CLOGGING SUSCEPTIBILITY STUDY OF DRIP EMITTERS

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report "CLOGGING SUSCEPTIBILITY STUDY OF DRIP EMITTERS" is a bonafide record of project work done by us during the course of project and that 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 **"CLOGGING SUSCEPTIBILITY STUDY OF DRIP EMITTERS"** is a record of project work done jointly by BIJU A. GEORGE, E.B. GILSHABAI, S. RINI RANI, ROY THARAKAN under my guidance and supervision and that it has not previously formed the basis for award of any degree diploma, fellowship or associateship to them.

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SYMBOLS AND ABBREVIATIONS

Agric - Agricultural

ASAE - American Society of Agricultural Engineers

Assoc. - Assosiation

cm - centimetre(s)

CPCRI - Central plantations crop research institute

CWRDM - Central water resource development and management

Congr - Congress

Dept - Department

Engng - Engineering

et al. - and others

Fig. - figure

GI - galvanised iron

g - gram(s)

ha - hectare(s)

hdpe - high density poly ethelene

hr - hour

hortic - horticulture

hp - horse power

Irrig - Irrigation

J - Journal

kg/cm^2 - kilogram per square centimetre kpa - kilo pascal

l - litre(s)

l/hr - litre per hour

m - metre

mm - millimetre

mg/l - milligram per litre

m/s - metre per second

No. - number

proc. - proceedings

psi - pounds per square inch

PVC - Poly vinyl chloride

ppm - parts per million

rpm - revolutions per minute

Soc. - Society

Tr. - Transaction

% - per cent

°C - degree centigrade

INTRODUCTION

Effective utilisation of the limited water resource for irrigation is the primary concern for Indian agriculture. Seventy per cent of the area under cultivation still depends upon unreliable monsoon for its water supply. Judicious use of irrigation water is possible only through scientific and efficient irrigation management practices. Adoption of advanced methods of irrigation which can economise financial budget and water use has become necessary to increase production and bring more area under cultivation

Commonly employed surface irrigation methods lead to problems such as erosion, salinisation and water logging. Here comes the importance of adopting a technologically advanced irrigation system which can overcome the drawbacks of surface irrigation methods.

Drip irrigation is one of the recent developments in irrigation methods. It is defined as a controlled and uniform, drop by drop application of water right at plant root zone through emission points. The modern technique of drip irrigation was developed in Israel by Simca Blass , a water engineer in 1959. Now this system is very common in countries like America, Israel, Canada, Australia,South Africa and parts of Europe. This method is rapidly generating popularity among Indian peasants.

Drip irrigation system can be used for all far growing crops, as in orchards, plantations, row crops and others. It has got many advantages of its own and also over other methods of water application. This system can save about 50 per cent of water because of its high water application efficiency, conveyance efficiency and water use efficiency. Reports show that a high increase in yield can also be achieved using drip irrigation.

Drip irrigation method can be used in waste lands, marginal lands and hilly terrains for growing high value crops. Also, it is equally beneficial on small and large farms. Thus drip irrigation provides best and quickest possible solution for increasing agricultural production along with justified use of precious resources as water and energy.

The most common and serious problem faced by the drip irrigation system is clogging of emitters. The blockage of system or emitter clogging is the gradual closing of emitter opening due to settlement of sediments contained in the water thus causing reduction in discharge. Emitter clogging can be caused by physical, chemical and biological factors. The significant contributor to this problem depends on the conditions of the use of the system. The emitter clogging depends on water quality, rate and pressure of discharge, size of mesh opening of the filter and type and diameter of the orifice of the emitter.

The common physical factors are suspended clay, silt, fine sand, plastic particles and also plant, animal and bacterial debris. The common chemical factors include the precipitation of carbonates of calcium or magnesium, calcium sulphate, iron oxides and fertilizers added to the water. Biolological factors are bacteria and algae that form filamentous slimes and chemical deposits.

The clogging problem can result in complete rejection or severe restriction of this promising, efficient method of water application. Filtration with the help of sand and screen filters can avoid clogging problem to a certain extent. Sand filters are not commonly used as they are costly. Construction of sedimentation tanks for removing heavy silt load before filtration is also in practice. Acid treatment or acid flushing for removing chemical clogging is usually practiced. The common acids used for this purpose are hydrochloric acid, sulphuric acid and nitric acid.

In Kerala the scope for development of drip irrigation has immense potential, due to topography, socio economic and agro climatic conditions and type of crop grown. Plantation crops occupy about 46 per cent of the total cropped area. It is very essential to study the emitter clogging with the river and ground water available under Kerala conditions.

This project is a sincere attempt to study the clogging problems associated with drip emitters. The objectives of this work are

1) Comparison of extent of clogging in emitters of different types.
2) Effect of clogging on emission uniformity.
3) Effect of clogging on emitter flow consistencies.

REVIEW OF LITERATURE

2.1 Drip irrigaition system

Drip irrigation is one of the latest innovative methods of irrigation which enables slow and prcise application of water and nutrients to precise locations, avoiding soil erosion and wastage of water by deep percolation.

Present drip irrigation technology owes to Simca Blass, who developed and used this technology in 1963 in Israel. With the success stories of this system waving around, a number of inventors and companies began to develop and study drip irrigation system. Goldberg (1971) described drip irrigation as a multi disciplinary agricultural practice and has enormous potentials and possibilities.

Drip system is very advantageous as compared to other methods of irrigation. The CPCRI (1987) reported following advantages of drip system.

1) Water saving and increased beneficial use of water.
2) Enhanced plant growth and yield.
3) Saving in labour and energy.
4) Suitability in poor and problem soils.
5) Sparse weed growth.

6) Possibility of using saline water.

7) Improved cultural practices.

8) Improved efficiency of fertilization.

Although drip irrigation is best suited it has got some disadvantages. They are,

1) Persistant 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) The most widely faced problem of emitter clogging

2.2 Emitter clogging

Emitter clogging has become a major problem with many systems unless preventive measures are taken. Clogging will adversely affect the rate of water application and uniformity of water distribution and increase operational cost (Bucks _et al_. 1979). Gilbert and Ford (1986) reported that emitter clogging continues to be the major problem associated with drip irrigation operations. Clogging problem often discourages operators and consequently cause abandonment of the system and return to his previous irrigation method.

2.3 Reasons for emitter clogging

Clogging problems are caused by the presence of particles or materials that develop in the system which will reduce water flow. Clogging will be accelerated due to reduced flow rate. Clogging can occur at any place in the system. According to the studies conducted by Ford and Tucker (1975) clogging is closely related to the quality of water used in drip system.

Bucks *et al*. (1979) Classified the emitter clogging factors into three main categories namely physical, chemical and biological (Table 1).

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 carbonate	a) Algae
Sand (50 - 250 m)		b) Bacteria
Silt (2 - 50 m)	b) Calcium sulphate	filament
Clay (< 2 m)	c) Heavy metal	slime
Plastic cutting	Hydroxides	c) Microbial
	oxides, carbonates	depositions
b) Organic materials	silicates and	Iron
Aquatic plants	sulphides	Sulphur
phytoplankton	d) oil and other	Manganese
algae	lubricants	
Aquatic animals	e) Fertilizers	
Zoo plankton	i) phosphates	
Snail	ii) aqueous ammonia	
Bacteria (0.4-2 m)	iii) Fe, Cu, Zn ,Mn	

These three factors are closely interrelated.

Shannon et al. (1982) Studied the sediment transport and deposition in drip irrigation laterals and emitters. Suspended loads in water used for drip irrigation contributes to sedimentation in laterals and plugging of emitters.

The extensive study conducted by Vermieren and Jobling (1984) reveals that the causes of clogging are as follows.

Biological	37 per cent
Chemical	22 per cent
Physical	31 per cent
Uncertain	10 per cent

This indicates the variability of the causes of emitter clogging. The relative high incidence of biological clogging is believed to be due to lack of the protection against biological action during the installation of the system.

Abbott (1985) observed that physical factors are the main cause of emitter clogging. He did not provide any precise data on the relative importance of the causes.

Root intrusion into emitter openings and tubing that restrict water flow has been observed for some types of buried tubing (Kinoshite and Bui, 1988)

2.3.1 Physical factors

Physical factors which may cause clogging include particles of sand, silt, clay and water borne debris that are too large to pass through the small openings of the emitters.

Plastic particles remaining in the network due to installation faults or breakdowns may cause significant clogging. Experiments conducted in the united states over four years using Colarado River water 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 occured, followed by sand particles, 17 per cent and microbial slimes, 11 per cent.

Algae, bacteria or their already lifeless bodies and eggs and larvae may cause severe obstruction (Bucks _et al_., 1982).

Silt and clays are often carried in the irrigation water supply originating from rivers, lakes, canals and reservoirs; while sand may be sucked from the ground water sources such as wells and bore holes. Sand and silt can also enter lateral lines through careless assembly of the irrigation system or through repair work carried out when line damage has occured (Vermeiren and Jobling, 1984). Abbott (1985) reported that problems also occur in areas suffering from wind erosion where emitters become covered with fine silt and sand suction created at the end of an irrigation cycle or water hammer will also drift in soil particles. Polluted external water can also be drawn in, if the emitter lies in a pool of water.

2.3.2 Chemical factors

The important factors causing chemical clogging are carbonates of magnesium and calcium, heavy metal compounds, fertilizers and oily substances.

Chemical clogging occurs when ground water source is used for irrigation, as it frequently contains dissolved salts in significant quantities (Goldberg _et al_., 1976). Carbonates and sulphates of calcium and mangnesium are the most common cause of dripper clogging. Chemical clogging can be caused by salts precipitating at the end of the dripper passage. Goldberg _et al_. (1976) reported that precipitation will take place inside laterals if fertilizers were added to irrigation water without sufficient care.

Award (1982) reported that where the calcium carbonate saturation index is above 0.5 and calcium hardness above 200 milligrams per litre, there is likely to be clogging of emitters. The problem is most severe where the temperature in pipe line rises significantly between application because calcium in solution is mostly in bicarbonate form.

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).

2.3.3 Biological factors

Biological activity in irrigation water and its by-products may produce organic matter 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.

The formation of complexes of iron become particularly serious when pH of the water is between 7 and 7.8. Also aerobic sulphur slimes are formed by the transformation of hydrogen sulphide to elemental sulphur when pH range is within 6.7 to 7.2. Problems with sulphur slime may occur when the hydrogen sulphide content of water is in excess of 0.5 mg/l. The manganese content above 0.1 mg/l increases possibility of formation of manganese slime due to bacterial action (Ford, 1977).

2.4 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 findings on emitter clogging and experience gained in controlling it, a classification scheme that included the major factors involved in emitter clogging was derived. This is related to irrigation water composition (Table 2). The 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~~0~~-100	> 100
Suspended solids			
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)			
Baterial number	< 10000	10000-50000	>50000

Bucks et al. (1982) suggested that any classification system should be used with care bacause water quality will fluctuate with time and the field situation. Except possibly for microbial population analysis, measurements of suspended load and chemical composition can be made by the operator or most agricultural service laboratories.

2.5 Prevention of emitter clogging

Prevention is the best solution for reducing or eliminating emitter clogging. Preventive maintenance practices include water filtration, field inspection, pipe line flushing and chemical water treatment. Water filtration and pipe line flushing are essential. Flushing can help to minimise sediment build up and chemical treatment can improve the long term performance of a drip irrigation system.

Wilson (1972) suggested that the best approach to solve clogging problems is to select emitter devices which may require less or minimum maintenance. Ford and Tucker (1974) suggested that attention should be focussed on improving the quality of irrigation water before it reaches the emitter.

Emitter manufacturers have made special effort in producing non clogging emitters. They have manufactured emitters with automatic or manual flushing capabilities or with easy dismantling features for cleaning.

Gilbert et al. (1981) conducted a study on emitter clogging and other problems of drip irrigation. Drip irrigation experiments with Colarado River water on citrus trees in South Western Arisona were conducted to develop water treatment methods for preventing emitter clogging and maintaining long term operation of the system under actual field conditions. Eight drip emitter systems in combination with six water treatments were evaluated during a comprehensive four year study. Emitter clogging was related to emitter design and degree of filtration. If not positioned upright emitters designed with moving parts were more susceptible to clogging and malfunctioning. Emitters with flexible membranes either failed after a few months of use with chemically conditioned water or showed serious deterioration and decomposition after four years. The dominant cause of emitter clogging was physical particles. The next and minor in comparison was the combined development of biological and chemical deposits.

According to Jackson and Kay (1986) 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 in turn 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 the higher discharge if the flow is pulsed.Emitters with large pores can also fail when water of poor quality is used in them. Ravina et al. (1992) reported that long term operation of most emitter types 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.

2.5.1 Water filtration

Filter units used to prevent emitter clogging are widely recognised as key to successful operation of drip system. Filters remove unwanted physical contaminants, which include suspended or undissolved organic and inorganic materials. Suitable filters include pressure filters and gravity filters. In selecting the type, size and capacity of the filtration unit, the primary factors to be considered are the initial water quality and emitter design.

Bucks et al. (1979) suggested that the final filtration screen size should be one tenth the diameter of the smallest emitter opening. When conditions for clogging become severe, two or more types of filter in series may be effective. The filter capacity should be sufficiently large to permit the rated 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 qualities may fluctuate during the irrigation period.

Abbot (1985) identified that screen filters are the most widely used type of filters because of their simplicity and ease of operation. Screen filter elements are usually made of metal, plastic or synthetic cloth. Aquatic algae in the water tend to cause screen blockage and can reduce the filtering capacity. Filters should be cleaned as frequently as needed to maintain the operating pressure within 10 per cent to 15 per cent of the design presure.

Media filters consists of fine gravel and sand of selected sizes placed in a pressurised tank. Since media filters are not easily plugged by algae they can remove relatievely large amount of suspended solids before clogging. However, media filters can provide conditions favourable for increased bacterial growth. This may cause cementation of the sand and 'rat holing' resulting in transfer of clogging material into drip system. Media filters retain particle sizes in the range of about 25 microns to 100 microns. Water flow through the filters should not exceed 800 litre per minute per square metre of filtration surface area and the filtration media should be atleast 45 cm thick.

Sand seperators, hydrocyclones or centrifugal filters remove suspended particles that have a specific gravity greater than water and that are larger than 75 microns. These filters are ineffective in removing most organic solids.

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. Unless settling basins, ponds and reservoirs have protective covering, the water is exposed to wind blown contamination and subject to algae growth that should be controlled by commercially available algicides. These structures are normally not used for water sources from wells.

2.5.2 Field inspection

Systematic inspection of a drip system is required 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 condition. Screen, media and centrifugal filters must be cleaned periodically. Operation of filters, chemical injectors, pressure regulators, water meters and the pump must also be checked routinely and repairs made according to manufacturers recommendation.

2.5.3 Pipe line flushing

Even careful filtration does not remove all suspended material and eventually sediments will accumulate in the tubing and emitters. Hence, regular flushing of laterals is another recommended maintenance practices, especially for water with high content of silt, clay or biological residues (Shearer, 1977). Valves should be provided at the end of mains and submains and provisions made for flushing of lateral lines.

Pipe lines can be flushed either manually or automatically. Automatic flushing is beneficial where the water is extremely high in silt and clay content. Periodic hand flushing of drip lines can also be used. Flushing should begin with the mains and proceed to submains and laterals. A minimum flow velocity of 0.3 m/s is required for effective flushing of lateral lines.

2.5.4 Chemical water treatment

Small particles can pass through filters and emitters, but when they interact with microbial by-products, such a combination can clog emitters. Away from filtration and flushing, chemical treatments are necessary.

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 milligram per litre or more dissolved iron because chemical reaction will form iron oxide which can precipitate and cause blockage of emitters. In such cases chlorine injection should be made at a sufficient distance upstream from the filtration system to allow sufficient time for mixing, chemical reaction and coagulation to take place before the iron flocculant reaches the filter for removal. Chlorination does not cause any injury to roots unless it is applied at very high rate.

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 one 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 from 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 and hudrochloric acid are commonly used acids to reduce precipitation. Titration of the water with dilute acid is a method for determining its acid requirement.

According to Bucks and Nakayama (1991) where acid treatment can adversely affect 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 homo polymer 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.

2.6 Laboratory evaluation of drip irrigation equipment

Moser (1979) reported the laboratory evaluation of drip irrigation equipment. 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, susceptibility to 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, uniformity of emission rate etc.

2.6.1 Manufacturing uniformity

This property is quantified by the coefficient of variation 'CV'. ISO recommended the use of 25 unused samples of the same emitter functioning at 23 +_ 1°C to calculate discharge rates under the nominal test pressure for non regulating emitters and under the mid range pressure for regulating emitters. The coefficient of variation may be calculated as follows

$$CV = \frac{s}{q_m} \times 100$$

where,

s = Sample standard deviation

q_m = Mean emission in l/hr

2.6.2 Emission uniformity

A recently introduced uniformity measure is the emission uniformity 'EU'. According to Karmelli and Keller (1974) emission uniformity can be calculated as follows.

$$EU = \frac{q_{min}}{q} \times 100$$

where,

q_{min} = average of the lowest one fourth of the flow rates

q = average discharge of all the emitters

2.6.3 Susceptibility to pressure

This property may be defined as a measure of change of emission rate as a function of inlet presure. For this test also ISO has recommended guidelines. 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 emission rate 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 manufacuturing variation among emitters were measured for commercial drip emitters by Smajstrla and Clark (1992)

2.6.4 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 a emitter depends also on the water temperature and viscosity of water. He studied the effect of water temperature in the range of 8°C to 60°C on flow variation of different types of emitters. 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.

2.6.5 Susceptibility to clogging

This property is a measure of flow reduction over time. The clogging susceptibility of an emitter is directly related to the degree of filtration and amount of sediment load present in irrigation water.

Influence of sediment concentration of 250 gram per cubic metre on the discharge rate of different types of emitters has been investigated by Moser and Sinn (1978). They used a sediment grade of 0.1 mm and smaller. Each of the tests was running for 50 hours. During this time the water flow was stopped 10 to 15 times to simulate the flushing and cleaning effects taking place under actual conditions. They used quartz sand with particle size 0.001 mm to 0.1 mm mixed with normal tap water.

Janney (1980) used 60 size grit to determine clogging susceptibility of different types of emitters. A circular tank with smooth interior was used to avoid lodging of particles on sides. A quantity of grit was added to get desired concentration. Jet action was used to mix the grit in the water and the emitters were operated on grit laiden water. Start time, concentration and size of the grit were recorded and units checked at one hour intervals. If no clogging occured after four hours, more grit was added to achieve the next desired concentration level. Grit was added in predetermined amounts until either clogging occured within four hours of runtime or desired test concentration level reached. At the end of the test, time to clog and concentration to clog were recorded.

Decroix and Malaval (1985) reported a more detailed clogging susceptibility test. They used five samples and test was made up of four seperate 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. At each stage a new quantity of mineral particles was mixed to the water, with successive additions of each whose granulometry is well known.

David.J.Hills et al. (1989) conducted an experiment to determine the effect of chemical clogging on drip irrigation uniformity. The following four management schemes were evaluated for reducing the chemical clogging effects of high calcium content water in drip system.

1) Above ground day time water application
2) Above ground night time water application
3) Subsurface placement of drip-emitters
4) Lowering the pH of irrigation water.

Irrigation duration for each management scheme was four hours daily, over the 100 day investigation. Volumetric flow rate and emission uniformity were monitored. Partial and full clogging due to chemical precipitation occured in all management schemes for the water with highest salt content.

An emitter discharge evaluation of sub surface drip irrigation system was conducted by Numan Mizyed and Gordon Kruse (1989). They determined the reduction in emission flow rates due to plugging and other aging factors, even if the original flow capacity of the system is not measured. A computer model was used to determine discharge of a system and compare results with measured values after a period of use.

Adin and Sacks (1991) investigated dripper clogging factors in waste water irrigation. The study is aimed at defining the clogging factors and mechanisms 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 number 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 <u>et al</u>. (1992). The experiment set up consists of three arrays of twelve metre long laterals each with different types of emitters at 1 m spacing. The system was automatically operated at a regime of 20 hour operation and a 4 hour intermission at night, six days a week under a regulated pressure head of 18+_1m. Automatic hourly measurement of the discharge from individual emitters in each of the various laterals were performed atleast once a month. At the end of the irrigation season three emitters were removed from the central section of the lateral and carefully cut open in the laboratory to visually determine the location and amount of deposits and to identify the nature of clogging material with the aid of a microscope. Water was sampled before and after each filter and fifth emitter in each lateral for the measurement of total and volatile suspended solid loads, turbidity, numeric and volumetric particle size distributions and for quantitative microscopic examinations.

MATERIALS AND METHODS

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

3.1 Location

The experiment to study the extent of emitter clogging in various types of emitters used in drip irrigation was conducted in the Soil and Water laboratory of KCAET, Tavanur.

3.2 Experimental set-up

Emitter clogging is a function of quality of irrigation water and degree of filtration. A poor quality of irrigation water was imitated by mixing colloidal clay of particle size less than 75 micron into normal tap water. The study was conduted at 500 ppm and 1000 ppm sediment concentrations. Five types of commercially available drippers were used for the study.

The layout of the experimental set up is shown in figure 1. The overall picture of the experimental arrangement is shown in plate 1. Five emitters of each type were operated at a pressure of 1 kg/cm^2, for 48 working hours for each treatment.

1. Operating tank
2. Suction pipe
3. Pump
4. Delivery cut-off valve
5. Pressure gauge
6. Filter
7. Ball valve
8. Bypass cut-off valve
9. Bypass line
10. Main line
11. Discharge collecting bucket
12. Lateral

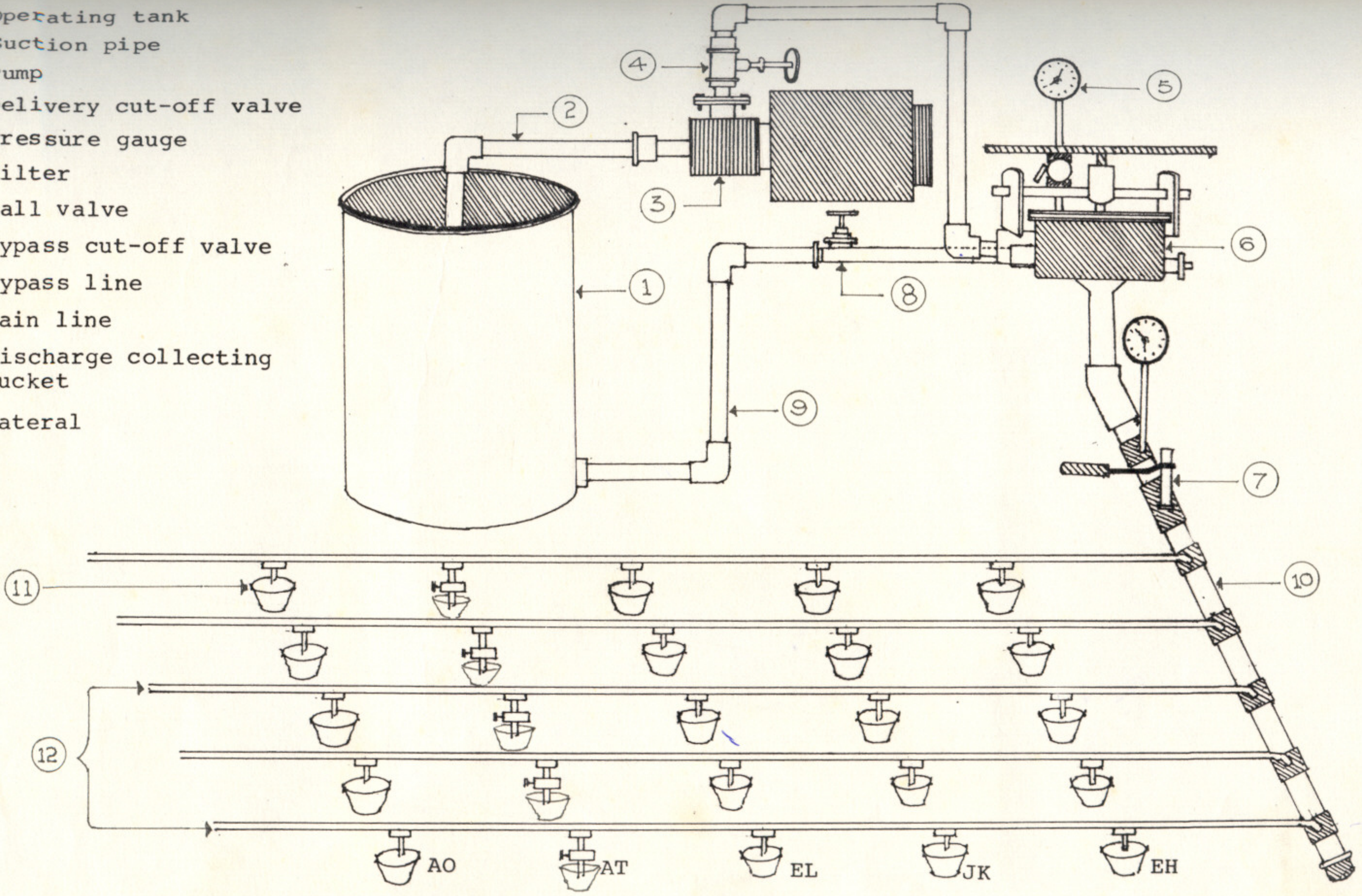

FIG.1 SCHEMATIC LAYOUT OF THE EXPERIMENTAL SET-UP

PLATE I OVERALL PICTURE OF THE EXPERIMENTAL SET UP

3.3 Materials and equipments

The main equipment used for this study is the drip emitter testing rig (DETR) developed for testing emitter clogging in the laboratory. The DETR consisted of operating tank, water supply unit, control unit, filter, main line, laterals, emitters and collecting unit as its main parts. The accessories used are stop watch measuring jar, common balance and sieve shaker.

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 barrel 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 and to provide smoothness.

3.3.2 Pumping unit

A centrifugual pump of specification
Discharge - 2.3 litres/second
Head - 21.5 m
Horse power - 1 h.p.
r.p.m. - 2800
was used for this study.

PLATE II VIEW OF THE CONTROL HEAD

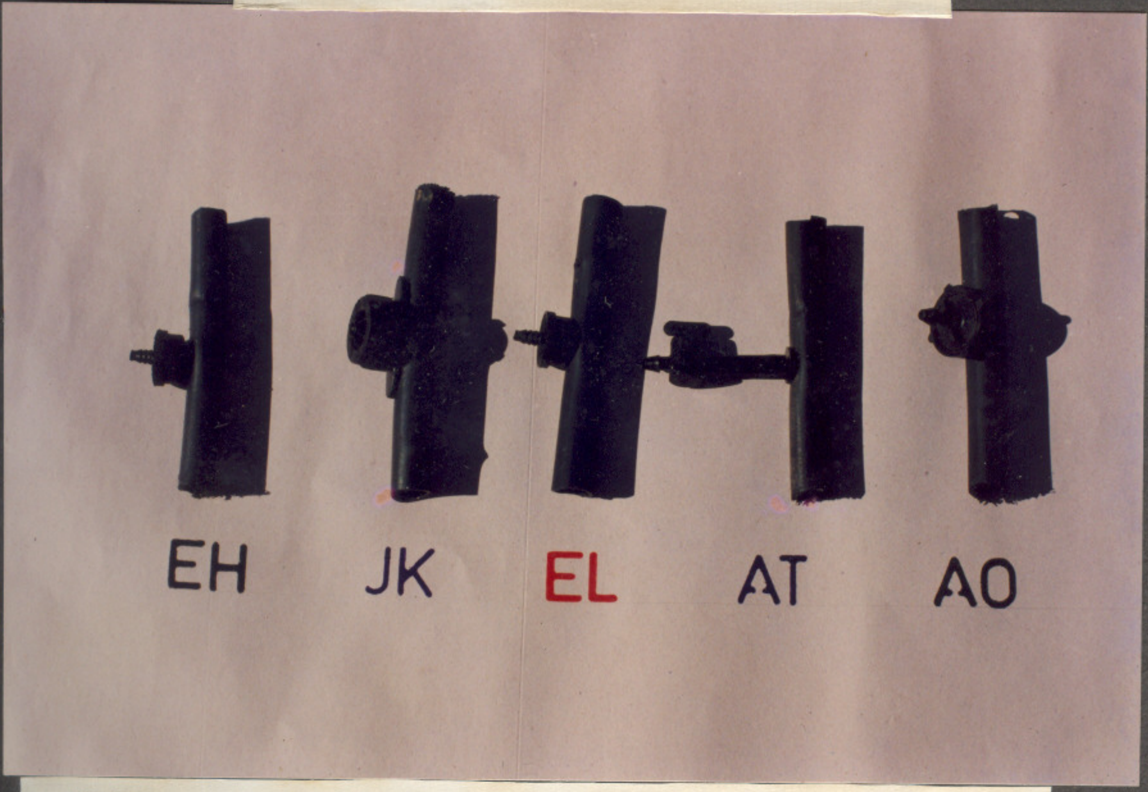

PLATE III CLOSE VIEW OF THE ALL TYPE OF EMITTERS

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 pressure of 1 kg/cm^2 was obtained by adjusting the bypass control valve. Pressure gauges were installed at the inlet and outlet port of the filter. The operating pressure in the laterals was read from the pressure gauge at the outlet of the filter. 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 litres per hour and of *screen* size 100 microns was used. The filter element was made of steel wire mesh.

3.3.5 Main line and laterals

The PVC mainline used was of 32 mm diameter and 5 m length. It was closed at the farther end. Five lateral pipes of HDPE of 12.5 mm diameter were taken from the main line at an interval of 1 m. Start connectors were used for perfect connections between main and lateral pipes.

3.3.6 Emitters

Emitters of different types commonly available in the market were selected for the study. All the emitters used were of discharge 4 litres per hour. The five different types of emitters used are,

EH - High pressure compensating emitter

JK - Long path type emitter

EL - Low pressure compensating emitter

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

AO - Long path type for low pressure.

The emitters were placed at a distance of 1 m on the lateral. The same sequence of EH, JK, EL, AT and AO was maintained on all the five laterals.

3.3.7 Discharge collection

The individual discharges were collected in buckets. The mainline and laterals were fixed on benches to facilitate collection of discharge into the 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 micron, passing through 1S 75 sieve were collected.

3.5 Preparation of clay suspension

Two treatments of 500 and 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

So, 500 ppm = 500 milligram per litre

for 1000 ppm = 1000 milligram per litre

Therefore, 100 grams and 200 grams of clay particles are required to prepare 200 litre of 500 ppm and 1000 ppm clay suspension. The barrel was filled to full capacity of 200 litres. About 1 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 this suspension was transferred to the water in the barrel carefully. For thorough mixing, the pumping unit was switched on, with ball valve closed. By opening discharge and bypass valves, stirring was given to the water in the barrel.

3.6 Testing procedure

The testing was conducted in the Soil and Water laboratory. The daily mean temperature during the period of study was 29°C. Daily one reading was taken in the morning. Each treatment continued for 48 working hours at a pressure of 1 kg/cm^2 with daily working time of 3 hours.

The 500 ppm treatment was done first. The weighed quantity of clay particles of size less than 75 micron was added to the water in the barrel. The procedure of preparation of clay suspension was same as said previously. Before opening the supply to the mainline, the suspension was stirred throughly for 10 minutes by circulating the water through bypass line only. The ball valve was opened slowly and pressure was correctly adjusted, by regulating the bypass valve. Additional amount of clay suspension was prepared in buckets and transferred to the barrel. The discharge measurement for individual emitters was done during the last half hour of the 3 hour interval. The collected discharge was measured using measuring jar.

Thousand ppm treatment was done secondly, with new set of emitters. The same procedure, as for previous treatment was repeated.

The problems associated with emitter blockages such as clogging susceptibility, variation in emission uniformity and relative discharge were analysed.

3.6.1 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.

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

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$$EU = \frac{q_{min}}{q} \times 100$$

where,

EU = Emission Uniformity in per cent

q_{min} = Average discharge of the lowest one fourth of the emitters, in l/hr.

q = Average discharge of all the emitters 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 situations, the lowest 1/4th of the flow rates is taken as least flow rate among the emitters on the lateral.

In this study, average discharge of lowest 1/4th 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 for both treatments.

3.6.3 Determination of relative discharge

The relative discharge is a measure of decrease or increase in mean discharge of a type of emitters during the operation. Relative discharge for all the emitters when treated with clean water was taken as 100 per cent. Thus variation in relative discharge at any time can be found out as

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

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.

RESULTS AND DISCUSSION

Experiments were conducted to study emitter clogging in various types of drip emitters. The results obtained from the study are discussed in this chapter.

4.1 Extent of emitter clogging

The emitters EH, JK, EL, AT and AO were tested for two different concentrations of sediment load of 500 ppm (Case-A) and 1000 ppm (Case-B). The testing was done for 48 working hours and observations were taken at 3 hours interval. Five emitters of each type were tested.

The variation in discharge with time of operation for EH emitters is shown in figure 2 when treated with 500 ppm sediment concentration. The test results are presented in Table 3. From the figure it is seen that the discharge decreases in slow rates during the initial stage. The discharge fluctuates at the later stages. This is due to the self cleaning action of the drippers. EH-2A was most efficient in self cleaning action, since it showed maximum fluctuation and least clogging percentage of 3.41 per cent, whereas the average clogging percentage of EH group was 5.68 per cent.

Table 3. DISCHARGE FROM EH EMITTERS FOR 500 ppm SEDIMENT CONCENTRATION (CASE-A) IN ml/hr.

Sl. No.	Time of opern. (hrs)	EH-1A	EH-2A	EH-3A	EH-4A	EH-5A	Mean
1	0	3900	4100	4120	3960	4180	4052
2	3	3880	4090	4110	3940	4160	4036
3	6	3870	4080	4090	3930	4140	4022
4	9	3850	4070	4060	3910	4120	4002
5	12	3820	4050	4030	3880	4120	3980
6	15	3800	4050	4010	3860	4140	3972
7	18	3780	4070	3990	3850	4150	3968
8	21	3800	4070	3980	3860	4140	3970
9	24	3780	4060	3960	3840	4130	3954
10	27	3760	4040	3940	3810	4110	3932
11	30	3740	4020	3910	3780	4090	3908
12	33	3720	4020	3940	3760	4110	3910
13	36	3690	3990	3920	3730	4080	3882
14	39	3660	3960	3900	3750	4050	3864
15	42	3670	3940	3880	3720	4020	3846
16	45	3640	3970	3860	3690	4020	3836
17	48	3600	3960	3840	3680	4030	3822
Reduction in discharge (%)		7.7	3.4	6.8	7.1	3.6	5.7

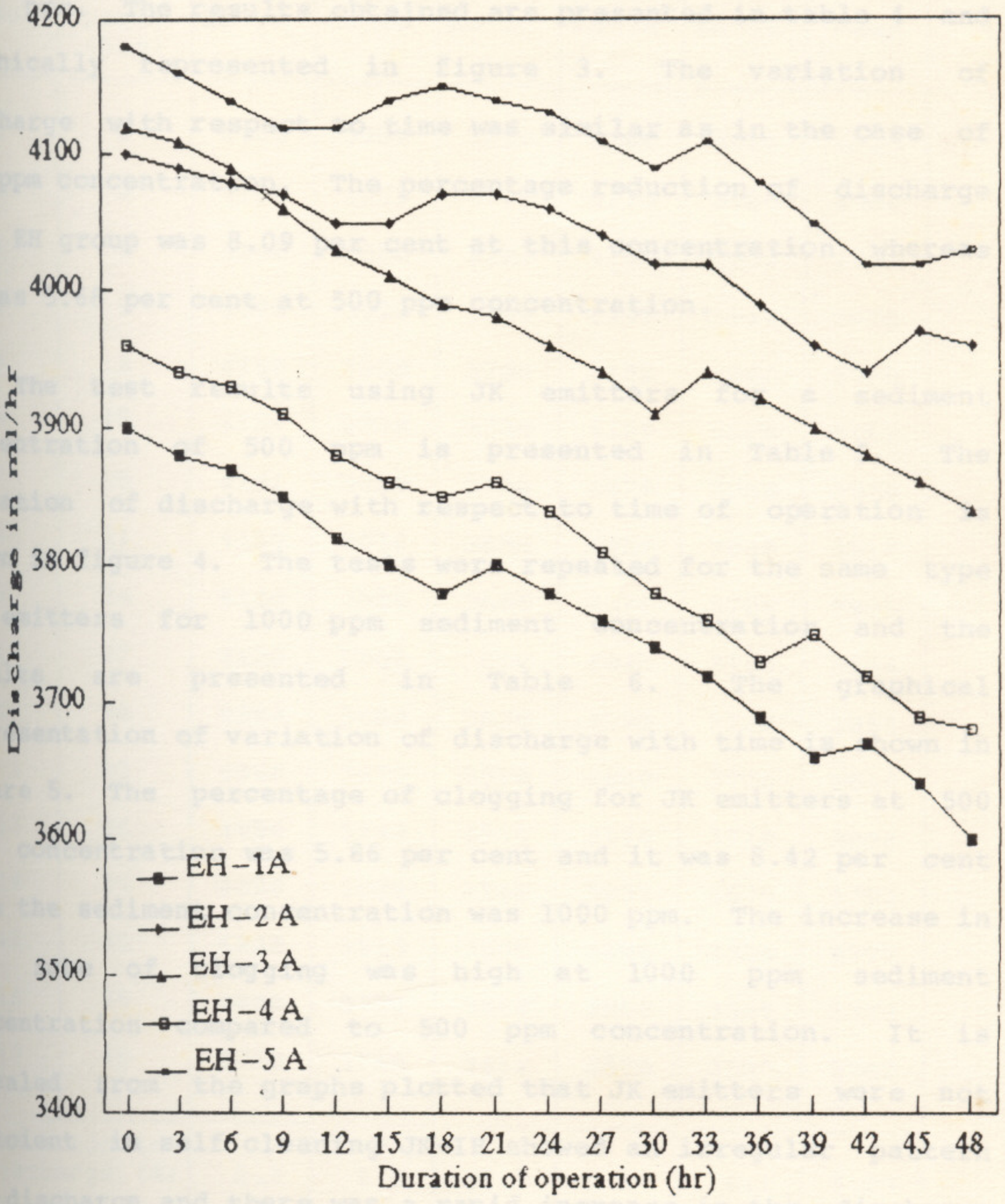

Fig. 2 DISCHARGE FROM EH EMITTERS WITH 500 ppm SEDIMENT CONCENTRATION

The tests were repeated for the sediment concentration of 1000 ppm. The results obtained are presented in table 4 and graphically represented in figure 3. The variation of discharge with respect to time was similar as in the case of 500 ppm concentration. The percentage reduction of discharge for EH group was 8.09 per cent at this concentration whereas it was 5.68 per cent at 500 ppm concentration.

The test results using JK emitters for a sediment concentration of 500 ppm is presented in Table 5. The variation of discharge with respect to time of operation is shown in figure 4. The tests were repeated for the same type of emitters for 1000 ppm sediment concentration and the results are presented in Table 6. The graphical representation of variation of discharge with time is shown in figure 5. The percentage of clogging for JK emitters at 500 ppm concentration was 5.86 per cent and it was 8.42 per cent when the sediment concentration was 1000 ppm. The increase in the rate of clogging was high at 1000 ppm sediment concentration compared to 500 ppm concentration. It is revealed from the graphs plotted that JK emitters were not efficient in self cleaning JK-IB showed an irregular pattern of discharge and there was a rapid increase in the discharge after 30 hours of operation. JK emitters were more susceptible to clogging because of the long path of flow

Table 4. DISCHARGE FROM EH EMITTERS FOR 1000 ppm SEDIMENT CONCENTRATION (CASE-B) IN ml/hr.

Sl. No.	Time of opern. (hrs)	EH-1B	EH-2B	EH-3B	EH-4B	EH-5B	Mean
1	0	4180	3980	3820	4200	3960	4028
2	3	4160	3950	3790	4170	3950	4004
3	6	4140	3950	3780	4160	3920	3990
4	9	4140	3920	3760	4140	3940	3980
5	12	4150	3950	3760	4130	3900	3978
6	15	4120	3930	3730	4100	3880	3952
7	18	4140	3900	3700	4070	3840	3930
8	21	4150	3910	3680	4050	3800	3918
9	24	4140	3880	3660	4070	3780	3906
10	27	4120	3860	3660	4040	3740	3884
11	30	4080	3860	3620	3990	3730	3856
12	33	4090	3870	3580	4000	3700	3848
13	36	4050	3840	3580	3970	3710	3830
14	39	4020	3800	3540	3930	3670	3792
15	42	4020	3810	3500	3900	3630	3772
16	45	4000	3770	3460	3860	3600	3738
17	48	3960	3760	3410	3820	3560	3702
Reduction in discharge (%)		5.3	5.5	10.7	9.0	10.1	8.09

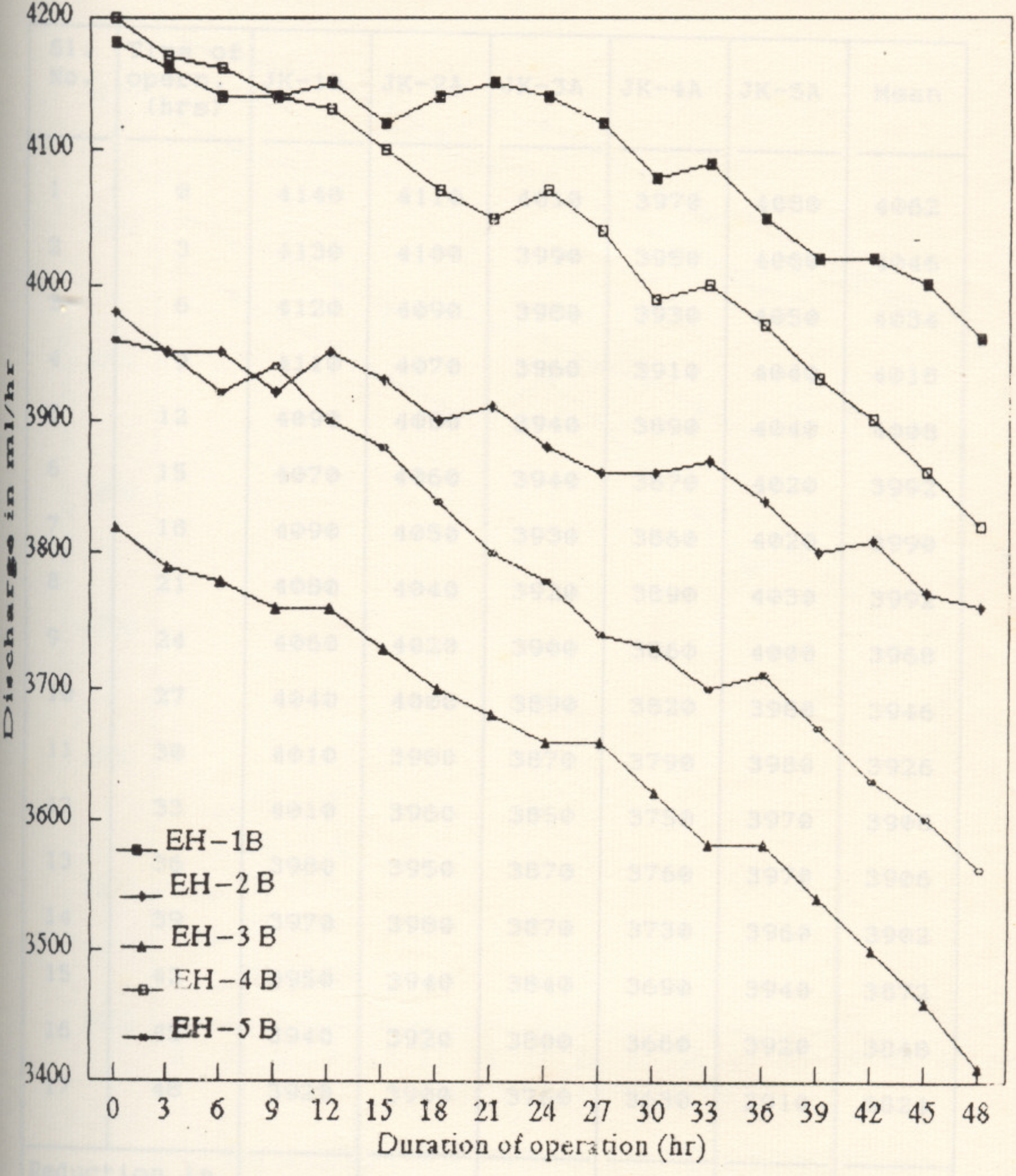

Fig. 3 DISCHARGE FROM EH EMITTERS WITH 1000 ppm SEDIMENT CONCENTRATION

Table 5. DISCHARGE FROM JK EMITTERS FOR 500 ppm SEDIMENT CONCENTRATION (CASE-A) IN ml/hr.

Sl. No.	Time of opern. (hrs)	JK-1A	JK-2A	JK-3A	JK-4A	JK-5A	Mean
1	0	4140	4110	4010	3970	4080	4062
2	3	4130	4100	3990	3950	4060	4046
3	6	4120	4090	3980	3930	4050	4034
4	9	4110	4070	3960	3910	4040	4018
5	12	4090	4080	3940	3890	4040	4008
6	15	4070	4060	3940	3870	4020	3992
7	18	4090	4050	3930	3860	4020	3990
8	21	4080	4040	3920	3890	4030	3992
9	24	4060	4020	3900	3860	4000	3968
10	27	4040	4000	3890	3820	3980	3946
11	30	4010	3980	3870	3790	3980	3926
12	33	4010	3960	3850	3750	3970	3908
13	36	3980	3950	3870	3760	3970	3906
14	39	3970	3980	3870	3730	3960	3902
15	42	3950	3940	3840	3690	3940	3872
16	45	3940	3920	3800	3660	3920	3848
17	48	3920	3900	3760	3630	3910	3824
Reduction in discharge (%)		5.3	5.1	6.2	8.6	4.2	5.9

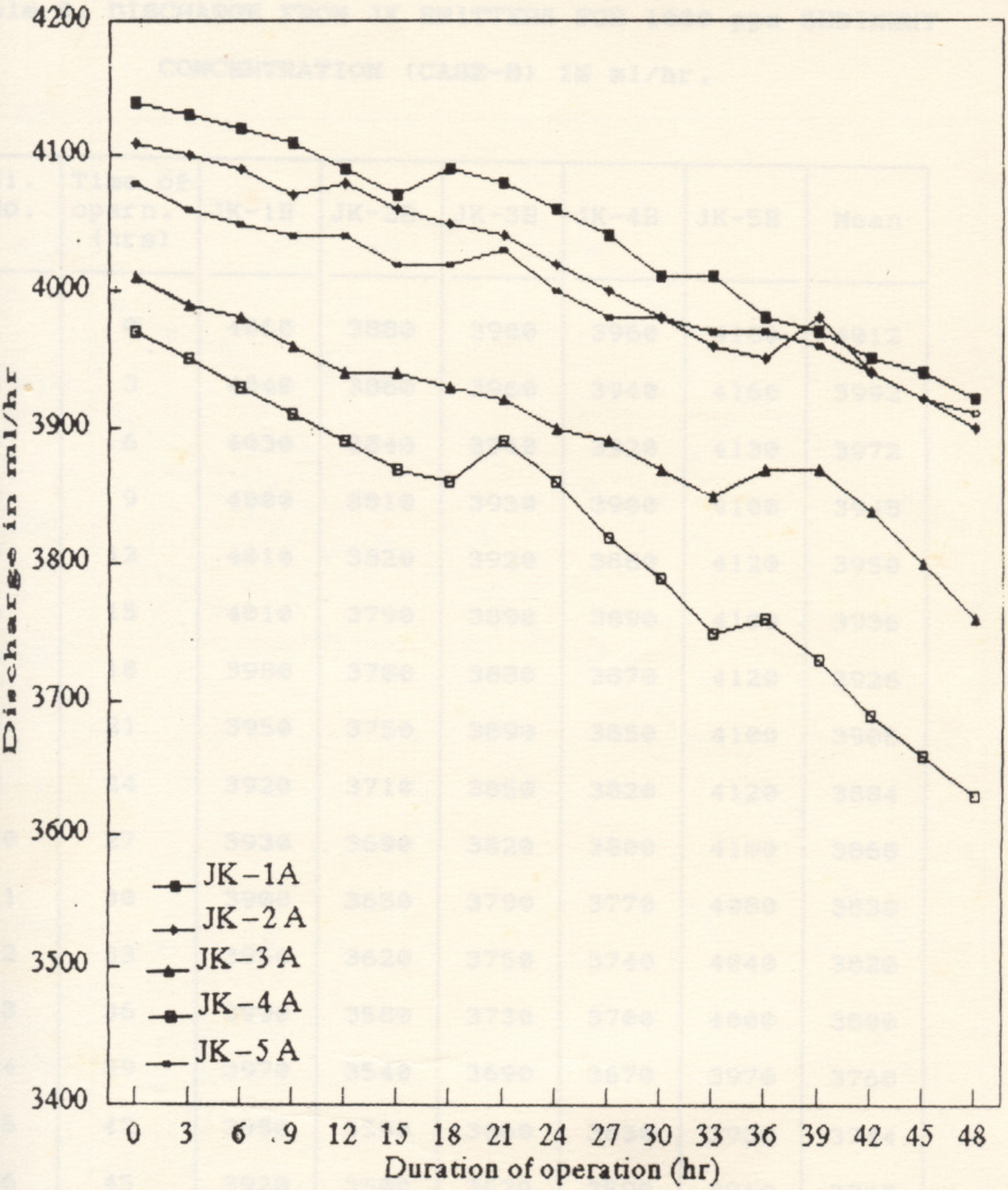

Fig. 4 DISCHARGE FROM JK EMITTERS WITH 500 ppm SEDIMENT CONCENTRATION

Table 6. DISCHARGE FROM JK EMITTERS FOR 1000 ppm SEDIMENT CONCENTRATION (CASE-B) IN ml/hr.

Sl. No.	Time of opern. (hrs)	JK-1B	JK-2B	JK-3B	JK-4B	JK-5B	Mean
1	0	4060	3880	3980	3960	4180	4012
2	3	4040	3860	3960	3940	4160	3992
3	6	4030	3840	3940	3920	4130	3972
4	9	4000	3810	3930	3900	4100	3948
5	12	4010	3820	3920	3880	4120	3950
6	15	4010	3790	3890	3890	4100	3936
7	18	3980	3780	3880	3870	4120	3926
8	21	3950	3750	3890	3850	4100	3908
9	24	3920	3710	3850	3820	4120	3884
10	27	3930	3690	3820	3800	4100	3868
11	30	3900	3650	3790	3770	4080	3838
12	33	3950	3620	3750	3740	4040	3820
13	36	3990	3580	3730	3700	4000	3800
14	39	3970	3540	3690	3670	3970	3768
15	42	3950	3550	3660	3630	3930	3744
16	45	3920	3500	3620	3590	3910	3708
17	48	3900	3450	3580	3560	3880	3674
Reduction in discharge (%)		3.9	11.1	10.1	10.1	7.2	8.4

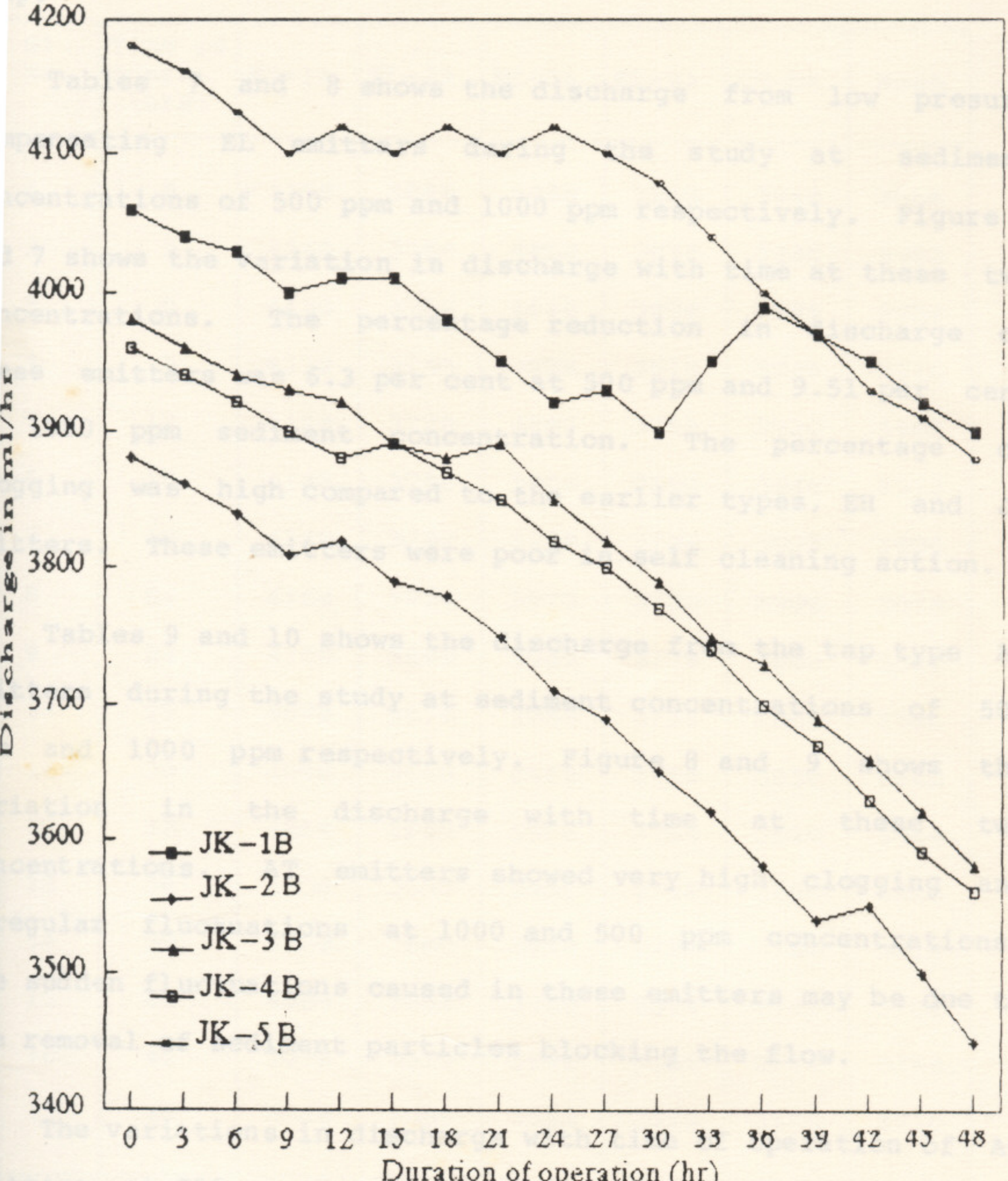

Fig. 5 DISCHARGE FROM JK EMITTERS WITH 1000 ppm SEDIMENT CONCENTRATION

inside the emitter were the sediment settles due to pressure drop.

Tables 7 and 8 shows the discharge from low presure compensating EL emitters during the study at sediment concentrations of 500 ppm and 1000 ppm respectively. Figure 6 and 7 shows the variation in discharge with time at these two concentrations. The percentage reduction in discharge of these emitters was 6.3 per cent at 500 ppm and 9.51 per cent at 1000 ppm sediment concentration. The percentage of clogging was high compared to the earlier types, EH and JK emitters. These emitters were poor in self cleaning action.

Tables 9 and 10 shows the discharge from the tap type AT emitters during the study at sediment concentrations of 500 ppm and 1000 ppm respectively. Figure 8 and 9 shows the variation in the discharge with time at these two concentrations. AT emitters showed very high clogging and irregular fluctuations at 1000 and 500 ppm concentrations. The sudden fluctuations caused in these emitters may be due to the removal of sediment particles blocking the flow.

The variations in discharge with time of operation of AO emitters at 500 ppm and 1000 ppm sediment concentrations are shown in Figure 10 and 11 respectively. Table 11 and 12 shows the discharge of AO emitters during the study at these two

Table 7. DISCHARGE FROM EL EMITTERS FOR 500 ppm SEDIMENT CONCENTRATION (CASE-A) IN ml/hr.

Sl. No.	Time of opern. (hrs)	EL-1A	EL-2A	EL-3A	EL-4A	EH-5A	Mean
1	0	4150	3800	4080	3860	3940	3966
2	3	4140	3780	4060	3850	3930	3952
3	6	4120	3760	4040	3830	3920	3934
4	9	4110	3740	4020	3810	3900	3916
5	12	4100	3720	4000	3790	3920	3906
6	15	4140	3700	3980	3800	3940	3912
7	18	4140	3700	3990	3780	3920	3906
8	21	4120	3720	3970	3780	3900	3898
9	24	4100	3690	3960	3770	3880	3880
10	27	4070	3670	3980	3750	3860	3866
11	30	4050	3640	3960	3730	3830	3842
12	33	4060	3630	3960	3750	3820	3844
13	36	4030	3590	3950	3740	3800	3822
14	39	4020	3600	3940	3720	3780	3812
15	42	4000	3560	3920	3690	3740	3782
16	45	3970	3520	3890	3660	3710	3750
17	48	3960	3480	3850	3620	3670	3716
Reduction in discharge (%)		4.6	8.4	5.6	6.2	6.9	6.3

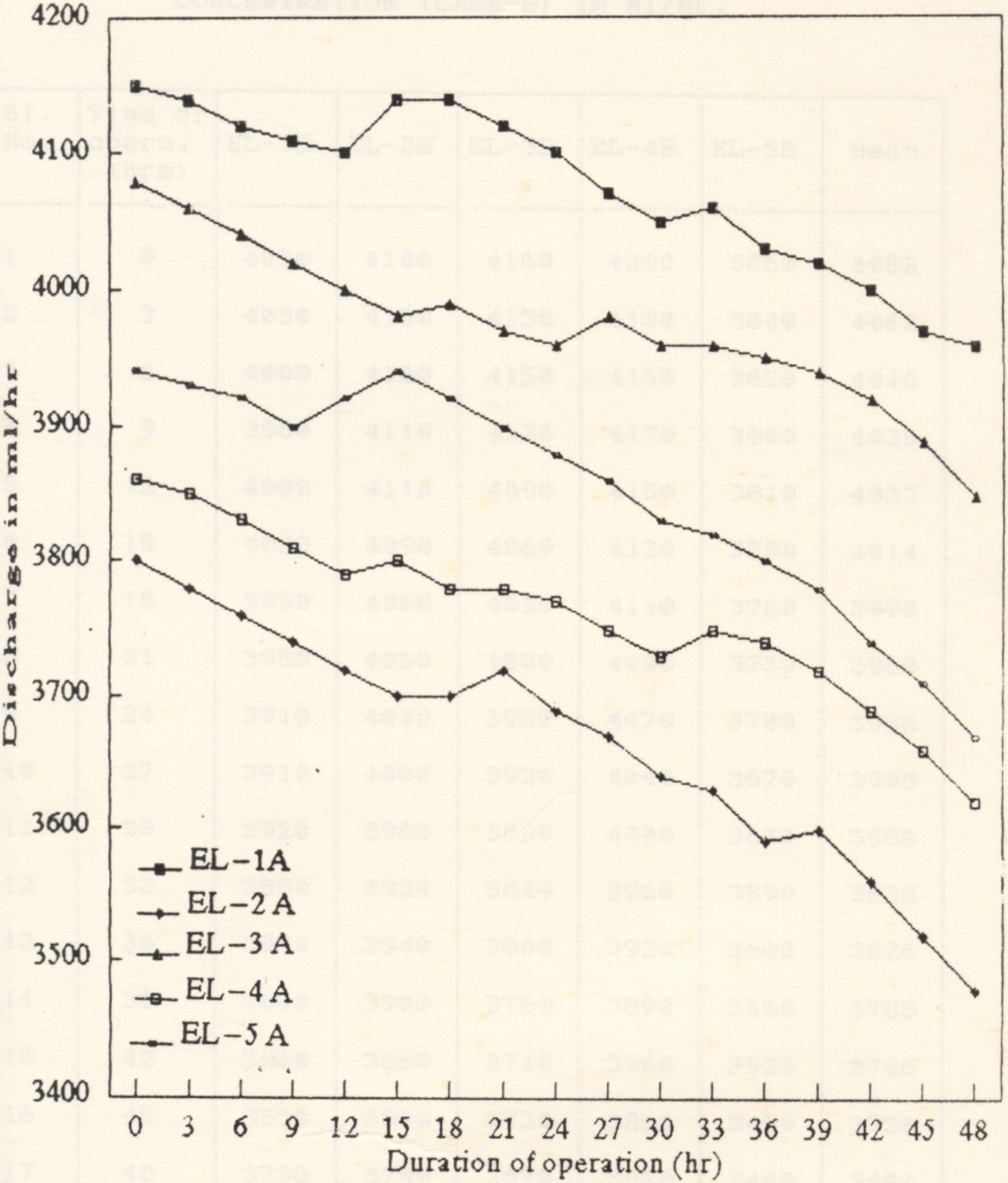

Fig. 6 DISCHARGE FROM EL EMITTERS WITH 500 ppm SEDIMENT CONCENTRATION

Table 8. DISCHARGE FROM EL EMITTERS FOR 1000 ppm SEDIMENT CONCENTRATION (CASE-B) IN ml/hr.

Sl. No.	Time of opern. (hrs)	EL-1B	EL-2B	EL-3B	EL-4B	EL-5B	Mean
1	0	4050	4140	4160	4200	3860	4082
2	3	4030	4130	4130	4180	3840	4062
3	6	4000	4100	4150	4160	3820	4046
4	9	3980	4110	4120	4170	3800	4036
5	12	4000	4110	4090	4150	3810	4032
6	15	4020	4090	4060	4120	3780	4014
7	18	3990	4060	4030	4110	3760	3990
8	21	3950	4030	4000	4090	3730	3960
9	24	3910	4040	3960	4070	3700	3936
10	27	3910	4000	3920	4040	3670	3908
11	30	3920	3960	3890	4000	3630	3880
12	33	3880	3920	3840	3960	3590	3838
13	36	3870	3940	3800	3920	3600	3826
14	39	3840	3900	3760	3890	3550	3788
15	42	3860	3860	3710	3900	3500	3766
16	45	3830	3820	3720	3860	3450	3736
17	48	3790	3790	3670	3820	3400	3694
Reduction in discharge (%)		6.4	8.4	11.8	9.0	11.9	9.5

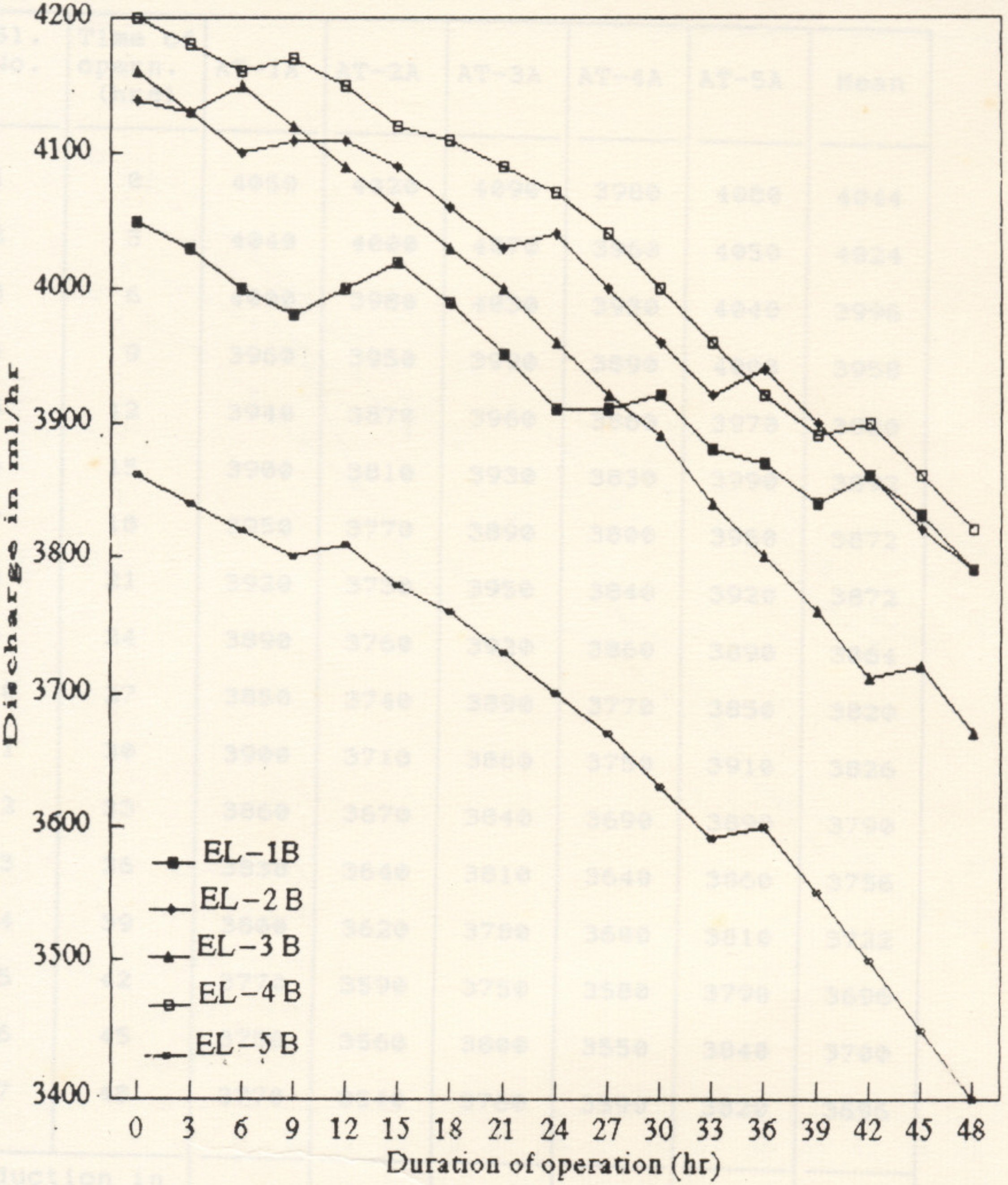

Fig. 7 DISCHARGE FROM EL EMITTERS WITH 1000 ppm SEDIMENT CONCENTRATION

Table 9. DISCHARGE FROM AT EMITTERS FOR 500 ppm SEDIMENT CONCENTRATION (CASE-A) IN ml/hr.

Sl. No.	Time of opern. (hrs)	AT-1A	AT-2A	AT-3A	AT-4A	AT-5A	Mean
1	0	4050	4020	4090	3980	4080	4044
2	3	4040	4000	4070	3960	4050	4024
3	6	4000	3980	4030	3930	4040	3996
4	9	3960	3950	3990	3890	4000	3958
5	12	3940	3870	3960	3860	3970	3920
6	15	3900	3810	3930	3830	3990	3892
7	18	3950	3770	3890	3800	3950	3872
8	21	3920	3730	3950	3840	3920	3872
9	24	3890	3760	3920	3860	3890	3864
10	27	3850	3740	3890	3770	3850	3820
11	30	3900	3710	3860	3750	3910	3826
12	33	3860	3670	3840	3690	3890	3790
13	36	3830	3640	3810	3640	3860	3756
14	39	3800	3620	3780	3600	3810	3722
15	42	3770	3590	3750	3580	3790	3696
16	45	3750	3560	3800	3550	3840	3700
17	48	3770	3540	3760	3590	3820	3696
Reduction in discharge (%)		6.9	11.9	8.1	9.8	6.4	8.6

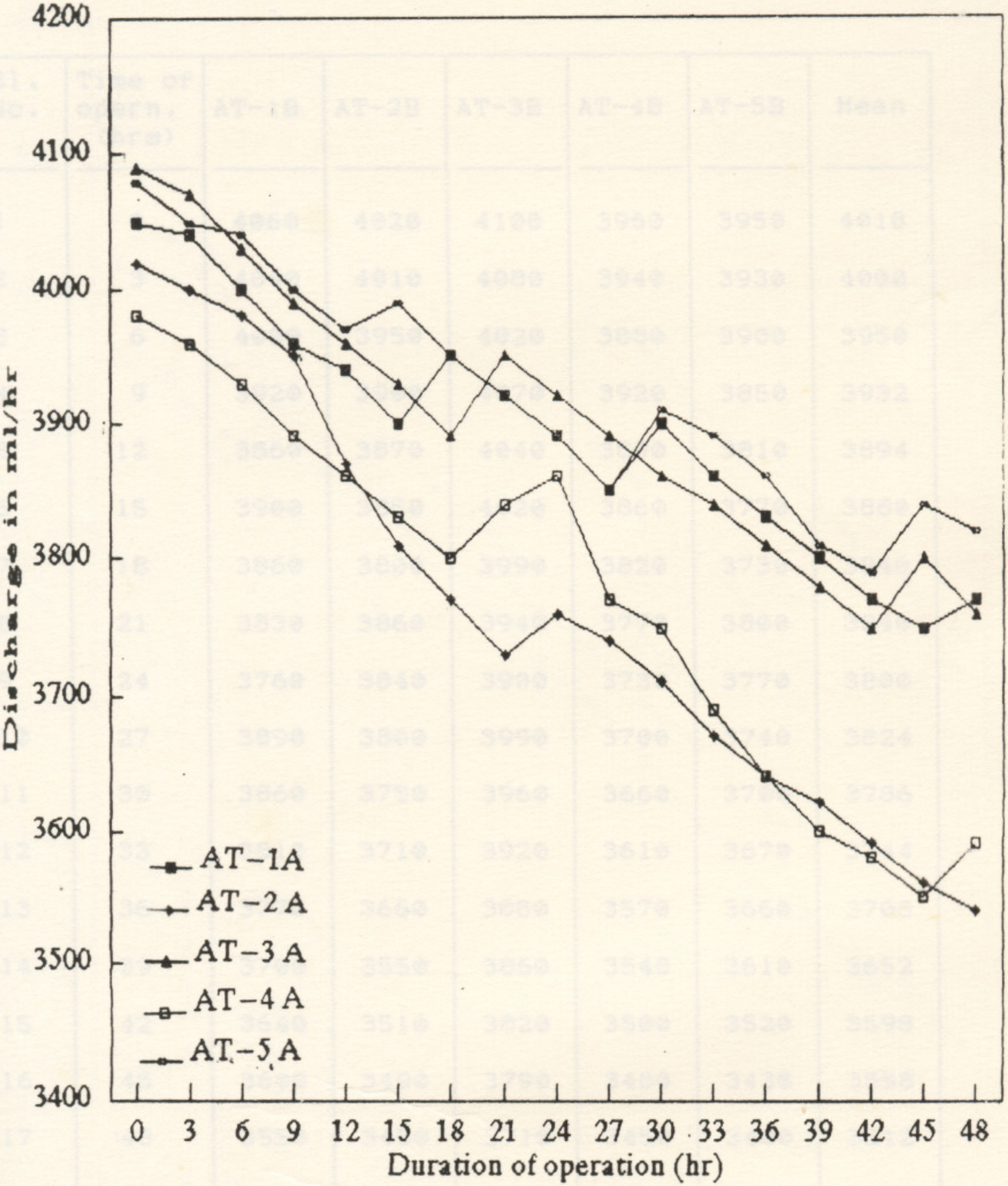

Fig. 8 DISCHARGE FROM AT EMITTERS WITH 500 ppm
SEDIMENT CONCENTRATION

Table 10. DISCHARGE FROM AT EMITTERS FOR 1000 ppm SEDIMENT CONCENTRATION (CASE-B) IN ml/hr.

Sl. No.	Time of opern. (hrs)	AT-1B	AT-2B	AT-3B	AT-4B	AT-5B	Mean
1	0	4060	4020	4100	3960	3950	4018
2	3	4040	4010	4080	3940	3930	4000
3	6	4000	3950	4020	3880	3900	3950
4	9	3920	3900	4070	3920	3850	3932
5	12	3860	3870	4040	3890	3810	3894
6	15	3900	3850	4020	3860	3770	3880
7	18	3860	3800	3990	3820	3730	3840
8	21	3830	3860	3940	3770	3800	3840
9	24	3760	3840	3900	3730	3770	3800
10	27	3890	3800	3990	3700	3740	3824
11	30	3860	3750	3960	3660	3700	3786
12	33	3810	3710	3920	3610	3670	3744
13	36	3770	3660	3880	3570	3660	3708
14	39	3700	3550	3860	3540	3610	3652
15	42	3640	3510	3820	3500	3520	3598
16	45	3600	3490	3790	3480	3430	3558
17	48	3550	3450	3710	3450	3400	3512
Reduction in discharge (%)		12.6	14.2	9.5	12.9	13.9	12.6

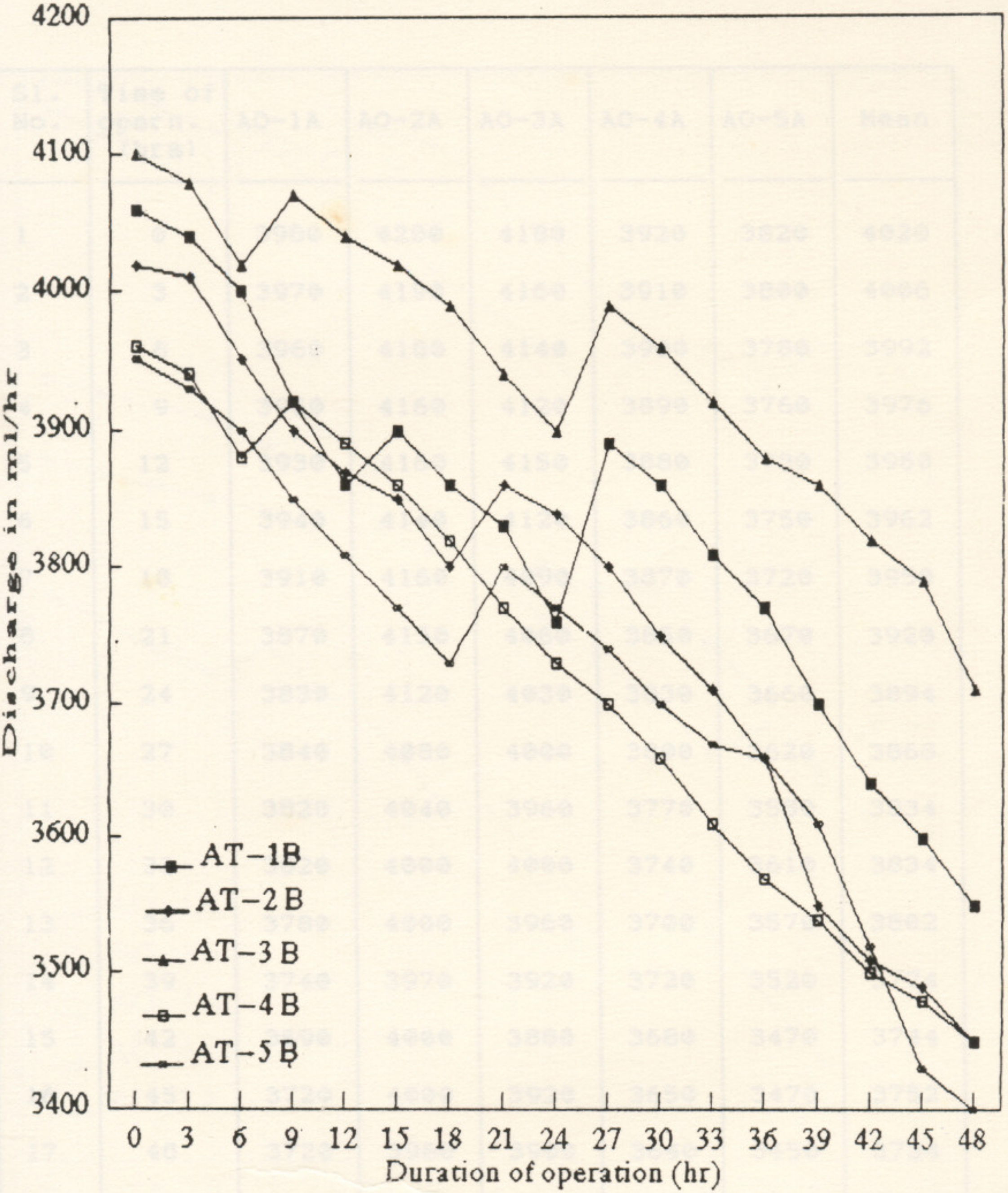

Fig. 9 DISCHARGE FROM AT EMITTERS WITH 1000 ppm SEDIMENT CONCENTRATION

Table 11. DISCHARGE FROM AO EMITTERS FOR 500 ppm SEDIMENT CONCENTRATION (CASE-A) IN ml/hr.

Sl. No.	Time of opern. (hrs)	AO-1A	AO-2A	AO-3A	AO-4A	AO-5A	Mean
1	0	3980	4200	4180	3920	3820	4020
2	3	3970	4190	4160	3910	3800	4006
3	6	3960	4180	4140	3900	3780	3992
4	9	3950	4160	4120	3890	3760	3976
5	12	3930	4160	4150	3880	3780	3980
6	15	3940	4140	4120	3860	3750	3962
7	18	3910	4160	4090	3870	3720	3950
8	21	3870	4150	4060	3850	3670	3920
9	24	3830	4120	4030	3830	3660	3894
10	27	3840	4080	4000	3800	3620	3868
11	30	3820	4040	3960	3770	3580	3834
12	33	3820	4000	4000	3740	3610	3834
13	36	3780	4000	3960	3700	3570	3802
14	39	3740	3970	3920	3720	3520	3774
15	42	3690	4000	3880	3680	3470	3744
16	45	3720	4000	3920	3650	3470	3752
17	48	3720	3960	3900	3640	3450	3734
Reduction in discharge (%)		6.5	5.7	4.5	7.1	9.6	7.1

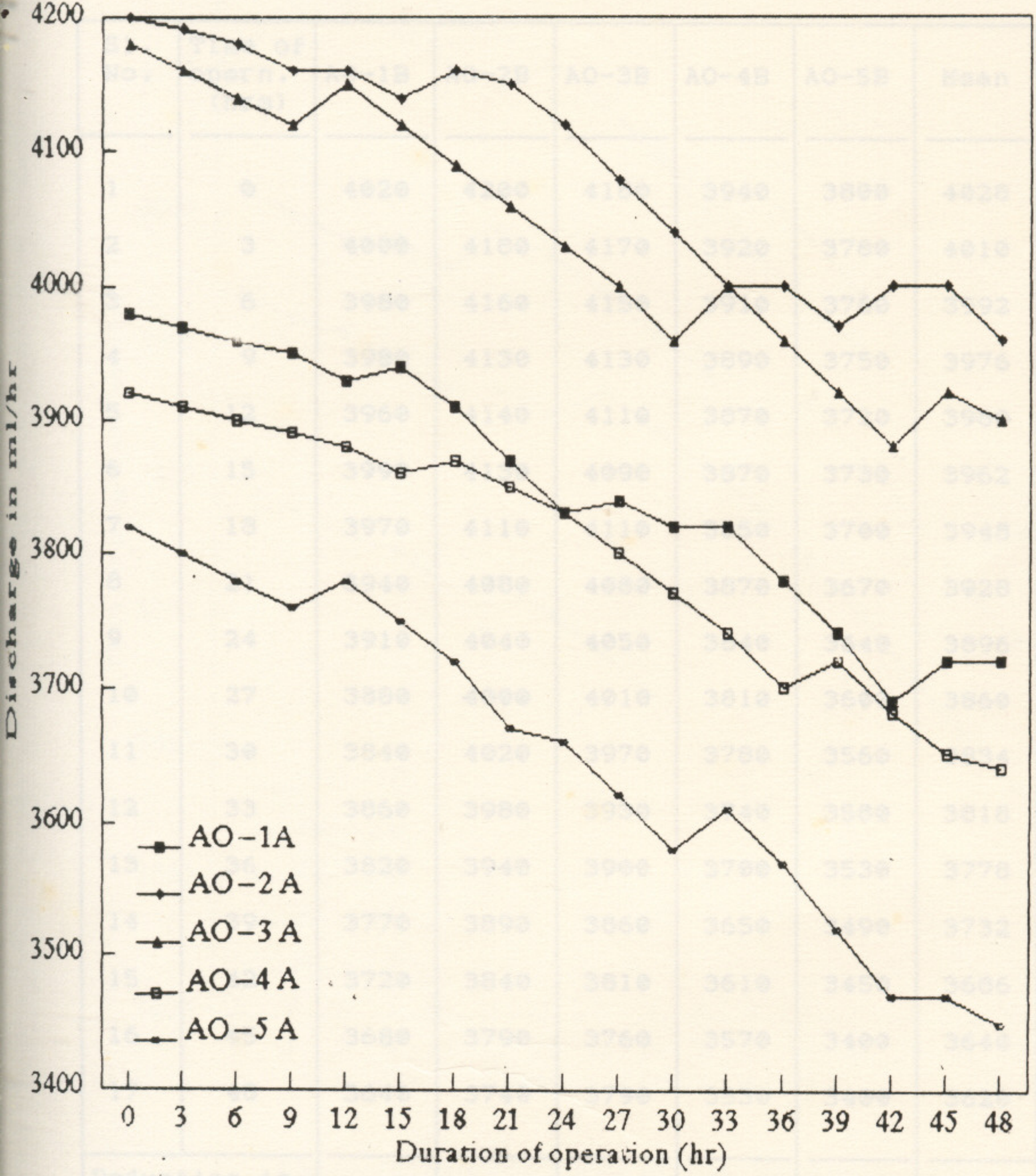

Fig. 10 DISCHARGE FROM AO EMITTERS WITH 500 ppm SEDIMENT CONCENTRATION

Table 12. DISCHARGE FROM AO EMITTERS FOR 1000 ppm SEDIMENT CONCENTRATION (CASE-B) IN ml/hr.

Sl. No.	Time of opern. (hrs)	AO-1B	AO-2B	AO-3B	AO-4B	AO-5B	Mean
1	0	4020	4200	4180	3940	3800	4028
2	3	4000	4180	4170	3920	3780	4010
3	6	3980	4160	4150	3910	3760	3992
4	9	3980	4130	4130	3890	3750	3976
5	12	3960	4140	4110	3870	3720	3960
6	15	3990	4130	4090	3870	3730	3962
7	18	3970	4110	4110	3850	3700	3948
8	21	3940	4080	4080	3870	3670	3928
9	24	3910	4040	4050	3840	3640	3896
10	27	3880	4000	4010	3810	3600	3860
11	30	3840	4020	3970	3780	3560	3834
12	33	3860	3980	3930	3740	3580	3818
13	36	3820	3940	3900	3700	3530	3778
14	39	3770	3890	3860	3650	3490	3732
15	42	3720	3840	3810	3610	3450	3686
16	45	3680	3790	3760	3570	3400	3640
17	48	3640	3740	3790	3530	3400	3620
Reduction in discharge (%)		9.4	10.9	9.3	10.4	10.5	10.1

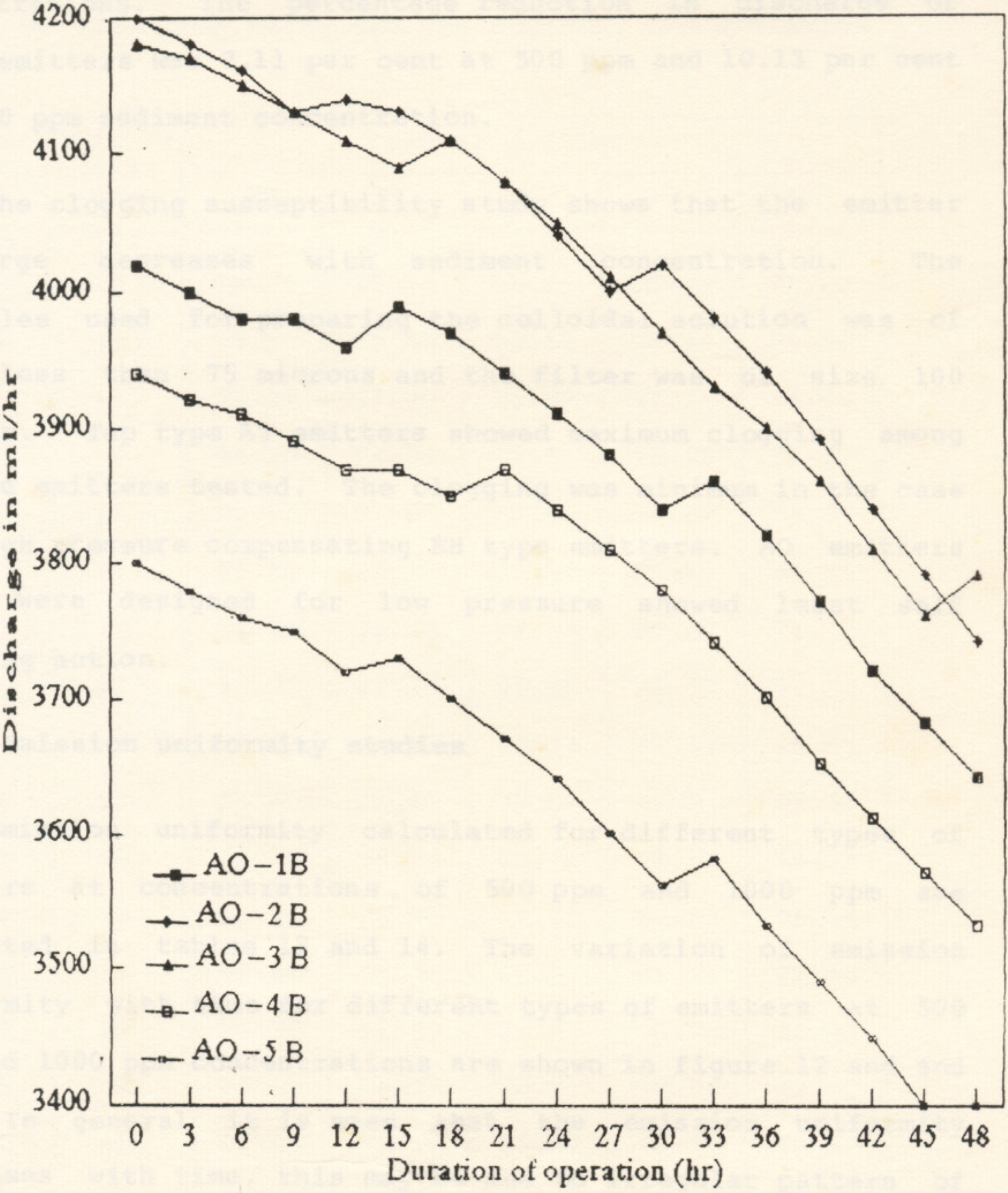

Fig. 11 DISCHARGE FROM AO EMITTERS WITH 1000 ppm SEDIMENT CONCENTRATION

concentrations. The percentage reduction in discharge of these emitters was 7.11 per cent at 500 ppm and 10.13 per cent at 1000 ppm sediment concentration.

The clogging susceptibility study shows that the emitter discharge decreases with sediment concentration. The particles used for preparing the colloidal solution was of size less than 75 microns and the filter was of size 100 microns. Tap type AT emitters showed maximum clogging among all the emitters tested. The clogging was minimum in the case of high pressure compensating EH type emitters. AO emitters which were designed for low pressure showed least self cleaning action.

4.2 Emission uniformity studies

Emission uniformity calculated for different types of emitters at concentrations of 500 ppm and 1000 ppm are presented in tables 13 and 14. The variation of emission uniformity with time for different types of emitters at 500 ppm and 1000 ppm concentrations are shown in figure 12 and and 13. In general it is seen that the emission uniformity decreases with time, this may be due to irregular pattern of clogging and self cleaning.

Emission uniformity of EH emitter showed very small fluctuations and it reduced to 94.19 per cent from the initial

Table 13. VARIATION OF EMISSION UNIFORMITY DURING 48 HOURS OF OPERATION USING 500 ppm SEDIMENT CONCENTRATION

Sl. No.	Time of opern. (hrs)	Type of emitter				
		EH	JK	EL	AT	AO
1	0	96.25	97.74	95.81	98.42	95.02
2	3	96.13	97.63	95.65	98.41	94.86
3	6	96.22	97.42	95.58	98.35	94.69
4	9	96.20	97.31	95.51	98.28	94.57
5	12	95.98	97.06	95.24	98.47	94.97
6	15	95.67	96.94	94.58	97.89	94.65
7	18	95.26	96.74	94.73	97.37	94.18
8	21	95.72	97.44	95.43	96.33	93.62
9	24	95.60	97.28	95.10	97.31	93.99
10	27	95.63	96.81	94.93	97.91	93.59
11	30	95.70	96.54	94.74	96.97	93.38
12	33	95.14	95.96	94.43	96.83	94.16
13	36	95.05	96.26	93.93	96.91	93.90
14	39	94.72	95.59	94.44	96.72	93.27
15	42	95.42	95.30	94.13	96.86	92.68
16	45	94.89	95.11	93.87	95.95	92.48
17	48	94.19	94.93	93.65	95.78	92.39

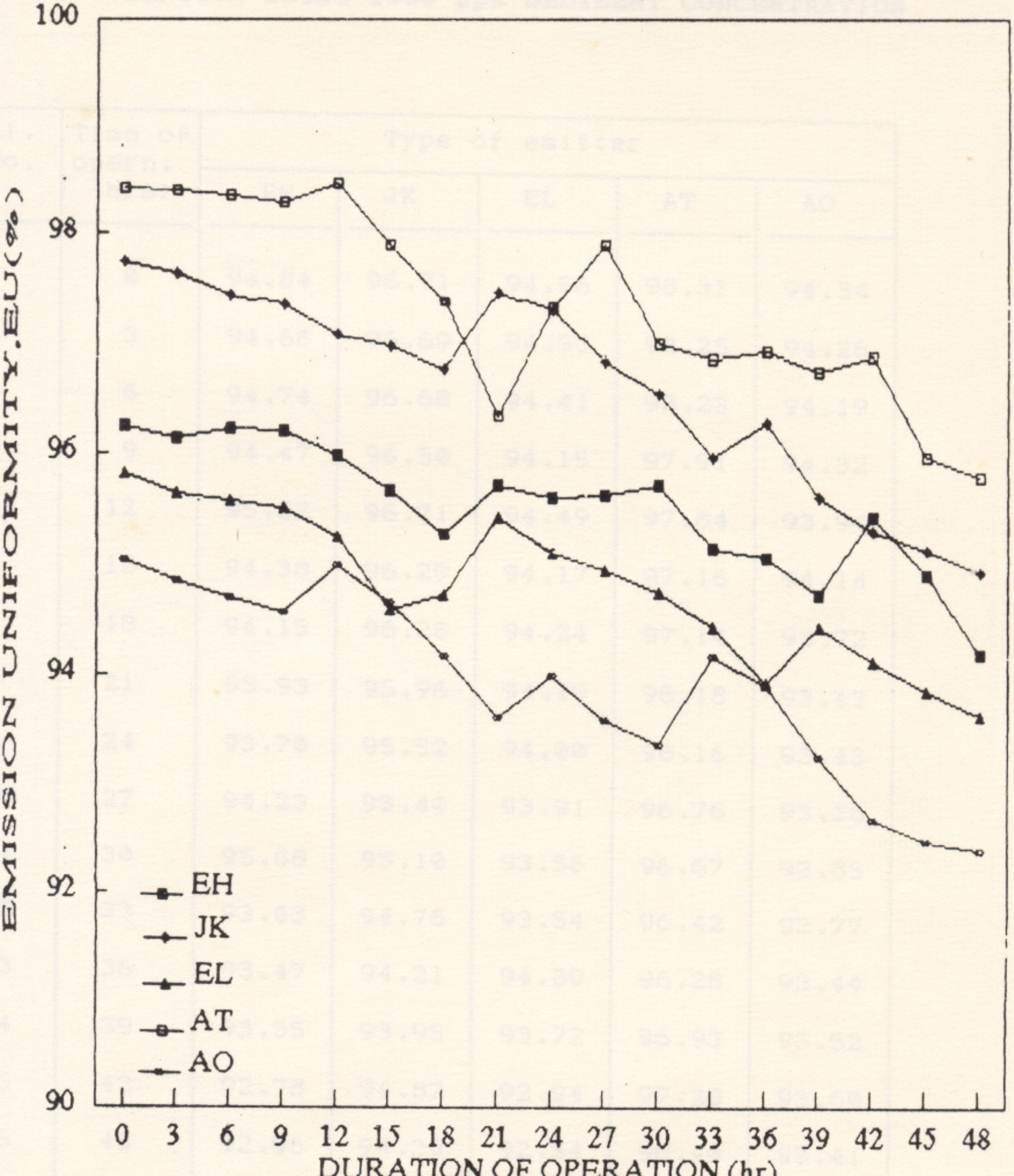

Fig. 12 VARIATION OF EMISSION UNIFORMITY DURING 48 HOURS OF OPERATION USING 500 ppm

Table 14. VARIATION OF EMISSION UNIFORMITY DURING 48 HOURS OF OPERATION USING 1000 ppm SEDIMENT CONCENTRATION

Sl. No.	Time of opern. (hrs)	Type of emitter				
		EH	JK	EL	AT	AO
1	0	94.84	96.71	94.56	98.31	94.34
2	3	94.66	96.69	94.53	98.25	94.26
3	6	94.74	96.68	94.41	98.23	94.19
4	9	94.47	96.50	94.15	97.91	94.32
5	12	95.52	96.71	94.49	97.84	93.94
6	15	94.38	96.29	94.17	97.16	94.14
7	18	94.15	96.28	94.24	97.14	93.72
8	21	93.93	95.96	94.19	98.18	93.43
9	24	93.70	95.52	94.00	98.16	93.43
10	27	94.23	95.40	93.91	96.76	93.26
11	30	95.88	95.10	93.56	96.67	92.85
12	33	93.03	94.76	93.54	96.42	93.77
13	36	93.47	94.21	94.09	96.28	93.44
14	39	93.35	93.95	93.72	96.93	93.52
15	42	92.78	94.82	92.94	97.28	93.60
16	45	92.56	94.39	92.34	96.40	93.41
17	48	92.11	93.90	92.04	96.81	93.92

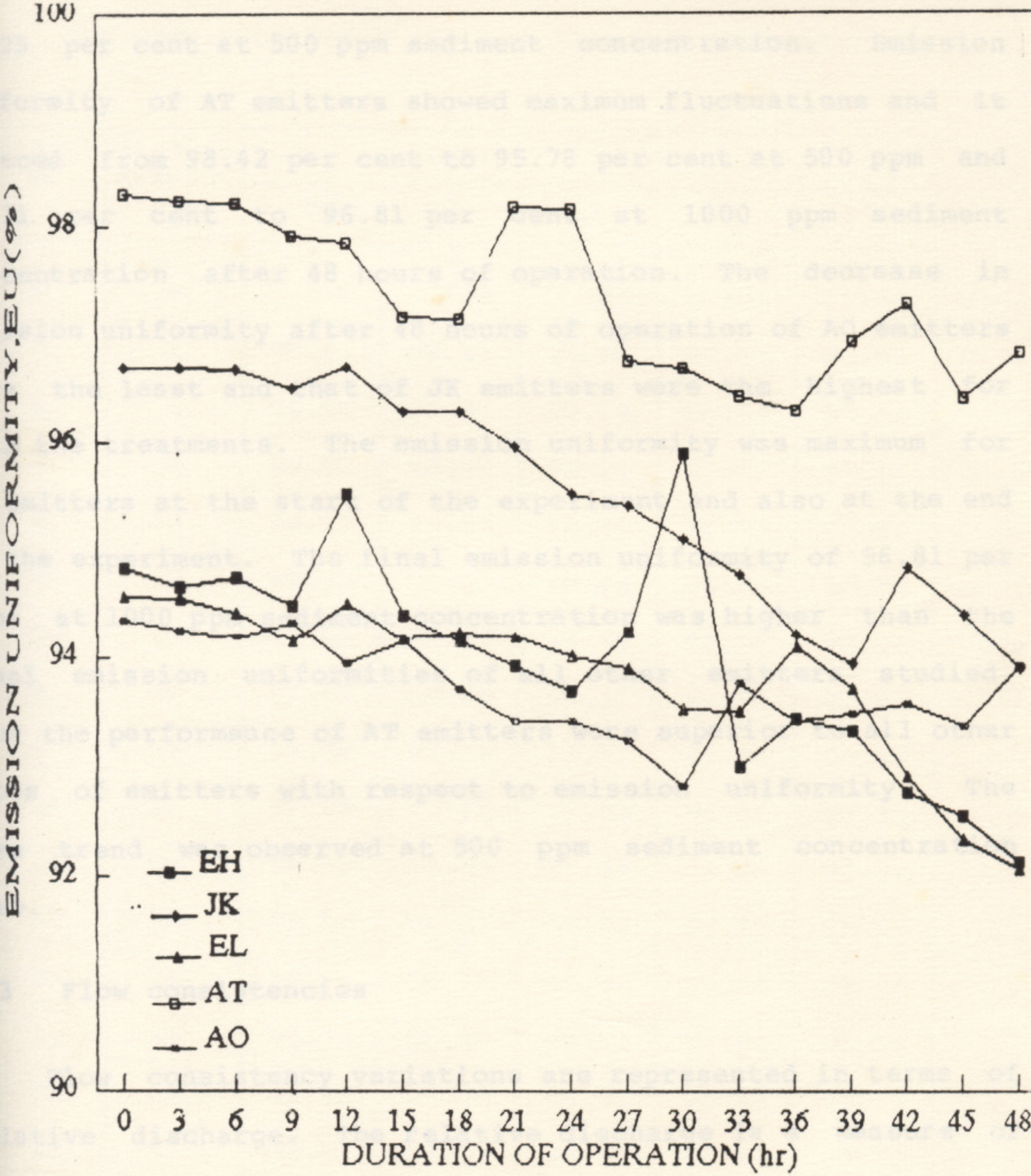

Fig. 13 VARIATION OF EMISSION UNIFORMITY DURING 48 HOURS OF OPERATION USING 1000 ppm

96.25 per cent at 500 ppm sediment concentration. Emission uniformity of AT emitters showed maximum fluctuations and it reduced from 98.42 per cent to 95.78 per cent at 500 ppm and 98.31 per cent to 96.81 per cent at 1000 ppm sediment concentration after 48 hours of operation. The decrease in emission uniformity after 48 hours of operation of AO emitters were the least and that of JK emitters were the highest for both the treatments. The emission uniformity was maximum for AT emitters at the start of the experiment and also at the end of the experiment. The final emission uniformity of 96.81 per cent at 1000 ppm sediment concentration was higher than the final emission uniformities of all other emitters studied. Thus the performance of AT emitters were superior to all other types of emitters with respect to emission uniformity. The same trend was observed at 500 ppm sediment concentration also.

4.3 Flow consistencies

Flow consistency variations are represented in terms of relative discharge. The 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 at sediment concentrations of 500 ppm and 1000 ppm are shown in tables 15 and 16. Graphical representations of the changes in relative

Table 15. RELATIVE DISCHARGE OF EMITTERS DURING 48 HOURS OF OPERATION USING 500 ppm SEDIMENT CONCENTRATION

Sl. No.	Time of opern. (hrs)	Type of emitter				
		EH	JK	EL	AT	AO
1	0	100	100	100	100	100
2	3	99.61	99.61	99.65	99.51	99.65
3	6	99.26	99.31	99.19	98.81	99.30
4	9	98.77	98.92	98.74	97.87	98.91
5	12	98.22	98.67	98.49	96.93	99.00
6	15	98.03	98.28	98.64	96.24	98.56
7	18	97.93	98.23	98.49	95.75	98.26
8	21	97.98	98.28	98.29	95.75	97.51
9	24	97.58	97.69	97.83	95.55	96.87
10	27	97.04	97.14	97.48	94.46	96.22
11	30	96.45	96.65	96.87	94.61	95.37
12	33	96.50	96.21	96.92	93.72	95.37
13	36	95.80	96.16	96.37	92.88	94.58
14	39	95.36	96.06	96.12	92.04	93.88
15	42	94.92	95.32	95.36	91.39	93.13
16	45	94.67	94.73	94.55	91.49	93.33
17	48	94.32	94.14	93.70	91.39	92.89

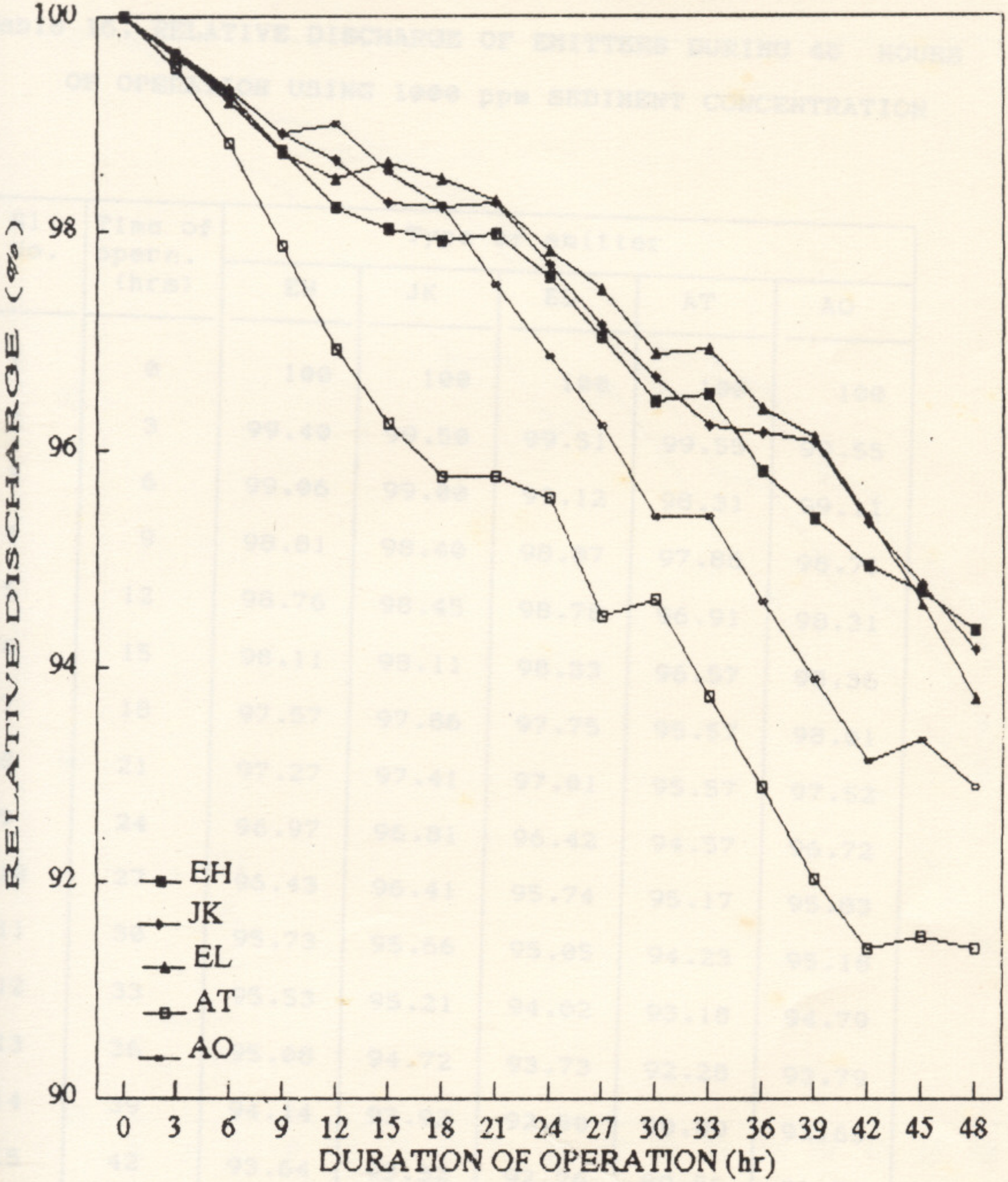

Fig. 14 RELATIVE DISCHARGE OF EMITTERS DURING 48 HOURS OF OPERATION USING 500 ppm

Table 16. RELATIVE DISCHARGE OF EMITTERS DURING 48 HOURS OF OPERATION USING 1000 ppm SEDIMENT CONCENTRATION

Sl. No.	Time of opern. (hrs)	Type of emitter				
		EH	JK	EL	AT	AO
1	0	100	100	100	100	100
2	3	99.40	99.50	99.51	99.55	99.55
3	6	99.06	99.00	99.12	98.31	99.11
4	9	98.81	98.40	98.87	97.86	98.71
5	12	98.76	98.45	98.78	96.91	98.31
6	15	98.11	98.11	98.33	96.57	98.36
7	18	97.57	97.86	97.75	95.57	98.01
8	21	97.27	97.41	97.01	95.57	97.52
9	24	96.97	96.81	96.42	94.57	96.72
10	27	96.43	96.41	95.74	95.17	95.83
11	30	95.73	95.66	95.05	94.23	95.18
12	33	95.53	95.21	94.02	93.18	94.79
13	36	95.08	94.72	93.73	92.28	93.79
14	39	94.14	93.92	92.80	90.89	92.65
15	42	93.64	93.32	92.26	89.55	91.51
16	45	92.80	92.42	91.52	88.55	90.37
17	48	91.91	91.58	90.49	87.41	89.87

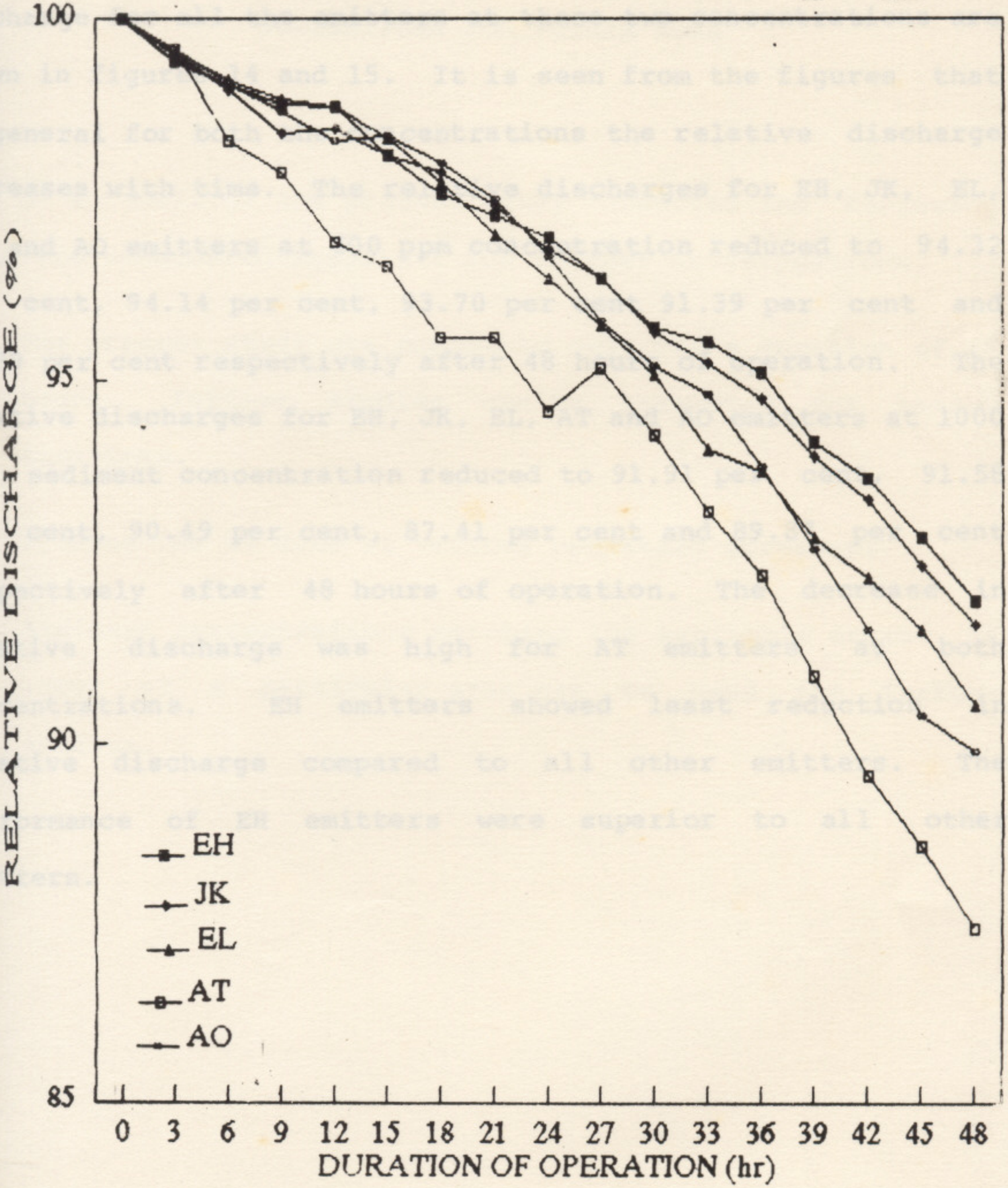

Fig. 15 RELATIVE DISCHARGE OF EMITTERS DURING 48 HOURS OF OPERATION USING 1000 ppm

discharge for all the emitters at these two concentrations are shown in figures 14 and 15. It is seen from the figures that in general for both the concentrations the relative discharge decreases with time. The relative discharges for EH, JK, EL, AT and AO emitters at 500 ppm concentration reduced to 94.32 per cent, 94.14 per cent, 93.70 per cent 91.39 per cent and 92.89 per cent respectively after 48 hours of operation. The relative discharges for EH, JK, EL, AT and AO emitters at 1000 ppm sediment concentration reduced to 91.91 per cent, 91.58 per cent, 90.49 per cent, 87.41 per cent and 89.87 per cent respectively after 48 hours of operation. The decrease in relative discharge was high for AT emitters at both concentrations. EH emitters showed least reduction in relative discharge compared to all other emitters. The performance of EH emitters were superior to all other emitters.

SUGGESTIONS FOR FUTURE WORK

As a result of the present study conducted the following areas are considered important for further investigations.

1) The present study was conducted only for a duration of 48 hours. Further studies can be attempted for longer durations.

2) Studies can be done at various operating pressures.

3) Sediment concentrations matching the available source of water at a particular area can be used for further studies.

SUMMARY

Drip irrigation has immense potential for water saving nd complete irrigation management and also for overcoming the rawbacks of surface methods of irrigation. Drip irrigation s a recent development in irrigation methods. It is the ontrolled and uniform drop by drop application of water at he plant root zone through emission points. The common and erious problem associated with drip irrigation is the logging of emitters. Emitter clogging is caused by physical, hemical and biological factors. The common physical factors re suspended clay, silt and sand.

An attempt is made here to study the clogging problem ssociated with drip emitters with objective of comparing the logging in emitters of different types. The experiment was onducted in the Soil and Water laboratory of KCAET, Tavanur.

A drip emitter test rig was developed for testing emitter logging in the laboratory. The test rig consisted of an erating tank, water supply unit, control unit, filter, main ne, laterals and emitters. Emitters of five different types mely high pressure compensating (EH), long path type (JK), w pressure compensating (EL), tap type adjustable emitter T) and long path type for low pressure (AO) were used in this study. Tests were conducted for sediment concentrations of 1000 ppm and 500 ppm of irrigation water. The sediments were of size less than 75 micron. The experiment was conducted for a total duration of 48 working hours spread over 16 days with three working hours per day for each concentration. The operating presure was 1 kg/cm^2.

Emitter discharges after each three hour duration were measured to study the extent of emitter clogging. The emitter discharge varied with time of operation for all the emitters studied. The average percentages of clogging were 5.68, 5.86, 6.3, 8.6 and 7.11 for EH, JK, EL, AT and AO at 500 ppm concentration. At 1000 ppm concentration the respective clogging percentages were 8.09, 8.42, 9.51, 12.6 and 10.13. Clogging was maximum in the case of tap type AT emitters where as it was minimum in the case of high pressure compensating EH type emitters.

Emission uniformities were calculated for all types of emitters at concentrations of 500 ppm and 1000 ppm. Emission uniformity of EH emitters showed very small fluctuations and it reduced to 94.19 per cent from the initial 96.25 per cent at 500 ppm concentration.AT emitters showed maximum fluctuations and it reduced to 95.78 per cent from the initial 98.42 per cent at 1000 ppm concentration. The decrease in emission uniformity was the least for AO emitters and it was maximum for JK emitters. Considering emission uniformity alone the performance of AT emitters was superior to other types.

Flow consistency studies were conducted for various types of drip emitters. Flow consistencies are represented in terms of relative discharge. It was found that relative discharge decreased with time for all the emitters. The relative discharges for EH, JK, EL, AT and AO emitters at 500 ppm concentration reduced to 94.32, 94.14, 93.70, 91.39 and 92.89 per cent in 48 hours. At 1000 ppm concentration the respective final relative discharges were 91.91, 91.58, 90,49, 87.41 and 89.87 per cent. Decrease in relative discharge was high for AT emitters at both concentrations. EH emitters showed least reduction in relative discharge.

As a result of the present study it was observed that adjustable tap type AT emitters were more susceptible to clogging compared to all other types and the high pressure compensating EH type was least susceptible to clogging. EH emitters showed very small fluctuations in emission uniformity but initial and final emission uniformities were higher for AT emitters. AT emitters showed maximum reduction in relative discharge but in the case of EH emitters the reduction in relative discharge was low. Thus it is seen that the high pressure compensating EH emitters performed superior to all other types of emitters studied.

REFERENCES

*Abbot. J.S. (1985). Emitter clogging - causes and prevention. Report by ICID Group on micro irrigation ICID Bulletin (1985) **34** (2): 11-20

Adin, A. and Sacks, M. (1991). Dripper-clogging factors in waste water irrigation. Journal of Irrigation and Drainage 117 (6): 813-820

Bhullar, N.S. (1988). A laboratory investigation of emitter clogging using sediment laden water M.Sc thesis. Cranfield Istitute of Technology.

Bucks, D.A., Nakayama, F.S. and Gilbert, R.G. (1979). Trickle irrigation water quality and preventive maintenance. Agric. Water Management 2: 149-162

Bucks, D.A., Nakayama, F.S. and Warwick, A.W. (1982). Pricniples, practices and potentialities of trickle (drip) irrigation. Advances in Irrig. 1: 219-298

*Calder, T. (1988). Iron control in water. Fourth Intern. Micro. Irrig. Congr. 4 A-3.

*Decroix, M. and Malaval, A. (1985). Laboratory evaluation of trickle irrigation equipment for field system design. Proceedings of Third Intern. Drip Irrig.Congr. 1: 325-330

Ford, H.W., Tucker, D.P.H. (1974). Clogging of drip systems from metabolic products of iron and sulfur bacteria. Second Intern. Drip Irrig. Congr. Proc. San Diego. 212-214

*Ford, H.W. and Tucker, D.P.H. (1975). Blockage of drip irrigation filters and emitters by iron-sulfur bacterial products. Hortic. Science 10: 62-64

Ford, H.W. (1977). Controlling certain types of slime clogging in drip/trickle systems. Proc. of 7th Intern. Agric. Plastic Congr. San Diego. 118-123

Ford, H.W. (1977). The importance of water quality in drip/trickle irrigation systems. Proc. Intern. Soc. Citriculture 1: 184

Giay, M.A. and Zelenka, R.F. (1988). Economic variations in drip irrigation systems with different types of emitters. Proc. 15th ICID European Regional Conference, Yugoslavia (3): 45-54

Gilbert, R.G., Nayakama F.S., Bucks, D.A., French, O.F. and Adamson, K.C. (1981). Trickle irrigation: Emitter clogging and other flow problems. Agric. Water Management 3: 159-178

Gilbert, R.G. and Ford, H.W. (1986). Emitter clogging. In: Nakayama, F.S., Bucks, D.A. (eds). Trickle irrigation for crop production-design, operation and management. Elsevier. Amsterdam. pp 142.

*Goldberg, D., Gormat, B. and Rimon, D. (1976). Drip irrigation principles, design and agricultural practices. Drip Irrigation Scientific Publications Kfar Shmaryahu, Israel.

Hills David, J., Nawar Fakher, M. and Waller Peter, M. (1989). Effect of Chemical clogging on drip irrigation uniformity . Tr. ASAE 33 (4): 1202-1206

Jackson, R.C. and Kay, M.G. (1987). Use of pulse irrigation for reducing clogging problems in trickle emitters. The British Soc. for Res. in Agric. Engng. 223-227

Janney, J. (1980). Clogging suceptibility of trickle emitters. ASAE Paper No.80-2062:6

Karmelli, D. and Keller, J. (1974). Evaluation of trickle irrigation system. Proc. of Second Intern. Drip Irrig. Congr. San Diego. 287-292

*Kinoshita, C.M. and Bui, W. (1988). Emitter plugging in drip irrigation-causes and solutions. Fourth Inter. Micro. Irrig. Congr. : 4 A-1

*Meyer, J.L., Snyder, J.J., Valenzuda, L.H., Harris A. and Strohman,R. (1991). Liquid Polymers keep drip irrigation from clogging. Calif Agric. 45 :24.

Mizyed Numan and Kruse Gordon (1989). Emitter discharge evaluation-subsurface trickle irrigation system. Tr. ASAE 33 (4): 1223-1228

*Moser, E. (1979). Technically oriented research on drip-irrigation equipment for special crops. Technical communications of International Society for Horticultural Science No.89

Nakayama, F.S., Bucks, D.A. and French, O.F. (1977). Reclaiming partially clogged trickle emitters. Tr. ASAE 278-280

Nakayama, F.S. (1986). Water treatment. In: Nakayama, F.S., Bucks, D.A. (eds) Tricle iirrigation for crop production -design, operation and management. Eisevier, Amsterdam, pp.45

Nakayama, F.S. and Bucks, D.A. (1991). Water quality in drip/trickle irrigation: A review. Irrig. Science 12: 187-182

Ravina, I., Paz, E., Sofer, Z., Marcu, A., Shisha, A. and Sagi, G. (1992). Control of emitter clogging in drip irrigation with reclaimed waste water. Irrig. Science 13: 129-139

Schwab Glenn, O ., Freverk Richard, K., Edminster Talcott, W. and Barnes Kenneth, K. (1981). Soil and Water Conservation Engineering, John Wiley & Sons, New York, 3rd Ed. pp. 474-486

Shanon, W.M., James, L.G., Bassett, D.L. and Mith, W.C. (1982). Sediment transport and deposit in trickle irrigation laterals. Tr. ASAE. 25: 160.

*Shearer, M.N. (1977). Minimum screening and automatic flushing. Proc. 4th Annual Meeting Intern. Drip Irrig. Assoc. Fresno CA:32.

Smajstrla, A.G. and Clark, G.A. (1992). Hydraulic performance of Micro Irrigation drip emitters. ASAE Paper No.92-2057: 9

*Yermeiren, L. and Jobling, A. (1984). Localised irrigation. Design, installation, operation and evaluation. FAO Irrigation and Drainage Paper 36 Fao, Rome.

*Wilson, D.L. (1972). Filtration, Fitters and Water Treatment. Third drip Irrig. Seminar Proc. San Diego. 212-214

* Orginals not seen

CLOGGING SUSCEPTIBILITY STUDY OF DRIP EMITTERS

By
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ABSTRACT OF THE PROJECT REPORT

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1993

ABSTRACT

Emitter clogging is the common and serious problem associated with drip irrigation. An attempt was made to study drip emitter clogging problems with objective of comparing clogging in different types of emitters. A drip emitter testing rig was developed for testing the emitter clogging in the laboratory. Five different types of emitters EH, JK, EL, AT and AO were used in this study. The study was conducted at 500 ppm and 1000 ppm sediment concentrations with sediment size less than 75 microns. Experiment was conducted at an operating presure of 1 kg/cm^2 for a total duration of 48 working hours. The system was operated for 3 hours per day and emitter discharges after each three hour duration were measured.

The emitter performance with both the treatments were analysed. Emitter discharge varied with time of operation for all the emitters studied. Clogging was maximum in the case of tap type AT emitters, whereas it was minimum in the case of high pressure compensating EH type emitters. Emission uniformities were calculated for all types of emitters for both the small fluctuations and AT emitters showed maximum fluctuations. The decrease in the emission uniformity was least for AO emitters but it was maximum for JK emitters.

Flow consistencies were represented in terms of relative discharge. Relative discharge decreases with time for all the emitters. Decrease in relative discharge was high for AT emitters and EH showed least reduction. It was observed from the study that high pressure compensating EH emitters were least susceptible to clogging and showed very small fluctuations in emission uniformities.