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ORIGINAL PAPER

Engineering and hydraulic factors affecting irrigation channels efficiency

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ABSTRACT

Field experiments were conducted during the summer of 2024 in the Middle Delta Gharbia Governorate in the Zifta area to study the engineering and hydraulic factors affecting Egypt's most common irrigation channel efficiency. Five channels (plain, rough, cement-lined, precast concrete, and buried pipes) were evaluated for hydraulic coefficients. Also, land saving, conveyance efficiency, and cost analysis of the type of channel irrigation compared to the channel irrigation system. The results of this study showed that the area added by buried pipes was 150 m², representing a 100 % increase in the cultivated area. Also, using the cement-lined channel instead of the plain and rough channel led to increased agricultural areas. The area added by the cement-lined channel was 90 m² with a percentage of 60 % added area. On the other hand, results indicated that the conveyance efficiency (C.E.) was 80.77, 78.46, 93.85, 92.31, and 99.62 % under the plain, rough, cement-lined, precast concrete channel, and buried pipes, respectively. Also, the results indicated that the total cost was 180, 200, 225, 260, and 305 LE per length meter under plain channel, rough channel, cement lined channel, precast concrete channel and buried pipes, respectively. Data of the hydraulic factors evaluation of irrigation channel showed that indicated average water depth in different types of channels (m) for plain, rough, cement lined, precast concrete and buried pipes was 0.31, 0.22, 0.52, 0.63, 0.90 m, respectively, the values of the cross-sectional area through different types of channels were 0.44, 0.25, 0.31, 0.78 and 0.03 m² for plain, rough, cement lined, precast concrete and buried pipes, respectively, the values of discharge rates through different types of channels were 0.029, 0.028, 0.034, 0.033 and 0.036 m³/s for plain, rough, cement lined, precast concrete and buried pipes respectively, and the values of the velocity through different types of channels were 0.0828, 0.1431, 0.1157, 0.0462 and 1.1141 m/s for plain, rough, cement lined, precast concrete and buried pipes, respectively. Also, the results show that the values of the Manning coefficient through different types of channels were 0.025, 0.033, 0.014, 0.013 and 0.011 for plain, rough, cement-lined, precast concrete and buried pipes, respectively, values of the hydraulic radius through different types of channels were 0.174, 0.120, 0.190, 0.262 and 0.001 m for plain, rough, cement lined, precast concrete and buried pipes respectively, and values of the wetted perimeters through different types of channels were 1.95, 1.53, 1.64, 2.39 and 0.31 m/s for plain, rough, cement lined, precast concrete and buried pipes, respectively. Thus, predicated on these findings, the study suggests broadening the employment of irrigation channels, particularly buried pipes, in place of plain channels.

1. Introduction

Surface irrigation is one of the largest irrigation systems in the world, especially in Egypt. Water is delivered to fields from the main canals, which draw their water from the Nile River, through a network of subsidiary canals and field canals. Field canals vary

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depending on the construction method or the type of lining material. The most used in Egyptian fields are plain channels and rough channels. The development of field canals has played a significant role in preventing water loss due to leakage from traditional canals. It is also a technology used to improve the conveyance efficiency of irrigation channels by preventing water loss through evaporation or seepage.

Ghulam et al. (2023) stated that assessing how efficiently lined irrigation channels operate within the Indus Basin Irrigation System is key. It helps us understand how well the system performs and pinpoints places where better management could boost efficiency.

Aybek et al. (2023) found that to minimize the water seepage rate in unlined ditches, you must account for the hydraulic properties and soil makeup of the channels already in place. A key issue in canal design today is creating hydraulically efficient designs. A smaller wetted perimeter in the channel will help solve this because it cuts down on seepage.

Abduraimova et al. (2022) showed that creating trapezoidal ridges in cotton irrigation can improve water flow patterns. Simultaneously, specifically designed water meters were employed for irrigation. The hydraulic characteristics of the field's water flow and erosion levels were assessed. This evaluation considered the movement and energy dynamics of the flow within the fields, using a water meter with a 15 mm diameter.

El-Attar et al. (2022) indicated that the average water application efficiencies were 82%, 79% and 49% for buried pipes, lined mesqa and earthen mesqa, in that order. Moreover, the average water distribution efficiency via buried pipes and lined mesqa, compared to traditional irrigation methods, were 78%, 75% and 72%, respectively, throughout the season.

Askaraliev et al. (2024) found that employing contemporary irrigation methods, including drips systems and automated controls driven by the Internet of Things, substantially boosts water usage effectiveness in farming.

Kosichenko and Baev (2020) found that, under regular conditions, issues impacting throughput and channel effectiveness have been noted; data necessary for pinpointing additional hydraulic efficiency factors is included as well. Using real-world data analysis, it was found that the efficiency of main canals is 0.790 when using an earthen bed and 0.870 for canals using cladding, a significantly lower figure.

Tabari et al. (2014) abbreviated the design of a canal cross-section for minimal cost, viewed as the objective, as focusing on minimizing the overall expenses for each unit length. These expenses encompass direct costs like excavation per cubic meter and lining per meter, alongside indirect costs from water loss due to seepage and evaporation. Because the direct and indirect costs depend on the canal's shape and measurements, optimizing the defined objective function can lead to reduced costs.

Jadhav et al. (2014) reported that water losses from the lined and unlined portions of the canal irrigation system were assessed as they are, and potential management strategies were created to use the water that would be saved for irrigation in the Panchnadi Minor Irrigation Project. The overall efficiency and total water lost from the lined, unlined canal sections and unlined field channels under current conditions were found to be 75, 52, and 35 percent, and 0.184, 0.61, and 0.183%, respectively.

Barkhordari et al. (2020) mentioned that agricultural water systems lose water primarily due to seepage and incorrect management of canal structures. Findings revealed that significant decreases in operational and seepage losses were possible for different target levels in the absence of inline storage. Yet, the effectiveness ratings for all off-takers were low, indicating the water delivery method was undependable and unsatisfactory. Employing inline storage led to an 8–9% decrease in operational losses and a 3–7% reduction in seepage, along with good adequacy ratings signified satisfactory water delivery.

Khan et al. (2024) pointed out that water is a highly precious natural resource. Some of these resources are lost through seepage during its movement through a canal. The findings reveal that average losses in PCC, brick, and unlined canals were 2.25%, 6.04% and 19.07%, respectively. The typical conveyance efficiency of an unlined canal is 81.93%, which is considerably lower compared to PCC and brick canals, which are 97.75% and 93.96%, respectively. It was estimated that lining with PCC and brick would decrease seepage losses by 16.82% and 13.03%, respectively.

Abdelmoaty (2013) revealed that the most practical maintenance program is to boost the hydraulic effectiveness of the investigated area, decrease the water level reduction, and guarantee the area can deliver the necessary water flow to downstream segments. Canal Cross-sections were examined, flow velocities were measured, and water discharge was estimated along the studied section. Abdusamadovich (2020) developed a model for controlling canal flow depth using hydraulic principles. Its dependability was established based on how water moves over time. Analyses focused on understanding hydraulic relationships within trapezoidal irrigation canals, considering varying hydraulic characteristics of the water flow.

Mohamed et al. (2019) mentioned that across all categories, Egypt's irrigation canal systems struggle with insufficient water and unfair distribution among users.

Consequently, modernization is crucial to address the issue of water scarcity at the canal's endpoints. A key area for improving irrigation systems is switching from earthen mesqa channels to elevated lines or underground pipes.

Fatxulloyev (2020) concluded that using XSLEM-Doppler (River Surveyor Live), research into how soil channel beds deform allowed us to understand the flow dynamics, its movements and the rise of hydraulic resistance. A velocity profile was generated by analysing the flow's motion, which illustrates how flow velocity changes with depth within the natural soil channel.

Sheta et al. (2024) said that water use efficiency is strategically crucial in dry and semi-dry areas dealing with water shortages. This suggests that surge flow irrigation (SF) may positively influence crop yields in water scarcity regions, improving water use efficiency (WUE). Improving water use efficiency is strategically significant in arid and semi-arid regions where water scarcity is an issue. This implies that surge flow irrigation (SF) could positively impact crop production in water-scarce areas by enhancing water use efficiency (WUE).

This research aims to study the engineering and hydraulic factors affecting irrigation channels efficiency.

2. Materials and methods

Field experiments were conducted during the summer of 2024 in the Middle Delta, Gharbia Governorate, in the Zifta area. Five channels used ditches (plain, rough, cement lined, precast concrete, and buried pipes) were evaluated. A Predetermined Length (100 m) was established for the various kinds of irrigation channels under investigation. These experiments were administered to study the effect of the types of irrigation channels irrigation on land saving, water conveyance efficiency, and analysis of construction and maintenance costs per linear meter. On the other hand, it is important to study hydraulic factors. It includes discharge, velocity, depth, and different dimensions of irrigation channels.

2.1. Pumping Unit

It consists of a centrifugal pump that is driven by a diesel engine under various conditions. A flow meter, discharge valve, and pressure gauge were all included on each pumping unit discharge side to measure the flow head at the pumping head. Pumping units with the specifications of the pumps and engines are shown in Table 1.

2.2. Description of the Types of Channels

2.2.1. Plain Channel (P.C)

Plain channel (P.C) is a canal where the natural ground is simply excavated or dikes. Clay or clay loam soil is used for both irrigation and drainage canals. Side slope is 1:1.0 (consolidated gravelly clay) to 1:2.0 (gravel-mixed sandy loam). Receives irrigation water by individual farmer's pumping units. The pump lifts irrigation water from the branch canal to convey irrigation water to plain channel by gravity and then to the field. The area served by a channel is usually 20 to 100 feddan. The channel has an average breadth of 1.5 m, an average depth of 0.40 m, and an average bed width of 1.2 m as shown in Fig. 1.

2.2.2. Rough Channel, (R.C)

Rough Channel (R.C) is a canal where the natural ground is simply excavated or dikes, and canals where inner flow portions are protected by turf, stabilizer, or granular fill. Clay or clay loam soil is used for both irrigation and drainage canals. Side slope is 1:1.0 (consolidated gravelly clay) to 1:2.0 (gravel-mixed sandy loam). Receives irrigation water by individual farmer's pumping units. The pump lift irrigation water from the branch canal to convey irrigation water to rough channel by gravity then to the field. The area served by a channel is usually 20 to 100 feddan. The channel has an average breadth of 1.2 m, an average depth of 0.30 m, and an average bed width of 1 m, as shown in Fig. 2.

2.2.3. Cement Lined Channel (C.L.C)

Cement Lined Channel (C.L.C) is a canal where the wall body is independent from the canal base, and the retaining wall itself plays a role in maintaining stability against earth pressure from behind, groundwater pressure, etc. Applied to irrigation canal having an advantage in structural durability and its suitability for the canal system. It is created using masonry and cement. The side slope is Less than 1:1.0, and the channel has a rectangular cross-section. It is about lifting channels up to the ground. Channel aspects and the base of bricks: channel height is 60 cm, and width is 60 cm. The water is lifted to the channels using pumps. The irrigation water comes through holes located at the head of each channel. Fig. 3. shows a schematic diagram showing cement-lined channel dimensions and current state conditions of the cement-lined channel.

2.2.4. Precast Concrete Channel (P.C.C.)

Precast Concrete Channel (P.C.C.) is a canal where concrete slabs are used for pavement material. These materials have higher resistance against corrosion than other materials and are adaptable to comparatively large velocities. It is created using concrete slabs, plain concrete and reinforced concrete. Side slope is more than 1:1.0, determined by considering soil character, canal size, construction method, maintenance, etc. In cases of unsuitable soil, such as where slopes are not stable, designs shall be performed on the necessity of replacing banking, conditions of groundwater, etc. In the present work, one U-section channel was used. It is about lifting channel up to the ground. Channel aspects and its base of Concrete U-section height 71 cm and width 76 cm. The water is lifted to the channel using pumps. The irrigation water comes through holes located at the head of each channel. Fig. 4. A schematic diagram shows precast concrete channel dimensions and current state conditions of the precast concrete channel.

Table 1

The specifications of the pump

Type of pump	Pump made	Engine speed, (rpm)	Engine power, (hp)	Max. discharge, (m^3/h)	Max. operating pressure, (bar)	Suction pipe diameter (Inch)	Delivery pipe diameter (Inch)
Centrifugal	Diesel Shobra	1460	12 hp 9 kW	144 m^3/h 40 l/s	1 bar 100 kPa	6 inch 150 mm	6 inch 150 mm

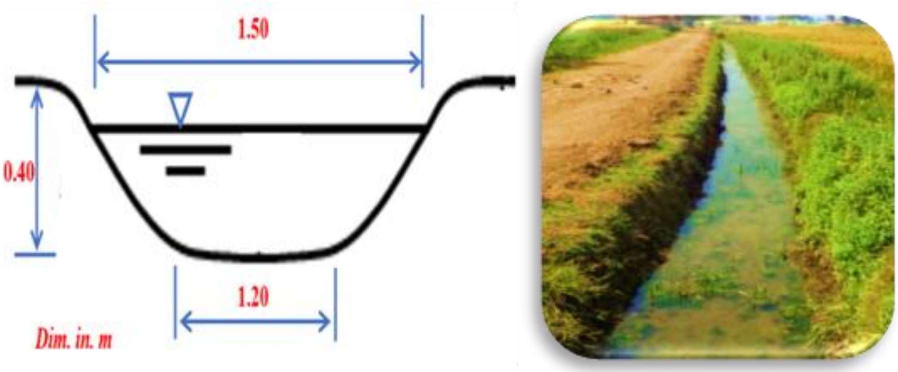


Fig. 1. A schematic diagram showing plain channel dimensions.

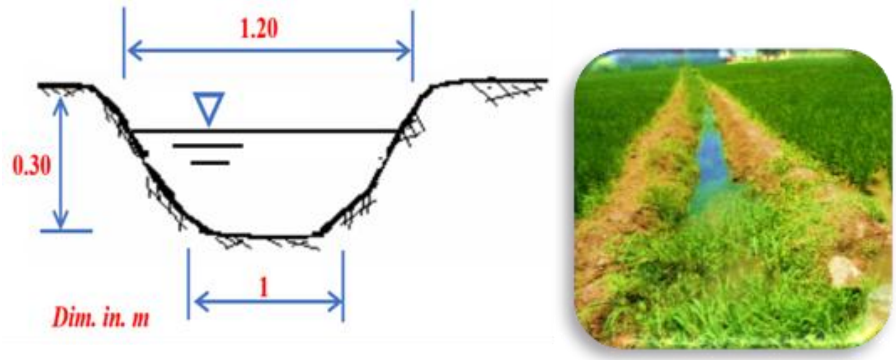


Fig. 2. A schematic diagram showing rough channel dimensions

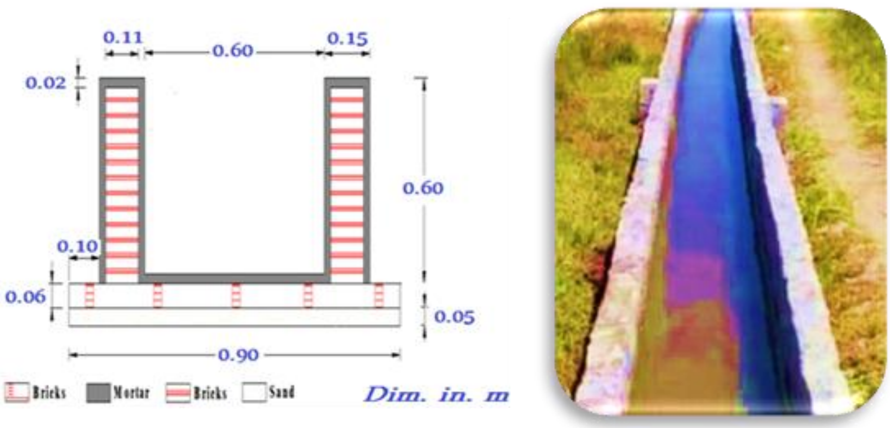


Fig. 3. A schematic diagram showing cement-lined channel dimensions

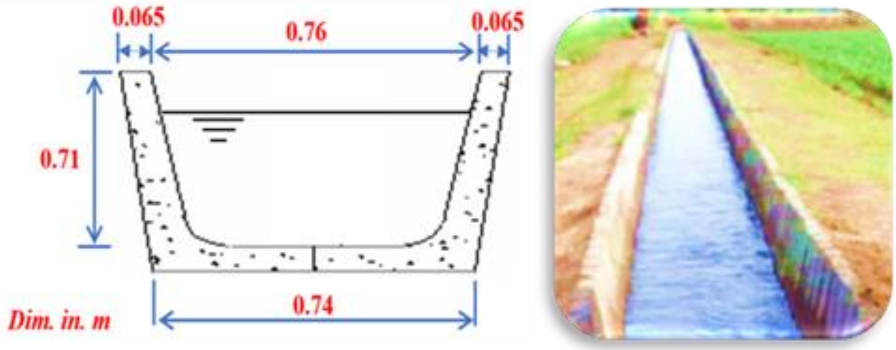


Fig. 4. A schematic diagram showing precast concrete channel dimensions

2.2.5. Buried Pipes (B.P)

Buried Pipes (B.P) are the field received irrigation water from the branch canal through electric pumping unit to the main and branch buried pipes. The line's outer diameter was 168 mm and the thickness was 4.5 mm. The UPVC pipes were connected using faucet rubber ring jointing system. On the branch line there are risers ended by 160 mm hydrant valve.

The headland facilities for surface irrigation can also consist of surface or buried pipes. Basin and border irrigation systems usually employ buried pipes serving one or more gated risers within each basin or border. An illustration of the use of riser outlets to irrigate is also shown in Fig. 5.

2.3. Land saving, (L.S)

One of the disadvantages of ditches channel, that used in surface irrigation, occupies part of the total area of the field. Five different zones were surveyed to calculate land saving area for different channels and determine the zone's total area. Five cases of different areas were chosen as the following treatments to determine land saving ratio in channels.

In channels the lengths were measured by linen scale tape and width was measured every 20 m along channels also, in channels lengths and width were measured by the linen scale tape. Land area dimensions measured by the linen scale tape. These percentages of land saving are determined as formula (1).

$$\text{Land saving } (\%) = \left(\frac{\text{areas occupied by channels}}{\text{total area}}\right) \times 100 \quad \ldots [1]$$

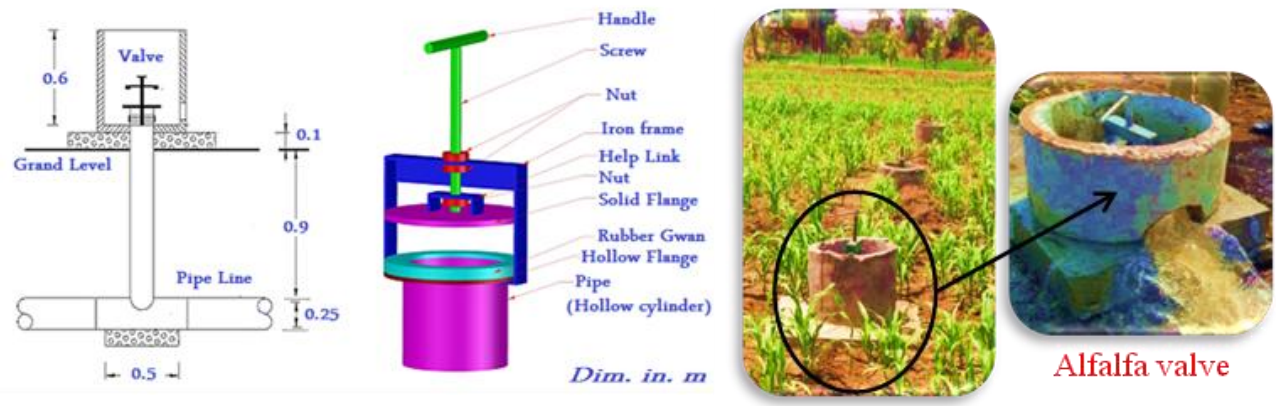


Fig. 5. A schematic diagram showing buried pipes dimensions

2.4. Conveyance efficiency (C.E)

It was measured at channels by measuring discharges from the pump using flow meter and discharge from the alfalfa valve in the field entrance measuring by using known size tank in known time. The conveyance efficiency was measured in channels by measuring discharges from pump using known size tank at known time and discharge from the field's entrance were measured by using pipe and a known size tank at a known time. Discharge was calculated using equation (2). This test was replicated four times.

$$Q = \frac{V}{T} \quad \text{... [2]}$$

where: Q = discharge m³/ h.
V= the volume m³.
T= time (hour) h.

Multiple researchers determined and described the effectiveness of water conveyance systems linked to canal networks, water sources and field channels. It's also relevant where the water is conveyed in channels from well to individual fields. calculated from the subsequent formula (3) according to (Howell, 2003).

$$C.E = \frac{W_f}{W_d} \times 100 \quad \text{... [3]}$$

where: C.E = Conveyance efficiency, %
W_f = Water delivered to the irrigation plot (m³)
W_d = Water diverted from the source (m³).

2.5. Hydraulic design by normal calculation of channels

The values of both our discharge and velocity were ascertained as the most important engineering design parameters for the channel.

2.5.1. Discharge through channel

In hydraulic design of the canal, the following equation (4) is used generally according to Khurmi, 1982.

$$Q = A \times v \quad \text{... [4]}$$

where: Q: Discharge, m³/s
A: Cross-sectional area of flow, m²
v: Mean velocity, m/s

2.5.2. Mean velocity for open channel system

The mean velocity of uniform flow in the open channel system is calculated by the Manning's equation (5) according to Khurmi (1982). The relation of each element is shown in Fig. 6.

$$v = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot S^{\frac{1}{2}} \quad \text{... [5]}$$

The channels were trapezoidal and rectangular cross sections respectively; the breadth and depth were calculated from the following formula (7) through (9).

$$A = (b + n\,y)y \quad \text{... [6]}$$

$$P = b + 2\,y\sqrt{(1+n^2)} \quad \text{... [7]}$$

$$A = b \times y \quad \text{... [8]}$$

$$P = b + 2\,y \quad \text{... [9]}$$

where: v: Mean velocity (m/s)
n: Coefficient of roughness
R: Hydraulic mean depth (m) R = Cross-sectional area (A) / Wetted perimeter (P)
S: Canal slope
A: area of flow, m².
P: wetted perimeters, m.
b: breadth of the channel, m.
y: depth of the channel, m.

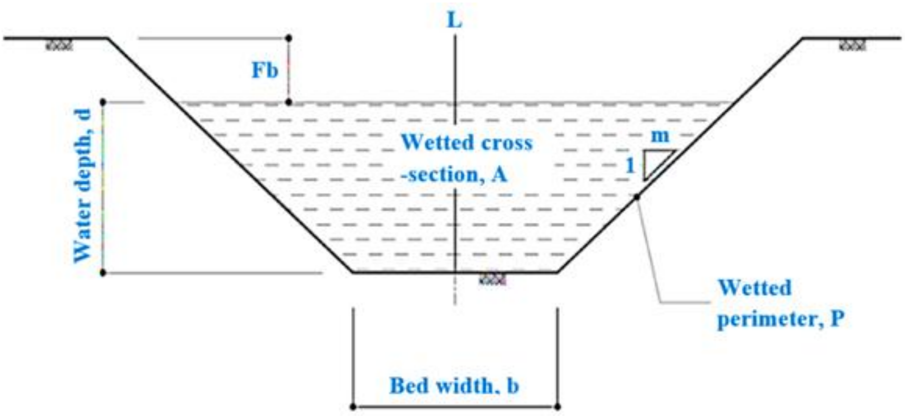


Fig. 6. Channel parameters

2.6. Cost Analysis

A foundation for choosing channel irrigation from feasible options is the expenses of setting up and servicing the system. Evaluating an irrigation system involves estimating all costs and revenues anticipated from its development due to introducing this system. The channel irrigation expenses must encompass all costs associated with operating and maintaining the irrigation system. Because of the many factors that affect the total cost of channel irrigation, it was considered to express these factors as variables in a mathematical equation to help farmers and designers compute a primary cost of channel irrigation per unit area at any time resulting from any change in price of any unit or component of irrigation systems. Total construction cost for a channel irrigation per unit area can be calculated as an employing Equation (10).

Total construction expenses are split into two categories. The initial group deals with operating, while the subsequent group includes maintaining. The devaluation of construction costs is assumed to be 20 years. The construction expenses (Cc) per unit length (m) can be computed based on the following formula (Basiuony, 1999).

$$Cc = \frac{G + M}{L} \quad \dots [10]$$

where: Cc = Total construction cost to establish a channel irrigation, L.E./m.

L = Length of the channel, m.

G = Excavation and backfill cost, LE.

M = Maintaining costs, LE (according to the prices of 2024).

3. Results and discussions

3.1. Effect of Type of irrigation channels on the land saving

The results of the computation of land saving in type of channels irrigation different are shown in Table 2 and Fig. 7 to facilitate the discussion.

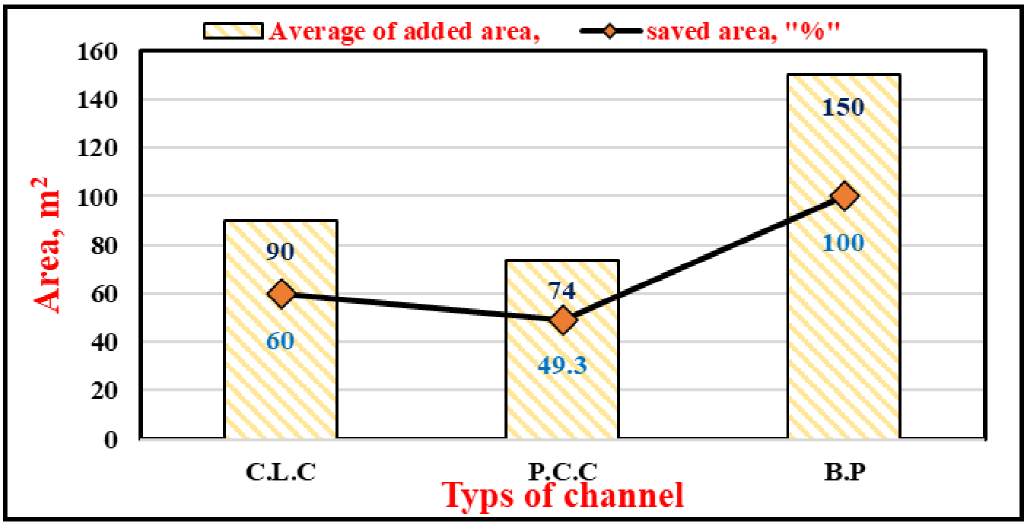
Table (2) and Fig. 7 show the land saving in type of channels of irrigation Data show that the land saving increased in the buried pipes about of the cement lined channel and precast concrete channel. As a result of the exploitation of all areas for buried pipes.

When data illustrated in Table 2 showed that by using the buried pipes network instead of plain channel and rough channel led to an increase in agricultural area (150 m^2) which represents 100 % increase in the cultivated area. While, by using the cement lined channel instead of plain channel and rough channel led to an increase in agricultural areas (90 m^2). with a percentage of 60 % added area. also, using precast concrete channel instead of plain channel and rough channel led to increasing agricultural areas (74 m^2) with percentage of 49.3 % added area.

Table 2

Effect of type of channels irrigation on saving agriculture area.

Type of channels	Length of channel, "m"	Average of channel width, "m"	Average of saved area, "Fed"	Average of added area, "m²"	saved area, "%"
Plain Channel	100	1.50	0.036	150	00
Rough Channel	100	1.50	0.036	150	00
Cement Lined	100	0.60	0.014	90	60
Precast Concrete	100	0.76	0.018	74	49.3
Buried Pipes	100	0.00	0.036	150	100



Note: C.L.C at Cement Lined Channel, P.C.C at Precast Concrete Channel, and B.P at Buried Pipes.

Fig. 7. Effect of Type of channels irrigation on the added area and average added area

3.2. Conveyance efficiency (C.E. %)

Fig. 8. shows the values of conveyance efficiency (C.E.) were 80.77 % and 78.46 %, 93.85 %, 92.31 % and 99.62 % for 100 m length of plain channel, rough channel, cement lined channel, precast concrete channel and buried pipes, respectively. Generally, the conveyance losses in plain channel and rough channel ranged 19.23 % and 21.54 %, respectively, because of evaporation and seepage into the soil from the surfaces of the sloping side sand bed of the canal.

On the other hand, in the cement lined channel and precast concrete channel, there isn't seepage. Hence, the conveyance losses are less than plain and rough channel ranging from 6.15 % and 7.69 %, respectively. In comparison, the conveyance losses in buried pipes were 0.38 % because of small evaporation from valves or small seepage from pipes.

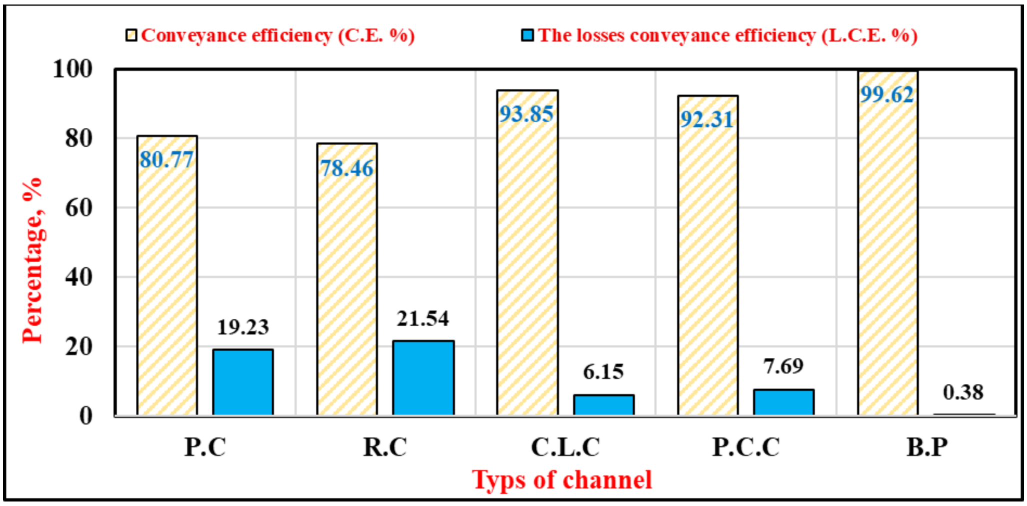


Fig. 8. Effect of using the type of channels irrigation on conveyance efficiency (C.E.) and the losses conveyance efficiency (L.C.E. %).

3.3. Cost analysis of type of channels irrigation

Table 3 and Fig. 9 show the construction, maintenance, and total costs per unit length for all irrigation channels according to the market prices of (2024). The values of construction cost were 140, 140, 210, 250, and 300 LE per unit length for plain channel, rough channel, cement lined, precast concrete, and buried pipes, respectively. Meanwhile, the maintenance costs were 40, 60, 15, 10, and 5 LE per unit length for the plain channel, rough channel, cement lined, precast concrete, and buried pipes. On the other hand, the results illustrated that the buried pipes channel was the highest total cost (305 LE), followed by the precast concrete channel (260 LE), then cement-lined channel (225 LE), while the lowest total costs were (180 LE) for plain channel.

3.4. Hydraulic evaluation of irrigation channels

The values of both velocity and discharge of water control the engineering design of the channels in terms of the velocity and volume of water passing through the channel.

3.4.1. Effect of water depth in different irrigation channels

Irrigation channels are designed to keep the flow constant along the canal; however, the actual flow is spatially varied. Fig. 10 shows the variation of water depth in different types of channels for constant flow, respectively. As shown from that figure, considering the flow is constant in the canal results in smaller water depth along the canal. It is noticeable from that figure the water depth decreases along the canal.

The average water depth in different types of channels (m) for plain, rough, cement-lined, precast concrete, and buried pipes was 0.31, 0.22, 0.52, 0.63, and 0.90 m, respectively.

3.4.2. Effect of water discharge in different irrigation channels

The results of the measurements of the average values of cross-sectional area and discharge rates through different channels are shown in Fig. 11.

Fig. 11 shows that the cross-sectional area values through different types of channels were 0.44, 0.25, 0.31, 0.78, and 0.03 m^2 for plain, rough, cement-lined, precast concrete and buried pipes, respectively. Also, the values of discharge rates through different types of channels were 0.029, 0.028, 0.034, 0.033 and 0.036 m^3/s for plain, rough, cement-lined, precast concrete and buried pipes, respectively. The maximum cross-sectional area was (0.44 m^2) in the plain channel, while the minimum cross-sectional area was (0.03 m^2) in the buried pipe. On the other hand, the maximum value of the discharge rate was (0.036 m^3/s) in the buried pipes, while the minimum value was (0.028 m^3/s) in the rough channel. We conclude that the bigger the cross-sectional area of the channel, the higher the discharge of the channels in open channels.

Table 3

Construction and total costs for type of channels irrigation per unit length (m)

Item	Construction cost, LE.	Maintaining costs, LE.	Total cost, LE.
Plain Channel	140	40	180
Rough Channel	140	60	200
Cement Lined	210	15	225
Precast Concrete	250	10	260
Buried Pipes	300	5	305

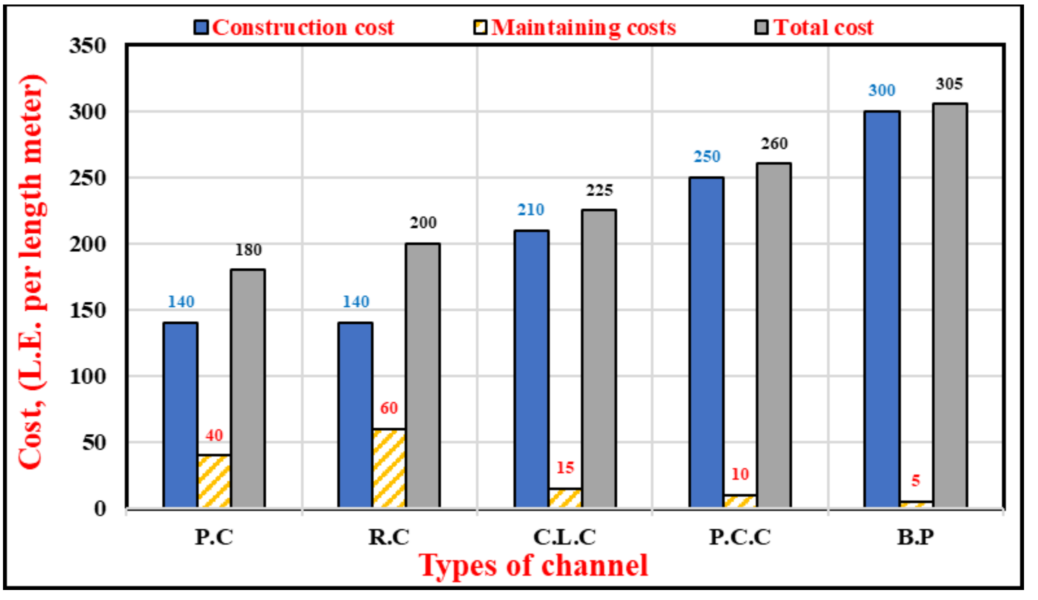


Fig.9. Construction, maintenance and total costs for channel irrigation

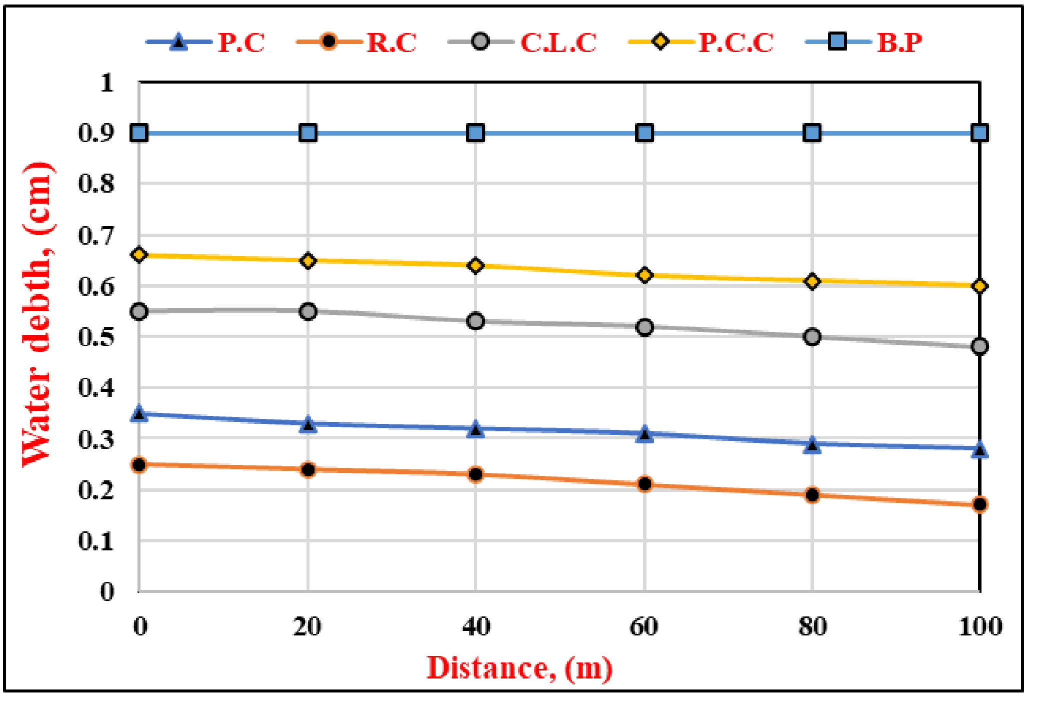


Fig.10. Variation of water depth in different irrigation canals along the canal.

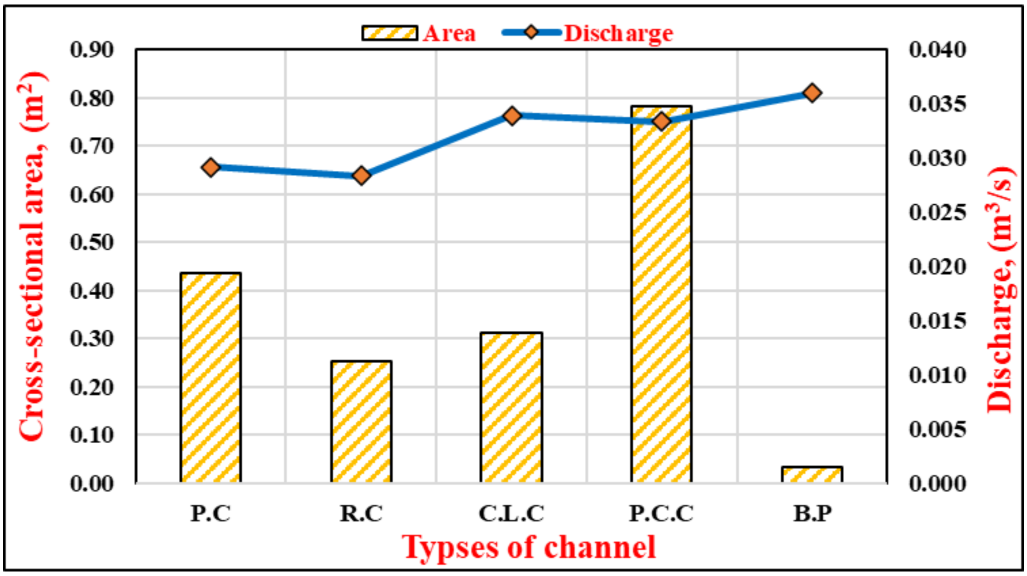


Fig.11. The relationship between Cross-Sectional Area and Discharge for channel irrigation.

3.4.3. Effect of water velocity on different irrigation channels

Fig. 12 shows that the values of the velocity through different types of channels were 0.0828, 0.1431, 0.1157, 0.0462 and 1.1141 m/s for plain, rough, cement lined, precast concrete and buried pipes, respectively. Also, the results illustrated in Fig. 12 indicated that the values of the Manning coefficient through different types of channels were 0.025, 0.033, 0.014, 0.013 and 0.011 for plain, rough, cement-lined, precast concrete and buried pipes, respectively. The maximum velocity value was (1.1141 m/s) in the buried pipe, which is less than 1.5 m/sec and higher than 0.1 m/sec for all types of channels. As shown, the minimum velocity value for a rough channel is less than 0.10 m/sec. However, this small velocity may occur at the last reach of the channel. The Manning coefficient leads to the channel velocity varying from one type to another according to the type of channel material. We conclude that the bigger the design cross-sectional area of the channel, the higher the water velocity in open channels. However, it is noted that the rise in water velocity in buried pipes is because of the reduction in friction losses within them.

3.4.4. Effect of wetted perimeters and hydraulic radius in different irrigation channels

Fig. 13 shows that the maximum value of the hydraulic radius was (0.262 m) in the precast concrete channel. In comparison, the minimum value of the hydraulic radius was (0.001 m) in the buried pipe. On the other hand, the maximum value of wetted perimeters was (2.39 m) in the precast concrete channel, while the minimum value of wetted perimeters was (0.31 m) in the buried pipes.

4. Conclusion

The results of this study can be summarized as follows:

- Cement-lined channel, precast concrete channels and buried pipes displayed improved flow conditions regarding velocity compared to the channel's current and design state conditions.
- The ultimate selection of canal maintenance or modernization strategy must also consider aspects such as economic feasibility, environmental impact, and material availability.
- A comprehensive understanding of channel hydraulic behavior has the potential to inform sound policies for water resource management, thereby establishing a distribution system that optimizes water utilization.
- Moreover, optimizing the design and operation of irrigation canals based on hydraulic analysis can enhance yields and reduce costs.
- These outcomes emphasize the potential of hydraulic modeling in guiding the design and management of irrigation canals to ensure sustainable water use practices.
- In addition to the above, from a health perspective, pathogens, including mosquitoes and snails, are eliminated. It is preferable to use the channel irrigation system instead of the plain channel. Thus, it is recommended that the modernized channel, especially the buried pipes, be utilized.

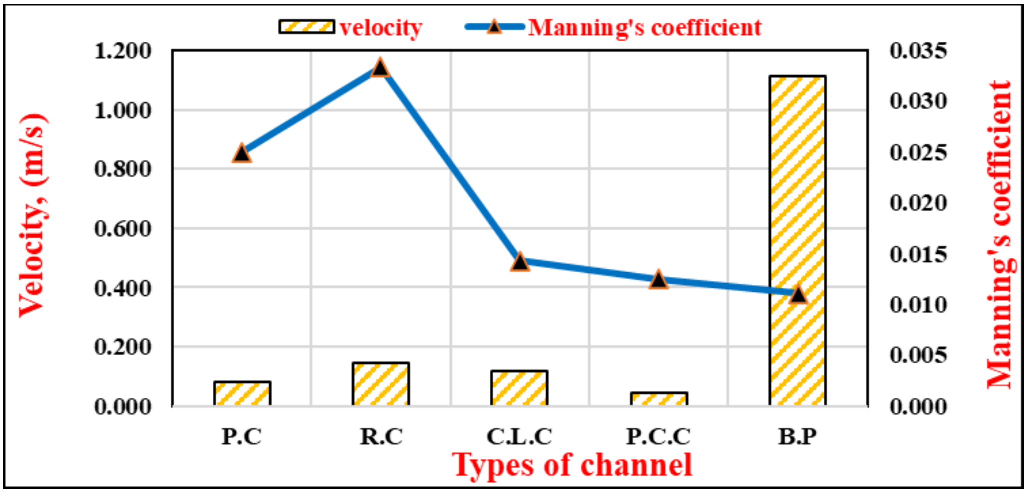


Fig. 12. The relationship between velocity and Manning coefficient for channel irrigation.

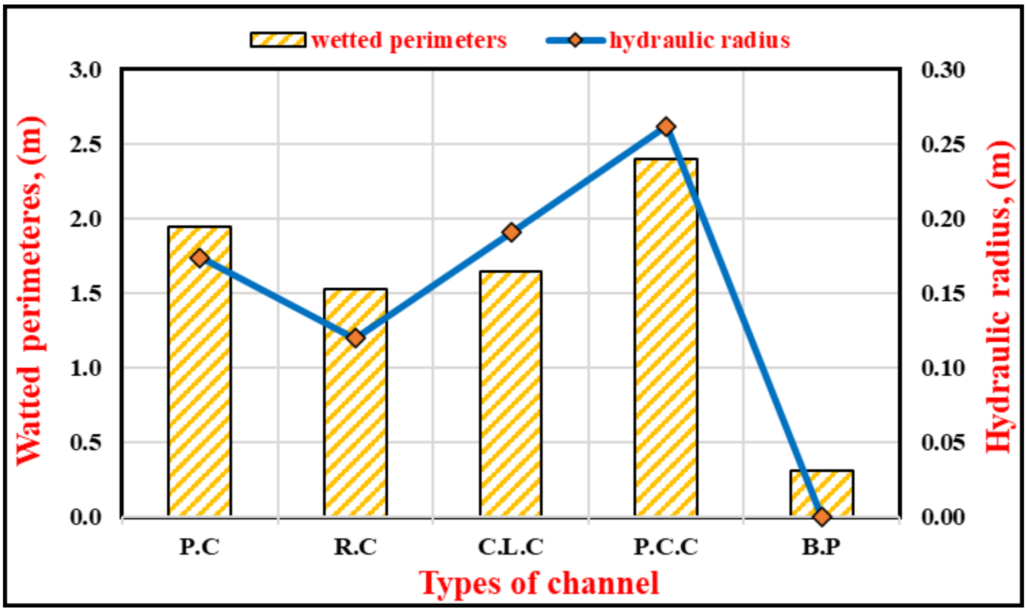


Fig.13. The relationship between wetted perimeters and hydraulic radius for channel irrigation.

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العوامل الهندسية والهيدروليكية المؤثرة على كفاءة قنوات الري

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الملخص العربي

نظام الري السطحي هو أحد أكبر أنظمه الري في العالم لاسيما في مصر، حيث يعتمد توصيل المياه الى الحقول من القنوات الرئيسية التي تأخذ مياهها من نهر النيل على شبكه من القنوات الفرعية والقنوات الحقلية. القنوات الحقلية متعددة وفقا لطريقه الإنشاء او نوع ماده التبطين وأكثرها استخداما في الحقول المصرية القنوات التقليدية بنوعيها العادية والخشنة (التي تحتوي على حشائش او طمي). يلعب تطوير القنوات الحقلية دوراً هاماً حيث أدى الى عدم فقدان المياه بسبب تسريها من القنوات التقليدية، كما أنها تقنيه تستخدم لتحسين كفاءه قنوات الري من خلال منع فقدان المياه بالبخر او التسرب، وذلك باستخدام إحدى القنوات التالية (القنوات المبطنة بالأسمنت، الأنابيب المدفونة وقنوات الخرسانة الجاهزة). يهدف هذا البحث إلى دراسة العوامل الهندسية والهيدروليكية المؤثرة على مساقي الري الأكثر انتشارا في مصر. ولتحقيق هذا الغرض، تم تقييم خمسة أنواع من القنوات شائعة الاستخدام (العادية، الخشنة، المبطنة، الخرسانية، والأنابيب المدفونة). تم إجراء تقييم ميداني للحصول على البيانات اللازمة لهذه الدراسة. **وأظهرت نتائج هذه الدراسة الآتي:**

أولاً: تقييم تأثير العوامل الهندسية لقنوات الري:

- المساحة المضافة بواسطة الأنابيب المدفونة بلغت ١٥٠ م^{٢}، مما يمثل زيادة بنسبة ١٠٠ ٪ في المساحة المزروعة من مساحة القناة لكل ١٠٠ متر طولي. كما أن المساحة المضافة بواسطة القنوات المبطنة بلغت ٩٠ مترًا مربعًا، بنسبة إضافة ٦٠ ٪ في المساحة المزروعة من مساحة القناة لكل ١٠٠ متر طولي.
- كفاءة نقل المياه خلال القنوات المختلفة بلغت ٨٠,٧٧، ٧٨,٤٦، ٩٣,٨٥، ٩٢,٣١، ٩٩,٦٢ ٪ للقنوات العادية والقنوات الخشنة والقنوات المبطنة بالأسمنت والقنوات الخرسانية والأنابيب المدفونة على التوالي.
- التكلفة الإجمالية بلغت ١٨٠، ٢٠٠، ٢٢٥، ٢٦٠، ٣٠٥ جنيهًا مصريًا للقنوات العادية والقنوات الخشنة والقنوات المبطنة بالأسمنت والقنوات الخرسانية والأنابيب المدفونة على التوالي.

ثانياً: تقييم تأثير العوامل الهيدروليكية لقنوات الري:

- متوسط عمق المياه في مختلف أنواع القنوات كانت للعادية والخشنة والمبطنة بالأسمنت والخرسانية والانابيب المدفونة بلغت ٠,٣١، ٠,٢٢، ٠,٥٢، ٠,٦٣، ٠,٩٠ متر، على التوالي.
- قيم مساحة المقطع العرضي عبر مختلف أنواع القنوات بلغت ٠,٤٤، ٠,٢٥، ٠,٣١، ٠,٧٨، ٠,٠٣ م^{٢} للقنوات العادية والخشنة والمبطنة بالأسمنت والخرسانية والمدفونة، على التوالي.
- قيم معدلات التصرف عبر مختلف أنواع القنوات بلغت ٠,٠٢٩، ٠,٠٢٨، ٠,٠٣٤، ٠,٠٣٣، ٠,٠٣٦ م^{٣}/ث للقنوات العادية والخشنة والمبطنة بالأسمنت والخرسانية والأنابيب المدفونة، على التوالي.
- قيم السرعة عبر الأنواع المختلفة من القنوات كانت ٠,٠٨٢٨، ٠,١٤٣١، ٠,١١٥٧، ٠,٠٤٦٢، ١,١١٤١ م/ث للقنوات العادية، الخشنة، المبطنة بالأسمنت، الخرسانة الجاهزة والمدفونة على التوالي.

- قيم معامل مانج عبر الأنواع المختلفة من القنوات كانت ٠,٠٢٥، ٠,٠٣٣، ٠,٠١٤، ٠,٠١٣، ٠,٠١١ للقنوات العادية، الخشنة، المبطنة بالأسمنت، الخرسانية والانابيب المدفونة على التوالي.
- قيم نصف القطر الهيدروليكي عبر أنواع مختلفة من القنوات كانت ٠,١٧٤، ٠,١٢٠، ٠,١٩٠، ٠,٢٦٢، ٠,٠٠١ م للقنوات العادية، الخشنة، المبطنة بالأسمنت، الخرسانة الجاهزة والانابيب المدفونة على التوالي.
- قيم المحيط المبتل عبر أنواع مختلفة من القنوات كانت ١,٩٥، ١,٥٣، ١,٦٤، ٢,٣٩، ٠,٣١ م/ث للقنوات العادية، الخشنة، والمبطنة بالأسمنت، والخرسانية، والأنابيب المدفونة، على التوالي.

لذلك ووفقا لهذه النتائج، توصي الدراسة بتوسيع نطاق استخدام قنوات الري وخاصةً الأنابيب المدفونة.