ACTIVATED SLUDGE TREATMENT OF DAIRY PROCESSING WASTEWATERS:

THE ROLE OF SELECTORS FOR THE CONTROL OF SLUDGE BULKING.

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ABSTRACT

The typical wastewater from a milk processing facility producing butter and milk powder was treated in a modified activated sludge system in order to establish process characteristics and investigate operational problems.

A synthetic wastewater was developed with similar average physical and chemical characteristics to that from a full scale facility. The relative biodegradability of the wastewater fractions was assessed and basic microbial growth parameters also determined. A laboratory scale activated sludge reactor configuration was then established and its performance monitored. Although effective treatment was achieved in terms of suspended and soluble organic matter removal, the use of a completely mixed reactor resulted in the system becoming inoperable due to the excessive growth of filamentous microorganisms, with Type 0411 being the dominant filament.

In order to inhibit filamentous bulking, various selector reactor configurations were trialed. As nitrification of feed stream proteins had been indicated, unaerated selectors were used with the intention of effecting anoxic substrate removal in the initial selector zone; but due to the limited supply of oxidised nitrogen, insufficient substrate removal occurred in the selectors to prevent filamentous bulking, with Type 021N becoming dominant.

The next series of trials used aerated selectors, with some configurations demonstrating the ability to both prevent and cure filamentous bulking. The unsuccessful trials resulted in the proliferation of *Haliscomenobacter hydrossis*. From selector trials conducted it was established that the requirements for successful suppression of filamentous growth were the incorporation of an initial selector zone in which greater than 95% of removable soluble substrate was removed and the bulk solution was maintained in a fully aerobic state. Serial selector configurations demonstrated improved performance over a single selector.

From observations of the physical conditions and substrate concentrations in the reactor configurations employed, a correlation of filament type to environmental condition can be tentatively made: Types 0411 and 021N were indicated to be low organic loading type filaments, whereas *H. hydrossis* was indicated to be a low dissolved oxygen filament.

Rapid substrate removal rates were attributed to biosorption, accumulation and storage mechanisms, increasing as the selector configuration trials progressed. In general floc formers possessed a higher specific growth rate and substrate affinity than the filamentous microorganisms. Filament Type 021N was indicated to lack biosorptive capacity, however *H. hydrossis* was indicated as having a greater biosorptive capacity than the floc formers present.

The highly degradable nature of the substrate and high substrate concentration gradients imposed by the selector configuration caused rapid oxygen uptake rates; resulting in aerobic, anoxic and anaerobic substrate removal mechanisms all occurring in the initial selector zone. The occurrence of simultaneous nitrification, denitrification and phosphorus accumulation resulted in significant nutrient removals from the aerated selector reactor system, with influent nitrogen and phosphorus levels each reduced by up to 96% in the effluent stream.

This study found that an activated sludge process was an appropriate method for the effective treatment of milk processing wastewaters, as effluent suspended solids of less than 10 $g.m^{-3}$ and soluble COD of less than 30 $g.m^{-3}$ were consistently obtained, however a modified configuration would be required to prevent the growth of filamentous microorganisms and attendant operability problems. Due to the nature of dairy processing wastewaters, a selector reactor configuration could be employed not only to overcome potential filamentous bulking problems, but also to provide an opportunity for biological nutrient removal without the inclusion of dedicated anoxic / anaerobic reaction steps or the complex flow regimes conventionally employed for nutrient removal activated sludge systems.

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ABBREVIATIONS AND NOMENCLATURE

AS	Activated Sludge
ATU	Allylthiourea
BOD	Biochemical Oxygen Demand $(g.m^{-3})$
COD	Chemical Oxygen Demand $(g.m^{-3})$
DO	Dissolved Oxygen $(g.m^{-3})$
DRI	NZ Dairy Research Institute, Palmerston North, NZ.
DRP	Dissolved Reactive Phosphorus $(g.m^{-3})$
EBPR	Enhanced Biological Phosphorus Removal
HRT	Hydraulic Retention Time (d)
K_S	Substrate half saturation co-efficient $(g\ COD\ .m^{-3})$
μ_{max}	Maximum specific growth rate (d^{-1})
N	Nitrogen
NTU	Nephelometric Turbidity Units
OUR	Oxygen Uptake Rate $(g\ O_2\ .m^{-3}\ .\ min^{-1})$
O_X	COD content of biomass $(g\ COD.g\ TSS^{-1})$
PAO	Phosphorus Accumulating Organism
P	Phosphorus
RAS	Return Activated Sludge
RBCOD	Readily Biodegradable Chemical Oxygen Demand
sCOD	Soluble COD $(g\ COD\ .m^{-3})$. Defined as GFC filterable COD for this study.
S	Substrate concentration $(g\ COD\ .m^{-3})$
S_I	Soluble Inert substrate concentration $(g\ COD\ .m^{-3})$
S_H	Rapidly hydrolyseable substrate $(g\ COD\ .m^{-3})$
S_O	Initial substrate concentration $(g\ COD\ .m^{-3})$
S_S	Readily biodegradable substrate $(g\ COD\ .m^{-3})$
SMP	Soluble Microbial Products
SpOUR	Specific Oxygen Uptake Rate $(g\ O_2\ .\ g\ VSS^{-1}\ .\ d^{-1})$
SRT	Solids Retention Time (d)
SVI	Sludge Volume Index $(ml\ .\ g^{-1})$
TKN	Total Kjehldahl Nitrogen $(g\ .m^{-3})$
TN	Total Nitrogen $(g.m^{-3})$
TP	Total Phosphorus $(g.m^{-3})$
TS	Total Solids $(g.m^{-3})$

TSS	Total Suspended Solids ($g.m^{-3}$)
VSS	Volatile Suspended Solids ($g.m^{-3}$)
X	Biomass concentration ($g.m^{-3}$)
X_I	Particulate inert substrate concentration ($g\ COD\ .m^{-3}$)
X_O	Initial biomass concentration ($g.m^{-3}$)
X_S	Slowly biodegradable substrate ($g\ COD\ .m^{-3}$)
Y	Cell growth yield (g cell mass . g substrate COD^{-1})
Y_H	Heterotrophic growth yield (g cell COD . g substrate COD^{-1})