STUDY ON THE PERFORMANCE OF DRIP EMTTERS

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled "STUDY ON THE PERFORMANCE OF DRIP EMITTERS" is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this project report, entitled **"STUDY ON THE PERFORMANCE OF DRIP EMITTERS"** is a record of project work done jointly by **P. Josni, Roshni Sebastian, Susmitha R. Nair** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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SYMBOLS AND ABBREVIATIONS USED

Agric.	-	Agricultural
ASAE	-	American Society of Agricultural Engineers
ASCE	-	American Society of Civil Engineers
BIS	-	Bureau of Indian Standards
cm	-	centimetre(s)
cm/sec	-	centimetre per second
Congr.	-	Congress
CWRDM	-	Central Water Research Development and Management
Drain.	-	Drainage
Eds.	-	Editors
Engng.	-	Engineering
et al.	-	and others
Fig.	-	Figure
HDPE	-	high density poly ethelene
hp	-	horse power
hr	-	hour
Intern.	-	International
Irrig.	-	Irrigation
J.	-	Journal
kg/cm^2	-	kilogram per square centimetre
l	-	litre(s)
l/hr	-	litre per hour

LDPE	-	low density polyethelene
m	-	metre
mm	-	millimetre
ml/hr	-	millilitre per hour
No.	-	number
Opern.	-	Operation
ppm	-	parts per million
Proc.	-	Proceedings
psi	-	pounds per square inch
PVC	-	Poly Vinyl Chloride
res.	-	research
rpm	-	revolutions per minute
soc.	-	society
Tr.	-	Transactions
°C	-	degree centigrade
%	-	per cent
Univ.	-	University

INTRODUCTION

Agriculture is the science or art of cultivating the soil, growing and harvesting crops, and raising livestock. The word agriculture comes from the Latin words 'ager' meaning field and 'cultera' meaning cultivation. Agriculture has no simple, single origin. The art of making land more productive is practised throughout the world.

Over the years Agricultural Engineering has become an increasingly important part of the technical foundation for supporting agricultural productivity well above the subsistence level.

Irrigation is the artificial application of water to soil for the purpose of crop production. It is a human activity and a social undertaking. Attention to the human aspects of irrigation is a vital part of proper development and a prerequisite to success. Water is a scarce resource and it is a critical input in agricultural production. If agricultural production is to be intensified, more attention should be paid to the development of irrigation resources and to the utilization of the potential.

Irrigation can be called as the backbone of agriculture for it is a necessary input for successful and profitable farming. Irrigation is an attempt by man to locally alter the hydrological cycle in order to make water available to farmer with respect to time, location and quality as per the crop requirement.

The increased farm production and productivity created by irrigation, enable us to feed the growing population. It also helps us to meet the mounting demands of raw materials.

Irrigation affects agriculture in three different ways and makes it profitable. The use of high yielding varieties (HYV) of seeds to get higher yields depends mainly on irrigation. The use of improved variety of seeds, chemical fertilizers and pesticides will not be of much use unless proper irrigation facilities are made available. Cultivable land can be increased by bringing more land under irrigation and also two or more crops can be grown in a year instead of one. With full irrigation facilities a farmer can go in for commercial crops which require greater investment.

Irrigation water may be applied to crops by flooding it on the field surface, by applying it beneath the soil surface, by spraying it under pressure or by applying it in drops. The common methods of irrigation are surface, sub-surface, sprinkler and drip irrigation.

Drip irrigation is one of the latest innovative methods of irrigation. It enables slow and precise application of water and nutrients to precise locations. This method is economical when compared to other irrigation methods. The use of drip irrigation has not been practical very recently because of the lack of suitable economic materials.

The modern day drip irrigation technology was developed in Israel by S. Blass in 1963. About four lakh hectares of cultivated land in India utilises this system of irrigation. In Kerala, with its highly undulating topography and vagaries of monsoon, drip irrigation is highly suitable. It can be effectively adopted for crops like rubber, cardamom, coconut and arecanut.

Drip irrigation of row crops is increasing in many parts of the country. This form of low volume irrigation offers a potential for increasing yields, while reducing water, chemicals and tillage costs. The potential, however, depends on site specific conditions, such as soil texture, soil variability and the existing irrigation systems management requirements.

In drip irrigation method, the plants are watered frequently and with a volume of water approaching the consumptive use of plants. This low volume application is accomplished by the use of devices called emitters or drippers. Selection of different types of emitters depends on factors such as the desired level of emission uniformity, manufacturing quality, sensitivity of emitter to discharge, discharge rate to pressure changes, clogging susceptibility.

The emission uniformity is a measure of how evenly the water is discharged through the field. It is a measure of the irrigation efficiency of a properly managed system. This means that the least watered parts of the field receive an amount equal to the needed application rate. Uniformity of irrigation water emission can vary with manufacturing variation, emitter spacing, flow, pressure variations and length of lateral.

The manufacturing process can affect the variability of emitter discharge rates. The quality of the manufacturing process is described by the coefficient of manufacturing variation.

The emitter discharge rate depends on the pressure. Thus, changes in pressure throughout the irrigation system will vary the discharge rate throughout the field. Pressure changes are caused by elevation differences and friction losses in pipe lines.

The susceptibility of an emitter to clogging depends to a large degree on the dimensions of the flow passages.

This project attempts to study the performance of different emitters used in drip irrigation system. The objectives of this work are to study:

1. the effect of pressure on discharge rates.
2. the variations in flow consistencies with pressure.
3. the variations in emission uniformity.
4. the variation in manufacturing quality.
5. the extent of clogging for different emitters.

REVIEW OF LITERATURE

Water is not always adequate to meet the requirements of man. The basic source of water is precipitation in the form of rainfall. In many areas of the world the amount of rainfall is not sufficient to meet the moisture requirement of crops. To obtain highest productivity with minimum water and least disturbance to the ecosystem, scientific irrigation practice such as drip irrigation are to be practised.

2.1 Drip irrigation

Drip irrigation is a method of watering plants frequently and with a volume of water approaching the consumptive use of the plants. It therefore minimises losses such as deep percolation, run-off and soil water evaporation. There is no movement of water over the surface of soil. The lateral and vertical spread of water occurs inside the soil only to a limited extent. This form of application is attained with the help of a special equipment called the emitter. It is designed to produce low discharges at specific points. This has the advantage of wetting only a fraction of the soil surface generally between 10 and 50 per cent (Michael, 1978).

2.2 Advantages and disadvantages of drip irrigation

2.2.1 Advantages

The Central Plantation Crop Research Institute reported the following advantages.

1. Water saving
2. Enhanced plant growth and yield
3. Saving in labour and energy
4. Suitability in poor soils
5. Sparse weed growth
6. Improved cultural practices
7. Possibility of using saline water
8. Improved efficiency of fertilizers

2.2.2 Disadvantages

1. Persistent maintenance requirement. Filter cleaning, lateral and emitter flushing, acid flushing and other maintenance done when required.
2. Restricted plant root development. Plant roots develop within the wetting zone, since there is no deep movement, there is tendency of root to remain scattered near and just beneath the surface of soil.
3. Accumulation of salts in the interface between the irrigated and non irrigated zones in the soil.
4. Emitter clogging

2.3 Trickle irrigation methods

Trickle irrigation is the frequent application of small quantities of water directly on or below the soil surface. Usually water is applied as discrete drops, continuous drops, tiny streams or miniature spray through emitters placed along a water delivery line. Trickle irrigation includes a number of methods such as drip, bubbler and spray irrigation (BIS, 1984).

2.3.1 Drip irrigation

The application of water to the soil surface, as discrete or continuous drops, or tiny streams, through emitters. Often the terms drip and trickle irrigation are considered synonymous, however, trickle irrigation also includes those systems which have higher discharge rates than most drip systems. For drip irrigation, discharge rates for point-source emitters are generally less than 12 l/hr for single outlet emitters, and line source emitters, are generally less than 12 l/hr/m of lateral.

2.3.2 Bubbler irrigation

The application of water to the soil surface as a small stream or fountain, where the discharge rates for point-source bubbler emitters are greater than for drip emitters, but generally less than 225 l/hr.

2.3.3 Spray irrigation

The application of water by a small spray or mist to the soil surface, where travel through the air becomes instrumental in the distribution of water compared to drip and bubbler irrigation. Discharge rates for point source spray emitters are generally lower than 115 l/hr.

2.4 Hydraulics of drip system

The flow regime is characterized by the Reynold's number, Re which represents the ratio of inertia forces to viscous forces during flow. It is important wherever viscosity is important, when flow occurs in small, closed conduits, or around small objects (Michael, 1978).

The Reynold's number is given by,

$$Re = \frac{VD}{\nu}$$

Where,

Re = Reynold's number, dimensionless

V = flow velocity, cm/sec

D = any characteristic length such as flow section diameter, cm. and

ν = kinematic viscosity of water in cm^2/sec a function of temperature

Usually, $= 0.01\ cm^2/sec$

For a circular flow path (with Q in cm^3/sec)

$$Re = \frac{Q}{\pi D^2/4} \cdot \frac{D}{\nu} = \frac{4}{\nu} \cdot \frac{Q}{\pi D}$$

If D is in mm, 'Q' for pipes in m^3/hr and 'q' for emitters in l/hr,

$$Re = 3.537 \times 10^3 \frac{Q}{D\nu} \text{ for pipes}$$

and $$Re = 3.537 \times \frac{q}{D\nu} \text{ for emitters}$$

According to Reynold's number, four regions of flow regime are specified.

Laminar	$Re \leq 2000$
Unstable	$2000 < Re \leq 3500$ or 4000
Partially turbulent	$3500 < Re \leq 10000$
Fully turbulent	$10000 \leq Re$

These types of flow regime have an effect on the relationship of friction head loss to flow velocity and conduit size.

For plastic pipes, which generally show turbulent flow with smooth boundary conditions,

$$\frac{1}{\sqrt{f}} = 2 \log (Re\sqrt{f}) - 0.8$$

According to Blassius empirical formula,

$$f = \frac{0.3164}{Re^{1/4}} \approx (0.01/Re)^{1/4}$$

Relationship between pressure and discharge (Nir, 1982).

From Darcy-Weisbach formula,

for a given pipe, $h_f = f \times \frac{V^2}{D} \times \frac{L}{2g}$

Substituting $\frac{Q}{A} = \frac{Q}{\pi D^2/4}$ for V,

$$h_f = f \times \frac{L}{2g} \times (4/\pi)^2 \times Q^2/D^5$$

In drip emitters, the principle is that all available head is dissipated in the device or that,

$$h_f = \Delta H = H$$

$$Q \propto h_f^m$$

$$Q \propto H^m$$

2.5 Emitter clogging

Clogging of emitters is a major problem associated with drip irrigation system. The quality of irrigation water used has great influence on emitter performance (Ford *et al*., 1974). Bucks and Nakayama (1979) studied the effects of emitter clogging on drip irrigation uniformity and found that the uniformity was greatly reduced when 1-5 per cent of emitters were clogged.

Centrifugal filters, sand separators, gravel filters and screen filters are the generally used filters. They are the key factors for preventing emitter, clogging. Suspended loads in water used for trickle irrigation contributes to sedimentation in laterals and plugging of emitters (Shanon *et al*., 1982). David (1989) studied the effects of chemical clogging on drip tape uniformity using water containing high amount of calcium. Full or partial clogging occurred with reduction in irrigation uniformity. A reduction of pH from 7.6 to 6.8 by sulphuric acid injection provided least clogging.

2.6 Factors affecting clogging

Biological, physical and chemical factors contribute to 37, 22 and 31 per cent of the clogging of emitters and another 10 per cent is due to uncertain factors (Yermeiren and Jobling, 1984).

Table 1. Physical, chemical and biological factors involved in emitter clogging (Bucks et al., 1979).

Physical	Chemical	Biological
a. Inorganic materials	a. Calcium or Magnesium	a. algae
sand (50-250 μm)	carbonate	b. Bacteria
Silt (2-50 μm)	b. Calcium	Filament Slime
Clay (<2 μm) Plastic cutting	sulphate	
	c. Heavy metal	c. Microbial
b. Organic materials	hydroxides, oxides,	depositions
Aquatic plants	carbonates, silicates	Iron Sulphur
Phytoplankton	and sulphides	Manganese
algae, aquatic animals	d. Oil and other lubricants	
Zoo plankton, Snail	e. Fertilizers	
	(i) Phosphates	
Bacteria (0.4-2 μm)	(ii) Aqueous ammonia	
	(iii) Fe, Cu, Zn, Mn	

Biological activity in irrigation water and its byproducts may produce organic matters which appears as a slimy deposit in the laterals and drippers. If organic production remains undisturbed, even solid suspended particles join the slimes and significantly clog the system.

Chemical clogging occurs when ground water source is used for irrigation, as it frequently contains dissolved salts in significant quantities (Goldberg et al., 1976). Chemical clogging can be caused by salts precipitating at the end of the dripper passage. Presence of oil and grease particles from leakage of bearing seals of well and booster pumps also cause clogging.

Experiments conducted in the United States by Gilbert et al., (1981) showed that plastic particles from the system itself were a common cause of emitter clogging, being responsible for 26 per cent of all the blockages which occurred, followed by sand particles 17 per cent and microbial slimes 11 per cent. Abbott (1985) reported that problems occur in areas suffering from wind erosion where emitters become covered with fine silt.

2.7 Water quality evaluation and classification

There is no proven practical method that will encounter clogging problems and if so how much and what can be done about it. Based on the finding on emitter clogging and experience gained in controlling it, a classification scheme that included the major factor involved in emitter clogging was derived. This is related to irrigation water composition (Table 2). Lower the quantities of salts, solids and bacteria in the water, the lesser is the clogging hazard (Bucks et al., 1979).

Table 2. Water quality classification relative to its potential for drip emitter clogging (Bucks et al., 1979).

Clogging factors	Minor	Moderate	Severe
Physical (mg/l)	<50	50-100	>100
Chemical (mg/l)			
pH	<7.0	7.0-8.0	>8.0
Dissolved solids	<500	500-2000	>2000
Manganese	<0.1	0.1-1.5	>1.5
Total iron	<0.2	0.2-1.5	>1.5
Hydrogen sulphide	<0.2	0.2-2.0	>2.0
Biological (no./l)			
Bacterial number	<10000	10000-50000	>50000

2.8 Prevention of emitter clogging

Prevention is the best solution for reducing or eliminating emitter clogging. Preventive measures included water filtration, field inspection, pipe line flushing and chemical water treatment. Wilson (1972) suggested that the best approach to solve clogging problems is to select emitter devices which may require less or minimum maintenance. Emitter manufacturers have manufactured emitters with automatic or manual flushing capabilities or with easy dismantling features for cleaning.

Small particles can pass through filters and emitters, but when they interact with microbial by-products, their combination can clog emitters. Chemical treatment in conjunction with filtration has become an integral part of drip irrigation system, especially in large commercial operations. Chlorination is the most widely used chemical treatment to control microbial population. According to Ford and Tucker (1974) chlorination for bacterial control is not recommended when water has 0.4 mg/l or more dissolved iron because chemical reaction will form iron oxide which can precipitate and cause blockage of emitters. Chlorination does not cause any injury to roots unless it is applied at very high rate.

Systematic field inspection of a drip system is necessary to spot malfunctioning emitters, pipe line leaks and accessory equipment failures (Bucks <u>et al</u>., 1979). Good maintenance requires filtration and chemical injection units kept in perfect operating conditions. Screen, media and centrifugal filters must be cleaned periodically.

Filters are key units for the successful operation of drip system. In selecting the type, size and capacity of the filter unit, the primary factors to be considered are the initial water quality and emitter design. Buck et al. (1979) suggested that the final filtration screen size should be one tenth the diameter of the smallest emitter opening. When clogging conditions become severe, two or more types of filters in series may be effective. The capacity of the filter should be sufficiently large enough to permit the rate of flow of filtered water without frequent cleaning of the filter.

As a general rule filtration units should be designed with atleast 20 per cent to 30 per cent extra capacity, since water quantities may fluctuate during the irrigation period. Screen filters are the most widely used type of filters because of their simplicity and ease of operation. They are usually made of metal, plastic or synthetic cloth. The operating pressure must be within 10 to 15 per cent of the design pressure. Media filters consists of fine gravel and sand of selected sizes placed in a pressurized tank. Media filters retain particle sizes in the range of about 25 microns to 100 microns. Water flow through the filters should not exceed 800 $l/min/m^2$ of filtration surface area and the filtration media should be atleast 45 cm thick. Sand separators, hydrocyclones or centrifugal filters remove suspended particles that have specific gravity greater than water and that are larger than 75 microns. According to Nakayama (1986) removal of a portion of suspended particles using sedimentation ponds prior to water filtration can lessen the load on the filters.

According to Jackson and Kay (1987) an alternative approach to the clogging is to increase the size of water way in the emitters. However this may increase the emitter discharge which inturn would change the pattern of wetting in the soil and may adversely affect the water availability to the plants. Established wetting patterns in the soil can still be maintained at a higher discharge if the flow is pulsed. Emitter with large pores can also fail when water of poor quality is used in them.

Clogging resulting from iron precipitates is especially difficult to control. The presence of dissolved iron in natural water is usually caused by microbial activity. To complex soluble iron, Calder (1988) added sodium silicate to the irrigation water. However this treatment is limited to water less than 10 mg/l iron and low in calcium and magnesium, since the high pH of the silicate solution would cause carbonate precipitation. Oxidation of the soluble reduced form of iron to insoluble oxide form prior to filtration is another method for removing iron from solution.

When irrigation water have pH above 7.5 and high calcium or magnesium content, calcium or magnesium carbonate can precipitate out either in filter, tubing or emitter. Adding acid to water will lower the pH and reduce chemical precipitates. Sulphuric acid and hydrochloric acid are the commonly used acids to reduce precipitation. Titration of water with dilute acid is a method for determining its acid requirement.

According to Bucks and Nakayama (1991) where acid treatment can adversely affect the soil pH, an alternative to acid treatment is the use of compounds that will inactivate the heavy metal cations and prevent them from precipitating. Meyer _et al_. (1991) used the homopolymer maleic anhydride compound to complex calcium and magnesium cations so that the calcium and magnesium carbonates would not precipitate.

The pH control is also important for bacterial control. Some of the alternative chemicals used to control bacteria and algae are xylene, permanganate, ozone, quaternary ammonium salts, copper salts, acrolein, hydrogen peroxide, Bromine and iodine.

Ravina et al. (1992) reported that long term operation of most emitter type was achieved with filtration at 80 mesh combined with daily chlorination and bimonthly lateral flushing. Regular lateral discharge monitoring was found to be a convenient way to detect the initiation of the clogging process.

2.9 Evaluation

Evaluation of trickle irrigation system is an important factor in obtaining system performance. The best field evaluation method is to determine the application efficiency of irrigation systems and to find out where, why and to what extent inefficiencies exist in the system from the water source to various emission points.

Decroix and Malaval (1985) reported the total lack of test standards until the year of 1984. They performed four main tests on emitters which include manufacturing uniformity, susceptibility to pressure, susceptibility to temperature of water and susceptibility of clogging.

Giay and Zelenka (1988) conducted a study on economic variations in drip irrigation systems with different types of emitters. The performance of various emitter types are compared with respect to pressure discharge relations, water temperature sensitivity and uniformity of emission rate.

2.9.1 Emission uniformity

Emission uniformity (EU) is a measure of how evenly the water is discharged throughout the field. The emission uniformity is a measure of the potential irrigation efficiency of a properly managed system meaning that the least watered parts of the field receive an amount equal to the needed application. The higher the emission uniformity, the higher the potential irrigation efficiency. BIS suggested the following equation to estimate design emission uniformity in terms of manufacturer's coefficient of variation and pressure variations at the emitter.

$$EU = 100 \left(1.0 - \frac{1.27}{n} C_v\right) \frac{q_m}{q_a}$$

where,

EU = design emission uniformity in per cent;

n = for a point source emitter on a permanent crop, the number of emitters per plant; for a line source emitter on an annual row crop, either the spacing between plants divided by the same unit length of lateral line used to calculate Cv or 1, whichever is greater;

C_v = manufacturer's coefficient of variation for point or line source emitters;

q_m = minimum emitter discharge rate for the minimum pressure in the system in l/hr; and

q_a = average or design emitter discharge rate in l/hr

2.9.2 Manufacturing quality

The manufacturing process can affect the variability of emitter discharge rates. The quality of manufacturing process is described by the coefficient of manufacturing variation (Cv). The coefficient is determined by measuring discharge rate at the same pressure of a large number of emitters (Hanson, 1994). The coefficient of variation may be calculated as follows:

$$Cv = \frac{S}{q_a} \times 100$$

where,

S = sample standard deviation

q_a = average emission in l/hr

2.9.3 Susceptibility to temperature of water

This property can be defined as a measure of change of emission rate as a function of temperature of water. Moser (1979) reported that discharge of an emitter depends also on the temperature and viscosity of water. The discharge with laminar flow regime increase with increase in water temperature while the discharge of emitters with turbulent flow regime was almost constant at different water temperature.

2.9.4 Sensitivity to pressure changes

The emitter discharge rate depends on the pressure. Thus, changes in pressure throughout the irrigation system will vary the discharge rates throughout the field, except in the case of pressure compensating emitters. Pressure changes can be caused by elevation differences and friction losses in pipe lines. The sensitivity of the emitter discharge rate to pressure changes is described by the emitter discharge exponent. This exponent is calculated from emitter discharge rates measured at several pressures. The exponent ranges in value between zero and one. The higher the exponent, the more sensitive the discharge rate is to pressure changes (Hanson, 1994).

BIS has recommended certain guidelines for the test. The emitters tested in manufacturing uniformity test are numbered in ascending order as No.1 emitter of lowest emission rate. No. 25 emitter of highest emission rate. Four emitters were selected and their emitter rates measured as a function of inlet pressure. Each emitter should be tested in steps not greater than 50 kPa. For each pressure value the average emission rate should be calculated, at rising pressure in the case of an unregulated emitter while at both rising and falling pressure for regulated emitter. Hydraulic characteristics including the relationship between operating pressure and flow rate, and manufacturing variation among emitters were measured for commercial drip emitters by Smajstrala and Clark (1992).

2.9.5 Clogging susceptibility

The susceptibility of an emitter to clogging depends to a large degree on the dimensions of the flow passages. Generally, large flow passages result in less clogging (Hanson, 1994). Also, the clogging susceptibility of an emitter is directly related to the degree of filtration and amount of sediment load present in irrigation water.

2.10 Economy

Davis (1975) reported that under drip irrigation energy conservation can also be obtained because of reduction in the amount of water pumped.

Drip irrigation is advantageous over surface methods and overhead methods of irrigation due to its low operational cost and incremental yield. Drip irrigation systems have the potential to obtain high efficiency of 85 to 95 per cent and may become even more economical in the future. The operation and maintenance cost vary greatly depending on local circumstances and irrigation efficiencies achieved (Michael, 1978).

Miller (1990) studied on the establishment of low head drip irrigation system for small holdings. The low head system can provide all the advantages of a standard system while being substantially less costly. Shajari et al. (1990) conducted research on water saving on sandy soil in drip irrigation. The experiment concludes that in dry agricultural areas, plastic mulch could be a good tool in keeping moisture in drip irrigated plant rows to an optimal level before seeding is received. The problems due to reduced rate of application can be compensated by high frequency irrigation.

2.11 Development and performances

The first work in subsurface drip irrigation in which the water was applied to the root zone without raising the water table was conducted in the United States at Colarado State University in the year 1913 by E.B. House. In 1920, the drainage tubes of subirrigation were replaced experimentally by porous pipes. In late 1940's drip irrigation systems included plastic pipes which were used to water green house plants in U.K.

According to Sivanappan (1977), weed growth in other irrigation methods is three times, more, than that in drip irrigation method. Therefore, herbicides can be avoided and hence a better economy in drip system. George (1977) developed a drip irrigation technique by introducing the distributor. The distributor was made from a polyethylene pipe used for laterals, plugged at both ends with plastic caps.

Bralts et al. (1980) conducted analysis for comparison of manufacturer's coefficient of variation and drip irrigation uniformity. Wu and Giltin (1980) studied the preliminary concept of a drip irrigation network design. Bralts et al. (1981) conducted experiments to analyse the drip irrigation uniformity considering emitter plugging. The coefficient of variation was used to measure the effects of emitter plugging on the uniformity of emitter flow along single and dual chamber lateral lines.

Bralts et al. (1981) performed a study for the field evaluation of drip irrigation submain units. The coefficient of variation was used to develop field evaluation procedures for drip irrigation submain units. Decroix and Malavel (1985) reported a more detailed clogging susceptibility test. They used fine samples and test was made up of four separate and successive stages, each 40 hours long. The discharge of each sample was measured at the end of clogging period and compared with initial discharge in order to evaluate degree of clogging.

Riss and Chestners (1989) introduced a simplified design procedure to determine the wetted radius of a trickle emitter. Soil texture, emitter flow rate and soil water depletion potential were the only inputs required.

Jayakumar et al. (1988) suggested that HDPE main pipes of diameter 40 and 20 mm with wall thickness of 2.5-3 mm and pressure withstanding capacity of 4 kg/cm^2 can be used for big gardens. They reported on the use of gravel filters to remove light suspended materials such as algae, organic materials, fine sand and soil particles. The mesh, size selected for drip irrigation is 100 to 200 mesh. Giay and Zelenka (1988) conducted a study on economic variations in drip irrigation systems with different types of emitters. The performance of various emitter types are compared with respect to pressure-discharge relations, water temperature sensitivity, uniformity of emission etc.

Numan *et al*. (1989) conducted emitter discharge evaluation of subsurface trickle irrigation systems. This presents a procedure to evaluate trickle irrigation systems which allows determination of the reduction in emitter flow rates due to plugging and the model can also be used to simulate the effects of hydraulics and manufacturer's variation on the uniformity.

Iron contents of the water over the acceptable limit may cause problems even on a much lower level if iron bacteria are present. Presence of oil and grease particles from leakage of bearing seals of well and booster pumps that are connected directly into the drip system can also cause clogging (Nakayama and Bucks, 1991).

Adin and Sacks (1991), investigated dripper clogging factors in waste water irrigation. The study is aimed at defining the clogging factors and mechanism of blockage within three types of drippers as a basis for developing technical measures to overcome the problem. The relevant constituents are defined and physical and chemical properties of the deposits in hundreds of emitters were examined using both field and laboratory experiments. The sediment built up begins with the deposition of amorphous slimes to which other particles adhere. The clogging rate is more affected by particle size than by particle member density. The chemical composition of the deposits in the dripper changes with the season. Clogging potential may be decreased by modifying the emitter structure and by chemical pretreatment.

Experiments were carried out to evaluate the performance of various types of drip irrigation emitters, widely used in Israel, using waste water from a storage reservoir by Ravina et al. (1992). A small scale trickle irrigation unit was constructed and tested in the lab by Ahmed et al. (1992) for emitter flow rate to determine whether there were significant differences in mean emitter discharge rates among emitters and laterals or due to position of emitters on the laterals. Results indicated that slight differences in flow rates were closely related to emitter hole size and/or partial restriction of emitters on laterals. Filtering devices coupled with slightly larger emitter holes may reduce clogging of emitter holes.

In 1993 a study was conducted by Biju et al. at KCAET, Tavanur on the clogging susceptibility of various drip emitters. Emitters of five different types were used. It was seen that the high pressure compensating emitters performed superior to all others emitters studied.

Types of materials available for drip irrigation was studied by Hanson (1994) which includes double chamber tape

MATERIALS AND METHODS

Materials used for the study and methodology adopted are discussed in this chapter.

3.1 Location

The experiment was conducted in the Soil and Water Engineering Laboratory of KCAET, Tavanur.

3.2 Experimental set up

The performance of various emitter types are compared with respect to pressure - discharge relations, uniformity of emission rate. The experiment was first conducted using clean water at varying pressures of 0.5, 1 and 1.5 kg/cm^2. Four types of commercially available drippers were used for the study.

Emitter clogging is a function of quality of irrigation water and degree of filteration. A poor quality of irrigation water was imitated by mixing colloidal clay of particle size less than 75 micron with normal tap water. The study was conducted at 1000 ppm sediment concentration and at a pressure of 0.5 kg/cm^2. A time period of 25 hours was adopted for each set of experiment.

3.3 Materials and equipments

The main equipment used for this study is the drip emitter testing rig (DETR). The DETR consists of a network of 12.5 mm diameter LDPE pipes. Water is supplied through 25 mm diameter main PCV pipes to the centre of the network. For maintaining an equal pressure in the network, 25 mm diameter HDPE pipes were joined from the central line to the further sides of the networks.

The layout of the experimental set up is shown in figure 1. The overall picture of the experimental arrangement is shown in plate 1.

3.3.1 Operating tank

A 200 litre oil barrel was used as the water storage tank. An inlet was provided at 5 cm above the bottom of the tank to receive flow from bypass line of the DETR. The interior of the barrel was painted with two coatings of asphalt to give protection against rusting.

3.3.2 Pumping unit

A centrifugal pump of specification

Discharge	-	2.3 litres/second
Head	-	21.5 m

1. Operating tank
2. Suction pipe
3. Pump
4. Delivery cut-off valve
5. Filter
6. Pressure gauge
7. Ball valve
8. Bypass cut-off valve
9. Bypass line

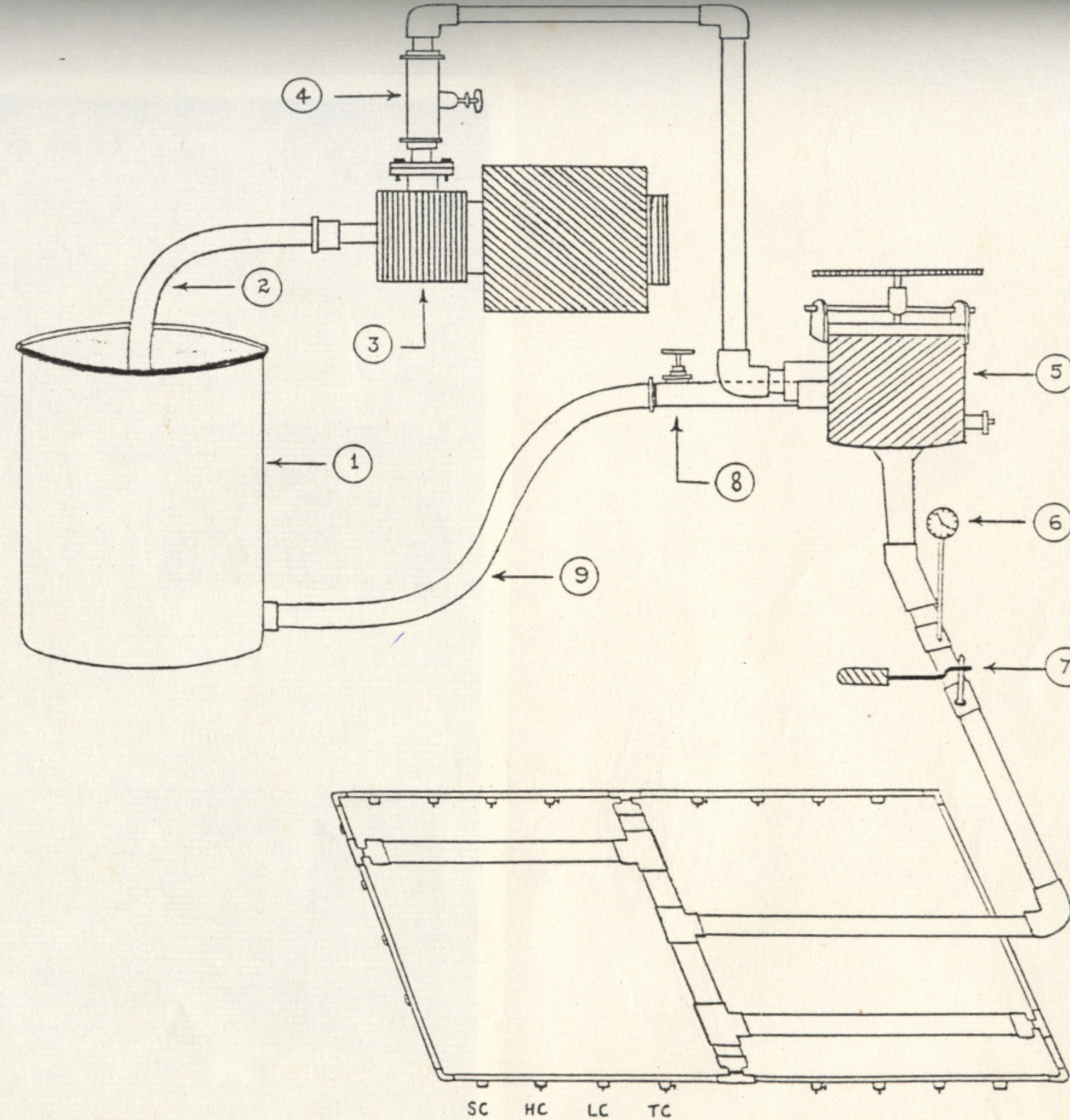


FIG. 1 SCHEMATIC LAYOUT OF THE EXPERIMENTAL SET UP

Plate 1 Overall picture of the experimental set up

Plate 2 View of the control head

Horse power - 1 hp

r.p.m - 2800

was used for this study.

3.3.3 Control unit

A 40 mm diameter gate valve was provided at the delivery line to control the discharge. Another gate valve of 25 mm diameter was used to control the bypass flow. The operating pressures of 0.5 kg/cm^2, 1 kg/cm^2 and 1.5 kg/cm^2 were obtained by adjusting the bypass control valve. A pressure gauge was installed at the outlet port of the filter. The operating pressure in the laterals was read from this pressure gauge. A ball valve of 32 mm diameter was used to cut off the flow into the main line.

3.3.4 Filter unit

A screen filter of capacity 10,000 l/hr and of screen size 100 microns was used. The filter element was made of steel wire mesh.

3.3.5 Emitters

Emitters of different types commonly available in the market were selected for the study. All the emitters used were of discharge 4 l/hr. The four different types of emitters used are:

SC - Long path type emitter

HC - High pressure compensating emitter

LC - Low pressure compensating emitter

TC - Tap type emitter whose discharge can be adjusted as required

The emitters were placed at a distance of 30 cm on the network. The same sequence of SC, HC, LC and TC was maintained on all the five laterals.

3.3.6 Discharge collection

The individual discharges were collected in buckets.

3.4 Clay preparation

The clay from the paddy field was collected. It was cleaned of organic matter and stone particles and oven dried at 105°C for 24 hours. The dried clay was crushed and powdered. Using sieve shaker, clay particles of size less than 75 microns, passing through IS 75 sieve were collected.

3.5 Preparation of clay suspension

A treatment of 1000 ppm colloidal clay water was given to the emitters. The amount of clay required for colloidal water is calculated as

1 ppm = 1 milligram per litre

for 1000 ppm = 1000 milligram per litre

So, 200 grams of clay particles are required to prepare 200 litre of 1000 ppm clay suspension. The barrel was filled to full capacity of 200 litres. About a litre of water was taken out of it, in a jar and weighed quantity of clay particles were added gradually and stirred continuously. After mixing thoroughly the suspension was transferred to the water in the barrel carefully. For thorough mixing, the pumping unit was switched on, with ball valve closed. By keeping the discharge and bypass valves open, stirring was given to the water in the barrel.

3.6 Testing procedure

The testing was conducted in the Soil and Water Engineering Laboratory. The daily mean temperature during the period of study was 30°C.

The experiment was started using clean tap water. A 200 litre capacity barrel was filled with tap water and it was pumped to the main line. The ball-valve was opened and pressure of 0.5 kg/cm^2 was obtained by regulating the bypass valve. The discharge measurement for individual emitters was done during the last five minutes of the 5 hours interval. The collected discharge was measured using a measuring jar.

The same procedure was repeated at pressures of 1 and 1.5 kg/cm^2. Each set of experiment continued for 25 working hours with daily working time of 10 hours.

To determine the variation in discharge due to clogging, clay suspension was added to the water in the barrel. The same set of emitters were used. The weighed quantity of clay particles of size less than 75 microns was mixed such that the concentration was 1000 ppm. The procedure of preparation of clay suspension was same as said previously. Before opening the supply to the main line, the suspension was stirred thoroughly for 10 minutes by circulating the water through bypass line only. The pressure was adjusted to 0.5 kg/cm^2. Discharge measurement is the same as before.

The variation in discharge rates, flow consistencies, emission uniformity and manufacturing quality with pressure were analysed. The extent of clogging for different emitters was also determined.

3.6.1 Determination of relative discharge

The relative discharge is a measure of decrease or increase in mean discharge of a type of emitter during the operation.

$$RD = \frac{q'}{q} \times 100$$

where RD = Relative discharge in per cent

q' = Average discharge of emitters at given time

q = Average initial discharge

The relative discharge for different types of emitters were calculated using the above formula.

3.6.2 Determination of emission uniformity

Emission uniformity for drip irrigation means that all emitters controlled by the same control head should have same discharge or as close as possible. In field, water distribution efficiency of the system is closely related to emission uniformity.

The emission uniformity was based on the mean of the lowest 1/4th of the flow rates among the emitters. Emission uniformity was calculated using the equation

$$EU = 100\left(1.0 - \frac{1.27}{n} Cv\right) \frac{q_m}{q_a}$$

where,

EU = design emission uniformity in per cent

n = for a point-source emitter on a permanent crop, the number of emitters per plant, for a line-source emitter on an annual row crop, either the spacing between plants divided by the same unit length of lateral line used to calculated Cv or l, whichever is greater,

Cv = manufacturer's coefficient of variation for point or line source emitters,

q_m = minimum emitter discharge rate for the minimum pressure in the system in l/hr, and

q_a = average or design emitter discharge rate in l/hr

Karmeli and Keller (1974) recommended the use of the lowest 1/4th of the flow rates principle for evaluating field system emission uniformity, by considering the flow rates of first, one third point, two third point and last emitter on the corresponding lateral in the block, but in this case as the length of the lateral is very small as compared to that in actual field conditions, the lowest 1/4th of the flow rates is taken as flow rate among the emitters, on the lateral.

In this study, average discharge of lowest one-fourth of the emitters was taken as the discharge of one emitter with least discharge since total number of emitters was five. The variation in emission uniformities were calculated for all types of emitters.

3.6.3 Determination of manufacturing quality

The quality of manufacturing process is described by the coefficient of manufacturing variation (Cv). The coefficient is determined by measuring discharge rates at the same pressure of a large number of emitters.

BIS recommended the use of 25 unused samples of the same emitter functioning at 23 ± 1°C to calculate discharge rates under nominal test pressure for non-regulating emitters. The smaller the coefficient of variation, the smaller the variability of emitter discharge rates due to manufacturing, and the better the manufacturing quality.

The coefficient of variation was calculated using the following equation.

$$Cv = \frac{S}{q_a} \times 100$$

where,

S = sample standard deviation

q_a = average emission in l/hr

3.6.4 Determination of clogging of emitters

The clogging of emitters can be determined in terms of the percentage reduction in discharge using the formula

$$DR = \frac{ID - FD}{ID} \times 100$$

where,

DR = Discharge reduction in per cent

ID = Initial discharge of the emitter

FD = Final discharge from the emitter

Percentage reduction in discharge for each individual emitter of each type and also for mean discharge of each type were calculated.

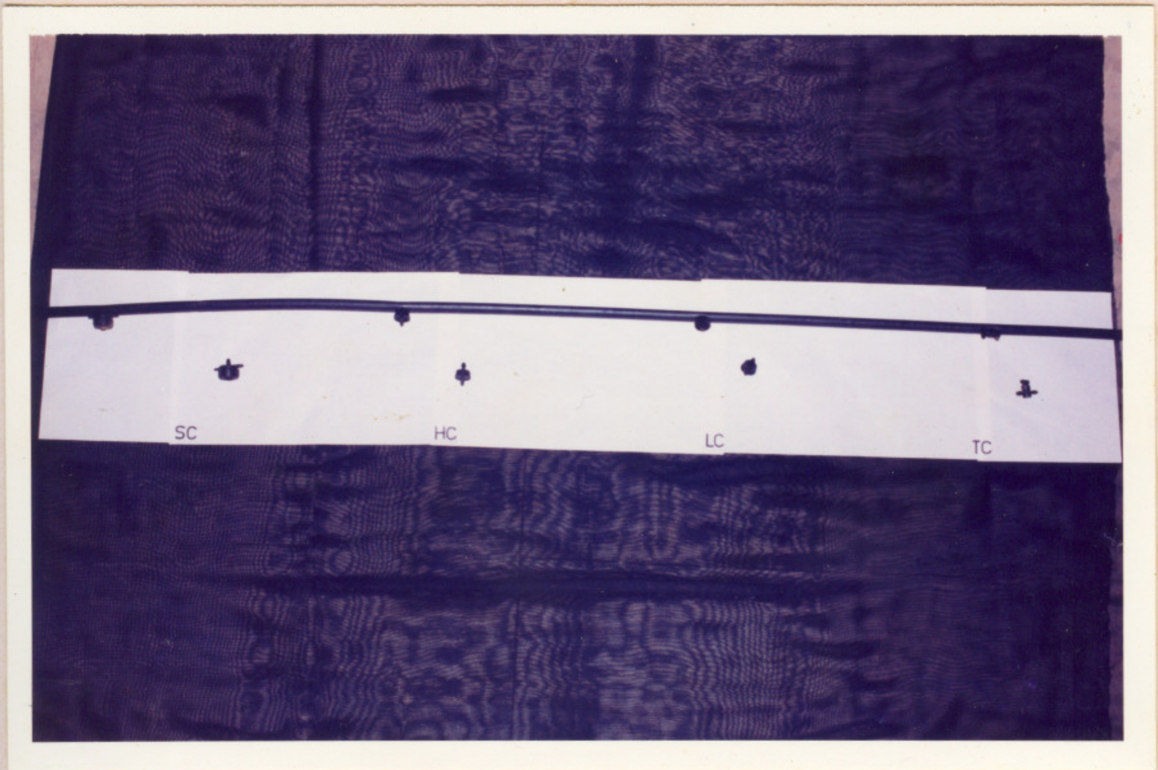


Plate 3 Close view of all types of emitters

(commonly known as bi-wall), turbulent flow tape, which has a single chamber, porous tubing and tubing within line emitters or emitters attached to the inside of the tubing. Drip tapes were available in wall thicknesses ranging between 4 and 25 mils. Recommended operating continuous operating pressure of about 15 psi for 15 mil tape and 8-12 psi for lesser thickness. Emitter discharge rates decreased along the length for all tapes.

RESULTS AND DISCUSSION

Experiments were conducted to study the variation in discharge rates, flow consistencies, emission uniformity and manufacturing quality with pressure in various types of emitters. The results obtained are discussed in this chapter.

4.1 Effect of pressure on discharge rate

The emitters SC, HC, LC and TC were tested at pressures of 0.5, 1.0 and 1.5 kg/cm^2. The testing was done for 25 working hours spread over 10 days. Observations were taken at 5 hours interval. Test results for each emitters are shown in Tables 3-8. In the case of SC emitters the discharge rate was 3480 ml/hr at 0.5 mg/cm^2. At 1 kg/cm^2 SC emitters gave a discharge of 5568 ml/hr and it increased further to 6504 ml/hr at 1.5 kg/cm^2. The same trend of increase in the discharge with increase in pressure was seen in the case of all the emitters. In the case of HC emitters the discharge at 1.5 kg/cm^2 was less by 192 ml/hr than that in 1 kg/cm^2. But an increasing trend in discharge with pressure is observed generally.

Table 3. Initial discharge from various emitters

Sl. No.	Operating pressure (kg/cm^2)	Discharge rate (ml/hr)			
		SC	HC	LC	TC
1.	0.5	3480	3864	3552	1560
2.	1.0	5568	4512	4512	4944
3.	1.5	6504	4320	5136	6000

Table 4. Discharge from emitters after 5 hours of operation

Sl. No.	Operating pressure (kg/cm^2)	Discharge rate (ml/hr)			
		SC	HC	LC	TC
1.	0.5	3144	3360	3048	1368
2.	1.0	5472	4200	4464	4944
3.	1.5	6480	4128	5136	5856

Table 5. Discharge from emitters after 10 hours of operation

Sl. No.	Operating pressure (kg/cm^2)	Discharge rate (ml/hr)			
		SC	HC	LC	TC
1.	0.5	3312	3504	3456	1560
2.	1.0	5376	4224	4368	476
3.	1.5	6384	4272	5040	5904

Table 6. Discharge from emitters after 15 hours of operation

Sl. No.	Operating pressure (kg/cm^2)	Discharge rate (ml/hr)			
		SC	HC	LC	TC
1.	0.5	3216	3456	3216	1464
2.	1.0	5424	4176	4416	4848
3.	1.5	6432	4224	5136	5952

Table 7. Discharge from emitters after 20 hours of operation

Sl. No.	Operating pressure (kg/cm^2)	Discharge rate (ml/hr)			
		SC	HC	LC	TC
1.	0.5	3360	3384	3240	1536
2.	1.0	5376	4176	4368	4704
3.	1.5	6384	4320	4992	5808

Table 8. Final discharge from various emitters

Sl. No.	Operating pressure (kg/cm^2)	Discharge rate (ml/hr)			
		SC	HC	LC	TC
1.	0.5	3312	3456	3360	1512
2.	1.0	5376	4080	4272	4560
3.	1.5	6336	4320	5064	5520

The long term effect of pressure on discharge was studied for all the emitters. The results are graphically presented in figures 2, 3 and 4. In the case of SC emitters at 0.5 kg/cm^2 the initial discharge was 3480 ml/hr an after 15 hours of working it was 3216 ml/hr and at 25 hours of operation the discharge was 3312 ml/hr. The decrease in discharge between 15 and 20 hours of operation was 144 ml/hr whereas the decrease between 20 and 25 hours was only 48 ml/hr. In the case of HC emitters initial discharge was 3864 ml/hr and it dropped to 3360 ml/hr after 5 hours of operation and after 20 hours of operation it was 3384 ml/hr. From the figures it is observed that there is no considerable variation in discharge rates after 20 hours of operation for each emitters.

At 1 kg/cm^2 the initial discharge in the case of SC, HC, LC and TC were 5568, 4512, 4512 and 4944 ml/hr respectively. The discharges of each emitters after 15 hours were 5424, 4176, 4416 and 4848 ml/hr respectively. Again after 25 hours the corresponding discharges were 5376, 4080, 4272 and 4460 respectively. From figure 3 it is observed that the discharges remained without considerable variations. The same trend is observed at 1.5 kg/cm^2.

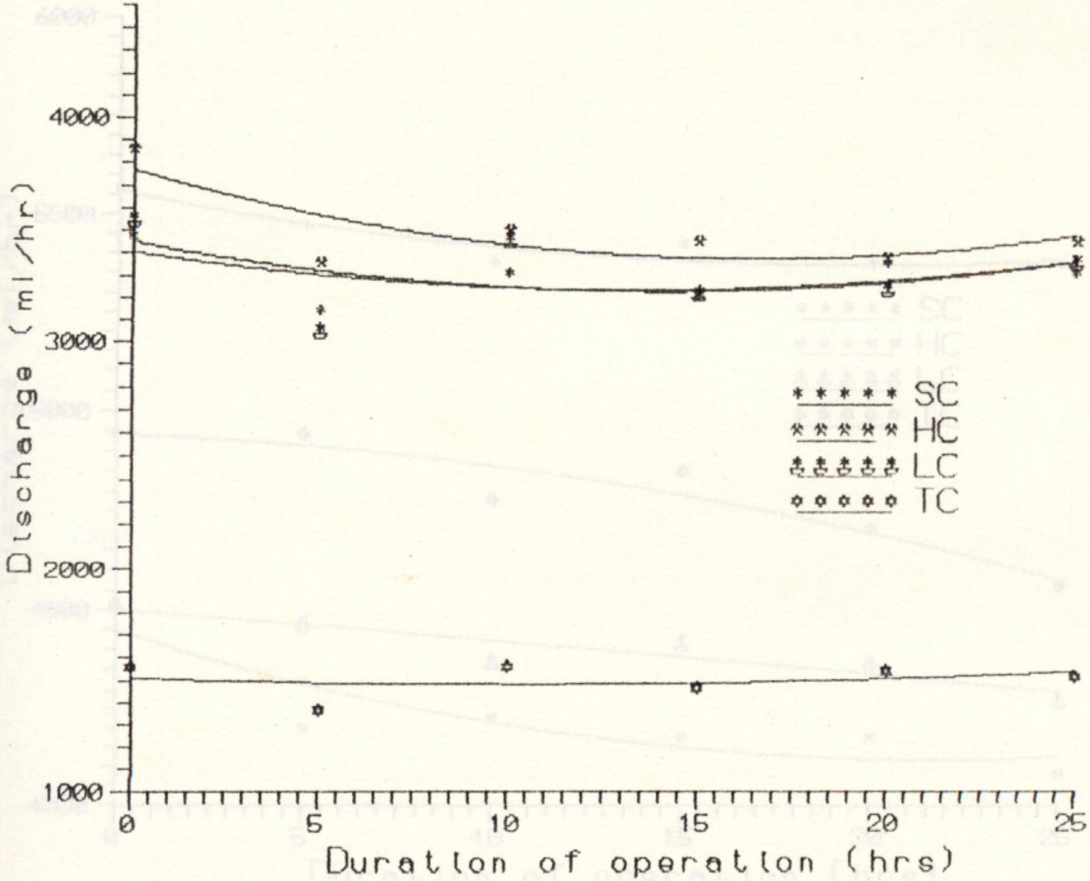


Fig.2 Discharge rate of emitters at 0.5 kg/sq.cm

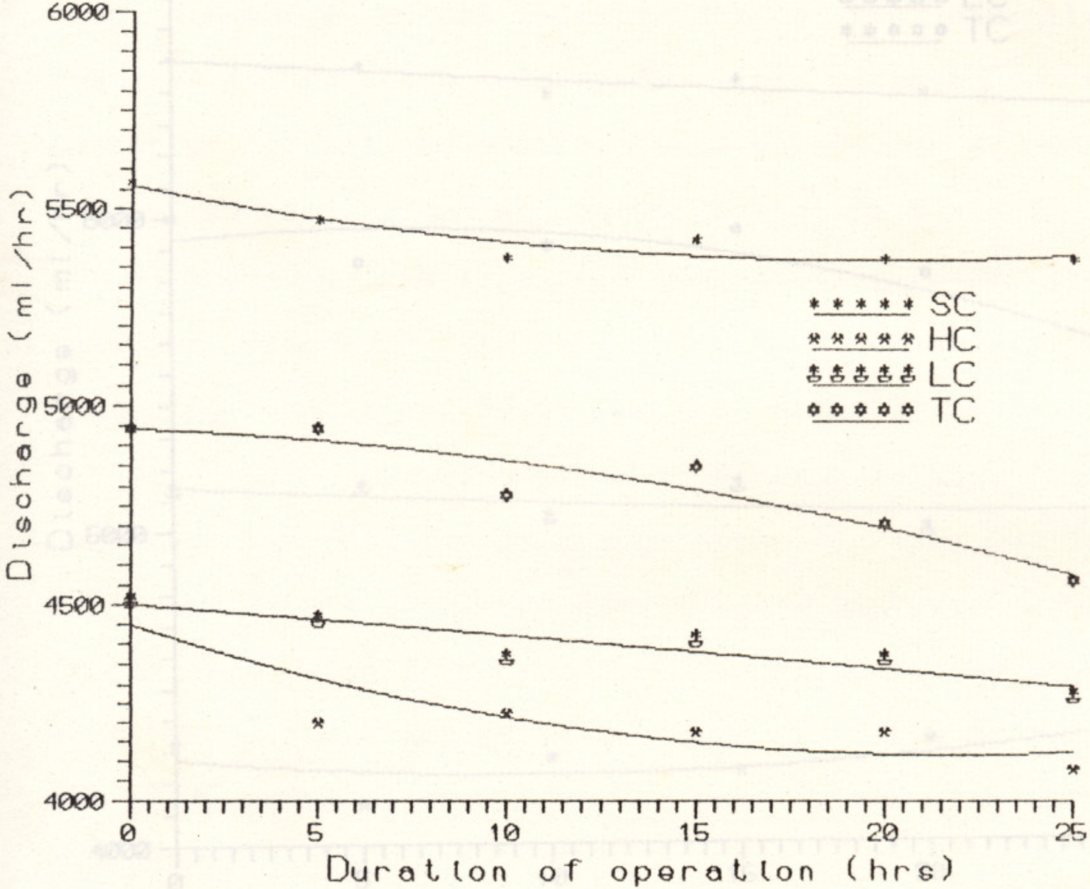


Fig.3 Discharge rate of emitters at 1 kg/sq.cm

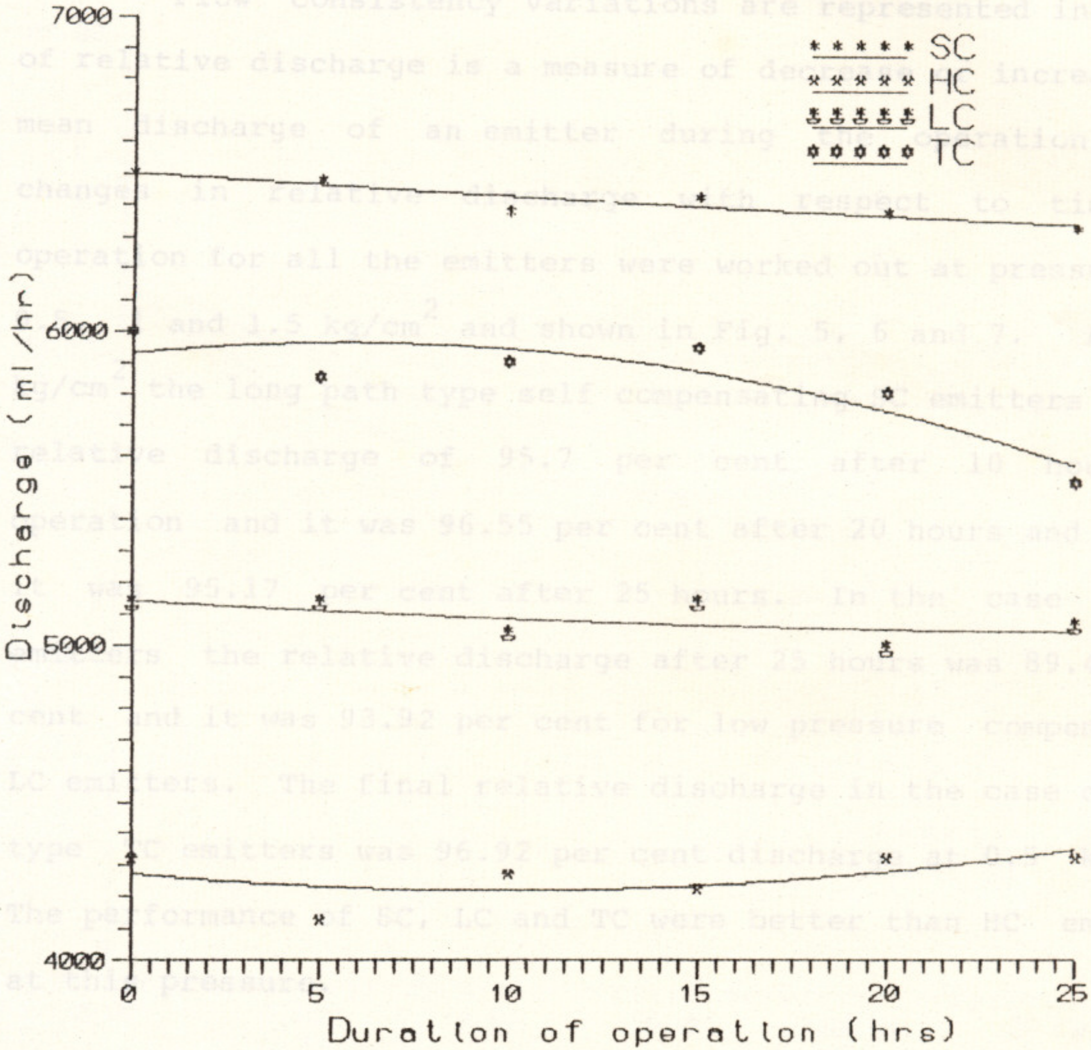


Fig.4 Discharge rate of emitters at 1.5 kg/sq.cm

4.2 Flow consistencies

Flow consistency variations are represented in terms of relative discharge is a measure of decrease or increase in mean discharge of an emitter during the operation. The changes in relative discharge with respect to time of operation for all the emitters were worked out at pressures of 0.5, 1 and 1.5 kg/cm^2 and shown in Fig. 5, 6 and 7. At 0.5 kg/cm^2 the long path type self compensating SC emitters gave a relative discharge of 95.7 per cent after 10 hours of operation and it was 96.55 per cent after 20 hours and again it was 95.17 per cent after 25 hours. In the case of HC emitters the relative discharge after 25 hours was 89.44 per cent and it was 93.92 per cent for low pressure compensating LC emitters. The final relative discharge in the case of tap type TC emitters was 96.92 per cent discharge at 0.5 kg/cm^2. The performance of SC, LC and TC were better than HC emitters at this pressure.

At 1 kg/cm^2 pressure the relative discharge after 25 hours of operation for SC, HC, LC and TC were 96.55, 90.43, 94.68 and 92.23. At this pressure also the long path type SC emitters performed better. At 1.5 kg/cm^2 the high pressure compensating HC emitters gave relative discharges of 100 per cent after 20 and 25 hours. At the initial stages of 5, 10 and 15 hours there was no considerable reduction in relative

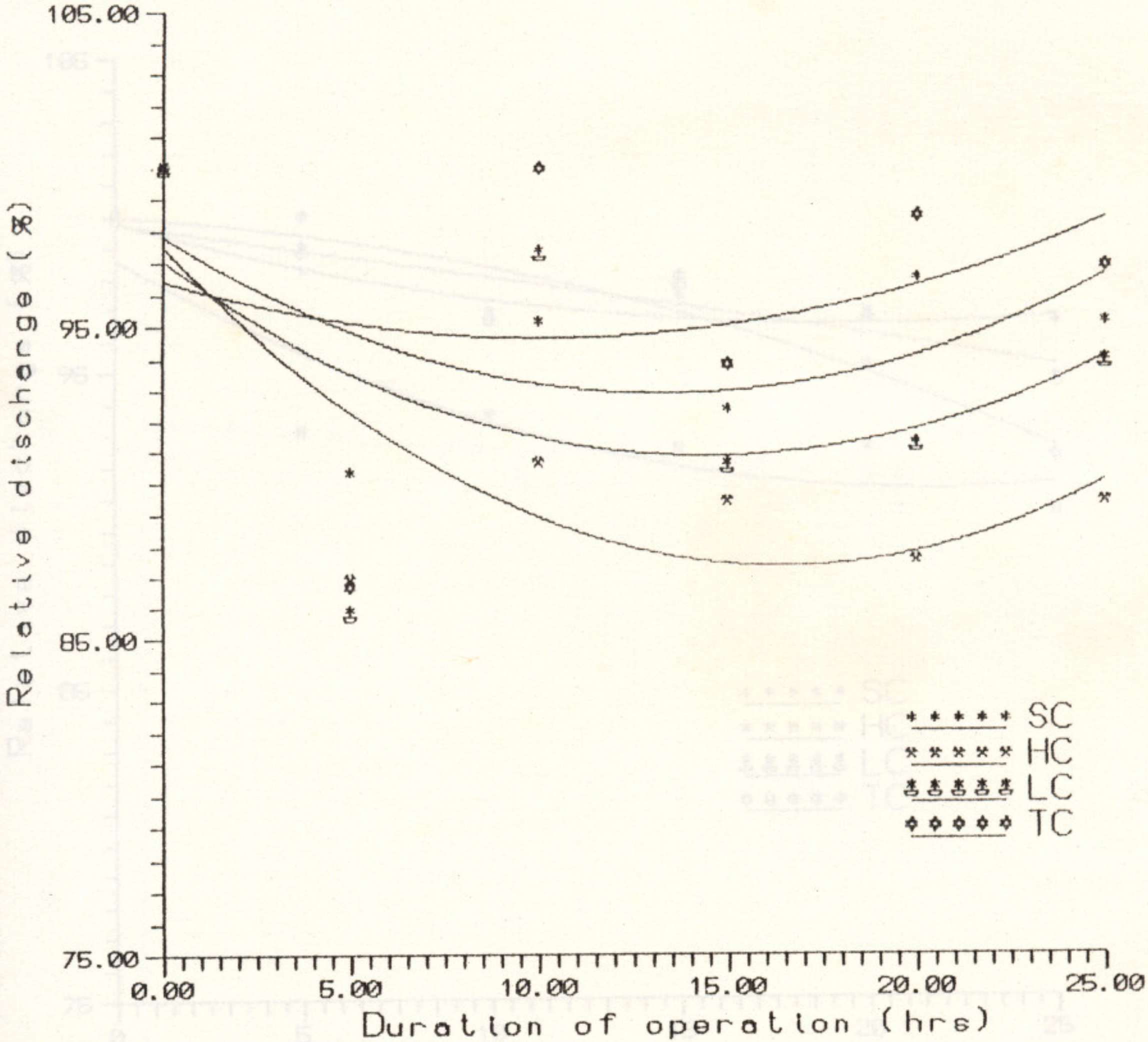


Fig.5 Relative discharge of emitters at 0.5 kg/sq.cm

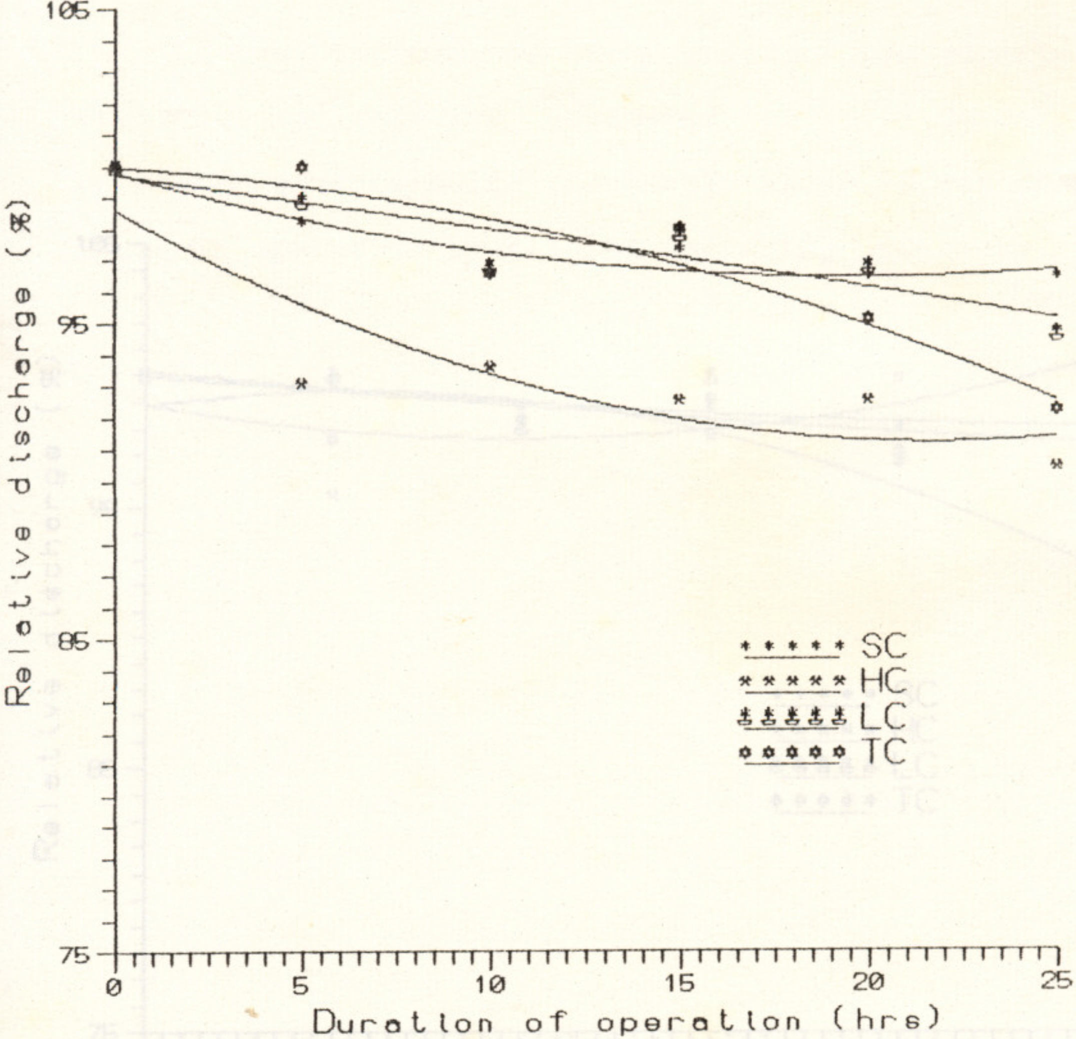


Fig.6 Relative discharge of emitters at 1.0 kg/sq.cm

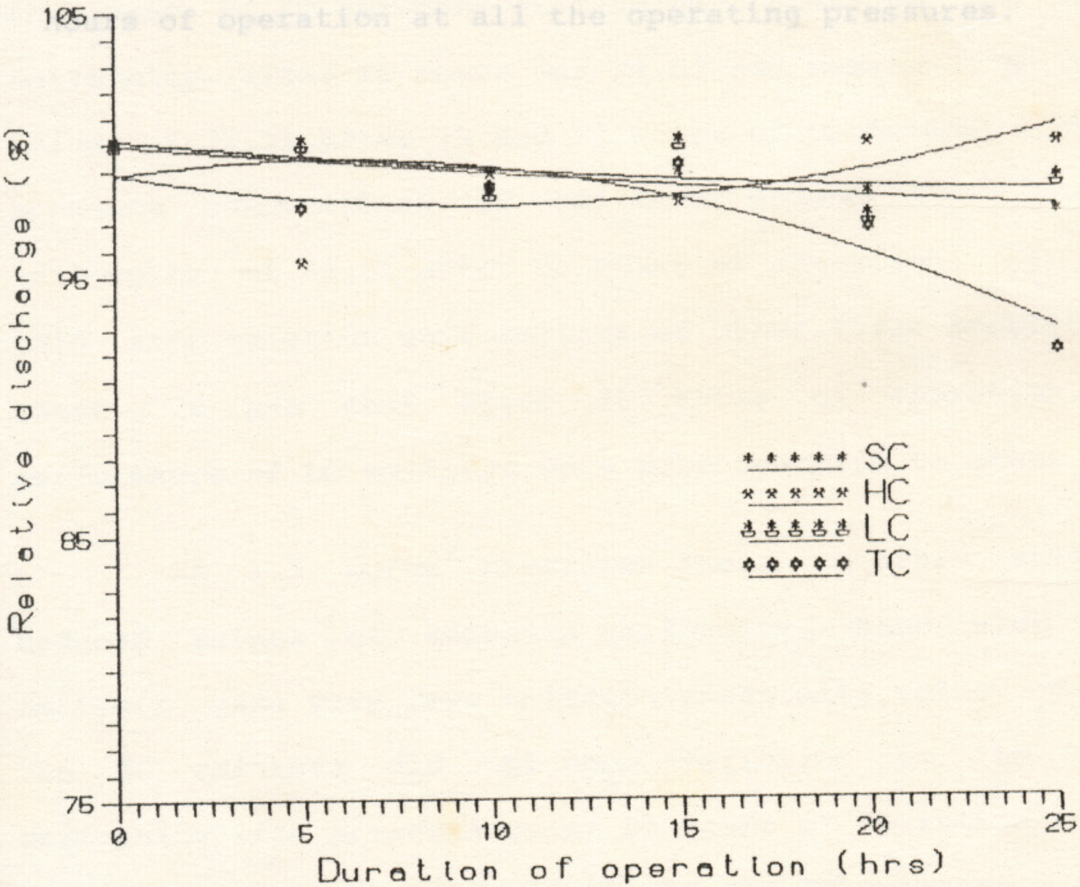


Fig.7 Relative discharge of emitters at 1.5 kg/sq.cm

discharge of HC emitters. The SC and LC emitters gave relative discharges of 97.42 and 98.60 after 25 hours of operation.

The performance of HC emitters was superior to other emitters in relative discharge at 1.5 kg/cm^2. All the emitters gave relative discharges above 90 per cent after 25 hours of operation at all the operating pressures.

4.3 Variation in emission uniformity

Emission uniformity was calculated for all types of emitters at pressures of 0.5, 1 and 1.5 kg/cm^2 and are shown in figures 8, 9 and 10. The emission uniformity of SC, HC, LC and TC emitters were only 64.74, 89.62, 64.27 and 70.30 after 25 hours of operation at 0.5 kg/cm^2 operating pressure. In the case of SC emitters at 1 kg/cm^2 pressure the emission uniformity after 15 hours was 74.89 and remained a constant value of 71.11 after 20 and 25 hours of operation. The low pressure compensating LC emitters showed least emission uniformity of 41.91 after 25 hours of operation. It can be told that emission uniformities of other three emitters were about 70 per cent after 25 hours of operation. The performance of LC emitters were poor compared to other three.

At 1.5 kg/cm^2 pressures these emitters still gave reduced values of emission uniformity. Here also the LC emitters gave very less emission uniformity value of 37.74. The SC emitters did not show variation in the emission uniformity with pressure after 25 hours of operation seen from Table 9. But in the case of HC, LC and TC emitters, emission uniformity values decreased considerably. The low pressure compensating LC emitters showed large decrease of emission uniformity with pressure.

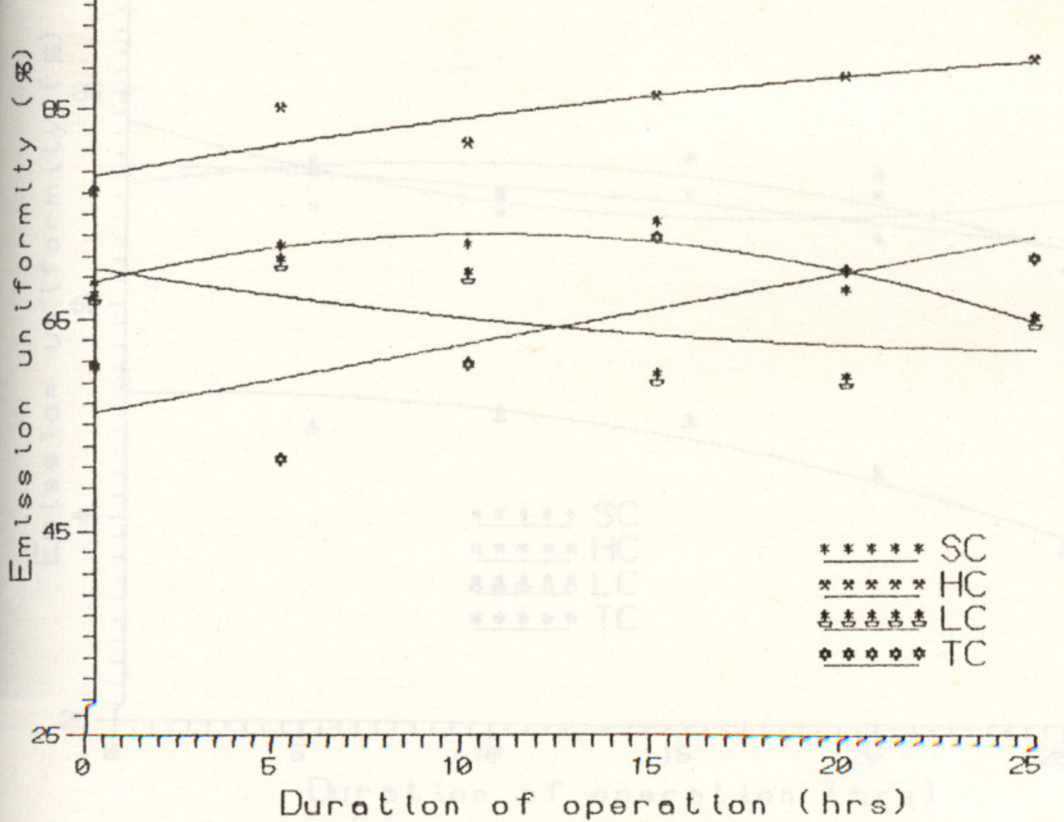


Fig.8 Variation of emission uniformity of emitters at 0.5 kg/sq.cm

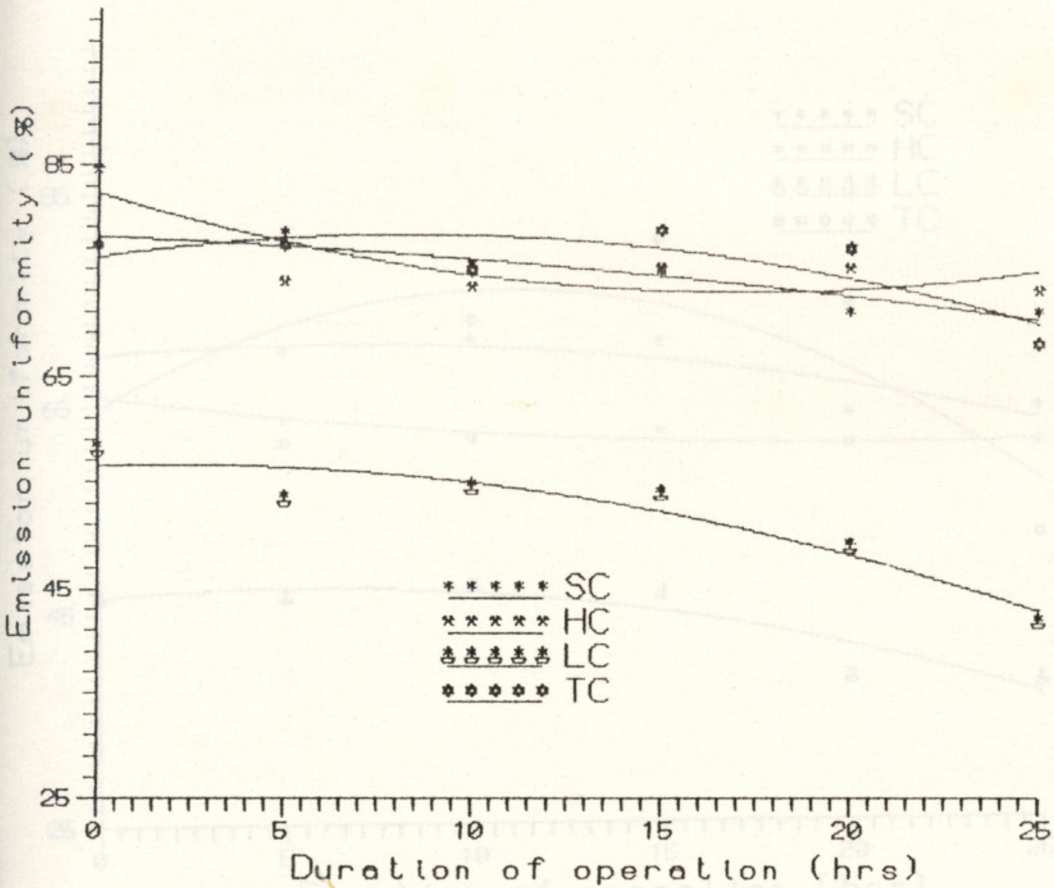


Fig.9 Variation of emission uniformity of emitters at 1.0 kg/sq.cm

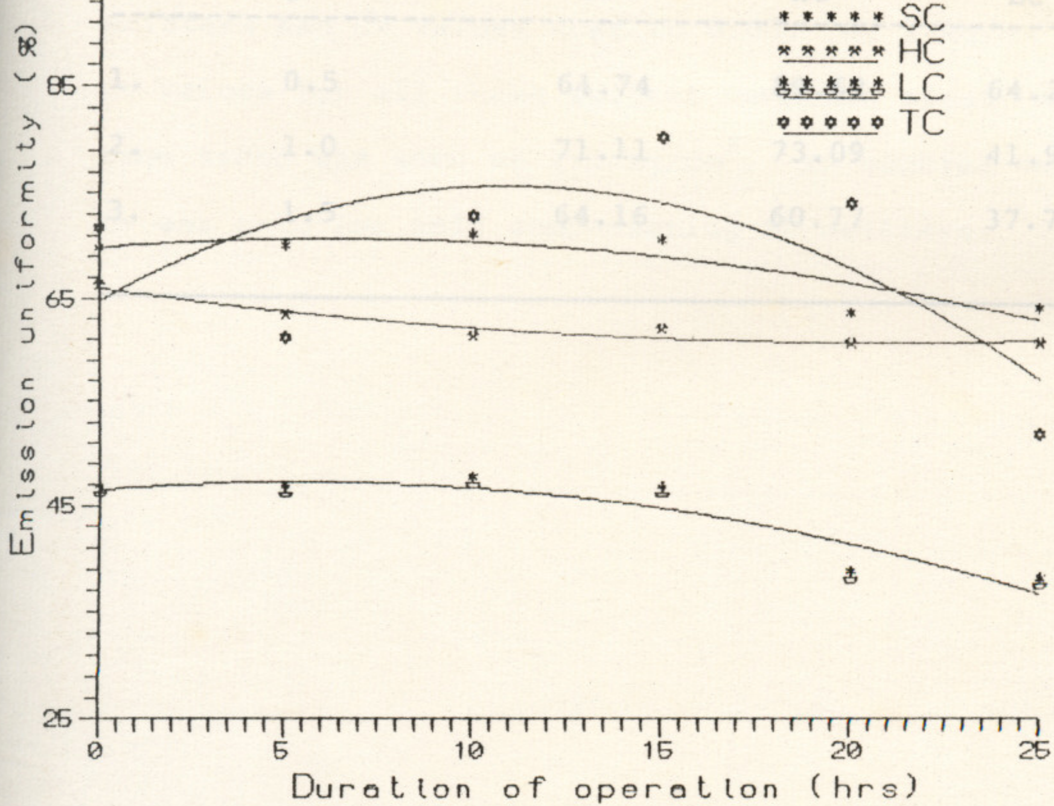


Fig.10 Variation of emission uniformity of emitters at 1.5 kg/sq.cm

Table 9. Variation in emission uniformity at final stage

Sl. No.	Operating pressure (kg/cm^2)	Emission uniformity (%)			
		SC	HC	LC	TC
1.	0.5	64.74	89.62	64.27	70.30
2.	1.0	71.11	73.09	41.91	68.06
3.	1.5	64.16	60.77	37.74	51.94

Table 10. Variation in manufacturer's coefficient of variation of emitters at 0.5 kg/cm^2

Sl. No.	Time of operation (hrs)	Manufacturer's Cv (%)			
		SC	HC	LC	TC
1.	0	0.0279	0.0253	0.0276	0.0605
2.	5	0.0308	0.0295	0.0320	0.0679
3.	10	0.0294	0.0279	0.0282	0.0600
4.	15	0.0301	0.0285	0.0304	0.0649
5.	20	0.0286	0.0291	0.0304	0.0613
6.	25	0.0288	0.0286	0.0291	0.0625

Table 11. Variation in manufacturer's coefficient of variation of emitters at 1.0 kg/cm^2

Sl. No.	Time of operation (hrs)	Manufacturer's Cv (%)			
		SC	HC	LC	TC
1.	0	0.0170	0.0216	0.0213	0.0197
2.	5	0.0173	0.0230	0.0251	0.0197
3.	10	0.0177	0.0232	0.0219	0.0203
4.	15	0.0175	0.0232	0.0217	0.0199
5.	20	0.0176	0.0232	0.0219	0.0205
6.	25	0.0176	0.0237	0.0219	0.0209

Table 12. Variation in manufacturer's coefficient of variation of emitters at 1.5 kg/cm^2

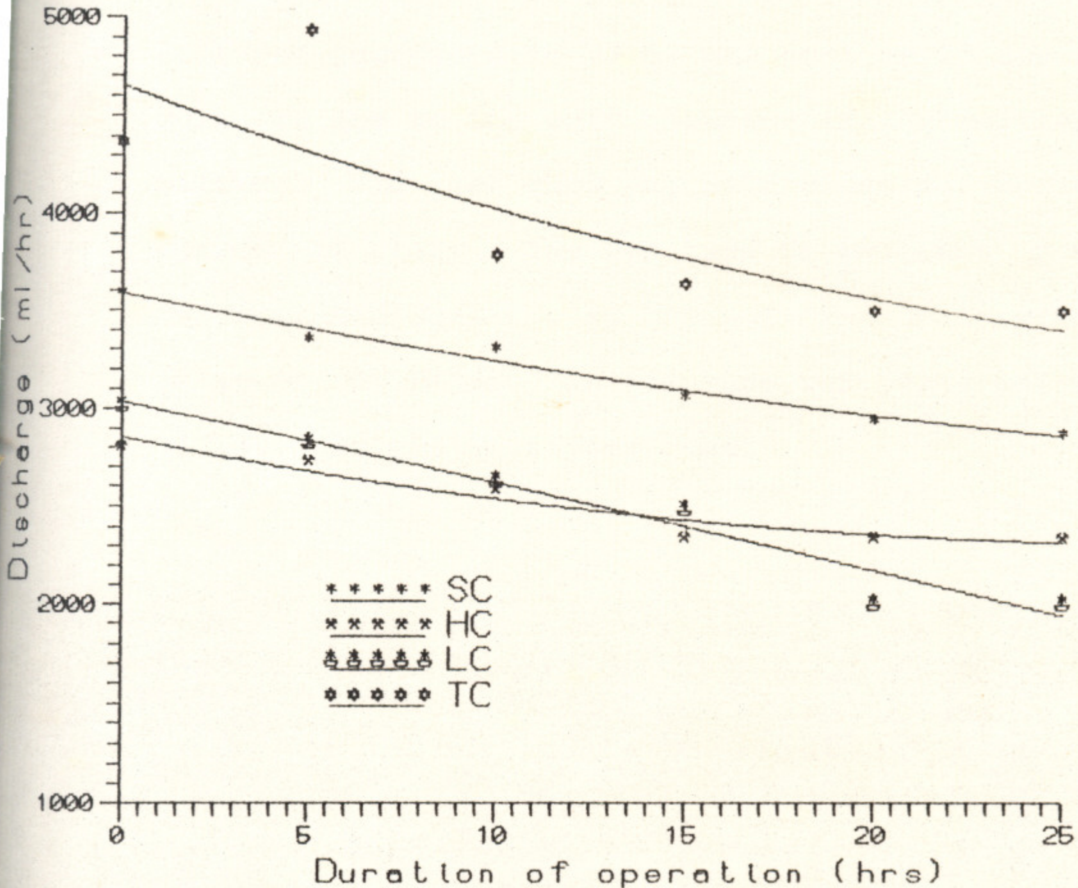
Sl. No.	Time of operation (hrs)	Manufacturer's Cv (%) SC	HC	LC	TC
1.	0	0.0145	0.0222	0.0186	0.0162
2.	5	0.0145	0.0232	0.0184	0.0166
3.	10	0.0148	0.0224	0.0189	0.0165
4.	15	0.0149	0.0227	0.0185	0.0163
5.	20	0.0148	0.0221	0.0189	0.0167
6.	25	0.0148	0.0221	0.0187	0.0173

4.5 Extent of emitter clogging

The emitters SC, HC, LC and TC were tested at sediment concentration of 1000 ppm. The testing was done for 25 hours spread over 5 days. Five emitters for each type were tested. The operating pressure was maintained at 0.5 kg/cm^2.

4.5.1 Variation in discharge rate

The variation in average discharge of the emitters with time of operation for each type is shown in Figure 11. From the figure it is observed that the discharge decreases with time of operation. During the initial 5 hours of operation the discharge in the case of SC emitters is decreased by 240 ml/hr whereas at the final stage of 20-25 hours the decrease was only 72 ml/hr. In the case of HC emitters the initial discharge was 2808 ml/hr and it reduced to 2736 ml/hr after 5 hours of operation. And beyond 15 hours of operation the discharge remained at a constant value 2352 ml/hr. The same trend as in the case of SC emitters was also observed in the case of LC emitters. The TC emitters gave constant discharge of 3504 ml/hr, beyond 20 hours of operation. It is generally seen that there was no considerable decrease in the discharge beyond 20 hours of operation. The initial reduction in the discharge is attributed to the initial clogging. Since there was no



g.11 Discharge rate of emitters for 1000ppm sediment concentration.

increase in the discharge at the initial stages there was no self cleaning of the emitters. The percentage reduction in the discharge was minimum in the case of high pressure compensating HC emitters. The low pressure compensating LC emitters gave a maximum reduction in discharge of 33.3 per cent.

4.5.2 Emission uniformity studies

Emission uniformity calculated for different types of emitters are presented in Table 13. In general, it is seen that the emission uniformity decreases with time. This is due to the clogging of the emitters. In the case of LC emitters, the emission uniformity at 15 hours of operation was 19.23 per cent and increased to 23.81 per cent at 20 hours of operation. This is due to the self cleaning of the emitters. The other emitters did not show any self cleaning action during the course of study. The tap type TC emitters remained without considerable decrease in the emission uniformity. The initial emission uniformity in its case was 71.43 per cent and after 25 hours it was 61.64 per cent.

Table 13. Variation in emission uniformity for 1000 ppm sediment concentration

Sl. No.	Time of operation	Emission Uniformity			
		SC	HC	LC	TC
1.	0	46.67	59.83	31.75	71.43
2.	5	50.00	61.40	33.90	73.17
3.	10	43.48	55.55	27.27	69.62
4.	15	39.06	51.02	19.23	59.21
5.	20	36.59	51.02	23.81	61.64
6.	25	33.33	51.02	23.81	61.64

4.5.3 Variation in relative discharge

The relative discharge is a measure of decrease or increase in the mean discharge of an emitter during the operation. The changes in relative discharge with respect to time of operation for all the emitters are shown in Table 14. The final relative discharges in the case of SC, HC, LC and TC emitters were 80, 83.76, 66.66 and 80.22 per cent respectively. The reduction in the relative discharges were in the order of HC, TC, SC and LC with HC emitters giving the least reduction. The performance of HC emitters was superior than other types.

Table 14. Relative discharge for emitters for 1000 ppm sediment concentration

Sl. No.	Time of operation	Relative discharge (%)			
		SC	HC	LC	TC
1.	0	100.00	100.00	100.00	100.00
2.	5	93.33	97.44	93.65	90.10
3.	10	92.00	92.31	87.30	86.81
4.	15	85.33	83.76	82.54	83.52
5.	20	82.00	83.76	66.66	80.22
6.	25	80.00	83.76	66.66	80.22

SUGGESTIONS FOR FUTURE WORK

We recommend the following future works:

1. The present study was conducted only for a small duration. Further studies can be attempted for longer duration.

2. Studies can be done for other makes of drippers.

3. Various other sediment concentrations can be attempted for clogging susceptibility studies.

SUMMARY

Drip irrigation is an innovative method of irrigation. This method enables slow and precise application of water to precise location. A proper evaluation of the emitters is necessary for its recommendation for use. The performance of many of the drip emitters deteriorate with time. Emitter clogging may also occur during its use. The operating pressure should also be considered.

An attempt was made here to study the performance of different emitters. The experiment was conducted in Soil and Water Engineering Laboratory K.C.A.E.T., Tavanur.

A drip emitter test rig was developed for the present study. It consisted of a network of 12.5 mm diameter LDPE pipes. An operating tank, a pumping unit, a control unit and a filter was incorporated in the testing rig. Emitters of four different types namely the long path type (SC), high pressure compensating (HC), low pressure compensating (LC) and tap type adjustable emitter (TC) were tested.

Tests were conducted at pressures of 0.5, 1.0 and 1.5 kg/cm^2 for a duration of 25 working hours spread over 10 days. In the case of all the emitters the discharge increased with increase in pressure. In the case of SC emitters at 0.5

kg/cm^2, the initial discharge was 3480 ml/hr and after 15 hours of working it was 3216 ml/hr and at 25 hours of operation the discharge was 3312 ml/hr. There was no considerable variation in discharge rates after 20 hours of operation for each emitter at a particular pressure.

The changes in relative discharge with respect to time of operation for all the emitters were worked out at pressures of 0.5, 1.0 and 1.5 kg/cm^2. SC and TC emitters showed less reduction in relative discharge at 0.5 kg/cm^2. At 1 kg/cm^2 the SC and LC emitters gave relative discharges of 97.42 and 98.6 per cent after 25 hours of operation. The performance of SC and LC emitters were superior to other types at operating pressures of 0.5 and 1 kg/cm^2. At 1.5 mg/cm^2 the performance of HC emitters was superior to other types.

The emission uniformity for all the emitters were worked out at the above mentioned pressures. The emission uniformity of SC, HC, LC and TC emitters were only 64.74, 89.62, 64.27 and 70.3 per cent after 25 hours of operation at 0.5 kg/cm^2. At 1 kg/cm^2 the emission uniformities of the emitters SC, HC and TC were about 70 per cent after 25 hours of operation. At 1.5 kg/cm^2 the emission uniformity values decreased compared to the values at low pressures. The performance of LC emitters was poor compared to other types at 1 and 1.5 kg/cm^2 pressure.

The manufacturer's coefficient of variation was worked out for all the emitters at 3 different pressures. There was no considerable change in manufacturer's coefficient of variation at 0.5 kg/cm^2 pressure. At 1 and 1.5 kg/cm^2 pressures the Cv values for all the emitters remained almost constant. Small values of Cv was seen for SC emitters.

Studies were also conducted to study the extent of emitter clogging. The reduction in relative discharges were in the order of HC, TC, SC and LC with HC emitters giving the least reduction. The relative discharge in the case of LC emitters at 0.5 kg/cm^2 was 66.66 per cent. The final relative discharge in the case of HC emitter was 83.76 per cent. But in the case of SC and TC emitters the final relative discharge was 80 per cent. HC emitters gave an emission uniformity of 51.02 per cent. The tap type TC emitters gave a higher value of emission uniformity. It is observed that this HC emitters were less susceptible to clogging. The LC emitters were found more susceptible to clogging.

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STUDY ON THE PERFORMANCE OF DRIP EMTTERS

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ABSTRACT OF THE PROJECT REPORT

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ABSTRACT

Drip irrigation enables slow and precise application of water to precise locations. Drip emitters being the equipment giving this low discharges, the performance of the system depends to a large extent on the performance of the drip emitters. Performance of the emitters may vary with operating pressure and also with quality of irrigation water. An attempt was made to study the performance of different emitters. Four different types of emitters. SC, HC, LC and TC were tested at pressures ranging from 0.5 to 1.5 kg/cm^2 for 25 hours duration. There was no considerable variation in discharge rates after 20 hours of operation for each emitter at a particular pressure. The SC and the TC emitters showed less reduction in the relative discharge at 0.5 kg/cm^2. At 1.0 kg/cm^2 pressure, the SC and LC emitters gave relative discharges of 97.42 and 98.60 per cent after 25 hours of operation. At a higher pressure of 1.5 kg/cm^2, the HC emitters performed better than the other types. But at low pressures of 0.5 and 1.0 kg/cm^2, the performance of SC and LC emitters were better. The emission uniformities of SC, HC and TC emitters were about 70 per cent after 25 hours of operation at 1 kg/cm^2. At 1.5 kg/cm^2 emission uniformity values were low. Performance of LC emitters was poor compared to other

types at 1.0 and 1.5 kg/cm^2. There was no considerable change in manufacturer's coefficient of variation at 0.5 kg/cm^2 pressure. At 1.0 and 1.5 kg/cm^2 pressure, the Cv values for all the emitters remained almost constant.

Clogging susceptibility studies was also conducted for these emitters. The reduction in relative discharges were in the order of HC, TC, SC and LC with HC emitters giving the least reduction. The final relative discharge in the case of HC emitter was 83.76 per cent. HC emitters gave a final emission uniformity of 51.02 and the tap type gave an emission uniformity of 61.42 per cent. The high pressure compensating HC emitters were less susceptible to clogging.