Micro Irrigation Engineering
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Lecture - 39
Bubbler Irrigation System

Hello, participants of micro irrigation engineering subject. Now we are starting lecture 39. In lecture 39 we will discuss about bubbler irrigation in the family of micro irrigation emission devices. We discussed various types of emission devices where drippers we discussed, online, inline, point source, line source. Then we discussed in the previous class on micro sprinklers. Now, this is another type of micro irrigation emission device which is known as a bubbler irrigation system.

So in this particular lecture, we will discuss about what is the importance of a bubbler irrigation system, how does it work, and what are its components and its layout, and what are the points which should be considered while designing a bubbler irrigation system.

Bubbler irrigation is a localized low-pressure solid set permanent installation system used in trees. The application rate generally exceeds the infiltration capacity of the soil. Therefore, a bubbler irrigation system is more relevant to basin or furrow methods of irrigation. They are needed to control the water distribution on the land. So either we form a basin or we form furrows.

Water infiltrates into the soil and wets the root zone. So here overland flow takes place and then it goes slowly through the infiltration process and then means as in other cases here the gravity component, a gravity-flow component in the porous medium is more as compared to the other kind of system, in case of micro sprinkler you have seen or in case of the drip irrigation we have seen.

Although the bubbler application is extensively used in the landscape irrigation system and its use in agriculture is limited. Because we are talking of reducing the water supply. So we want to minimize the losses. So it is likely that it may wet more than the desired root zone depth. So when the water supply is not a constraint that is one part and then another one is that the quality of water from the debris or the sand, silt which is flowing with the water that causes the clogging problem. From that point of view, this is more important. So in those situations, it is very good and one should go for bubbler irrigation.

Now, two types of bubbler irrigation systems are used. One is of low head or gravity type and pressurized system. So low head or gravity system when we say this is limited to 10 kilo Pascal pressure, whereas pressurized we say, this goes up to 150 kilo Pascal.

Bubbler systems are well suited for perennial crops like orchards, vines because irrigation system typically includes buried pipeline and small earthen basins are made around the particular plant. And bubbler system can also be adopted to row crops that utilizes the furrow. So furrows are constructed to take water from the bubbler tube means to guide the water.

The bubblers are small plastic head emitters. This is what you see these are the small plastic head emitters and with threaded joints, means here it is threaded joint. So it can be connected with there is another plastic stem which is also threaded. So they were originally designed to use on risers, above the ground for flood irrigation or of small ornamental areas.

But now these are being used. Initially, they were used for such purposes. But now these are used for irrigating fruit crops. They perform well under a wide range of pressure delivering water in the form of a fountain. This is what it looks like in the form of a fountain or small stream or tiny umbrella. This is the way you see here in the vicinity of the emitter.

An emitter is this particular device. So this particular device, the way the water is coming out from this particular emission device. This type of emission of water is known as a bubbler emitter. They operate at 1 to 3 bars and then the discharge rate is 100 to 200 liter per hour. These are available at higher discharge and filtration is not required. This is another beauty that the filter part is eliminated in the case of the bubbler system.

The potential advantage that compared with other micro irrigation systems, the bubbler system have some potential advantages. It requires low energy, maintenance is low, susceptibility to the emitter clogging is low, water with a higher suspended solid concentration can also be used, the operating cost is low, the interval between irrigation is long, and the short duration because of the amount of water or flow rate is large. So irrigation interval is short, the irrigation event is short. Accumulated salts are uniformly leached. Bubbler basins increase the catchment of rainfall.

There are some disadvantages or limitations we can say. Very few agricultural bubbler system have been installed or in operation. As I told you that it requires more water and then basic purpose or the main advantage of having micro irrigation system is lost when we talk of the giving water through the bubbler. Design criteria and recommended operating procedures are not well documented.

This is another thing. And then entrapment of air in the pipeline network can lead to blockage, and then farm topography needs to be level. This is another important thing that otherwise water will not guide, so because there is overland flow takes place. Bubblers are not suitable for sandy soil. The small earthen basins are typically required around the plant so that the water can be guided in a proper way.

Cultural practices are more difficult to perform around the earthen basin because we are flooding the whole field. We are giving the water in larger point. So it is likely there will be more weed problems. So that becomes more difficult to perform around the plant.

Now let us come to the system layout and components. The bubbler system layout is typical among all the pressurized irrigation systems. However, some basic differences exist relating to operating pressure and flow rates. It consists of a simple head control unit without filters and fertilizer application operators. So fertigation is not done by using the bubbler system.

Because of the fertilizer, which we will give the dissolved fertilizer, it will not only be available to the plant but it will be flowing as overland flow to other places. The mains and sub-mains are usually buried PVC pipe hydrants arising on the surface. The manifolds and laterals are also often buried rigid PVC pipes.

The bubblers are placed above the ground supported on a stake and connected to the lateral with a small flexible tube rising on the surface or they can be fitted on small dia PVC risers that are connected to the buried laterals. The difference between the bubbler system and other micro irrigation systems is that in other installations the lateral lines are 12 to 32 mm.

That is the maximum in case of micro sprinkler 32 mm it can be and normally we use 10 mm, 12 mm, 16 mm pipeline for drip irrigation. Whereas in the bubbler system, laterals are usually of 50 mm in diameter because it is delivering higher discharge. So discharge rate is high. So the laterals are 50 mm high and these pipelines are laid below the ground level.

The other category of the bubbler is gravity flow bubblers. The gravity flow bubblers are unique because they are not designed to dissipate energy unlike the other types of micro irrigation. Bubbler emitters are essentially delivery tubes for transferring the water from irrigation laterals to the plants. The gravity bubbler system operates at very low pressure.

That is about 10 kilo Pascal where the flow rate through the delivery pipe tube, delivery tubes can be altered by adjusting their outlet elevations because the operating head of the bubbler is low. That is about 1 m head. Small changes in the elevation throughout the system have a large impact on discharge rates. Additionally, frictional losses within the pipe and tube affect the water pressure within the system. Therefore they affect the discharge rate. Because here again, discharge is a function of the operating pressure, and pressure gets affected because of the frictional losses. There are some connectors, so they affect the discharge rate.

For a small diameter smooth pipe, the Darcy-Weisbach and Blasius equation has been combined to predict the frictional head loss in bubbler tubes that has been given by Keller and Bliesner in 1990. The equation given by them is given that

$$h_f = K_{fdw} \times \frac{Q^{1.75}}{D^{4.75}} \times L$$

Where,

D = the inside diameter (mm),

Q = the flow within tube in (L s^{-1}),

L = the length of tube (m), and

$K_{fdw} = 7.89x10^5$, constant for SI units at a water temperature of 20^OC.

So one can find out the head loss in this pipe when the Darcy-Weisbach equation and Blasius equation have been combined in this part.

Now, one can find out how much head loss it takes place when these are the discharge rate and then head loss has been estimated for the different size of the pipeline, for the different size of the internal diameter of the pipeline. So let us say that it is the diameter of the pipeline, it is increasing. You can see 4 mm, 6 mm it is increasing in this direction. And this is the bound where Reynolds number is expressed.

So Reynolds number that is this 10 is to power 6 to that, 40 to the power 6. That is your 1 lakh to 4 lakh, that is the value. So head loss one can find out. Suppose we have been given the flow rate of 1 liter per second, the diameter of the pipeline is 104 mm and then one has to see that what is Reynolds number and corresponding to Reynolds number, the values of Reynolds number one has to choose. And then one can get the value of the head loss, gradient, or head loss that is expressed in meter by meter. So this particular factor one can get from this.

Pressurized bubbler system. The pressurized bubbler systems are similar in design to the alternative micro irrigation system and typically operate between 50 kilo Pascal and 150 kilo Pascal. The emission device, however, has a relatively high discharge rate that is up to 225 liter per hour. The length of a small-diameter emission tube controls the rates and in a manner similar to that of a capillary tube in the drip irrigation system.

Uniformity can be achieved by adjusting the length of the tube. This is important that is because as you have more length, more coiling length you are doing so more will be head loss and that will disturb the uniformity. So one has to see that part. Discharge rate as a function of tube length. It means it is a function of tube length and can be derived from the fundamental principle of energy conservation within the bubbler tube which can be derived from the Bernoulli equation where you see the pressure head, elevation head, velocity head at section 1 means at the upstream section of the tube, where the pressure head it is given by the p 1.

So this is at location 1. And then this is equal to

$$\frac{p_1}{\gamma} + z_1 + \frac{(V_1)^2}{2g} = \frac{p_2}{\gamma} + z_2 + \frac{(V_2)^2}{2g} + \sum h_f + \sum h_{ml}$$

Where,

h_f = the friction head loss in pipes (m)

h_{ml} = the minor losses at pipe fittings (m)

V_1 and V_2 = the flow velocities of water in the pipe at locations 1 and 2, respectively, (m s^{-1})

p_1 and p_2 = the pressures within the pipe at locations 1 and 2, respectively, (kPa)

z_1 and z_2 = the elevations of pipe at locations 1 and 2, with respect to a reference datum (m)

γ = the specific weight of water, 9790 (N m^{-3}) at 20ºC; and

g = the gravitational constant, 9.81 (m s^{-2})

So minor losses are due to connections. All the connectors, elbow joints that take care about the minor losses and this is as I told you that we need to calculate the head loss due to friction by using the appropriate equations which already I have discussed in previous class by using Hazen-Williams, by Darcy-Weisbach, or Scobey formula. Scobey formula is normally not used in pipes made up of plastics.

So this you can calculate. Now, these components one can mean these already I have explained. So this is for the second location or downstream location in the pipeline. When we apply the Bernoulli equation, bubbler tube points 1 and 2 can be set at the entry and outlet of the tube. There are several assumptions that have been made to simplify this equation. These assumptions are that minor losses are zero. No elevation when it is placed in the same elevation. And continuity equation applies, means V 1 is equal to V 2. And then the P 2 is equal to 0.

That means the water which is coming out is at atmospheric pressure. So P 2 is equal to 0. So finally, this equation results in this form. So discharge of a bubbler tube can be given by

$$q_b = K_b \times \left(\frac{P}{L_b}\right)^{0.57} \times D^{2.71}$$

Where,

q_b = the bubbler tube discharge (L h^{-1})

P = the operating pressure (kPa)

L_b = the length of bubbler tube (cm)

D = the diameter of bubbler tube (mm) and

K_b = 5.52, a constant for units of variables as defined

So if we are putting all these things, we need to put the Kb equal to 5. 52 to get the value of discharge from the bubbler tube.

Now one can find out what is the bubbler discharge by using this monograph. So this monograph has been developed when the diameter is ranging from 1 mm to 10 mm and then operating pressure is 10 kilo Pascal and length it is varying from 10 cm to 5 m. So this is the range which has been, this has been estimated. And you can see if I take any value and then we see, what is the diameter?

Let us say that my diameter, for my length of the tube is, length of the tube is 2 m that is 200 cm, and then the diameter is this. So I will be using say diameter is 10 mm. Then corresponding discharge, I can get that what is the discharge. So I will get a discharge. It is about we are getting about 500 liter per hour. So like this directly one can find out without calculation by using this type of graph.

Another one is if we are interested to find out what should be the required length. Then if it is the required length of 2 mm and then the 3 m tubing for the desired discharge rate in liter according to the inlet pressure. So I can find out what should be the desired discharge rate. So if this is one case. This is when the diameter is taken as 2 mm and then if I want to get what should be the discharge from this particular tube. So given pressure and then selecting a particular length I can know that what will be the discharge of the particular bubbler system.

So in this particular, in these two things, when the two means two diameters of the pipelines are available and then given the bubbler tube length and then one can know what is the given pressure what will be the required discharge. Or for an assumed discharge and the length of the tube, one can find out what will be the operating pressure so that one can get better uniformity of application.

Irrigation scheduling with bubbler irrigation percentage of root soil volume wetted is about 80% because water given is in more in quantity, large in quantity. So wetting zone, root zone wetting is more. So it is about 80%. And there is no restriction, there are no restrictions on the way of scheduling the program means it can be preprogrammed. So no restriction on the way the irrigation program is prepared.

This can be either fixed depletion or fixed interval means either we are fixing the depletion level that we need to have the depletion level of 80%, 70%. So depending on the depletion, an irrigation schedule can be made. Or someone wants to make the interval that every 5 days I need to give irrigation, this is also possible.

So taking into consideration the soil water holding capacity that is the field capacity of the soil and the availability of irrigation water and the size of the flow. Then the design criteria and concentration, the bubbler irrigation is mainly applied to fruit tree orchards. And the most important criteria apart from routine design criteria are the system's special features and characteristics. Bubbler emitter discharges water on the same part of the ground at high rates. Thus for a uniform distribution over basin area, minimum of land preparation is required.

A mature tree always takes two bubbler emitters on each side in order to ensure acceptable uniformity of water application because, in the case of mature trees, the water requirement is high. I think the bubbler irrigation is appropriate in that case and the two bubblers will take care of meeting the water requirement of such trees.

The common practice is to have one lateral per two rows of the trees with small flexible tube extended on both the side and connected to the bubbler. That is the normal common practice but in order to see that when the plants are old, and then the rooting systems are deep and they were being given the conventional irrigation. So the root systems are deep and then it has got large root zone depth. So in that case, this kind of practice that two bubblers are used.

In this way the same size of the lateral pipe placed, buried, it is kept below the ground level between two rows can serve the 12 trees on each side. So which is spaced 6 m interval with 48 bubblers system, bubbler emitters. So if we are putting it for the 12 trees and then two laterals are kept. So we will be putting two deeper surfaces there are 24 trees in total and that is at 6 m intervals. So we need 24 into 2 that is a 48 number of bubbler will be required.

The size of the equipment for installation should always be able to accommodate the flow required for maturity. This one should take care for longer laterals. Pressure compensated bubblers can also be used which involves higher energy consumption, more expensive, and higher pressure drop.

So this is a typical bubbler laying system where you can see this is laid in a 1.15 hectare area. So this is 120 m long and 96 m wide and these are the trees where you see this is a tree. And in between the tree, this is the lateral line which is passing. And then on each lateral pipeline, the bubblers are attached. And this bubbler will be given, there will be an appropriate number of bubblers depending on the requirement.

Maybe two bubblers or one bubbler to each tree. That can be taken care depending on after knowing the water distribution. So you can see there is a water source, from the water source the water is brought with the help of a pump. And then the pump is connected. Then there is the main pipeline and from the main pipeline, there is a sub-main manifold and from the sub-main manifold, these laterals are attached. These laterals go along the plant rows.

So you may refer to these books for this topic and then let us summarize this lecture. We have discussed about the bubbler irrigation system. We also discussed the two types of bubbler system. One is the gravity flow type of bubbler or pressure flow type of bubbler. We made the comparative advantages and disadvantages of this system.

We also discussed about irrigation scheduling and then what are the important design consideration one should take care. In the forthcoming class, we will discuss about sprinkler irrigation system, and thank you very much.