



## **Evaluation of online and inline emitters clogging with treated waste water and groundwater**

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### **Abstract**

Clogging is a serious problem in drip irrigation, especially under applied groundwater (Gw) and treated wastewater (TWW). This Clogging may uneven water distribution, and the regularity of this distribution decreases due to the emitter clogging. Laboratory tests were conducted with fresh water to evaluate the system under several applied pressures (40, 80,100,120,140,180,200 kPa) and two types of emitters (online with discharge 2 L/h and in line with discharge 8 L/h). A field experiment was also conducted from May to December 2020 at the experimental farm of the college of agricultural engineering sciences, Sulaimani University to monitor clogging of two types emitters and two types of water resources. The objectives of this study, were to evaluate the temporal changes of the emitter discharge rate and the rating of clogged emitters in the system and to quantify the effect of emitter clogging on irrigation system performance. In the experiments, two types of emitters and two types of water sources (treated wastewater and groundwater) were evaluated by measuring the emitter discharge rate of the system at seven -days intervals. Assessment time were (0, 14, 28, 42, 56, 70, and 84 hours). The water source had a very significant effect on the degree of drip emitter clogging. Of the two emitters tested during the entire trial period, emitters apply a more severe flow of Treated wastewater clogging, Results showed that the clogging percentages were 76.92% and 80.61% with inline emitter in use Groundwater and Treated wastewater and 29.76% and 26.76% with the online emitter when using Groundwater and Treated wastewater respectively.

### **Introduction**

There is a decrease in the volume of freshwater available worldwide, increasing the pressing need for its more effective usage. Iraq has an arid climate with limited sources of irrigation water. The main sources of irrigation, comprises water from the twin rivers (Tigris and Euphrates). Because of water shortages, drip irrigation is becoming very common in many parts of the world today [1]. For irrigation, TWW is an alternative sources of irrigation water. Waste water can be is recycled for private and public irrigation and, the consumption of potable water may be limited by up to 50 % [2]. One of the most important ways to reduce water scarcity in agriculture has been the reuse of treated wastewater for agricultural irrigation. While treated water meets the basic irrigation quality need, it contains solid particles, organic matter, inorganic ions, and microorganisms [3]. Drip irrigation

is very useful when nutrients are applied with water during irrigation crops. The benefit of using a drip irrigation system is that by providing a low, wet area in the root region, it can greatly minimize soil evaporation and raise water usage quality [1]. Most of the Iraqi farmers living in the new areas are smallholders; thus, clogging of emitters is the main problem that occurs under field conditions. The clogging of emitters varies depending on water quality, type of emitter, methods of filtration, and conditions environmental. Sometimes a mixture of these factors causes clogging. The kind of problems with emitter clogging will change with the source of water irrigation [4]. The creation of biofilms on the sidelines and drip emitters of drip irrigation systems has become a huge problem for farmers and researchers while using wastewater for irrigation [5, 6]. The clogging of drip emitters has a negative impact on operating pressure rate, rate of flow and, uniformity application. According this study was initiate to target the following objectives: (1) to describe two emitter models (inline and online) with different pressures as they were subjected to freshwater irrigation. (2) To determine whether drip irrigation systems have an appropriate long-term condition for drip irrigation purposes (Treated wastewater and groundwater). (3) To compare potential of the two types of emitter and water types for preventing blockage and production of biofilms.

**Materials and Methods**

**A. Laboratory testing**

A Laboratory experiment was conducted during the season of 2020 at the soil physical Laboratory of Natural Resources Department, College of Agricultural Engineering Sciences, the University of Sulaimani. The experiment was laid out in a randomized complete design (CRD) including fifteen treatments, each was replicated three to determine the parameters of the model emitter discharge to operating pressure under using tap water. Some characteristics of the applied tap water were given in table (1). Six laterals with the emitter were installed on a nearly level bench. Graduated cylinders (500 mL) for the determination of the emitter discharge, located under one of the emitters. The pressure values of the two emitters used in the field experiment were determined by a pressure gauge installed for laboratory calibration. The emitter's discharge was measured at seven operating pressure values. (40, 80, 100, 120,140,180, and 200) kPa, then the equation constants (x and k) were discharged by the emitter and the output coefficient of variance (Cv) was calculated in (Table 1).

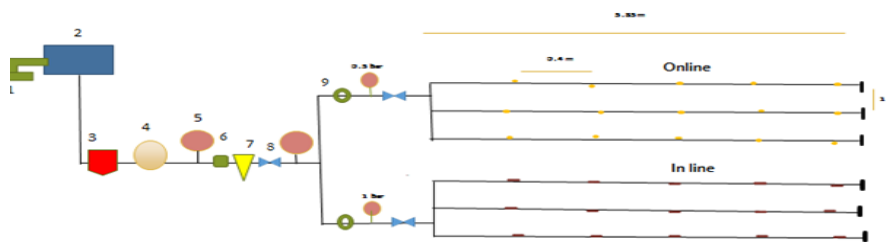


Figure-1: Presents laboratory experiment use to hydraulic characteristic dripper irrigation system (1. Source of water 2. Tank 3. Screen filter 4. Water pump 5. Pressure gauge 6. Water meter 7. Valve).

**B. Emitter Characteristics**

The performance of emitter discharges is defined by the parameters (x and k) of [7] Equation:

$$q = K H^x \dots\dots\dots (1)$$

$$\log q = \log k + x \log H$$

Where: q = emitter discharge rate (L/h.); h = h is entry water pressure (m), k = a dimensionless constant of proportionality that characterizes each emitter and x = a dimensionless emitter discharge exponent that is characterized by the flow regime.

$$x = \frac{\log\left(\frac{q1}{q2}\right)}{\log\left(\frac{H1}{H2}\right)} \dots\dots\dots (2)$$

$$kd = \frac{q_2}{H_2^x} \dots\dots\dots (3)$$

The manufacturing coefficient of variation (CV) of new emitters determined using [8]:

$$CV = \frac{S}{q} \dots\dots\dots (4)$$

Where: CV=manufacturer’s coefficient of variation (Dimensionless); S = the standard deviation of the emitters discharge in the sample (ℓ/h) and q = emitter discharges mean (ℓ/h).

**C. Water quality**

Water samples were taken during the field test to determine the most important factors affecting emitter clogging [9]; [10]: (EC), pH, (TSS), (TDS), (Fe), (Ca), (Mg), (Mn), (Bc), and bacterial number. Water analyses were carried out in the laboratory; chemical and microbial changes in some factors were stopped by appropriate sample treatment [11].

**D. Field experiment**

**-Field Evaluation of Emitter Clogging**

A field experiment was conducted on 1 June 2020 at the research station of the College of Agricultural Engineering Sciences, University of Sulaimani. The study area was located at the west of Sulaimani city (Latitude: 35° 34' 19" N; Longitude 45° 22' 02" E at the altitude of approximately 750 m above sea level). The minimum temperature was 17.8 °C with the maximum mean temperature of 41.1°C (June). As shown in Figure (2), the drip irrigation system layout, with individual two different water supply systems one of TWW and GW source. The experiment was laid out in a randomized complete design (CRD) with twenty-four treatments by three replications, each plot consisted of six laterals with a 10m length at a distance of 0.4 meters, and each lateral has composed of 30 emitters, 0.30 m apart. Pressurized water was supplied for each system by a pump with a capacity of 35 l/min and a lift of 38 m from a 15000L tank. At the supply mainline, a screen filter with a mesh opening size of 120 mesh was equipped to prevent physical. Screen filters were also manually cleaned, by pulling out the filter basket and washing it. There were four similar subunits for the TWW system and four subunits for the Gw system with two types of emitters for each system (online with discharge 2.0 L/h and in line with discharge 8 L/h). Every subunit has consisted of 3 laterals of 10 m in length and 0.4 m apart, that were fixed by a frame with a (0 slope). The subunits were linked to the mainline through a sub-main line. To control the working pressure, a pressure gauge was mounted at the inlet of the feeder line at 140.0 KPa of the subunits during the experiments. The filters were cleaned manually every month. Catch cans were used to measure the emitter discharges during the experiments and assessment times (0, 14, 28, 42, 56, 70, and 84) hrs. In order to determine the effects of different emitters and different sources of water on clogging.

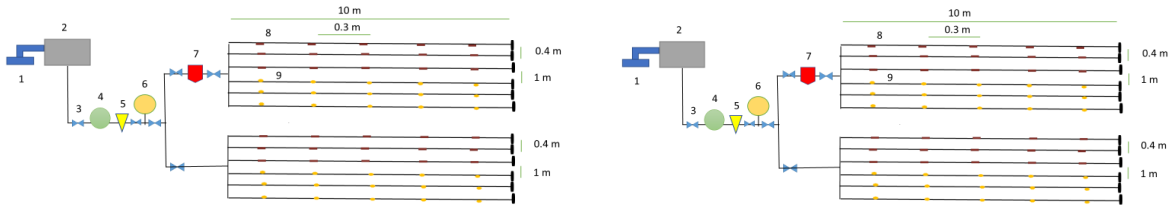


Figure-2: Shows a layout of the drip irrigation system, including two individual systems of water supply. (1-Source water (A. Groundwater or B. Treated wastewater) 2-Tank 3- Valve 4-Water pump 5- Disc filter 6-Pressure gauge 7- Tank fertilizer 8- Inline emitter 9-Online emitter).

*- Evaluation parameters*

After all the experimental measurements were completed, some criteria to measure emitter clogging were used as follows: percentage of clogged emitters and percentage of discharge reduction from the initial starting of the experiment was calculated by (eq. 5):

$$q_r = \left( \frac{q_b - q_d}{q_b} \right) \times 100 \dots\dots\dots (5)$$

Where:  $q_r$  = percentage of reduction in emitter (%);  $q_d$  = emitter discharges at a given time, (l/h) and

$q_b$  = emitter discharges at the beginning of the experiment (l/h).

Emission uniformity (EU) is one of the most frequently used design criteria for Micro Irrigation Systems. It is one of the indices for evaluation of micro-irrigation performance recommended by [12]

$$EU = 100 \left( \frac{q - 1/4q_{min}}{q -} \right) \dots\dots\dots (6)$$

The evaluation system is classified according to the EU values, those supporting [13, 11].

The coefficient of uniformity (CU) shown in equation 1, can use to define the spatial uniformity of the drip irrigation system [14, 15].

$$Cu = \left( 1 - \frac{\sum |q_i - q_a|}{n \cdot q_a} \right) \times 100 \dots\dots\dots (7)$$

Where:  $q_i$  = individual emitter flow rate,  $q_a$  = mean emitter flow rate, and

$|q_i - q_a|$  =absolute deviation from the mean value

*-Statistical Analysis of data*

Using the XLSTAT (2016) package, the data were analyzed statistically and the variations were compared at the 5% significance stage by LSD.

**Results and Discussion**

*A- Characteristics of emitters*

The characteristics of variation coefficient (CV), discharge exponent (X), and discharge coefficient (Kd) for emitters were estimated and are presented in Table 1.

Table-1: Some hydraulic characteristics of the two emitter types with fresh water measured in the laboratory.

Commercial names	Letter designation	Pathway dimensions of inline emitter			Area (mm <sup>2</sup> ) [a]	Nominal discharge (L h <sup>-1</sup> )	Spacing of the emitters (cm)	Emitter discharge coefficient (k),	Emitter discharge exponent (x),	Coefficient of determination R <sup>2</sup>	Manufacturing coefficient of variation CV
		Width	Depth	Length							
	Inline (E1)	16 mm	13 mm	32 mm	201.061	8	30	0.512	0.454	0.2818	0.235
	Online (E2)	-	-	-		2	30	0.537	0.534	0.1396	0.828

The emitter discharge equations including the coefficient (x) dependent on the flow system and the flow coefficient (k) as well as the regression values (R<sup>2</sup>) are given in Figure. 3. Since the correlation coefficients were strong (R = 0.2818) with the inline emitter, the emitter discharge was observed to be affected by various operating pressures and the correlation coefficient was small for the online emitter (R<sup>2</sup> = 0.1396). An x-value of the two types of emitter close to 0.5 flow showed was perfectly turbulent and that this outcome was in similar with the finding and observations data of the manufacturers from other obtained by [16,17]. Since CV values for (E1) at the operating pressure of 140 kPa are smaller than 5%, they were placed in the “excellent” class according to [10] also similar to the findings of [18]. In Figure.3 indicates the emitter discharge (L.h<sup>-1</sup>) increases with increasing pressures of (40-140) kPa. As shown in Figure. 3(A), the emitter discharge rate as a function of pressure in the inline emitter. It is seen that exponent x is not constant. Its value depends, basically, on the range of the operating pressure used to determine [2]. Six zones can be distinguished. The first one includes pressure ranges below a minimum pressure where no elastomer distortion results. Thus, an increase in flow is produced with increasing pressure, with no compensation. The second, three, and four respectively include pressures within the range of regulation, where the elastomer distortion counteracts the increasing flow caused by the increasing pressure. Thus, the emitter works as many typical flow regulators. Finally, the sixth one refers to higher pressures, which gradually squeeze off the flow of the passageway Figure. 3(B) shows emitter discharge as a function of pressure in the online emitter first until five Similarly Figure. 3 (A). Increased emitter discharge significantly (1%) at other pressures except between (90 and 120) kPa operating pressures, similarly, [19]. Hence except for zone six because when increase pressure 140 KPa decreases the discharge rate of the online emitter. Also, observation of this figure presented a regression equation with high pressure of determination (R<sup>2</sup>) at E1<%5, and at E2<%5.

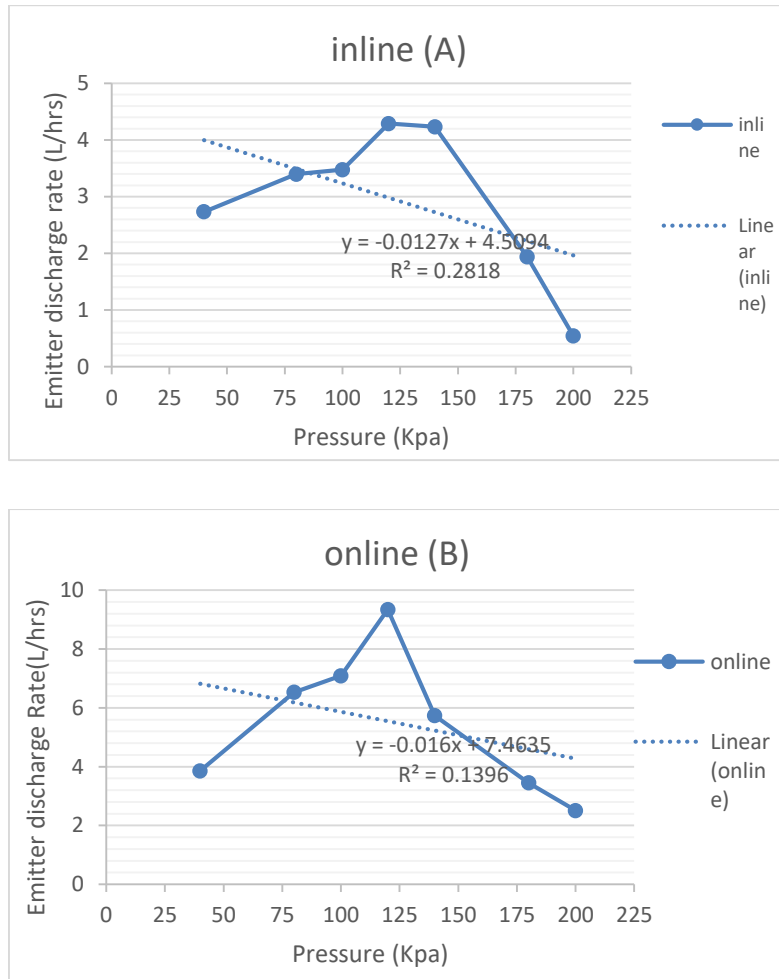


Figure-3: Illustrates the relationship of pressure to the discharge of inline and online emitters that are commonly used locally.

### B- Water quality

The chemical, biological, and physical water quality parameters for TWW and GW are presented in Table 2. According to their classification, the present study found that the TSS value for TWW (0.161) was lower than that for while GW (0.181) both of them had low potential on the emitter clogging. PH value for TWW (8.2) was higher than that for GW (7.63), while both of them had severe and medium potential on the emitter clogging respectively. With the values of Fe, Cl, Mn, Ca<sup>2+</sup>, Mg<sup>2+</sup>, HCO<sub>3</sub><sup>-1</sup>, SO<sub>4</sub><sup>2-</sup>, EC, and Bacteria of a number, there is a low clogging risk for performance emitter for both of them. The values of TDS for TWW and GW have medium clogging potential on emitter performance. The effect of pH on the clogging capacity was classified as <7.0 (slight), 7–8 (medium), and >8.0 (severe) [20]. The potential of biological oxygen demands (BOD<sub>5</sub>) on emitter clogging was classified as <15 ppm (low), 15–40 ppm (medium), and >40 ppm (severe) [21]. In this study, the potential value of the concentration of BOD<sub>5</sub> for (TWW) on emitter clogging is 9.097 mgO<sub>2</sub>/l (Moderate polluted) and for (GW) is 6.679 mgO<sub>2</sub>/l (severe). Rising the organic matter and suspended solids organic matter which is related to BOD<sub>5</sub> would lead to an increase in the percentage of clogged emitters and a decrease in the emitter discharge and EU [22]. Also, the salt concentration in the water did not cause emitter clogging because the EC values of the GW (1.47 mS/cm) and TWW (1.50 mS/cm) is low.

Table-2: Some selected physical and chemical properties of the treated wastewater and groundwater.

Terms	Treated wastewater (TWW)	Risk of emitter clogging		Ground water (Gw)	Risk of emitter clogging	
		Nakayama and Bucks (1991)	Capra and Scicolone (1998)		Nakayama and Bucks (1991)	Capra and Scicolone (1998)
		TSS, mg/l	0.161		Low	
LSI	1.1	Non corrosive		-0.18	Slightly corrosive	
pH	8.2	High		7.63	Moderate	
BOD <sub>5</sub> , mg/l	38.333	Moderate		27.97	Moderate	
EC, mS/cm	1.5		Low	1.47		Low
TDS, mg/l	960	Moderate		943	Moderate	
Fe, mg/l	0.023	Low		0.01	Low	
Mn, mg/l	0.08	Low		0.021	Low	
Cl, mg/l	95.85	ND		136.32	NA	
Mg <sup>2+</sup> , mg/l	16.47		Low	3.16		Low
Ca <sup>2+</sup> , mg/l	76.2		Low	27.2		
HCO <sub>3</sub> <sup>-1</sup> , mg/l	502.64		Low	260.47		Low
SO <sub>4</sub> <sup>2-</sup> , mg/l	28.32		Low	100.8	Moderate	
Bacteria number, no./ml	10 <sup>4</sup>		Low	42*10 <sup>4</sup>		Low

Table (3) shows the Characteristics of the emitters used in the study and Fig. 4 (A and B) indicates the relation between values of (CU, CV, Us, and qr %) and pressure (kPa). When a comparison between (inline and online) emitter, the highest value of (Cu %) was (98.64%) in 140 kPa but the lower value was (74.6%) in 200 kPa. Also, the highest value of (CV) was (29.0%) in 200 kPa but the lower value was (2.0%) in 140 kPa. As well as, the highest value of (Us %) was (98.02%) in 120 kPa but the lower value was (70.88%) in 200 kPa. In addition, the highest value of (qr %) was (48.108%) in 200 kPa, but the lower value was (3.72%) in 140 kPa. In the final experiment, results showed that different pressure relation between values of (CU, Cv, qr and Us%) was higher in the inline emitter. These results are following the findings of [23]. The higher the difference in emitter flow values, the lesser the uniformity coefficient of the emitter flow values (CU %). In addition, the CV value involves the difference in the flow of the emitter due to all factors, including piping effects and hydraulic properties of the emitter, including interference. [24]. in the previous experiments conducted in the laboratory, the emitters recommended by manufacturers usually had a strong manufacturing variance coefficient, a factor directly affecting the uniformity coefficient [25]. It can also be due to the variance of lateral pressure, as stated by [23].

Table-3: Illustrates characteristics of the emitters used in the study.

Pressure Kpa	Inline emitter				Online emitter			
	Cv%	Us%	qr%	CU%	Cv%	Us%	qr%	CU%
40	7.4	92.57	13.33	94.05	24.0	76.49	36.35	80.75
80	21.0	78.66	31.47	81.47	24.0	76.40	4.42	84.93
100	9.7	90.35	18.33	91.84	4.9	95.05	9.09	96.04
120	14.0	86.23	21.4	88.09	9.0	90.89	6.72	92.82
140	2.0	98.02	3.72	98.64	6.0	93.79	5.59	94.90
180	14.7	85.32	15.31	87.48	21.0	78.80	34.94	85.26
200	29.0	70.88	48.108	74.6	17.0	83.0	28.52	86.89

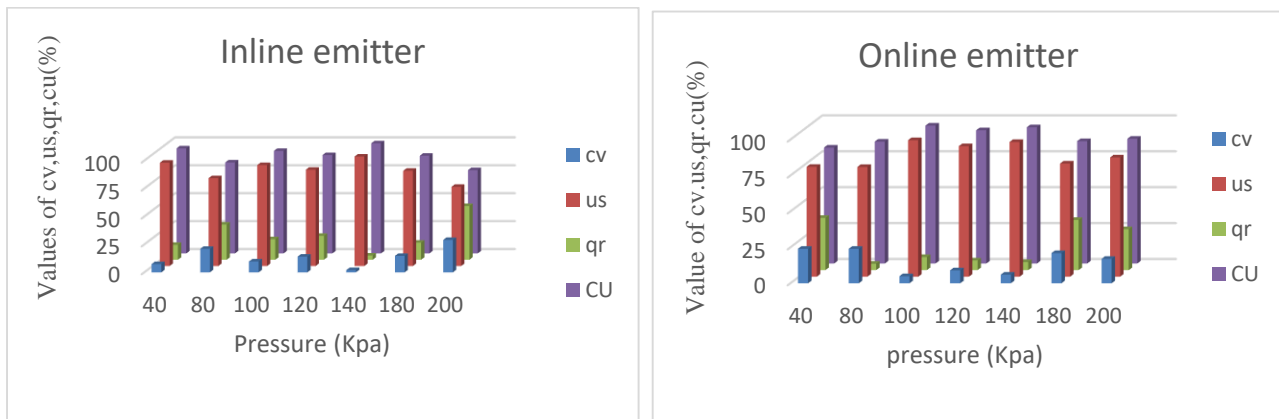


Figure-4 (A, B): Provides the relation between values of (CU, CV, EUd, and q var %) and pressure (kPa).

**C-Effects of slop irrigation system different pressure on performance of emitter.**

Table (4) and Fig. (5) shown the results effects of different pressure, two slops and with two different types of emitter on performance of emitters (E1 2.0% S, E2. 2.0% S, E1. 0.0% S, E1. 0.0% S) used by groundwater. The effect of different pressure with (E1) 2.0% range of values (3.63-3.07) l/h flow rate from (40 to 200) kPa, the high value was 4.98 l/h in 120 kPa, but the lower value was 2.51 l/h in 180 kPa. While, the effect of different pressure with use for (E2) 2.0% the range of value (6.87-8.66) l/h flow rate between (40 and 200) kPa, the high value was 10.37 l/h flow rate in 120 kPa, but the lower value was 4.33 l/h in 180 kPa. On the other hand, different pressure (E1) 0.0% the range of value (2.94-0.51) l/h flow rate after among (40- 200) kPa, the high value was emitter 4.46 l/h flow rate in 120 kPa, but 0.51 l/h flow rate in 200 kPa was low. However, the effect of different pressure uses for (E2) 0.0% the range of value (4.25-2.41) l/h flow rate at the same time, the high value was 9.68 l/h in flow rate in the 120 kPa but the lower value was 2.41 l/h flow rate in 200 kPa. The relationship between the discharge and the pressure head plays a crucial role in the choice of the emitter. When the water pressure at the inlet was high, the discharge rate rose slightly. The relationship between the pressure head and the discharge rate suggested that the discharge was raised by the rise in the pressure head. It is found that due to pressure variations, the emitter discharge variance may also occur, this result is supported by [26].

Also, Low or high emitter discharge exponent values indicated low or high emitter discharge response to operating pressure changes, respectively. This obtained by [27].

1- When the effect of different pressure used to groundwater was a comparison between two different types emitter ((E1) 2.0% and (E2) 2.0% flow rate after (40to 200) kPa. (E1) 2.0% was high significantly varied ( $P \leq 0.05$ ) between the treatments with the mean emitter 10.37 l/h flow rate in 120 kPa, however (E1) 2.0% was lower value 2.51 l/h flow rate in 180 kPa. All of them significant together accept 4.33 l/h in (E2) 2.0% were not significant with (3.63, 4.96, 4.24, 4.98, 4.71, and 3.07) l/h in (E1) 2.0%.

2- When the effect of different pressure used to ground water was comparison between two different types emitter (E1) 0.0% and (E2) 0.0% flow rate after (40 to 200) kPa. ((E2) 0.0% was high significantly varied ( $P \leq 0.05$ ) between the treatments with the mean emitter 9.68 l/h flow rate in 120 kPa, however (E1) 0.0% was lower value 0.51 l/h flow rate in (200) kPa. All of them significant together except (4.25, 3.30) l/h in ((E2) 0.0% were not significant with (3.66, 3.4, 4.33, and 4.46) l/h in (E1) 0.0% respectively. In addition, 3.30 l/h in (E2) 0.0% was not significant with 2.94 l/h in (E1) 0.0%. Furthermore, 2.41 l/h in (E2) 0.0% were not significant with (2.94, 3.66, 3.40, 1.86) l/h; in (E1) 0.0%.

3-When the effect of different pressure used to ground water was comparison between two different types emitter (E1) 2.0% and (E2) 0.0% flow rate after (40 to 200) kPa. (E1) 2.0% was high significantly varied ( $P \leq 0.05$ ) between the treatments with the mean emitter 4.96 l/h flow rate in 80 kPa, however (E1) 0.0% was lower value 0.51 l/h flow rate in 200 kPa. Moreover, 0.51 l/h in (E1) 0.0% was significant all of them (E1) 2.0%, also 1.86 l/h at similar situation expect (2.51, 3.07) l/h in (E1) 0.0%. While 3.66 l/h flow rate in 80kpa was not significant to all of them in(E1) 2.0%. Also, 3.40 l/h in (E1) 0.0% was not significant all of them (E1) 2.0% Expect (4.96, 2.51) l/h in(E1) 2.0% were significant. In addition, 1.86 l/h (E1) 0.0% was significant all of them (E1) 2.0% Except (2.51, 3.07) l/h in(E1) 2.0% were not significant effect.

\*p-value significant at 0.05 Level.

4- When the effect of different pressure used to ground water is comparison between two different types emitter

Table-4: The discharge of inline and online emitters as affected by operating pressure under two lateral slopes

Pressure (Kpa)	Freshwater			
	Inline emitter (L/h) E1.2.0% S	Online emitter (L/h) E2. 2.0 %S	Inline emitter (L/h) E1. 0.0% S	Online emitter (L/h) E2. 0.0% S
40	3.63 cdefg	6.87 jk	2.94bcd	4.25defgh
80	4.96 zhi	6.63 jk	3.66 cdefgh	6.73jk
100	4.24 defgh	7.15 jk	3.40 cdefg	6.85jk
120	4.98 hi	10.37 n	4.33 efgh	9.68 mn
140	4.71 ghi	7.52 kl	4.46 fgh	6.00ij
180	2.51bc	4.33 efgh	1.86 a	3.30 cdef
200	3.07 bcde	8.66 lm	0.51 a	2.41 bc

(E1) 2.0% and (E2) 0.0% flow rate after (40 to 200) kPa (E2) 2.0% was high significantly varied ( $P \leq 0.05$ ) between the treatments with the mean emitter (10.37) l/h flow rate in 120 kPa, however (E2) 0.0% was lower value 2.41 l/h flow rate in 200 kPa/30sec. Moreover, 2.41 l/h in (E2) 0.0% was significant all of them (online 2.0%, also (10.37,8.66) l/h at similar situation expect 9.68 l/h flow rate in (E1) 2.0%. While (6.73,6.85,6.00) l/h flow rate in (E2) 0.0% was significant all of them in(E1) 2.0% except (6.87,6.63,7.15 ,7.52) l/h were not significant. Also, 4.33 l/h in (E2) 2.0% was significant all of them (E2) 0.0% expect (4.25,3.30) l/h in (E2) 2.0%

were not significant. In addition, 1.86 l/h (E2) 0.0% was significant all of them (E2) 2.0% except (2.51, 3.07) l/h in (E1) 2.0% were not significant effect.

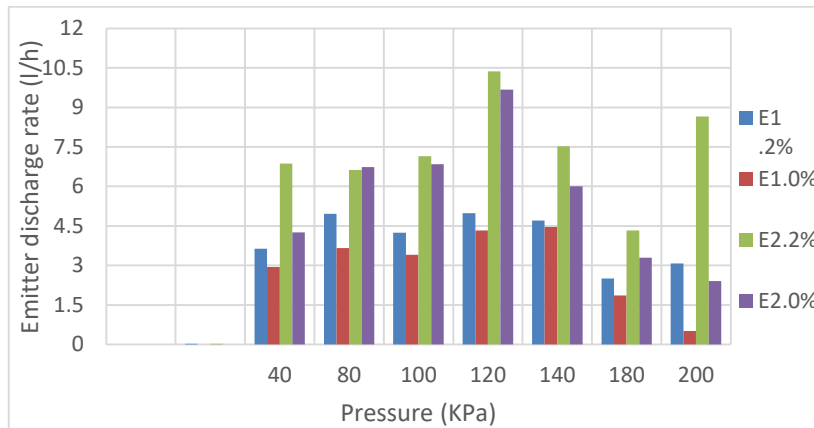


Figure-5: Indicates Laboratory different pressure between two types of emitters.

#### D. Results of the field experiment

##### -Variation of time for Emitter Discharges

From Figure 6. (A and B) shown changes in the mean discharge ratio for the different emitter types and the two water sources. According to equation 5, the least value of the changes in the mean discharge ratio (qr), the more severe were the clogging of the emitters. The different types of emitter indicated different levels of sensitivity to clogging; The emitters were considered clogged when their discharge decreased by more than 25% compared with the initial discharge [28] however, the emitter discharge rates display similar decreasing methods overtime for all the emitter types tested. The reductions in qr were little at the starting of the experiments; however, the (qr) value decreased speedily over time as the period of the operation exceeded (14-84) hours for the treated wastewater application of inline emitters and from (14-84) hours for the groundwater application, varying with emitter types. At the same time, there is not any difference between the two water sours in online emitters. This suggests that the formation of clogs in the emitter is quite slow at the beginning of irrigation, but that clogging increases quickly once a slight clog forms in the emitters. Table (5) provides the initial and final flow rate and relative changes for 6 periods of run irrigation (84 hrs). After (84 hrs) of continuous irrigation the inline emitters distributing ground water showed lower clogging than treated wastewater between (67.11% and 74.87%) respectively. The flow rates of online emitters distributing treated wastewater were reduced by 35.99 % overall with the most severe reduction being 32.42 % for the same emitter in the Groundwater. The change% between inline and online emitter 11.56%.and percentage change between online Groundwater and Treated wastewater were 3.58, the percentage change between inline and online emitter in Groundwater was reduced to18.548.

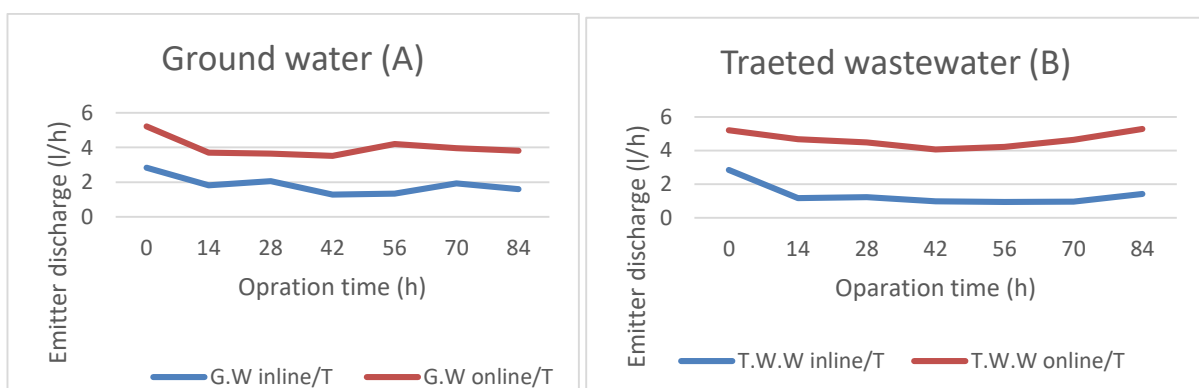


Figure-6: Presents mean discharge of the two emitter types (E1) and (E2) with the application of (GW) and (Tww)

Table-5: Shows initial and final flow rate for six periods of run irrigation (84 hrs).

Hours No.	Ground water						Treated wastewater					
	Inline			Online			Inline			Online		
	Initial	Final	% Change	Initial	Final	% Change	Initial	Final	% change	Initial	Final	% Change
14	4.234	1.5	64.57	5.736	3.5	38.98	4.234	1.2	71.66	5.736	4.4	23.29
28	4.234	1.9	55.13	5.736	3.6	37.24	4.234	1.4	66.93	5.736	3.5	38.98
42	4.234	1.362	67.83	5.736	3.404	40.66	4.234	1.04	75.44	5.736	4.452	22.38
56	4.234	1.652	60.98	5.736	3.368	41.28	4.234	1.06	74.96	5.736	4.437	22.65
70	4.234	0.965	77.21	5.736	3.217	43.92	4.234	0.86	79.59	5.736	3.985	30.53
84	4.234	0.977	76.92	5.736	4.029	29.76	4.234	0.82	80.61	5.736	4.201	26.76
Total			402.64			231.8			449.19			164.59
% Change (average)			67.1067			38.64			74.865			27.4317
% Change between inline and online emitter =GW					28.46				47.433			
% Change between inline Groundwater and Treated wastewater										Increase of 11.56%		
% Change between online Groundwater and Treated wastewater										Increase of 11.208		

It is observed from results in Table (6) shows that the drip irrigation system discharge reduction percentage with the time operation, (inline -online) emitter used by two sources (groundwater and treated wastewater). Discharge reduction percentage inline emitter used to GW range of value (64.83-68.27) l/h flow rate from (14 to 84) hrs, the high value was 69.77 l/h but the lower value was 51.03 l/h. While, the discharge reduction (%) use for online emitter used by GW the range of value (38.45-26.84) l/h flow rate between (14 and 84) hrs., the high number was 39.45 l/h but the lower value was 26.84 l/h. On the other hand, Discharge reduction percentage inline emitter used to treat wastewater range of value (70.87-77.89) l/h flow rate after among (14 to 84) hrs., the high value was 77.89 l/h flow rate after 84 h but 65.91 l/h in the same emitter was low. However, the results indicate that the discharge reduction (%) use for online emitter used by treated wastewater the range of number (22.57-26.37) l/h flow rate at the same time, the high value was 39.45 l/h but the lower value was 18.64 l/h.

1- When used to groundwater is a comparison between two different types of emitter (GW E1 and GW E2) flow rate after (14 to 84) hrs. (GW E1) was high significantly varied ( $P \leq 0.05$ ) between the treatments with the mean emitter 69.77 l/h flow rate after 70 hrs. however (GW E2) was lower significant in these treatments, Discharge reduction percentage was relative during time flow rate 84 hrs. and the quantities of added irrigation water were 26.84 l/h to the emitter capacity.(inline emitter and online emitter) and flow reimbursement or not is in line with that received by other authors when using irrigation by low-quality water, wastewater of poor quality. This is because wastewater intensifies the ability of microorganisms on the internal surfaces of a micro-irrigation system to grow and create a biofilm layer. The formation of biofilm can result in decreased or uneven discharge and clogging of emitters. The decrease in uniformity documented with the increase in hours of irrigation with regenerated water in all emitter models also correlates with that achieved by other authors. This is because the formation of biofilms is a mechanism of biomass aggregation that rises with the presence of regenerated water. The formation of the biofilm has various phases before the creation of the biofilm, with different structural characteristics, and there is a connection between the accumulation of biomass and the obstruction in a drip irrigation system that receives reclaimed wastewater. [29].

2- When used to treated wastewater is comparison between two different types emitter (T.W.W E1 and T.W.W. E2) flow rate after during of this time, some of them was significant in those emitters (T.W.W E1) was high significantly varied ( $P \leq 0.05$ ) between the treatments with the mean emitter 77.89 l/h flow rate after 84 hrs. However (T.W.W. E2) was lower significant in these treatments, Discharge reduction percentage was relative

during time flow rate 42 h, and the quantities of added irrigation water were 18.64 l/h to the emitter capacity. While except (54.42, 57.01, and 51.03) l/h was not significant with (38.45, 36.95, 35.50, 36.42, and 38.69) l/h in addition to 51.03 l/h was not significant with 26.84 l/h. The online emitters recorded the lowest clogging percentage, followed by online emitters, with inline emitters showing the highest value in (Tables 7).

In both emitter forms, the clogging percentage ( $P_{clog}$ ) also increased with time. This may be attributable to the fact that the clogging materials were precipitated by the inline emitters rather than the online emitters. Also, due to emitter form and water quality, the clogging percentage differed. This outcome is supported by the discovery of [30].

3- When used to GW and treated wastewater is a comparison as the same types of emitter (GW E1 and T.W.W E1) flow rate between (14 -84) hrs. All of them were not significant together but 51.03 l/h with (76.78, 77.89) l/h were significant. Furthermore, the high value was 77.89 l/h flow rate after 84 h. In their work on clogging drip emitters using GW and treated wastewater effluent, this finding is close to those obtained [29], as they note that the risk of emitter obstruction increased when treated wastewater was applied. Furthermore, clogging fluctuated as the hours of irrigation with regenerated water of lower quality rose and decreased as the quality of water improved [31]. This happens because there may be a loosening of particles from the inner wall of the pipes in certain instances, which will travel to the inner part of the drippers, raising the clogging problem [32]. As well as, In the trickle emitter models, complex biofilm usually develops from the relationship between physical (pH, suspended solids), chemical (dissolved solids, calcium, magnesium, and manganese), and biological agents (bacteria) [33].

4-When used to GW and treated wastewater is a comparison as the same types of the emitter (GW E2 and T.W.W E2), while they were not significant effect together.

Table-6: Influence time of operation and different water resource on discharge percentage (%) of emitters.

Time (hrs)	Ground water		Treated waste water	
	Inline emitter GW E1	Online emitter GW E2	Inline emitter T.W.W E1	Online emitter T.W.W. E2
14	64.83 abc	38.45 defg	70.87 ab	22.57 g
28	54.42 abcde	36.95 defg	65.91 ab	39.45 cdefg
42	57.01 abcd	35.50 defg	72.29 ab	18.64 g
56	51.03 bcdef	36.42 defg	71.15 ab	21.99 g
70	69.77 ab	38.69 defg	76.78 a	29.22 efg
84	68.27 ab	26.84 fg	77.89 a	26.37 fg

\*p-value significant at 0.05 Level.

## Conclusion

Changes in the discharge rate were measured for two different emitter types during daily treated wastewater and groundwater applications for 70 hrs., to investigate the development process of emitter clogging in drip irrigation systems. The reduction of the emitter discharges due to clogging was very slight at the beginning of the water application, but the development of clogging accelerated once a partial clog was formed in the Inline emitter of groundwater and treated wastewater. Clogging was affected by the duration of irrigation, water quality, emitter type, in drip emitters, and quality of manufacturing. The treated wastewater used in the experiments caused much more severe clogging than the groundwater since a considerably larger population of bacteria in the treated wastewater accelerated biofilm build-up in the inline emitter.

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