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Development of Head-Loss Evaluation Application Using JAVA for Drip Irrigation System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Drip irrigation is considered as one of the most efficient irrigation methods used in agricultural field. This method of irrigation is suitable not only in saving water as well as application of fertilizer can also be done very precisely at the crop root zone through fertigation. The drip irrigation set up is a micro irrigation process and it consist of pump, pipe network (Main line, sub main line and laterals), filter unit, drippers, valves, end-cap etc. One model application was developed to introduce with drip irrigation system which will help in efficient water application and used in field to increase the yield of crop the model is developed using java programming language to estimate the major head loss, minor head loss and the total head loss of sub-main and laterals of drip irrigation and it contain two types of calculators. One kind of the calculator is to calculate the head loss when laterals emerged in one side from subs main line and another is to calculate the head loss when laterals are emerged in both sides from the sub-main line in drip irrigation system. Due to head loss when water flow through pipes, there is reduction of total energy occurs and thus uniformity of drip irrigation system is affected. It further affects the flow rate and thus precision of drip system is also reduced due to head loss.

Keywords: Drip irrigation; head-loss; java programming model application.

1. INTRODUCTION

Water is considered as basic need for all the living beings in the world and which covers almost two third of the earth. However, despite the importance of water for the continuation of life, 97.5 % of existing water is in ocean and in seas and which is not suitable for use directly as it is. The remaining just 2.5 % is fresh water and can be used by living things; however, the vast majority, like 90% of this fresh water is in the poles and underground water and it doesn't have useable form. A major part of water is used by the farmers in the agricultural practice through different techniques.

Affordable irrigation technologies are developed by the scientists to help small farmers to increase agricultural productivity and which results the financial stability to the farmers. To achieve better yield from agricultural practice an adequate water supply is considered as most important factor and the plants must receive additional water through irrigation where amount of rainfall is not enough for crop production. In modern agricultural practice various methods of irrigation can be adopted in the field to supply irrigation water precisely and each method has its own characteristics with different advantages and limitations. Amongst all the irrigation methods, drip irrigation system is one of the advanced methods of irrigation system with higher efficiency of saving water, fertilizer, pumping energy and by using the same, water can be distributed uniformly to the plants. The system offer not only excellent control of water but also high efficiency in the application of water directly to the root zone of plants.

The drip irrigation pipe network consists of elbows, T-junction, bends, contractions, expansion, valves and many other components and these components cause loss in pressure due to change in momentum of flow caused due to friction and pipe components.

In water supply network of drip irrigation system, head-loss may vary depending on the type of components present in the network, material of pipe and type of fluid used through system. Head losses are of two types namely major and minor head loss. Major head loss occurs mainly due to friction on the other hand minor head losses occur due to pipe components like bends, valve, fittings, contraction in pipe, sudden enlargement, obstruction in flow, sudden change in pipe diameter *etc.*

Java programming language can be used different ways in agricultural field and services like development of farm management system, E-agriculture for farmers knowledge portal, various model development, water management, water monitoring, crop health analysis and various application software in utilizing technology in the sector *etc*.

The study was conducted during October 2018 in the Agriculture Engineering department of Assam University, Silchar.

2. HYDRAULICS OF DRIP IRRIGATION

There have been many studies on the hydraulics of drip irrigation systems. These studies have commented on the methods and parameters used for micro-irrigation system design. Provenzano et al. [1] stated "a procedure for evaluating total hydraulic head losses, including an extended local loss evaluation procedure, and a simplified procedure based on the assumption of constant outlet discharge. The results showed a 2.4% error when compared with total head loss measurements on 15 commercially available drip irrigation laterals. One difficulty in drip irrigation lateral hydraulics is in determining a correct estimation of the friction factor *f*, as used in the Darcy-Weisbach equation to determine hydraulic head loss in the lateral. This difficulty arises because of the variation of *f* along the lateral due to changes in discharge with respect to location". Vallesquino et al. [2] accounted "for this problem by creating an equivalent friction factor for the length of the lateral. However, it is unknown how this method would apply to a circular pipe cross-section due to flexible pipe walls and a low inlet pressure head". "Other authors have shown the successful use of the Blasius equation to determine the friction factor for small-diameter drip irrigation laterals" [3,4].

$$f = 0.32 \times R_e^{-0.25} \quad (2.1)$$

where,

R_e is the Reynolds Number.
The Reynolds number is defined as:

$$R_e = (V \times D)/v \quad (2.2)$$

where,

V is the velocity in the pipe (m/s);
D is the diameter of the pipe (m);
v is the kinematic viscosity (m^2/s).

The kinematic viscosity is a function of temperature and can be approximated by:

$$v = \left(83.9192T^2 + 20{,}707.5T + 551{,}173\right)^{-1} \quad (2.3)$$

According to Merkley *et.al.* [5] for,

v (m^2/s) and, T(°C), Equation (1) is considered valid for Reynolds numbers between 2,000 and 1,00,000 in circular pipes flowing full. In cases where the Reynolds number is less than 2,000 (i.e. laminar flow) the following Equation (4) can be used [6].

$$f = 64/R_e \quad (2.4)$$

In traditional drip irrigation lateral design, the head loss gradient for the lateral is found using equation (5), as described by Watters *et.al.* [7] which combines the Reynolds number, Darcy-Weisbach and Blasius equations to obtain:

$$J = \frac{K \times Q^{1.75}}{D^{4.75}} \quad (2.5)$$

Where,

J is the head loss gradient in m/100m;

K is a conversion constant that can be adjusted to average conditions; Q is the flow rate in Lps; and, D is the inside diameter (ID) of the pipe in mm. The friction loss, h_f, can then be calculated as:

$$h_f = (J \times L)/100 \quad (2.6)$$

For non-circular cross-sections, it is generally accepted to use an equivalent diameter, calculated from equation (7) for full pipe flow:

$$D = 4R_h \quad (2.7)$$

Where,

R_h is the hydraulic radius (m):

$$R_h = A/P \quad (2.8)$$

in which A is the cross-sectional area (m^2); and P is the perimeter of the cross-section(m). equation (8) gives reasonably accurate results for turbulent flow, but the results are poor for laminar flow and which was established by Finnemore et al. [6].

"It is well documented that minor losses caused by the emitter connections on a lateral can have a significant impact on the overall hydraulic design of the system" [3,8].

Yildirim et al. [9] proposed "a simple method for the hydraulic design of trickle irrigation laterals and showed that in some cases when the local hydraulic losses were ignored, the system designs had significant error".

Bagarello et al., [10] proposed "a procedure for evaluating local losses caused by the Emitter barb (for those emitters that have barbs) by characterizing pipe-emitter system with an obstruction index. They showed that the loss depends not only on the emitter geometry, but also on the emitter connection and deformation of the pipe around the stem". "There has been much discussion on which method of evaluating drip irrigation system performance is the most appropriate or correct. However, the conclusion can be reached that any uniformity expression can be used because they are all highly correlated" [11].

Wu, [12] showed that "the emitter spacing and manufacturer's variation have a much greater effect on overall system uniformity than the hydraulic design of the drip irrigation system".

3. METHODOLOGY

The calculator is designed and developed to calculate major head loss, minor head loss and the total head loss in drip irrigation pipe network system. Java programming is used to developed this precise Calculator Application.

This application calculator considers various dimensions and input to calculate Head loss in different orientation setup of drip system quickly and easily. And consideration of head-loss is very important to design and install an efficient drip system in farming plot.

The water flow rate in a pipe can be described as follows

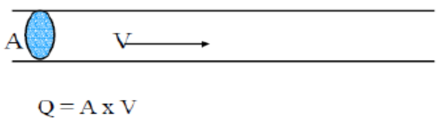

Fig. 1. Water flow in a pipe (continuity equation)

where,

Q=water flow rate (m^2/sec)
A=cross section area of pipe (m^2)
V=velocity of water flow (m/sec)

Use of the continuity principle is to determine the velocities in pipes coming from a junction.

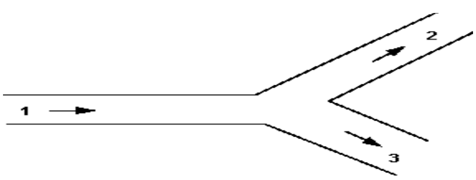

Fig. 2. Continuity equation in junction

Total mass flow into the junction = Total mass flow out of the junction

$$\rho_1 Q_1 = \rho_2 Q_2 + \rho_3 Q_3 \quad (3.1)$$

When the flow is incompressible (*e.g*. if it is water)

$$\rho_1 = \rho_2 = \rho \ldots 3.2 Q_{1=} Q_{2+} Q3 \quad (3.2)$$

This concept is applicable also in drip irrigation which consists of several pipe junctions.

Several research work had done on hydraulics of irrigation. Lots of empirical formula derived to measure head loss of pipe. Based on hydraulics, suitable design for irrigation purpose had been derived. Similarly in case of micro-irrigation also from various design head loss estimated formula was derived. In this work by following simpler and novel approach an application is developed by using java programming to estimated head loss of laterals and sub-main in drip irrigation system. The standard formulas given in the textbook of fluid mechanics and Hydraulic machines, by Dr. R.K. Bansal, [13] Laxmi publications (P) Ltd. were followed to calculate major and minor head loss of pipes and fittings. Application calculator estimates major head loss, minor head loss of laterals and sub-main of drip irrigation which is designed according to layout [14,15].

Geometrical figure of drip irrigation system consisting a sub-main and *n* numbers of laterals and there are *m* numbers of drippers in each lateral showed in the following figure (Fig. 3) is Considered.

4. RESULTS AND DISCUSSION

Drip irrigation system consists of large network of pipelines through which water is carried and applied nearer to the plant root zone through an emitting device. It is a slow application of water to the plant root zone and the system uses network of tubes, emitters to deliver water. Since it consists of large network of pipelines, so it encounters frictional head loss that is major head loss as well as minor head loss. The pipeline network of drip irrigation system mainly consists of sub-mains and laterals. So this calculator evaluates major head loss and minor head loss of lateral and sub-main of drip irrigation system. Calculator application is developed using java coding which calculates the major head loss , minor head loss, and total head loss taking input variable diameter of sub-main (D_1), diameter of lateral (D_2), Inlet discharge of sub-main (Q), discharge by dripper (q), distance between dripper (d_1), distance between lateral (d_2), diameter of emitter path (D_3),no of laterals (n), no of drippers per lateral (m).The unit of all the output results are in meter [16].

The calculator has the option to store the mathematical values and the record data can be obtained. In general we can see two types of arrangements of lateral in drip irrigation viz. 1) laterals are emerging out in one side from the sub-main, 2) laterals are emerging out in both sides from the sub-main. So the calculator has two option, one for head loss when laterals are emerged out in one side from the sub-main and another for when laterals are emerged out in both side from the sub-main. The different head loss in sub-main and laterals of drip irrigation system is calculated by the designed calculator [17].

The calculator application is developed (Fig. 4 & Fig. 5) for both kind of layout mentioned above and both the option in calculator takes same kind of input variables to calculate the head-loss differently and can be seen in Figs. 6 and 7 respectively.

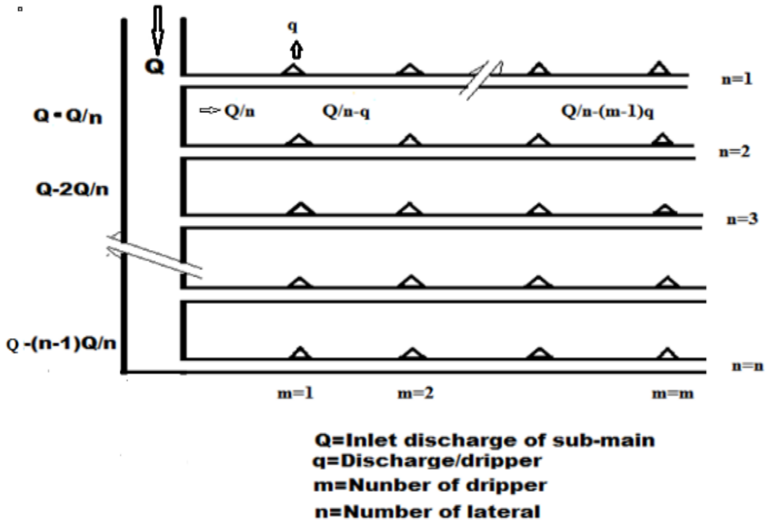

Fig. 3. Input variables in the system

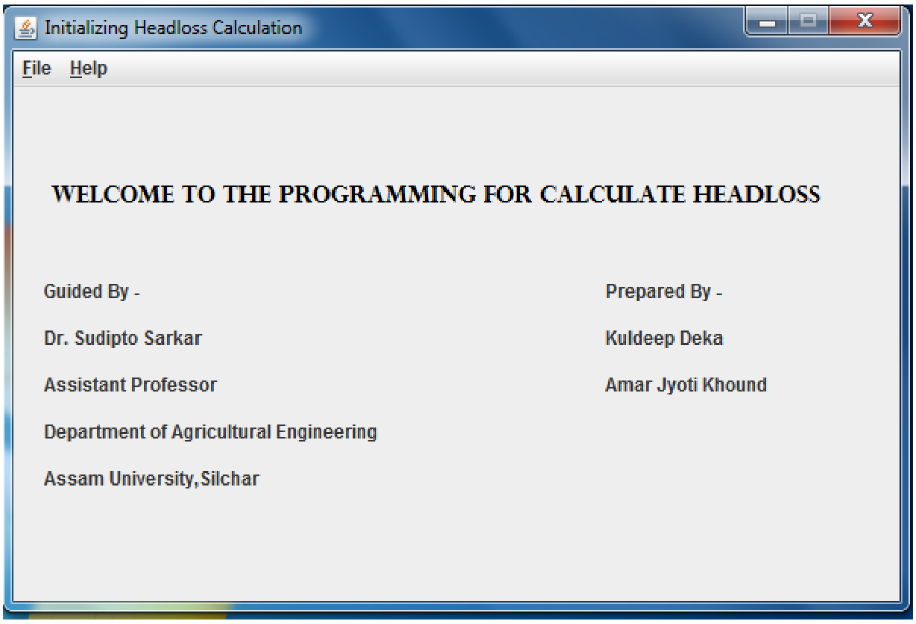

Fig. 4. Initiation window of application

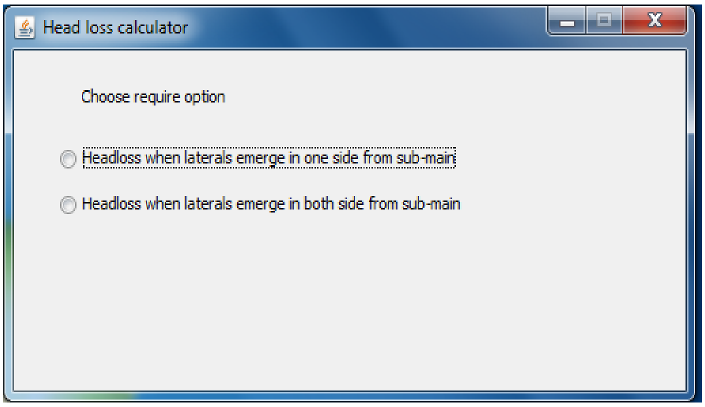

Fig. 5. Option choosing screen

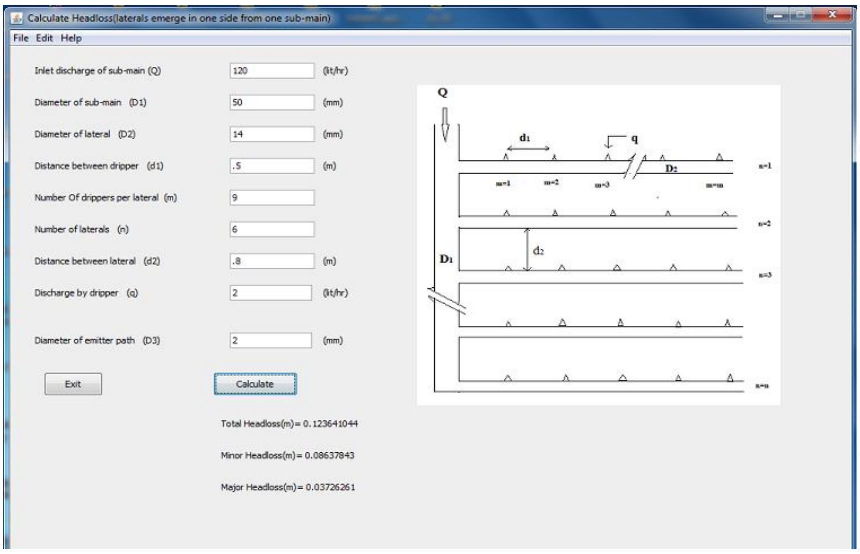

Fig. 6. Laterals emerge in one side from sub-main

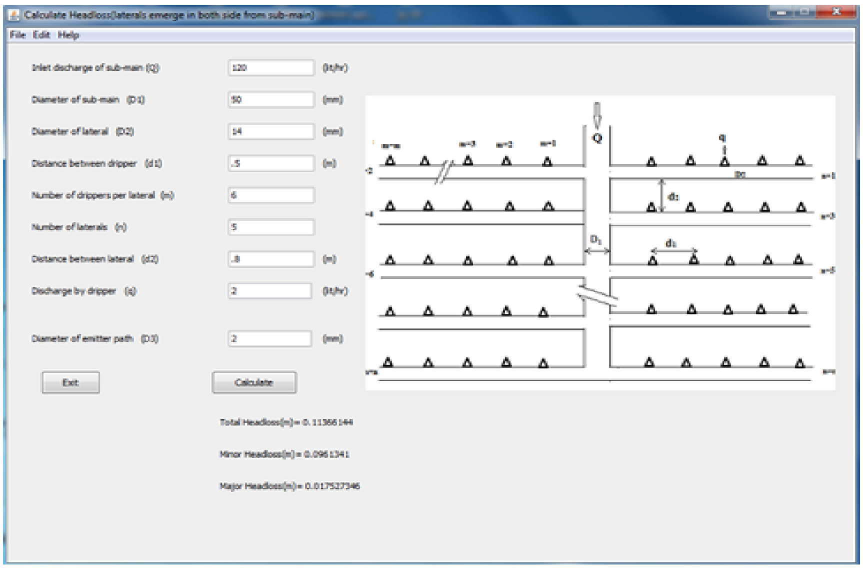

Fig. 7. Laterals emerge in both side from sub-main

5. CONCLUSION

Head loss calculations can often be tedious and repetitive. In a drip irrigation system to calculate the head loss a longer time is required due to several steps and factors need to deal. So requirement of time for calculate head loss can be minimize by using this calculator application. Also chances of human errors and mistakes increases in manual calculation. By using the calculator application committing mistakes and the error thereof can be eliminated. Calculations with different input variable parameters can be done to compare and select the suitable layout by using this calculator application. Also, to investigate the flow properties in drip pipe network, this application will be helpful. Moreover, with the help of this application head-loss can be predicted and further precaution and measures can be taken to reduce it.

With increase in the adoption of Java programming language and similar programming language like python, C++, PHP *etc.* and their application in the Agriculture sector can solve various difficult task smoothly and it will help the farmers and farming community in different way for better productivity. Thus application of technologies will become easier in the field of agriculture

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Provenzano G, Pumo D, Dio PD. Simplified procedure to evaluate head losses in drip irrigation laterals. Journal of Irrigation & Drainage Engineering. 2005; 131(6):525-532.
2. Vallesquino P, Luque PL. Equivalent friction factor method for hydraulic calculation in irrigation laterals. Journal of Irrigation & Drainage Engineering. 2002; 128(5):278-286.
3. Provenzano G, Pumo D. Experimental analysis of local pressure losses for micro irrigation laterals. Journal of Irrigation & Drainage Engineering. 2004;130(4):318-324.
4. Juana L, Sinibas LR, Losada A. Determining minor head losses in drip irrigation laterals, I: Methodology. Journal of Irrigation & Drainage Engineering. 2002; 128(6):376-384.
5. Merkley GP, Allen RG. Sprinkle and trickle irrigation lecture notes, Biological and Irrigation Engineering Department, Utah State University. 78-90.
6. Finnemore EJ, Franzini JB. Fluid mechanics with engineering applications (10thEdn.). Mc Graw-Hill, Boston. 2002;53-59.
7. Watters GZ, Keller J. Trickle irrigation tubing hydraulics. In: Proceedings of ASAE summer meeting, American Society of Agricultural Engineers, St. Joseph, Mich. 1978;78-91.
8. Juana L, Sinobas LR, Losada A. Determining minor head losses in drip irrigation laterals, II: Experimental study and validation. Journal of Irrigation &Drainage Engineering. 2002;128(6):385-396.
9. Yildirim G. An assessment of hydraulic design of trickle laterals considering effect of minor losses. Journal of Irrigation & Drainage Engineering. 2007;56(4):399-421.
10. Bagarello V, Ferro V, Provenzano G, Pumo D. Evaluating pressure losses in drip irrigation lines. Journal of Irrigation & Drainage Engineering. 1997; 123(1):11-17.
11. Barragan J, Bralts V, Wu IP. Assessment of emission uniformity for micro-irrigation design. Biosystems Engineering. 2006;93 (1):89-97.
12. Wu IP. An assessment of hydraulic design of micro-irrigation systems. Agricultural Water Manage. 1997;32(3):275-284.
13. Bansal RK. Textbook of fluid mechanics and hydraulic machines. Laxmi Publications (P) Ltd.; 1983. ISBN- 13: 978-8170083115.
14. Babel MS, Shrestha S, Pandey VP. Climate change and water resources (1stEdn.). Taylor and Francis; 2014. ISBN:9781466594661, 1466594667
15. Eakins BW, Sharman GF. Volumns of the Worlds Ocean from ETOPO 1 Archieved 2015-03-11 at Wayback, NOAA National

Geophysical Data Center, Boulder, CO; 2010.
16. Oviroh PO, Austin-Breneman J, Chien CC, Chakravarthula PN, Harikumar V, Shiva P, Kimbowa AB, Luntz J, Miyingo EW, Papalambros PY. Micro water-energy-food (Micro WEF) Nexus: a system design optimization framework for integrated natural resource conservation and development (INRCD) projects at community scale. Applied Energy. 2023; 333:120583.
17. Bekker A, Van Dijk M, Niebuhr CM, Hansen C. Framework development for the evaluation of conduit hydropower within water distribution systems: A South African case study. Journal of cleaner production. 2021;283:125326.

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