Microthrix parvicella foaming at the Fusina WWTP

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Abstract The Fusina WWTP receives civil and industrial wastewater from Venice and its hinterland. Its treatment capacity is in the range of 4,000–5,000 m³/h. In winter the Fusina WWTP is subjected to brown and viscous foams developed on the surface of the aeration basins and of the clarifiers. The microscopic observation of biological foams and activated sludge samples showed high concentration of the filamentous organism Microthrix parvicella. This paper investigates the growth of M. parvicella from January 1998 to January 1999 and relates it to foams developed on the aeration basins and clarifiers, to temperature, surfactants, BOD₅, NH₄, NO₃, NO₂, DO, PO₄ and pH of the wastewater influent, to SVI and the other species of filamentous organisms of mixed liquor. The results demonstrate the strong connection of the foams developed with M. parvicella abundance, the synergic action with surfactants, the dependence of M. parvicella on temperature and no relation to the other chemical and physical parameters investigated.

Keywords Foaming; Microthrix parvicella; surfactants; SVI; temperature

Introduction
The Fusina WWTP, which is located in the industrial area of Porto Marghera (Venice), treats both domestic and industrial wastewater, serving an equivalent population of more than 300,000 people organic BOD₅ load. Domestic wastewater is collected in the South-West and North-West basins of the Mestre area (Venice), industrial wastewater is collected by the sewer of the industrial area of Porto Marghera. It may treat about 4,000–5,000 m³/h, 18,000 kg of BOD₅ per day and 5,500 kg of total nitrogen per day. Current processes include: screening (mechanical bar rakes), equalization, aerated grit removal, denitrification, biological oxidation/nitrification, final sedimentation, disinfection, gravity thickening, anaerobic digestion, sludge dewatering with filter presses. The biological step consists of three parallel lines.

In winter the Fusina WWTP is affected by foaming: brown and viscous foams develop on the surface of aeration basins and of the clarifiers. This phenomenon determines a difficulty in maintaining the sludge detention time and a good removal efficiency because of a suspended solid loss into the effluent; it causes an increase of the Cl₂ dosed in the final effluent and of the cost due to extra maintenance required for cleaning clarifiers. The microscopic observation of biological foam and activated sludge samples showed high concentration of the filamentous organism Microthrix parvicella. This organism has been associated by many authors to the formation of this kind of foams because of their hydrophobic cell wall, due to the presence of long chain hydrocarbon acids on their surface (Jenkins et al., 1993; Goddard and Forster, 1987; Pujol et al., 1991). This paper investigates the role of M. parvicella in activated sludge scumming, the influence of temperature, surfactants, BOD₅, NH₄, NO₃, NO₂, DO, PO₄ and pH on its growth and foam development.

Materials and methods
Sampling: activated sludge mixed liquor samples were taken weekly from the mixed liquor channel between the aeration basins and the clarifiers.
Microscopic examination and identification of the filamentous organisms: the examination of the structure of the flocs as well as of the abundance of filamentous organisms was effected with a phase-contrast microscope Olympus BH2. The morphologic characterization, Gram and Neisser stains, were done according to the identification manuals (Eikelboom and van Buijsen, 1983; Jenkins et al., 1993). The assessment of *M. parvicella* is expressed as “number of intersections per µl”.

**Sludge volume index (SVI):** SVI-values were calculated from the 30 min settling sludge volume determinated in unstirred 1,000 ml cylinders (Standard Methods, 1992).

**Surfactants:**
- anionic surfactants as MBAS (methylene blue active substances): three successive extractions from acid aqueous medium containing excess methylene blue into chloroform, were followed by an aqueous backwash and by spectrophotometric measurement at 652 nm (Standard Methods, 1992)
- nonionic surfactants as Tetrakis Active Substances (TAS): aqueous medium, added with 5 ml of dichloroethane, was titolated with Tetrakis solution 0.0005 M (UNICHIM, 1993)

**Chemical and physical parameters:** chemical and physical parameters were measured on line at the influent of the plant and controlled by a SCADA (System Control And Data Acquisition) system.

**Abundance of foams:** the presence of foams on the aeration basins was valued as the covering percentage on the whole surface.

**Multivariate analysis:** the computer program used was Statistical for Windows.

**Results and discussion**
The growth of *Microthrix parvicella* has been followed from January 1998 to January 1999 and it has been related to the temperature (Figure 1).

The data show how *M. parvicella* depends on the temperature: the growth of this type of filamentous organism was, in fact, seasonal, with the lowest value of 1 intersections/µl in summer and the maximum value of 918 intersections/µl in winter. The presence of foams and their abundance have been associated with the number of *M. parvicella* intersections, which had a very similar trend (Figure 2).

The greatest value of the foams on the aeration basin (80% of the surface) was observed from February to March 1998 when the number of *M. parvicella* filaments was between...
631 int./µl and 563 int./µl, and the temperature between 12°C and 15°C. The foams, than, declined gradually from March to the first week of July and remained absent thereafter till to September, when the number of \( M. \) parvicella was about 0–1 int./µl and the temperature higher than 20°C. From October to November the number of \( M. \) parvicella intersections multiplies. On the 25th of November the foams were observed again in the aeration basins, when \( M. \) parvicella filaments were 83 int/µl and the temperature was 13°C. The abundance of foams returned to a value of 80% on the 23rd of December, when \( M. \) parvicella filaments were 296 int/µl and the temperature was 11°C. The course of the growth of \( M. \) parvicella and the abundance of foams have been related to the “sludge volume index” (SVI) (Figure 2). Values less than 150 ml/g were checkable from 16th April to 2nd December, when the foams were absent or in low concentration and the number of \( M. \) parvicella intersections per µl was reduced. Values greater than 150 ml/g were from 22nd January to 9th April 1998 and from 9th December to 7th January 1999, when the number of \( M. \) parvicella intersections and the presence of foams on the aeration basins were maximum. The filamentous organisms rotation and their total abundance have been examined in relationship with the seasons. From January 1998 to April 1998 \( M. \) parvicella was predominant and almost the only filamentous organism present. It grew inside and outside the flocs making bridges, so that the sludge compacted poorly. Getting close to summer, the floc structure changed in species of filamentous organisms. From August to October \( M. \) parvicella turned out to be a secondary component of floc macrostructure compared to Type 0041 and Type 0675, which were largely dominant: the total abundance of the organisms had a value between 3–4, the floc macrostructure was regular, compact and with a good sedimentation. The concentration of surfactants was valued by analysing the concentration of anionic surfactants (MBAS) and non-ionic surfactants (NI) in the plant influent and in the mixed-liquor. These analyses were carried out from 30th March to 18th June 1998, when the foams percentage on the aeration basins changed from 25–30% to 0%. The concentration of surfactants was almost constant (10.01 mg/l MBAS, 4.50 mg/l NI), and it was possible to exclude them as the first cause of foaming.

The course of the growth of \( M. \) parvicella has also been studied in relation to BOD\(_5\), NH\(_4\), NO\(_3\), NO\(_2\), DO, PO\(_4\) and pH, characterizing the influent and the mixed liquor. These parameters oscillated around medial values and they didn’t show a seasonal trend which is typical of the growth of \( M. \) parvicella. The concentrations of the most significant parameters have been correlated to \( M. \) parvicella intersections by multivariate analysis (Table 1).

**Conclusions**

The filamentous organism \( Microthrix \) parvicella is strictly associated with the presence of foams in Fusina WWTP. In fact whenever the foams were present on the aeration basins and settling tanks, \( M. \) parvicella was the dominant filament organism which caused the
total filamentous category; when its abundance progressively decreased, also the foaming got less with a very similar trend: its count may be, therefore, an efficient procedure for diagnosing and control of foaming. The SVI values are well correlated to *M. parvicella* abundance \( (r = 0.73, p<0.05) \). This correspondence confirms that this organism is able to grow abundantly inside the flocs to make it irregular, diffuse and unable to settle correctly. The surfactants present in the influent, on the contrary, don’t seem to have a primary role in foaming, but a synergetic action with *M. parvicella* abundance. Their concentrations were almost constant (14.51 mg/l), whereas foam covering percentage on the aeration basins decreased, during the same investigation time, from 30% to 0%.

The *M. parvicella* growth is strictly associated with temperature, according to other authors (Knoop and Kunst, 1998; Holmström et al., 1996), with the maximum value in winter, the minimum in summer and a critical temperature value of 20.4°C below which the growth rate increased and became exponential. The growth was independent of BOD\(_5\), NH\(_4\), DO and PO\(_4\), as shown by the results of multivariate analysis.

**References**


