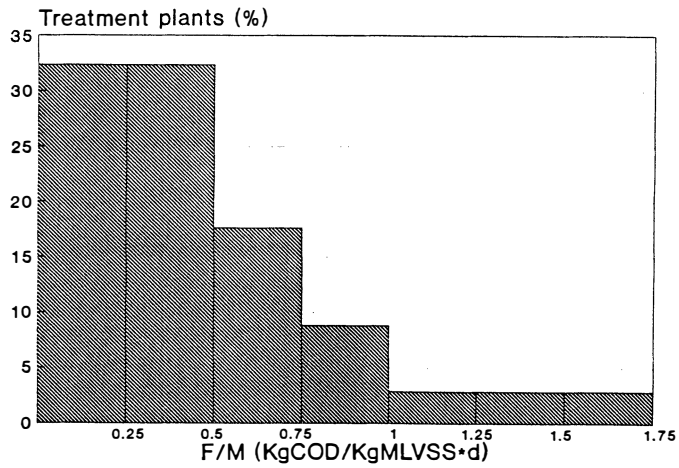

Fig. 3. Organic loading rates (F/M) distribution for the treatment plants investigated

Moreover, it was found that systems operating with alternating aeration conditions (like Carrousel type reactors or treatment plants, usually of small size, working with short alternating anoxic-aerobic periods) show permanent high levels of low F/M filaments. Of the 8 plants investigated, having these characteristics and operating at low organic loading, 7 were subjected to bulking due to *Microthrix parvicella*; anyhow it is suspected (Slijkhuis and Deinema, 1988) that this filament can denitrify and certainly the low DO concentrations in the aeration basin can favour it, too. The remaining plant showed *Thiothrix spp.* as the dominant filament and *type 0914* as the secondary. Their growth is usually caused by septic wastewaters containing high amounts of sulphides and, for *type 0914*, by low F/M conditions and presence of unaerated phases.

Another factor greatly affecting the biological floc structure is represented by the influent wastewater composition. During the survey, no bulking event caused by low pH was encountered, while in two cases *type 021N*, usually associated with a nutrient deficiency, was observed as the dominant microorganism.

The readily biodegradable COD fraction (RBCOD) tests showed a sufficiently homogeneous composition (about 22% of RBCOD) of the wastewaters examined with only a few exceptions; no significant correlation was consequently observed even considering the effect on that fraction of the primary sedimentation tanks, when present.

Some wastewater samples with composition atypical with respect to the usual characteristics of a municipal sewage were encountered during the survey. For instance, in some treatment plants receiving, in particular periods, a considerable amount of oil-mill wastewaters, the operation and efficiency are seriously compromised due to the proliferation of *Microthrix parvicella*. This filamentous microorganism shares with *Nocardia spp.* the ability of forming highly viscous and stable foams. However, particularly serious events of foaming were not found and the few cases observed were always associated with bulking caused by the same filamentous organisms.

CONCLUSIONS

The survey pointed out that the tendency to maintain biological sludges at high values of MCRT and, in some cases, at alternating aeration conditions, greatly favours the growth of low F/M filaments, with subsequent poor sludge settleability. In particular *Microthrix parvicella* represents the most widespread microorganism and, for the few foaming events observed, it shares with *Nocardia spp.* the responsibility for foam formation.

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