

# Solids management for the control of extended aeration systems: An analysis of classical and advanced strategies

M von Sperling

Department of Sanitary and Environmental Engineering, Federal University of Minas Gerais, Av. Contorno 842 - 7º andar, 30110-060 - Belo Horizonte, Brazil

## Abstract

This paper initially presents a detailed critical assessment of the conventional methods for solids management in the activated sludge process, with a particular view to extended aeration systems. The following control strategies are analysed:

- control of process indicators: sludge loading (F/M), sludge age and oxygen utilisation rate (OUR),
- control of MLSS and sludge mass and
- control based on the clarifier behaviour.

The main limitations of these strategies are discussed, namely the incapacity of covering on an integrated basis the dynamic state of the system, the interactions between the reactor and the final clarifier and the various process variables involved. In order to address the above limitations, 2 control strategies developed by the author based on an integrated and optimal approach to the system are described. The first strategy comprises the optimal control of the process (effluent quality and operating costs), while the second strategy is a rule-based control. A comparison, using Monte Carlo simulations, between the 2 proposed strategies and some of the conventional strategies indicated the 2 strategies to be superior to the conventional ones in terms of cost-benefit.

## Nomenclature

ARIMA	=	auto-regressive integrated moving average model
BOD	=	biochemical oxygen demand
COD	=	chemical oxygen demand
DO	=	dissolved oxygen
F/M	=	food-to-micro-organism ratio
$K_1a$	=	overall oxygen mass transfer coefficient
MCRT	=	mean cell residence time
MLSS	=	mixed liquor suspended solids
OUR	=	oxygen utilisation rate
$Q_r$	=	return sludge flow
$Q_w$	=	waste sludge flow
R	=	recycle ratio
RASS	=	return activated sludge suspended solids
SCOUR	=	specific carbonaceous oxygen utilisation rate
SNOUR	=	specific nitrogenous oxygen utilisation rate
SRT	=	solids retention time
SS	=	suspended solids
SSVI <sub>3,5</sub>	=	stirred sludge volume index at a concentration of 3,5 g/l
STOUR	=	specific total oxygen utilisation rate
SUR	=	substrate utilisation rate
SVI	=	sludge volume index

## Introduction

Among the many variants of the activated sludge process for waste-water treatment, extended aeration is probably the most used. Its behaviour is a direct function of the large mass of solids kept in the system and the long residence time of these solids. The particular features of extended aeration systems, which result from these 2 characteristics, are:

- low effluent soluble BOD;
- significant aerobic stabilisation of the sludge;
- high oxygen consumption for biomass respiration;
- low production of surplus sludge;
- potential for achieving nitrification at all times;
- great damping capacity and resistance to shock loads;
- high energy consumption per unit BOD oxidised; and
- conceptual simplicity (primary sedimentation not necessary, only one type of sludge to be handled, sludge stabilisation within the reactor).

Because extended aeration systems have been traditionally considered to be inherently efficient, there has not been additional motivation for efforts towards performance improvement. However, due to the fact that in many cases extended aeration systems operate virtually unattended, eventual process failures may even remain unnoticed, and no change in the operating mode is thus regarded as justifiable.

Two of the most common failures are not caused by exogenous sources, but are mainly a product of an internal overloading of the system, brought about by an excessive mass of solids in the reactor or final clarifier. The first example is the loss of nitrification due to lack of dissolved oxygen, which is frequently due to high MLSS levels causing a high oxygen consumption for biomass respiration. The second frequent failure is high effluent suspended solids (and the associated particulate BOD) as a result of final clarifier overloading, again frequently caused by high MLSS levels.

Other important aspects related to the solids in the system are the high energy consumption for aeration, and the production of relatively small quantities of excess sludge. The balance between a higher energy cost and lower sludge handling and disposal costs is site-specific, and there is no general rule to bring about the lowest overall cost.

Because the performance and costs of extended aeration plants are essentially dominated by the solids in the system, the control of the process has to be directed towards their management. The

---

Received 9 February 1993; accepted in revised form 27 October 1993.