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# Factors influencing optimal micro-screen drum filter selection for recirculating aquaculture systems

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ABSTRACT

Recirculation aquaculture systems (RAS) are susceptible to contamination due to the accumulation of waste matter including faecal material in the water. It is imperative that contaminant levels are maintained within acceptable limits. The maintenance of good water quality is a pre-requisite to the success of the fish farming operation. Micro-screen drum filters are a popular solution for the removal of suspended solid material and are nominally rated by their screen aperture size measured in microns. Negligence in this area will adversely affect animal growth rates and thus the economic performance of the system. Many variables influence mechanical filter performance, this presents a common issue during equipment selection. For simplicity, vendors have simplified selection criteria for filters to the flow capacity at vendor specified TSS levels, without reference to a specific culture species. This paper outlines a method for micro-screen drum filter selection for site and species specific applications using simple equipment, aiding in the identification of an optimal filtration solution, in terms of cost and filtration performance. Furthermore, the potential of cake filtration for increased filtration mechanical efficiency is also evaluated; this evaluation considers the impact of cake filtration on filter flow rate and mechanical filtration efficiency, for an analysis that is more representative of real world operating conditions. It has been found that the formation of a cake does not significantly increase the mechanical filtration efficiency achieved.

## 1. Introduction

As populations continue to grow worldwide, the demand for protein derived from aquatic life will also increase (Delgado et al., 2002). Declining wild fish stocks combined with the growing popularity of seafood worldwide provides an unsustainable situation for food markets. In order to preserve wild fish stock levels and satisfy the worldwide demand in a sustainable way, the expansion and further development of aquaculture is essential (Timmons et al., 2002).

One way in which this may be achieved is through the use of RAS. In order for a RAS to achieve successful operation, an optimally designed water treatment system that can continuously and effectively remove the waste products created by the culture process before they can have a detrimental effect on system water quality parameters is required.

At the forefront of optimised water treatment systems, is an effective filtration solution for the removal of solid waste. Solutions to the problems presented in solids filtration can aid in the expansion of RAS worldwide, through the reduction of capital and operational costs (Johnson and Chen, 2006). It has been shown that high levels of TSS are detrimental to animal health, and that stress may be induced (Alabaster and Lloyd, 1982; Chapman et al., 1987; Davidson and Summerfelt, 2005; Magor, 1988). If left within the re-circulated waters, these solids will influence the efficiency of all the other water treatment systems, increase the BOD placed on the system, as well as providing a habitat that enables the proliferation of pathogens (Cripps and Liltved, 1999). Management of solid particulate levels is in a RAS is required in order to safeguard culture water quality (Cripps and Bergheim, 2000). One type of solids removal system often utilised in RAS's is micro-screen drum filters.

The selection of an optimally configured micro-screen drum filter should be based on the micro-screen rating (μm), particle size distribution of the suspended solids in the RAS waters and the required water quality. The character and density of particulates in recirculation aquaculture systems is also of paramount importance for filter selection but is not well defined (Patterson et al., 2003)

### 1.1. Drum filter description

Drum filters come in varying configurations including enclosed, channel mounted, fully or partially submerged. In all

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*Abbreviations:* BOD, biochemical oxygen demand; PSD, particle size distribution; RAS, recirculation aquaculture system; RPM, revolutions per minute; TSS, total suspended solids.

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**Nomenclature and units**

| | |
|---|---|
| $A_t$ | Area of test micro screen ($m^2$) |
| $A_p$ | Area of required for process flow ($m^2$) |
| $Q_p$ | Process flow rate (L/min) |
| $Q_t$ | Maximum micro screen flow rate (L/min) |

configurations, filtration of the influent water is achieved though radial passage of the influent through a micro-screen; for aquacultural applications this is typically a 60–200 micron-screen present on the curved surface of the drum (Cripps and Bergheim, 2000). See Fig. 1.

#### 1.1.1. *Drum filter operation*

Suspended solids that are larger than the micro-screen aperture size are retained. As they accumulate on the inside of the screen, blinding of the screen will occur and cause an obstruction to the flow of water. The corresponding increase in resistance to water flow through the screen caused by blinding manifests itself as an increase in the level of influent water inside the drum. This will continue until a maximum tolerable level is reached, before which the filter must be backwashed to prevent water bypassing the screen (Greencorn, 2009).

Backwashing may be continuous or intermittent in its operation. Typically, a filter operating at continuous backwash is operating at its maximum flow capacity; continuous backwashing ensures an un-blinded screen and hence maximum flow rates can be achieved (Richardson et al., 2002). Intermittent backwashing is acceptable when there is extra flow capacity within the filter. The time duration between each backwashing event is determined by the degree of excess flow capacity. During such time intervals filter cakes may be established on the screen. This cake can also be instrumental in the filtering process, however if it is allowed to become too dense, the filtering process may be adversely affected.

#### 1.1.2. *Flow capacity of a micro-screen*

Whilst backwashing frequency is a leading contributory factor influencing the flow capacity of a filter, the filter flow capacity also depends on other factors (Boucher, 1947), including;

- Micron rating of the screen.
- Submerged area of the screen (or differential water level).
- TSS concentration of the water.
- Particle size distribution (PSD) of suspended solids in the water.

#### 1.1.3. *Filter mechanical efficiency and water quality*

The mechanical efficiency of a drum filter is important in order to quantify the performance of the unit. The mechanical efficiency is a measure of the amount of material being removed by the filter, relative to the total amount of material contained in the influent waters.

Previous studies having been conducted regarding the mechanical filtration efficiency of micro-screens in aquacultural applications (Kelly et al., 1997). Our results for micro-screen mechanical filtration efficiency are provided in Section 4.2 for comparison.

Many parameters such as particle shape and integrity influence the mechanical filtration efficiency of a micro-screen filter. However, the single most influential factor is the particle size distribution of the solids in the influent relative to the pore size of the micro-screen.

#### 1.1.4. *Particle size distribution*

In aquaculture facilities solids are primarily comprised of uneaten feed, faeces and biofloc (suspended bacterial colonies). These particles vary in size, and are characterised by size into the following classes:

- Settleable (>100 $\mu$m)
- Fines (1 < $\mu$m < 100)
- Colloidal (0.001 < $\mu$m < 1)
- Dissolved (<0.001 $\mu$m) (Timmons et al., 2002).

In relation to mechanical drum filtration, settleable solids, once entrained in the water stream are easily removed. Fine suspended solids; require greater consideration due to the higher costs incurred in their removal (Chen and Malone, 1991). Profound changes in the flow capacity of micro-screens are seen with decreasing aperture size (Section 4.1), decreasing aperture sizes are required for the removal of “Fines”.

### 1.2. *Cake filtration*

As a filter screen becomes blinded, a layer or cake of accumulated material will be formed; this may have the potential to provide greater filtration efficiencies than the screen alone (Patil, 2007). However, the formation of a cake results in an increase in the resistance to flow and hence manifests as a decrease in flow rate through the screen (Richardson et al., 2002).

The method chosen to examine the performance of cake filtration is a constant pressure method which is signified by a decreasing flow rate under constant pressure. The drum filter operates under constant rate filtration conditions, this is signified by an increasing water level (pressure) due to the deposition of a filter cake. The two methods are complimentary, with any tests carried out in one method will have analogous data in the alternate method. Therefore, cake filtration tests under constant pressure are suitable for replicating the performance of a constant rate filtration process.

This paper investigates if cake filtration increases the mechanical efficiency of filtration and also if the expected decrease in flow rate is acceptable relative to the increase in mechanical efficiency.

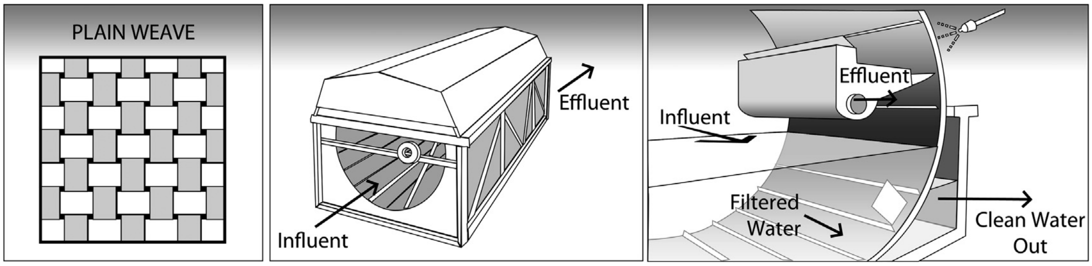

**Fig. 1.** Representation of mono-filament micro-screen, open channel drum filter and operating principle of drum filter showing routes of water streams.