# Application Note

**AN05ME0411**

# Activated Sludge Diagnostic Tool: MICROexpert

## Introduction

This application note introduces MICROexpert, a knowledge based software tool for diagnosis and trouble-shooting of operational problems in activated sludge.
It deals with suspended-solid systems in aerobic or in nutrient removing (N and P) processes, in CSTR (Continuous Stirred Tank Reactor) or Plug Flow reactors.
The main goal of this tool is:

- Detecting, at the right time, functional instability and anomalies in progress;
- Advising on possible corrective operations to prevent solid separation problems (bulking, foaming, rising, pin point floc, etc.);
- Avoiding failures of effluent quality.

## Why?

The activated sludge processes consist of a primary clarifier, one or more biological reactors and a secondary clarifier.
The primary clarifier makes a first separation of solids contained in the wastewater to be treated.
The biological reactor provides to the community of microorganisms, forming a structure known as activated sludge, favorable environmental conditions for the transformation and removal of organic matter in a drain.
The secondary clarifier provides to separate the current output from the biological reactor in two phases: a liquid clarified phase that is the effluent plant and a solid thickened phase, part of which is recycled in the top of the plant (after primary sedimentation) and partly directed towards the sludge treatment units.
The overall efficiency of the process will depend on both the efficiency of the biological reactor to that of the secondary clarifier, so all the factors that influence both the biological process that the separation of solids are important in determining the overall efficiency of the process.
Most of the problems of activated sludge solids separation may be related to the nature of the sludge. These problems can be interpreted in terms of microstructure or macrostructure of the flocs and can be identified in:

- Foaming;
- Filamentous Bulking;
- Viscous Bulking;
- Rising Phenomena;
- PinPoint Phenomena;
- Dispersed Growth.

So, there is a need to have a software for the diagnosis (early and predictive) of process malfunctions and the resulting decision support for corrective action. This software should allow you to emulate the process of "solving" the human being, on the basis of such qualitative/quantitative information, such as those arising from the analysis of microscopic sludge.

## Features

MICROexpert major strength is its data-fusion, which is the ability to merge consistently different type of data and information to the best diagnosis:

- Microscopic sludge analysis on microfauna, sludge biotic index (SBI), sludge floc morphology and filamentous bacterial growth;
- Laboratory physical-chemical analysis;
- Operative parameters evaluated on field;
- Visual investigation on efficiency of each wastewater treatment.

MICROexpert exploits the peculiar “slow” dynamics of activated sludge and its incubation time (days before the effects of biological undesiderable anomalies) to predict diagnosis.
In fact, a problem could not be promptly detect before it has occurred, by the only physical-chemical parameters. Generally, an incubation period is a considerable lapse of time. This period (sometimes weeks), has to deal with a lack of a timely diagnosis.
Basic functionalities of the product are:

- Data fusion among microfauna, filamentous bacteria data-input, visual observations and in security conditions, operative parameters (SVI, OD, ORP, ecc.) and laboratory results;
- Diagnosis of Biological Efficiency (SBI) and separation problems (BULKING, FOAMING, RISING, PIN POINT FLOC, etc.);
- Early Warning indicator of dysfunctions in progress;
- Decision support models of corrective actions.

MICROexpert allows operating with different kind of data, but it is necessary to define some of the operational characteristics of the process, as the followings:

- CSTR or Plug Flow reactor;

- Aerobic or Nutrient Removal treatment.

In general, MICROexpert data input deals with:

- Preliminary assessment (general investigation data on micro-macroscopic points of view: i.e. filamentous abundance, floc size/floating sludge, presence of scum,...);
- Filamentous microorganism species (if their abundance >3 [Jenkins]);
- Operational parameters (proposed by the system according to the case: i.e. OUR, ORP, F/M, DO, SVI, etc.);
- Protozoa keygroups for SBI (Sludge Biotic Index) calculation and protozoa species too.

MICROexpert doesn't require all the data above-mentioned simultaneously: it requires just the same ones (or even less) of quali-quantitative data that would be necessary to an expert biologist to get diagnosis.

Starting by preliminary general investigation data, the program leads the user to the data input by proposing appropriate schemes of data, according to the particular case study.

## Advantages and Innovation

The technology of the expert system MICROexpert is fundamentally based on an original application of the technique of Fuzzy Reasoning, which is well suited to applications where domain knowledge is not limited by mathematical relationships.

Each of solids separation problems described has been analyzed in a systematic way, looking for all the elements (input) chemical, physical, chemical/physical and microbiological processes that can contribute, either alone or together, to get considered problem, determining the causes and proposing for each of them one or more remedies.

## Conclusion

MICROexpert is a knowledge based software tool for diagnosis and troubleshooting of operational problems in activated sludge. It allows to control the solid separation problems (Bulking, Foaming, Rising, Pin Point Floc, etc.) in activated sludge systems, based on microfauna and filamentous bacteria microscopic examinations.

This software allows to prevent solid separation problems (bulking, foaming, etc.) in activated sludge.

It is based on Fuzzy Reasoning, and proposes for each solid separation problem one or more remedies.

## References


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