

DESIGN AND EVALUATE A DRUM SCREEN FILTER DRIVEN BY UNDERSHOT WATERWHEEL FOR AQUACULTURE RECIRCULATING SYSTEMS.

Samir Ahmad Ali*

ABSTRACT

Micro-screen rotating drum filters are an alternative to sand filtration especially when excessive waste water is a concern. The filtering process of drum screen filters is very simple, yet very efficient and reliable due to their overall design and operation. Drum filters are designed with few moving parts to ensure a long life with low operating/ maintenance costs. Micro-screening essentially captures particles on a screen fabric while letting the water pass. This paper describes a design of an industrial-scale drum screen filter driven by undershot wheel and its performance installed in recirculating aquaculture system culturing tilapia at El-Nenaeia fish farm. The results indicate that the design parameters of the filter such as surface area and rotation speed were affected by the water flow rate, where the surface area and drum speed ranged from 1.58-27.87 m², and 1.05-8.40, respectively. The results also indicated that the efficiency of filter decreased during the first two months compared to the last two months of fish growth period, with an average 34.22 ±8.85% during the first 60 days and an average 52.41 ±16.77 % during the last period.

Using water wheels for driving the screen filter is very important in saving energy, where the filter with such dimensions needs 1.0 hp for driving it, which represents 18.0 kW daily.

Keywords: Undershot - Waterwheel – Recirculating system – Design drum filter

1. INTRODUCTION

Water quality maintenance in recirculating aquaculture systems (RAS) is focused on the detoxification of nitrogenous wastes, oxygenation, removal of suspended solids and controlling the accumulation of organic compounds. Once the system's oxygen

*Agric. Eng. Dept., Fac. Agric., Moshtohor, Toukh, Qalubia, P.O. Box, 13736, Egypt.
Phone: +2 013 2467 034 Fax: +2 013 2467 786 E-Mail samir.ali@fagr.bu.edu.eg

requirement, which includes that needed for fish respiration and microbial processes, is met, nitrogenous wastes, primarily management and removal of solids is one key process in an RAS. In recirculating finfish systems the main particulate waste materials are feces, uneaten feed, decaying fish, and tank and pipes biofilm slough (Chen et al., 1993; Patterson and Watts, 2003). Since the adverse effects of solids on recirculating systems were recognized, research on solids removal has been recommended by many investigators (Brinker et al., 2005; Summerfelt and Penne, 2005; Davidson and Summerfelt, 2005; Steicke et al., 2007; Merino et al., 2007; Bai, 2007; Timmons and Ebeling, 2007; Sandu et al., 2008; Pfeiffer et al., 2008; Couturier et al., 2009; d'Orbcastel et al., 2009). Solids that are not removed from the RAS have numerous consequences for the fish in the system and system components. The presence of suspended solids in recirculating finfish aquaculture systems can cause damage to fish gills, increase biochemical oxygen demand, reduce biofilter nitrification, and increase ammonia in the system (Chapman et al., 1987; Bergheim et al., 1998; Wong, 2001; Zhu and Chen, 2001). The solids found in RAS operations vary in size and settling properties and have an effect in the design and operation of the solid removal mechanisms (Merino et al., 2007). All recirculating aquaculture systems utilize processes to remove waste solids, oxidize ammonia and nitrite-N, and aerate and/or oxygenate the water. Methods or processes that improve solids removal also improve water quality, which can potentially enhance production and certain operating costs. However, selection of the best treatment system for a particular aquaculture operation is difficult, given the variety of processes available, and the lack of uniform methodology for evaluation of water treatment effectiveness and economic accounting and other practical considerations (Bai, 2007 and Timmons and Ebeling, 2007).

The effective management of solids in aquaculture is one of the major obstacles to the continued development of the aquaculture industry (Piedrahita et al., 1996) and is often considered the most critical process to manage in aquaculture systems (Summerfelt, 1996).

Feed input into the system controls the production of solids and particulate matter (feces and uneaten feed). Solids and particulate matter

are the major sources of carbonaceous oxygen demand and nutrient input into the water, especially if they degrade within the system. The feed portion is not assimilated by the fish excreted as an organic waste (fecal solids) and the uneaten feed consume dissolved oxygen and generate total ammonia nitrogen (TAN) when broken down by bacteria within the system (Timmons and Ebeling, 2007).

Microscreening is very common in the potable and wastewater industries where a woven metal mesh or fabric of 15-200 μm may be attached to the periphery of a rotating drum typically 1.0-3.3 m diameter and 0.6-5.1 m long. Flow enters in the center and is radially filtered through the drum mesh. The drum rotates and the solids retained on the screen are removed in a section by back-flushing with the previously filtered water. A separate launder takes the back-flush suspension off for further processing. Rotation speed usually varies from 20 to 120 s, and flow rates of up to 3900 $\text{m}^3 \text{h}^{-1}$ for single unit are claimed (Anon, 1993). Rotational speed usually fixed (4.6 to 26 m min^{-1} , tangentially) (Patterson, 2001).

Rotating microscreens are an alternative to primary sedimentation (Tchobanoglous and Burton 1991) and so have been more commonly installed at farms in recent years. These usually comprise a fine mesh screen (often 60 to 200 mm pore size) in the form of a rotating drum or disc through which the wastewater is passed. Particles held back on the mesh are backwashed or scraped, to a waste collection trough. Rotating microscreens are especially suited to applications where blockage is likely (Wheaton, 1977), and so are used in fish farms because of the large flow of wastewater which must pass through the screen and the small screen pore size which is required to separate out the solids.

Several workers (Liltved and Hansen, 1990; Bergheim et al., 1991; Ulgenes, 1992b; Bergheim et al., 1993a,b) have tested the treatment efficiency of a commercially available Unik disc microscreen. Similar to the drum screen results, treatment efficiency estimates using this unit vary considerably, both due to variations in effluent quality and characteristics, and with the pore size of the screens chosen. Ulgenes (1992b) testing 250- and 120-mm pore screens together achieved a wide range of SS removal efficiencies of 16–94%, whilst Bergheim et al. (1991) achieved an

average 40% suspended dry matter (SDM) removal using 35 and 60-mm pore size screens.

The capacity of a drum screen is proportional to its length and its diameter, while the capacity of a disc screen is limited by the diameter (Wheaton, 1977). Drum microscreens are therefore not as capacity limited as disc screens. In practice however, at high flow rates, such as those in aquaculture applications, several disc or drum units are operated in parallel. This also allows for a unit to be out of operation, for repair or maintenance.

The main aim of this work is to design and evaluate a microscreen rotating filter driven by undershot waterwheel for aquaculture recirculating systems to remove solids with less power consumption.

2. MATERIALS AND METHODS.

2.1. Design Objectives.

The intended design of drum screen filter is to serve a commercial recirculating aquaculture system, which was described by Ali et al., 2006 (Fig. 1). Water exiting the culture tanks A1, A2 and A3 (145 m^3) flowed through two industrial drum screen filter (E) (1.35m diameter, 1.85m long) and was then directed through two industrial scale rotating biological contactor (RBC) unit. The treated water was then pumped downflow oxygenation system before reentering the culture tank. Each RBC unit was constructed and positioned with the central axis perpendicular to the treatment flow (Figure 1). The two drum screen filters were equally sized (1.35m diameter, 1.85m long). The drum screen filters were operated at 40% submergence.

These filters are consisted of a woven metal mesh $100 \mu\text{m}$. Flow enters in the center and is radially filtered through the drum mesh. The drum rotates and the solids retained on the screen are removed in a section by back-flushing with the previously filtered water. A separate launder takes the back-flush suspension off for further processing. Rotation speed usually varies from 3 to 6 rpm, and flow rates of up to $130 \text{ m}^3 \text{ h}^{-1}$ for single unit are claimed (Fig. 2).

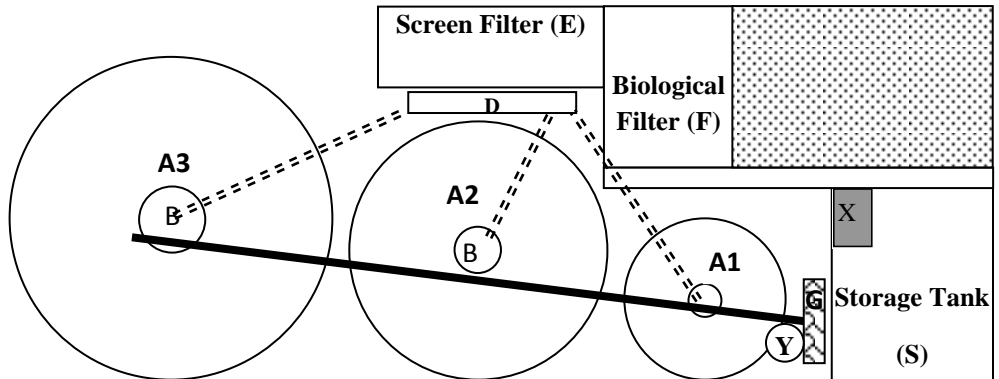


Fig. (1). Sketch of the water recycle system. Fish tank, A; particle trap, B; channel collector, D; screen filter, E; biological filter, F; storage tank, S; pumps, G; heat exchanger, X; Downflow oxygen contactor, Y.

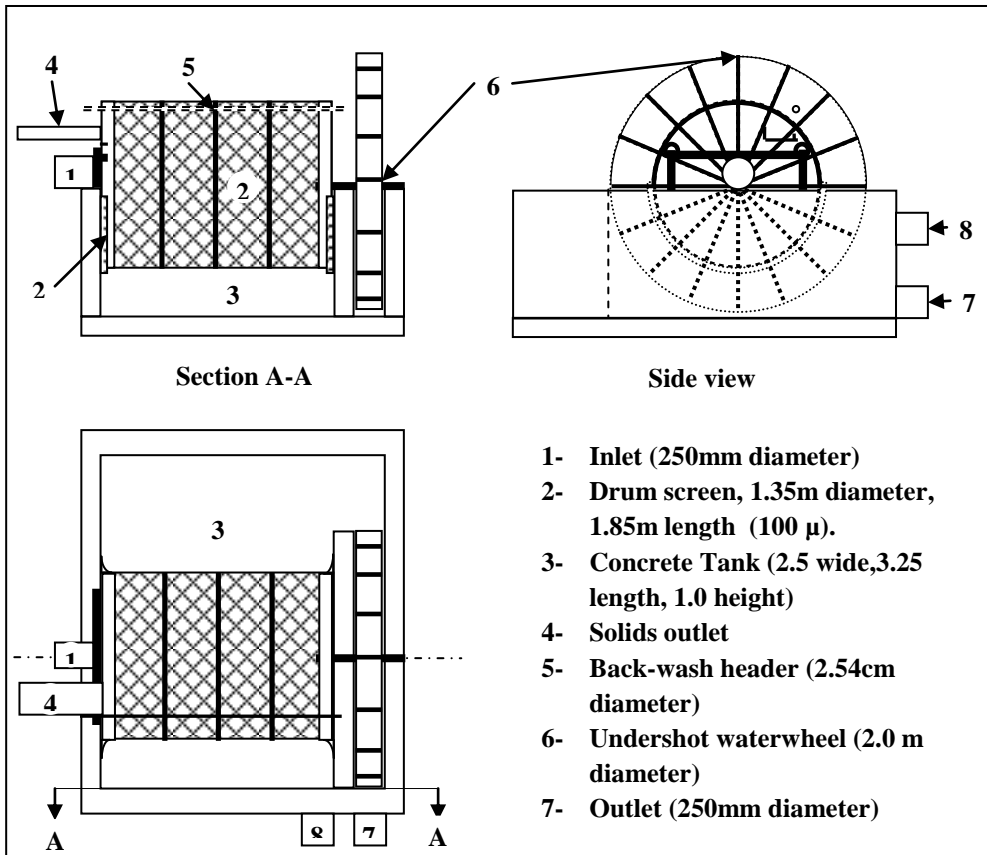


Figure (2): Layout of drum screen filter.

2.2. Drum Screen Filter Design and Manufacture.

2.2.1. Drum screen design:

Six factors are considered in the hydraulic design of a microscreen: maximum flow rate, allowable head losses, porosity of the medium, effective submerged surface area, drum speed and characteristics of the feed. These factors are numerically combined in Boucher's filterability index for water (Rushton, et. al., 2000).

The design procedures for microscreens are detailed in the following steps (US Army, 1978).

2.2.1.1. Input Data

(a) Wastewater flow:

1. Average flow, $l\ min^{-1}$
2. Peak flow, $l\ min^{-1}$

(b) Suspended solids concentration, $mg\ l^{-1}$.

(c) Effluent requirements, $mg\ l^{-1}$.

2.2.1.2 Design Parameters

(a) Head loss across microscreen, m., $\cong 0.0152$ m. water.

(b) Initial resistance of clean filter fabric, in m, at a given temperature and standard flow conditions. Manufacturer's requirements.

(c) Filterability index of influent measured on fabric in use (volume of water obtained per unit head loss when passed at a standard rate through a unit area of standard filter). From laboratory study.

(d) Speed of strainer (number of square meter of effective fabric entering water in given time), m^2/min (1.3–2.4 m^2/min).

(e) Constants: $m = 0.0267$; $n = 0.1337$.

2.2.1.3 Design Procedures

Wheaton (1977) discusses Boucher' (1947) design equation for microscreens:

(a) The effective submerged area of the screen could be calculate using the following equation:

$$A = \frac{mQC_f e^{nIQ/40.65S}}{488.25H}$$

where A = effective submerged area, m^2 ; $m = 0.0267$; Q = total rate of flow through unit, $l \text{ min}^{-1}$; C_f = initial resistance of clean filter fabric, m , at a given temperature and standard flow conditions (manufacturer's requirements) (0.549 m for 23- μm , 0.3048 m for 35- μm screen, 0.152 m for 100- μm screen); $n = 0.1337$; I = filterability index of influent measured on fabric in use (laboratory) = 0.5; S = speed of strainer, m^2/min ; H = head loss across microscreen, m , $\cong 0.0152 \text{ m}$.

(b) Hydraulic rate of application is calculated as follows:

$$HR = \frac{Q}{A_s}$$

where HR = hydraulic rate, $l \text{ min}^{-1} m^{-2}$; A_s = screen area, m^2 .

(c) Calculate solids rate of application.

$$SR = \frac{Q \times C_i}{A_s \times 10^6}$$

where SR = solids loading rate, $kg \text{ m}^{-2} \text{ min}^{-1}$; C_i = influent suspended solids, $mg \text{ l}^{-1}$.

(c) The amount of backwash water is determined as:

$$BW = (3-6\%)(Q)$$

where BW = backwash rate, $l \text{ min}^{-1}$.

2.2.1.4. Output Data

(a) Effective submerged area, m^2 .

(b) Hydraulic rate of application, $l \text{ min}^{-1} m^{-2}$.

(c) Solids rate of application, $kg \text{ m}^{-2} \text{ min}^{-1}$.

2.2.2. Conventional undershot waterwheel design.

To estimate the speed of undershot waterwheels is consider fig. (3). we assuming that wheel radius is large, so that the water flow is normal to the vanes. Thus, if the effective water wheel area is A_v , then the mass of water that presses against each vane per unit time is:

$$m = \rho A_v (v - v')$$

$v' = \omega R \equiv cv$ is the mean water speed afterwards, both assumed constant.

Thus we expect $0 < c < 1$. This peaks for $c = \frac{1}{3}$ (so that the waterwheel vanes move at a third of the initial water speed in the millrace) so that the maximum efficiency of the undershot waterwheel is about 30%.

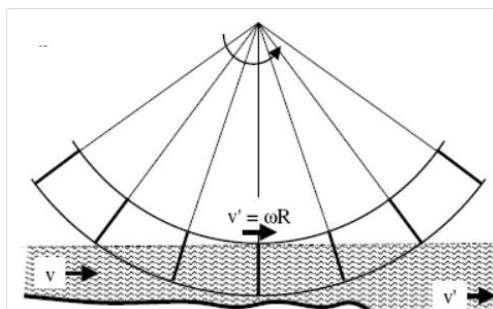


Fig. (3)

Table (1) illustrates the farm characteristics which used the intended design of the drum screen filter will serve.

Operating the previous steps using the design parameters of table (1), table (2) shows the results upon which the filter was manufactured.

Table (1): Given farm characteristics.

Characteristic	Tank	Tank	Tank
Water Volume (m ³)	20	50	75
Final Fish Density (kg m ⁻³)	35	120	250
Feed Protein Content (%)	40%	30%	25%
Number of Fish per Tank	20,000		
Water flow rate, l min ⁻¹	800	1300	2050
Water flow rate, l min ⁻¹	2100		2050

2.3. Drum Filter Manufacture.

The two units of drum screen filters were (1.35m diameter, 1.85m length) manufactured from stainless steel at private company for steel industry. The units were driven by undershot waterwheel to give the recommended rotating speed (3-6 rpm).

Table (2): The design results of drum screen filter.

Item	Abbreviation	Unit	Value
Peak water flow rate	Q	l min ⁻¹	4150
Effective submerged area	A	m ²	0.693
Hydraulic rate of application	HR	l min ⁻¹ m ⁻²	2956
Solids loading rate	SR	kg m ⁻² min ⁻¹	0.0026
Screen area	As	m ²	7.75
Rotating speed	ω	rpm	1.05-8.40
Amount of backwash water	BW	l min ⁻¹	123
Undershot waterwheel diameter	R	m	2.0
No. of waterwheel puddles		No	16
Width of waterwheel puddle		m	0.2
Drum diameter		m	1.35
Drum length		m	1.85
No. of units (drums)		No	2

2.4. Sample collection and analysis

Water samples were collected daily at the inlet and the outlet of the screen filter for measuring suspended solids according to APHA (1998). The samples were stored in refrigeration for analysis. Unionized ammonia (NH₃), nitrite and nitrate were measured by an ion selective electrode (ORION 710). Dissolved oxygen was measured by a digital oxygen analyzer (ORION 810), provided with a dissolved oxygen prop (No. 81010). The pH was measured by the pH meter (ORION 230A), provided with pH electrodes (No. 910500).

2.5. Feed Management.

In feeding the fish, the recommendations of feeding rates for different size groups of tilapia in tanks of Rakocy, 1989 and, the recommendations of Jauncey and Ross, 1982 for the feed pellets diameter were used.

2.6. Drum screen filter efficiency

Drum screen filter efficiency was calculated as follows:

$$\eta_f = \frac{SS_{f_{in}} - SS_{f_{out}}}{SS_{f_{in}}} \times 100$$

where $SS_{f_{in}}$ = the suspended solids at the inlet the screen filter, $mg\ l^{-1}$; $SS_{f_{out}}$ = the suspended solids at the outlet the screen filter, $mg\ l^{-1}$; η_f = the screen filter efficiency for suspended solids (%)

3. RESULTS AND DISCUSSION

3.1. Water quality monitoring.

Dissolved Oxygen was monitored before and after downflow oxygen contactor. pH, unionized ammonia, nitrite and nitrate were monitored before and after rotating biological contactor (RBC) during the study period; the results are summarized in table (3). It indicate that the dissolved oxygen ranged from 4.6 to 5.4 $mg\ l^{-1}$ with an average of 5.0 $\pm 0.4\ mg\ l^{-1}$ and from 6.5 to 7.7 $mg\ l^{-1}$ with an average of 7.1 $\pm 0.6\ mg\ l^{-1}$ over the study before and after the downflow oxygen contactor, whereas water pH stayed in the range of 6.7 to 7.7. Unionized ammonia concentration ranged from 0.0093 to 0.018 $mg\ l^{-1}$ with an average of 0.0131 $\pm 0.0027\ mg\ l^{-1}$ and from 0.005 to 0.0135 $mg\ l^{-1}$ with an average of 0.0083 $\pm 0.0027\ mg\ l^{-1}$ over the study before and after the (RBC), respectively. Nitrite–nitrogen concentration over the same period varied from 0.05 to 0.62 $mg\ l^{-1}$ with an average of 0.26 $\pm 0.19\ mg\ l^{-1}$ and from 0.03 to 0.46 $mg\ l^{-1}$ with an average of 0.18 $\pm 0.15\ mg\ l^{-1}$ before and after the RBC, respectively. Nitrate–nitrogen concentration over the same period varied from 0.409 to 18.94 $mg\ l^{-1}$ with an average of 4.0 $\pm 4.56\ mg\ l^{-1}$ and from 1.39 to 34.93 $mg\ l^{-1}$ with an average of 8.4 $\pm 8.4\ mg\ l^{-1}$ before and after the RBC, respectively.

Table (3): Water quality monitoring.

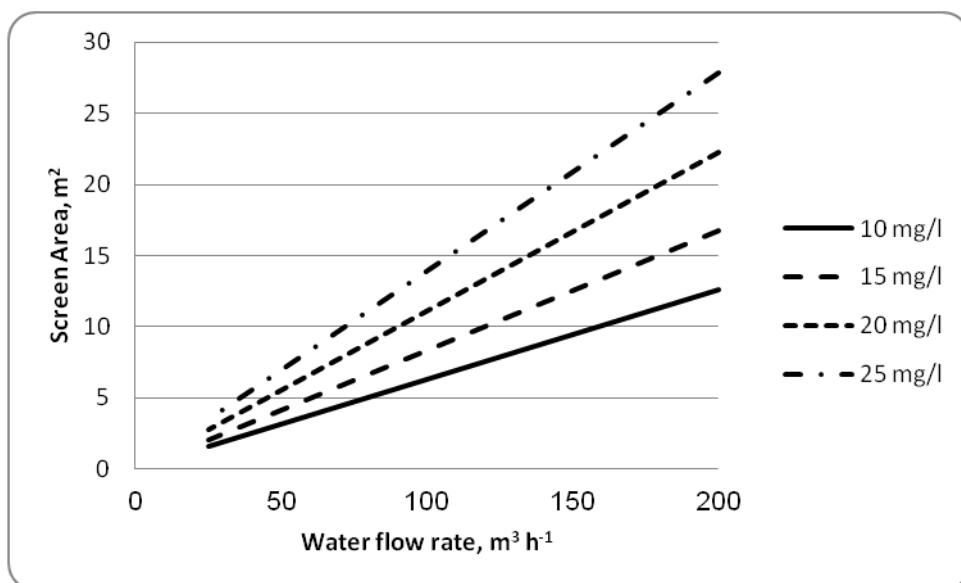
Item	Before	SD	After	SD
Dissolved Oxygen ($mg\ l^{-1}$)	5.0	± 0.4	7.1	± 0.6
pH	6.7	± 0.4	7.7	± 0.7
Unionized ammonia ($mg\ l^{-1}$)	0.0131	± 0.0027	0.0083	± 0.0027
Nitrite ($mg\ l^{-1}$)	0.26	± 0.19	0.18	± 0.15
Nitrate ($mg\ l^{-1}$)	4.0	± 4.56	8.4	± 8.4

The data in the table indicated that water quality in the system remained excellent of tilapia production according to **Boyd (1982), Lawson (1995) and Soderberg (1995)** during the study.

3.2. Effect of water flow rate on design parameters of the drum screen filter.

3.2.1. Screen surface area.

The screen surface area of the filter was affected mainly by the water flow rate through it. Fig. (4) shows the effect of water flow rate on the screen surface area at different solids concentrations (10-25 mg l⁻¹). It could be seen the required surface area of the filter increased linearly with increasing the water flow rate, were increased from 1.58-27.87 m² when the flow rate increased from 25-200 m³h⁻¹ at different solids



concentrations (10-25 mg l⁻¹).

Fig. (4): Effect of water flow rate and solids concentration on screen surface area.

3.2.2. Rotation speed of the filter.

Selection of the rotational speed of the drum filter and its relationship with the water flow is shown in fig. (5). The results indicate that the drum speed increased with increasing the water flow rate, where it ranged from 1.05-8.40 rpm at different flow rates that ranged from 25-200 m³h⁻¹.The

relationship between the measured and predicted drum speeds as shown in figure (5) indicated that the measured drum speed was lower than the predicted values, where it ranged from 0.6-5.7 rpm, which is attributed to the water leakage through the undershot waterwheel puddles which is not considered during the calculation of the drum speed. The recommended drum speed of these kinds of filters ranged from 3-6 rpm (Patterson, 2001).

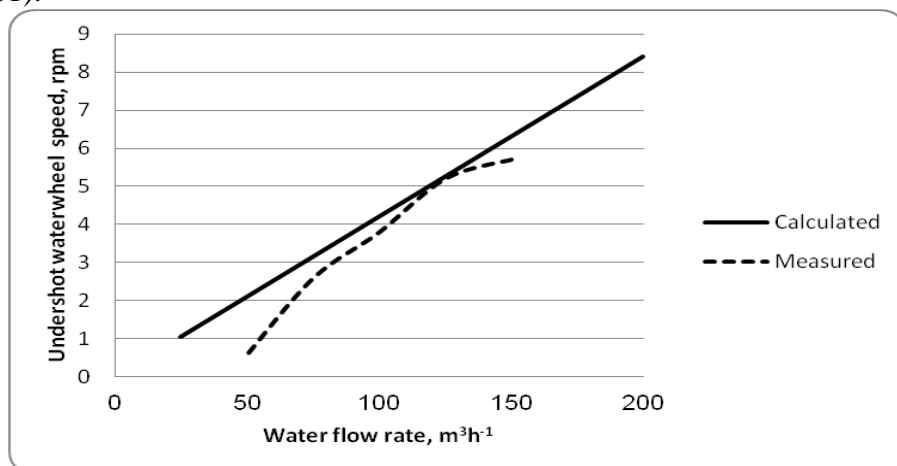


Fig. (5): Effect of water flow rate on undershot waterwheel speed.

3.3. The drum filter efficiency:

The efficiency of the drum filter was determined by measuring the suspended solids concentration in the water entering and leaving the drum. Since the drum was continuously rotated and the backwash water was always on, this provided a convenient means of measuring drum efficiency. The data presented in fig. (6) shows the efficiency of the drum filter. It could be seen that the efficiency of filter decreased during the first two months compared to the last two months of fish growth period, with an average $34.22 \pm 8.85\%$ during the first 60 days and an average $52.41 \pm 16.77\%$ during the last period. This could be due to that the efficiency is greatly dependent inversely on the suspended solids entering the filter. These solids are affected by the rate and shape of feeds and the rate of feces of fish. At the early age of fish, feeds are added as a powder, which causes more loss in the water before filtering. By the time, feeds are served to the fish as pellets which decrease the loss of particles in the

water which in turn increase the efficiency of the filter. These results are in agreement with those obtained d'Orbcastel et al (2009) whose found that the suspended solids efficiency of $40 \pm 18.5\%$.

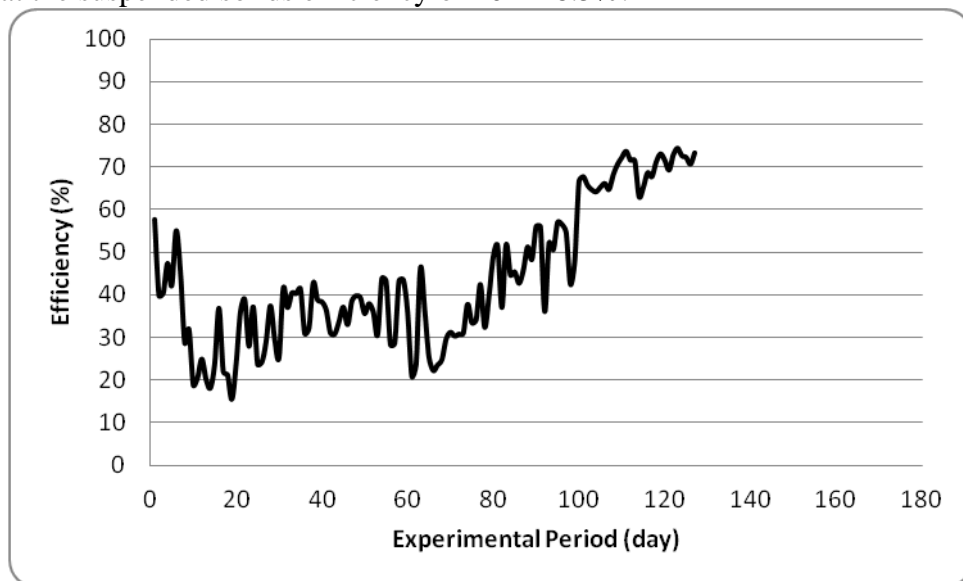


Fig. (6): The efficiency of the removal suspended solids (%)

Conclusions:

A micro-screen drum filter was designed and evaluated within a recirculating aquaculture system. The drum surface area and rotating speed were mainly affected by the water flow rate through the system, the screen surface area of the filter ranged from 1.58-27.87 m² at different water flow rate (25-200 m³h⁻¹), meanwhile, the designed drum rotation speed ranged from 1.05-8.40 rpm at previous flow rate. The results also indicated that the efficiency of filter decreased during the first two months compared to the last two months of fish growth period, with an average 34.22 ±8.85% during the first 60 days and an average 52.41 ±16.77 % during the last period. Using water wheels for driving a screen filter is very important in saving energy, where the filter with our dimensions need 1.0 hp for driving it, which needs 18.0 kW daily.

Acknowledgement

The financial support of this work from Eng. Ahmad Gharieb, the owner of El-Nenaia Company (One of Gharieb Group), Egypt. The author is highly acknowledged.

REFERENCES

- Ali SA, El-Haddad ZA, Ghareib A, (2006) Design and Management of El-Nenaia Fish Farm: as a Recirculating Aquaculture System. *Misr Journal of Agricultural Engineering*, 23 (2): 396–408.
- Anon, (1993) Filtration and Separation. 30: p 289.
- APHA, (1998) Standard Methods for Examination of Water and Wastewater, American Public Health Association, American Water Works Association, Water Pollution Control Federation Washington, DC.
- Bai C, (2007) President's column. *World Aqua. Mag.*, 38 (4): 3.
- Bergheim A, Kristiansen R, Kelly LA, (1993a) Treatment and utilization of sludge from land based farms for salmon. In: Wang, J.-W. (Ed.), *Techniques for Modern Aquaculture. Proceedings of an Aquaculture Engineering Conference, 21–23 June 1993, Spokane, WA. American Society of Agriculture Engineers, St. Joseph, MI, pp. 486–495.*
- Bergheim A, Cripps S, Litved H, (1998) A system for the treatment of sludge from land-based fish farms. *Aquatic Living Resources*, 11: 279 –287.
- Bergheim A, Sanni S, Indrevik G, Hølland P, (1993b) Sludge removal from salmonid tank effluent using rotating microsieves. *Aquacultural Engineering*, 12, 97–109.
- Bergheim A, Tyvold T, Seymour EA, (1991) Effluent loadings and sludge removal from landbased salmon farming tanks. In: *Proceedings of Aquaculture Europe'91: Aquaculture and the Environment International Aquaculture Conference, Dublin, Ireland, 10–12 June, 1991. EAS Special Publ. 14. EAS, Bredene, Belgium, p. 27.*
- Boucher PL, (1947) A new measure of filterability of fluids with application to water engineering, *ICE J. (British)*, 27(4): 415 – 446.
- Boyd CE, (1982) *Water Quality Management for Pond Fish Culture.* Elsevier, Amsterdam.

- Brinkera A, Schröder HG, Röscha R, (2005) A high-resolution technique to size suspended solids in flow-through fish farms. *Aquacultural Engineering*, 32 (4): 325–341.
- Chapman PE, Popham J.D, Griffin J, Michaelson J, (1987) Differentiation of physical from chemical toxicity in solid waste fish bioassay. *Water, Air, and Soil Pollution* 33: 295–309.
- Chen S, Timmons MB, Aneshansley DJ, Bisogni JJ, (1993) Suspended solids characteristics from recirculating aquacultural systems and design implications. *Aquaculture*, 112: 143–155
- Couturier M, Trofimencoff T, Buil JU, Conroy J, (2009) Solids removal at a recirculating salmon-smolt farm. *Aquacultural Engineering*, 41 (3): 71–77.
- d’Orbecastel RE, Blancheton JP, Belaud A, (2009) Water quality and rainbow trout performance in a Danish Model Farm recirculating system: Comparison with a flow through system. *Aquacultural Engineering*, 40 (2): 135–143.
- Davidson J, Summerfelt ST, (2005) Solids removal from a coldwater recirculating system—comparison of a swirl separator and a radial-flow settler. *Aquacultural Engineering*, 33(1): 47– 61.
- Douglas JF, Matthews RD, (1996) *Fluid Mechanics* (Harlow, UK: Longman)
- Jauncey K, Ross B, (1982) *A Guide to Tilapia Feeds and Feeding*. Institute of Aquaculture, University of Sterling, Scotland, 111 pp.
- Liltved H, Hansen BR, (1990) Screening as a method for removal of parasites from inlet water to fish farms. *Aquacultural Engineering*, 9: 209–215.
- Lawson TB, (1995) *Fundamental of Aquacultural Engineering*. Elsevier Scientific Publishers, Amsterdam.
- Merino GE, Piedrahita RH, Conklin DE, (2007) Settling characteristics of solids settled in a recirculating system for California halibut

- (*Paralichthys californicus*) culture. *Aquacultural Engineering*, 37(2): 79 – 88.
- Patterson RN, (2001) Micro-particles in recirculating aquaculture systems. Ph.D, Dalhousie University, Halifax, Nova Scotia.
- Patterson RN, Watts K, (2003) Micro-particles in recirculating aquaculture systems: microscopic examination of particles. *Aquacultural Engineering*, 28 (2): 115–130.
- Pfeiffer JT, Osborn A, Davis M, (2008) Particle sieve analysis for determining solids removal efficiency of water treatment components in a recirculating aquaculture system. *Aquacultural Engineering*, 39 (1): 24 – 29.
- Piedrahita RH, Giovannini P, (1989) Diel aquaculture models: listings, descriptions and operating instructions. Technical Committee Meeting 1989, PD/A CRSP, Davis, CA, 50 pp.
- Rakocy JE, (1989) Tank culture of tilapia. In the biology and culture of tilapia, ed. R. S. V. Pullin & R. H. Lowe-McConnell-ICLARM conference proceedings 7. International center for living aquatic resources management, manila, the Philippines.
- Rushton A, Ward AS, Holdich RD, (2000) *Solid-Liquid Filtration and Separation Technology*, Second, completely revised edition. P: 249.
- Sandu S, Brazil B, Hallerman E, (2008) Efficacy of a pilot-scale wastewater treatment plant upon a commercial aquaculture effluent I. Solids and carbonaceous compounds. *Aquacultural Engineering*, 39 (2): 78–90.
- Soderberg RW, (1995) *Flowing Water in Fish Culture*. Lewis Publishers, Boca Raton, Florida.
- Steicke C, Jegatheesan V, Zeng C, (2007) Mechanical mode floating medium filters for recirculating system in aquaculture for higher solids retention and lower freshwater usage. *Bioresource Technology*, 98 (17): 3375 – 3383.

- Summerfelt RC, Penne CR, (2005) Solids removal in a recirculating aquaculture system where the majority of flow bypasses the microscreen filter. *Aquacultural Engineering*, 33 (2): 214 – 224.
- Summerfelt ST, (1996) Engineering design of modular and scaleable recirculating systems containing circular tank, microscreen filters, fluidized-sand biofilters, cascade aerators, and low head or u-tube oxygenators. In *Successes and Failures in Commercial Recirculating Aquaculture*, editors Northeast Regional Agricultural Engineering Service (NRAES). NRAES-98, 1: 217 – 244.
- Tchobanoglous G, Burton FL, (1991) *Wastewater Engineering: Treatment, Disposal and Reuse*, 3rd edn. McGraw-Hill, New York, p. 1334.
- Timmons MB, Ebeling JM, (2007) *Recirculating aquaculture*. Cayuga Aqua Ventures, Ithaca, NY.
- Ulgenes Y, (1992a) Undersøkelse av utslippsmengder, renseutstyr og slambehandlings-metoderved settefiskanlegg. Delrapport I: Renseeffekt og driftserfaring med HYDROTECH trommelfilter. SINTEF NHL Report No. STF60 A92071. SINTEF, Trondheim, Norway, 25 pp. [in Norwegian].
- Ulgenes Y, (1992b) Undersøkelse av utslippsmengder, renseutstyr og slambehandlingsmetoder ved settefiskanlegg. Delrapport III: Renseeffekt og driftserfaring med UNIK hjulfilter type 1200. SINTEF NHL Report No. STF60 A92100. SINTEF, Trondheim, Norway, 25 pp. [in Norwegian].
- US Army, (1978) *Engineering and Design—Design of Wastewater Treatment Facilities Major Systems*, Engineering Manual No. 1110-2-501, U.S. Army, Washington, DC.
- Wheaton FW, (1977) *Aquacultural Engineering*. Wiley, Chichester, UK.
- Wong K, (2001) Enhanced solids removal for aquaculture raceways. Doctoral Dissertation. Biological and Agricultural Engineering, University of California, Davis, CA.
- Zhu S, Chen C, (2001) Effects of organic carbon on nitrification rate in fixed film biofilters. *Aquacultural Engineering*, 25 (1): 1–13.

الملخص العربي

تصميم وتقييم مرشح شبكي إسطواني يدار بالساقية ذات الدفع السفلي في نظام إعادة تدوير المياه في الزراعة المائية

سمير أحمد على*

تعتبر المخلفات الصلبة ذات تأثير ضار على الأسماك في نظم إعادة تدوير المياه في الزراعة المائية، حيث يكون الهدف الأول في تلك النظم هو إزالة المخلفات الصلبة. ويعتبر مصدر المخلفات الصلبة هو إخراج الأسماك والبكتريا الميتة أو الحية وبقايا الغذاء الذي لم يؤكل. وتعد عملية الترشيح الميكانيكي من أهم العمليات في الاستزراع المائي، للتخلص بصفة مستمرة من تلك المخلفات. وتعتبر المرشحات الشبكية أبسط أنواع المرشحات المستخدمة في تلك النظم لأنها تعمل تحت ضغط منخفض ولا تشغل مساحة كبيرة من الأرض. ويقوم المرشح الشبكي بحجز المخلفات الصلبة العالقة في المياه التي قطرها أكبر من قطر فتحات الشبكة (٤٠-١٠٠ ميكرون) ويتوافر المرشح الشبكي بأشكال مختلفة منها المرشح الإسطواني. ومن ثم كان الهدف من هذه الدراسة هو تصميم وتقييم مرشح شبكي إسطواني يتم تدويره عن طريق ساقية ذات الدفع السفلي. وهذا المرشح هو جزء من مكونات المزرعة السمكية المكثفة الذي سبق وصفها في الدراسة التي قام بها على وآخرون (٢٠٠٦)، وكانت أهم نتائج الدراسة مايلي:

- بالنسبة لتأثير معدل سريان المياه على المساحة السطحية لشبكة المرشح عند تركيزات مختلفة للمخلفات الصلبة (١٠-٢٥ ملجرام لتر^{-١}). نجد أن مساحة شبكة المرشح الشبكية تزداد خطياً مع زيادة معدل سريان المياه التي تمر خلال المرشح، حيث تزداد المساحة السطحية من ١.٥٨-٢٧.٨٧ م^٢ عند زيادة معدل السريان المار خلال المرشح من ٢٥-٢٠٠ م^٣ ساعة^{-١}، عند تركيزات مختلفة من المخلفات الصلبة.
- بالنسبة لتأثير معدل سريان المياه على السرعة الدورانية للمرشح. نجد أن سرعة المرشح الدورانية تزداد مع زيادة معدل سريان الماء المار خلال المرشح الشبكي، حيث تراوحت السرعة بين ١.٠٥-٨.٤٠ لفة د^{-١} عند زيادة معدل السريان المار خلال المرشح من ٢٥-٢٠٠ م^٣ ساعة^{-١}. ثم تم مقارنة النتائج المحسوبة بالنتائج المقاسة، حيث تبين من المقارنة إنخفاض القيم المقاسة عن القيم المحسوبة.
- إما بالنسبة لكفاءة المرشح فقد حسبت عن طريق قياس تركيز المخلفات الصلبة العالقة في المياه عند دخول وخروج المرشح. وأوصحت النتائج إنخفاض كفاءة المرشح في بداية التجربة ولمدة شهرين حيث كان متوسطها ٣٤.٢٢ ± ٨.٨٥% خلال الـ ٦٠ يوم الأولى وهذا يرجع إلى أن التعذية في البداية كانت تعتمد نوع البودرة، إلا أنها ارتفعت بعد ذلك، حيث وصلت إلي ١٦.٧٧ ± ٥٢.٤١% وذلك للتغذية على العلف الطافي.

* أستاذ الهندسة الزراعية المساعد - كلية الزراعة بمشهر - جامعة بنها