A review of characterisation requirements for in-line prefermenters Paper 2: Process characterisation

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Abstract

The operational factors having a significant effect on in-line prefermentation efficiency include the sludge recycle rate and the subsequent sludge elutriation rate, solids concentrations and retention times. The prefermenter configuration employed is a determining factor, which allows for some degree of operational flexibility. Side-stream and multiple tank systems are superior in this regard and outnumber the use of in-line single tank prefermenters, which are mainly employed due to lower space and capital cost requirements. This paper reviews the basic design and monitoring requirements for in-line prefermenters, to establish simple strategies on which prefermenter evaluations could be based.

Nomenclature

ADWF	=	average dry weather flow
APT	=	activated primary tank
BEPR	=	biological excess phosphorus removal
BNRAS	=	biological nutrient removal activated sludge
C	=	carbon
COD	=	chemical oxygen demand
DO	=	dissolved oxygen
DR	=	downflow velocity rate (stilling chamber)
DWAF	=	Department of Water Affairs and Forestry
HRT	=	hydraulic retention time
HRT_{eff}	=	effective hydraulic retention time
N	=	nitrogen
NH_3	=	ammonia
NH_3+NH_4-N	=	total ammonia nitrogen
NO_3	=	nitrate
MUCT	=	modified University of Cape Town
o-PO_4	=	orthophosphate
P	=	phosphorus
PST	=	primary settling tank
r_{VFA}	=	rate of VFA production
RAS	=	return activated sludge
SER	=	sludge elutriation rate
SetS	=	settleable solids
SO_4	=	sulphate
SRR	=	sludge recycle rate
SRT	=	sludge retention time
SS	=	suspended solids
T	=	ambient temperature
TDS	=	total dissolved solids
TKN	=	total Kjeldahl nitrogen
TOD	=	total oxygen demand
TP	=	total phosphorus
TS	=	total solids
UCT	=	University of Cape Town
UR	=	upflow velocity rate (tank)
VFA	=	volatile fatty acid
WCW	=	water care works

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Introduction

The significance of prefermentation

Approximately 98% of the potable water supply in South Africa is drawn from closed surface water sources such as dams and lakes (Lötter and Pitman, 1992). The primary nutrients that cause eutrophication in surface water are C, N and P, with P usually considered to be the limiting nutrient (major contributor) (Lilley et al., 1997). The current review of legislative standards by DWAF, which includes the reduction of WCW effluent P and N concentrations discharged into surface water, emphasises the necessity to optimise contemporary nutrient removal processes. Pitman (1999) reports that the proposed constituent limits for the northern catchment of Johannesburg includes a 2.0 mg N/ℓ (NH_3+NH_4-N), a 6.0 mg N/ℓ NO_3 and a 0.6 mg P/ℓ *o*-PO_4 standard. Complete compliance with stricter regulations should ideally be met at existing WCW without the need for additional capital expenditure, or at a higher operational cost due to chemical dosing.

Research must therefore be directed on enhancing the biologically mediated prefermentation processes, to enrich settled sewage with biodegradable organic matter for BNRAS performance improvement (Lötter and Pitman, 1997). A controlled anaerobic environment, devoid of molecular or chemically bound oxygen, is required for prefermentation. Adequate wastewater characterisation and prefermenter performance guidelines are essential for operational control to ensure that the prefermented settled sewage is suitable for the downstream BNRAS process.

The factors governing prefermentation

The full-scale prefermentation of primary sludge was implemented successfully at WCW in the early 1980s as a primary treatment process to enhance BNRAS (Pitman et al., 1992). PSTs and thickeners were retrofitted or constructed from this stage as in-line or side-stream prefermenter configurations to enrich the settled sewage with soluble fermentation products. In a single (in-line)