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Decision support system for designing underground pipeline system

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Abstract
Underground pipeline water distribution system is a water conveying system to different points in the farm and allied structure required for the efficient use of water. It saves the cultivation area upto 2-4% which get covered in open channel system (Michael, 1978). The optimum pipe diameter gives the least total cost for annual pumping power and fixed cost. Underground pipe lines are fixed and permanent thus require high accuracy and skill in installation to avoid various hydraulic losses. Therefore it is important to study the designing of underground pipeline. Therefore to help the farmer about the selection of most appropriate diameter of underground pipeline, a decision support system is to be designed. For the development of software visual basic 6.0 programming language was used. The input data required for the software is Discharge of tube well (lt/sec), length of pipe (m), no. of bends, type of pipe, elevation difference between input and output (m). The output is suitable pipe size.

Keywords: Open channel, pipe diameter, discharge, visual basic, hydraulic losses etc.

1. Introduction
Water is one of the most valuable resources. The agriculture sector is the largest consumer of water resources in the developing countries. Assured supply of water is necessary for sustainable agriculture. But, farmers of our country are making irrational use of water and the level of utilization of water at the farmer's field is poor. Most of irrigation projects operate at a low efficiency in the range 30-40%, thereby losing 60-70% of irrigation water during conveyance and application. Though, the application and use-efficiencies of irrigation water can be improved by using underground pipe line system.

Underground pipeline water distribution system is a 'water conveying system' to different points in the farm and allied structure required for the efficient use of water. These are installed to carry water from main source to the point of application via main and lateral. It is used in drip, sprinkler, sub-irrigation and other methods of irrigation also. It has several advantages: It saves the cultivation area upto 2-4% which get covered in open channel system, It eliminates water loss by evaporation, Since they operate under high pressure, can be laid uphill or downhill, thus permitting delivery of irrigation water to areas not accessible by open channels, The pipeline are not clogged by vegetation and blown material, it has long life and low maintenance cost (Michael, 1978) [4]. The optimum pipe diameter gives the least total cost for annual pumping power and fixed cost.

A Decision Support System is an interactive, flexible and adaptable computer based information system specially developed for supporting the recognition and solution of a complex, poorly structured or unstructured, strategic management problem for improved decision making. The model allows creating and comparing a set of design alternatives relative to the pipe system and emitters, either drip or microsprinkling emitters. For each alternatives, the pipe system is sized and irrigation system is simulated to produce performance, environmental and economic indicators (Pedras *et al*, 2008) [5]. It uses data and models, provides an easy, user-friendly surface and can incorporate the decision's makers own insights. The program simulates the economically driven decision processes of farmers, permitting an accurate description of production and irrigation in terms of technology and agronomics (Bazzani, 2005) [3]. As large number of farmers in our country now a days are adopting modern methods of irrigation due to scarcity of good quality of irrigation water and depleting water table. Drip and sprinkler irrigation are getting popular in which we basically require pipe line above and below the surface. Underground pipe lines are fixed and permanent thus require high accuracy and skill in installation to avoid various hydraulic losses. Therefore it is important to study the designing of underground pipeline. Therefore to help the farmer about the selection of most appropriate diameter of underground pipeline, a decision support system is to be designed.

2.1 Materials and Methodology
The design of the underground pipe line system, some basic information about the field is required as

- Discharge(Q)It/sec
- Length of pipe required (m) or (feet)
- Material of pipe
- Elevation difference between inlet and outlet
- No. of bends

2.2 Language used
For designing the decision support system VISUAL BASIC 6.0 is used due to following reasons (Arora, 2004) [1].

- It uses data and models, provides an easy, user-friendly interface, and can incorporate the decision's makers own insights.
- Any type of mathematical to logical programming can be developed
- Corrections and modifications can be made easy in it

2.3 Algorithm for developing the software to suggest suitable diameter pipe
- First page of the software is homepage on which selection of language can be done.
- On second page, insert the information required in the software.
- A pump stand of standard height (4.5m) is assumed to be constructed (suggested as maximum height).
- On the third page, you can get diameter of underground pipeline best suitable to the conditions.

2.4 Calculation of head loss in the pipe
If total head loss in the pipe is less than or equal to the available head then we suggest that size (diameter) is the most appropriate for the conditions provided.
Therefore, total head loss has to be calculated for the various sizes of pipe as per the following steps:
Total head losses (H_t) comprises of major and minor losses discussed below:

2.4.1 Major loss (H_f): it is due to frictional loss in the total length of pipe

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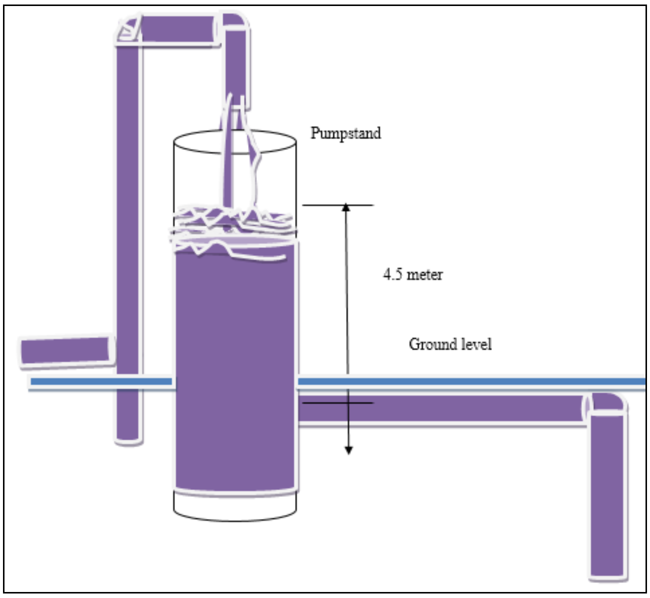
Method 1: Height of pumpstand is fixed (4.5 m)



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2.4.2 Minor losses

a) Losses at entrance(H_e)
b) Losses at outlet(H_o)
c) Losses due to velocity(H_v)
d) Losses due to bend (H_b)
e) Losses due to fitting and air release valves(H_{fv})

Total head losses (H_t) = (H_f) + (H_e) + (H_o) + (H_v) + (H_b) + (H_{fv})
Loss due to friction in the pipe (H_f) is calculated by using the following formula

$$H_f = \frac{4 \times f \times L \times v^2}{2g \times d} \quad \ldots\ldots \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots (2.1)$$

Where,

f = Coefficient of friction which is a function of Reynold's Number

$$f = \left[\frac{1}{2 \times \log_{10}\left(\frac{R_e}{K}\right) + 1.74}\right]^2$$

L = length of pipe
V = velocity of flow
d = diameter of pipe
g = acceleration due to gravity (9.81m/s^2)

Calculating f, certain diameter of the pipe is assumed and value of Reynold's number for this diameter will be worked by using the formula

$$R_e = \frac{v \times d_{assumed}}{kinematic\ viscosity\ of\ water}$$

Where, kinematic viscosity of water is 0.4 x 10^{-4}

$$R_e = \frac{v \times d_{assumed}}{0.4 \times 10^{-4}}$$

We know V = velocity of flow = $\frac{Discharge}{Area} = \frac{Q}{\pi/4 \times d_{assumed}^2}$

$$R_e = \frac{Q}{\pi/4 \times d_{assumed}^2} \times \frac{d_{assumed}}{0.4 \times 10^{-4}}$$

$$R_e = \frac{Q}{\pi \times d_{assumed} \times 10^{-5}}$$

Now f is calculated on the basis of Reynold's number by using Kerman-Prandtl equation,

$$f = \left[\frac{1}{2 \times \log_{10}\left(\frac{R_e}{K}\right) + 1.74}\right]^2 \ldots\ldots\ \ldots\ldots\ \ldots\ (2.2)$$

Where, K = Coefficient of friction and its value depends upon the material of pipe

Table 2.1: Coefficient of friction for different material

Material	Value of K
PVC	1 x 10^{-6}
Concrete	7 x 10^{-4}

Now, we have H_a (Total available head) = (4.5 ± h) m and (f) from equation (2.2).
Total available head = Height of Pump stand ± Elevation difference
Positive sign will be considered when oulet point is lower than base of the pump stand.
Negative sign will be considered when oulet point is higher than base of the pump stand.
By using equation (3.1), the value of d is calculated.

$$4.5 \pm h = \frac{4 \times f \times L \times v^2}{d \times 2g}$$

$$4.5 \pm h = \frac{4 \times (f) \times L \times Q^2 \times 16}{\pi^2 \times d^5 \times 2g}$$

$$d = \sqrt[5]{\frac{64 \times 2.2 \times 10^{-3} \times 400 \times 15 \times 15 \times 10^{-3}}{3.14 \times 3.14 \times (4.5 \pm h) \times 2 \times 9.8}}$$

Then assumed value of diameter will compared with this calculated value.
If $d_{calculated} < d_{assumed}$, then diameter of the pipe is selected as $d_{assumed}$
If not, the assume another d from Table 2.2 next to the assumed earlier and repeat the above process till $d_{calculated} < d_{assumed}$. satisfies.

Table 2.2: Range of pipe available in market (diameter)

inch	**1/2**	**3/24**	**1**	**1(1/4)**	**1(1/2)**	**2**	**2(1/2)**	**3**	**4**	**6**	**8**
meter	0.0125	0.01875	0.025	0.03125	0.0375	0.05	0.0625	0.075	0.1	0.15	0.20

After finalizing the diameter, calculate all losses
1. Major loss

$$H_f = \frac{4 \times f \times L \times v^2}{d \times 2g}$$

2. Minor losses
(a) Losses at entrance (H_e): it is calculated as

$$H_e = \frac{0.5 \times v^2}{2g}$$

(b) Head losses at outlet (H_o): it is calculated as

$$H_o = \frac{0.5 \times v^2}{2g}$$

(c) Head losses due to velocity (H_v): it is calculated as

$$H_v = \frac{v^2}{2g}$$

(d) Head losses due to bend 90^o (H_b): it is calculated as

$$H_b = K' \times \frac{v^2}{2g} \times (No. of\ bends)$$

Where K' is a constant and depends upon the ratio of curvature of bend and diameter of pipe. For 90^o bend, this ratio is one. The value of K for ratio 1 for different diameter of pipe can be obtained for the table 2.3

Table 2.3: value of K' for different pipes

Diameter of the pipe (inches)	Value of K'
0.50	0.54
0.75	0.50
1.00	0.46
1.25	0.44
1.50	0.42
2.00	0.38
2.50 to 3.00	0.36
4.00	0.34
6.00	0.30
8.00 to 10.00	0.28

(e) Head losses due to fitting and air release valves (H_{fv}) : it is calculated as

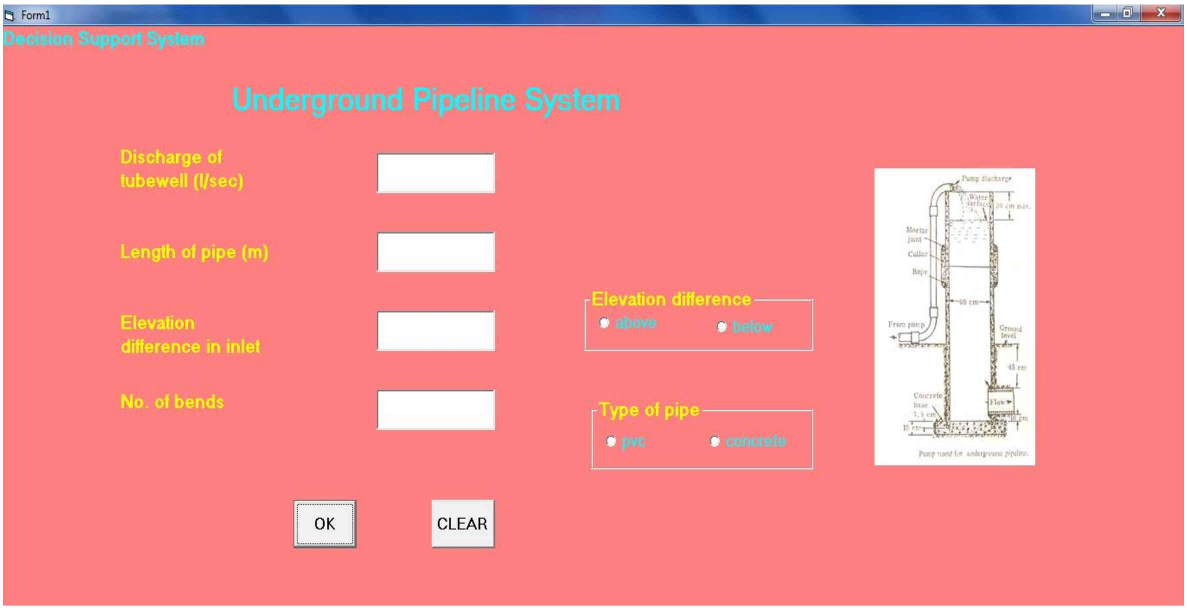
$$H_{fv} = K'' \times \frac{v^2}{2g} \times 2 \times (No. of\ bends)$$

(K'' is a coefficient of fitting =1)
Total head losses (H_T) = Major losses + Minor losses

$(H_t) = (H_f) + (H_e) + (H_o) + (H_v) + (H_b) + (H_{fv})$

With the assumed diameter if Total head loss (H_t) is less than the Available head (H_a) then our design is correct and the recommend size of the pipe for the given conditions.
If head loss is more than the available head then our design is not correct. Then bigger size of the pipe will be selected and tested again as per the points discussed. This process will continue till then head loss is less than the available head.

2.5 Decision Support System



3. Results and Discussion

The software for selecting the most appropriate pipe for designing the underground pipe line system under different conditions is developed with the following steps:

i. Home page

From this page, the user can select English and Hindi language.

ii. Main page

From this page the user can select the best pipe for installing underground pipeline system

4. Summary and Conclusion

Present study was planned with the objective to develop software for the calculation of suitable diameter for installment of underground pipeline system. For the development of software visual basic 6.0 programming language was used. The software was developed successfully with the following features.

1. Software is user friendly. It is designed in English and Hindi.
2. Software is very quick and accurate.
3. Pipe of suitable size can be selected.
4. The input data required for the software is
   - 4.1 Discharge of tube well(lt/sec)
   - 4.2 Length of pipe(m)
   - 4.3 No. of bends
   - 4.4 Type of pipe
   - 4.5 Elevation difference between input and output(m)
5. Output
   - 5.1 Suitable pipe size

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