DESIGN OF SMALL HOLDINGS IRREGULAR SHAPE MICRO IRRIGATION UNIT

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ABSTRACT

An interactive computer design model for irregular shape micro-irrigation unit was developed. This program analyzes the system design by predicting pressure and flow distributions and some other factors such as uniformity, flow variation and system piping sizes. The model provides designs rapidly for user inspection by comparing design options that would require extensive time and effort. The hydraulic design model involved in this design model is based on distal outlet back step method and golden search technique. Pressure and flow distributions were measured in field and compared quite well with those predicted from the design model. The results of field evaluation of the experimental unit designed by the model directly after installation indicated that both hydraulic and statistical uniformities are above 90% which means that the irrigation system was well designed and installed. The reevaluation after 6 months indicated that the statistical uniformity reduced due to the change of emitter performance by 4.74% to 12.12%. This suggested that chemical injection was required to restore the system uniformity to its original value. The hydraulic uniformity was also reduced. Therefore, system repair and maintenance is necessary.

INTRODUCTION

Micro-irrigation is a slow and frequent application of water on, above, or beneath the soil. Water is applied as discrete or continuous drops, tiny streams, or miniature spray through emitters placed along a water delivery line near the plant.

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Water pressure distribution in the pipe networks and the hydraulic properties of the emission devices used affect the uniformity of water from micro-irrigation system. Hydraulic properties of emission device include; the effects of emitter design, water quality, and water temperature. To study the uniformity of micro-irrigation, the emitter flow variation should be studied. Emitter flow variations are mainly caused by hydraulic, manufacturer and/ or clogging variations.

Micro irrigation, in all its varied forms, is now a proven water conservation technology, which provides a significant increase in overall yield and quality products. These factors have greatly increased the use of micro-irrigation on a wide variety of horticultural row crops and plant materials. In Egypt, the acreage used for production of these high value horticultural crops by individual producers is relatively small with the predominant range between 0.5 to 5 faddan. The rapid growth of micro-irrigation on small acreage by new relatively inexperienced producers has generated the need to provide detailed irrigation system design.

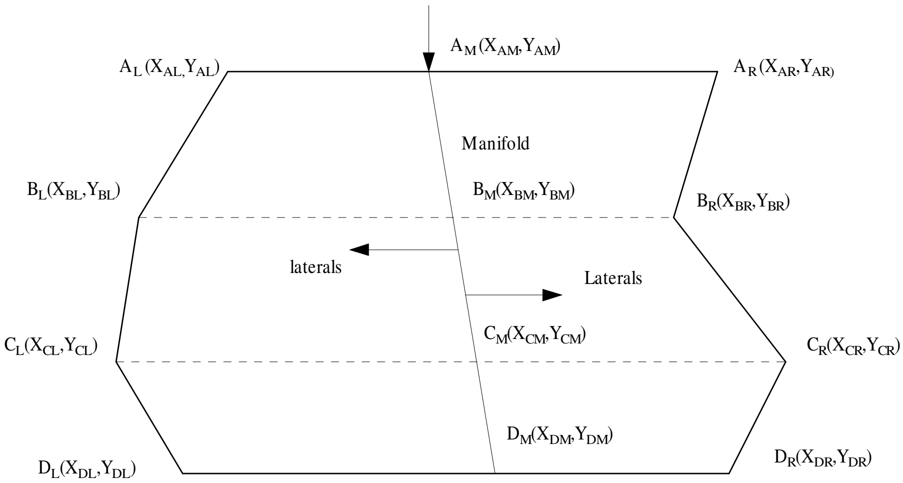
The objectives of this study were to develop and verify an interactive computer design model for small-holdings, simulating hydraulics of micro-irrigation system regardless of their shapes and slopes. Steps of the procedure include:

1. Determining the length and slope of each lateral line as they vary according to field shape and topography.
2. Determining pressure and flow distributions for the entire system.
3. Determining the effects of the hydraulic variation on the uniformity of emitter discharge.

MODEL DEVELOPMENT

Geometrical Simulation:

In order to use this program one should divide the irrigation set into a series of trapezoids. The number of trapezoids depends on the regularity of the set. For a regular set, one trapezoid is sufficient. Each trapezoid should have its base parallel to the lateral lines. The number of trapezoids and the coordinates of their corners are to be entered through the interactive program. The coordinate system to be used has its X-axis parallel to the lateral lines and Y-axis perpendicular to them. Fig. (1) shows an example of a field irrigation unit divided



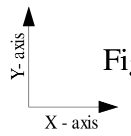


Fig.(1) Field divison into trapezoids for the simulation model.

in to 3 trapezoids. The lateral lines are running in the direction of X-axis on both sides of the manifold line. $A_M - B_M - C_M - D_M$ in the figure. The coordinates of all the points shown in the figure should be specified to the computer. The location of the manifold is to be specified by the user. It can be at one edge of the set or in between. Therefore, the laterals can be run one side or in both sides of the manifold. If the laterals run on both sides of the manifold, then the coordinates of the intersection of the manifold with the bases of the trapezoids should be entered. Then, the program estimates the number of laterals, their lengths and slopes in the set.

Hydraulic simulation:

The hydraulics involved in this design model is based on distal outlet back step method and golden search techniques. Combining these two techniques precisely predicts the pressure distribution along the micro-irrigation systems (Kang and Nishiyama, 1995 and Sharaf, 2004). Generally the first step was assuming pressure head at the manifold

$$Hm_{far} = SIP - \sum_{i=1}^{i=nt} Hfm(i) \pm \sum_{i=1}^{i=nt} Lm(i) * Sm(i) \qquad (1)$$

far end (Hm_{far}) by the following equation:

Where:

- SIP = system inlet pressure (m)
- $Hfm(i)$ =friction loss of manifold at the trapezoid No.(i)(m)
- $Lm(i)$ =length of manifold at the trapezoid No.(i)(m)
- $Sm(j)$ =slope of the manifold at the trapezoid No.(i)(m)
- nt =No of the trapezoids in the irrigation system.

The manifold or system inlet pressure (SIP) was determined by the

$$SIP = Ho + \sum_{i=1}^{i=nt} Hfm(i) + Hfl_{\max} + MED \qquad (2)$$

following eqation:

Where:

- Ho = emitter operating pressure (m)
- Hfl_{max} = friction loss at the maximum lateral length of the system (m)
- MED = maximum elevation difference between the manifold inlet and the highest point in the system (m).

Similarly, the pressure head at the last outlet for right side and left side connected to the manifold far end is:

$$Hl(l)_{far} = Hm_{far} + Hfl_{far} \pm L(l)_{far} * S(l)_{far} \qquad (3)$$

$$Hl(r)_{far} = Hm_{far} + Hfr_{far} \pm L(r)_{far} * S(r)_{far} \qquad (4)$$

Where:

- Hl_{far} = pressure head at the far end of the last lateral (m)
- Hf_{far} =friction loss of the last lateral (m)
- L_{far} = lateral length of the last lateral (m)
- S_{far} = slope of the last lateral (decimal)
- l,r = denoting left and right side laterals.

The pressure head at lateral far end (Hl_{far}) is used to estimate the farthest emitter flow rate then, the friction loss at the last lateral section. Adding the section elevation difference, the pressure head at the next emitter could be estimated then, emitter flow rate. The summation of emitter flow rates is the discharge causes friction in the next section (section is a distance between two successive emitters). This iterative procedure continued toward the first emitter and extended to the lateral inlet pressure. At this point, the calculated lateral inlet pressure is compared with the assumed pressure head at the manifold far end. If the difference is not within a specific tolerance (0.0001), the assumed pressure head at the manifold should be adjusted. The method of adjustment based on creating a ratio between the previous estimate of the pressure head at the lateral distal end and the lateral inlet head. To get a new estimate of the lateral distal head, the initial pressure head at the pipe inlet was multiplied by this ratio. This procedure is repeated until the calculated pipe inlet pressure head is closer to the actual value. After the pressure and flow profiles along the last lateral are obtained, the second side of the last lateral proceeds. The procedure is continued using the same logic till manifold inlet. Then, the estimated manifold inlet pressure compared with the inlet operating pressure head at the manifold inlet. If the difference is not within the specific tolerance, the golden search is applied again to adjust the distal pressure head of the manifold till the estimated manifold inlet pressure head is closer to the tolerance of the actual value of *SIP*. The logic algorism of the model is presented in Fig. (2).

Friction loss in both lateral and manifold was determined by the Darcy-Weisbach equation. Minor loss due to emitter on lateral was determined by applying the additional length method. Minor losses on manifold were accounted as entrance loss to the manifold and sudden expansion losses from the manifold to the lateral lines.

The lateral and manifold diameters were determined according to the design rule of economic pipe size that water maximum velocity is limited to 1.5 m/s., as:

$$D_M = (0.2359 * Q_T)^{0.5} \qquad (5)$$

$$D_L = (0.2359 * Ql_{\max})^{0.5} \qquad (6)$$

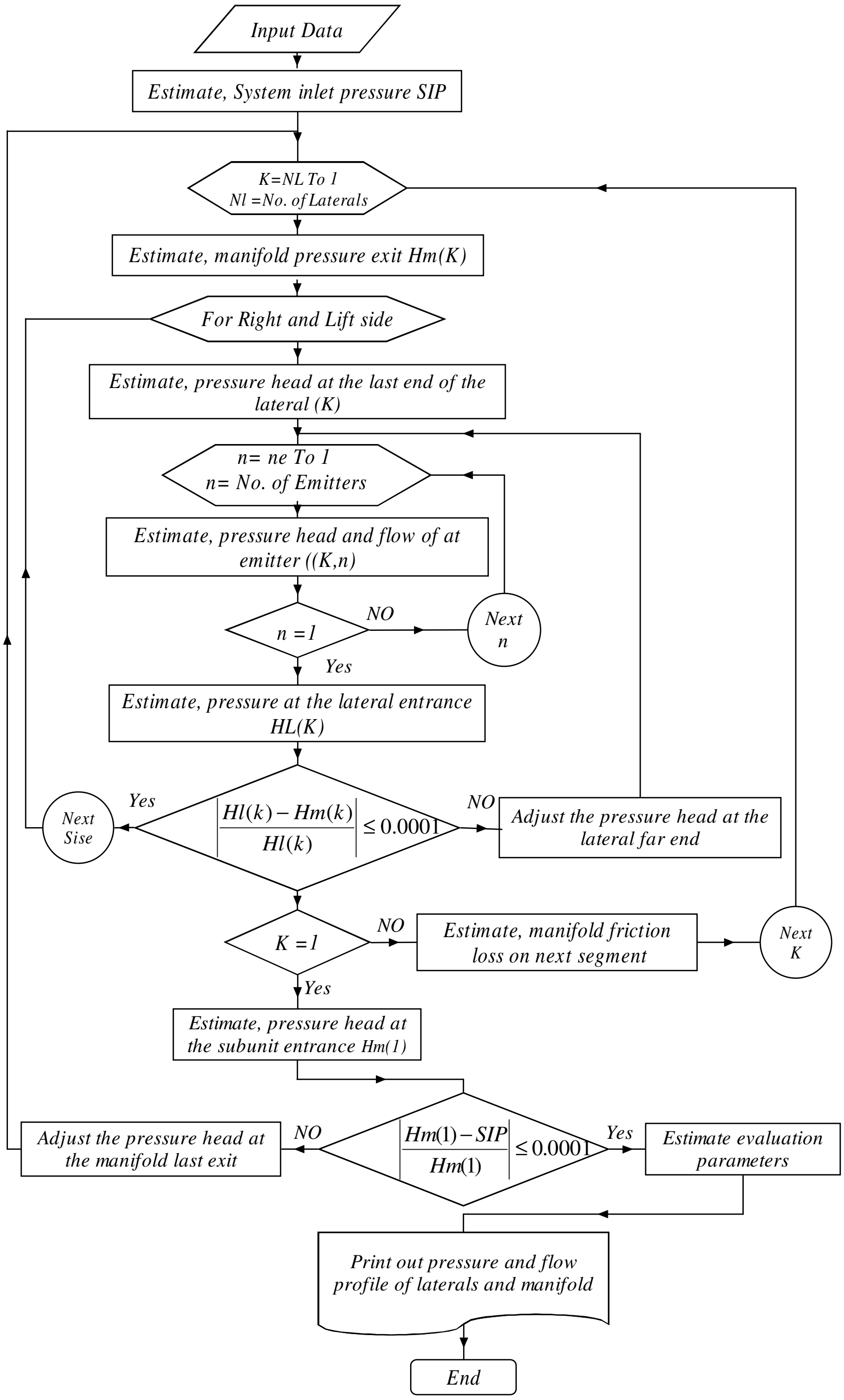


Fig. (2): The flow chart of the model.

Where:

D_M = inside manifold diameter (mm)

Q_T = system total flow rate (l/s)

D_L = inside lateral diameter (mm)

Ql_{max} = flow rate of the longest lateral in the system (l/s)

The system total flow rate (Q_T) was approximated as total number of emitters on the system multiplied by the emitter nominal flow rate. The flow rate of the longest lateral (Ql_{max}) was approximated as number of emitters per longest lateral multiplied by the emitter nominal flow rate. The calculated diameters of both lateral and manifold were rounded up to the next higher commercial diameter.

Field evaluation of system:

The emission uniformity EU`, and the absolute uniformity, EU`a, methods are proposed by Walker, 1980, for field evaluation of micro-irrigation systems as:

$$EU` = \frac{qave_{1/4}}{qave} * 100 \qquad (7)$$

$$EUa = \frac{1}{2} * \left[\frac{qave_{1/4}}{qave} + \frac{qave}{qave_{1/8}} \right] * 100 \qquad (8)$$

Where:

$qave_{1/4}$ = the average of the lower ¼ of the emitter discharge rates.

$qave$ = the average of all emitter discharge rates .

$qave_{1/8}$ = the average of largest 1/8 of the emitter discharge rates .

General criteria for EU` and EU`a values are:90% or greater, excellent; 80 to 90% , good ; 70 to 80%, fair; and less than 70% , poor. The primary disadvantage of this method is its nonstatistical base. For this reason, obtaining confidence limits and breaking down the components of emitter flow variation are not possible.

Statistical uniformity method (*Us*) uses the coefficient of variation as determined from randomly sampled emitters. It is defined (Bralts and Edwards, 1986) as:

$$Us = 100\ (1 - Vq) \qquad (9)$$

In emitter flow function ($q = K\ H^X$), the manufacturer variability is included in the proportionality factor K. The hydraulic variations are included in the emitter exponent X and the pressure H. Anyoji and Wu, 1985 considered K and H as two random variables and there is no correlation between them. Then by applying Taylor theorem:

$$Vq = \frac{(Vm^2 + X^2 Vh^2)^{0.5}}{1 + 0.5X(1 - X)Vh^2} \qquad (10)$$

The second term in the denominator of the previous equation is small compared with the first, so Eq. (10) is reduced to (Anyoji and Wu, 1985):

$$Vq = \sqrt{Vm^2 + X^2 Vh^2} \qquad (11)$$

Eq. (11) can also be derived by applying constant odds unnecessarily principles to the general emitter discharge equation. Using this principle, plugging effects can be included and then Eq. (11) becomes (Bralts et al., 1987):

$$Vq = \sqrt{Vp^2 + Vm^2 + X^2 Vh^2} \qquad (12)$$

Where:

Vq = coefficient of variation of emitter flow rate.

Vp = coefficient of variation of emitter plugging.

Vm = coefficient of manufacturer variation.

Vh = coefficient of variation of pressure head.

The general criteria for acceptable, Us, is 90% or greater, excellent, 80% to 90%, very good; 70% to 80%, fair; 60% to 70%, poor; and less than 60%, unacceptable.

Hydraulic uniformity refers to the effect of pressure variation on the uniformity of water application of a micro-irrigation system. Hydraulic uniformity U_{sh} is defined similar to the water application uniformity except that the emitter discharge exponent, X must be

$$U_{sh} = (1 - X\,Vh) * 100 \qquad (13)$$

considered (Smajstrla et al.,1990) as:

A lower value of U_{sh} is most often due to improper design. However, improper installation of components or the use of wrong components can also reduce U_{sh}. The values of U_{sh} may be due to pipe sizes are too small, laterals are too large, laterals are incorrectly oriented with respect to slope, improper emitter selection or other causes. All of these items must be properly designed and installed in order to obtain an acceptable uniformity of water application.

The coefficient of variation due to emitter performance, *Vpf*, was defined because it includes a variety of factors such as manufacturer variation, number of emitter per plant and emitter plugging. The concept permits differentiation between hydraulic and emitter

$$Vpf = \sqrt{Vq^2 - X^2 Vh^2} \qquad (14)$$

performance related variables. *Vpf* is determined by the following:

RESULTS AND DISCUSSION

A computer program model was written in C^{++} to analyze any micro-irrigation set regardless to its shape. The program is interactive, so the user is asked a series of questions to enter his data. This program estimates the following variables in a micro-irrigation unit.

- Total flow rate entering the unit.
- Average emitter flow rate and emitter pressure head.
- Pressure distribution and flow distribution for the entire system.
- Statistical uniformity and flow variation of discharge rates.
- Length and slope of each lateral line as they vary due to field shape.
- Manifold and lateral diameters due to water velocity limited to 1.5 m/s

Case study:

The utility of this simulation model is presented through design of field scale system at Saba Bacha Experimental Farm. The input data can be fed either by direct way from the keyboard or by using data file. The input data necessary for the design process are; the number of trapezoids, coordinates and elevations of their corners, the coordinates and elevations of manifold location, emitter constants and manufacturer variability, emitter nominal flow rate and operating pressure head, emitters and laterals spacing and the commercial pipe sizes list. The list of these variables is given in Tab. (1) and in Fig. (3).

Table (1): Variables applied in the design unit.

Item No.		Value
1	No. of trapezoid	3
2	Emitter type	Microsprinkler
3	Emitter name	Micro jet 7733
4	Emitter flow exponent	0.45
5	Emitter proportionality factor	10.3
6	Emitter flow rate	40 l/h
7	Emitter operating pressure	20 m
8	Manufacturer coefficient of flow variation	0.05
9	Emitter spacing	2 m
10	Lateral spacing	2 m

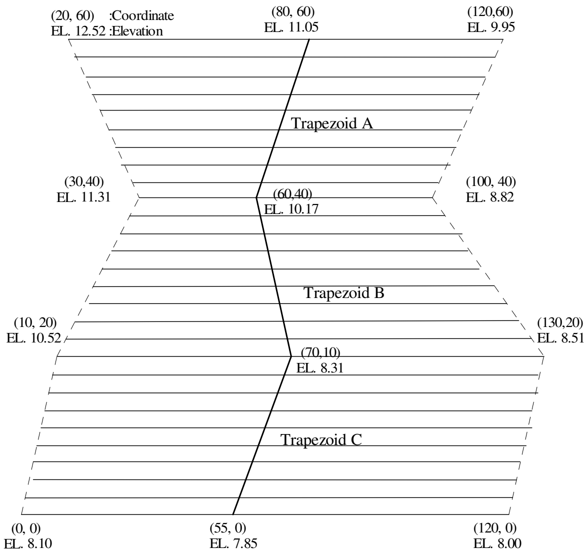


Fig.(3) Schematic diagram of experimental unit designed by the model

The output results are:

- Manifold and lateral diameters (121 mm and 20 mm, respectively)
- Length, slope and No. of emitters of each lateral, in Table (2).

- Pressure and flow distribution on system, in Tab.(3) and Fig. (4)
- System operating pressure head and total flow rate entering the unit (24.56 m and 26.2 m3/h, respectively).
- System statistical uniformity and flow variation of discharge rates
- (95.78 % and 10.6 %, respectively)
- System average emitter flow rate and emitter pressure head (34.91 l/h and 24.62 m, respectively).

Analysis of pressure distribution:

The pressure profile of the left side laterals in trapezoid A, B, C in Fig.(4) decreases with respect to lateral line lengths. This occurs because the laterals were laid on up-hill slopes. In this condition the dimensionless ratio of total friction drop (ΔH) along the laterals to energy loss by slope ($\Delta H`$) is less than or equal zero ($\Delta H/\Delta H` \leq 0$ Type I). The situation is different in the right side, where in trapezoid 1, the pressure decrease in all laterals with respect to the lateral lengths, reaches a minimum point and then increases with respect to the lateral lengths. This occurs under the slope conditions where the ratio of the total friction drop (ΔH) along the lateral to the energy gain by slope ($\Delta H`$) is lower than 1 and less than 2.75. For this condition the pressure at the end of the laterals is larger than the operating pressure ($1 < \Delta H/\Delta H` < 2.75$ Type II). In trapezoid 2, laterals from 11 to 14 followed type II of pressure profile, where the pressure head at the end of these laterals larger than the operating pressure due to overcoming the pressure gain due to the slope over total friction drop along the laterals. Lateral no 15 followed another type of pressure profile, where lateral inlet pressure is almost the same as the pressure at the far end (25.38 m). This occurs under the slope situation where the energy gained is equal to the total friction drop along the lateral ($\Delta H/\Delta H` =1$ Type III). In trapezoid 3, the pressure profile along the laterals followed type I where $\Delta H/\Delta H` \leq 0$.

Analysis of flow variation:

One of the design criteria applied for spiters (mini-sprinkler) as well as for many tricklers is the “10 percent rule“, which consider roughly half of the flow variation occurs along the lateral and the other half along the manifold. This hold when the land surface is more or less flat and the plot is regular in shape. There is some disagreement concerning the 10 % rule but this rule is still commonly used (Benami and Ofen, 1984). The pressure variation and flow variation are related by the flow exponent value (x), that means in system with turbulent flow (x=0.5) the pressure variation allowed to vary by 20%, for lower value of x, it is allowable to increase the variation to more that 20% (SCS, 1984). It should be pointed out that the value of 20% is arbitrary and planners occasionally use more values instead. For the herein model, the maximum pressure variation on the entire system was 22.04% (10.6% flow variation). The pressure variation along the manifold is 9.94% (4.6 % flow variation) which almost the half of the allowable flow variation. The pressure variation along of each lateral of the system is presented in Tab. (3). The results indicated that, the maximum pressure variation on laterals was found on lateral No.1 " left side) as 13.42% (6.3 % flow variation) followed by laterals No. 2, 3, 4, 21, 22, 23 (over 10%) at the same side. The reasons behind the increasing in the pressure variation along these laterals are; the longer lateral lengths and the higher up-slopes. In order to avoid this bias in the model, the solution is to decrease the constraint of the water velocity limit to be less than 1.5 m/s.. In this case we have to weighting between the extra cost of using higher lateral diameters and the reduction on total yield that affected by less uniformity. For example, Benami and Ofen, 1984 found that in sprinkler irrigation when the pressure head variation along the lateral was increased from 20% to 40%, the total yield was reduced by 1% . A further increase in pressure variation to 50% reduced the total yield by additional 1%. These results raise some doubt with respect to the "20% rule". Based on the above, it could be concluded that the design criteria of the model is fairly correct.

Field Verification of the Model

The design model was verified for actual field data after installation. The verification was based upon the typical natural existing configuration and the ability to analyze both the uphill and downhill conditions as illustrated in Fig. (5). The pressure into the submain manifold was controlled using pressure regulator at the entrance to the submain unit. A flow meter was also applied. The emitters are connected to the laterals using a small diameter flexible tubing with a barbed insertion fitting. The pressure was measured at the end of the tube near the emitter using a portable pressure gauge.

The pressure was measured while flow rates were being measured. The emitter flow rates in the field were determined by measuring the time required to fill a 1000 mL flask and then converted to emitter flow rate. 24 data points were selected randomly throughout the irrigated unit. In fact, to avoid being influenced by the appearance of an emitter as it operates. Emitters were selected and flagged before the irrigation system is turned on. This process was performed directly after the system had been installed. The irrigation system was again evaluated after 6 months of operation.

Table (2): Length, slope and No. of emitters of each lateral line in the system.

	Lateral No.	Left Side			Right Side		
		Length (m)	Slope %	No. of Emitters	Length (m)	Slope %	No. of Emitters
Trapezoid A	1	60.0	2.5	30	40.0	-2.7	20
	2	57.0	2.5	28	40.0	-2.8	20
	3	54.0	2.6	27	40.0	-2.9	20
	4	51.0	2.7	25	40.0	-2.9	20
	5	48.0	2.8	24	40.0	-3.0	20
	5	45.0	2.9	22	40.0	-3.1	20
	7	42.0	3.0	21	40.0	-3.1	20
	8	39.0	3.2	19	40.0	-3.2	20
	9	36.0	3.4	18	40.0	-3.3	20
	10	33.0	3.6	16	40.0	-3.3	20
	11	30.0	3.8	15	40.0	-3.4	20

Trapezoid B	11	30.0	3.8	15	40.0	-3.4	20
	12	33.0	3.4	16	42.0	-3.1	21
	13	36.0	3.1	18	44.0	-2.8	22
	14	39.0	2.8	19	46.0	-2.6	23
	15	42.0	2.5	21	48.0	-2.4	24
	16	45.0	2.3	22	50.0	-2.1	25
	17	48.0	2.1	24	52.0	-2.0	26
	18	51.0	2.0	25	54.0	-1.8	27
	19	54.0	1.8	27	56.0	-1.6	28
	20	57.0	1.7	28	58.0	-1.5	29
	21	60.0	1.6	30	60.0	-1.3	30
Trapezoid C	21	60.0	1.6	30	60.0	-1.3	30
	22	59.5	1.5	29	60.5	-1.2	30
	23	59.0	1.4	29	61.0	-1.0	30
	24	58.5	1.3	29	61.5	-0.8	30
	25	58.0	1.1	29	62.0	-0.7	31
	26	57.5	1.0	28	62.5	-0.5	31
	27	57.0	0.9	28	63.0	-0.4	31
	28	65.5	0.8	28	63.5	-0.2	31
	29	65.0	0.7	28	64.0	-0.1	32
	30	55.5	0.6	27	64.5	0.01	32
	31	55.0	0.5	27	65.0	0.02	32

Table(3): Pressure and flow distribution on the system.

	Lateral No.	Left side		Manifold		Right side	
		Pressure Variation %	Total flow rate (l/h)	Pressure head (m)	Total flow rate (l/h)	Total flow rate (l/h)	Pressure Variation %
Trapezoid A	1	13.42	1226.53	24.56	2140.97	878.45	2.00
	2	12.15	1853.44	24.61	2064.82	979.39	2.08
	3	11.52	1146.63	24.65	2027.00	880.36	2.15
	4	10.24	1067.38	24.71	1948.75	881.37	2.22
	5	9.69	1027.53	24.76	1909.94	882.41	2.27
	5	8.55	946.36	24.81	1829.83	883.48	2.33
	7	8.20	905.58	24.87	1790.15	884.57	2.41
	8	7.18	822.76	24.93	1708.45	885.69	2.47
	9	6.84	781.14	24.99	1667.98	886.83	2.58
	10	6.03	696.87	25.05	1584.87	888.00	2.61
	11	5.81	654.59	25.11	1543.77	889.19	2.68

Trapezoid B	11	5.81	654.59	25.11	1543.77	889.19	2.67
	12	5.80	698.90	25.18	1631.96	933.06	2.30
	13	6.38	785.71	25.25	1762.51	976.8	2.03
	14	6.48	829.95	25.32	1850.34	1020.39	1.77
	15	7.21	916.18	25.39	1980.00	1063.82	1.58
	16	6.83	960.14	25.46	2067.22	1107.07	2.08
	17	7.09	1045.58	25.53	2195.72	1150.14	2.66
	18	8.63	1089.17	25.61	2282.17	1193.00	3.28
	19	9.65	1173.50	25.69	2409.14	1235.64	3.97
	20	10.05	1216.56	25.76	2494.61	1278.05	4.66
	21	11.05	1299.48	25.84	2619.69	1320.21	5.46
Trapezoid C	21	11.30	1299.48	25.84	2619.66	1320.21	5.46
	22	10.28	1263.25	25.98	2585.45	1322.20	5.70
	23	10.03	1267.10	26.12	2591.28	1324.18	5.97
	24	9.79	1270.97	26.26	2597.25	1326.28	6.21
	25	9.55	1274.87	26.40	2644.41	1369.54	7.12
	26	8.63	1237.59	26.57	2609.34	1371.75	7.42
	27	8.36	1241.36	26.69	2615.27	1373.91	7.68
	28	8.09	1245.15	26.83	2621.30	1376.15	7.98
	29	7.86	1248.94	26.98	2668.23	1419.29	8.97
	30	7.00	1210.60	27.12	2632.21	1421.61	9.29
	31	6.75	1214.25	27.27	2638.21	1423.96	9.61

A graphical comparison and linear regression analysis of the actual versus predicted emitter flow rates by the model is shown in Fig. (4). The results of the design model correlated very well with the actual field data. The difference between the actual and predicted results can be partially attributed to the experimental error and partially explained by the choice of the techniques applied to predict pressure by the model.

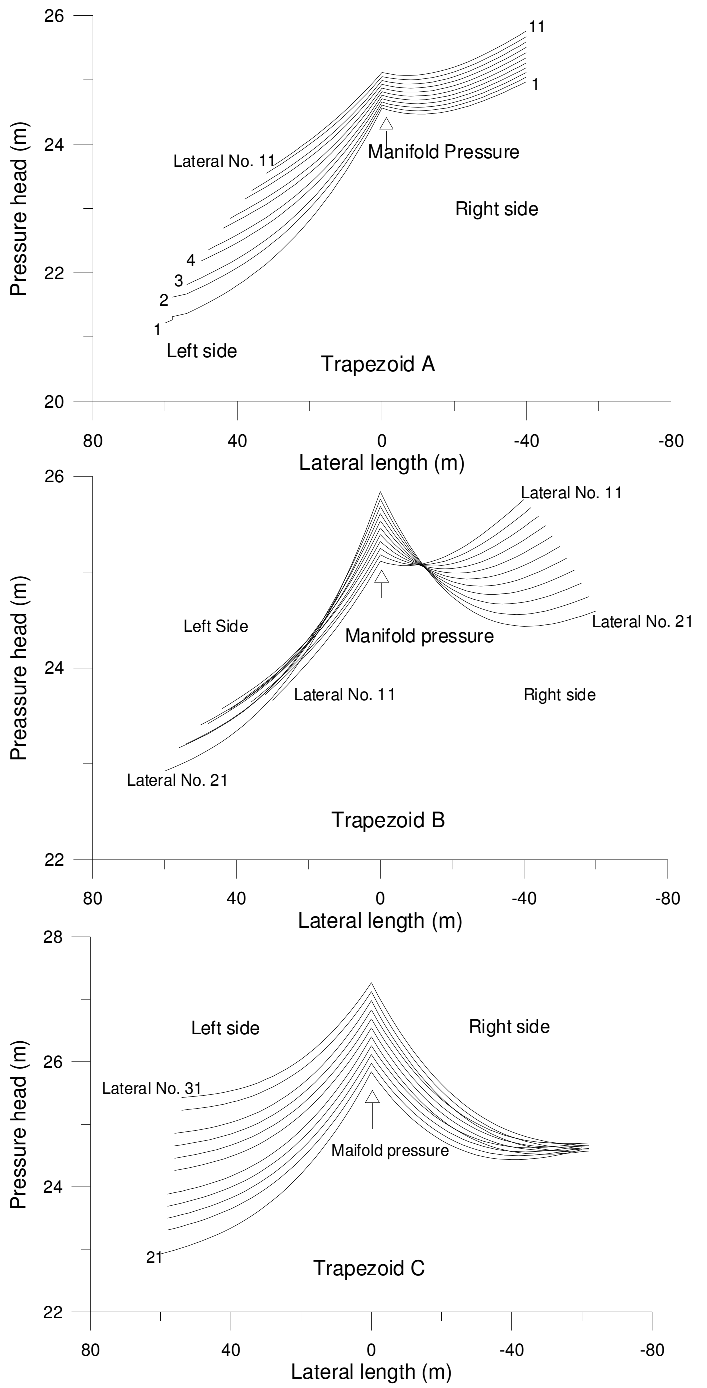


Fig. (4): Pressure distribution on the entire system

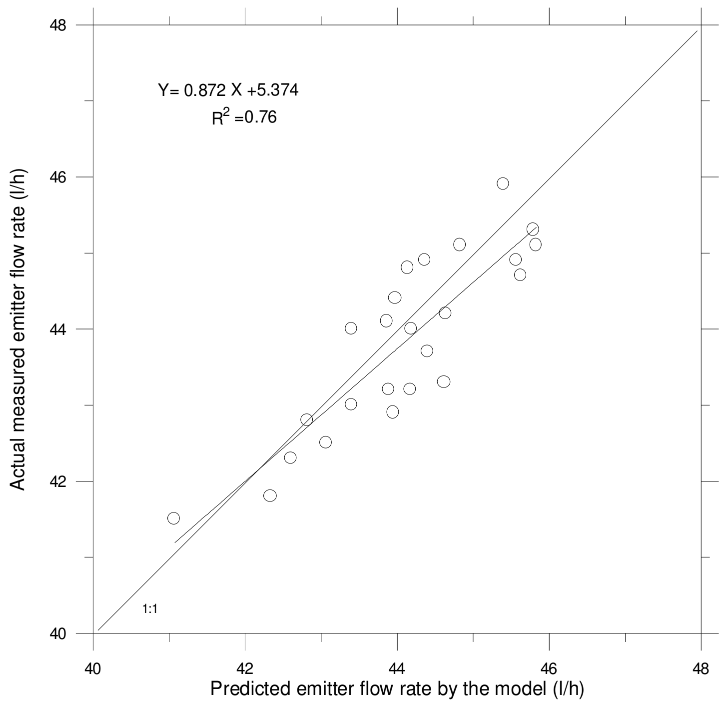


Fig. (5) Verification of the model by flow rate.

Model validation:

To validate the model, the average pressure head on the system is used to check the average discharge rate (by applying the emitter constant). If the difference is negligible, this implies that the accuracy of the results obtained from the model is high. By the model, the system average pressure and flow rate were 24.61575 m and 43.91235 l/h, respectively. Applying the emitter flow function, the flow rate was 43.91988 by a relative error 0.02%.

Field evaluation of the irrigation unit:

The statistical uniformity U_s is a measure of how evenly the values of water are applied from each emitter. U_s of the system was measured immediately after installation from flow measurements, it was 94.58%. Also, the system hydraulic uniformity U_{sh}, which determined from pressure measurements, was 97.42%. The emitter performance variation *Vpf* according to these values was 4.76% (about

5%). This value would be expected to be approximately the coefficient of manufacturing variation from the emitter because this system is newly installed, otherwise, no emitter plugging has been occurred. For this system, both hydraulic and statistical uniformities are above 90% and would be classified as excellent, indicating that the system was well designed and properly installed.

The irrigation system was again evaluated after operating six months. The hydraulic uniformity U_{sh} was found to be 90.55%, but the statistical uniformity U_s was changed to be 84.63%. The change of statistical uniformity is expected due to the change of emitter performance variation *Vpf*, probably emitter plugging. The operation of the system for six months shows that the emitter performance increased to 12.12%. The decreasing in hydraulic uniformity was unexpected, but it could be referred to water leakage or partial blockage in the piping system. This suggests that system repair and chemical water treatment or flushing of the lines may be required to restore the system to its original high uniformity.

The results of field evaluation directly after installation and after six months from operation are presented in Table (4)

Table (4) : Results of field evaluation:

Parameter	After installation	6 months later
U_s	94.58 Excellent	84.63 V. Good
U_{sh}	97.42	90.55
$EU`$	93.77 Excellent	78.36 Fair
$EU`a$	93.79 Excellent	81.94 Good
q_{var}	14.39 Acceptable	39.86 not Accept.
Vpf	4.76%	12.12%

CONCLUSIONS

The objective was achieved to develop interactive simulation design model uses fundamentals hydraulic relationships for design of irregular shape micro-irrigation unit. The model can predict the pressure and flow rates at each emitter for the entire system in addition to the economically optimum pipe sizes of laterals and manifold. The model was verified for a field scale system. The results indicated that the model correlated well with the actual field data (r^2 =0.76). The model was applied to study the pressure distribution on the existing field unit. The pressure distribution was classified according to the field slope condition and laterals total friction drop. Field evaluation was accounted directly after installation. The results indicated that both hydraulic and statistical uniformities are above 90% and classified as excellent, indicated that the system was well designed and properly installed. After six months of operation, the system was reevaluated. The statistical uniformity was reduced to 84.6%. The reduction was due to the emitter performance variation, which increased from 4.76% to 12.12%. The change could result from emitter plugging. This suggested that chemical water treatment might be required to restore the system to its original high uniformity. The hydraulic uniformity was reduced after six months to 90.55%. This reduction could be attributed to water leakage and partial blockage of the piping system. Therefore, system repair and maintenance was necessary.

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الملخص العربي

تصميم وحدات الري الشحيح للحيازات الصغيرة غير منتظمة الشكل

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الهدف من هذا البحث هو تطوير نموذج رياضي بواسطة الحاسب الآلي قادر على التصميم الهيدروليكي وتقييم أداء وحدة رى شحيح لأرض غير منتظمة الأبعاد تصلح للمساحات الصغيرة. ويبدأ العمل بهذا النموذج بتقسيم وحدة الرى المقترحة الى وحدات على أشكال أشباه منحرفات يتم إدخال إحداثياتها ومناسيبها والبيانات الخاصة بالمنقطات وموضع خط التوزيع. وتكون المخرجات هي أطوال وميول خطوط الرى المختلفة بالإضافة الى الأقطار الاقتصادية المقترحة لخط الرى وخط التوزيع. كذلك توزيع الضغوط والتصرفات على كافة أنحاء وحدة الرى بما فى ذلك الضغط اللازم للتشغيل. وقد استخدم هذا النموذج فى تصميم وحدة حقلية للتأكد من سلامة أداء النموذج الرياضي. فأثبتت النتائج توافق النتائج الحقلية بالقيم المحسوبة بواسطة الحاسب الآلي (r^2=0.76) . و قد تم تقييم حقلي لأداء الوحدة التجريبية بعد إنشائها مباشرة لقياس انتظام توزيع المياه، فأظهرت النتائج انتظامية عالية مما يعنى صحة النموذج المستخدم وسلامة الإنشاء. وقد أعيد التقييم مرة أخرى بعد مضى ستة اشهر من التشغيل، فانخفضت انتظامية توزيع المياه مما يعنى اختلاف فى أداء المنقطات والذي أعزي الى الانسداد الجزئي لها والذي قدر بحوالي ١٢،١٢% مما يستلزم حقن كيماوي لشبكة الري لإزالة هذا الانسداد. هذا بالإضافة إلى انخفاض الأداء الهيدروليكي لوحدة الرى بعد التشغيل هذه المدة والذي أعزى إلى تسرب المياه من بعض الأماكن فى وحدة الرى أو ترسب بعض الشوائب فى خطوط الري مما يستلزم ضرورة الصيانة والإصلاح وربما الإحلال لبعض الأجزاء. وبصفة عامة نجد أن البرنامج المقترح لديه القدرة على تصميم وتقيم أداء وحدة الري بالتنقيط للحيازات الصغيرة غير المنتظمة الأبعاد بدرجة جيده.

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