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PERFORMANCE EVALUATION OF DRIP IRRIGATION SYSTEM USING TWO TYPES OF IRRIGATION WATER

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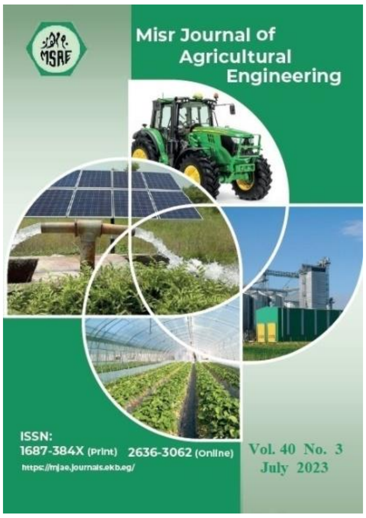


Keywords:
Irrigation; Fish waste water; Integrated culture; Fish effluent; Drip irrigation.

ABSTRACT

The acute lack of water in many arid and semi-arid countries is regarded as one of the major challenges to agricultural production globally. In such areas, fish farm drainage water would be a reliable water source.. Emitter clogging is the major factor limiting the effectiveness of fish farm drainage water drip irrigation systems. In this regard, great precision in the filtering process is necessary to provide increased efficiency when using fish farm drainage water with drip irrigation systems. From September 2021 to April 2022, the field experiment was carried out in the Wadi El Natroun region of Egypt's Beheira Governorate (29° 52° 31° N, 31° 30° 35° E). This study's primary objective was to assess the effectiveness of three distinct emitter types (GR line D1, Out line D2 and Flat line D3) in two types of irrigation water (well water and fish farms drainage water). Iron screen measuring 60 cm long by 22 cm diameter and a cylindrical inner filtration unit measuring 60 cm long × 15 cm wide made up the filtration unit. The main results revealed that fish farm drainage water caused more clogging for all investigated emitter types. The outline emitter was less clogged while the GR emitter was the most clogged one in all tested treatments. The outline emitter is recommended to be used with fish farms drainage water and need further study, while flat emitter is suggested to be used with high quality irrigation water.

1. INTRODUCTION

Water shortage is a serious issue the globe now faces, hence drainage water reuse is gaining popularity as a solution to expand the supply of water. The drainage water from fish farms is thought of as a substitute safe source of irrigation and nitrogen throughout the season, where the excessive use of mineral nitrogen fertilizers exceeds the main cost of crop production and degrades the agricultural environment, which also has an impact on the fertility of the soil. The availability of a continuous source of nitrogen during all development phases results from using fish farm drainage water for green-leaf crops, which aids in the continued growth without interruption and has a beneficial impact on the quality features. Every day, one feddan provided between 10 and 15 percent of fish drainage water (FW) (FAO Fish. Aquac. Dep. Rome, 2014). Water saving is only one of the many benefits of using drip irrigation to distribute treated fish water effluent Lamm and Camp (2006). It was determined that the drainage water from fish ponds may be used to irrigate different crops, and it was noted that this might increase while at the same time reducing the quantity of fertilisers needed to grow crops (Elmetwalli and Amer., 2019). Future availability to fresh water or well water (WW) in arid and semi-arid regions of the world may be severely hampered by population increase and restricted water supplies (Yerli et al., 2023). Since neither industry nor life would be possible without water, it is an extremely valuable natural resource. Since a permanent settlement cannot be established without a consistent supply of fresh water, water is crucial to the development of nations (Hashem and Bin., 2021). High amounts of suspended particles, nutrients (particularly N and P), and organic matter contaminate fish water effluent, which makes clogging of emitters in drip irrigation systems a serious issue. The causes of clogging may be broken down into three main groups. The first, Physical factors, such as suspended particles; Chemical factors, such as precipitation reactions; the second, Biological factors, such as microbe growth and metabolism, or biofilm creation (Rowan et a.l, 2013). An important step towards resolving the issue of irrigation water scarcity is the use of drainage water from fish farms to irrigate crops. Plants grow quickly with dissolved nutrients that are either excreted directly by fish or produced by the microbial breakdown of fish wastes. In the Asia-Pacific region, using fish pond effluent to irrigate wheat can increase grain yield when compared to conventional irrigation water and fertilization strategies (Attafy and Elsbaay., 2018).

As the salinity of irrigation water increased, so did the value of soil salinity. The effectiveness of water consumption was decreased by making irrigation water used in trickle and surface irrigation systems more salinated (El-Metwally ., 1999).

Hunce et al., 2018 discussed that Granular media filtration is one of the most significant and popular processes used to clean water. It is also frequently used to treat advanced wastewater. An accurate definition of backwash rates for filter cleaning is necessary for successful filter design. Recent years have seen significant advancements in the capacity to estimate accurately the backwash expansion of uniform (sieved) fractions of nonporous and porous non-spherical media. But gradated filter media have not yet been thoroughly and satisfactorily investigated. According to the results from the sieve analysis, a bed with a size gradation is now thought to consist of numerous layers that are roughly uniform in size, and the expansion of each layer is independently computed. By summing the expansions of each layer, the overall expansion is computed. By doing fluidization tests using genuine filter media such as silica sand, garnet sand, perlite, crushed recycled glass, activated carbon, anthracite coal, and zeolite, they were able to assess the correctness of this method as well as many other calculating techniques.

Accroding to De Deus et al., 2020 three commercial sand filter designs' hydraulic behaviour were contrasted. For each filter design, three sand particle sizes and three filter bed heights were evaluated to determine the treatments. The findings demonstrated that the examined sand filters exhibited diverse hydraulic behaviours during backwashing due to their various drainage architectures in terms of area and configurations. The surface velocity curves as a function of the % of filter bed expansion had steeper slopes when the sand particles were coarser, and the filter layers were taller.

The hydraulic performance of the system is impacted by emitter blockage, lowering the uniformity of water distribution and perhaps posing financial problems. (Borssoi, et al., 2012; Mesquita et al., 2012). Organic and/or inorganic suspended particles can be removed using filtration, a physical process. Sand filters are frequently used to remove organic debris and algae (Capra and Scicolone, 2007; Duran et al., 2009 ; Mesquita et al., 2019b ; Testezlaf, et al., 2014). Typically, the flow is downward. The diffuser plate (a building above the filter) is used to distribute water fed from the pipes over the filter layer in a regular pattern (Mesquita et al., 2012). The issue with this study is that the use of fish water causes emitter blockage, which lowers irrigation system efficiency and reduces production.

The aim of this research was examining the effects of well and fish water reuse on emitter clogging, selecting the best emitter for the well and fish water, and examining the influence of water quality on the performance of different emitter.

2. MATERIALS AND METHODS

Field experiments were carried out to evaluate drip clogging emitter using three different emitter and two types of irrigation water under the following sub-titles:

- Material

In this part will discuss Experimental location and Climatic Conditions, Components of drip irrigation network, Fish pond and the filtration unit

- Experimental location and Climatic Conditions

The outdoor testing were done from September 2021 to April 2022 at a private farm in Wadi El-Natrun centre, Beheira Governorate, Egypt, with coordinates of 31°30′35″E longitude and 29°52′31″N latitude and a mean altitude of 6.7 m above sea level.

- Components of drip irrigation network.

The irrigation system comprised a 120 m3/h submersible pump, a control unit with a flow meter, a 110 mm backflow prevention valve, a pressure regulator, pressure indicators, and a 110-butterfly control valve, as well as a 75 hp electrical motor. The 110 mm PVC outer diameter main line is used to transport water from the pump to the sub-main lines. Water is moved via HDPE manifold pipes with an outer diameter of 63 mm from the main line to the sub-main lines. Sub-main lines with an outer diameter of 50 mm constructed of HDPE were used to transport water to the laterals through a 32 mm HDPE manifold. The employed lateral lines were 30 m long, with emitters 30 cm apart, and had a nominal discharge rate of 4 L/h at an operating pressure of 125 kPa. They also had an outer diameter of 16 mm. The fish water was pumped into the irrigation system using a centrifugal pump with a 40 m3/h discharge and a 15 hp electrical motor, as indicated in figure 3. As seen in figures (1 and 3), solar energy was used to power both centrifugal and submersible pumps.

The fishpond is 50 m long, 40 m wide, and 5 m high within. It was built with a 20 cm thickness of concrete. 104 Nile tilapia fry were added to the fishpond. During the breeding season, the commercial diet included 30% crude protein, 4.96% fat, and 5.08% crude fiber. Water was pumped out of the fishpond three times a week at a rate of 20% of the pond's capacity each time, and it was refilled once a week. To avoid drawing silt from the pond, the suction tube was positioned 1.0 m below the water's surface. Table 1 contains some chemical evaluations of well and fish waters for the trial site.

Figure 1: Submersible and centrifugal pumps (A) and Solar cells, the source of power (B)

Table (1): Some chemical properties of applied water under study (WW and FW)

Water source	PH	EC_e ds/m	Cations meq / L				Anions meq / L				SAR	TDS^{-3}	No_3
			Na^+	K^+	Ca^{++}	Mg^{++}	$So^{=4}$	Cl^-	Hco-3	$Co_3^=$			
well water, (WW)	7.5	4.64	35.16	1.14	13.32	2.55	23.2	24.96	4.50	0.00	12.48	7.60	52.46
Fish water, (FW)	7.45	4.45	33.59	1.12	12.72	2.41	26.00	23.85	4.00	0.00	12.21	7.40	56.37

- The filtration unit

An iron screen filter with outside measurements of 220 mm and input and output diameters of 6.5 cm was used in this experiment. Internal PVC tubing with measurements of 600 mm in length, 150 mm in internal diameter, and 10 mm in thickness was used to create the primary filter cartridge .

The pipe was covered with 120 mesh nylon screen and perforated with holes of 16 mm in diameter spaced every 60 mm. The filter surface area was 0.283 m2 and the theoretical discharge rate was 16 m3/h, as shown in Figure 2. When the filter is in operation, water flows from the input through the nylon screen into the cartridge, where a significant amount of sediments are trapped, and then out the outlet into the irrigation system.

- Study variables:

1 - Irrigation water source: irrigation well water (WW) and fish water (FW) from a fishpond were provided.

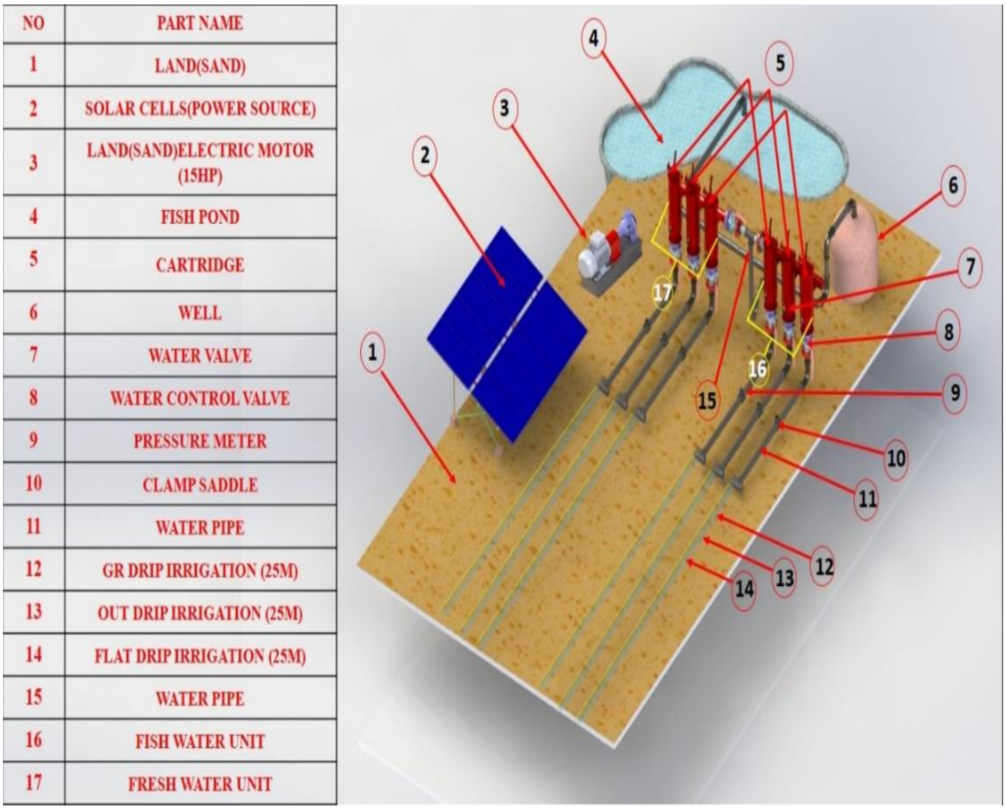
2 - Three types of point source non-pressure-compensating emitters were used in this study. The characteristics of the three emitters tested in these experiments are presented in Table 2.

Table (2): Characteristics of the emitters used in the experiments

Symbol	Name	Builting	Flow	Nominal discharge at 125 kPa operating pressure, L/h
D_1	GR	In-line	Long path flow	4
D_2	External	On-line	-----	4
D_3	Flat	In-line	-----	4

Figure (2): Specifications of the filtration unit.

The experimental field layout and treatments distribution as shown in Figure 3.



NO	PART NAME
1	LAND(SAND)
2	SOLAR CELLS(POWER SOURCE)
3	LAND(SAND)ELECTRIC MOTOR (15HP)
4	FISH POND
5	CARTRIDGE
6	WELL
7	WATER VALVE
8	WATER CONTROL VALVE
9	PRESSURE METER
10	CLAMP SADDLE
11	WATER PIPE
12	GR DRIP IRRIGATION (25M)
13	OUT DRIP IRRIGATION (25M)
14	FLAT DRIP IRRIGATION (25M)
15	WATER PIPE
16	FISH WATER UNIT
17	FRESH WATER UNIT

Figure (3): The experimental field layout and treatments distribution.

- Methods

In this part will discuss the following items:

- Operating pressure - emitter discharge rate relationship:

The emitter discharge rate was calculated at various operating pressures between 50 and 125 kPa for each 25 kPa increase in operating pressure. In the hydraulic laboratory of the AL Nakheel farm for modern irrigation, in Sadat City Menoufia Governorate, the test was conducted using a Damala Plast extrusion device.

Prior to starting a discharge test, the device was set up at a certain pressure and operating duration for 45 s to ensure a steady irrigation system during testing. The gadget produced samples of the lateral lines with a length of 2 m and 6 emitters after the test time; after the test time, the weight of the water released from each emitter is weighted and the discharge rate is automatically determined. The test was repeated four times for each drip line.

- Estimating the emitter discharge rates:

The drip line emitter discharge rates were checked every 20 operating hours. Plastic cans with a capacity of 500 mm were placed under the 28 selected emitters, each three emitters apart, from the third emitter to the 83rd emitter. To establish a consistent operational state, the system was operated for 15 min and evaluated for 5 min. A digital scale with a 0.01 g accuracy was then used to calculate the weight of the water that had been collected. The rate of emitter discharge was expressed in L/h.

- Emitter clogging rates

The relative emitter discharge and the clogging ratio were determined for each treatment at the conclusion of each estimating stage (20 h), as demonstrated by (Feng et al., 2017), as follows:

$$q_r = 100\, x\, ({}^{q}/_{q_{ini}}) \text{ ....[1]}$$

$$CR = 1 - q_r] \quad \text{.. [2]}$$

where:

qr = the relative emitter discharge in %, q = the mean emitter discharge at end of each stage in L/h, qini = the initial mean emitter discharge, L/h and CR = the clogging ratio of emitters in.%

- Christiansen uniformity coefficient (CU, %)

Christiansen's uniformity coefficient (CU, %), according to (Christiansen, 1942) calculates following, the effect of irrigation water source and emitter type on application uniformity at the start of the experiment and at the conclusion of each stage was stated and demonstrated .

$$\mathbf{CU = 100\ \left(1.0 - \frac{\sum|x_{i} - x^{-}|}{nx^{-}}\right)} \text{...[3]}$$

Where:

xi = volume caught at observation point, x– = average volume amount caught, and n = number of observations.

The relationship between relative emitter discharge and Christiansen uniformity coefficient was estimated for different treatments.

3. RESULTS AND DISCUSSION

In this part, many results were discussed to know the relationship between the study factors and the efficiency indicators. These results were covered Effect of operating pressure on discharge rate and CV, emitter discharge, relative discharge and Christensen uniformity coefficient.

3.1 Effect of operating pressure on discharge rate:

The discharge of emitters and their connection to operating pressure were tested in a laboratory experiment. Figure 4 investigated the connection between the emitter discharge (L/h) and operation pressure (kPa) to show the rate of emitter discharge.

The results showed that increasing operating pressure increased discharge rate and CV for various types of emitters. Emitter discharge CV is one of the extremely essential criteria for evaluating the performance of emitters. The external emitter (D3) had the highest discharge (3.99 L/h) at 125 kPa, while the external emitter (D2) had a lower discharge (3.45 L/h) at 50 kPa. The highest CV value was 4.2 for the D3 emitter at 125 Kpa, while the lowest CV value was 3.46 for the D2 emitter at 50 kPa.

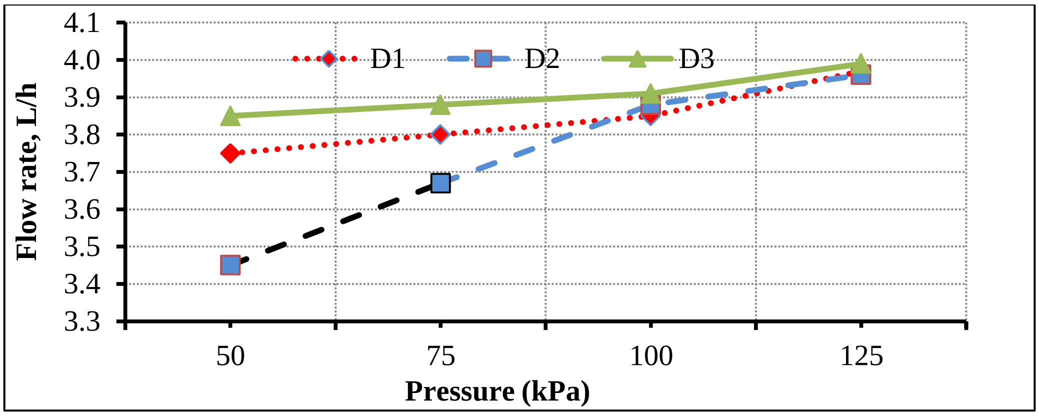


Figure (4): Relationship between the operating pressure and emitter discharge for emitter different type.

Table (3): Effect of operating pressure on the manufacturer's coefficient of variation of emitter flow (CV) % for emitter different type

operating pressure, kPa	**CV %**		
	D1	D1	D3
50	3.6	3.6	3.74
75	3.71	3.71	3.79
100	3.75	3.75	3.89
125	3.79	3.79	4.2

Effect of fish water and well water on emitter discharge at different operation hours:

The average discharge rate for each type of water during operational hours is depicted in Figures 5 and 6. According to the data between 20 and 140 operating hours, emitter discharge decreased as working hours rose.

After 20 operating hours: The Outline emitter (D2) had the highest discharge rate under using both types of irrigation water (WW and FW). The discharge rate was 3.89, 3.81, and 3.7 L/h at 20th, 56th and 83rd emitters respectively with using FW and it was 3.95, 3.87, and 3.82, L/h with using WW.

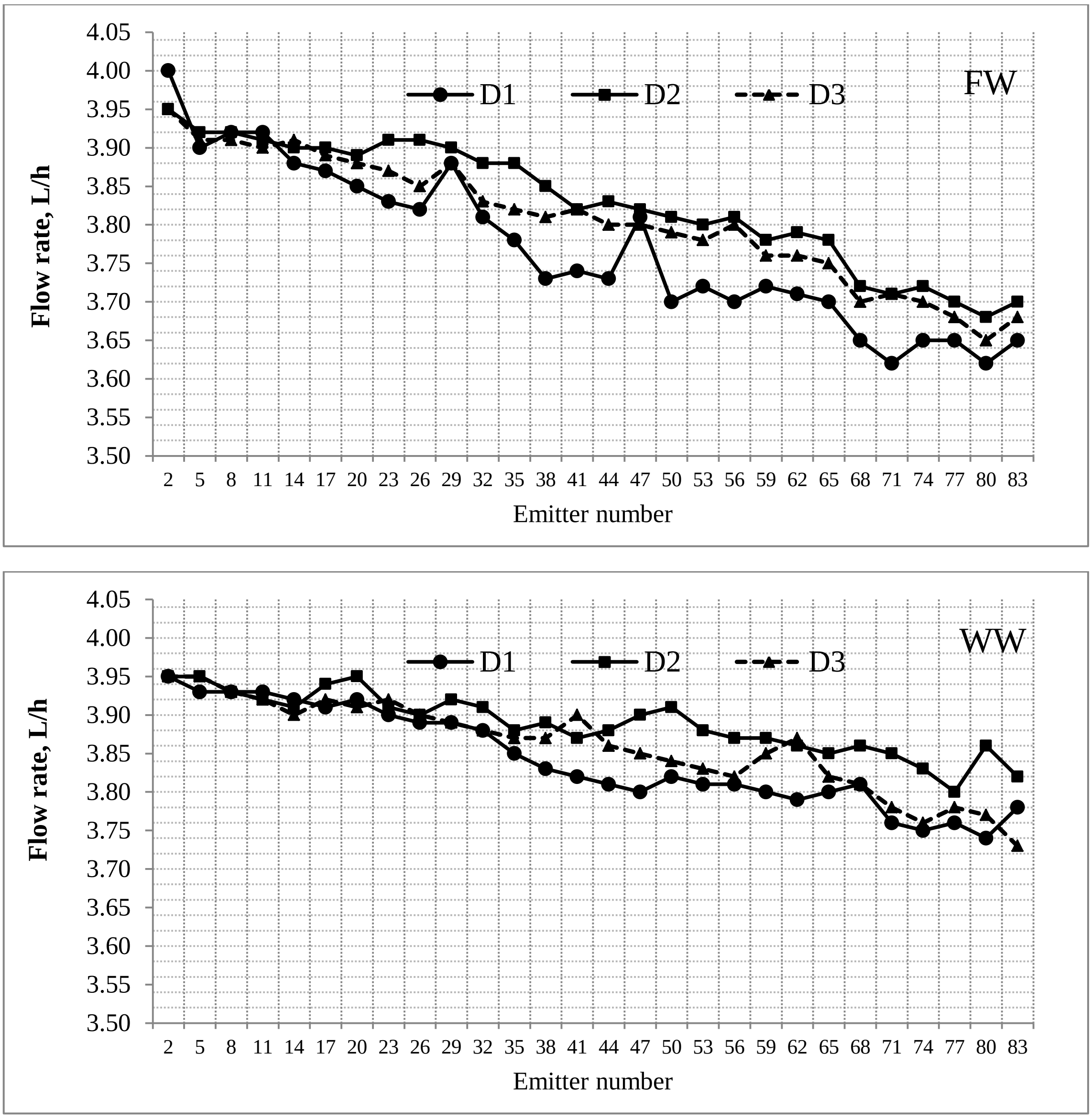


Figure 5: Effect of fish water and well water on emitter discharge at 20 operating hours

The Outline Emitter (D2) exhibited the greatest discharge rate while employing both types of irrigation water (WW and FW) after 140 operational hours. At the 20th, 56th, and 83rd emitters, respectively, the discharge rate was 3.78, 3.63, and 3.62 L/h when using FW, and it was 3.82, 3.76, and 3.72 L/h when using WW. From these results, FW is more clogging than WW through experimental work. D1 emitters are the most clogging, D2 is the least clogging and more discharge.

- Effect of irrigation water type on relative mean emitter discharge:

During the operation period with the two types of irrigation water, the relative mean discharge of the three emitter types (D1, D2, and D3) dropped. At 140 hours of operation, the relative mean emitter discharge was at its lowest point. The relative discharge fluctuated little during the first 20 hours of operation and gradually reduced after 20, 40, and 60 hours. The initial relative discharge emitter in all treatments decrease owing to concentration of suspend solids, physical clogging in the emitter flow channel, and emitter orifice, it was observed while comparing the influence of water type as shown at figures (7 and 8).

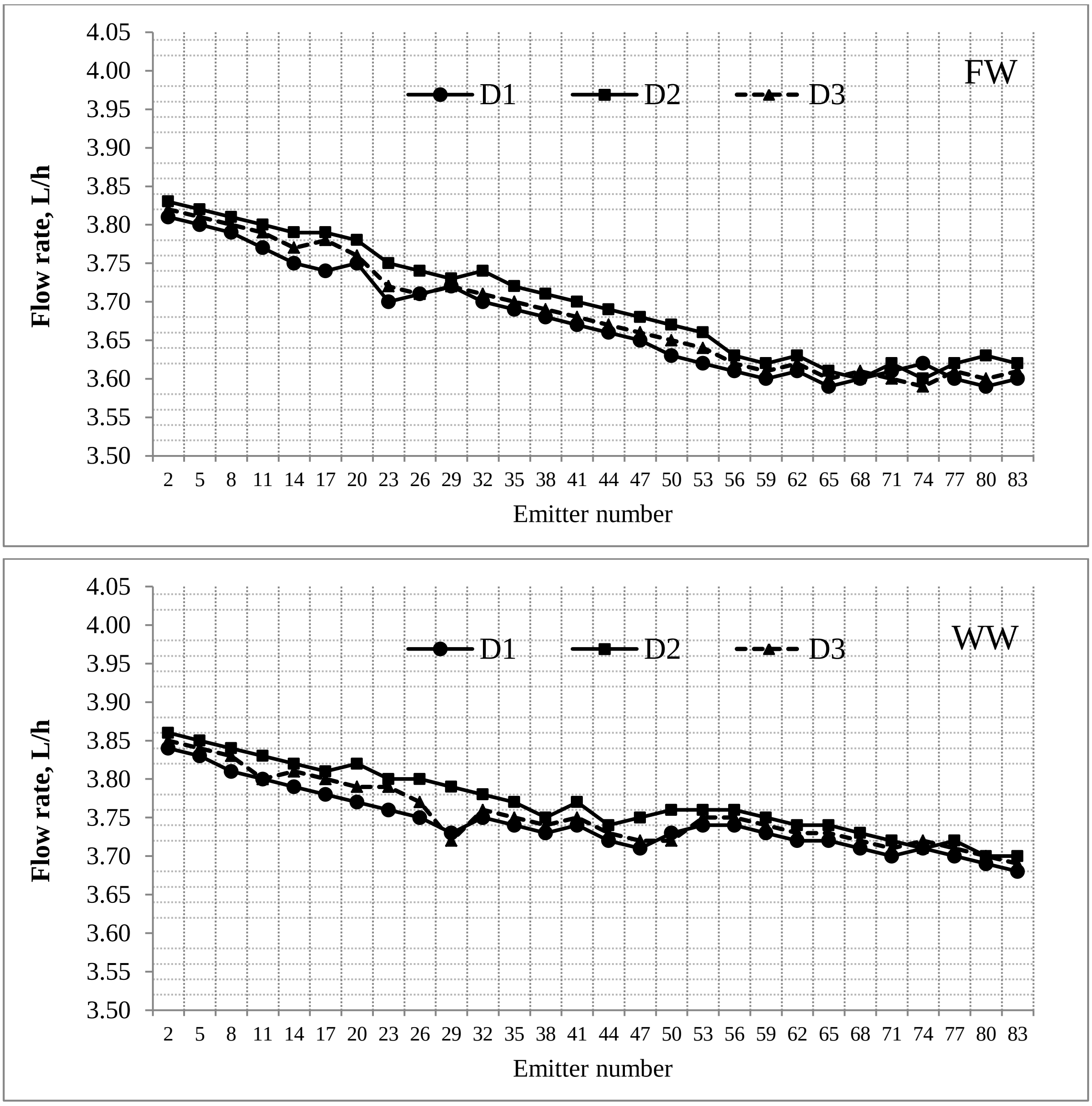
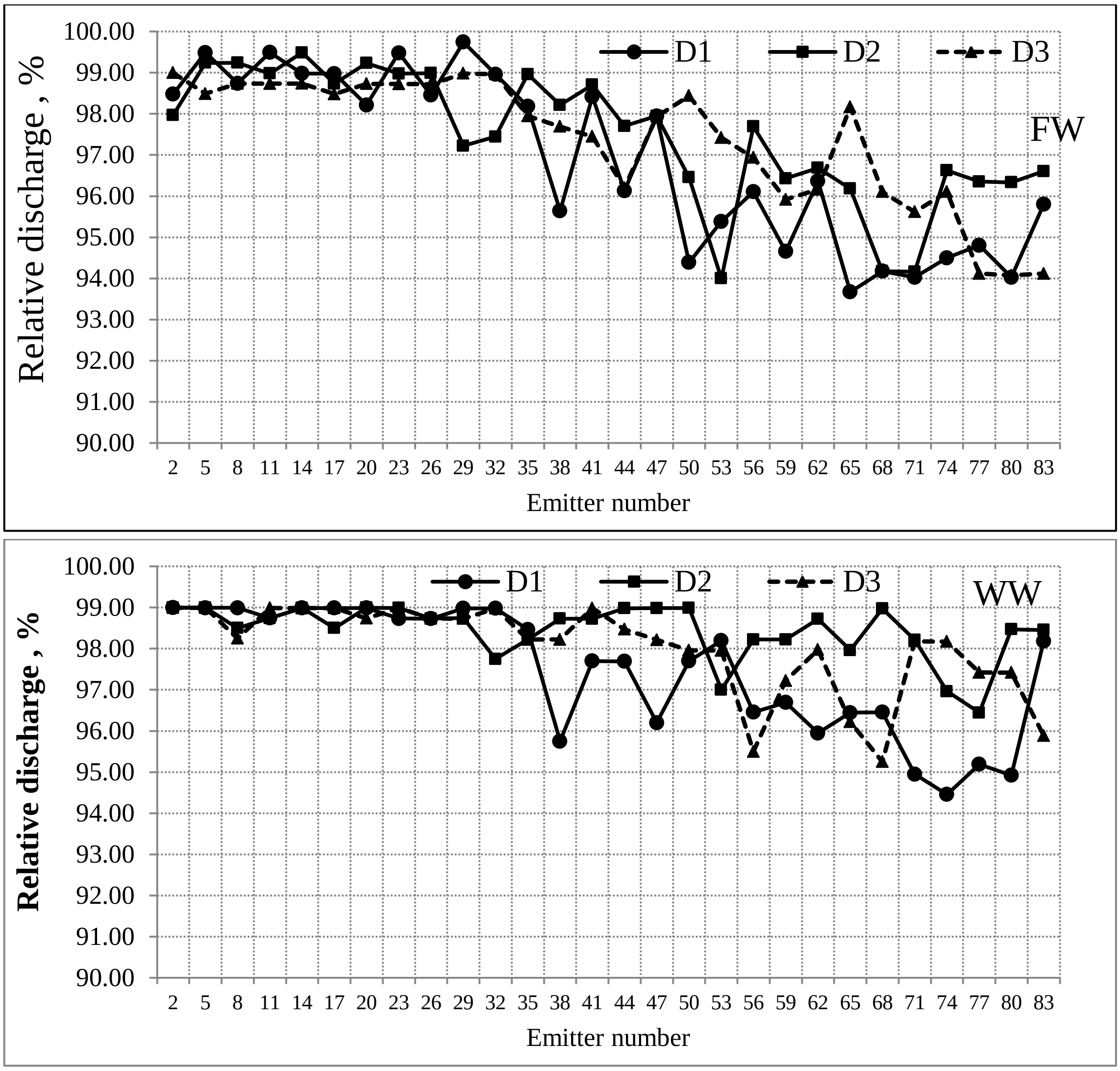


Figure 6: Effect of fish water and well water on emitter discharge at 140 operating hours

The highest relative discharge values during 20 operational hours were 99.23, 97.69, and 96.61% at the 20th, 56th, and 83rd D2 emitters, respectively, while employing FW at the same lateral. However, when utilizing the WW, the highest relative discharge values at the same emitters were 98.99, 98.62, and 98.45%. The relative mean emitter discharge for D2 at the 20th, 56th, and 83rd emitters, respectively, was 96.43, 93.88, and 94.52% at 140 operating hours with fish water. With D2 at the 20th and 56th emitters, the greatest relative discharge values for well water were 95.74 and 95.43%, respectively. At the 83rd emitter, however, the D3 had the highest relative discharge value, at 95.58%.

- Christensen uniformity coefficient

The results mentioned that, the increasing of operation hours, the Christensen uniformity coefficient decrease affecting by the irrigation water type as shown in figure (10). The D2 had the maximum CU values. The maximum values were at 99.13, 99.04, 98.67, 98.5, 98.2, 97.23, and 97.26 % at 20, 40, 60, 80, 100, 120, and 140 operating hours under using the WW. The D1 had the lowest CU values. These values were 96.76, 96.35, 95.8, 95.63, 95.22, 94.91, and 94.57% at 20, 40, 60, 80, 100, 120, and 140 operating hours under using the FW.



Figure(7) : Effect of relative mean emitter discharge on different emitter type at 20 operation time.

4. CONCLUSION

Drip irrigation has been utilized for fish water effluent and distribution and reuse where soil conditions prohibit traditional types of fish wastewater effluent. Many advantages of distributing treated fish water effluent with drip irrigation have been established including water conservation. Emitter clogging affects the hydraulic performance of the system, reducing the uniformity of the water distribution and possibly generating financial risks.

The aim of this study is Utilization of fish water cases emitter clogging; this clogging decrease efficiency of irrigation system and thus negatively affects the productivity. The results indicated that: Increasing operating hours increased discharge rate and CV for different type of emitters, the higest value for CV was 4.2 for D3 emitter at pressure 125 kPa , the least value for CV was 3.46 for D2 emitter at pressure 50 Kpa. The discharge of emitters had an inverse relationship with the increasing of operating hours. The emitter clogging had a positive relationship with the operating hours. Fish water had a negative effect on the emitter clogging. The relative mean discharge of three type of emitters (D1 , D2 and D3) for fish water and well water decrease through operating time , the greatest decrease of relative mean emitter discharge and CU occurred at 140 operating of all treatment.

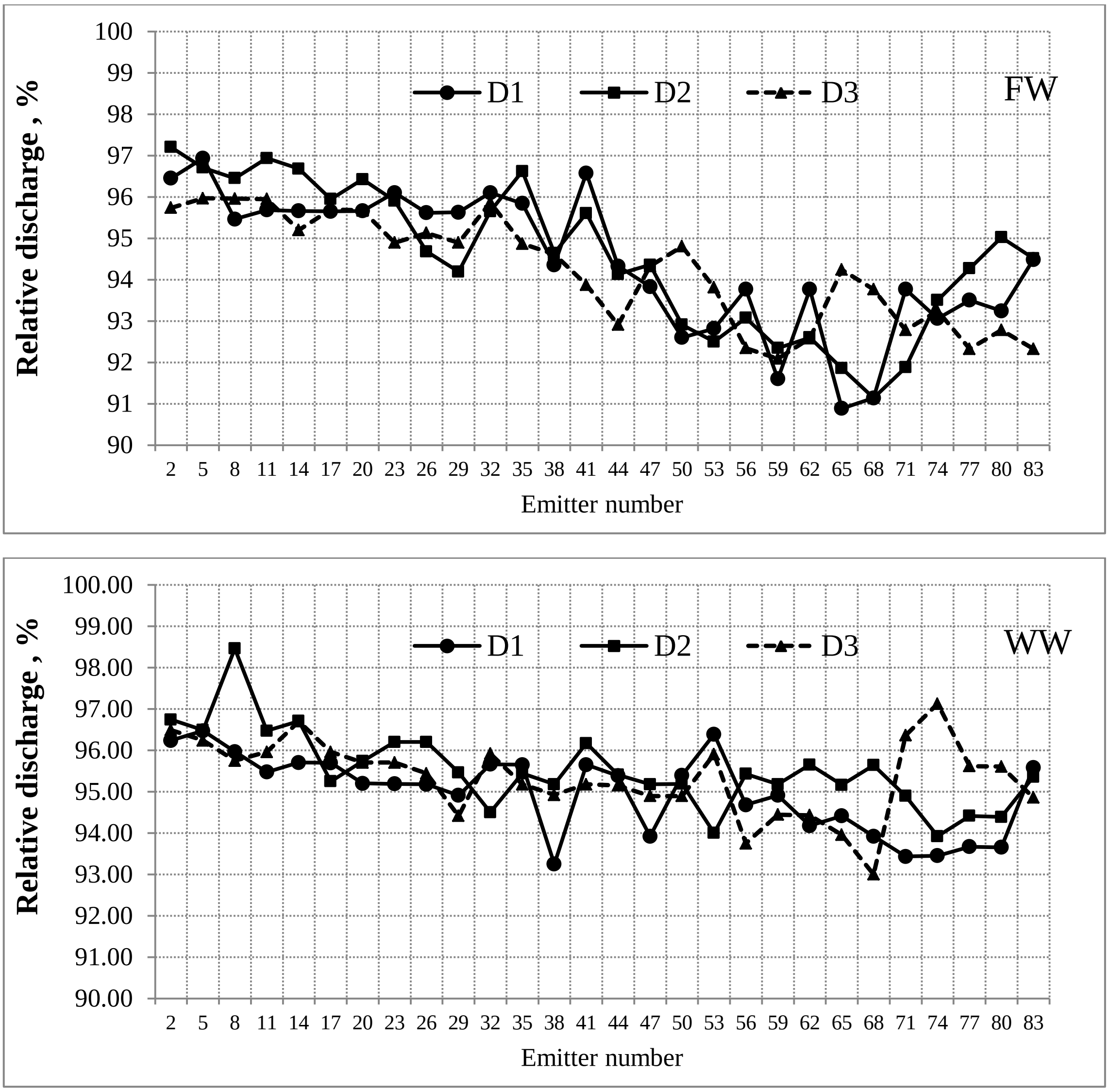


Figure (8) : Effect of relative mean emitter discharge on different emitter type at 140 operation time.

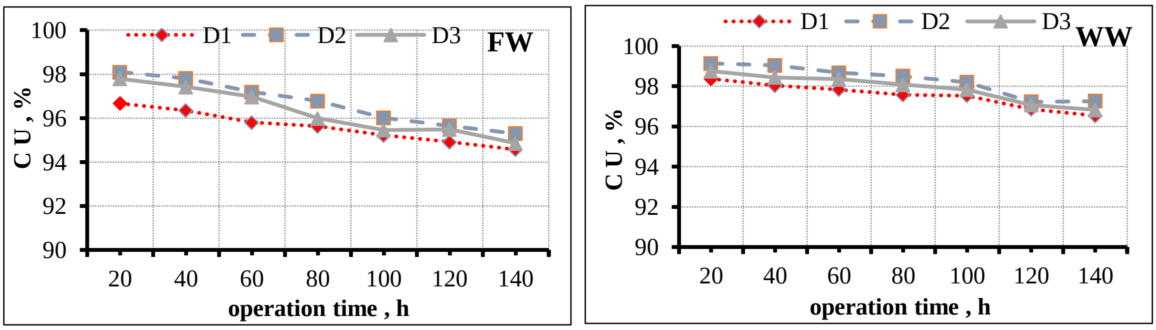


Figure (9): Operation hours – Christensen uniformity coefficient relationship for three different emitters at fish water and well water.

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تقييم أداء نظام الري بالتنقيط في ظل استخدام نوعين لمياه الري

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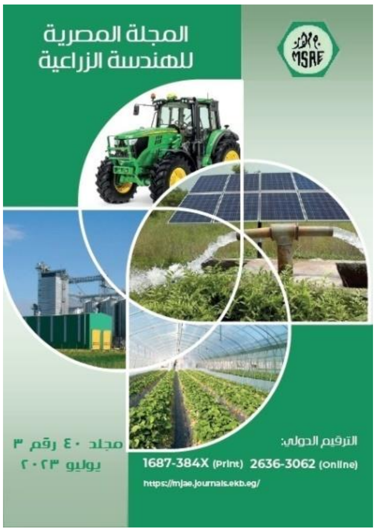

الكلمات المفتاحية:
الري؛ مياه المزارع السمكية؛ الزراعة المروية؛ المخلفات السمكية؛ الري بالتنقيط.

الملخص العربى

يعتبر النقص الحاد في المياه فى العديد من المناطق أحد المعوقات و التحديات التى تواجه الإنتاج الزراعى على مستوى العالم، فى مثل هذه المناطق سيكون صرف مياه مزارع الأسماك مصدرا للاستفادة منه لسد هذا النقص. مياه مزارع الاسماك غنية بالاسمدة و لكن يعاب عليها انسداد النقاطات و هو العامل الرئيسى الذى يحد من فعالية أنظمة الرى بالتنقيط بهذه المياه و لهذا فان الدقة العالية فى عملية الترشيح للمياه ضرورية لزيادة كفاءة المياه مع نظام الرى بالتنقيط ، أجريت التجربة خلال الفترة سبتمبر ٢٠٢١ حتى ابريل ٢٠٢٢ بمنطقة وادى النطرون محافظة البحيره مصر (٢٩ ′ ′ ٥٢ ٣١°) شمالا ، (٣١ ′ ′ ٣٠ ٣١°) شرقا. و هدفت الدراسة الى تقيم كفاءة ثلاثة انواع من النقاطات **(GR, D_1 – Flat, D_3 – Out line, D_2)** مع نوعين من ماء الرى (ماء البئر الجوفى – ماء حوض السمك) و تتكون وحدة الترشيح من اسطوانه من الحديد طولها ٦٠ سم و قطرها ٢٢ سم ، ووحدة الترشيح الداخلية طولها ٦٠ سم و قطرها ١٥ سم ، و خلصت النتائج الى ان ماء صرف مزرعة الاسماك تسبب فى انسداد جميع انواع النقطات بنسب مختلفه خلال فحصها و ان النقاط الخارجى **((D_3** اقل انسداد بينما النقاط **((D_1** كان الاكثر انسداد خلال التجربة و يمكن التوصية باستخدام النقاط الخارجي مع مياه صرف المزارع السمكية و الاحتياج فى الدراسات المستقبلية لهذا النقاط ، و توصى الدراسة باستخدام النقاط الفلات مع مياه الرى ذات الجودة العالية.