A NOVEL APPROACH TO WASTEWATER TREATMENT: *CLARKE* IC-SEP (INDUCED CYCLONIC SEPARATOR)

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ABSTRACT

Qualitative and quantitative trials were conducted on a newly developed wastewater treatment system. The system, called the *Clarke* IC-SEP (Induced Cyclonic Separator), works by air flotation, and as such was compared to traditional DAF (Dissolved Air Flotation) systems. These initial trials show that the IC-SEP can remove solids and other contaminants from waste and product streams much more efficiently than DAF systems. For a wide range of phase separation operations, the IC-SEP has displayed significant cost savings, which is of substantial interest all industries.

KEYWORDS

Wastewater, Dissolved air flotation, Phase separation, Chemical Unit Process, IC-SEP

1.0 INTRODUCTION

A commonly used method of wastewater treatment is the Chemical Unit Process. This is the process whereby a chemical reaction (or reactions) brings about the treatment of wastewater, which precipitates the dissolved solids. An important subset of the Chemical Unit process is the flotation operation. It is this operation that is of interest to this paper.

For waste treatment, Chemical Unit Processes alone are widely accepted to be far more effective that Physical Unit Processes. However, a common criticism of the Chemical Unit Process is that it is an additive process. Dissolved solids in the form of precipitation chemicals must be added to bring about an overall reduction of dissolved matter. In comparison to a Physical Unit Process, running costs of a Chemical Unit Process can be significant because of the chemicals used and additional energy required to effect phase separation.

Therefore in order to take advantage of the effectiveness of the Chemical Unit Process, it is of great interest to industry to find ways to reduce the chemical and energy costs of the procedure.

It was the application of these cost reduction criteria to traditional DAF (Dissolved Air Flotation) technology that brought about the development of the IC-SEP (Induced Cyclonic Separator). The purpose therefore of this paper is to ascertain the relative benefits of using the IC-SEP over other Chemical Unit Processes for the secondary treatment of industrial wastewaters.

1.1 Previous Research Activity

As the IC-SEP is a newly patented (pending) design, limited previous research into the operational parameters of the system has been undertaken. Therefore it is intended that this paper form the basis for further study, whilst still examining the system in enough detail order to gain an understanding of the possible future applications for the design.

1.2 IC-SEP Operation

The IC-SEP (Induced Cyclonic Separator) is a novel separating system that can be used in a wide variety of applications. Many separation operations that have previously been too costly, or in some cases impossible to achieve are easily and inexpensively undertaken using this system.

The system exploits the density difference between two phases primarily by attaching air bubbles to one phase and floating it away for collection. Often this operation requires the use of chemicals to bring about precipitation of solids that can then subsequently attach to the air bubble. This idea is not new, but the way it is achieved using the IC-SEP (Induced Cyclonic Separator) is quite revolutionary.

The IC-SEP (Induced Cyclonic Separator) works by entraining free air into the suction side of a positive displacement pump and then inducing a cyclone inside the specially designed IC-SEP (Induced Cyclonic Separator) unit. The pressures and shear forces generated in the uniquely shaped fluid channels ensure intimate mixing of the liquid/solid phase with the partially dissolved entrained air.

1.3 Testing Parameters and Procedures

For the purposes of this paper, the IC-SEP (Induced Cyclonic Separator) was trialed on the following waste streams shown in Table 1. In addition to the IC-SEPs performance for wastewater treatment using chemicals, as a control experiment, the IC-SEP was assessed for its efficacy in removing fruit fibre from fruit juice, without the use of chemicals.

Table 1: ***Industries and Effluent types chosen for IC-SEP testing***

INDUSTRY	EFFLUENT #	EFFLUENT TYPE
Margarine Processing	1	Factory Effluent
Meat Processing / Abattoir	2	Factory Effluent
Cheese Processing	3	Factory Effluent
Dairy Processing	4	Cream Washdown Effluent
Dairy Processing	5	Milk Washdown Effluent
Dairy Processing	6	Ice cream Washdown Effluent
Dairy Processing	7	Ageing area Washdown Effluent
Dairy Processing	8	Factory Effluent

For the purposes of data collection, the following methodology was used. A sample of the raw effluent was taken as a control sample. Next a sample was taken of the wastewater after treatment with the IC-SEP (Induced Cyclonic Separator) system. These samples were tested for appropriate effluent quality parameters for each industry.

2.0 DISCUSSION

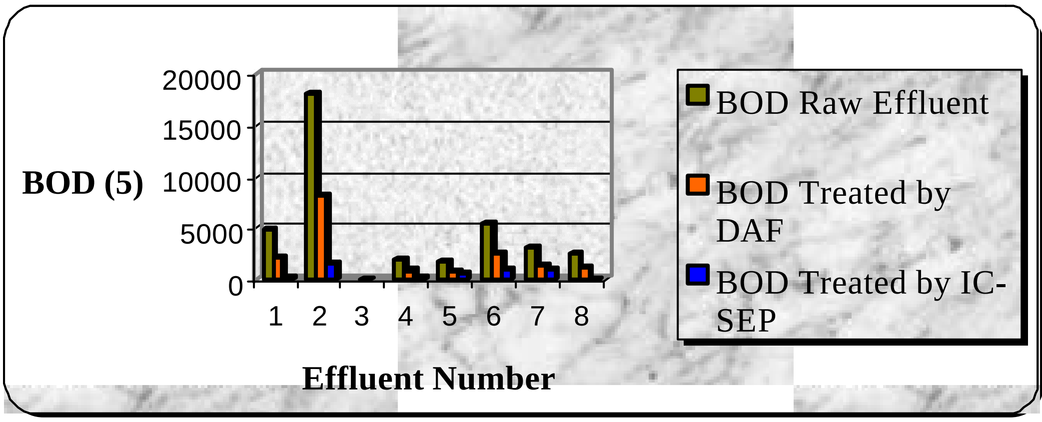
2.1 BOD_5 Reduction

BOD_5 reduction was measured for the effluent numbers 1, 2, 4, 5, 6, 7, 8. (See Table 1., for details). The results are shown graphically in *Figure 1.* The figures demonstrate the marked BOD_5 reduction possible using the IC-SEP. This is primarily due to the coagulation of suspended and dissolved solids using cationic coagulants.

Simple DAF (Dissolved Air Flotation) systems will also show a BOD_5 reduction but not to the same efficacy.

The average BOD_5 reduction for DAF (Dissolved Air Flotation) systems is shown in Figure 1., based on an assumed BOD_5 reduction of 40-70% (average 55%) (Metcalf & Eddy, 1991)

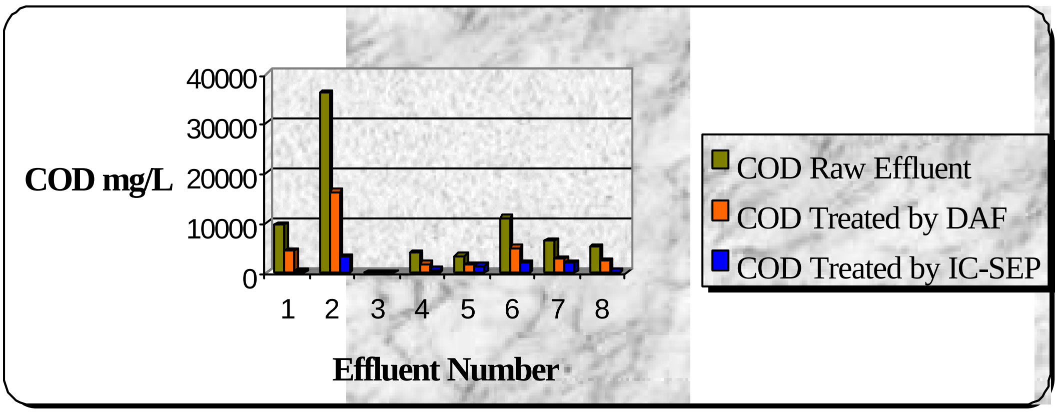
Figure 1: *BOD_5 Reduction using IC-SEP test unit*



2.2 COD Reduction

COD reduction was measured for the effluent numbers 1, 2, 4, 5, 6, 7, 8. (See Table 1., for details). The results are shown graphically in *Figure 2*. The figures demonstrate the marked BOD reduction possible using the IC-SEP. The average COD reduction for DAF (Dissolved Air Flotation) systems is shown in *Figure 2.*, based on an assumed COD reduction of 30-60% (average 55%) (Metcalf & Eddy, 1991)

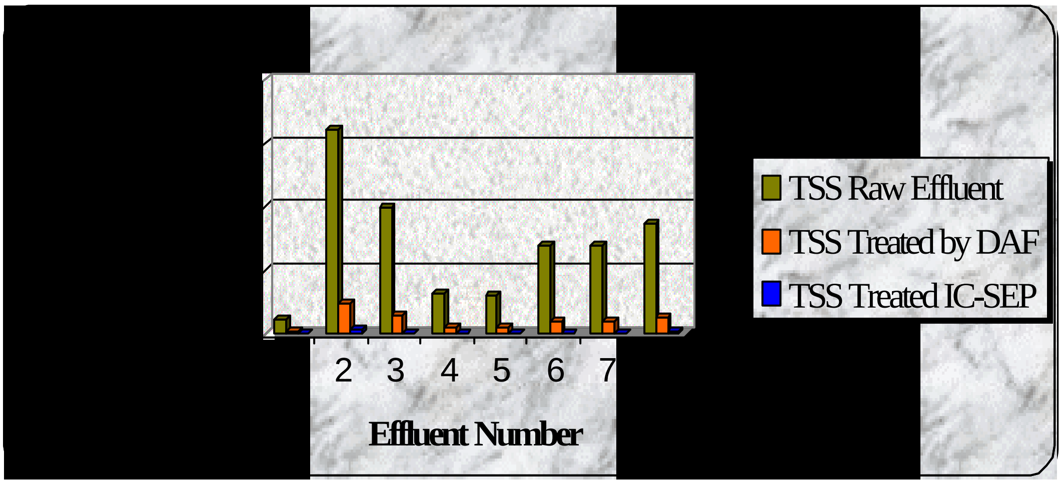
Figure 2: *COD Reduction using IC-SEP test unit*



2.3 TSS Reduction

TSS reduction was measured for the effluent numbers 1, 2, 3, 4, 5, 6, 7, 8. (See Table 1., for details). The results are shown graphically in *Figure 3*. The average TSS reduction for DAF (Dissolved Air Flotation) systems is shown in *Figure 3.*, based on an assumed TSS reduction of 80-90% (average 85%) (Metcalf & Eddy, 1991)

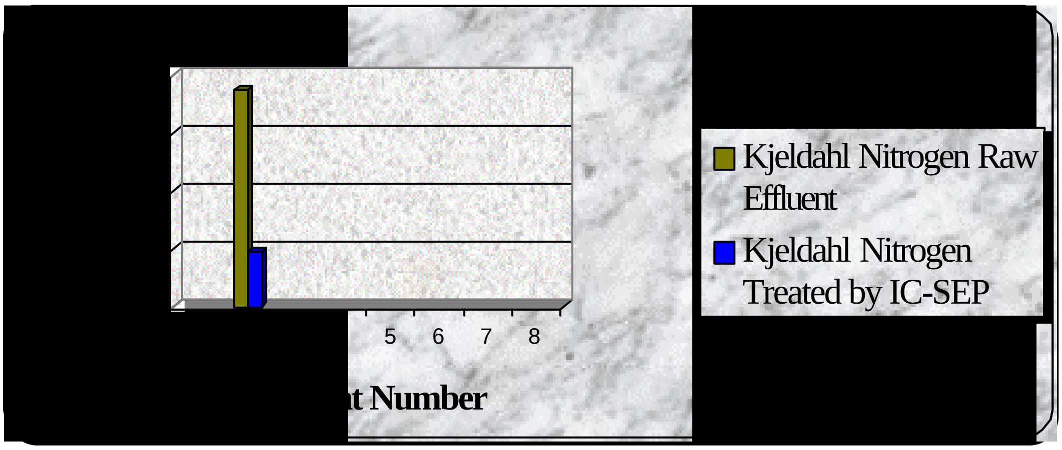
Figure 3: ***TSS Reduction using IC-SEP test unit***



2.4 Nitrogen Reduction

Nitrogen (Kjeldahl) was measured using effluent number 2 (See Table 1., for details). The results are shown graphically in *Figure 4.*

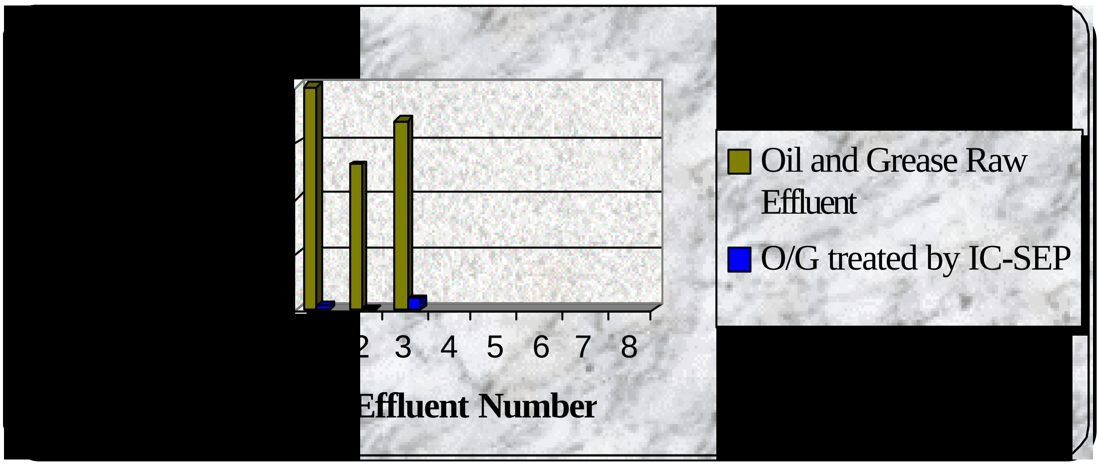
Figure 4: ***Nitrogen Reduction using IC-SEP test unit***



2.5 Oil and Grease Reduction

Oil and grease levels were measured using effluent numbers 1, 2, 3, (See Table 1., for details). The results are shown graphically in *Figure 5.*

Figure 5: ***Oil and Grease Reduction using IC-SEP test unit***



2.6 Chemical usage and Energy Consumption

Our investigation has highlighted scope for cost reduction over traditional DAF (Dissolved Air Flotation) systems. Operational costs will be markedly reduced using the IC-SEP (Induced Cyclonic Separator) system in at least four key areas.

Due to the high turbulence and shear created in the IC-SEP, the air particles are semi-dissolved to a size approaching 1-micron. This has two benefits to the separation operation. Firstly, the air bubbles are of an equivalent size to the smallest solid particles, and are able to be attached more easily. Secondly, the high shear also brings the air bubbles and solid particles into much closer proximity, so the adsorption is more likely. The combined result of these two effects augments the separation operation to such an extent, that in most cases, chemical usage is reduced dramatically. Cost savings can be very significant.

The operation is achieved without the use of compressed air. The suction to the positive displacement pump is kept in a continual negative pressure regime. As this is the place where the air is admitted into the system, the entrainment of air is performed with little or no additional energy consumption, and no additional high maintenance equipment. The air is dissolved into solution by the high shear and turbulence created by the IC-SEP (Induced Cyclonic Separator). Capital investment and operational costs associated with pressurisation equipment common to traditional air flotation systems are not incurred.

The enhanced water clarity is the result of improved BOD, TSS, and Oil and Grease reduction. This reduces the loading on the effluent stream, thus leading to reduced trade waste charges.

As the *only* moving part in the entire IC-SEP (Induced Cyclonic Separator) system is the rotor of the positive displacement pump, the maintenance cost for the unit is minimal. Standard servicing of this pump and the chemical dosing pumps is all that is required.

2.7 Fibre stripping from pear juice

In order to compare the effectiveness of the IC-SEP (Induced Cyclonic Separator) without the use of chemicals, the unit was tested with pear juice containing 2% fibre.

The IC-SEP (Induced Cyclonic Separator) was used to strip fibre from the juice prior to processing in an Ultra-filtration system in order to increase the processing time between filter backwashing. The IC-SEP (Induced Cyclonic Separator) was able to remove 98.5% of the fibre in a single pass operation. This increased cycle times on the filtration system by 800%. From these figures it was shown that the air dissolution in the liquid phase using the IC-SEP (Induced Cyclonic Separator) was ideal for phase separation operations. This perhaps explains the ability of the system to outperform normal DAF (Dissolved Air Flotation) systems when treating wastewater with precipitation chemicals.

3.0 CONCLUSIONS

In comparison to traditional DAF (Dissolved Air Flotation) systems, trailing with the IC-SEP (Induced Cyclonic Separator) clearly shows several significant economic and operational benefits.

The critical wastewater parameters of the IC-SEP (Induced Cyclonic Separator) treated effluent all show marked improvement over both the untreated and DAF (Dissolved Air Flotation) treated effluent.

For BOD_5 and COD reduction, the IC-SEP (Induced Cyclonic Separator) outperformed the DAF (Dissolved Air Flotation) by reducing loading by an average of 83.7% as opposed to a reduction of 55% using traditional DAF (Dissolved Air Flotation) systems. (Metcalf & Eddy, 1991)

For TSS, the IC-SEP (Induced Cyclonic Separator) showed an average reduction of 98.2% as opposed to a typical reduction of 85% by a DAF (Dissolved Air Flotation) system. (Metcalf & Eddy, 1991)

Whilst the maintenance and energy costs were not quantitatively examined during this study, it was very apparent from the discussion in section 2.6 above that the IC-SEP (Induced Cyclonic Separator) system would have much lower operating costs that equivalent traditional technology. These values would form the basis for valuable future studies.

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6.0 REFERENCES

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