# Micro Irrigation Engineering

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## Lecture - 25
## Types and Selection of Emission Devices

Hello, participants. Now, we will be discussing Lecture 25 of micro irrigation engineering subject. This lecture deals with types of emission devices and the selection of emission devices. We dealt in previous lectures on micro irrigation system components. We discussed about the importance of a micro irrigation system, its advantages, and its limitation. And we compared it with the existing conventional irrigation system.

Now, when we are deciding the design part of the micro irrigation system, we considered different types of emission devices. And these emission devices are selected on some certain considerations. So, this particular lecture will give you more details about different types of emission devices.

In detail, we will be talking about these devices. We will also in this lecture, we will deal with how to select a particular type of device and then hydraulics of flow through emission devices. Mainly it is dealing with drip irrigation system.

So, when we talk of emission devices, the actual application of water in a micro irrigation system is done through an emitter. An emitter is a metering device. Here all the component of the emission device is made up of plastic material. When we take another say sprinkler irrigation system, the nozzle is made up of brass or gunmetal or some other material. But here in a drip irrigation system, all the emission devices are made up of plastics.

These are small in size and deliver precise accurate discharge for which it is designed. The amount of water, which is emitting out of a drip emitter, it is expressed in liter per hour. That is a common unit we use. Now, the water which is delivered from emission devices they could be in a different form. If we are I mean the water is delivered in terms of or in the form of droplets or trickles it is applied through a drip emitter.

When it is delivered or discharging in the form of bubbles or it is coming out in the form of a continuous stream it is a bubbler means it is a device which is used to deliver water in the bubbles out, in the form of bubbling out then it is a bubbler. And then water which is sprinkled is sprayed or misted it is done through micro sprinkler.

These emission devices could be of different types. So, one type of emission device is a pressure compensating dripper. So, in pressure compensating dripper, the water is delivered uniformly on long rows and on uneven slopes. Means the effect of slope or change in the pressure does not affect on the amount of water it is being delivered by the device. These are manufactured with high quality flexible rubber diaphragm.

So, this is the rubber diaphragm. And then this rubber diaphragm, it contracts or expands depending on the pressure available. Higher the pressure, it will expand so that the orifice size reduces. When the pressure is less it will contract and then the orifice size means water which is coming out of the orifice it will be adjusted accordingly as per the design of a particular dripper it has been made. These drippers are mostly suitable for sloping land or when we are installing the system on uneven topographical terrain.

Non-pressure compensating type of drippers, here you see these are the different types of the family of the dripper's means maybe it is a button type of dripper. Here it is coming out of this form, it is in this form what you are seeing so. This is one kind of a dripper where this we will discuss in detail, this 3 component type of dripper.

So, here in non-pressure compensating type of dripper the discharge vary with operating pressure. So, they could be of simple thread type. There can be you know the flow arrangement by labyrinth type, zigzag path, vortex type flow path or they can have the float type of arrangement to dissipate energy. Normally, they are cheaper and available at an affordable price.

Point source type of emitters under this category, your the non-pressure compensating type of drippers. These could be point source type of drippers. So, they are typically installed on the outside of the distribution line. Outside of the distribution line means they are on the lateral. They are fitted. They are installed at the time of installing the lateral. Point source dripper dissipates water pressure through a long narrow path and vortex chamber or a small orifice before discharging into the air.

So, this is what you see that before the water comes out of this is the barb of the dripper. And then inside there is a system where there is a narrow path will be there and then vortex chamber and finally water comes out of this. So, the emitters take predetermined water pressure means what is the pressure available. So, at that particular pressure, we need to maintain that pressure at inlet. And reduce it to the means the pressure which is coming means at the time of exit it comes to the zero pressure. When the water exit from the outlet of the dripper the pressure available it at exit point it is 0. So, some drippers can be taken manually cleaned means taken apart and manually cleaned. The typical flow rate range from 2 liter to 8 liter per hour.

Now, a typical point source drip emitter, it consists of 3 components. You can see here, this is a 3 component dripper. So, one component in the previous if I tell you the previous slide, you see this is the barb of the dripper this particular component the barb of the dripper. So, this barb is located at this point. And then it comes to the inlet. And then inside this particular housing you find that there is an another device. And this device is the labyrinth button. And then these arrangement these are basically causing the labyrinth flow. So, dentate are made in this device which is causing the energy dissipation.

So, water flows through the labyrinth flow path and then it comes out of this. So, there is a function of emitter is to dissipate pressure and to deliver water in the form of drops or continuous flow rate at a non-erosive velocity here. The velocity of flow, it is non-erosive velocity. It should not form runoff number one and then the water which is coming out of this one this should not make any erosion.

Now, some of the drippers which we have made at IIT campus, a typical dripper, it has a 3 components dripper. So, a typical dripper commercially available dripper it is 3 component dripper. So, this is a barb of the dripper. And so, when we are twisting out then this component when we are removing it so this is the outer component. This is the lower component where the water enters.

And just now, which I was telling you there is a device. This is a button where the labyrinth and dentate components are seen here. So, water enters from the barb. It comes out of this and then it goes through this place. The water will be coming. And then in the dentate the water when it will pass again there is a hole if you see here there is one particular hole. This hole it is seen then it comes out water comes out at this end.

And then when it passes from this, then from this third component which is there which is on the top the water will come out in the form of droplets. So, we made some certain development and then here instead of having 3 components, we made 2 components dripper. So, a 2 components dripper means the component again this is a barb. This is another component where we are removing it.

And then that dentate path which I was showing you the tablet that tablet it made here itself and then the arrangement of the water to flow from this is from this end and then water comes out of the drip emitter at this point. Here there is one orifice is made out of this. So, water comes out at this point. Now here, there is one provision that as and when we want to twist, so there are some grooves we have made.

So, these grooves, actually this is for delivering the discharge at a predetermined rate. So, this is a flow regulated dripper. There what you have seen that it could be of 2 liter per hour, 2 liter per hour, 4 per liter per hour. Here we can have a regulated flow means whatever the flow we want to give to a plant then accordingly we will twist and put it at a particular location. So, this is a flow regulated dripper.

Then, another 2 component dripper which we have made, this 2 component dripper here you can see here this also we have made. Here, one can regulate. So, it is like means we are twisting it and then making it that it is a perfectly closed dripper. It means water will not come out and as when we are doing screwing it like a tap we are doing. Then water will be delivered.

And then we can keep it in a particular position and we can vary the discharge. So, this is another flow regulated dripper. So, as and when the water it is coming out so you, what you are seeing here, this is the first one was this one this is a, which I just now I have shown that is a 2 component flow regulated dripper. This is it again you know, this development which we have made this a 2 component dripper.

So, whatever amount of water we want to give, we can regulate. So, if the water requirement as if the plant grows so water requirement of the plant increases and we can regulate the flow. So, this is also another device which we have made, this is also a flow regulated 2 component dripper. So, here it is the same, we can see here this is also flow regulated 2 component dripper.

So, one component is this part. This is the outer component and then we can keep the dripper position at different position and accordingly the flow can be regulated. So, these are the development which we have made. We will discuss about what are the other features of 2 components. And then another development which we have done, this is a single component drip emitter.

So, initially commercially available drip emitter, you have seen that there were 3 components. Then we tried to reduce the material, the purpose is that such drippers are needed in a large area in a large quantity may be in the order of lakhs. So, cost increases. And the cost goes from 2 rupees per piece to 4 rupees per piece. So, the cost of drippers is significant. So, how to reduce the cost?

So, we are expecting that the cost will be less and then we can meet the requirement. Same single dripper it can be used. So, this is a single component dripper. This is the barb the water it comes and then in this particular stem, there is an outlet. So, water comes out of this one. That is strikes at one of the arm of this and then the water when it is strike then it converts to the droplet.

You can see here. This is a single component drip emitter. I am telling here that so. When it is fitted when this dripper is fitted on a lateral pipeline, it looks like this. And then water it appears in the form of a droplet. So, this is the arrangement. And then other improvements which we have brought to reduce the total material. Then the single component flow regulated dripper here as you we will fold this.

And then the discharge can be regulated. So, a single component dripper can also regulate. We can one can regulate the discharge.

So, these developed drippers, a single component or double component, 2 component dripper discharge can be regulated. There are some certain other novelties it requires. Less manufacturing cost means one component dripper it requires single operation whereas 3 component dripper requires 3 operations to manufacture means there will be 3 molds to manufacture one particular dripper.

Then, with less material cost compared to 3 component drippers the capital cost is less so, farmers can afford it. And since the orifice size, the water does not have to pass through the dentate path. So, clogging is expected to be less and it requires less maintenance. These drippers require less energy consumption. We have seen that up to the height of 1 feet.

The drippers are delivering discharge to the tune of about 1 liter per hour. So, as the pressure increases, of course, it is a non-pressure compensating type of dripper but for a particular operating pressure head, and low-pressure head it is possible to operate the dripper. Easy regulation of the discharge rate, one can regulate the flow rate. It is a simple design. An individual emitter can be closed. This is another feature that individual dripper we can fully close and then operate it.

Line source drip emitter, as you are seeing in these figures. So, line source drippers are used in close-spaced row crops. And these are available in thin walled drip line. This is what you see this is a thin walled drip line. We call it as a tape and then thick walled drip hose. So, this will look like as a typical lateral pipeline, but as the name say that is an inline source emitter is inserted inside the pipeline.

So, thin wall drip pipeline has an internal emitter molded or glued together at set distances within the thin plastic lateral pipeline or distribution line. The drip line is available in a wide range of diameters, wall thickness, and emitter spacing as well as the spacing of the emitters and flow rate. So, a typical inline type of dripper this is a transparent pipeline. It is not always transparent pipeline lateral pipeline just to show you a dripper is kept over here. And then what you are seeing, the water it enters, when it is, the water will be flowing inside the pipeline. So, there is an inside there is a hole and water is passing through these zigzag path.

And then finally, it will coming out of the hole which has been provided at this point. So, water will be emerging.

And this water from the hole, it will be coming in drop by drop. So, it behaves like a point source dripper, but these are more effective. And they are normally kept permanently for those crops which are to be means grown at a regular interval of 1 year so or 1 year or 2 year crop, such pipelines are inserted below the ground level. But, the drip type pipeline, which are thinner pipeline, such pipelines are used for seasonal vegetable crops.

Bubblers typically apply water per plant and they are very similar to point source external emitter in shape but differ in its performance. So, water from bubbler head either runs down from emission device or spreads in few inches to in an umbrella pattern means like a fountain shape the water distribution from bubbler it comes out. So, they are practically used. Of course, the discharge from these bubblers are large, this is large.

So, when water supply is not constant means when there is a water supply is not the constant but there is a water quality problem, lot of silt and sandy flowing with the water then bubblers are preferred and particularly for tea crops under tree irrigation the bubblers are preferred.

Micro sprinklers are emission devices. They apply water in the form of a jet or they supply water in the form of sprinkle the water or they could be in the form of a mist. So, depending on the shape as well as the size of the nozzle, the performance of the sprinkler it works. So, the emitters operate by throwing water in the air usually in predetermined patterns.

So, here what we are there is a serration means water it comes and then it gets distributed or what happened the water it comes from one end and then when it is strike this your spinner then it is start ejecting water. So, it could be micro spray, jet, or spinners. So, the one end of the micro tube is connected with the lateral pipeline, and then the water is supplied to the micro sprinkler head.

So, this micro sprinklers are desirable, because fewer sprinkler heads are necessary to cover large area, because the diameter of coverage is large and they deliver a relatively very large discharge. So, for close growing crops, micro sprinklers are preferred.

Selection of these devices what I discussed told you about that bubbler, micro sprinkler, drippers it will depend upon the particular type of crops, soil condition as well as the filtration requirement. So, need for a cover crop and or frost protection, suppose we want to have. This is a common problem in those areas whereas frost occurs then in that case micro sprinklers are preferred.

And then the line source emitters they are used for the row crops. Mainly for the closed growing crop, the bubblers or micro sprinklers are used for closed growing crops like spinach, fenugreek, the coriander for irrigating such crops they are preferred. And when the filtration requirement is high, then bubblers and micro sprinklers are preferred.

So, when we are considering particular type of emission device, they are considered based means based on the characteristics how they are working. So, this could be manufacturing characteristics, hydraulic characteristics, or operational characteristics. So, manufacturing characteristics means at the time of manufacturing of drip emitter the there could be some malfunctioning because of some rise in the temperature or some certain defect it occurs.

So, one has this needed to be evaluated. So, evolution means from the lot when the manufacturing is being done, the 20 25 number of samples are taken randomly, and then its coefficient of variation is evaluated. So, the coefficient of variation is evaluated by taking the standard deviation of the flow rates and divided by the average flow rate. This will give the coefficient of variation.

When comparing the emitters with similar flow property highest uniformity will be obtained by selecting the emitter with the smallest CV value. That is the manufacturing coefficient of variation.

Hydraulic characteristics of the drip emitter, so, it is evaluated based on the energy of the flow-through frictional resistance. So, here means laminar flow emitter regulates water by dissipating the energy via friction against the wall of the water passage. So, here this could be a micro-tube or a spiral path emitter. Turbulent flow emitters regulate water dissipating the energy in friction against the walls of water passage also between the particles themselves during their turbulent movement.

So, here dentate, which I was telling you that the dentate that is energy dissipater is basically that is causing the turbulence to occur. So, these types of drippers which follow the orifice or the nozzle emitter, tortuous path. Such type of drippers are turbulent flow type of drippers.

So, when we are evaluating we try to evaluate what is the flow characteristic is take place. So, it is correct means hydraulic characteristics is one of the important parameter is the Reynolds number. So, Reynolds number, it is given by inertial force to the viscous force which can be given by

$$R_e = \frac{Vd}{v}$$

Where V is the velocity of flow, d, the diameter and nu is the kinematic viscosity.

And the Reynolds numbers are classified means the flow regime is classified based on the Reynolds number. It could be laminar, unstable, partially turbulent, or fully turbulent based on the numbers which are given here.

Operational characteristics, the emitter must be resistant to the extreme condition in the environment and must maintain physical characteristics over their lifetime in order to have consistent flow rates. So, one has to evaluate the emitters which means the best fit the need of area to be wetted. According to the systems required and then the spacing, planning consideration, choose the specific type of emitter needed.

We need to establish the pressure discharge relationship. One need to evaluate emission uniformity. So, when we will evaluate particular dripper, we will be going in detail about these parameters.

Pressure discharge relationship of an emitter is given by

$$Q = C_d H^x$$

Where Q is the flow rate, Cd is the coefficient of discharge and H is the operating pressure. x is the exponent. And depending upon the value of x, the particular type of emission device is classified. So, for variable flow path emitter, the range of x is given from 0.0 to 0.3. Such emission devices are considered under pressure compensating dripper means when x is equal to 0, we can say Q equal to Cd.

So, means, irrespective of any change in the pressure, Q will remain constant. So, vortex flow, when x equal to 0.4. Similarly, for the orifice or tortuous type of the path when it takes place in this dripper the flow is turbulent and x is 0.5. Similarly, when the value of x increases, these type of category of emitters they start coming under the category of the laminar flow particularly for capillary or micro-tube we are getting the value of x equal to 0.9 or 1.

Now, in order to obtain the value of x, so, we have to conduct the test. Try to find out for you know set of the discharges. And then, what is the operating pressure? What is the discharge we are getting? And one can find out the value of x means, when we have got the set of operating pressures and set of the discharges then one can find out so, plotting those data in log-log paper and then one can get the value of x. And categorize a particular type of dripper. And also one can find out the coefficient of discharge of such type of dripper.

Emitters capacity can be obtained, is a simple system that how much is the area multiplied by the depth of irrigation. And then, what is the irrigation time and application efficiency? But so, one can find out what is the emitter capacity? So, means, this way one can find out area wetted by a particular emitter is given by the spacing between the emitter. And then, what is the spacing between the rows?

$$Q = \frac{A \times d}{H \times E_a}$$

Where

Q = emission device capacity (L $h^{-1}$)

d = depth of water application (mm)

A = area irrigated by the emission device ($m^2$)

H = irrigation time (h)

$E_a$ = application efficiency (%)

And then it's the wetting percentage and number of emitters per plant. When we are using these parameters, one can find out how much area one particular dripper it can irrigate.

$$A = \frac{L \times S \times W_p}{100 \times N_e}$$

Where,

A = area irrigated by emitter ($m^2$)

L = spacing between adjacent plant rows (m)

S = spacing between emission points (m)

$W_p$ = per cent of cropped area being irrigated;

$N_e$ = No. of emission devices at each emission point

So, this is a simple expression. These expressions can be used for finding out area of irrigation or capacity of the emitter system.

Now, for a single lateral equally spaced emitter, this is again you know one can find out how many number of emitters it is needed that can be gained by wetting percentage multiplied by this spacing between the emission point but and then length or spacing between the rows.

$$N_e = \frac{100\ W_p\ S\ L}{D_w\ S_e}$$

And then what is the maximum diameter a particular dripper it spreads that is wetted area wetted you know diameter. And Se is the spacing between the emission devices. Accordingly, for double lateral or multiple point one can find out the number of emission points.

$$N_e = \frac{2 \times 100\ W_p\ S\ L}{S_e\ (S_e + D_w)}$$

Where,

$D_w$ = maximum diameter of wetted circle formed by a single point source emission device (cm)

$S_e$ = spacing between the emission devices of an emission point (cm)

$W_P$ = percent of wetted area

L = spacing between adjacent plant rows (m)

S = spacing between emission points (m)

So, you can refer these books which are given. These are the standard, can be used as a textbook for this particular topic to study.

So, let us summarize this particular lecture. We discussed about what are the different types of emitters. We discussed about how to select a particular type of emitter depending on the quality of water, depending upon the type of crop, depending upon the type of soil. Accordingly, one need to select a particular type of emission device. And then, how to evaluate the particular type of emitter under which category it falls after, you know evaluating the hydraulics of emitters.

And then, in the coming lecture, we will discuss about the hydraulics of drip irrigation system pipes. Thank you very much.