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FINAL REPORT
ON

APPLICATION OF REED BED TECHNOLOGY

FOR

TREATMENT OF TANNERY EFFLUENT

Project No. US/RAS/92/120/PDU/1
Contract No. 97/305 P

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PREFACE

The United Nations Industrial Development Organisation (UNIDO) is currently implementing a "Regional Programme for Pollution Control in Tanning Industry in South-East Asia", in India, China, Indonesia, Nepal & Sri Lanka. UNIDO's Regional Programme for Pollution Control is demonstrating through Pilot cum Demonstration Units (PDUs) appropriate and cost effective treatment methodologies for the tanning industry for containing the environmental degradation caused by the wastes generated from the industry. As part of this programme, application of reed bed technology, an effective and low maintenance system, has been set up at Presidency Kid Leathers Limited (PKL), Kannivakkam, Chingelpet district, Tamilnadu, where the process is for manufacturing finished leather from semi finished wet blue. This Reed Bed system is operational from 15th August 1998. Encouraged by the results of the PKL project, a similar project at VISHTEC common effluent treatment plant (CETP), Melvisharam, Vellore District, Tamilnadu was also set up which went on stream on 17th July 1999, where the manufacturing process is from raw to finished leather. In this project, the focus was on making the low maintenance system a low cost one too. Whereas the TDS level in the effluent of PKL is in the range of 3500 - 4500 mg/l, the TDS in the effluent in the CETP at Melvisharam is 9000 - 12000 mg/l. The reed bed at VISHTEC CETP, Melvisharam has assisted evaluation of the performance of reed beds in dealing with highly saline effluent. Simultaneously, two mini scale units were set up at TALCO-RANITEC and SIDCO CETP both in Ranipet area to assess the potential of this technology as a tertiary treatment process.

The Solutions Centre, Cochin, India has been entrusted with the responsibility of design of the reed beds, identification and supply of appropriate reeds, performance monitoring of the reed beds in relation to the quantity and characteristics of the effluent and submitting specific recommendations for future action. This report, which forms part of the PDU implementation, covers the selection of treatment process, design of the treatment system and action plan for using a variety of species of vegetation for the reed beds.

G. ANAND
The Solutions Centre
Cochin
12th August 2000

List of abbreviations:

BOD5	:	Biochemical oxygen demand, 5 days, 20°C
COD	:	Chemical oxygen demand
CETP	:	Common effluent treatment plant
Cr^{3+}	:	trivalent chromium
°C	:	degree Celsius
D.S.	:	dry solids
d	:	day
dia	:	diameter
d.w.	:	dry weight
ETP	:	Effluent treatment plant
H	:	hour(s)
H	:	height
HDPE	:	High density polyethylene
HP	:	horse power
kg	:	kilogram
kwH	:	kilowatt-hour
LDPE	:	Low density polyethylene
lps	:	litres per second
m	:	meter
m3	:	cubic meter (1000 litres)
mg/l	:	milligrams per litre
min.	:	minutes
N	:	Nitrogen
no.	:	number
OH	:	overhead
PVC	:	Polyvinyl chloride
PCC	:	plain cement concrete
pH	:	negative logarithm of hydrogen ion concentration
RCC	:	Reinforced cement concrete
RePO	:	Regional Programme Office
s	:	seconds
SS	:	suspended solids
TSC	:	The Solutions Centre
UNIDO	:	United Nations Industrial Development Organisation
w	:	watts
yr	:	year

CONTENTS

1. INTRODUCTION

1.1. The United Nations Industrial Development Organization (UNIDO) in response to the request from the Govt. of India has agreed to provide technical assistance in carrying out the project "Regional Programme for Pollution Control in the Tanning Industry in South East Asia" in India. As part of the project, the programme addresses the issue of containment of environmental degradation caused by tanning industry. Under this 'umbrella project', appropriate cleaner production methods, efficient and cost effective end of the pipe treatment of tannery effluents etc., are demonstrated through Pilot cum Demonstration Units (PDUs).

1.2. Effluent treatment, particularly in tanning industry, has become a major concern in India over the last few years. In response to this, several Common Effluent Treatment Plants (CETPs) were set up of which many are performing well. However, research into for identifying appropriate low cost technologies for treatment of effluents generated from tanneries is going on. This is of particular relevance to the several small scale isolated tanneries spread across Tamil Nadu which can ill afford neither the capital investment nor the operational cost required for an Effluent treatment plant. Setting up CETPs in such cases is not viable due to the physical distance between the units.

1.3. Reed Bed technology is a well-known low maintenance system for treatment for various kinds of effluents. Originally developed as a system for treating domestic wastewater, this method was later developed and modified to treat various kinds of industrial effluents also. The industries where this technology has been used successfully include distilleries, pulp & paper, mines, oleoresin, ayurvedic pharmacies etc. Developed originally in the Netherlands, this technology has gained wide acceptance in Germany, the USA, France, UK, Australia etc.

1.4. In view of the success of the Reed Bed technology in different industries and especially due its efficacy in handling difficult effluents, it was considered an option worth trying for treatment of tannery effluents. The only known attempt to apply Reed Bed technology for treating tannery effluents was made in Laos; however, the performance of this unit could not be assessed since the tannery got closed down due to extraneous reasons.

1.5. The effluents from tanneries can be broadly classified as effluents from a Raw-Finished factory and effluent from Semi finished- finished factory. In order to assess the potential of the Reed Bed technology one PDU each for treating effluent from each of the categories was considered and consequently, the units selected were Presidency Kid Leathers Limited, Kannivakkam (Semi finished - Finished) and VISHTEC CETP (Raw-Finished), Melvisharam.

1.6. Independent of these, two small units of Reed Beds were set up at SIDCO CETP, Ranipet and TALCO RANITEC, Ranipet. In these two cases, the objective was limited to assessment of the technology as tertiary treatment of the effluent.

1.7. The details of the activities taken up under this project and the results obtained along with recommendations for further action based on the observations are given in this report.

2. BACKGROUND

2.1 One of the objectives of UNIDO's umbrella programme US/RAS/92/120 is to demonstrate cost effective and efficient effluent treatment technologies suitable for the South East Asia Region. This is being done by setting up Pilot cum Demonstration Units (PDUs).

2.2 Reed Bed (RB) technology, also known as root zone treatment and constructed wetlands, is a low maintenance system, which has proven its efficacy in treatment of domestic wastewater. Further, application of this technology in treatment of different types of industrial effluent in India also has given satisfactory results. The effectiveness and feasibility of RB technology for treatment of a variety of industrial effluents has been proven through several industrial treatment systems operating in the USA and Europe.

2.3 The advantages of reed bed technology include:

- low to moderate cost of construction (depending on site conditions)
- negligible maintenance cost
- negligible energy requirement
- no need of skilled personnel for operation and maintenance of the system
- possibility of the system to be operated as a means income
- flexibility in handling variations of loading rates
- aesthetic appeal
- possibility of development as an ecosystem of select flora and fauna in the case of large reed bed units.

The reported disadvantages of reed bed technology include:

- relatively high gestation period.
- large area requirement.
- Proven only in limited industrial effluents.

2.4 There are several isolated tanning units in South East Asia region, which are either too small to afford setting up and/or operating mechanised systems of effluent treatment or too backward in know how to operate a conventional effluent treatment plant effectively. The cost of treatment using reed beds is expected to be comparatively low, due to the low maintenance and operational requirements.

2.5 In view of the above, UNIDO has taken up the implementation and monitoring of a reed bed system each at PKL, Kannivakkam and VISHTEC CETP, Melvisharam, both of them with a capacity of 50 cubic meters per day of primary treated effluent. The unit at PKL was commissioned in mid July, 1998 and regularly operated from 15th August 1998; the unit at VISHTEC CETP, Melvisharam was commissioned on 17th July 1999.

2.6.UNIDO had deferred the installation of the reed bed system at VISHTEC CETP, Melvisharam, mainly due to uncertainty regarding survival of reeds in saline effluent. Some experts suggested that initially a reed bed nursery be developed and later if survival rates were encouraging, a full-fledged reed bed could be considered for the location.

2.7. Accordingly, simultaneous with the development of a reed bed system at PKL, UNIDO and TSC had taken up development of a nursery at VISHTEC and studied the survival/growth mainly with an aim to identify reeds capable of withstanding high salinity. After six months of feeding with treated effluent of high salinity, it was noted that all three varieties planted (Typha, Trema & Scirpus) are capable of withstanding the salinity of treated effluent. Based on the encouraging results obtained from the Reed Bed unit at PKL and the nursery at VISHTEC CETP, Melvisharam, it was decided to set up a Reed Bed system at VISHTEC CETP, Melvisharam.

2.8. Once such a decision was taken, a low cost design for the reed bed system was prepared and submitted to UNIDO for approval along with the fourth quarterly report. The objective was to have a simple design, which could be replicated in isolated small-scale tanneries. After getting approval for the design, the project execution was commenced by May 1999, and completed in July 1999.

2.9. One mini scale reed bed each was also set up at SIDCO CETP and TALCO RANITEC at Ranipet in Vellore district for assessing the efficacy of the system as a tertiary treatment process.

3. SELECTION OF TREATMENT PROCESS

3.1 Selection of Wetland System

3.1.1 Types of Wetland Systems

Wide variety of wetland systems can be utilized in the proposed treatment of the effluent. The various options include

- Free floating macrophyte - based systems
- Rooted emergent macrophyte - based system
- Submerged macrophyte - based system
- Multi-stage systems consisting of a combination of the above mentioned concepts and other kinds of low - maintenance systems (e.g. Oxidation ponds)

3.1.2 Free-floating macrophyte based system

Free floating macrophyte based systems are highly diverse in form and habit, ranging from large plants with rosettes of aerial and/or floating leaves and well developed submerged roots (e.g. water hyacinth) to minute surface floating plants with few or no roots ((e.g. duck weeds). Water hyacinth is one of the most prolific and productive plants in the world. The high productivity is exploited for wastewater treatment. Two different concepts are applied in water hyacinth based treatment systems.

Nutrient removal in which nitrogen and phosphorous are removed by incorporation into the hyacinth biomass.

BOD and nutrient removal, where degradation of organic matter and microbial transformation of nitrogen (nitrification - de nitrification) proceed simultaneously in the hyacinth based system.

Water hyacinth based systems are also known for their efficiency in removal of suspended solids and heavy metals. The retention time in a hyacinth based system, though dependent on the characteristics of the effluent and the treatment requirements usually is in the range 5 - 15 days.

Duckweed - based systems, though having wider geographic range due to their ability to sustain in very low temperatures (as low as 1 ° C), have much lower efficiency than water hyacinth based system due to absence of extensive root system. The extensive root system of water hyacinth facilitates

provision of a huge surface area for attached micro- organisms thereby increasing the potential for decomposition of organic matter
high rate of transfer of oxygen from the foliage to the rhizosphere providing sufficient oxygen for degradation of organic matter.

However, the water hyacinth systems are highly sensitive to salinity of the influent. It has been observed that seawater intruding into the backwaters cause mass destruction of water hyacinths.

3.1.3 Emergent aquatic macrophyte - based systems

Rooted emergent aquatic macrophytes are dominant life forms in a natural wetland. In general, they produce aerial stems and leaves; they have extensive root and rhizome system. The depth penetration of the root system and thereby the exploitation of sediment volume is different for different species. Typical species of emergent aquatic macrophytes are common reed (Phragmites), cattails (Typha) and bulrush (Scirpus). All these species are morphologically adapted to growing in waterlogged sediment by virtue of large internal spaces for transportation of oxygen to the roots and rhizomes. Most such species have an extensive internal lacunal system occupying 50 - 70% of the plant volume. Oxygen is transported to the roots and rhizomes through the gas spaces by diffusion and/or convective flow. Part of the oxygen may leak from the root system into surrounding rhizosphere, creating oxidized conditions in the otherwise anoxic sediment and stimulating both decomposition of organic matter and growth of nitrifying bacteria.

Emergent macrophyte based systems can be constructed using three different designs.

3.1.3.1 Emergent macrophyte- based system with surface flow

This is one of the oldest concepts of constructed wetlands. In this case, surface water flow is adopted in narrow and very long ditches planted mostly with bulrushes (Scirpus). The presence of submerged portions of the stems as well as litter is favoured, since they serve as substrate for attached microbial growth. This system has been used in the Netherlands for over 30 years for wastewater treatment systems.

3.1.3.2 Emergent macrophyte - based systems with horizontal flow

The typical design of an emergent macrophyte - based system with horizontal subsurface flow is a bed planted with Phragmites australis and under laid by an impermeable membrane to prevent seepage. The medium in the bed could be soil or gravel.

During the passage of effluent through the rhizosphere of the reeds, organic matter is decomposed biologically, nitrogen may be denitrified, phosphorous and heavy metals are fixed in the soil. The functions of the reeds include:

- supply of oxygen to the heterotrophic micro-organisms in the rhizosphere
- increasing and stabilising the hydraulic conductivity of the soil.

The experiences with such systems have indicated effective removal of SS, BOD, nitrogen and phosphorus.

Originated in Germany in early 70's, this system has been adopted for effluent treatment in several hundreds of cases in Germany, Denmark, The Netherlands, USA and the UK.

3.1.3.3 Emergent macrophyte - based system with vertical flow

The typical design of this system consists of several beds laid out in parallel with percolation flow and intermittent loading. During the loading period, air is forced out of the soil while the drying period draws air from atmosphere to fill the pore spaces, thereby increasing the soil oxygenation. Obviously, the soil oxygenation is several folds, compared to a horizontal subsurface flow system, particularly since the oxygen diffusion rate in air is about 10,000 times higher than in water. The limited information available on the field cases adopting this system indicates effective removal of BOD, SS, Phosphorus and Nitrogen.

In cold climates, since the bacterial and fungal activity is limited, the vertical subsurface flow systems are clearly preferable over horizontal subsurface flow systems. The vertical system will require much less land area and is likely to provide better quality treated effluent in cold climates. However, in hotter climates these advantages are less likely to be distinct, because higher levels of bacterial and fungal activity in hotter climates are likely to reduce the land area requirements for horizontal systems. One limitation with the vertical system could be likelihood of the surface be clogged due to SS and/or oily matter. This possibility is more or less absent in horizontal subsurface flow system.

3.1.4 Submerged macrophyte - based system

Submerged aquatic macrophyte based systems have their photosynthetic tissue entirely submerged. The morphology and ecology of the species vary from small, rosette - type, low productivity species growing only in oligotrophic waters to large eloedid - type, high-productivity species growing in eutrophic waters.

Submerged aquatic plants are capable of assimilating nutrients from polluted waters. However, these plants can survive only in oxygenated waters and therefore cannot be used in treatment of effluent with high content of biodegradable organic matter. The present limited knowledge on the system indicates that this can be used as a final polishing treatment system only.

3.2. Design of the system

Based on the above, it was decided to adopt the horizontal system at PKL Kannivakkam and VISHTEC CETP Melvisharam. The decision takes due recognition of

- The temperature conditions of the project sites at PKL, Kannivakkam and VISHTEC CETP, Melvisharam, which usually are above 25^0C, facilitating high level of microbial activity.
- The presence of high levels of inorganic matter in the suspended solids, which are likely to clog the surface of a vertical flow system.
- Availability of sufficient land
- Proven efficacy of the system
- Aesthetic appeal – a variety of plants with a 'clean' top surface of the wetland system.

3.2.1 Reed bed system for PKL, Kannivakkam

The reed bed will be utilized for treatment of secondary effluent in the first phase and effluent from primary treatment unit in the second phase of the project. The effluents from the primary treatment unit are seen to have the following characteristics.

Sl. No.	Parameter	Unit	Value
1.	pH	pH Unit	7.5 – 8.
2.	SS	mg/L	150 – 200
3	TDS	mg/L	4000 - 5000
4	BOD	mg/L	800 - 1000
5	COD	mg/L	2500 – 3000
6	Chromium as (Cr^{3+})	mg/L	2 - 3
7	Sulphates (as SO_4)	mg/L	1600 - 1800
8	Chlorides (as CI)	mg/L	500 – 1000

These values were taken into consideration for designing the reed bed system. In the first phase of the project, the reed beds will treat effluent from the secondary treatment unit. The characteristics of the effluents after secondary treatment are given below.

Sl. No.	Parameter	Unit	Value
1.	pH	pH Unit	7.5 – 8.0
2.	SS	mg/L	100 – 150
3	TDS	mg/L	4000 – 5000
4	BOD	mg/L	20 – 40
5	COD	mg/L	400 – 800
6	Chromium as (Cr^{3+})	mg/L	1-2
7	Sulphates (as SO_4)	mg/L	1000 – 1800
8	Chlorides (as CI)	mg/L	500 – 1000

3.2.1.2 The data used in designing the reed bed system are given below:

Min. water temperature	:	25O C
Max. intensity of rainfall	:	100 mm/hr
Annual rainfall	:	1500 mm
Flow rate of effluent	:	50 m^3/day
Type of flow	:	Continuous
Basin media	:	Graded gravel 5 – 10 mm*
No. of beds	:	3
Influent BOD	:	800 mg/L
Effluent BOD (required)	:	20 mg/L
Chromium content in influent	:	2 mg/L max.
Depth of media (assumed)	:	0.8 m
Slope of bed**	:	1 in 100
Minimum porosity of media, p	:	0.39
Temperature dependent first Order rate constant at 200 C, K20	:	1.35
Hydraulic conductivity, Ks	:	420m^3/m^2.d

** Slope of 1 in 100was provided to prevent deposition of solids in the inlet side of reed beds. The design computations are given below.

Width W	:	13m
Length (L) required	:	t'Q/WD p
	:	15.72 m
Length provided	:	16m
Depth provided	:	0.8 meters

Where t' = pore space retention time, days, Q = flow rate m^3/day, W = width in meters, D = depth in meters and p = porosity.

3 beds each of dimensions 16 x 13 x 1.2 m were provided.

Note 1: The depth provided includes depth of flow and free board for all types of reeds proposed. For calculation of the area requirement, minimum depth is assumed. However, the provision for deep-rooted species has been made. The water level within the bed is to be adjusted according to the kind of vegetation used. Since eight to ten varieties of plants were proposed in the experiment, this kind flexibility was required.

Since the site conditions did not permit gravity flow, pumping of the feed was required. Usually a collection tank is required to function as a sump from which the effluent is pumped. In the case of PKL, the existing polishing pond and anaerobic tank was used as collection tanks, which reduced the capital expenditure. A collection sump of 17 m^3 holding capacity for treated effluent from the reed bed is also provided.

Note 2:When similar projects are taken up elsewhere on successful completion of this PDU, site selection acquires immense importance, Ensuring gravity flow for the entire system can reduce capital expenditure, especially in earthwork excavation, quantity and mix of concrete etc. Gravity flow also eliminates the requirement of pumps which avoids:

- periodic and preventive maintenance
- energy requirement
- capital expenditure
- requirement of skilled personnel

Inlet and outlet arrangements for the reed bed

It is essential to get even flow distribution from the inlet to the bed in order to establish a uniform distribution of the effluent across the width of the bed. Among the various options available, a simple pipe with orifices is chosen. The pipe is fed by multiple inlets to maintain uniform distribution and pressure. The effluent is to be distributed over the width of the bed on stainless steel wire mesh gabion filled with evenly graded stones of 60 – 100 mm size.

The perforations in the inlet pipe are made in such a way that adjacent perforations are at 60° angle to each other. Effectively, two lines of perforations may be seen, resembling a series of rhombii, when viewed in a two dimensional plane. The lower perforations are pointing downwards and the other perforations are pointing towards the inlet.

The outlet is similar to the inlet in construction. Provision for raising and lowering of the outlet is proposed by having a flexible outlet pipeline with socketed joints in the vertical portion of the outlet pipe. This will facilitate controlling the depth of flow in the reed bed basin.

The outlet system will have provisions for either feeding the subsequent bed or discharge into the collection sump as desired according to the feeding arrangements.

3.2.1.3 The layout, flow diagrams, etc. are appended to this report.

3.2.2. Based on the encouraging results of the reed bed system at PKL as well as the high survival and propagation rates of the reed varieties in the nursery at VISHTEC CETP, it was decided to set up a reed bed system at VISHTEC CETP, Melvisharam. One of the objectives in applying reed bed technology for tannery effluent was its use a low maintenance system. To facilitate easy replication of the unit by small scale isolated tanneries, it was decide that the PDU at Melvisharam will be low cost too. Accordingly, a low cost design was prepared for this PDU and the project implementation started by May 1999. The design details of this PDU is given below.

3.2.2.1 Reed bed system for VISHTEC CETP, Melvisharam

The reed bed was to be utilized for treatment of effluent from primary treatment unit directly after commissioning unlike in the case of the Reed Bed system at PKL, Kannivakkam. The effluents from the primary treatment unit are seen to have the following characteristics.

Sl. No.	Parameter	Unit	Value
1.	pH	pH Unit	8.5
2.	SS	mg/L	150 – 200
3	TDS	mg/L	9000-11000
4	BOD	mg/L	800 - 1000
5	COD	mg/L	2500 – 3000
6	Chromium as (Cr^{3+})	mg/L	2
7	Chlorides (as CI)	mg/L	5000-6000

These values were taken into consideration for designing the reed bed system.

3.2.1.2 The data used in designing the reed bed system are given below:

Min. water temperature	:	25^{O} C
Max. intensity of rainfall	:	50 mm/hr
Annual rainfall	:	1500 mm
Flow rate of effluent	:	50 m^3/day
Type of flow	:	Continuous
Basin media	:	Sieved Sand
No. of beds	:	1
Influent BOD	:	800 mg/L
Effluent BOD (required)	:	20 mg/L
Chromium content in influent	:	2 mg/L max.
Depth of media (assumed)	:	0.4 m
Minimum porosity of media, p	:	0.30

Temperature dependent first Order rate constant at 200 ^{O} C, K20	:	1.35
Hydraulic conductivity, Ks	:	480m^3/m^2.d

Width W	:	33m
Length (L) required	:	t'Q/WD p
	:	47.3 m
Length provided	:	45.0 m
Depth provided	:	0.4 meters

Where t' = pore space retention time, days, Q = flow rate m^3/day, W = width in meters, D = depth in meters and p = porosity. One bed of dimensions 45 x 33 x 0.8 m was provided.

The depth provided includes free board and the depth of flow. The water level in the bed could be adjusted as per the requirements of the vegetation as well as for weed control.

3.2.2.2. The reed bed was proposed to have the following features.

a. The floor of the reed bed will be of LDPE film 600 micron thick sandwiched between clay layers each 100 mm thick.
b. The media proposed was sieved river sand of 2-5 mm with a uniformity coefficient of 1.3-1.5.
c. The depth of the media would be 400 mm.
d. The sides of the reed bed would be made up of clay covered earthen bunds with a slope of 1:3.

3.2.2.3 The site conditions permitted gravity flow of primary effluent from the clariflocculator to the reed bed which in turn facilitated reduction of both capital investment and operational costs.

3.2.2.4. The detailed drawings of the reed bed is appended.

3.3. To assess the feasibility of the Reed bed system as a tertiary treatment process two mini scale systems were considered at SIDCO CETP and TALCO RANITEC both located at Ranipet in Vellore district. In order to compare the results, the unit at SIDCO CETP was designed as a fill and draw type planted filter/ vertical flow system, while the unit at TALCO RANITEC was designed as a horizontal system.

4. PROJECT ACTIVITIES

4.1 It was decide to set up a nursery each at PKL and VISHTEC CETP of select species of reeds and irrigate them with treated effluent for familiarisation of the reeds to the effluent characteristics and the climatic conditions.

4.2 The critical part of the first step was survival of the reeds. To facilitate selection of the right type of reeds, a nursery was set up at the home office of the sub-contractor and were irrigated with water containing different concentrations of sodium chloride and different pH. From this experiment, certain results were obtained the details of which are given in Annexure-2.

4.3. Based on the observation of the survival and propagation rates of various types of reeds tried out in this nursery, the following reed species were selected for the nurseries at VISHTEC CETP and PKL.

- Typha angustfolia
- Phragmites australis
- Scirpus robustus
- Trema orientalis
- Canna indica
- Coix lachryma
- Saccharum spontaneum
- Bamboo sp.

4.4. Of these species, Canna indica was not considered for either of the nurseries since it is known to be a pest species likely to propagate faster and destroy other varieties, primarily due to allylopathic effect. Previous experience with Canna indica in reed beds indicated similar behaviour by this variety. Further, this was not the best of the species for highly saline conditions as per the performance at the nursery at the home office of the sub-contractor.

4.5 The process of setting up nursery at PKL, Kannivakkam was started on 20/01/1998 and the irrigation with treated effluent started by 31/01/1998. More reeds were sent to the nursery at PKL in March, 98 and the process of irrigation with treated effluent continued. The details of the performance of the different varieties of reeds at the PKL nursery are given in Annexure-3.

4.6 Similar operations were taken up at the nursery at VISHTEC CETP also. However, after 30-40 days all the varieties of the reeds planted were found completely wilted. Additional plants supplied and planted subsequently faced a similar fate. On detailed analysis of the problem, it was found that the basic problem was the quality of the soil at the site, which inhibits growth of any vegetation including draught resistant varieties of wild weeds. Hence, some nutrient rich soil was imported from a pond nearby which was laid carefully at the site for the nursery and the nursery redeveloped. The results and observations of the nurseries at VISHTEC CETP are given in Annexure- 4

4.7 Based on the performance of the various varieties of reeds tried out in the nursery at PKL, Saccharum spontaneum, Typha angustifolia, Scirpus robustus, Trema orientalis and Bamboo sp. were selected for the reed bed PDU at PKL.

4.8 A detailed design of the Reed Bed system proposed at PKL was prepared and submitted to UNIDO on 15/01/1998. After detailed discussion with the consultants of UNIDO, the design was finalised by 28/02/1998.

4.9 It was decided to have two separate contractors for the civil and mechanical parts of the project at PKL. Tenders were called for the two components of the work. M/s G. D. Constructions, Chennai was awarded the contract for the civil works and M/s S. V. V. Engineers, Hosur was awarded the contract for the mechanical works and maintenance of the system for a period of one year.

4.10 The project execution started on 22/05/1998 and was completed on 15/08/1998. Based on the performance in the nursery, Saccharum spontaneum was selected for Bed-1 and Typha angustifolia for Bed-3. Bed-2 was planted with a mix of Scirpus robustus, Trema orientalis, Typha angustifolia and Bamboo sp. initially and later Coix lachryma was added. A few saplings of Bamboo sp. and Phragmites australis were also planted in RB-1.

4.11 Bed-1 was commissioned on 30/07/98 and Bed-3 was commissioned on 04/08/1998. When Bed-2 was commissioned on 15th Aug. '98, the system was complete and feeding with treated effluent with operation in parallel was on. The decision on initial operation to be in parallel was taken to observe the survival, growth and propagation rates of different species under identical conditions, before offering the reeds more concentrated effluent with the operation in serial mode.

4.12. This phase of the experiment threw up a very interesting result that the Saccharum which performed best in the nursery was finding it difficult to grow or propagate. This also proved that a reed ideal in a given condition or set of conditions need not necessarily be the right choice in different conditions even for the same effluent.

4.13 The beds, RB-1 and RB-3 were operated with treated effluent up to 16/12/1998, they were offered a mix of 10 m^3 of partially treated and 10 m^3 of treated effluent per day. Bed-2 was offered 10 m^3/d of partially treated effluent from 18/11/1998 along with 10 m^3/d of treated effluent. The serial operation of the beds was started from 01/01/1999. with a lower feeding rate of 10 m^3/d of partially treated effluent and 10 m^3/d of treated effluent. The results of the operations are given in Annexure -5. Finding that the quantity of offer was too low for sustenance of the reeds, the feeding rate was subsequently increased to 50 m^3/d.

4.14. It was decided to install a similar system at VISHTEC CETP after observing the performance of the Reed Beds at PKL for a reasonable period. At the same time, the nursery at the site was continued and survival, growth and propagation rates of the different kinds of the reeds planted in the nursery were monitored. The high rate of survival and propagation of three species namely, Typha, Trema and Scirpus in the nursery along with the results in PKL was instrumental in deciding on the Reed Bed system at VISHTEC CETP.

4.15. Since the system set up at PKL was found to be expensive due to various factors, a low cost system was designed for VISHTEC CETP and the same submitted for approval to UNIDO as part of the 4th quarterly report.

4.16. The proposal for setting up a low cost reed bed system at VISHTECS CETP, Melvisharam was approved and taken up for implementation by UNIDO. It was decided to have a single contractor for executing the project. Accordingly, tenders were called for by RePO, UNIDO, Chennai and the work was awarded to M/s. Vignesh Builders, Ranipet. The project was statred in May 1999 and completed in July 1999. The system went on stream by 17th July 1999. It was offered only secondary effluent for the first two weeks and subsequently, from 30th July 1999, was offered 100% primary effluent. The varieties of reeds planted in the bed were Typha, Trema and Scirpus.

4.17. The offer to the Reed Bed system at VISHTEC CETP was maintained close to 50 m^3/d. The results and observations are presented in Annexure-6.

4.18 A low cost mini scale unit was designed for tertiary treatment of effluent at TALCO-RANITEC at Ranipet. The system was commissioned on 03/08/1998. The details of the performance of this system are given in Annexure - 7.

4.19. SIDCO CETP at Ranipet was having a sand filter currently not in use. This was modified to function as a Reed Bed with top feeding and bottom outlet resembling a vertical system. Fill and draw method was adopted. Like in the case of TALCO RANITEC, here also, the objective was to use the system for tertiary treatment of the effluent. Different loading patterns and different retention times were tried in this case. The results are appended as Annexure - 8.

5. DETAILS OF THE PKL PROJECT

5.1. The project was conceived as a multi-stage reed bed system to handle 50 m^3 of primary effluent per day after stabilization of the system. The project being first of its kind, without any basic data available, was expected to generate sufficient data for design and operation of Reed Bed systems for tannery effluent treatment in future.

5.2. The major consideration in selection of reed varieties was the capability of the reeds to survive/withstand the high salinity/ TDS of the effluent to be handled. The geo- climatic conditions at the site are also of importance to the growth, propagation and treatment efficiency of the reeds.

5.3 In order to ascertain the ability of the reeds to survive the high TDS of the effluent, experiments were conducted with sodium chloride solution in a nursery. Based on the performance in the nursery, some reed varieties were selected and a nursery was set up at PKL. Here, the reeds were irrigated with treated effluent from the existing ETP of PKL and the survival and propagation rates of different varieties of reeds assessed. The experiment continued for three months and based on the results obtained, some varieties were selected for planting in the Reed beds.

5.4 The reed beds were to handle 50 m^3 of effluent from the primary clarifier per day. The characteristics of the effluent to be treated in the reed bed are given in Table-1 below .The desired characteristics of the treated effluent are given in Table-2 below.

5.5. The total area of the reed bed was 624 m^2 with a depth of 0.8 m .The depth was provided to accommodate deep rooted varieties like Saccharum, Phragmites etc. The system consisted of three units each of dimensions 16 x 13 x 0.8m.

5.6. Since the site available was prone to water logging during rainy seasons, the beds were to be provided with a floor consisting of LDPE sheets and PCC M10. In order to prevent any possible rupture/ puncture/ damage to the LDPE sheets especially during laying and jointing the sheets were given 200 mm thick sand cushion above and below.

5.7. The beds were constructed of RR masonry walls, which were kept at a minimum height of 150 mm above the ground level to prevent storm water entering the beds from outside during rainy seasons.

5.8. The three units were constructed independent of each other with proper inter connections so that the system could be operated in series or parallel as per the requirements. Further, any one or more of the bed(s) could be taken out of service for maintenance or rest without affecting the entire system.

Each of the beds was provided with separate flow meters and valve chambers for ease and accuracy of monitoring. This facilitated measurement of input and output to each of the beds. The reed beds at PKL were operational from 15thAugust, 1998. immediately after commissioning, the beds were started in parallel. This method was adopted to study the effect of the feed on the reeds with particular focus on survival and propagation. It was essential to assess the potential of different varieties of reeds for survival and propagation in this type of

The pore space retention time was maintained at five days during this phase with a feeding rate of 50 m^3/d of secondary effluent.

The monitoring of the Reed Bed consisted of two distinct phase. The first was the stabilisation period, which lasted up to January 1999. During this perod, the operation was in parallel. In the second phase, the offer was a mixture of primary and secondary effluent with varying proportions and the operation was in serial mode..

The first phase of operation threw up an interesting set of results with regard to the growth and propagation of reeds in the beds. Saccharum, which was the best growing species in the nursery, where only treated effluent was used for irrigation, was finding even its survival difficult in the bed. So long the root system of the reeds were intact, some amount of treatment was taking place. However, once the root system also started dying off, the treatment of the effluent fed to the bed RB-1, which was practically a monoculture one with Saccharum alone planted, was negligible.

Typha angustifolia, which showed only moderate performance in the nursery, was found to multiply fastest in the beds RB-2 and RB-3. Other varieties, which showed some promise, were Bamboo sp. and Coix lachryma. The analysis reports covering various parameters as per the monitoring schedule originally proposed, and survival , growth and propagation of the reed varieties are given in Annexure-5.

When the feeding was in parallel and the offer was treated effluent, all the three beds performed well in terms of reduction of cod, bod and colour. The rate of reduction of bod was found to increase faster than the rate of reduction of COD.

RB-2 was considered the experimental bed where different varieties of reeds were planted .The bed was offered a mixture of 40% treated effluent and 10% primary effluent in November 1998 and the feeding pattern continued .At that time the other two beds were continued to be offered treated effluent. This experiment confirmed typha as the best variety as other species like Coix lachryma, Scirpus robustus, Bamboo sp., gradually wilted completely.

When a feeding pattern with the offer having 50 % of primary effluent and 50% of treated effluent was adopted for all the beds, and the operation changed to parallel, the feed rate was reduced to 20 m^3/d. This reduction in hydraulic loading with the pollution load almost being the same, had an immediate impact on the health of the reeds. Hence, the feeding rate was reverted to 50 m^3/d, with the operation in series.

The reed varieties showed different levels of tolerance to different compositions of the feed. Saccharum which was the best performing reed in the nursery was found to barely survive and propagate in the initial stages of the operation and completely wilted on applying higher pollution loads subsequently. Bamboo sp., which was a not very well performing species in the nursery, did propagate so fast in RB-1 while the offer was only treated effluent, but started wilting on increase in the concentration of primary effluents another case of inconsistent behaviour. Tyha was found to have the highest level of consistency under all conditions.

The performance monitoring of the reed beds at PKL was started from 1st September, 1998 and continued till the end of the project period, i.e., 31st March, 2000 .The flow rate of the feed, outflow, characteristics of the effluent under different stages of treatment, growth pattern of the reeds were monitored during this period.

The parameters monitored were pH, SS, BOD, COD, Chlorides, Sulphates and Ammoniacal Nitrogen.

The Chlorides were monitored for counter checking the flow measurements at then inlet and outlets since, in a reed bed, the chloride reduction will be negligible. The material balance in terms of chlorides and flow measurements were later found to match during the monitoring period. This also was of help to assess the effect of various factors affecting the evapo-transpiration rates. The mean evapo-transpiration for the system was assessed to be 12%.
Suspended solids (SS) were monitored to assess whether any accumulation of suspended solids was taking place in the bed, which can reduce the life of the bed.

Since TDS could contain both bio- degradable and non degradable matter, monitoring of TDS is likely to provide new information of value for future use in designing reed beds for treatment of similar effluents. Hence TDS also was monitored regularly during the project period.

Both BOD and COD were monitored on daily basis since assessment of the potential of the reed beds to reduce bod and COD is the primary objective of this pilot unit.
The analysis of sulphates in the feed and effluent was considered necessary since some reduction of sulphates was expected in the anoxic/ anaerobic zones within the reed bed.
In the case of many industrial effluents, an increase of pH was noticed when the media used was gravel/pebble. Since pH of the effluent generated in PKL is slightly alkaline, the change in pH was of interest. The effect of pH on the treatment efficiency of the system also is to be assessed.

The results obtained during the monitoring period are given in Annexure-5.

6. ANALYSIS OF PROJECT PERFORMANCE AT PKL

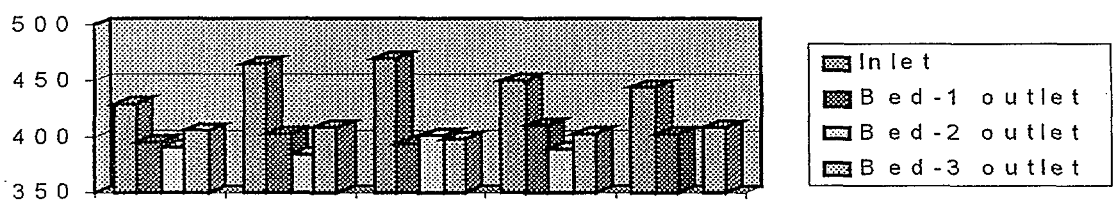
6.1. The reed bed project at PKL had two distinct phases of performance monitoring. They were assessment of viability of reed bed as a tertiary treatment system and a secondary treatment system. In the first phase, the reed beds were operated in parallel mode with offer of secondary effluent. This continued till January 1999. The offer was changed to a mixture of primary and secondary effluent subsequently with the objective of feeding 100% primary effluent finally. The first phase resulted in establishing the viability of application of reed bed technology as effective low maintenance tertiary treatment system. The efficacy of the system as a secondary treatment system is yet to be established due to fluctuation in the raw effluent quality. The results obtained so far indicate that the system could be integrated with the existing ETP for increasing the total effluent treatment capacity of the tannery.

6.1.1. As planned, the reed beds were operated as tertiary treatment system for the initial period (Aug-Dec, 1998) and the performance was monitored regularly and data consolidated. Overall performance of the system as a tertiary treatment is given in Table-6.1 below.

Table-6.1

Parameter	Influent	Final outlet	% reduction
	Value	Value	--
pH	7.9	7.2	
SS mg/l	45	25	44
TDS mg/l	5550	5625	1.3
COD mg/l	465	390	16
BOD mg/l	28	14	50

Variations in COD values in PKL reed bed



6.1.2 Some experts raised the doubts that the efficiency obtained in reed beds may be due to the removal of suspended solids by filtration by media and not really due to any biological action in reed beds. To verify this point, soluble BOD/COD in the inlet & outlet was measured and the values obtained were not very different from total BOD/COD, which established that the reduction is not due to the physical filtration of solids.

Since accumulation of inorganic suspended solids in the reed bed media would be the one eventually leading to clogging of the bed, a small computation was made using data from analysis of suspended solids at inlet and outlet and the ratio of organic (volatile) solids: inorganic solids in the inlet water was found to be around 60:40 based on continuous lab tests during the period Jan - March, 1999 and that in the effluent from reed bed was 20:80. In mass balance terms, the suspended solids inventory in PKL reed bed and inlet & outlet is as follows:

Suspended solids in inlet = 110 mg/l = 5.5 kg/day @ 50 m3/day flow rate
Organic solids in the inlet = 60% of the solids = 3.3 kg/day
Inorganic solids in the inlet = 40% of the solids = 2.2 kg/day
Out let suspended solids = 50 mg/l = 2.5 kg/day
Organic solids in the outlet = 20% of the solids = 0.5 kg/day
Inorganic solids in the outlet = 80% of the solids = 2.0 kg/day

Hence, the net organic solids accumulated/consumed in the beds = 2.8 kg/day

The net inorganic solids accumulated/consumed in the beds = 0.2 kg/day. This quantity represents approximately 3% of the total input solids.

Obviously, the quantity of inorganic solids accumulating in the bed is not high. Since any organic solids accumulating in the bed will get degraded over a period of time, the possibility of clogging is assumed to be very low.

6.1.3 To verify the efficacy of reed bed as a tertiary treatment, it was considered best to compare it with other conventional tertiary treatment systems. For this purpose, the same inlet water let into the reed bed was collected and subjected to tertiary treatment using various methods. Several sets of repeated experiments were done for each trial at various dosages. The results of these experiments are given in Table-6.2 below.

Table-6.2

REED BED AS A TERTIARY TREATMENT vs. OTHER TREATMENT SYSTEMS

% REDUCTION

Parameter	Ozonation*	Activated carbon**	Chemical oxidation***	Reed bed
BOD	10-20	10-15	12-20	45-60
COD	5-10	8-10	4-15	10-15
TSS	---	50-60	---	40-50
Colour	15-20	20-25	20-25	10-15

* Ozonation for period 30 minutes to 8 hours (28 trials)
** Using packed beds - contact time 30 minutes to 4 hours (16 trials)
*** Using sodium hypochlorite (50 - 500 ppm) - 18 trials and hydrogen peroxide (100-500 ppm) - 12 trials

It is evident that, though the reduction provided by reed bed may not offer high, its performance is indeed quite comparable with that of other systems. The reduction obtained by the reed bed system at PKL therefore need not be disappointing.

All experiments related to reed bed operation as a tertiary treatment was completed and hence studies on its efficacy as a partial or total replacement of biological treatment system were taken up.

6.1.4 It was not feasible to apply primary treated effluent alone to the reed beds initially because of likely damage to the reeds. Accordingly, the system was started first with an offer of a mixture of 10 m3 /d of primary treated effluent and 40 m3 /d of secondary treated effluent. The performance under this feeding pattern during January 1999 is given below.

Table 6.3

Parameter	Feed water (10 PTE: 40 STE)	Final outlet
pH	7.5	7.2
TSS mg/l	112	65
TDS mg/l	5531	5945
COD mg/l	835	485
BOD mg/l	210	72

6.1.5 The performance of reed bed system as a replacement of biological treatment system can be verified only after full stabilisation which is expected to take some more time.

Some experts had expressed doubts regarding the mechanism of biological treatment in reed bed opining that it was like an anaerobic contact filter. In order to assess the truth in this, the inlet to reed bed was subjected to anaerobic treatment also in the lab scale anaerobic contact filter (packed with same media used for reed bed), initiated anaerobic activity by seeding and stabilised the system. Then the efficiency of this contact filter was compared with reed bed using the same input and same hydraulic retention time.

The experiment established beyond doubt that efficiency of reed bed is not due to anaerobic filter action, as the efficiency of the filter compared to reed beds was meagre. A general comparison of efficiency of reed bed as observed is given in table-6.4 below.

Table-6.4

REED BED vs. CONVENTIONAL TREATMENT SYSTEMS
% REDUCTION

Parameter	Anaerobic treatment	Aerobic treatment	Reed bed
BOD	10-15	90-92	80-90
COD	8-16	85-90	50-60
TSS	10-15	40-50	30-40
Colour	45-50	10-15	5-10
Nitrogen	10-15	15-20	10-15
Sulphides	20-175	80-90	10-15

6.1.6 The assessment of the performance of different varieties of reeds during the monitoring period covered in this report has yielded the following results.

- Reeds procured from the locality perform better than reeds imported from far off places.
- The performance of a particular variety of reed in the reed bed can be significantly different from the performance in the nursery even when the same effluent is offered.
- In the specific case of PKL, Typha was found the best variety for treatment of effluent of various concentrations.

6.1.7 The performance analyses of different kinds of reeds both in the nursery and in the reed beds are given in Annexure-5.

6.1.8. By measurement of the influent and effluent quantity in each of the beds the evapo-transpiration losses could be assessed .To counter check the correctness of the measurements, analysis of the Chloride content of the influent and effluent of each of the beds were undertaken since, the reed bed hardly removes any Chlorides in the beds. Relevant meteorological data like relative humidity, temperature etc, for the PKL area was obtained from the Chennai office of the India Meteorological Department (IMD). From the meteorological data and actual evapo-transpiration rates measured, it could be inferred that the evapo-transpiration rate is a function of parameters like temperature, relative humidity, area of the reed bed, density of reeds in the bed, type of reeds (species, lacunal space in the stem of the reed variety, leaf area of the reeds etc.) and feeding rate. The mean evapo-transpiration loss in this reed bed system is found to be 12%.

6.2 From February 1999 onwards the reed beds were operated in series and the offer was a mixture of primary and secondary effluent.

6.2.1 The reduction of BOD ranged between 62% to 87% in absolute terms during this period. The influent BOD varied from 227 mg/l to 987 mg/l depending on the quality of primary effluent as well as the composition of the feed. The process efficiency vis-à-vis the influent BOD is given in Graph 5.II.3 It was observed that the influent BOD has some bearing on the rate of reduction. Graph 5.II.3. show an almost flat curve with the reduction dropping almost steadily when the influent BOD started exceeding 800 mg/l. Likewise, the impact of the influent BOD can be observed in the specific reduction as presented in graph 5.II.7. Here the specific reduction was found to increase with the influent BOD and decrease steadily when the influent BOD exceeded 800mg/l. Thus it can be concluded that the optimum influent BOD is less than 800mg/l for best results.

6.2.2 The graphs 5.II.2 and 5.II.4 show the rate of reduction of COD against BOD:COD ratio, influent COD. Graphs 5.II.6 and 5.II.8 show the specific reduction of COD against BOD:COD ratio and influent COD.

6.2.3 It may be noted that even though only a mixture of primary and secondary effluent was offered to the reed bed system, the actual influent BOD level has been close to the design conditions. This was due to the change in the quality of the raw effluent by January 2000, the offer had to be changed to a mixture of effluent from the reed bed and primary effluent. Still, the BOD of the offer was ranging from 600 mg/l to 1200 mg/l. The monthly mean value of the offer for the month of March 2000 was observed to be as high as 986.9 mg/l.

6.2.4 Thus, the reed bed experiment was successful enough to handle the type of effluent as designed. However, the effluent from reed bed was having a mean BOD of 147 mg/l if the entire fourteen months from February 1999 to March 2000 was considered.

6.2.5 This also shows that the design concept used, i.e., considering the BOD of the offer alone with ambient temperature is insufficient for designing such a system. The past experience with effluents from other types of industries as well as sewage had been the only data to rely on for designing the system. This in turn also indicates that in the case of tannery effluent, particularly for tanneries processing wet blue to finished leather there are other factors influencing the performance of the system. Since the climatic conditions were found to be of little significance on the performance of the system it has to be the various components of the offer, which influence the performance.

7. DETAILS OF THE VISHTEC PROJECT

7.1. The project was conceived as a single-stage low cost reed bed system to handle 50 m^3 of primary effluent per day after stabilization of the system. The project was expected to generate sufficient data for design and operation of Reed Bed systems for tannery effluent treatment in future.

7.2. The major consideration in selection of reed varieties was the capability of the reeds to survive/withstand the high salinity/ TDS of the effluent to be handled. The geo- climatic conditions at the site are also of importance to the growth, propagation and treatment efficiency of the reeds.

7.3 In order to ascertain the ability of the reeds to survive the high TDS of the effluent, experiments were conducted with sodium chloride solution in a nursery. Based on the performance in the nursery, some reed varieties were selected and a nursery was set up at VISHTEC. Here, the reeds were irrigated with treated effluent from the existing ETP of VISHTEC and the survival and propagation rates of different varieties of reeds assessed. The experiment continued for three months and based on the results obtained, some varieties were selected for planting in the Reed beds. They were Scirpus , Typha and Trema.

7.4 The reed beds were to handle 50 m^3 of effluent from the primary clarifier per day. The characteristics of the effluent to be treated in the reed bed are given in Table-1 below .The desired characteristics of the treated effluent are given in Table-2 below.

7.5. The total area of the reed bed was 1485 m^2 with a mean depth of 0.4 m .

7.6. Since the site available was of hard red earth with a very low water table, the concept of making a reed bed low cost also was implemented in this case. Instead of PCC flooring only a compacted clay layer was provided in the bottom. In order to prevent any possible rupture/ puncture/ damage to the LDPE sheets especially during laying and jointing the sheets were given 200 mm thick sand cushion below. The periphery of the reed bed was made of soil bund with a clay cover and LDPE film kept at a height of 300 mm above the ground level to prevent storm water entering the beds from outside during rainy seasons.

7.7 The inlet and outlet of the bed was provided with flow meters and valves for ease and accuracy of monitoring. This facilitated measurement of input and output to each of the beds.

7.8 The reed bed at VISHTEC CETP was commissioned on 14th July 1999 and operational from 17th July, 1999.

7.9 The reed bed was offered diluted primary treated effluent till 29th July after which primary effluent from the clarifier was fed. The analysis reports covering various parameters as per the monitoring schedule originally proposed, and survival, growth and propagation of the reed varieties are given in Annexure-6.

7.10 The reed varieties showed different type of tolerance, to different types of the feed. Scirpus which was the best performing reed in the nursery was found to barely survive and propagate.. Tyha was found to have the highest level of consistency under all conditions.

7.11 The performance monitoring of the reed beds at VISHTEC CETP was started from 31st July, 1999 and continued till the end of the project period, i.e., 31st March, 2000 .The flow rate of the feed, outflow, characteristics of the effluent under different stages of treatment, growth pattern of the reeds were monitored during this period.

7.12 The parameters monitored were pH, SS, BOD, COD, TDS and Chlorides. The Chlorides were monitored for counter checking the flow measurements at then inlet and outlets since, in a reed bed, the chloride reduction will be negligible. The material balance in terms of chlorides and flow measurements were later found to match during the monitoring period. This also was of help to assess the effect of various factors affecting the evapo-transpiration rates. The mean evapo-transpiration for the system was assessed to be 16%.

7.13 Suspended solids (SS) were monitored to assess whether any accumulation of suspended solids was taking place in the bed, which can reduce the life of the bed.

7.14 Since TDS could contain both bio- degradable and non degradable matter, monitoring of TDS is likely to provide new information of value for future use in designing reed beds for treatment of similar effluents. Hence TDS also was monitored regularly during the project period.

7.15 Both BOD and COD were monitored regularly since assessment of the potential of the reed beds to reduce BOD and COD is the primary objective of this pilot unit.

7.16 In the case of many industrial effluents, an increase of pH was noticed. Since pH of the effluent generated in VISHTEC CETP is slightly alkaline, the change in pH was of interest. The effect of pH on the treatment efficiency of the system also is to be assessed.

7.16 The results obtained during the monitoring period are given in Annexure-6.

8. ANALYSIS OF THE PROJECT PERFORMANCE AT VISHTEC CETP

8.1 As planned, the reed beds were operated as secondary treatment system straight away. Unlike in the case of PKL, it was found that the stablisation time required was found to be less than two months.

8.2 The assessment of the performance of different varieties of reeds during the monitoring period covered in this report has yielded the following results.

- Reeds procured from the locality perform better than reeds imported from far off places. The performance of a particular variety of reed in the reed bed can be significantly different from the performance in the nursery even when the same effluent is offered. The case of Scirpus robustus in this reed bed is significant.
- In the specific case of VISHTEC CETP, Typha was found the best variety for treatment of effluent of various concentrations.
- By measurement of the influent and effluent quantity in each of the beds the evapo-transpiration losses could be assessed .To counter check the correctness of the measurements, analysis of the Chloride content of the influent and effluent of each of the beds were undertaken since, the reed bed hardly removes any Chlorides in the beds. Relevant meteorological data like relative humidity, temperature etc., for the VISHTEC CETP area were obtained from the Chennai office of the India Meteorological Department (IMD). From the meteorological data and actual evapo-transpiration rates measured, it could be inferred that the evapo-transpiration rate a is function of parameters like temperature, relative humidity, area of the reed bed, density of reeds in the bed, type of reeds (species, lacunal space in the stem of the reed variety, leaf area of the reeds etc.) and feeding rate. However, it is also seen that the climatic conditions had only a nebulous impact on the performance of the reed bed. The mean evapo-transpiration rate of this reed bed was found to be 16%.

8.2 The reed bed was started with primary effluent alone. The reduction of BOD in absolute terms in the initial stages was about 54%. The system got stablised rapidly and the second month of operation showed an absolute reduction of 89%. The rate remained consistently above 90% in the subsequent months till March 2000 when it dropped to 89.74%. The mean reduction of BOD during the monitoring period was 87.31 %.

8.3 Likewise, the reduction of COD was 49% in the first month, rose to 79% in the second month and was in the area of above 75% subsequently. The mean reduction of COD during the monitoring period was 74.9%.

8.4 From the graphs prepared it could be seen that the BOD:COD ratio of .44 has resulted in the best performance as far as reduction of BOD and COD. However, it could be seen that the BOD:COD ratio remainedin the range initially. The problems in the primary treatment could be the reason for the subsequent reduction in the BOD:COD ratio.

8.5 The influent BOD was found to have very little effect on the rate of reduction till it exceeded 800mg/l and on specific reduction till it exceeded 750mg/l. From this it could be inferred that for best results, the influent BOD is to be matasined at less than 750 mg/l.

8.6 The influent COD had only a nebulous impact on the rate of reduction and specific reduction of COD.

8.7 The specific reduction of BOD ranged from 23.47g/m^2/d to 62.12 g/m^2/d with an average of 45.21 g/m^2/d. This has far exceeded the projections by United States Environment Protection Agency (USEPA) in the Manual for design of Constructed Wet lands (First edition) and their subsequent Technology Update Reports.

8.8 In the case of COD reduction also, similar situation was found to prevail. The mean specific reduction of COD during the monitoring period was found to be 101 g/m^2/d. The minimum specific reduction observed was 68.54 g/m^2/d during the month of March 2000 when the quality of the offer had deteriorated due to high SS. The maximum specific reduction observed was in the month of January 2000 at 146.26 g/m^2/d.

8.9 The reed bed was functioning smoothly till some mechanical problems in the clariflocculator resulted in the deterioration of the quality of the offer. The suspended solid content which usually was in the range of 150 mg/l to 200 mg/l increased upto 1000 mg/l. This had resulted in rapid increase in the Suspended Solids content in the offer, which led to partial choking of the reed bed. The choking led to reduction in the feed quantity to maintain the level of performance.

9. RECOMMENDATIONS FOR FUTURE ACTION

9.1 The Pilot cum Demonstration units at PKL, Kannivakkam and VISHTEC CETP, Melvisharam along with the two experimental reed beds at Ranipet area, namely, SIDCO CETP and TALCO RANITEC CETP, has yielded a mass of valuable information.

9.2 The major problem faced by the isolated tanneries especially in Tamil Nadu is the prohibitive cost of operation of the captive or common effluent treatment plants, particularly the power cost. In order to make operating an ETP economically viable for the small-scale tanner, the original concept of a Low Maintenance Treatment system was experimented with. With encouraging results observed in the Reed bed systems, the necessity of reducing the project cost was also addressed.

9.3 Based on the results obtained so far, a proposal to make Reed Bed System, a low maintenance system, low cost also was mooted. Accordingly, a low cost design for installation at VISHTEC, CETP, Melvisharam was set up.

9.4 A spin off of this set of experiments is development of a Rural Treatment System (RTS) that will include Reed Bed along with other natural treatment units. The concept is to use a low cost and low maintenance system that can be easily set up and operated by an isolated small-scale tannery. This will go a long way in mitigating the problems faced by isolated small-scale tanneries in Tamil Nadu in solving the pollution problems.

9.5 Wherever sufficient land is available, the Reed Bed could be adopted as secondary or tertiary treatment system for tannery effluent depending upon the characteristics. This will be particularly beneficial in CETPs since the pollution load in the Reed Bed increases gradually thereby eliminating or reducing the normally required stabilization period.

9.6 The selection of reeds is of utmost importance for achieving best results. As seen in the case of PKL, a reed variety available locally can adapt itself to the conditions in the reed bed faster than those, which are brought from far off places. Further, it may be inferred that a particular variety of reed effective in one case need not be the best option for another case; the implication is that the selection of reed variety also is case specific.

9.7 In spite of the technical and financial feasibility of the reed, bed system for effective treatment of various types of industrial effluents, lack of awareness of the technology at various levels is a major constraint. In order to overcome this, it is necessary to educate the potential users of the technology especially in the leather sector regarding the type of work already taken up and the results of the actions taken.

10. CONCLUSION

10.1 The reed bed units tried at PKL, VISHTEC CETP, SIDCO CETP and RANITEC CETP have thrown up various results of interest.

10.2 Performance of the reed beds at PKL indicates that

- the excessive caution against clogging shown in selection of the media was not required.
- Salinity/TDS is not a limiting factor for operation of reed beds since there are several varieties of reeds, which easily survive, grow and propagate in saline effluents and still yield results.
- a variety of reed found to be the best for a given set of conditions like effluent, climate, media etc. need not necessarily be the best in a different situation; that is the selection of the reed variety could be case-specific.
- the quantity of feed is to be maintained at a certain minimum level irrespective of the quality to sustain the reeds. This is valid for most of the species of reeds even though most of them are draught resistant.
- atmospheric temperature has an influence on the performance of the reed beds; higher temperature leads to better performance particularly with respect to reduction of BOD and partially with respect to COD reduction.
- atmospheric humidity has practically no role in the performance, though along with temperature, it plays a major role in the evapo-transportation rates.
- the influence of BOD :COD ratio has an appreciable impact on the performance; though usual for other biological process, this ratio was found to have nebulous impact on reed beds handling certain types of effluents.
- pH of the influent has practically no effect on the performance of the reed bed system. Further, it may also be concluded that the reed bed is a pH correcting system. Reed beds used for treating highly acidic effluents were seen to yield effluent of pH close to 7. In the case of PKL, alkaline offer was found to have a pH reduction with the effluent having Ph close to 7.
- the reed bed system is an effective - Low Maintenance Method for colour removal/reduction; however, selection of media rather than the reeds play major role in this aspect.
- it is an effective method of tertiary treatment for tannery effluent
- it takes quite a long period for stabilization (over a year) in any mode of operation of treatment of effluent from tanneries processing wet blue to finished.
- The reeds available locally far outperformed those, which were imported from other locations, which have different geo-climatic conditions.

10.3 Performance of the reed beds at VISHTEC CETP indicates that

- the excessive caution against clogging shown in selection of the media was not required.

- Salinity/TDS is not a limiting factor for operation of reed beds since there are several varieties of reeds, which easily survive, grow and propagate in saline effluents and still yield results.

- a variety of reed found to be the best for a given set of conditions like effluent, climate, media etc. need not necessarily be the best in a different situation; that is the selection of the reed variety could be case-specific.

- the quantity of feed is to be maintained at a certain minimum level irrespective of the quality to sustain the reeds. This is valid for most of the species of reeds even though most of them are draught resistant.

- atmospheric temperature has an influence on the performance of the reed beds; higher temperature leads to better performance particularly with respect to reduction of BOD and partially with respect to COD reduction.

- atmospheric humidity and rainfall have practically no role in the performance, though along with temperature, it plays a major role in the evapo-transportation rates.

- the influence of BOD :COD ratio has an appreciable impact on the performance; though usual for other biological process, this ratio was found to have nebulous impact on reed beds handling certain types of effluents.
- pH of the influent has practically no effect on the performance of the reed bed system. Further, it may also be concluded that the reed bed is a pH correcting system. Reed beds used for treating highly acidic effluents were seen to yield effluent of pH close to 7. In the case of VISHTEC CETP, alkaline offer was found to have a pH reduction with the effluent having pH close to 7.

- the reed bed system is an effective - Low Maintenance Method for colour removal/reduction; however, selection of media rather than the reeds play major role in this aspect.

- it is an effective method of secondary and tertiary treatment for tannery effluent for tanneries processing raw to finished leather.

- it takes very little time for stabilization (less than a month) for treatment of effluent from tanneries processing raw to finished.

- The reeds available locally far outperformed those, which were imported from other locations, which have different geo-climatic conditions.

10.4 The Reed Bed experiment at TALCO - Ranitec, though a crudely designed and constructed one with soil media with a crushed stone support system for the media with a limited objective of studying the colour removal efficiency of the system, has shown interesting results by achieving a good rate of reduction of COD in spite of a very low BOD: COD ratio. Though the offer had BOD in the range of 10 mg/l to 32 mg/l only reduction of up to 72% were also observed. One distinct advantage of the bed was very deep root penetration achieved. This was along with the root system having a good 'grip' in the substrate. Of the species tried, Typha did best especially when the system was maintained at flooded/inundated conditions. However, the same conditions were not conducive to the growth and propagation of Trema. The high TDS of the offer was practically of no consequence to the reeds selected and planted.

10.5 The experiment at SIDCO CETP, also confirmed the high level of colour removal efficiency of reed beds. The different hydraulic loading patterns tried have resulted in finding that the optimum pore space retention time (PSRT) is in the range 2.5 to 3 days. Further reduction in PSRT was found to have drastically changed the performance, the reduction in efficiency almost exponentially related to the reduction in PSRT.

10.6 The nurseries at PKL and VISHTEC CETP has shown that Phragmites is not suitable to the prevailing geo-climatic conditions in the areas, which approximates that of PKL area. The fact that Phragmites sp. is not native to eastern parts of Tamil Nadu could be due to the incompatibility of the climate with the requirements of the reeds. However, it has also been observed that tissue cultured variety of Phragmites australis has survived fairly well in the experimental reed bed at TALCO RANITEC. Scirpus, which was the best growing species in the nursery, was found to lose 'grip' over the substrate after achieving certain height. This phenomenon is not observed in the case of Typha & Trema, which have more height. Indication, that the selection of the media is also dependent on the type of reeds to be planted and the structure of their root system are available from this. However, the growth rate, propagation rate etc. in the nursery per se need not necessarily show that the particular variety is best for that type of effluent in the bed when the media in the bed could be different level of nutrients in the nursery could be higher.

The characteristics of the offer to the Reed Bed could be different from the effluent used for irrigation.

10.7 In view of the above it could be inferred that a reed bed over and above being a low maintenance system could be made a low cost project also. This could be achieved by proper site selection to reduce construction costs, power requirements etc.

10.8 Excessive care and prophylactic measures need not be taken to avoid clogging since the possibility of clogging is found to be very low even in sand media/soil media. However, it is contingent upon proper primary treatment to ensure free flow of the primary effluent through the reed bed system.

Reeds may preferably be selected from local areas. Any possible shock by transfer from one climatic condition to another and subsequent lead-time for stabilization of the systems can be avoided by this method.

Wherever only a polishing treatment in required, RB system can be safely adopted with more or less assured results.

RB system is, effective as a colour removal unit especially when media of smaller size are used.

It cannot be adopted as a secondary system for a new tanning unit processing wet blue to finished leather due to the system requiring a long stabilisation time, which will not satisfy the legal requirements to operate the tannery.

Reed Bed System can be effectively used as a primary or secondary treatment system for a new CETP depending on the type of tanneries connected to the CETP. In the case of the CETP, the various units generating the effluents to be treated start production at different times. The offer quantity will be low in the beginning making the system under loaded initially. When all the tanneries become operational over a period, the system would have already stabilised. Further, any additional requirement of water for the system could be met by any source of water available locally irrespective of its quality. Polluted ground water with high TDS or other pollutants could be used without any negative impact at this phase to meet the quantity requirements of the RB.

10.7 Further observations of the Reed Bed system at PKL and VISHTEC CETP in the extended maintenance period up to February 2001 could yield more valuable data, which could provide further insight about the operational efficacy of RB for treatment of tannery effluent.

10.8 A better constructed larger version of RB could be tried in TALCO - Ranitec for reconfirming the results obtained so far before setting up a full side unit there for tertiary treatment of the effluent with colour removal as the major objective. The proposed unit at P.M. Meera Hussain & Co. at Nandiyalam by conversion of polishing ponds into RBs could also yield valuable information since the unit has a different type of effluent from all the other units under consideration due to the vegetable tanning process adopted there.

10.9 Creation of awareness of the potential of this technology and developing facilities for easy transfer of technology will go a long way in assisting many industries especially in Leather sector to overcome the pollution problems in an economically and socially acceptable.

Annexure 1

Terms of Reference : Sub contractor 1, PDU/1

US/RAS/92/120

TERMS OF REFERENCE
FOR SUBCONTRACTOR 1, PDU/1
REED BED TECHNOLOGY FOR TREATMENT OF TANNERY EFFLUENT
(Design, plants selection, monitoring)

A) BACKGROUND INFORMATION

Brief Description of the Programme

The UNIDO Regional Programme of Pollution Control addresses the issue of containment of environmental degradation emanating from the tanning industry in the region. Under this "umbrella project" appropriate cleaner production methods, efficient and cost effective end of pipe treatment of tannery effluent, conversion / utilisation solid wastes from tanneries and/or disposal etc. are demonstrated through establishing Pilot and Demonstration Units (PDUs).

General aspects

Effluent treatment has become a major concern among tanneries in India over the last few years. Several individual and common effluent treatment plants are now installed and under operation in the state of Tamilnadu. Performance of almost all the CETPs and most of effluent treatment plants are reported to be good. Research activities to find out more efficient and economical treatment methods are in progress.

Reed beds have been used since the 1970s and 1980s to treat domestic sewage and certain types of industrial waste, mostly in Germany but in the 90s increasingly in the UK and the USA. The perceived advantages are efficient treatment and at the same time lower investment, operation and maintenance cost than conventional treatment systems. The major disadvantage is that it requires more land than conventional treatment systems. Till date however, with one exception of a tannery in Laos, reed bed technology has not been applied in the treatment of tannery effluent.

Reed bed treatment brings out break down of organic matter mainly due to aerobic/anaerobic cycles caused by bacteria present in root zone of reeds. The gravel media based reed bed system using a variety of phragmite reeds is popular for treatment of domestic sewage and likely to be suitable for partially treated tannery effluent. While many components present in tannery effluents such as ammonium sulphate, lime gypsum and slow release high organic nitrogen products are considered helpful for reed growth, components like salinity may adversely affect the growth. However, these aspects could be verified through a plant scale experiment.

Though there is practically no significant experience in application of reed bed system for treatment of tannery effluent, there appears to be scope for its application. Initially this may be for tertiary treatment and gradually for reducing pressure on the biological treatment. To minimise the risk of survival of the reed due to high TDS (8000 - 12,000 mg/l) it is suggested to mix the treated effluent with fresh water for an initial period of 4 to 5 months. It is suggested to adopt 5 days detention time taking into account 40% as void in the media and horizontal flow with gentle slope for free flow to avoid any anaerobic condition. If reed bed is able to take up high BOD / COD load, the cost of operation of the biological treatment would be reduced.

It has been proposed to set up one reed bed to treat 50 m^3 per day of effluent from the CETP Melvisharam which receives and treats effluent from tanneries processing raw hides and skins into finished leather likewise another reed bed of like capacity will be set up at PKL tannery at Kannivakkam to treat effluent from a tannery processing semi finished hides and skins into finished leather.

B) Objective / output

In conformity with information and explanation provided earlier, the objective is to investigate the viability of applying the reed bed technology (well established for treatment of domestic waste water) for final treatment of tannery effluents. Two semi-industrial scale pilot and demonstration units (PDUs) for two locations and different conditions are to be set up, and practical test conducted.

D) SERVICES TO BE PROVIDED:

In order to produce the outputs mentioned earlier the subcontractor, acting as the main source of expertise on the agricultural aspects of the pilot and demonstration unit for reed bed technology for tannery effluent treatment, will provide the following services:

The Regional Programme Office of UNIDO in Madras, in consultation with the pre-identified common effluent treatment plant at Melvisharam and with the ETP at PKL, Kannivakkam, both of Tamilnadu, India, has identified sites for pilot and demonstration units for reed bed technology for tannery effluent treatment and through contractors develop the sites so as to make these suitable for reed bed system.

C) Suggested system

C.1. Suggested capacity of the system

- The expected initial volume of effluent to be processed by the reed bed is 50 m^3/day at each at two proposed locations in the state of Tamilnadu.

C.2 Brief description of the suggested system

- Reed beds would be established in 3 beds operating in series with dimensions 16.0 m x 1.2 (TD) . There should be provision for operating these in parallel too.

- The inlet to the bed is through pipeline (initially secondary treated effluent and later primary treated effluent would be admitted into the bed) and distribution of effluent into the bed will be through overflow from inlet channel constructed on the inlet side of the bed.

- The bed is filled up with media (5-10 mm pebbles) for a depth of 0.8 meter.

- For preventing any plug flow of effluent, a baffle wall would be constructed at the outer side of the bed.

- Overflow from one bed is taken to the next bed through inlet arrangement similar to first bed. The reduction of pollutants should be monitored at the outlet of each bed.

- Inlet of the reed bed is measured through a water meter.

- Outlet from the reed bed is collected in a small collection sump from where the same is pumped out as treated effluent or to the treatment units, depending on the degree of purification achieved.

- A water meter fixed on the pumping line to record the daily flow.

- The following general specifications will apply for three beds in series of size 16.0 m x 16.0 m x 1.2 m @ 0.8 m media depth, shallow sides at an angle of 45° , the total height of the walls is 1.6 meter; Clay puddling, thickness 0.3 m; Sand layer-1 (sieved sand), thickness 8 cm; LDPE sheet @ 600 micron 1.6 square meter per kg; Sand layer-2 (sieved sand), thickness of layer 8 cm; plain cement concrete PCC (1:3:6), thickness 8 cm; inlet and outlet arrangement in brick masonry; inlet flow distribution channel & outlet channel in between beds; Gravel Media, height 80 cm; Piping, valves etc.; Flow meters, water pump centrifugal, treated effluent sump, size 2.0 m x 2.0 m x 1.0 m of brick masonry etc. complete. However the subcontractor is responsible for the final design for implementation. These activities will be carried out through an independent arrangement under the overall supervision of the subcontractor.

C.3. Proposed location

The Regional Programme Office of UNIDO in Madras (RePO), in consultation with potential recipients of technical assistance has identified sites for pilot and demonstration units for reed bed technology for tannery effluent treatment.

One proposed location is at the effluent treatment plant (ETP) of the Presidency Kid Leather (PKL), Kannivakkam, Chingelpet District, Tamilnadu and the second location is at the VISHTEC common effluent treatment plant (CETP), Melvisharam, North Arcot Ambedkar District of Tamilnadu. The sites for the reed bed have been pre-identified at both the locations.

D. 1 Responsibilities of the subcontractor

- Detailed design and lay out for reed bed at selected sites including survey and contour mapping for gravity flow. The design will enable UNIDO to invite tenders directly for implementation of the construction work at each site separately.

- Hydraulic testing of the reed bed.

- Identification of most suitable reeds based on saline resistance and development.

- Planting of reeds, monitoring of their growth and replacement of non-performing species.
- Detailed monitoring schedule for assessment of tertiary treatment by the reed beds and detailed implementation schedule for increasing strength of effluent.
- Implementation of schedule for increase of effluent strength through avoidance of dilution and secondly by using effluent from primary treatment / first stage aerobic treatment.
- Monitoring of effluent strength vis-à-vis performance of different species of reeds.
- Supply of reeds and provide details on sources of reeds
- Replacement of reeds during the development period.
- Regular reporting as per indicated schedule.

D.2. Direct technical inputs

The subcontractor shall provide the following services on turn key basis.

- Detailed engineering design including field survey, contour mapping for gravity flow etc. as per basic design provided under B.2. Supervision during civil work implementation through site visits, recommend modifications if need be, in writing and together with contractor perform hydraulic testing for at least one week for the reed bed systems.
- Identification of the most suitable species taking into account effluent characteristics at the two identified sites. It is expected that species already growing under conditions similar to those in reed beds will be identified, *phragmites* species likely to be included.
- Collection and /or purchase and supply these species to the site, (re)planting and monitoring their establishment. After establishment of reeds, recommend increase of effluent strength by reducing amount of fresh water at the site at Melvisharam and ground water at the PKL site including optimum pH and TDS range for discharging effluent into reed bed.
- Provide and implement the detailed monitoring schedule for performance of reed beds with respect to different reed species, different strength and type of effluent, varying quantity of effluent taking into account other elements such as climatic conditions etc.. Specifically, monitor through sampling two times per week and analyse results of reed bed experiments (pH, TDS, chlorides, BOD, COD, chromium, nitrogen, ammonium) on influent to reed bed and effluent from reed bed.
- Replace species either individually or collectively which are not performing well with new or other species.
- Monitor results for a period of one year for each site for each of the parameters listed above as well as other elements such as plant growth, root structure analysis etc..

- Train the effluent treatment plant personnel in monitoring, operation and maintenance of reed bed treatment system.

- Analyse reeds before planting after planting and during operation for uptake of pollutants in tannery effluent.

- Final report including all work undertaken and drawings, designs of reed bed, implementation and development arrangement, supply sources etc. as well as a paragraph on recommendations for future implementation.

D.3 Report

The subcontractor will give the final report with all work carried out including list of suppliers of reed, recommended increase of strength of effluent for treatment etc. The beneficiaries will provide access to sites for carrying out the activities outlined.

E) Time schedule for project implementation

Within one month from the date of confirmation of the award of contract by UNIDO the entire activities will be completed within fifteen months.

	Duration
Briefing at RePO, Madras of subcontractor's team leader / specialists and review of implementation of work at the two sites.	3 days
Identification and selection of reeds for the sites at Melvisharam and Kannivakkam	
Supervision of construction of reed bed as per the design prepared by the sub-contractor	3 months
Supply and planting of reeds at PKL, Kannivakkam and later at CETP, Melvisharam.- first quarterly report	2 weeks
Monitor experiments and increasing strength of effluent at each location : first quarterly report	3 months
Monitor experiments and increasing strength of effluent at each location: second quarterly report	3 months
Monitor experiments and increasing strength of effluent at each location: third quarterly report	3 months
Monitor experiments and increasing strength of effluent at each location: fourth quarterly report	3 months
Draft final report	1 month
Review of draft final report by RePO	2 days
Final report submission	1 week

F) MODALITIES OF IMPLEMENTATION

The subcontractor will in its work be guided, primarily through its Team Leader, by the Regional Programme Office of UNIDO located in Madras, India and will interact with Team leader and staff of the Reed Bed construction subcontractor(s) as well as with the main subcontractor for technical inputs under the project, i.e. CTC, France and other staff of the Regional Programme Office in madras as well as with the selected tannery/CETP. The RePO will be in close liaison with the Project Manager at UNIDO, Vienna.

1. Period: Approximately 15 months, from December, 1997

2. Time input:

Field :
Total

Team leader (senior agricultural specialist with practical experience in tannery effluent)	0.5 w/m
Agricultural specialist with experience in tannery effluent (on site)	12 w/m
Civil engineer for detailed design drawings, contouring, survey etc. supervision of civil works, hydraulic testing etc.	1 w/m
Support staff	2 w/m

Home base:

Team leader (over period)	1.5 w/m
Civil engineer	
Support staff	2 w/m
GRAND TOTAL	**19 w/m**

Project team:

- Senior agricultural specialist with practical experience in tannery effluent treatment and utilisation (Team Leader)
- Agricultural specialist with experience in tannery effluent treatment and utilisation (on site)
- Civil engineer
- Support staff, chemist, typist etc..

Reporting

Reporting will consist of papers containing specific technical inputs such as reed bed species, performance, cost estimates etc.; technical comments, suggestions from studies and activities prepared and/or implemented. One final report will be submitted as per the format prescribed by UNIDO. At the end of the period a draft final report will be submitted and following evaluation of the draft final report the sub contractor will submit a final report.

Annexure 2

Performance of Different varieties of reeds in the nursery developed at Cochin

Development of Nursery at Cochin

To supply reed varieties for PKL Kannivakkam and VISHTEC Melvisharam, a nursery was set up at Cochin. The main objective was to study lhs tolerance of reed varities to various parameters like pH end salinity/TDS. A paddy field was made available for setting up the nursery.

Several plots of 3.0 x 3.0m were developed for conducting trials. 25 saplings of each species were procured from various natural wet lands in Cochin and were planted in the 9 m^2 plots at a spacing of 0.5 m. Trials were conducted with the following 12 species.

- Typha angustifolia
- Typha latifolia
- Sachharum spontaneum
- Scirpus validus
- Scirpus robustus
- Coix lachryma
- Canna indica
- Canna lilly
- Phragmites (wild reed)
- Phragmites australis (common reed)
- Trema orientalis
- Bamboo sp.

Trials were conducted from 28th December 97 to 20th April 98. The reeds were irrigated with an average quantity of 16 lpd per reed.

Observations of this trial are given below. Based on these results the following reed varieties were recommended for PKL.

1. Typha angustifolia
2. Sachharum Spontaneum
3. Scirpus robustus
4. Phragmites australis

Table 2-1 (i)

SPECIES : Typha angustifolia
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
5000	25	25	25	25	25	22	22	22	22	22	22	22	22	20	20	20
10000	25	25	25	22	22	22	22	21	21	21	21	21	20	20	18	18
15000	25	25	25	25	23	21	21	20	20	20	19	19	19	17	17	15
20000	25	24	24	22	22	22	21	21	20	19	18	18	17	17	16	16
25000	25	23	22	21	19	19	19	17	16	16	14	13	12	12	12	12

Table 2 - 1 (ii)

SPECIES : Typha latifolia
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
5000	25	20	18	18	17	16	13	10	7	5	2	0	**	-	-	-
4000	25	23	22	20	17	17	15	12	12	10	6	6	6	**	-	-
3000	25	23	23	21	21	20	19	17	15	14	12	10	8	8	8	8
2000	25	24	24	24	23	23	20	17	17	16	16	16	14	14	12	12
1000	25	25	25	22	22	22	22	22	17	17	17	14	14	14	14	14
500	25	25	25	20	20	20	20	20	20	20	20	20	20	20	20	20

** Trials discontinued

Table - 2-1 (iii)

SPECIES : Scirpus robustus
No. Planted : 25

Parameter Chlorides as Cl (mg/l)	Days/ No. Survived															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
5000	25	25	25	25	25	22	22	22	22	22	19	19	19	19	19	19
10000	25	25	25	25	22	25	25	21	20	19	17	17	17	17	15	15
15000	25	22	20	19	19	19	19	19	19	19	19	19	16	16	16	14
20000	25	20	19	19	19	15	15	15	15	**	-	-	-	-	-	-
25000	25	25	19	19	14	14	12	12	10	10	**	-	-	-	-	-

** Trials discontinued

Table - 2-1 (iv)

SPECIES : Scirpus validus
No. Planted : 25

Parameter Chlorides as Cl (mg/l)	Days/ No. Survived															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
5000	25	25	25	19	19	16	10	10	5	**	-	-	-	-	-	-
4000	25	25	25	22	19	15	15	15	12	10	**	-	-	-	-	-
3000	25	25	25	25	24	22	22	22	20	14	14	14	14	**	-	-
2000	25	25	25	25	22	19	19	19	19	15	15	15	15	12	12	12
1000	25	24	24	22	22	22	22	22	19	17	17	17	17	12	12	12
500	25	23	23	23	23	23	23	23	23	23	23	21	21	21	21	21

** Trials discontinued

Table - 2-1 (v)

SPECIES : Sachharum Spontaneum
No. planted : 25

Parameter Chlorides as Cl (mg/l)	Days/ No. Survived															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
5000	25	25	24	22	22	22	22	21	21	19	19	19	19	18	18	18
10000	25	25	25	25	21	20	20	20	20	16	14	12	**	-	-	-
15000	25	25	25	21	20	20	20	20	20	16	14	12	**	-	-	-
20000	25	25	18	16	12	**	-	-	-	-	-	-	-	-	-	-
25000	25	25	15	**	-	-	-	-	-	-	-	-	-	-	-	-

** Trials discontinued

Table - 2-1 (vi)

SPECIES : Coix lachryma
No. Planted : 25

Parameter Chlorides as Cl (mg/l)	Days/ No. Survived															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
5000	25	25	25	15	10	8	**	-	-	-	-	-	-	-	-	-
4000	25	25	18	18	10	7	**	-	-	-	-	-	-	-	-	-
3000	25	12	19	18	15	15	12	**	-	-	-	-	-	-	-	-
2000	25	21	17	17	15	15	12	10	**	-	-	-	-	-	-	-
1000	25	25	18	16	15	12	10	10	10	10	**	-	-	-	-	-
500	25	22	22	19	16	16	16	15	12	12	10	10	**	-	-	-

** Trials discontinued

Table 2 - 1 (vii)

SPECIES : Phragmites australis (Common reed)
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
5000	25	25	25	23	22	22	22	22	22	22	22	22	22	22	22	22
10000	25	25	24	24	23	23	22	22	20	20	20	20	20	20	20	20
15000	25	25	25	24	24	23	23	22	22	22	21	21	21	21	21	21
20000	25	25	24	24	23	23	23	22	21	20	20	19	19	19	19	19
25000	25	24	23	22	21	21	19	19	18	18	16	16	14	14	14	14

Table 2-1 (viii)

SPECIES : Phragmites sp. (Wild reed)
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
5000	25	25	25	25	24	24	23	23	22	22	22	22	22	22	22	22
10000	25	25	24	24	24	23	23	22	21	21	21	21	21	21	21	21
15000	25	24	24	24	22	22	22	21	21	19	19	19	19	19	19	19
20000	25	24	24	23	23	23	22	22	21	21	20	20	20	20	20	20
25000	25	24	23	22	20	20	20	19	19	18	17	17	17	16	16	16

Table 2-1 (ix)

SPECIES : Canna indica
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived*															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
5000	25	25	25	25	18	18	15	15	15	12	**	-	-	-	-	-
4000	25	25	25	25	25	17	17	17	17	15	**	-	-	-	-	-
3000	25	25	25	25	19	19	19	19	19	19	16	15	14	12	12	12
2000	25	25	25	25	18	16	16	16	16	16	15	15	15	15	15	15
*1000	25	25	25	22	22	22	22	22	19	22	24	24	25	27	27	27
*500	25	25	25	25	22	22	22	24	26	29	31	32	32	34	35	36

* No. increased after one month in spite of wilting due to fast propogation rate of the species.

** Trials discontinued

Table 2-1 (x)

SPECIES : Canna lilly
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
5000	25	20	20	19	17	15	14	10	10	8	8	6	5	4	4	4
4000	25	23	23	20	20	17	15	10	10	**	-	-	-	-	-	-
3000	25	24	23	22	20	20	19	16	16	15	14	10	10	8	**	-
2000	25	23	22	20	19	19	18	18	18	17	15	12	12	12	10	10
1000	25	25	23	21	21	21	19	19	18	18	18	16	16	15	15	15
500	25	25	24	24	24	23	23	22	22	20	20	20	20	20	20	20

Table 2-1 (xi)

SPECIES : Bamboo sp.
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
5000	25	25	25	24	21	21	21	21	21	21	21	20	20	20	20	20
10000	25	25	25	25	24	23	22	22	21	21	21	20	20	19	19	19
15000	25	23	23	22	22	21	21	20	20	20	19	19	18	18	17	17
20000	25	23	20	20	19	18	18	18	18	17	17	17	17	17	17	17
25000	25	20	18	17	17	16	16	15	14	13	12	11	11	11	11	11

Table 2-1 (xii)

SPECIES : Trema Orientalis
No. planted : 25

Parameter chlorides as Cl (mg/l)	Days/No. survived															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
5000	25	20	20	18	17	15	10	8	**	-	-	-	-	-	-	-
4000	25	24	20	19	18	18	14	14	12	11	11	10	**	-	-	-
3000	25	24	23	22	20	20	18	18	16	16	14	10	9	9	**	-
2000	25	24	23	23	22	22	19	19	19	17	17	15	10	10	10	10
1000	25	24	23	22	22	21	20	20	19	17	17	15	15	13	13	13
500	25	24	23	23	23	20	20	20	20	19	19	19	19	18	18	18

** Trials discontinued

Table 2-2 (i)

SPECIES : *Typha angustifolia*
No. planted : 25

Parameter pH in pH Units	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
3	25	23	20	20	20	18	17	15	13	10	10	10	10	**	-	-
4	25	23	20	20	20	17	15	14	14	13	13	13	12	12	12	12
5	25	24	24	23	22	20	16	16	16	15	15	14	13	13	13	13
6	25	24	24	24	23	23	23	21	21	20	19	17	16	16	16	16
7	25	24	24	24	24	23	23	23	21	20	20	20	20	20	20	20
8	25	25	24	24	23	23	23	23	22	21	21	21	21	21	21	21
9	25	23	23	22	20	18	18	16	14	13	12	12	12	12	12	12
10	25	22	21	19	17	15	14	11	10	9	8	8	8	**	-	-

** Trials discontinued

Table 2 - 2 (ii)

SPECIES : Typha latifolia
No. planted : 25

Parameter pH in pH Units	Days/No. survived															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
3	25	24	23	22	22	21	20	17	16	15	14	13	11	10	10	10
4	25	23	22	22	21	21	21	20	19	18	16	14	11	11	11	11
5	25	24	23	22	21	21	20	20	19	17	15	14	14	13	13	13
6	25	24	24	23	22	21	21	20	17	16	15	14	14	14	14	14
7	25	25	24	24	23	22	22	21	21	21	21	21	21	21	21	21
8	25	24	24	23	22	22	22	22	21	20	20	20	19	19	19	19
9	25	24	24	23	22	20	19	18	18	18	16	15	14	13	12	12
10	25	24	20	20	16	15	13	12	11	10	8	**	-	-	-	-

** Trials discontinued

Table 2-2 (iii)

SPECIES : Scirpus robustus
No. planted : 25

Parameter pH in pH Units	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
3	25	24	23	22	20	18	16	13	10	10	8	8	8	8	-	-
4	25	24	23	20	20	20	19	19	18	16	14	13	12	11	11	11
5	25	23	20	20	20	19	19	19	17	17	17	17	17	17	17	17
6	25	24	24	23	22	21	20	19	19	18	18	18	18	18	18	18
7	25	25	25	24	24	23	22	21	21	21	21	21	21	**	-	-
8	25	23	22	20	20	20	20	20	19	19	19	19	**	-	-	-
9	25	24	23	22	21	21	20	20	17	16	16	14	14	14	14	14
10	25	20	18	16	14	13	12	11	10	9	9	9	8	8	8	8

** Trials discontinued

Table 2 - 2 (iv)

SPECIES : Scirpus validus
No. planted : 25

Parameter pH in pH Units	Days/No. survived															
	1	***4***	***7***	***10***	***13***	***16***	***19***	***22***	***25***	***28***	***31***	***34***	***37***	***40***	***43***	***46***
3	25	20	18	18	16	14	13	12	10	10	8	8	8	7	7	7
4	25	23	21	21	21	19	19	18	16	14	14	12	12	12	12	12
5	25	23	23	22	22	22	20	18	16	16	16	16	16	16	16	16
6	25	24	23	23	23	22	22	22	22	18	18	18	18	17	17	17
7	25	24	24	24	24	23	23	22	22	22	21	21	21	21	21	21
8	25	25	24	24	24	23	23	23	22	22	21	21	20	20	20	20
9	25	23	20	20	18	18	17	16	15	13	12	12	11	11	11	11
10	25	20	18	16	14	13	11	10	9	8	7	5	5	**	-	-

** Trials discontinued

Table 2 - 2 (v)

SPECIES : Sachharam spontaneum
No. planted : 25

Parameter pH in pH Units	Days/No. survived*															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
3	25	25	25	24	22	22	22	22	22	22	22	22	22	22	22	22
4	25	25	25	24	22	22	22	22	22	22	22	22	22	22	22	22
5	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
6*	25	25	25	25	25	25	25	25	25	25	25	25	25	25	28	28
7*	25	25	25	25	25	25	25	25	25	25	25	25	25	25	28	28
8*	25	24	22	20	20	20	20	20	18	21	21	21	24	25	26	27
9	25	22	20	18	18	17	17	15	15	15	12	12	12	12	12	12
10	25	25	25	18	18	18	18	18	17	17	17	17	15	18	20	20

* No. of plants has increased in certain conditions due to fast propagation rate of the species.

** Trials discontinued

Table 2-2 (vi)

SPECIES : Coix Lachryma
No. planted : 25

Parameter pH in pH Units	Days/No. survived															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
3	25	25	10	10	**	-	-	-	-	-	-	-	-	-	-	-
4	25	25	15	15	15	10	**	-	-	-	-	-	-	-	-	-
5	25	25	25	22	22	22	20	20	20	20	20	20	20	20	20	20
6	25	25	25	22	22	22	20	20	20	20	20	20	20	20	20	20
7	25	25	25	22	22	22	20	20	20	20	20	20	20	20	20	20
8	25	25	25	22	22	22	20	20	20	20	20	20	20	20	20	20
9	25	24	22	20	18	17	17	17	15	**	-	-	-	-	-	-
10	25	20	18	16	15	12	10	10	**	-	-	-	-	-	-	-

Table 2-2 (vii)

SPECIES : Phragmites australis (Common reed)
No. planted : 25

Parameter pH in pH Units	Days/No. survived															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
3	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-
4	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-
5	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-
6	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-
7	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-
8	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-
9	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-
10	25	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-

*** Trials discontinued due to 100% survival at the end of one month

Table 2 - 2 (viii)

SPECIES : Phragmites sp. (Wild reed)
No. planted : 25

Parameter pH in pH Units	Days/No. survived															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
3	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-
4	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-
5	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-
6	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-
7	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-
8	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-
9	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-
10	25	25	25	25	25	25	25	25	25	25	25	***	-	-	-	-

*** Trials discontinued due to 100% survival at the end of one month

Table - 2-2 (ix)

SPECIES : Canna indica
No. planted : 25

Parameter pH in pH Units	Days/ No. Survived*															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
3	25	25	24	20	20	19	18	16	15	13	10	10	10	10	10	10
4	25	23	23	20	20	20	19	18	17	17	17	16	16	16	16	16
5*	25	24	23	22	22	20	20	20	18	18	18	18	21	24	26	31
6*	25	25	25	25	25	24	24	30	30	30	32	35	35	35	38	38
7*	25	25	25	25	25	25	25	25	31	33	35	37	40	45	48	50
8*	25	24	24	24	24	24	24	23	23	25	30	33	36	37	38	39
9	25	24	23	22	22	22	22	22	22	22	22	22	22	22	22	22
10	25	23	20	20	19	18	17	15	12	11	11	11	11	11	11	11

* No. of plants has increased in certain conditions due to fast propagation rate of the species.

Table - 2-2 (x)

SPECIES : Canna lilly
No. planted : 25

Parameter pH in pH Units	Days/ No. Survived*															
	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
3	25	23	20	19	17	16	13	12	12	12	11	10	10	10	9	9
4	25	23	23	22	21	21	19	17	15	12	12	**	-	-	-	-
5	25	25	25	21	18	18	15	15	15	15	15	15	15	15	15	15
6*	25	25	25	25	25	25	24	22	22	23	25	25	27	27	29	31
7*	25	25	25	22	22	20	20	20	18	20	24	26	26	26	30	34
8*	25	25	25	25	25	22	22	22	22	20	22	22	22	25	25	25
9	25	22	20	18	15	10	**	-	-	-	-	-	-	-	-	-
10	25	25	12	**	-	-	-	-	-	-	-	-	-	-	-	-

* No. of plants has increased in certain conditions due to fast propagation rate of the species.

** Trials discontinued

Table - 2-2 (xi)

SPECIES : Bamboo sp.
No. planted : 25

Parameter pH in pH Units	Days/ No. Survived															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
3	25	25	25	15	15	15	10	8	8	-	-	-	-	-	-	-
4	25	25	25	25	25	20	20	18	18	18	15	15	15	15	15	15
5	25	24	22	22	22	22	22	22	22	22	22	22	22	22	22	22
6	25	25	25	25	22	22	22	22	22	22	22	22	22	22	22	22
7	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
8	25	25	25	25	25	22	19	16	15	15	15	18	18	18	17	15
9	25	25	25	24	24	24	24	24	24	24	24	24	24	24	24	24
10	25	22	22	20	18	18	16	16	16	16	16	16	16	16	16	16

Table - 2-2 (xii)

SPECIES : Trema Orientalis
No. planted : 25

Parameter pH in pH Units	Days/ No. Survived*															
	1	*4*	*7*	*10*	*13*	*16*	*19*	*22*	*25*	*28*	*31*	*34*	*37*	*40*	*43*	*46*
3	25	25	25	25	22	22	19	19	19	19	19	15	15	15	15	15
4	25	25	25	24	24	24	24	22	22	22	22	22	20	20	20	20
5	25	25	25	24	23	23	23	21	21	21	20	20	22	22	22	22
6*	25	25	25	25	25	25	26	26	26	27	27	27	27	27	29	29
7*	25	25	25	25	25	28	28	28	28	28	28	28	34	34	34	34
8	25	25	25	25	25	22	19	16	15	15	15	18	18	20	17	15
9	25	25	25	22	20	17	15	12	12	**	-	-	-	-	-	-
10	25	25	25	22	21	21	12	12	10	**	-	-	-	-	-	-

* No. of plants has increased in certain conditions due to fast propagation rate of the species.

** Trials discontinued

Table 2.3

Sl.No.	*Required pH*	*Vol. of 0.01 M NaOH added to 1 L of 0.01 M HCl (ml)*
1	3	750
2	4	980
3	5	998
4	6	999
5	7	1000
6	8	1001
7	9	1002
8	10	1020

2.13 Results and Discussion

1) Among the two Typha species, namely Typha angustifolia and Typha latifolia, Typha angustifolia showed very good tolerance to chlorides and pH variations. 40% of T. angustifolia survived in irrigation water containing 25000 mg/l of chlorides while 80% survived in 5000 mg/l chlorides. 40% survived in pH conditions of upto 9 while survival rate was 80% and 84% in pH of 7 and 8 respectively. [Table 2-1 (i) and Table 2-2 (I)], but, Typha latifolia seemed very senstitive to chlorides and its tolerance was < 500 mg/l of chlorides [Table 2-1 (ii)]. Even though its pH tolerance is as much as Typha angustifolia, it was not considered for use in the nursery at PKL Kannivakkam since chlorides is the major concern.

2) In the case of Scirpus species, Scirpus robustus performed better than the Scirpus validus. More than 50% Scirpus robustus was found to survive chlorides upto 15000 mg/l while less than 50% of Scirpus validus only survived chlorides >500 mg/l [Table 2-1 (iv)] . The pH tolerance of both the species was found to be almost same [Tables 2-2 (iii) and 2.2 (iv)]. So, for the nursery at VISHTEC, Melvisharam, Scirpus robustus is considered to be a good option.

3) The third reed variety used in trials was Sachharum spontaneum, results of which are shown in Tables 2-1 (v) and 2-2 (v). From the results it can be seen that Sachharum spontaneum shows good tolerance to chlorides and pH variation in the ranges 3 - 8. Another interesting feature was its fast lateral spread. The results show that Sacchharum spontaneum also will be a good option for the Reed Bed at PKL, Kannivakkam and VISHTEC, Melvisharam.

4) Coix lachryma, another wetland plant which was tried, showed high sensitivity to chlorides (<500 mg/l) [Table 2-1 (vi)]. pH tolerance was found to be in the range 5-8 [Table (2-2-(vi)]. But the lateral and vertical

spread of root was surprisingly very good in the case of surviving plants. This species was tried in the nursery at PKL Kannivakkam.

5) Two species of Canna were experimented with for chlorides and pH tolerance. Canna india and Canna lilly showed tolerance to chlorides upto 1000 mg/l [Tables 2.1 (ix) and 2.1 (x)]. Both species showed tolerance to the pH range 4-9. But these species were excluded from the nursery preparation owing to its low chlorides tolerance and their tendency to compete with and win against any type of reeds and very fast propogation rates.

6) The Bamboo species used for the trial showed good tolerance to chlorides (68% survival at 20000 mg/l) [Table 2-1 (xi)]. The tolerance to pH range of 4-9 also was showed by this species. So this species was also included in the nursery at PKL, Kannivakkam.

7) Another plant species which showed good tolerance to chlorides and pH variation was Trema orientalis [Tables 2-1 (xii) and 2-2 (xii)].

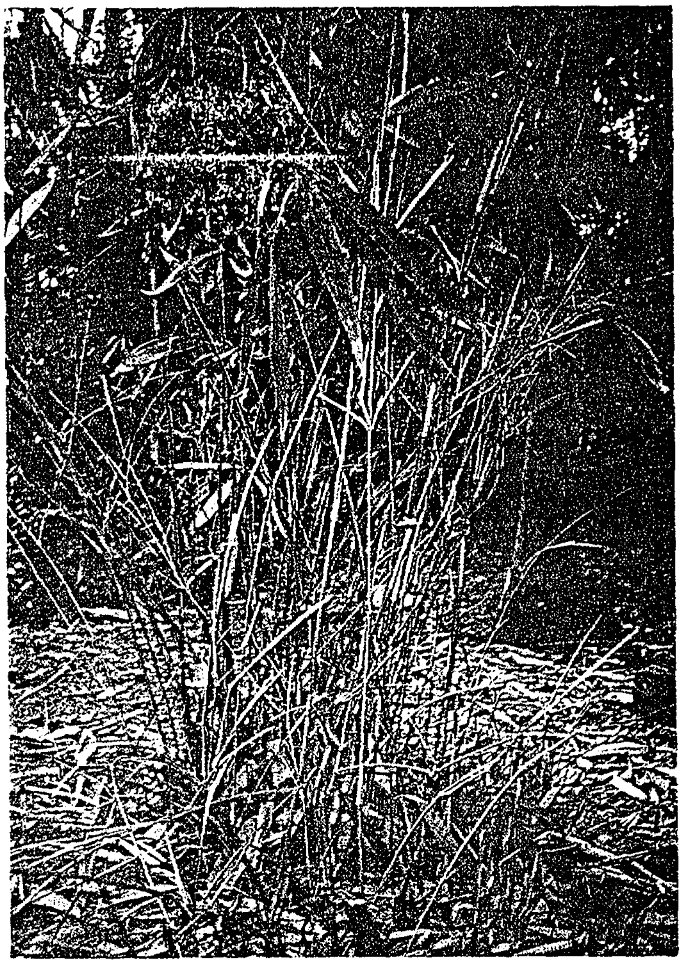
8) Both species of Phragmites (common reed and wild reed) gave good results [Tables 2-1 (viii) and 2.2 (vii)]. Both the species showed more than 50% survival be upto 25000 mg/l of chlorides. Tolerance to a pH range of 3-10 was also observed. These two species are expected to perform well in the reed beds at PKL, Kannivakkam and VISHTEC, Melvisharam.

9) From the above results it is seen that the following species are likely to perform well in the proposed reed beds at PKL Kannivakkam and VISHTEC, Melvisharam.

1. Typha angustifolia
2. Scirpus robustus
3. Sachharam spontaneum
4. Phragmites sp. (both common seed and wild reed)

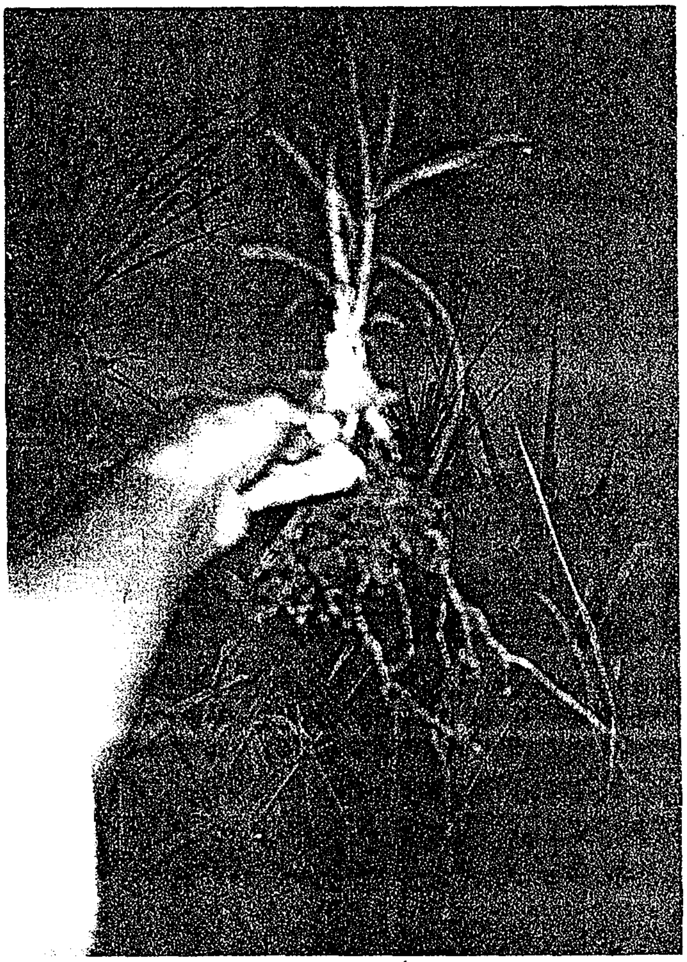
PHOTOGRAPHS OF NURSERY AT COCHIN

Phragmites sp



Typha sp.

Sachharam sp.



Annexure 3

Performance of Different varieties of reeds in the nursery developed at PKL

A nursery of reeds was developed at PKL Kannivakkam. 8 plots of total area of 397.98 m^2 were developed and following varieties of reeds were planted.

1. Typha angustifolia
2. Sachharam spontaneum
3. Phragmites australis
4. Coix lachryma
5. Bamboo sp.

Initially, on 20.1.98 sachharam spontaneum, Typha angustifolia, Coix lachryma and Bamboo sp. were planted. They were irrigated with fresh water for one month and with treated effluent subsequently. The initial trial was only to assess the adaptability of the species to the local climatic conditions. However, the trial run going on at the home office during the same period indicated high potential for Sachharum spontaneum, Typha angustifolia, Phragmites and Scirpus robustus.

The supply of reeds was started in large scale on 4th March 1998, based on the observations at home office. All the reeds were irrigated with treated effluent and their growth/survival were monitored. The observations are given in Table 3.1 to 3.6.

The reeds were irrigated with an average quantity of 10 lpd/plant of treated effluent. The effluent quality during the period is given in Table 3.7.

Table 3.1

Date of Planting : 20.1.98

Site : PKL, Kannivakkam

Sl. No	***Name of species***	***Date of monitoring***					
		20.1.98	***30.1.98***	***10.2.98***	***20.2.98***	***04.3.98***	***% Survival***
1.	Sachharum spontaneum	25	18	18	18	18	72
2.	Typha angustifolia	40	32	30	30	30	75
3.	Coix lachryma	20	10	9	7	7	35
4.	Bamboo sp.	20	5	3	2	2	10

Table 3.2

Date of Planting : 4.3.98

Site : PKL, Kannivakkam

Sl.No.	***Name of species***	***No. supplied***	***No. survived as on 24.4.98***	***% survival***
1.	Typha angustifolia	350	297	85
2.	Sachharum spontaneum	200	130	65
3.	Phragmites australis	100	86	86

Table 3.3

Date of Planting : 17.3.98

Site : PKL, Kannivakkam

Sl.No.	*Name of species*	*No. supplied*	*No. survived as on 24.4.98*	*% survival*
1.	Typha angustifolia	500	380	76
2.	Sachharum spontaneum	200	148	74
3.	Phragmites australis	100	89	89
4.	Bamboo sp.	60	9	16

Table 3.4

Total No. of Plants supplied and survived

Site : PKL, Kannivakkam

Sl.No.	*Name of species*	*No. supplied*	*No. survived as on 24.4.98*	*% survival*
1.	Typha angustifolia	890	707	79
2.	Sachharam spontaneum	425	296	69
3.	Phragmites australis	200	175	87
4.	Coix lachryma	20	7	35
5.	Bamboo sp.	80	11	13

Table 3.5

Plotwise Distribution of reeds as on 24.4.98

No. of plots : 8

Site : PKL. Kannivakkam

Sl.No.	Name of species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Total
1.	Typha angustifolia	90	68	30	112	36	158	213	0	707
2.	Sachharam spontaneum	0	57	18	19	31	70	101	0	296
3.	Phragmites australis	86	0	0	0	89	0	0	0	175
4.	Coix lachryma	0	0	7	0	0	0	0	0	7
5.	Bamboo sp	0	2	0	0	0	0	0	9	11
	Total	176	127	55	131	156	228	314	9	1196

Table 3.6

Dimension of each plot in the nursery

Site : PKL. Kannivakkam

Plot No.	***Length (m)***	***Width (m)***	***Area m^2***
1	5.2	6.7	34.84
2	9.5	6.7	63.65
3	4.4	6.7	29.48
4	11.8	6.7	79.06
5	6.0	6.7	40.20
6	7.0	6.7	46.90
7	12.5	6.7	83.75
8	3.0	6.7	20.10
Total	59.4	6.7	397.98

Table 3.7

Quality of treated effluent at PKL, Kannivakkam (monthly mean value)

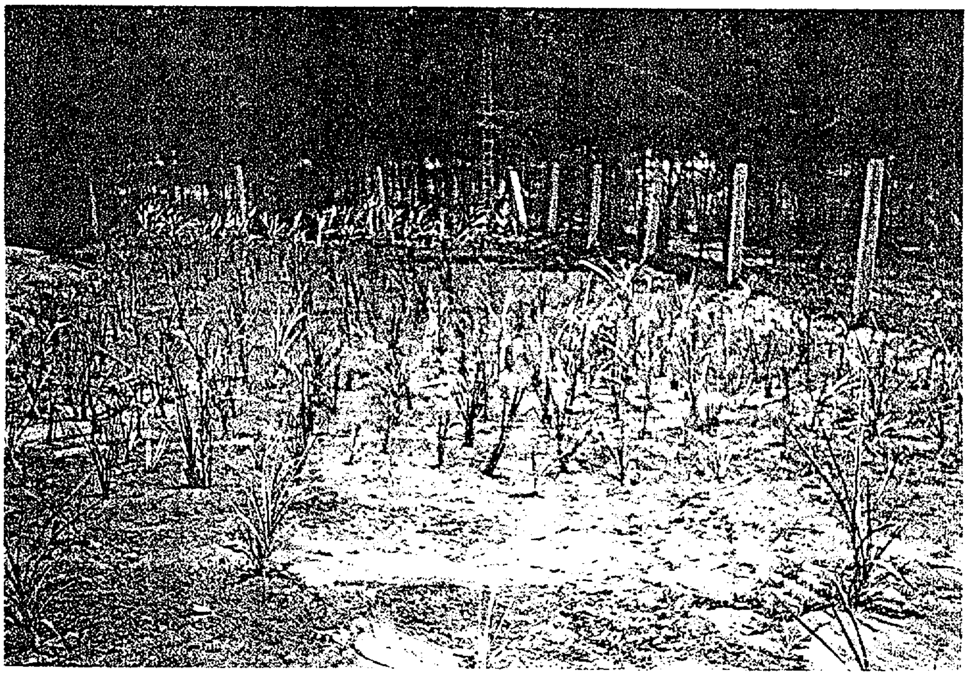
Sl. No.	*Month*	*Parameter*						
		BOD (mg/l)	*COD (mg/l)*	*TDS (mg/l)*	*Chlorides as Cl (mg/l)*	*Sulfates as SO_4 (mg/l)*	*Ammoniacal nitrogen (mg/l)*	*pH (pH units)*
1	January '98	60.5	690.0	5122	660	2000	54.5	7.7
2	February '98	70.0	790.0	4992	700	1900	56.2	7.8
3	March '98	71.0	844.0	5705	720	2020	56.2	8.0
4	April '98	13.0	517.0	5540	740	2000	55	7.8

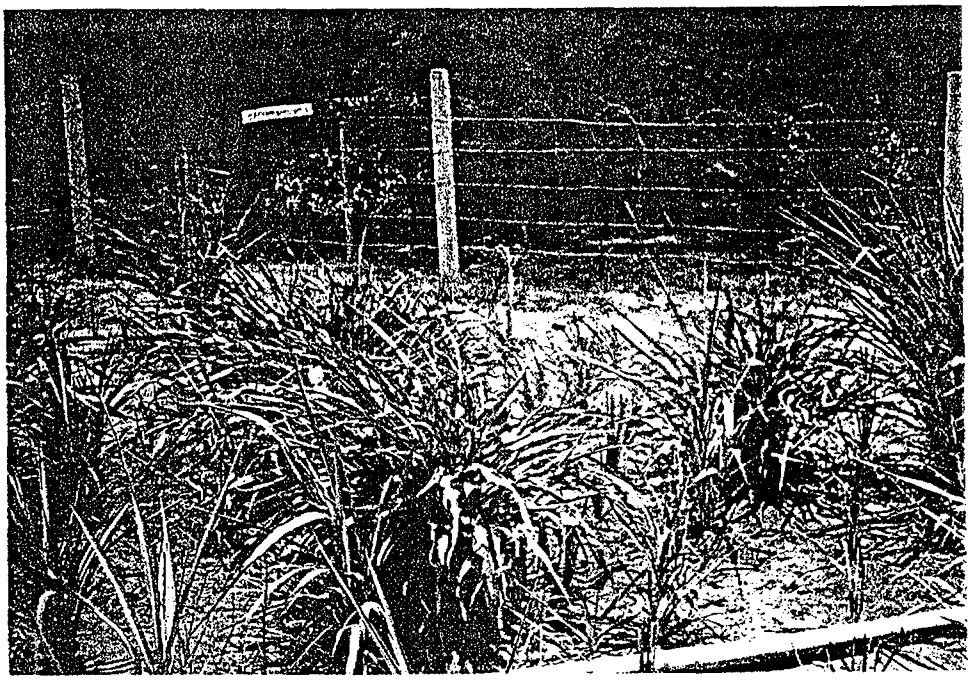
Table 3.8

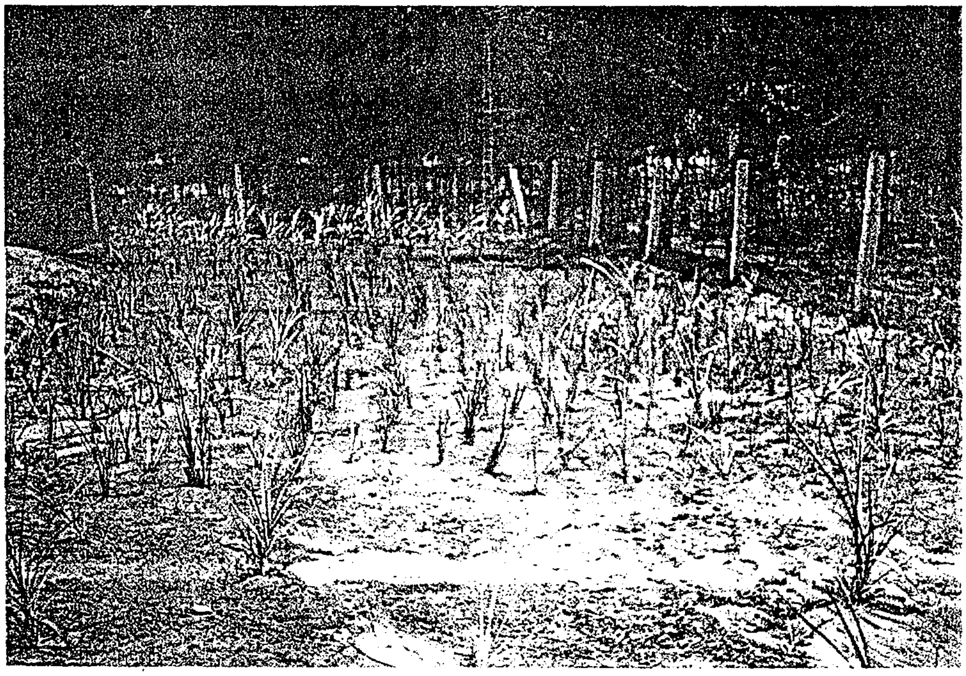
Monitoring of growth of reeds at PKL, Kannivakkam

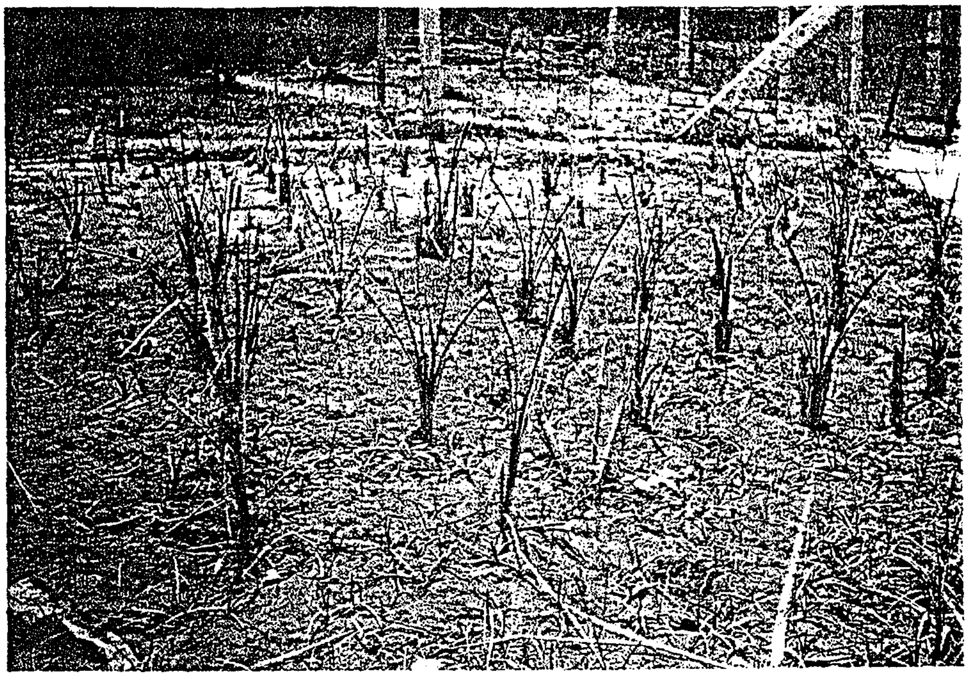
Sl.No.	*Species*	*No. of days*	*Height (cm) (mean value)*
1	Typha angustifolia	94	98
2	Sachharum spontaneum	94	165
3	Phragmites australis	94	37
4	Coix lachryma	94	64
5	Bamboo sp	94	42

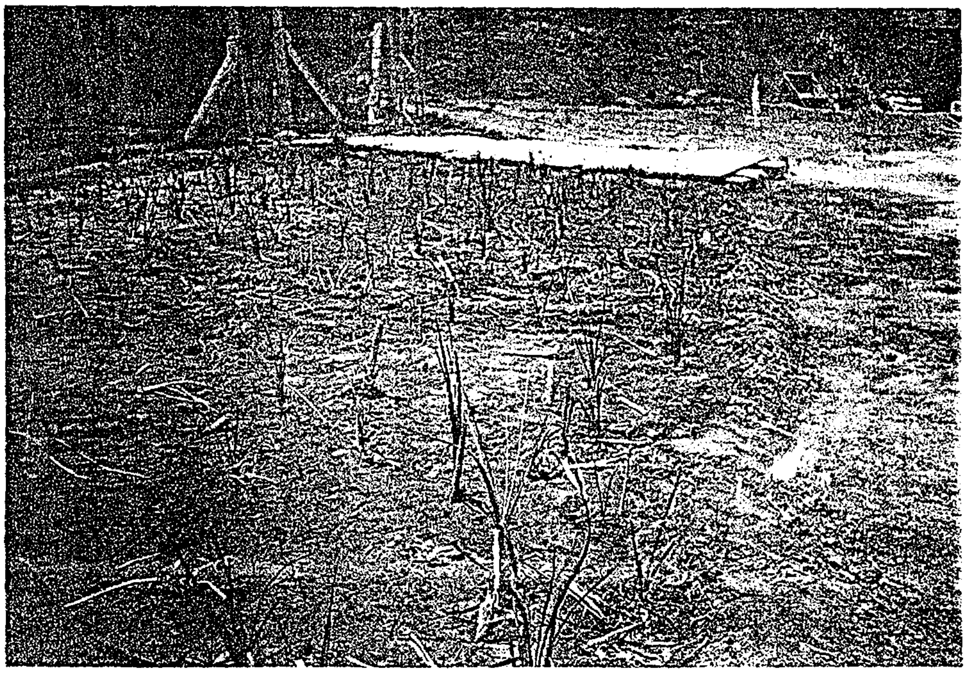
PHOTOGRAPHS OF NURSERY AT PKL

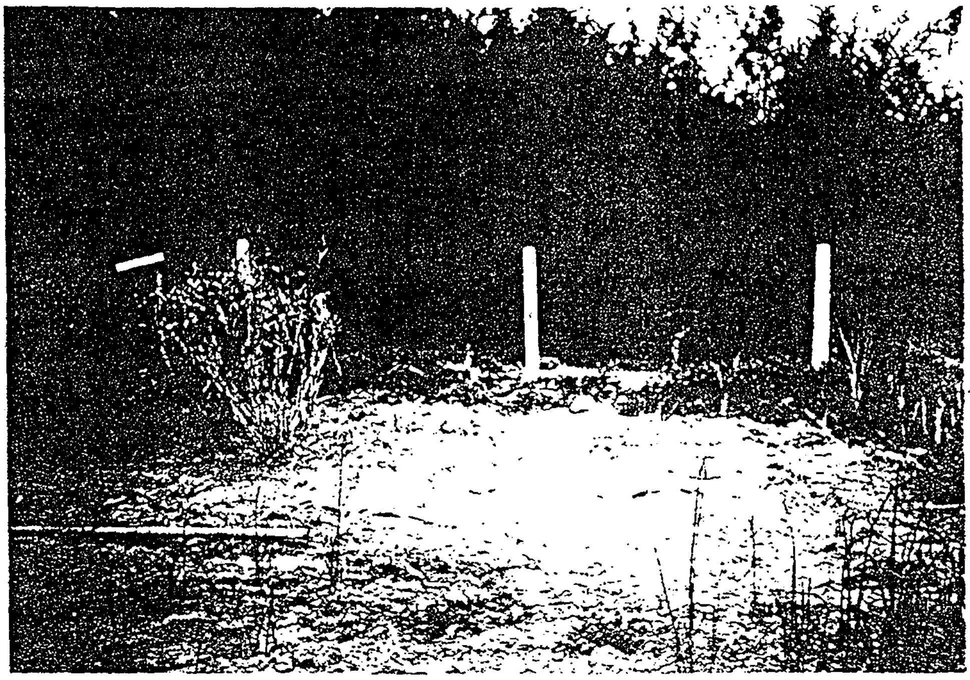


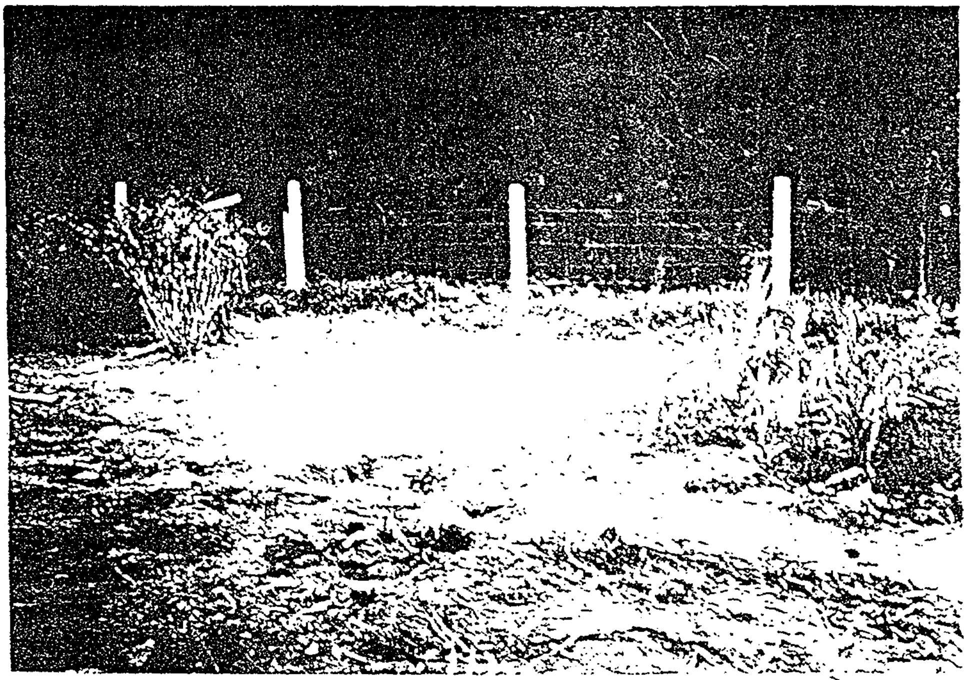




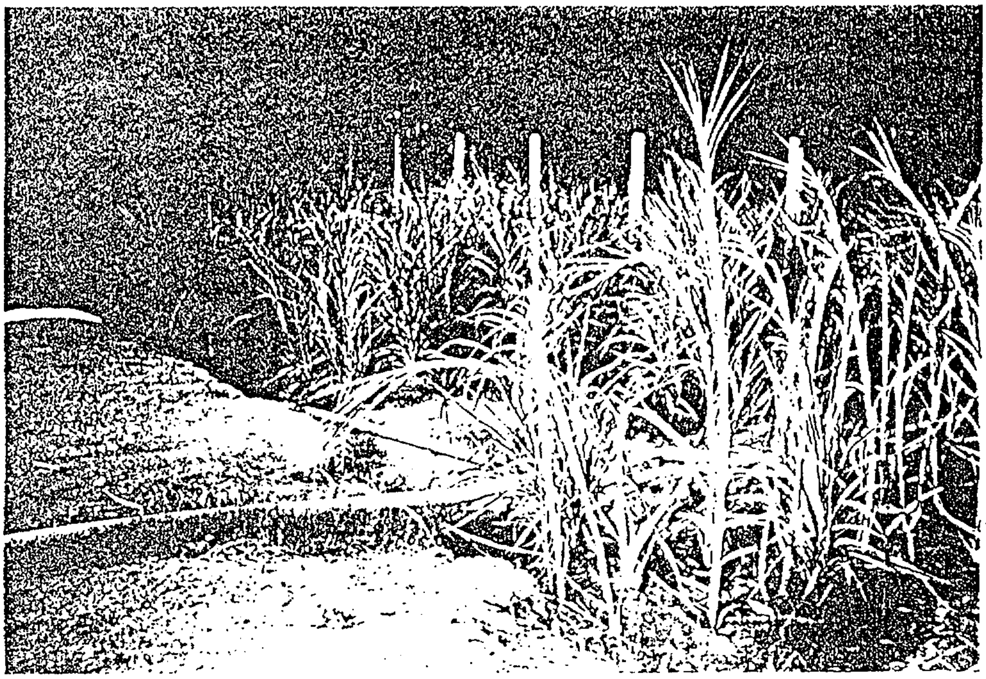




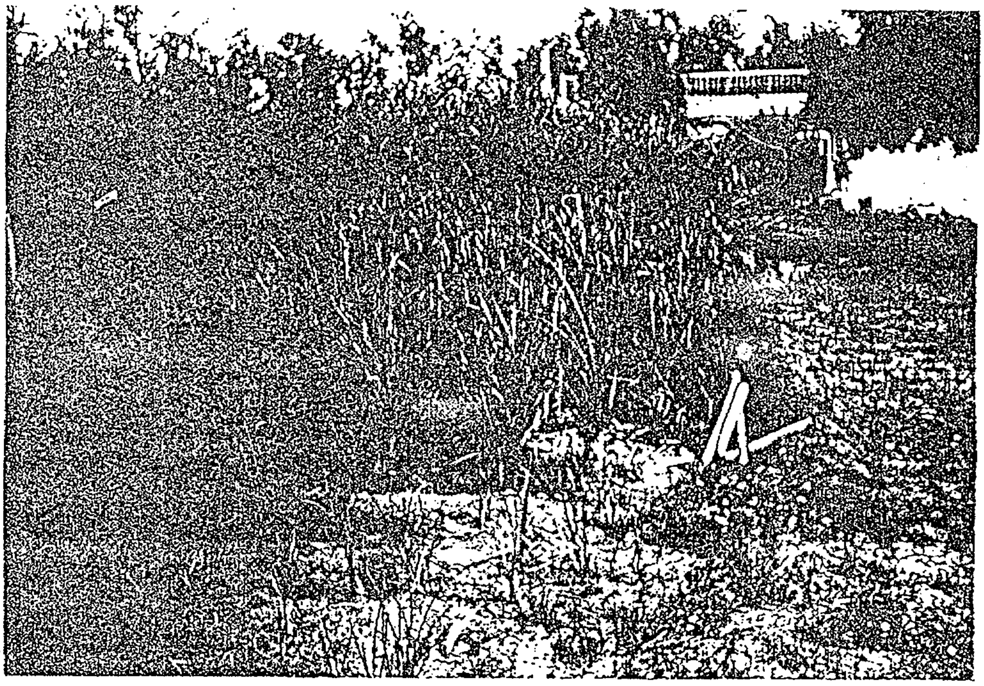




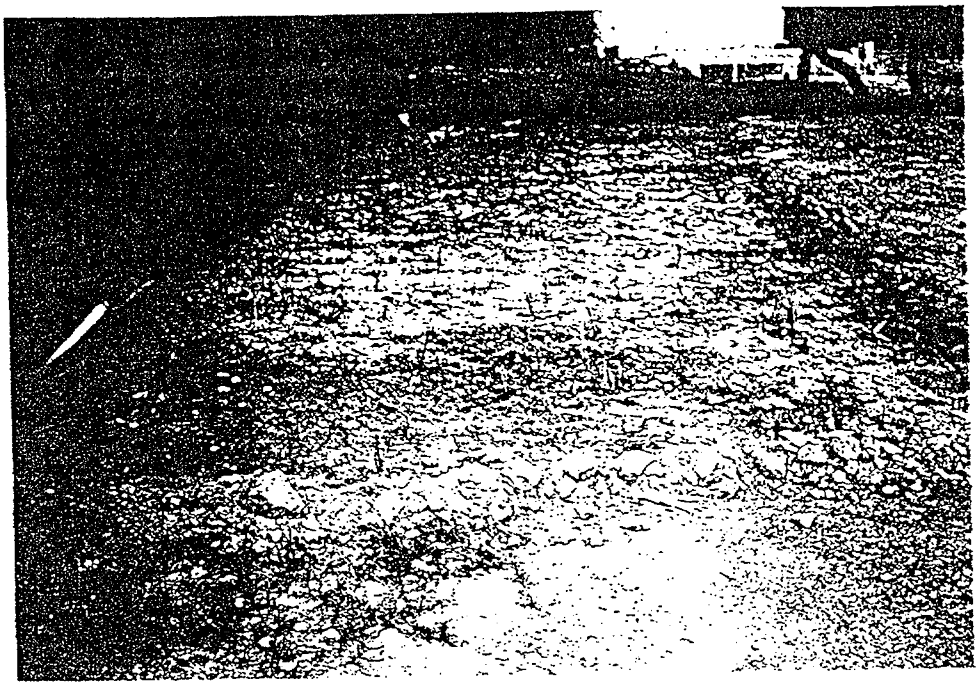
Coix Lachryma which survived. Note that the space which was occupied by Sachharum is free of any weed.



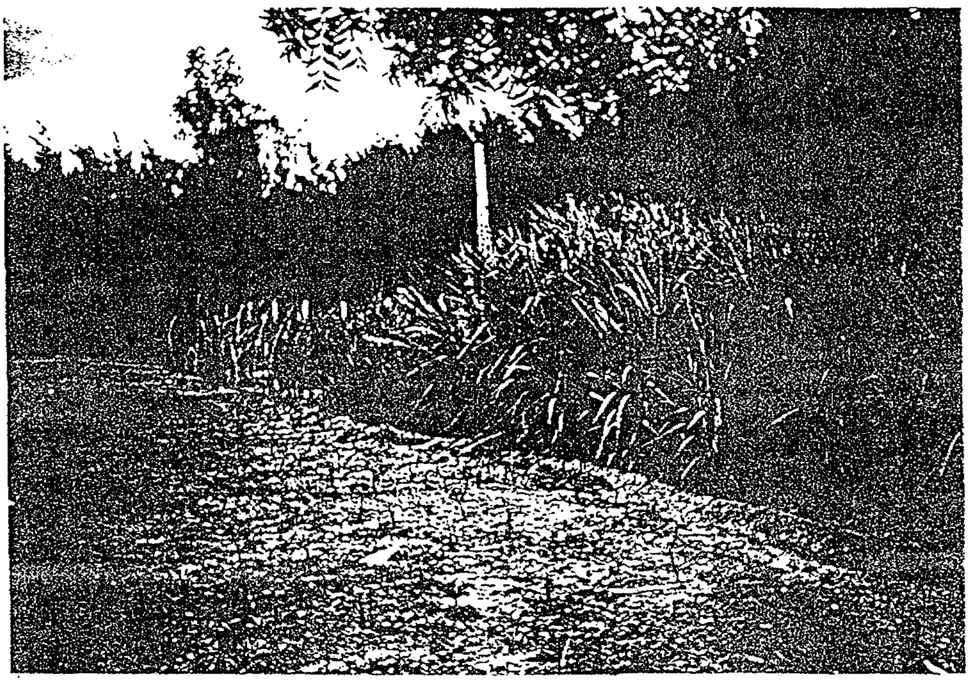
Sachharum spontaneum after separation of shoots and replanting



Typha angustifolia



Scirpus robustus



Sachharum spontaneum

Planting Trema orientalis and Phragmites (Palar)

Scirpus robustus

Annexure 4

Performance of Different varieties of reeds in the nursery developed at VISHTEC CETP

1. **Details of Nursery**

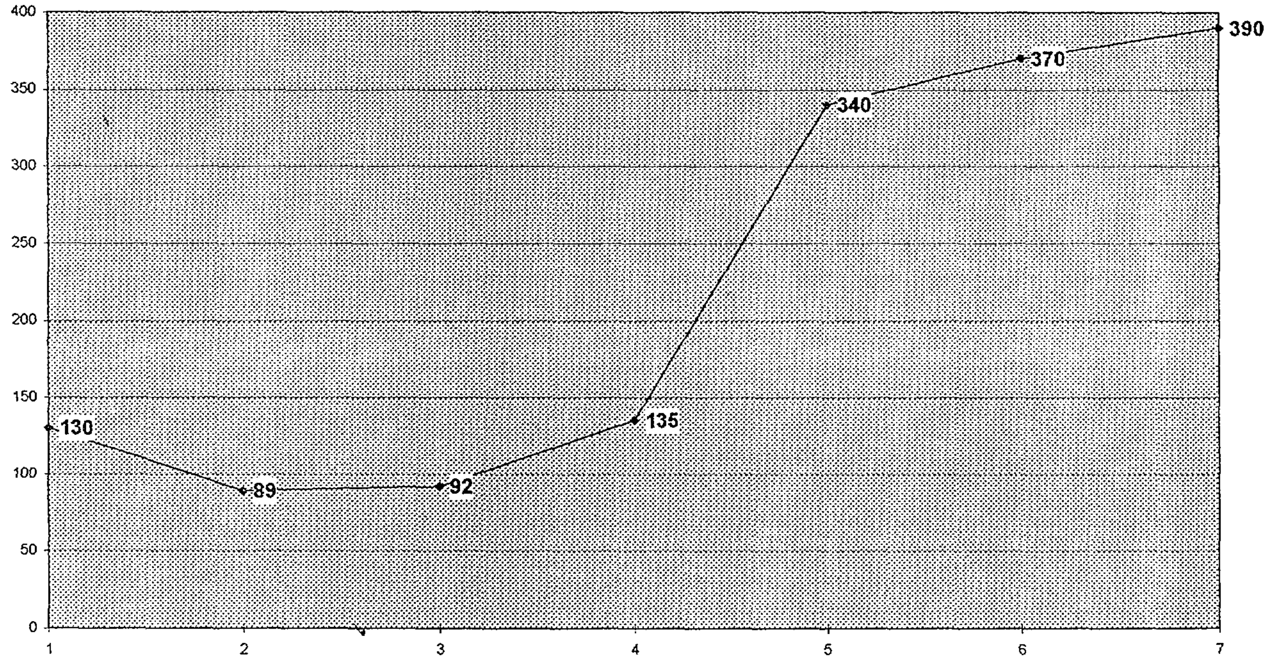
Soil used for plantation	:	Clay from bottom of a pond
No. of units	:	4
Dimensions / unit	:	8 x 5 x 0.9m
Feeding	:	10 m^3/d of treated effluent from polishing pond.
Reed varieties planted	:	Phragmites, Scirpus, Typha, Trema

2. **Performance of reeds**

Two varieties scirpus robustus were planted. One lot was imported from Kerala and the other was procured locally. Both had survived and propagated very well. Typha was procured locally while Trema was brought from Kerala. In all conditions, Scirpus performed best. Typha showed rapid growth and propagation when the plot was kept saturated. Trema performed better when the plot was not kept saturated. All the Phragmites wilted in a short time and no fresh shoots developed.

The details of the performance of the reeds are given in the graphs attached.

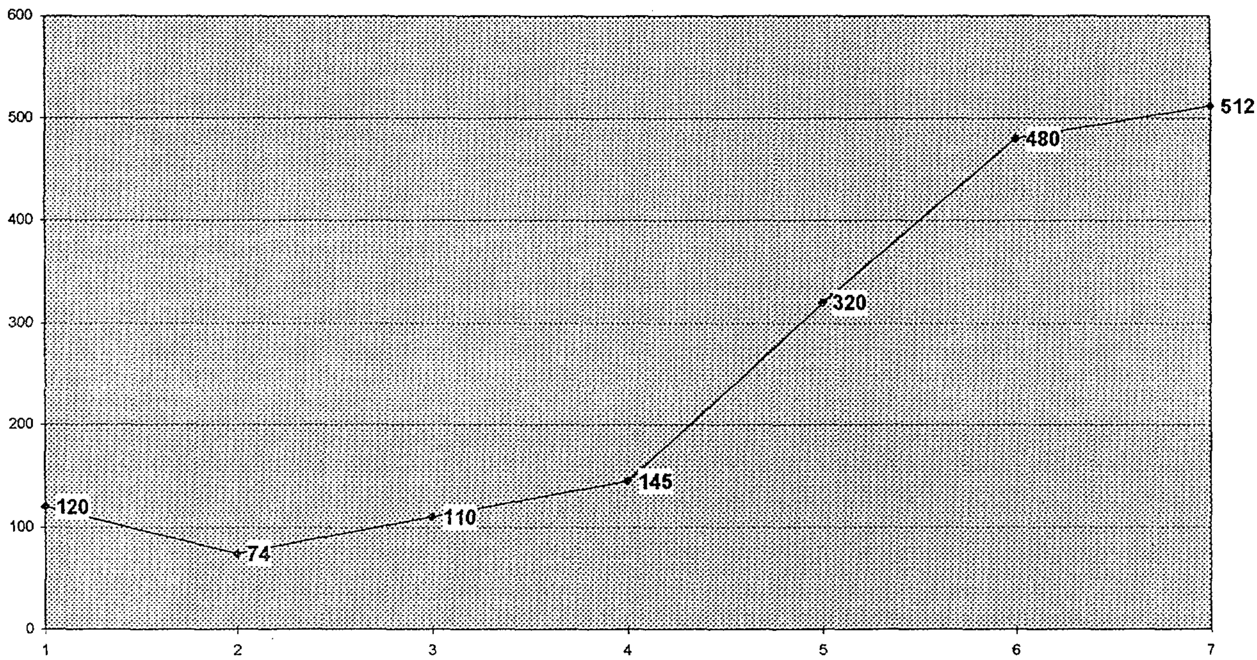
X axis 2.5 cm = 1 month
Y axis 1 cm = 100 reeds



Graph 4.1

SURVIVAL AND PROPAGATION OF TREMA

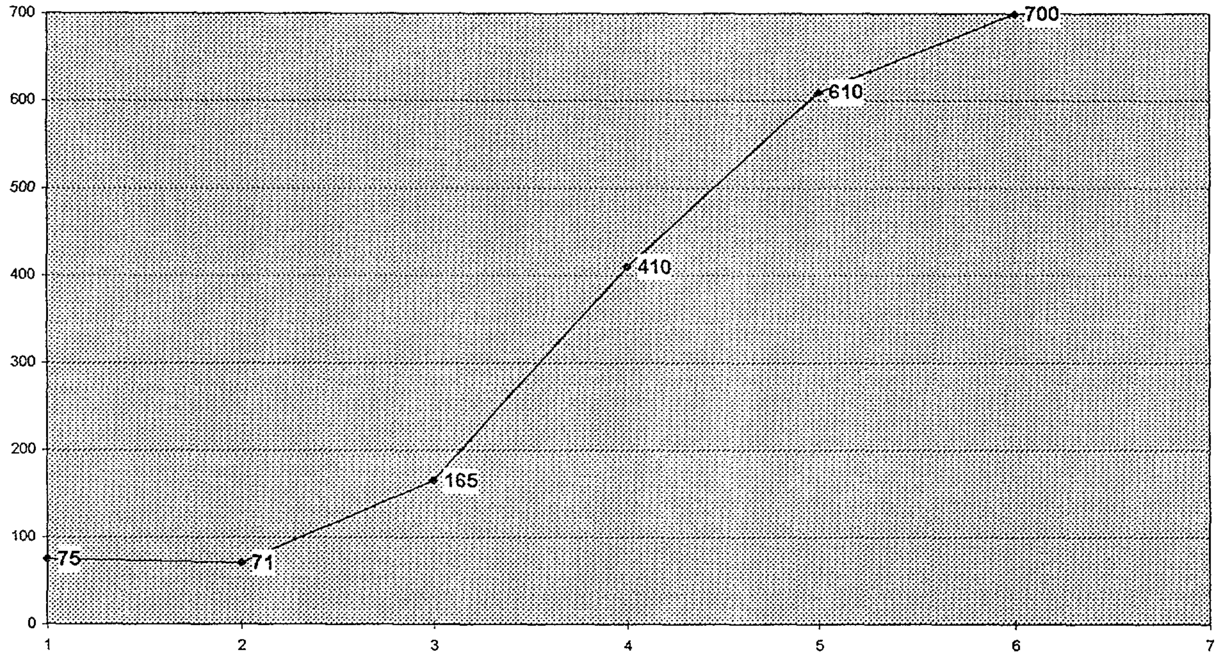
X axis 2.5 cm = 1 month
Y axis 1 cm = 100 reeds



Graph 4.2

SURVIVAL AND PROPAGATION OF TYPHA

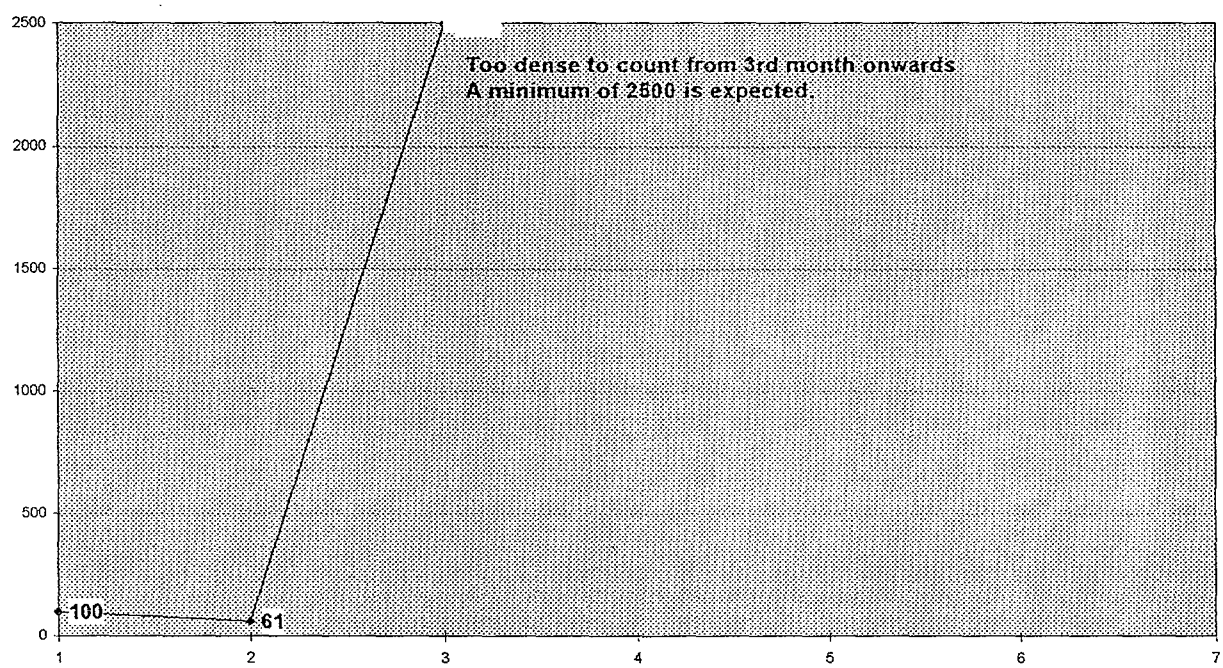
X axis 2.5 cm = 1 month
Y axis 1 cm = 100 reeds



Graph 4.3

SURVIVAL AND PROPAGATION OF SCIRPUS ROBUSTUS (KERALA)

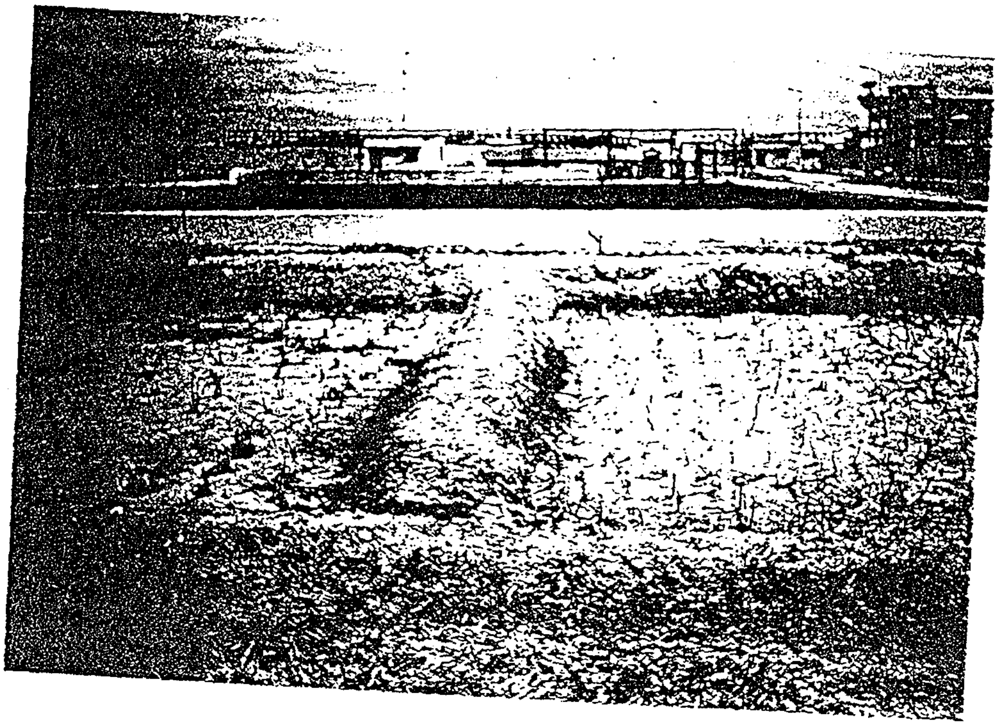
X axis 2.5 cm = 1 month
Y axis 1 cm = 100 reeds

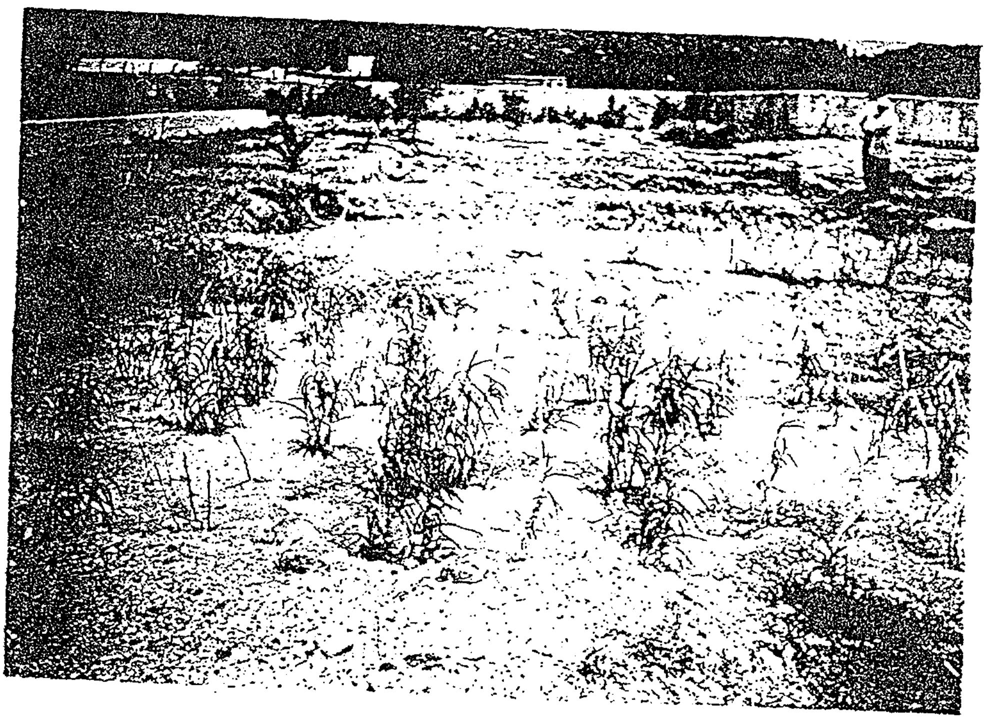


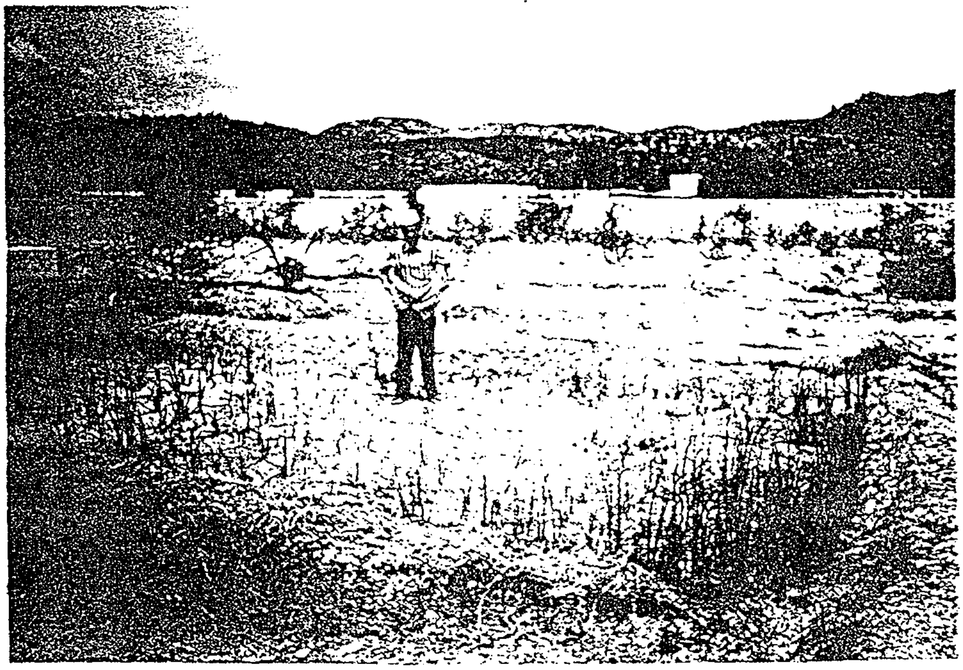
Graph 4.4

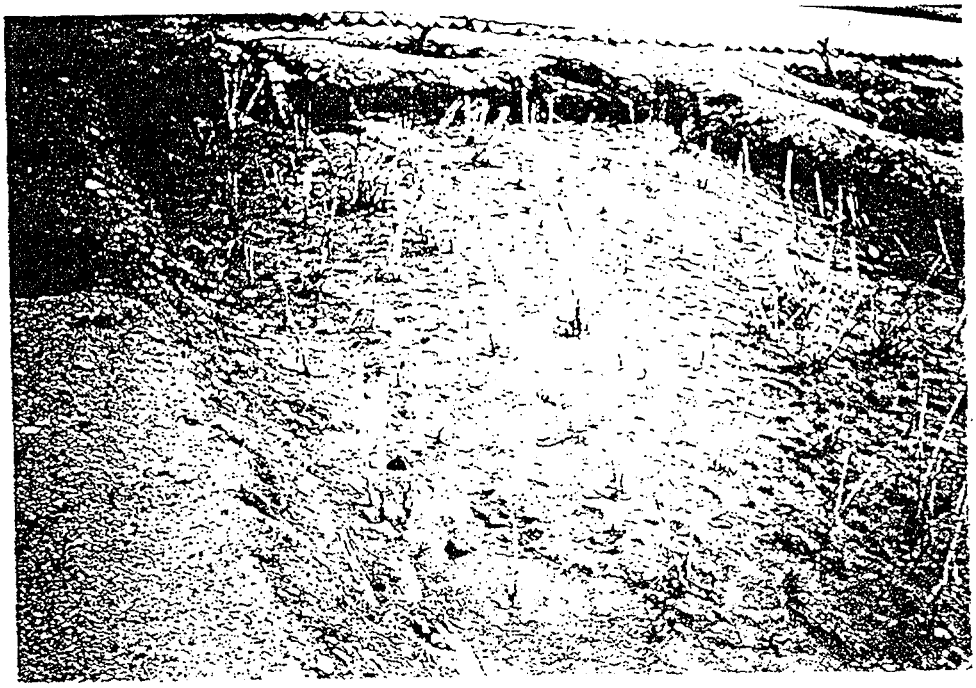
SURVIVAL AND PROPAGATION OF SCIRPUS ROBUSTUS (LOCAL)

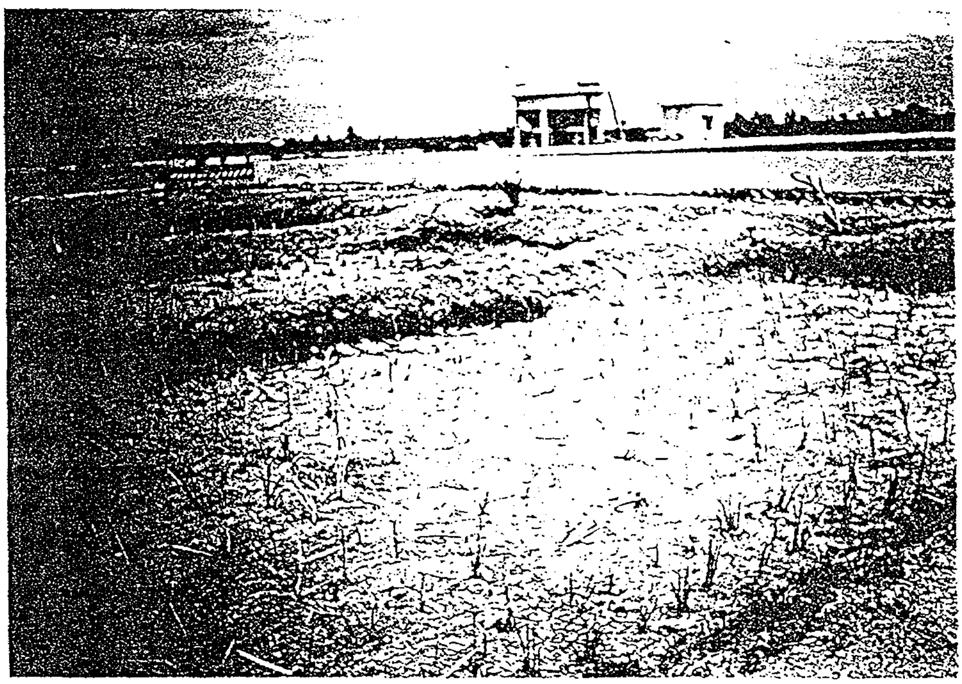
PHOTOGRAPHS OF NURSERY AT VISHTEC CETP











Annexure 5

PERFORMANCE OF REED BEDS AT PKL

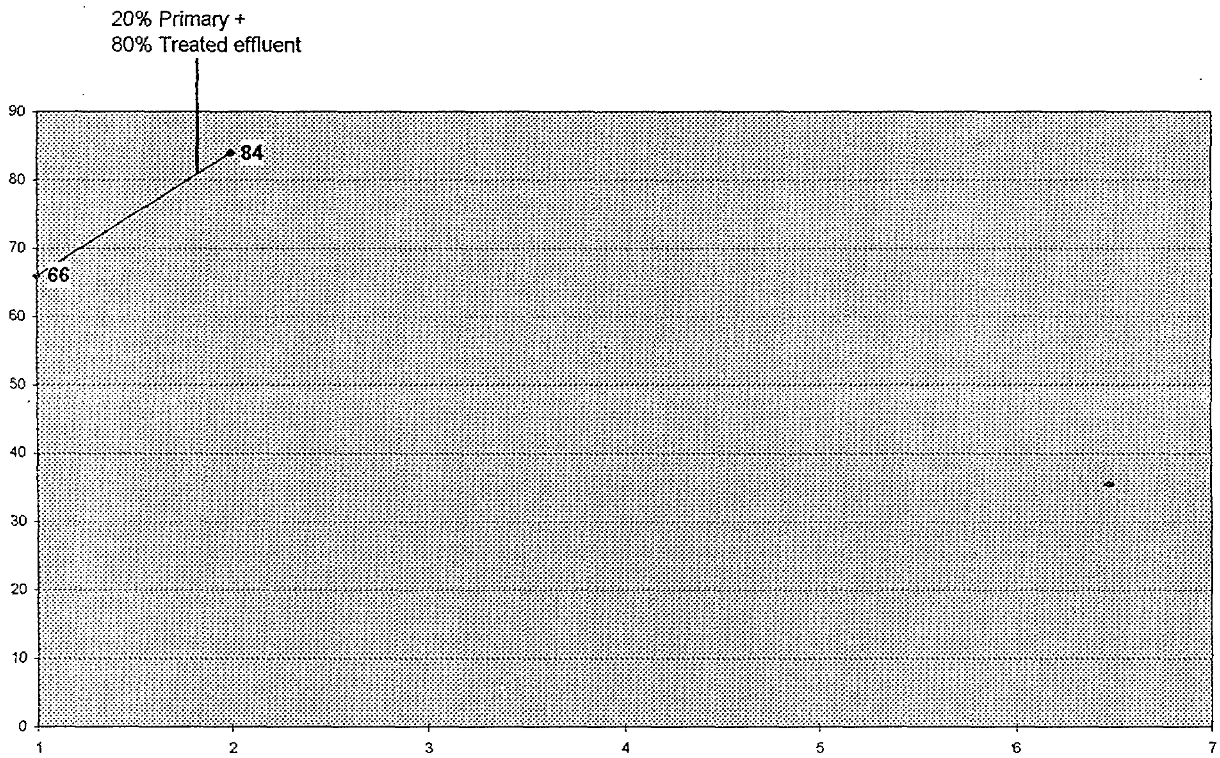
AVERAGE VALUES OF BOD

Month	Mean Input m³/d	Mean Output m³/d	Inlet Mean BOD mg/l	Inlet Mean BOD kg/d	Outlet Mean BOD mg/l	Outlet Mean BOD kg/d	Reduction of BOD %	Specific Reduction of BOD g/m²/d
Feb-99	55.1	49.2	354.5	19.53	61.7	3.04	84.46	26.44
Mar-99	55.3	49.4	227.4	12.58	57.0	2.82	77.61	15.64
Apr-99	49.2	43.9	535.1	26.33	152	6.67	74.65	31.50
May-99	61.7	55.1	612.7	37.8	91.5	5.04	86.66	52.50
Jun-99	57.0	50.9	403.3	22.99	124.3	6.33	72.48	26.70
Jul-99	62.3	55.6	545.5	33.98	106.3	5.91	82.61	44.99
Aug-99	66.4	59.3	823.8	54.7	138.9	8.24	84.94	74.46
Sep-99	47.4	42.3	584.8	27.72	89.1	3.77	86.4	38.38
Oct-99	48.8	43.6	588.3	28.71	85.8	3.74	86.97	40.01
Nov-99	61.3	54.7	569.8	34.93	236.9	12.96	62.9	35.21
Dec-99	43.1	38.5	840.6	36.23	197.1	7.59	79.05	45.90
Jan-00	59.4	53.0	610.7	36.28	175.7	9.31	74.33	43.21
Feb-00	56.7	50.6	733.7	41.6	200.4	10.14	75.62	50.42
Mar-00	57.5	51.3	986.9	56.75	341.9	17.54	69.09	62.83
Mean	55.8	49.8	601.2	33.55	147.0	7.36	78.41	42.01

AVERAGE VALUES OF COD

Month	Mean Input m³/d	Mean Output m³/d	Inlet Mean COD mg/l	Inlet Mean COD kg/d	Outlet Mean COD mg/l	Outlet Mean COD kg/d	Reduction of COD %	Specific Reduction of COD g/m²/d
Feb-99	55.1	49.2	849.0	46.78	493.5	24.28	48.1	36.06
Mar-99	55.3	49.4	896.8	49.59	567.4	28.03	43.48	34.56
Apr-99	49.2	43.9	1671.5	82.24	1069.4	46.95	42.91	56.56
May-99	61.7	55.1	1702.0	105.01	965.2	53.18	49.36	83.06
Jun-99	57.0	50.9	1364.3	77.77	579.0	29.47	62.1	77.39
Jul-99	62.3	55.6	1369.3	85.31	543.4	30.21	64.58	88.29
Aug-99	66.4	59.3	1716.1	113.95	611.7	36.27	68.17	12.48
Sep-99	47.4	42.3	1515.3	71.83	408.4	17.28	75.95	87.42
Oct-99	48.8	43.6	1298.3	63.36	318.1	13.87	78.11	79.31
Nov-99	61.3	54.7	1220.0	74.79	670.3	36.67	50.97	61.09
Dec-99	43.1	38.5	1962.3	84.58	663.6	25.55	69.79	94.59
Jan-00	59.4	53.0	1526.6	90.68	737.1	39.07	56.92	82.71
Feb-00	56.7	50.6	1813.7	102.84	896.8	45.38	55.87	92.08
Mar-00	57.5	51.3	2196.6	126.30	1320.3	67.73	46.37	93.87
Mean	55.8	49.8	1507.3	84.11	703.2	35.28	58.05	77.96

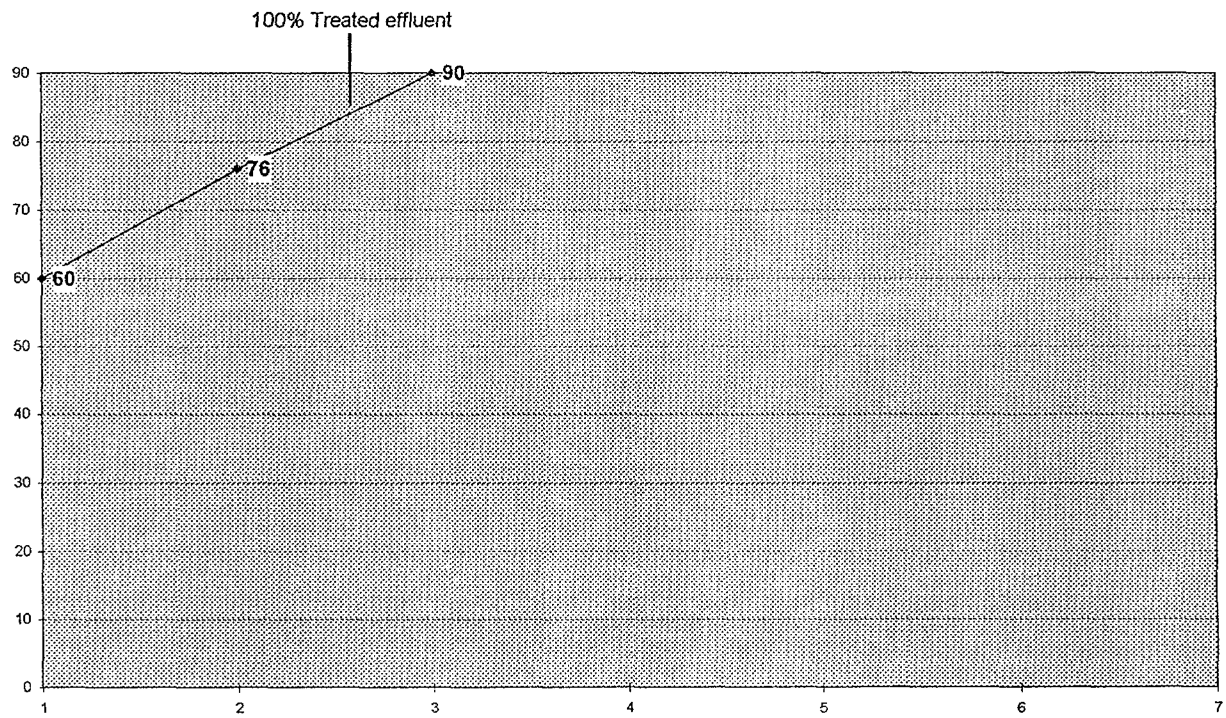
X axis 2.5 cm = 1 month
Y axis 1 cm = 10%



Graph 5.I.1

RATE OF REDUCTION OF BOD AGAINST TIME

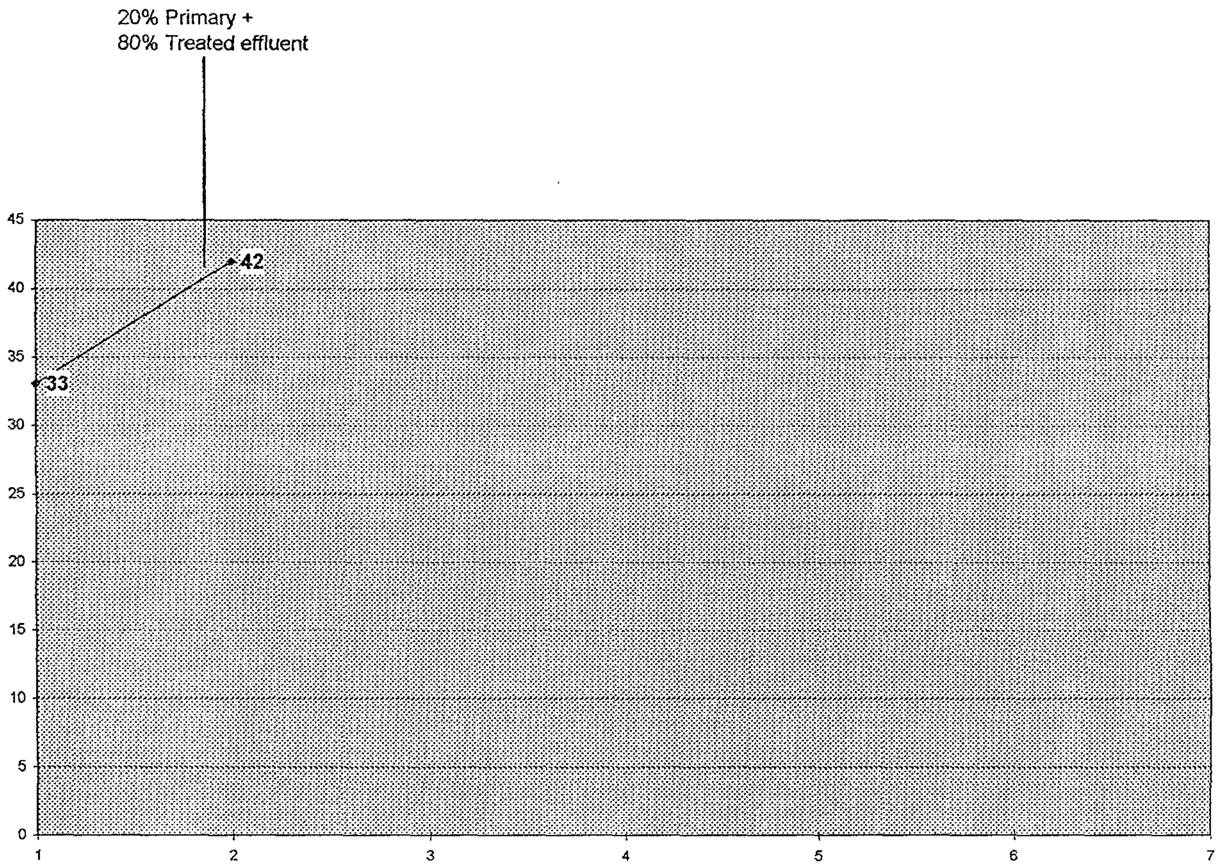
X axis 2.5 cm = 1 month
Y axis 1 cm = 10%



Graph 5.I.2

RATE OF REDUCTION OF BOD AGAINST TIME

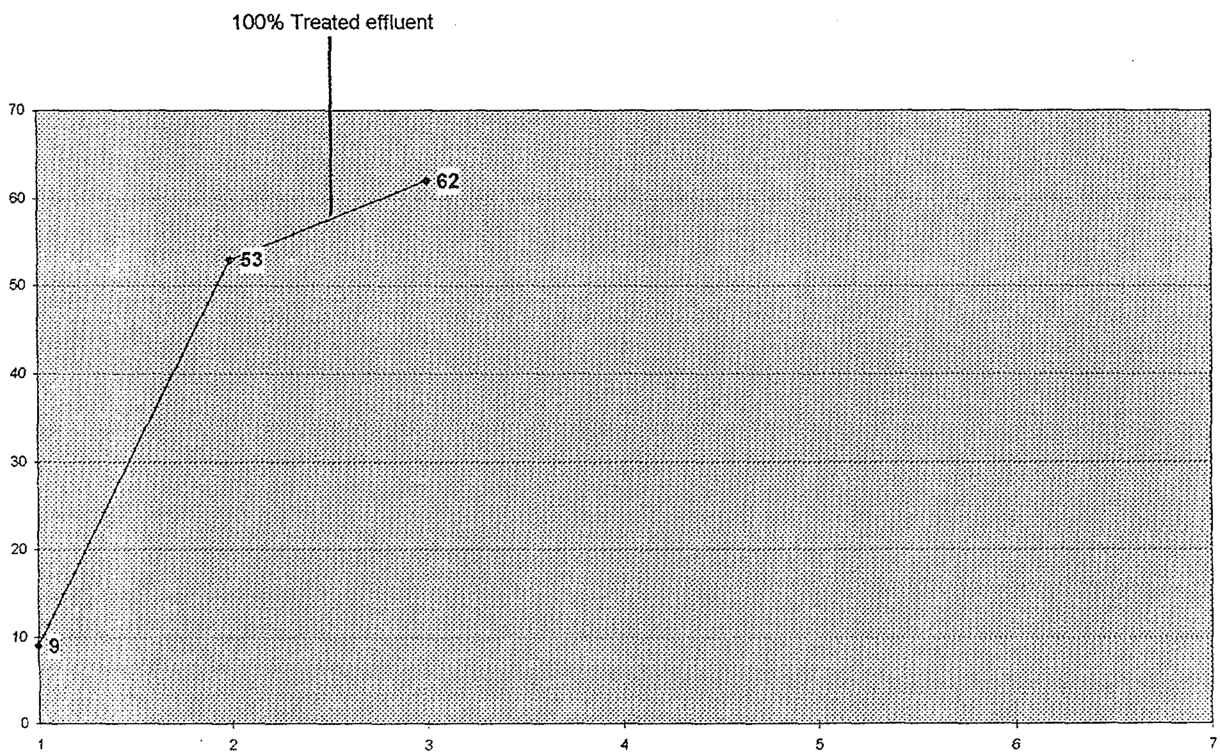
X *axis 2.5 cm* = *1 month*
Y axis 1 cm = 10%



Graph 5.I.3

RATE OF REDUCTION OF COD AGAINST TIME

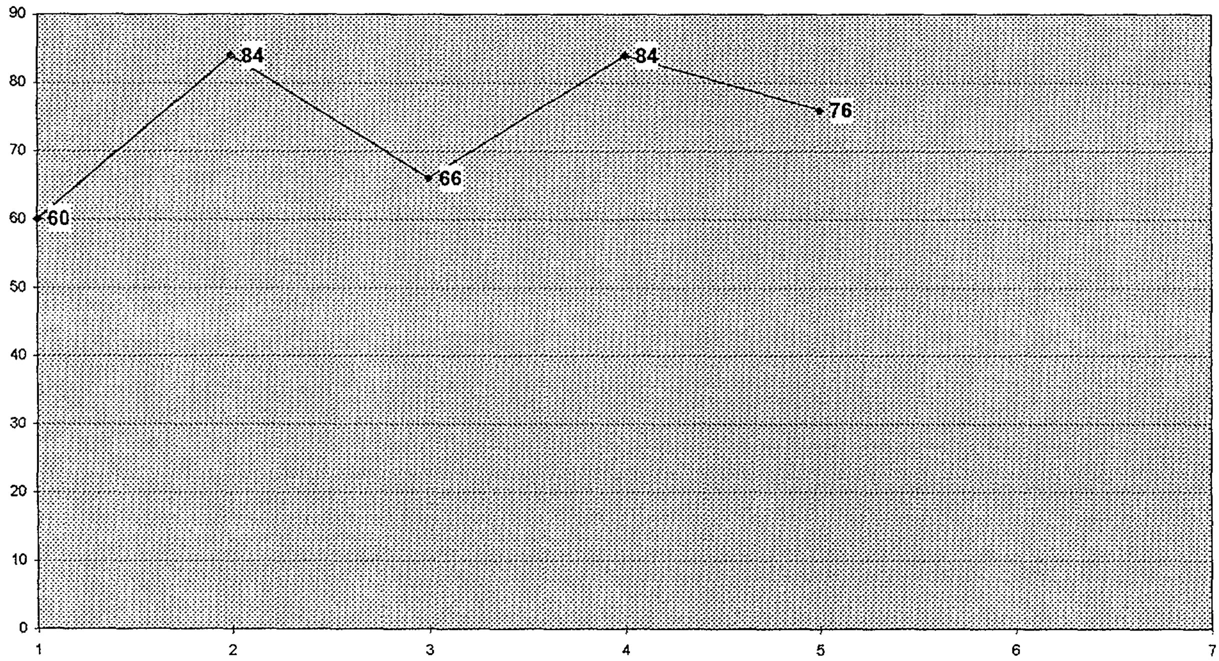
X axis 2.5 cm = 1 month
Y axis 1 cm = 10%



Graph 5.I.4

RATE OF REDUCTION OF COD AGAINST TIME

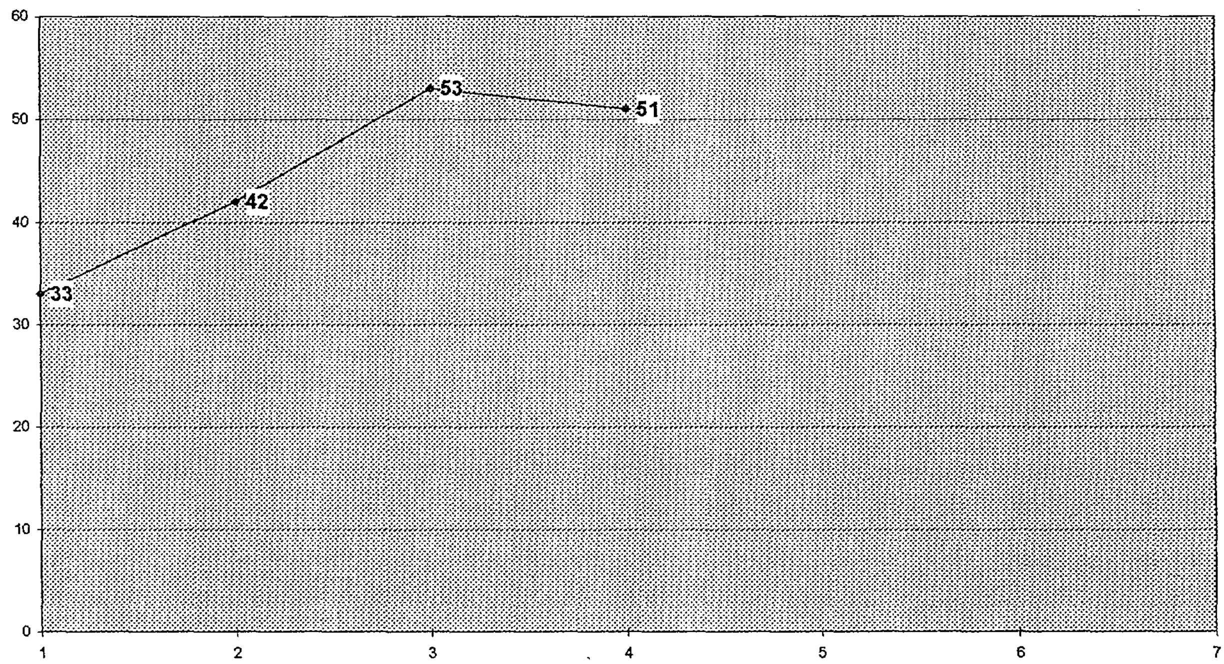
X axis 2.5 cm = 50mg/L BOD_5
Y axis 1 cm = 5%



Graph 5.I.5

RATE OF REDUCTION OF BOD AGAINST INFLUENT BOD

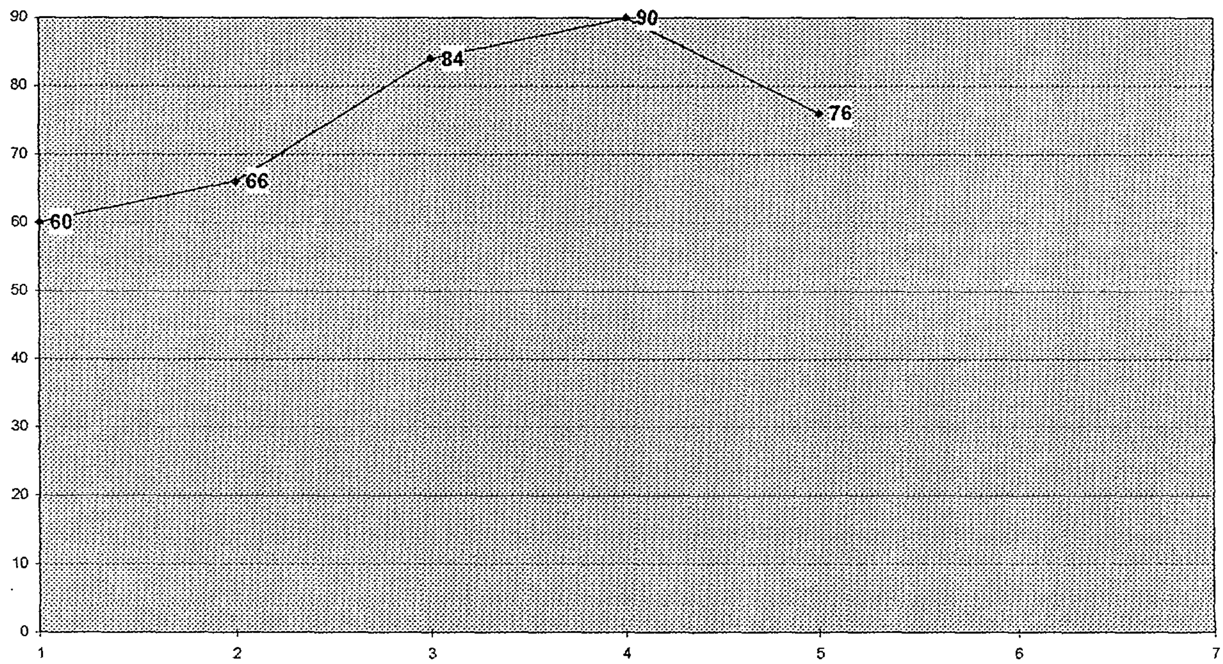
X axis 2.5 cm = 50mg/L BODs'
Y axis 1 cm = 5%



Graph 5.I.6

RATE OF REDUCTION OF COD AGAINST INFLUENT COD

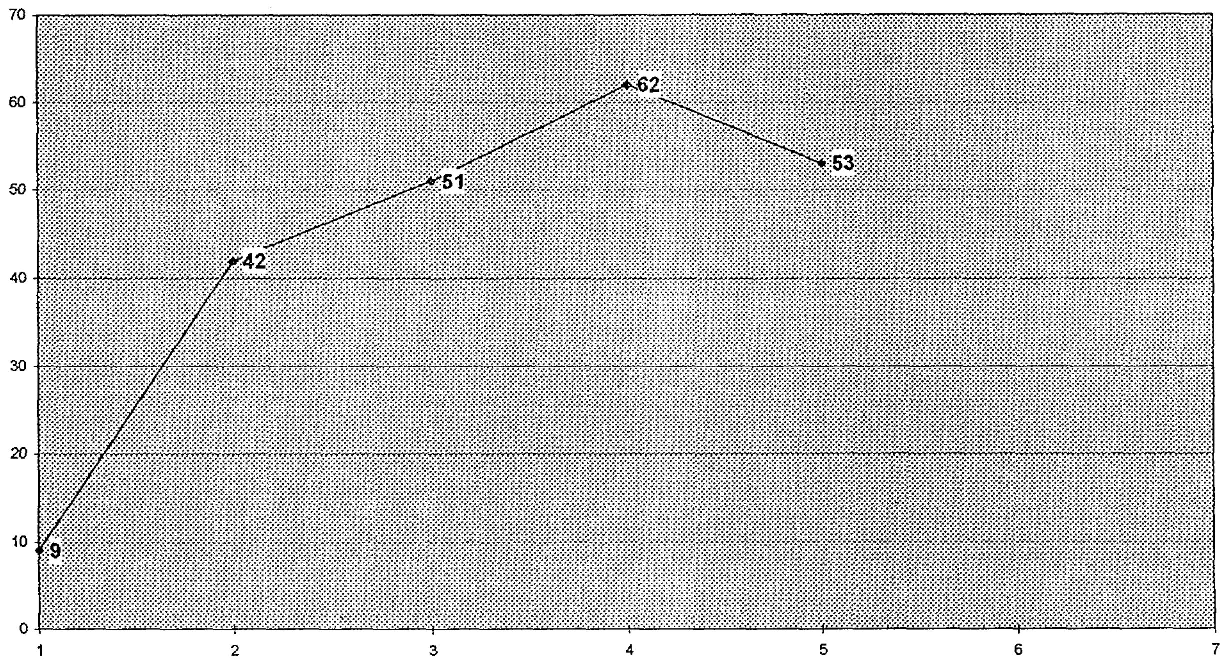
X axis 2.5 cm = 0.1
Y axis 1 cm = 10%



Graph 5.I.7

RATE OF REDUCTION OF BOD AGAINST BOD : COD RATIO

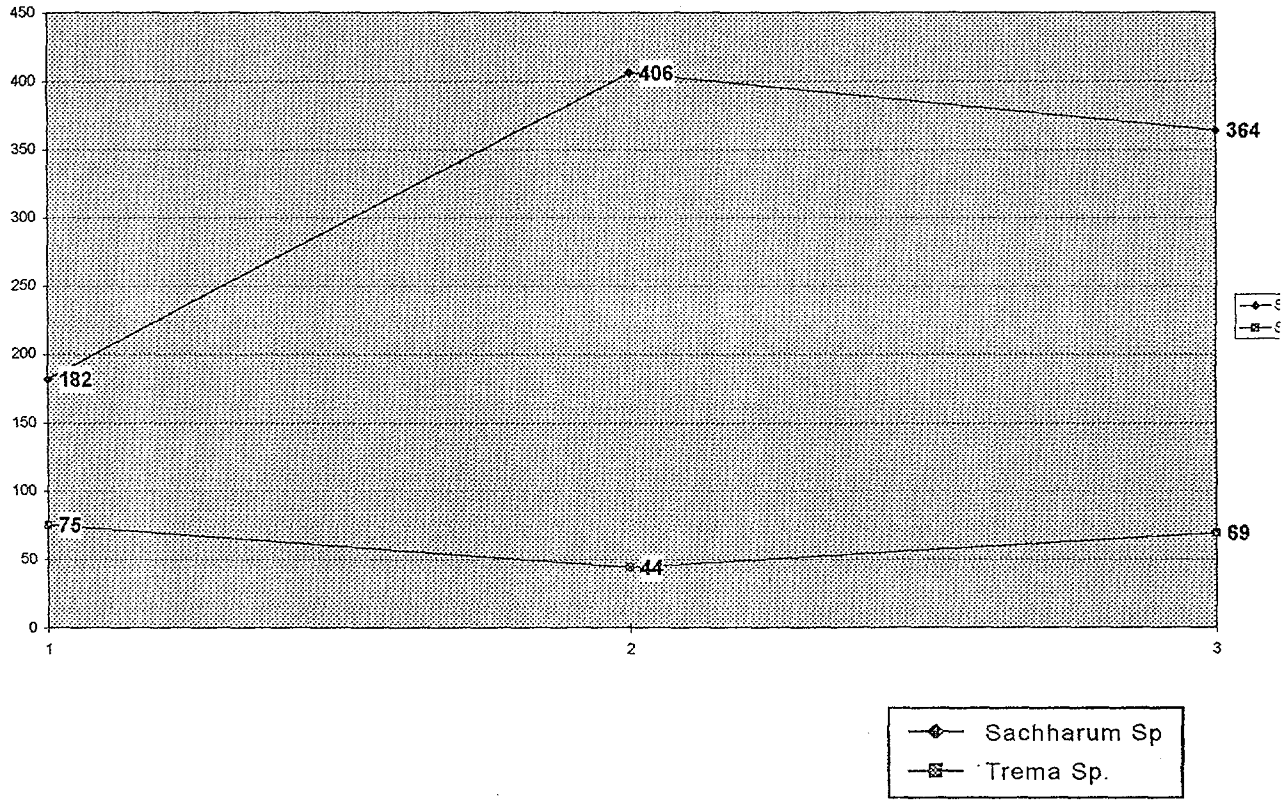
X axis 2.5 cm = 0.1
Y axis 1 cm = 10%



Graph 5.I.8

RATE OF REDUCTION OF COD AGAINST BOD : COD RATIO

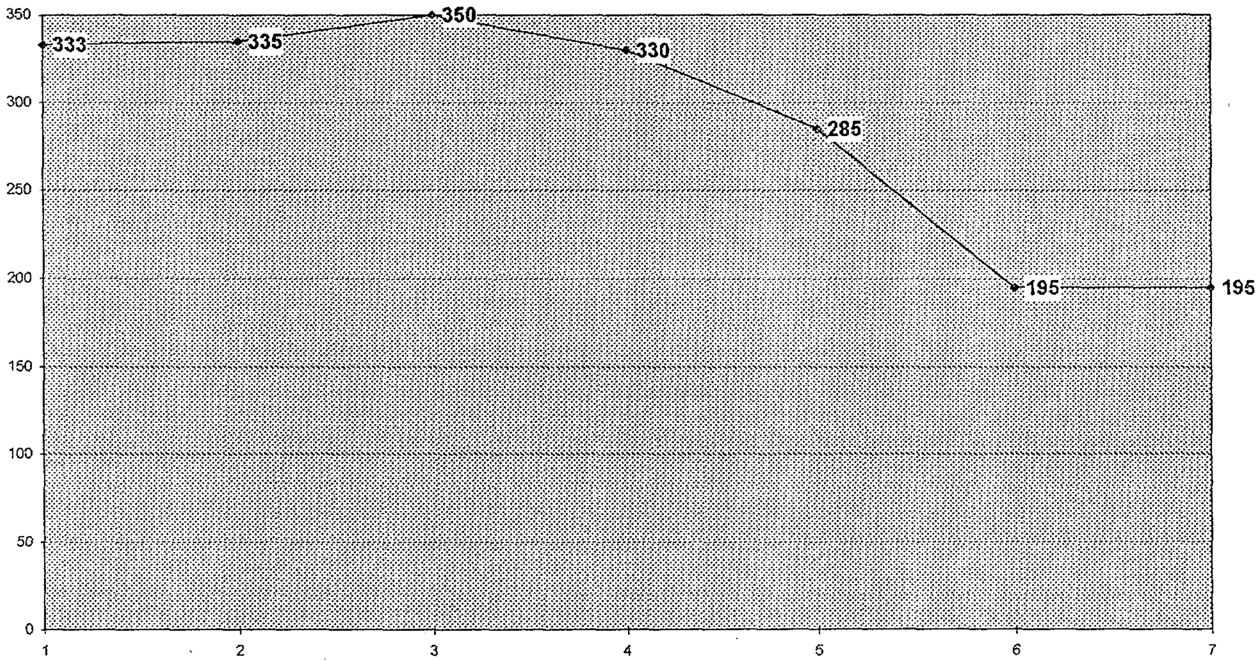
X axis 2.5 cm = 1 month
Y axis 1 cm = 100 reeds



Graph 5.I.9

SURVIVAL AND PROPAGATION RATES OF REEDS AGAINST TIME
(SACHHARUM & TREMA)

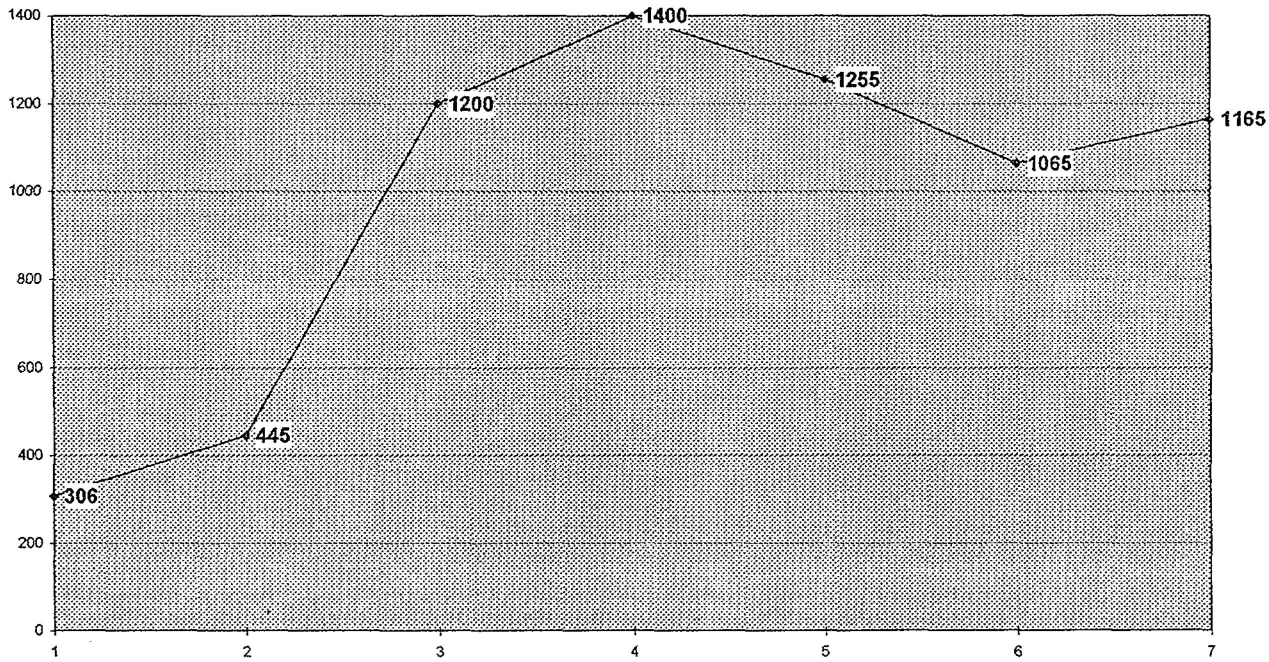
X axis 2.5 cm = 1 month
Y axis 1 cm = 100 reeds



Graph 5.I.10

SURVIVAL AND PROPAGATION OF SCIRPUS AGAINST TIME

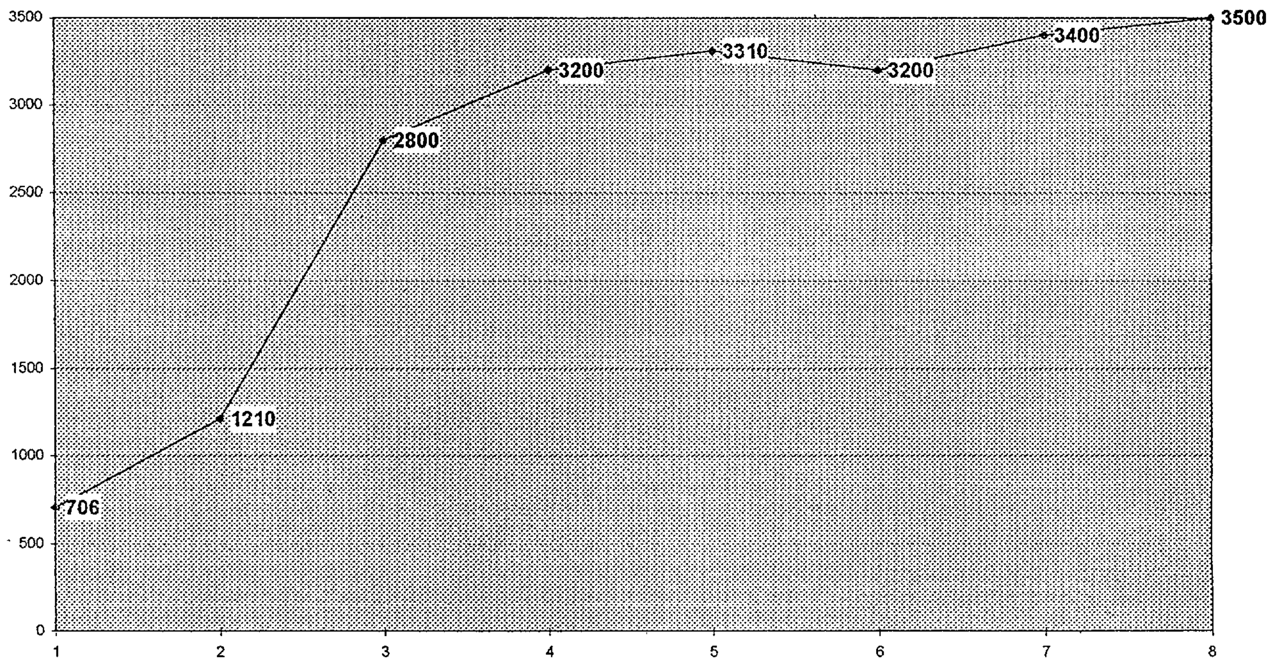
X axis 2.5 cm = 1 month
Y axis 1 cm = 100 reeds



Graph 5.I.11

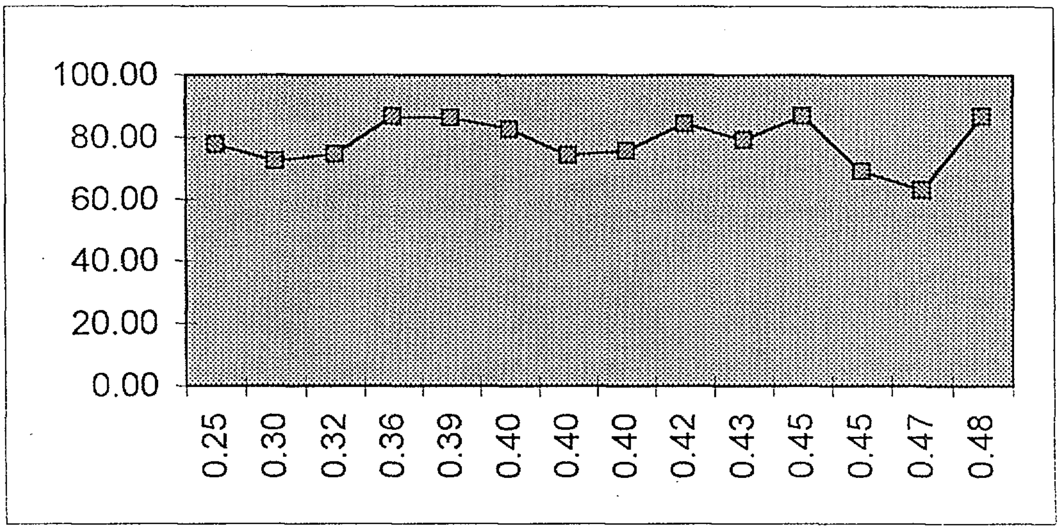
SURVIVAL AND PROPAGATION OF TYPHA IN RB-2 AGAINST TIME

X axis 2.5 cm = 1/2 month
Y axis 1 cm = 200 reeds

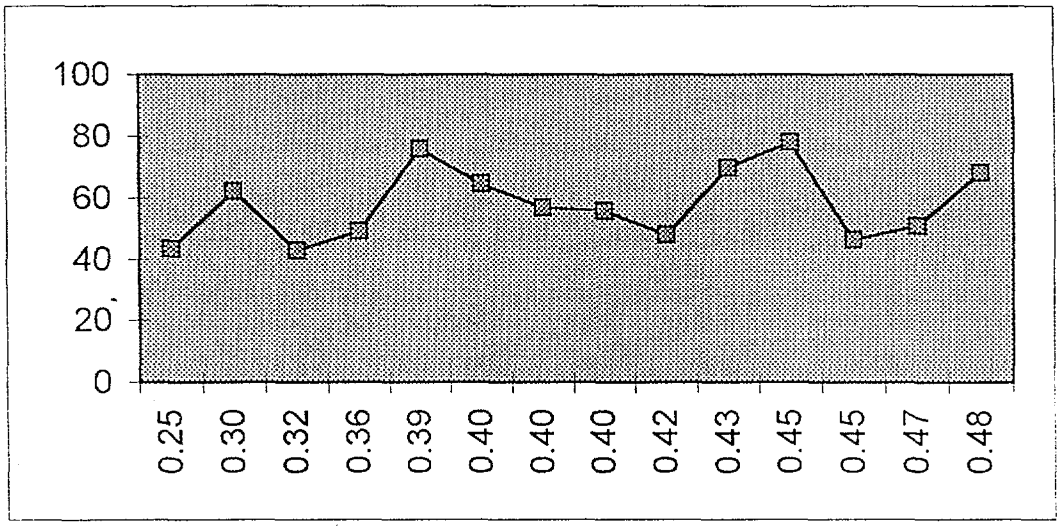


Graph 5.I.12

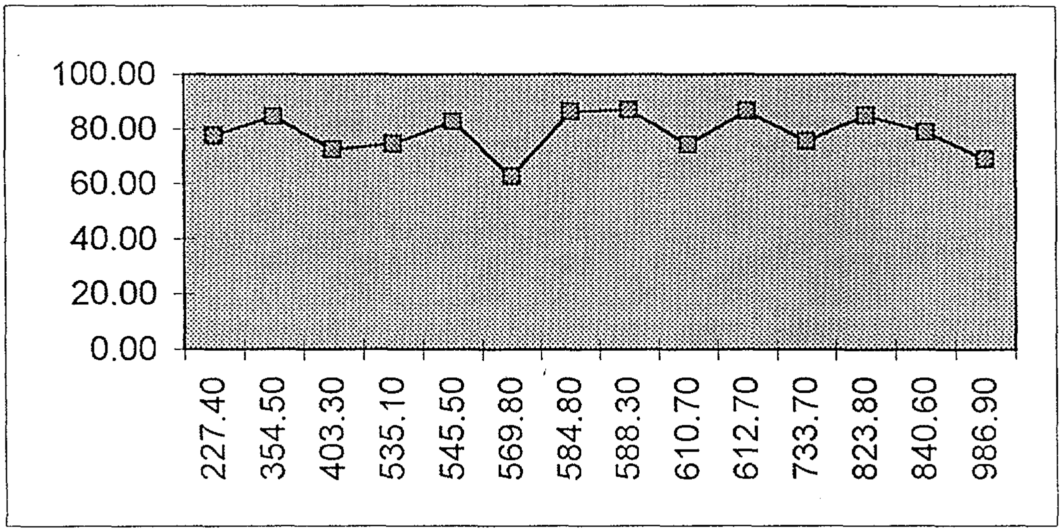
SURVIVAL AND PROPAGATION OF TYPHA IN RB-3 AGAINST TIME



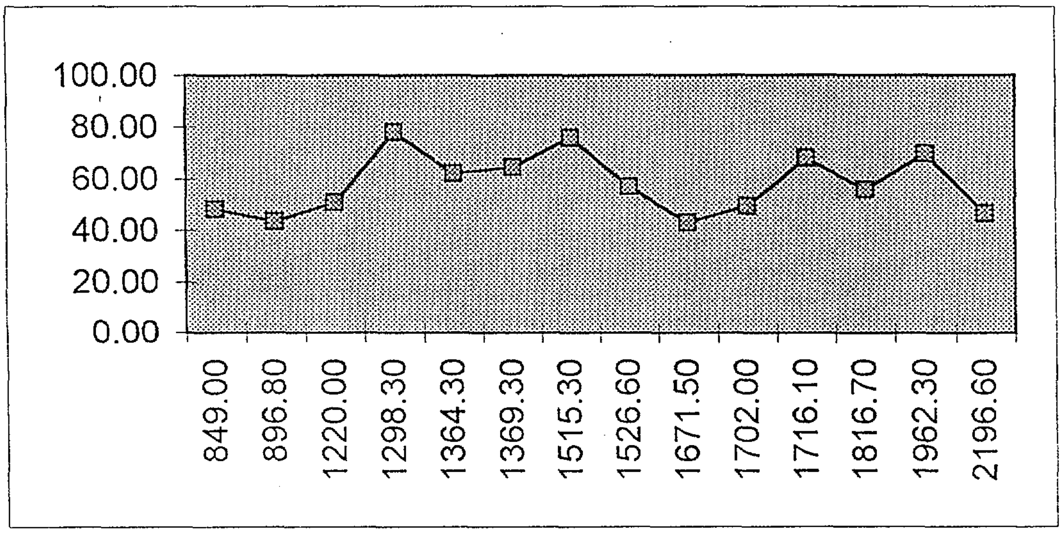
Graph 5.II.1. Rate of reduction of BOD against BOD:COD ratio



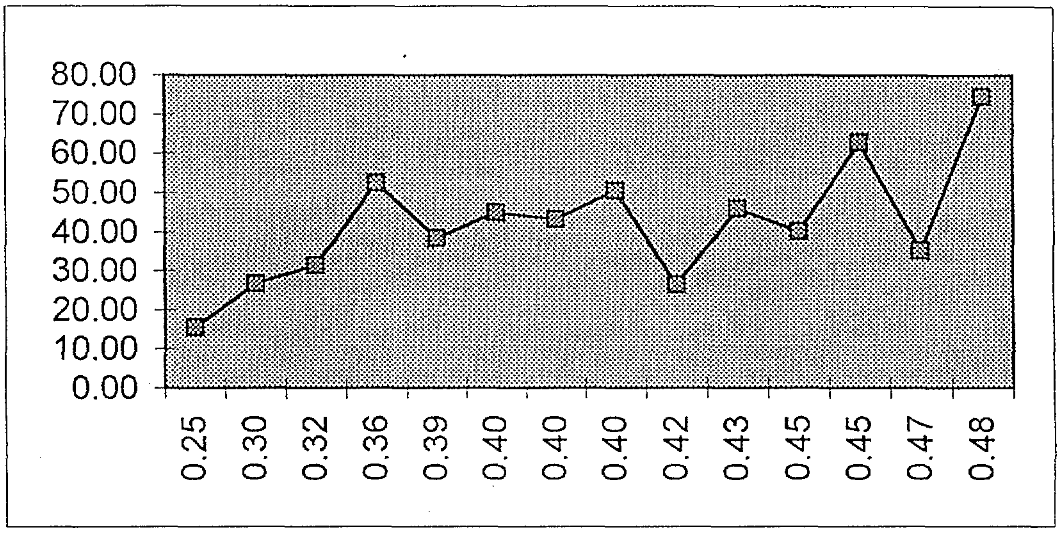
Graph 5.II.2. Rate of reduction of COD against BOD:COD ratio



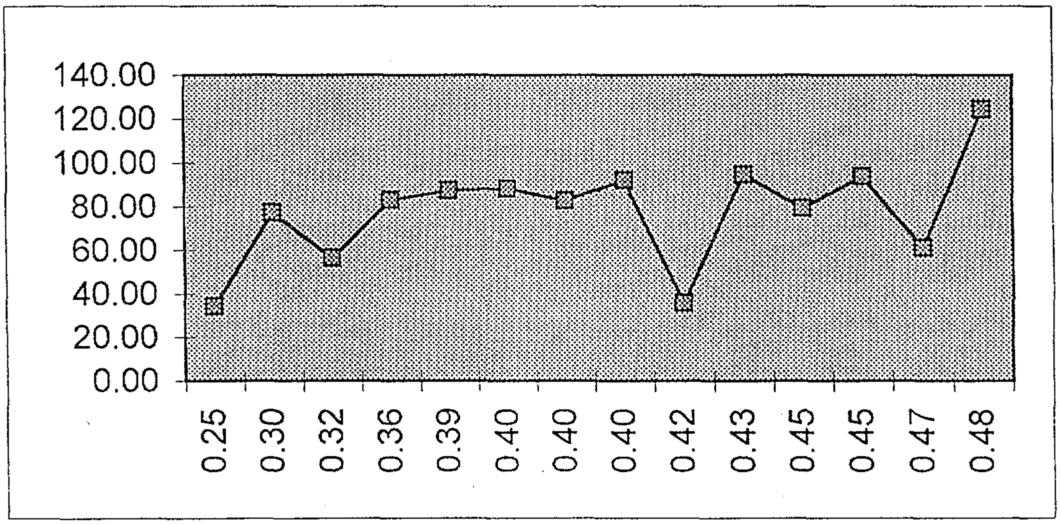
Graph 5.II.3. Rate of reduction of BOD against influent BOD



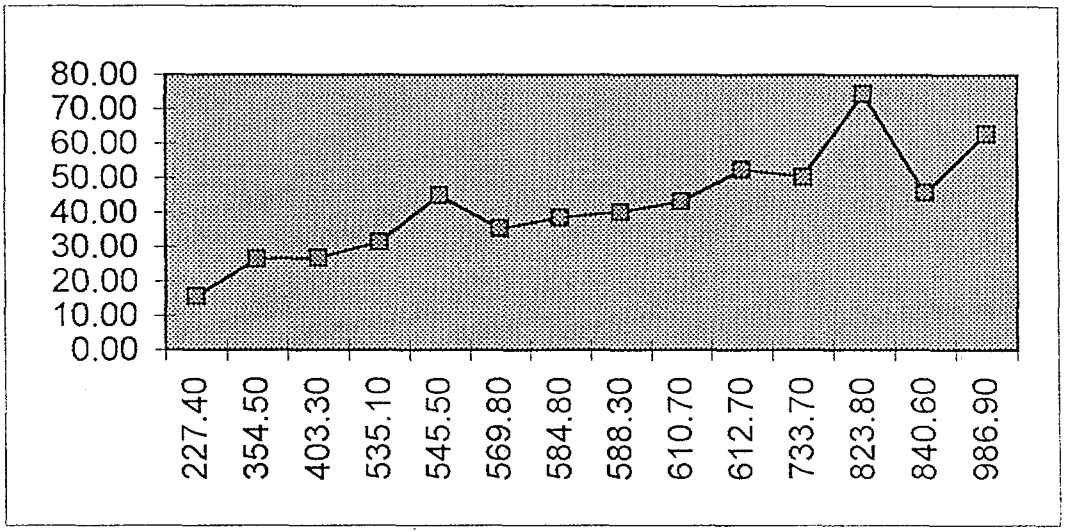
Graph 5.II.4. Rate of reduction of COD against influent COD



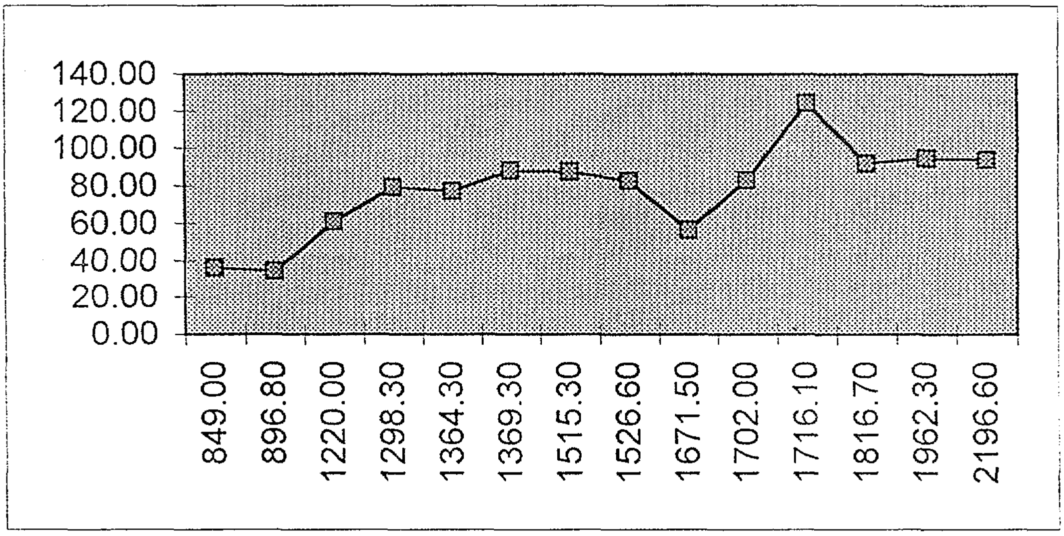
Graph 5.II.5. Specific reduction of BOD against BOD:COD ratio



Graph 5.II.6. Specific reduction of COD against BOD:COD ratio

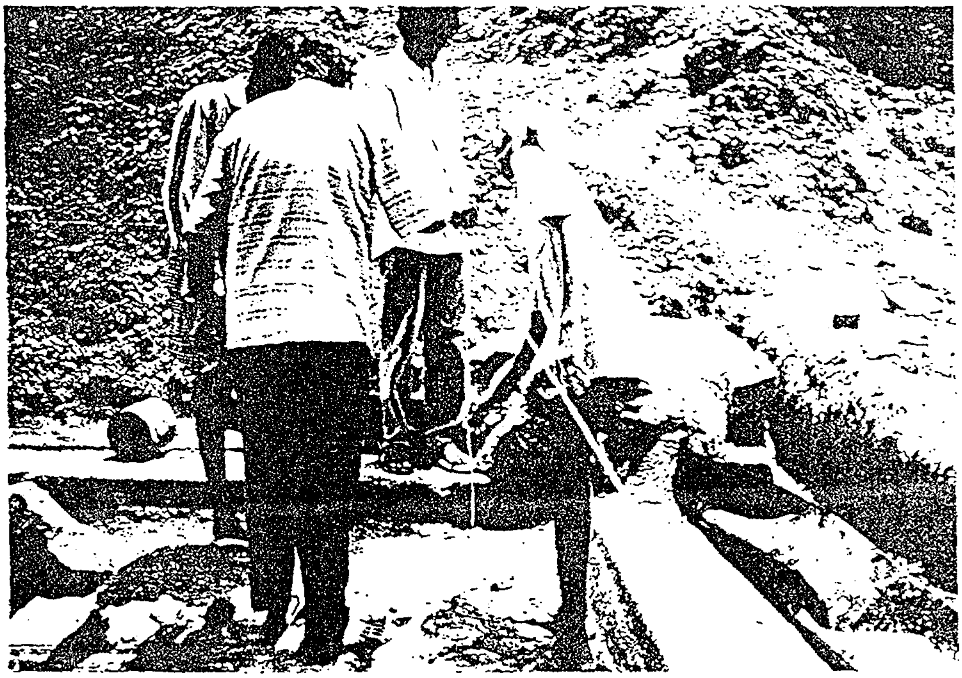


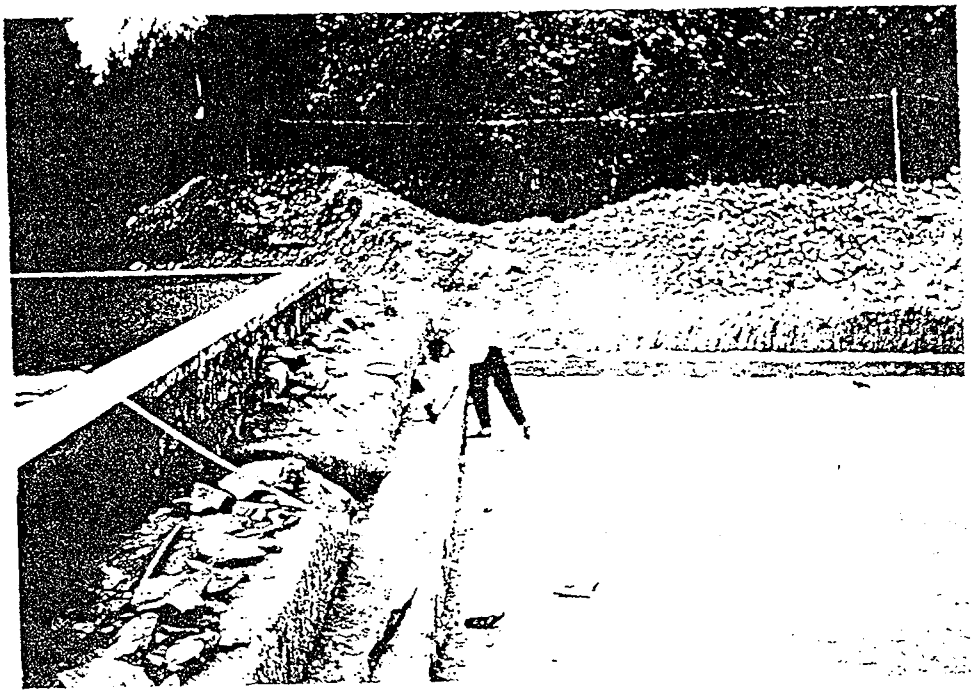
5.II.7. Specific reduction of BOD against influent BOD

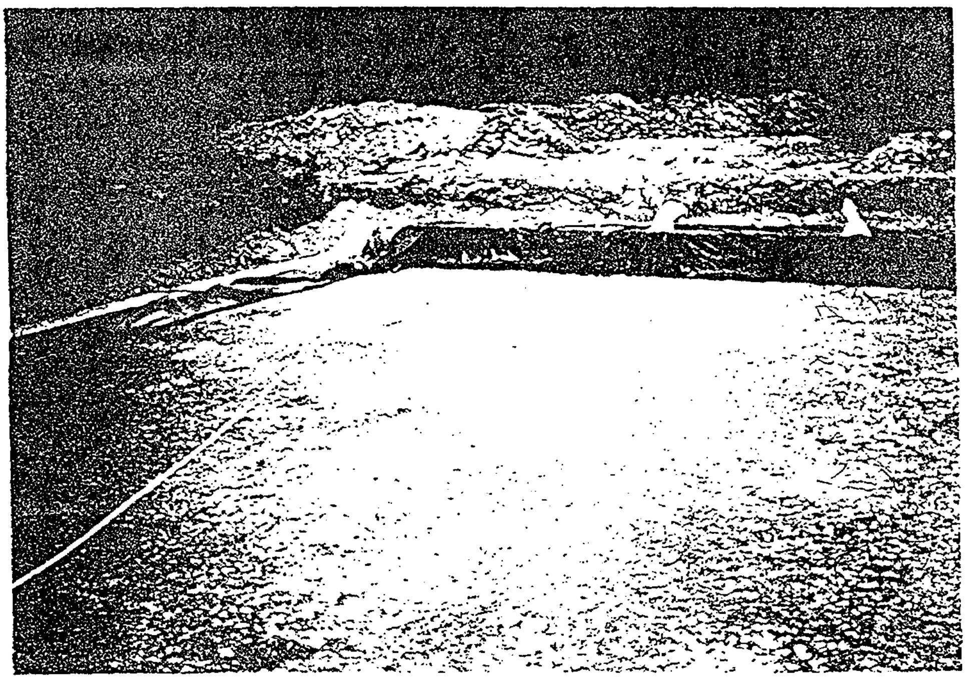


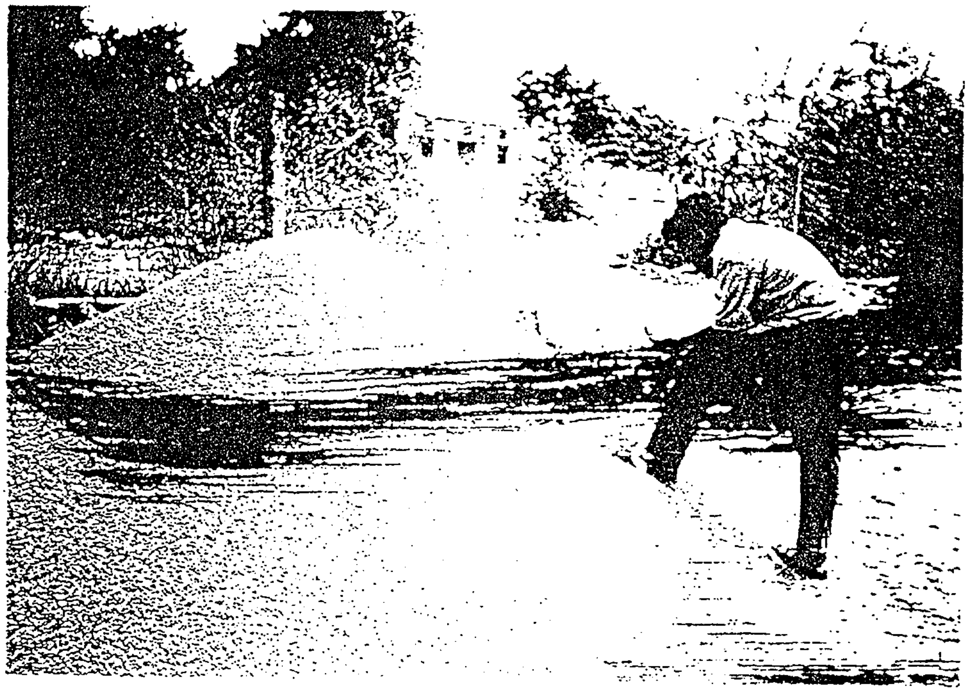
5.II.8. Specific reduction of COD against influent COD

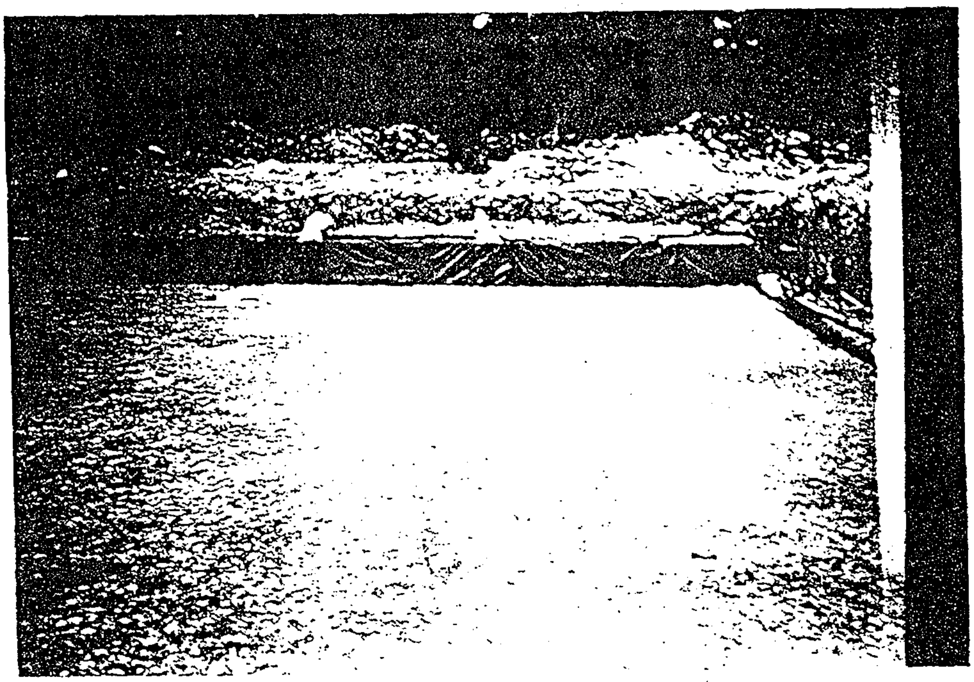
PHOTOGRAPHS OF PKL PROJECT

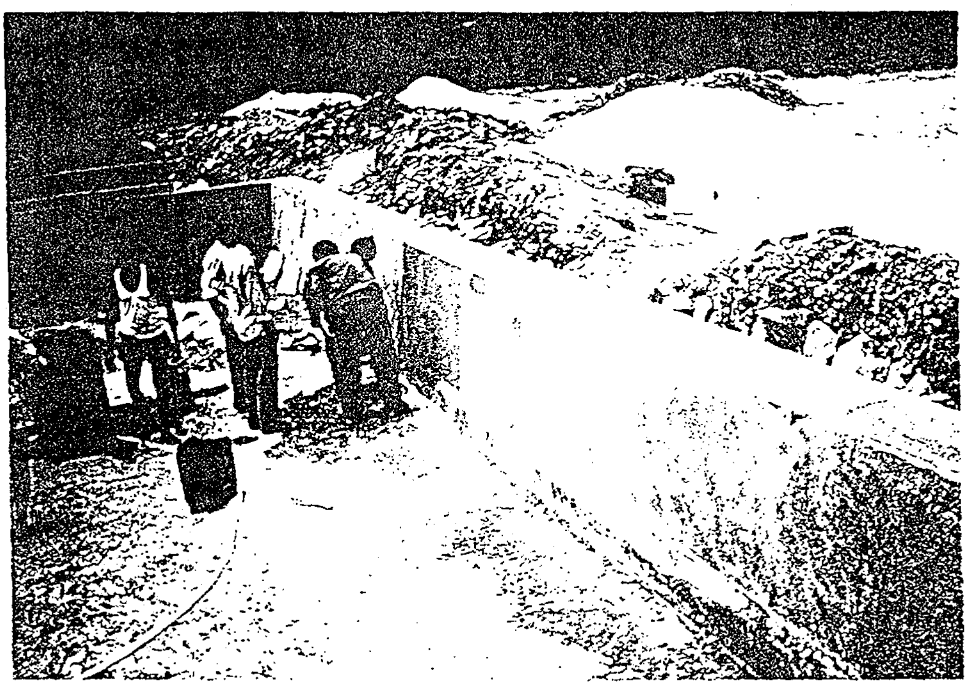


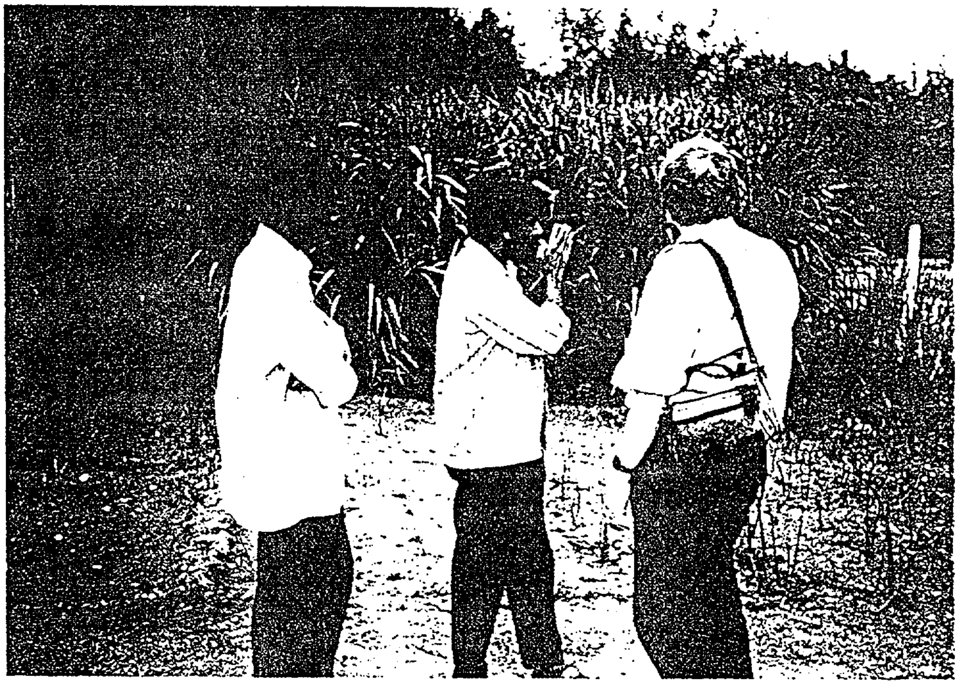




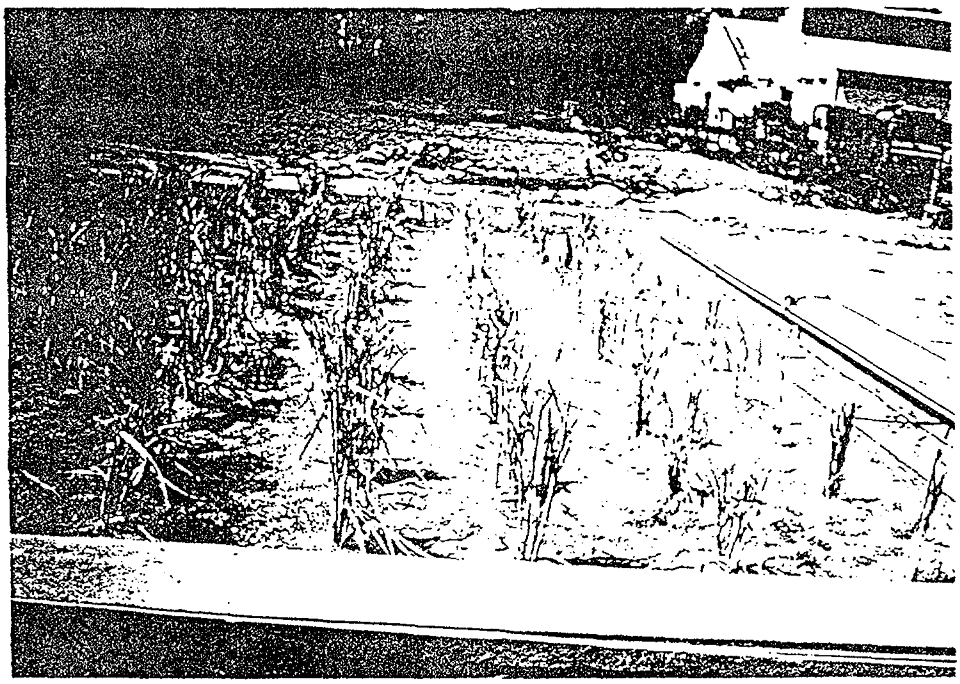




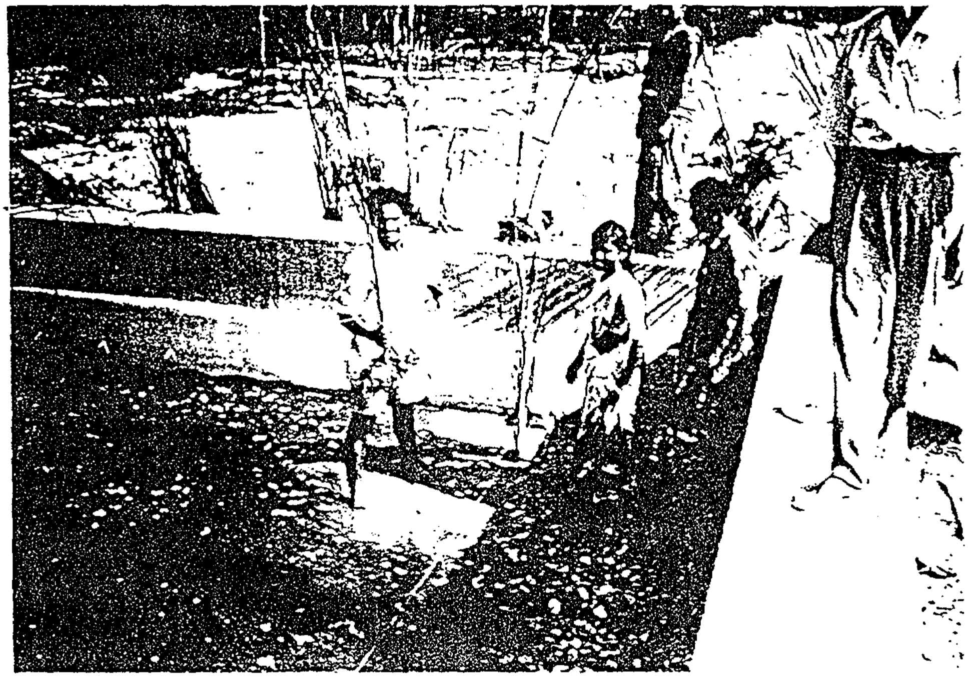




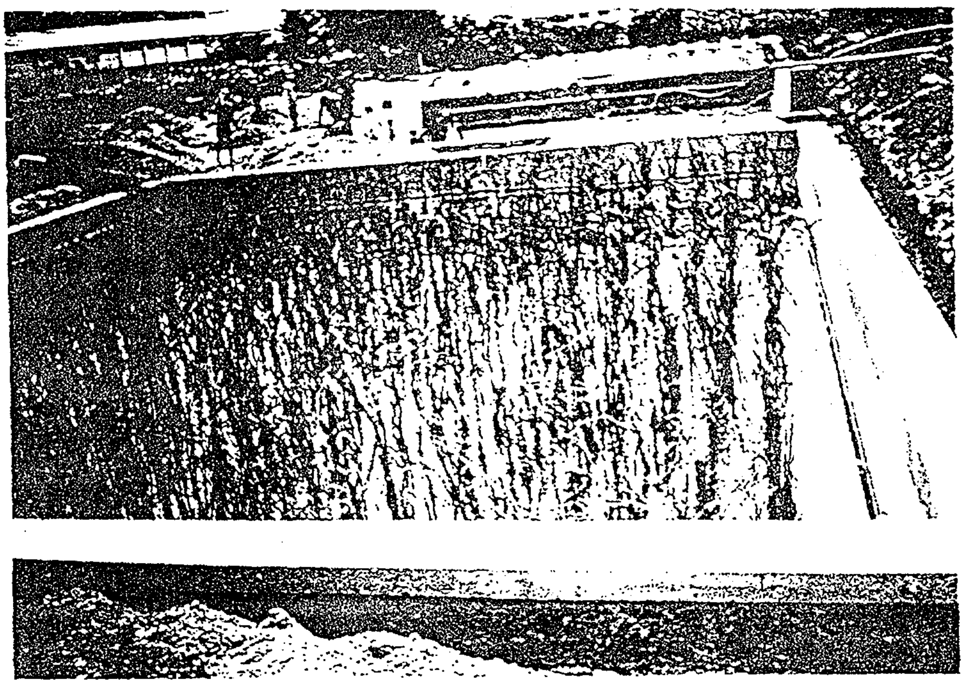
Planting of reeds in RB-1



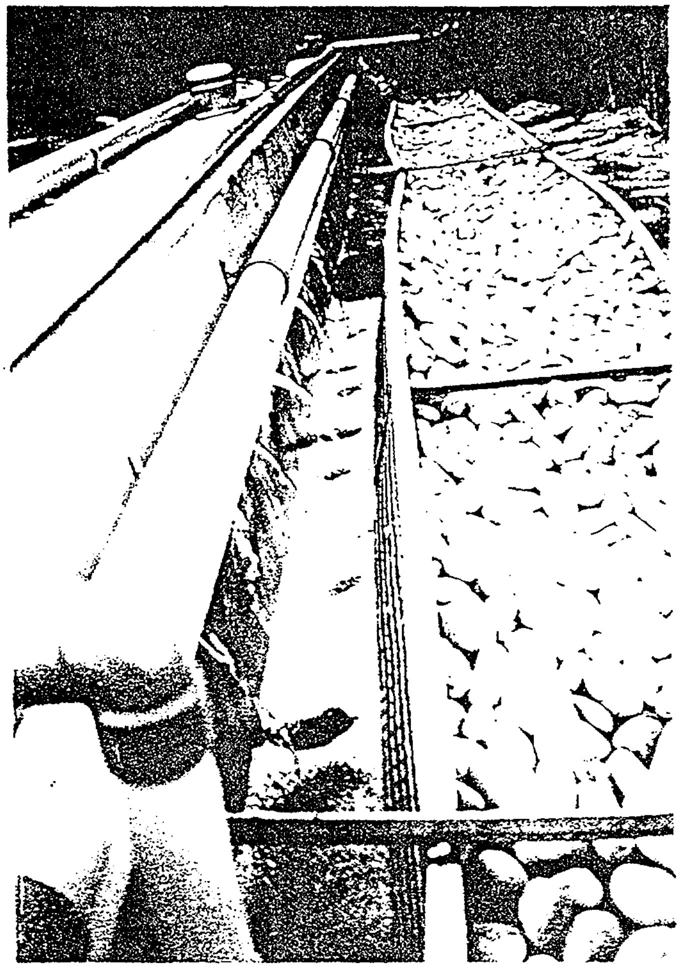
RB-1 after planting



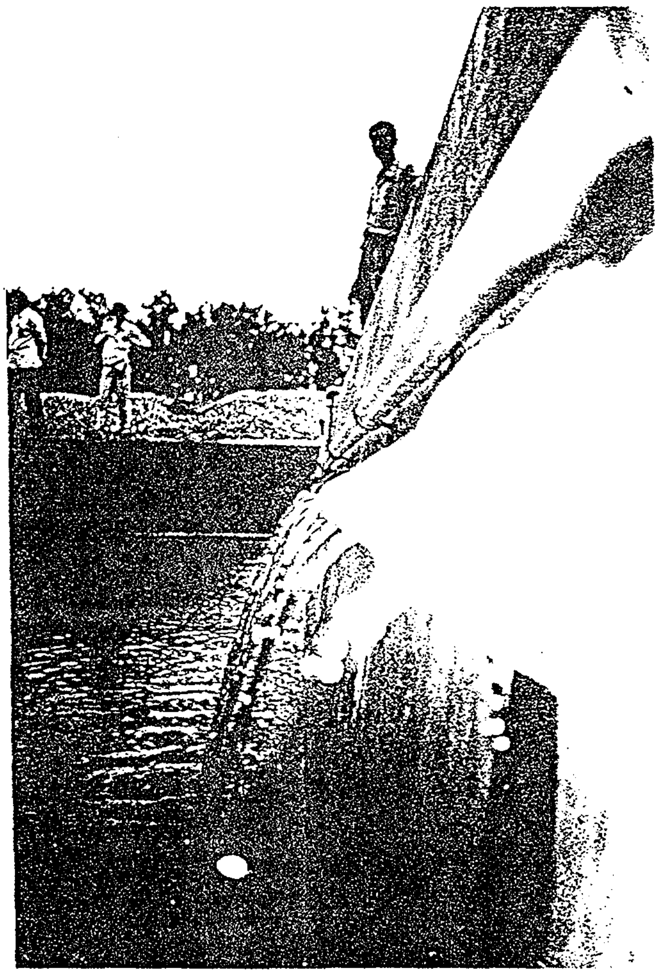
Planting in RB-3



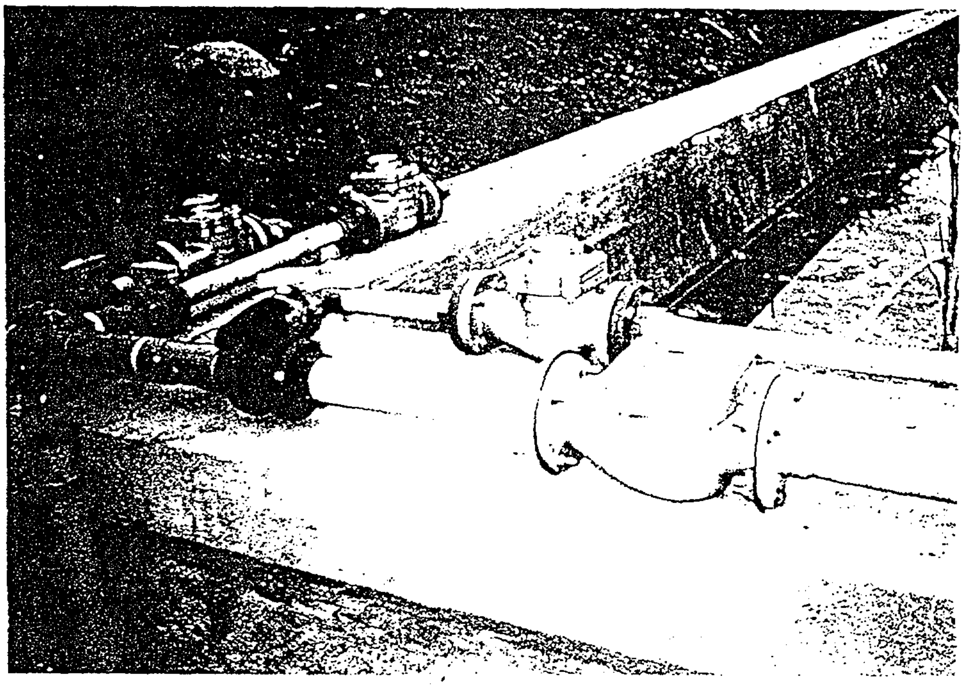
RB-3 after planting



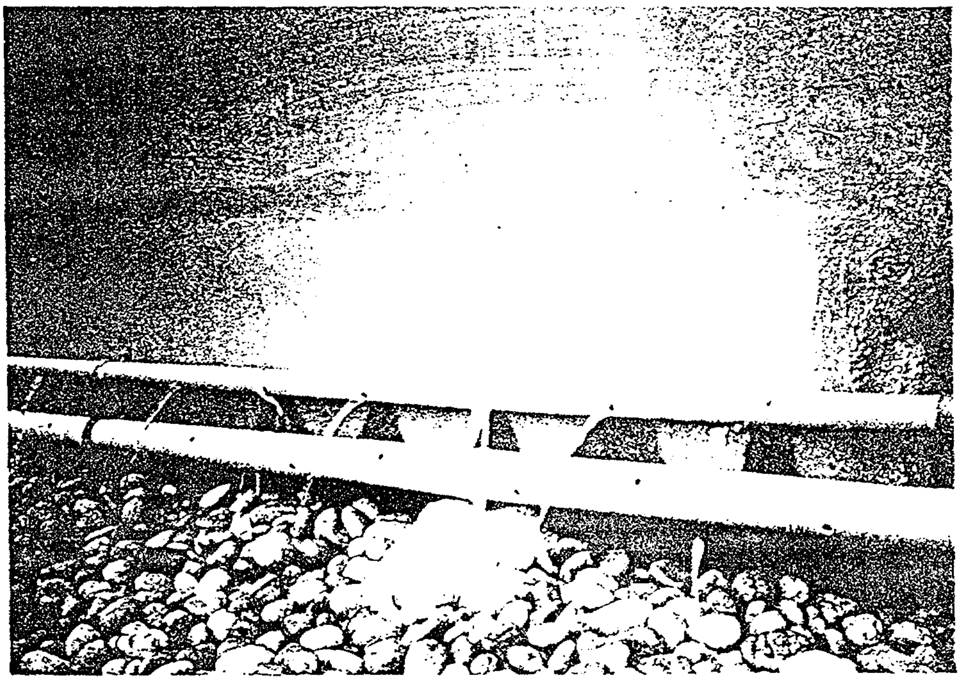
Inlet of RB-1



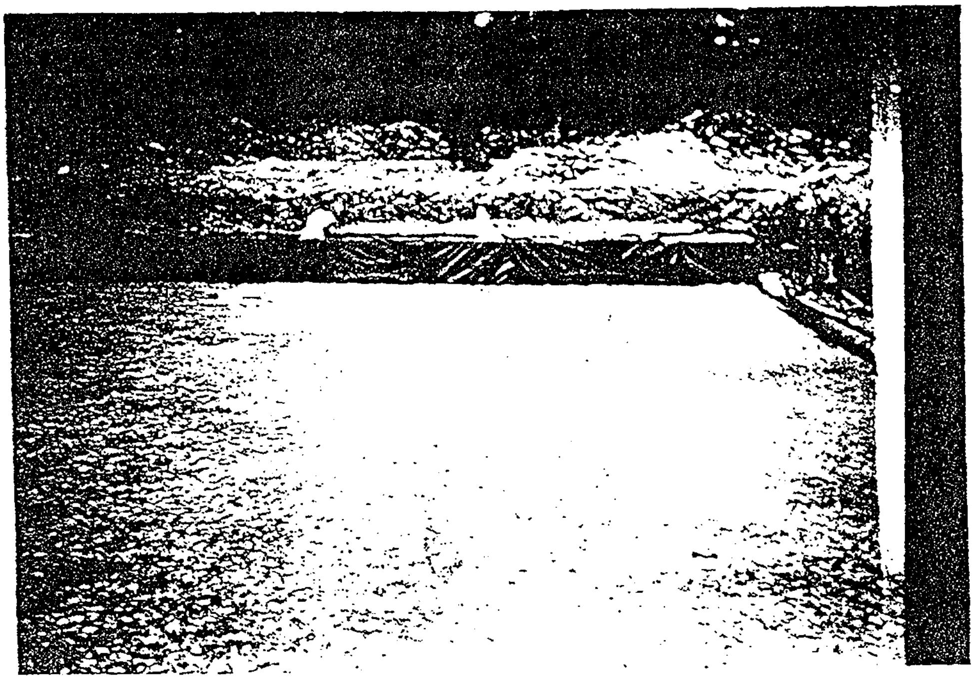
Inlet of RB-2

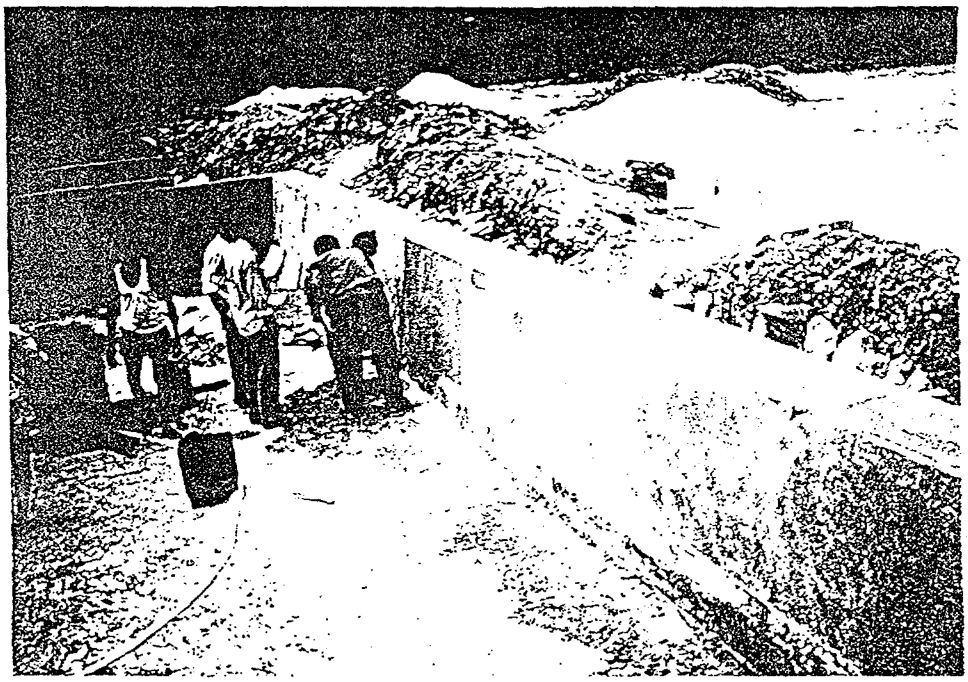


Pipe connection for serial and parallel feeding



Inlet of RB-3





Annexure 6

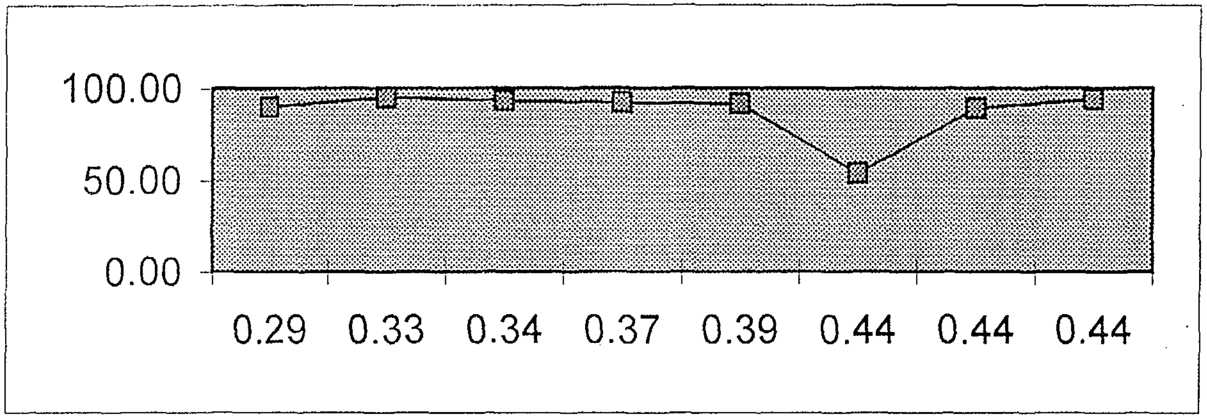
PERFORMANCE OF REED BEDS AT VISHTEC CETP

AVERAGE VALUES OF BOD

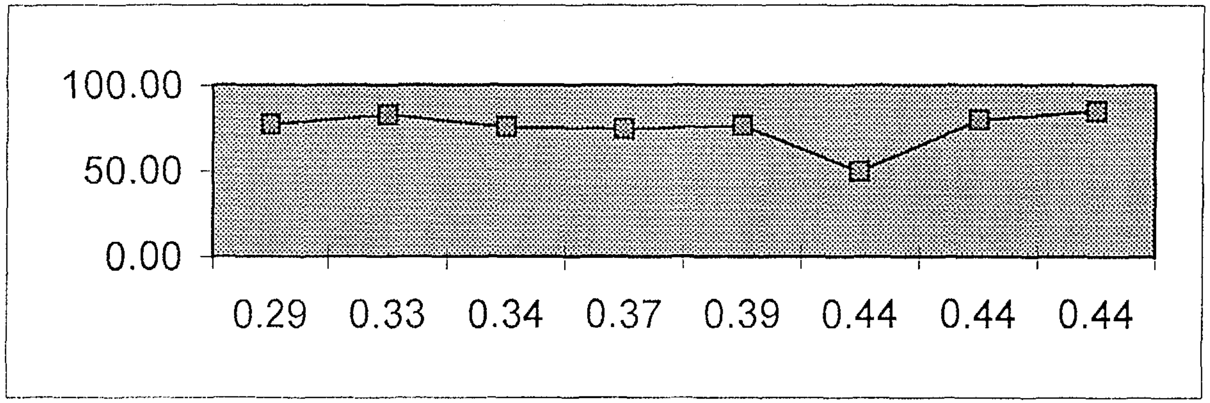
Month	Mean Input m³/d	Mean Output m³/d	Inlet Mean BOD mg/l	Inlet Mean BOD kg/d	Outlet Mean BOD mg/l	Outlet Mean BOD kg/d	Reduction of BOD %	Specific Reduction of BOD g/m²/d
Aug-99	54	46.6	800.0	43.20	428.0	49.54	53.83	37.27
Sep-99	51.4	44.3	753.0	38.70	97.0	18.03	88.9	55.14
Oct-99	37.8	32.6	733.0	27.63	50.0	9.55	94.1	41.67
Nov-99	39.8	34.3	681.0	27.10	39.0	14.23	95.06	41.29
Dec-99	53.7	46.3	685.0	36.78	62.0	25.79	92.2	54.35
Jan-00	55.2	47.5	753.0	41.57	59.0	29.4	93.26	62.12
Feb-00	39.8	34.5	795.0	31.64	79.0	19.08	91.39	46.34
Mar-00	24.5	21.2	666.0	16.32	79.0	12.85	89.74	23.47
Mean	**44.5**	**38.4**	**733.0**	**32.87**	**111.6**	**22.31**	**87.31**	**45.21**

AVERAGE VALUES OF COD

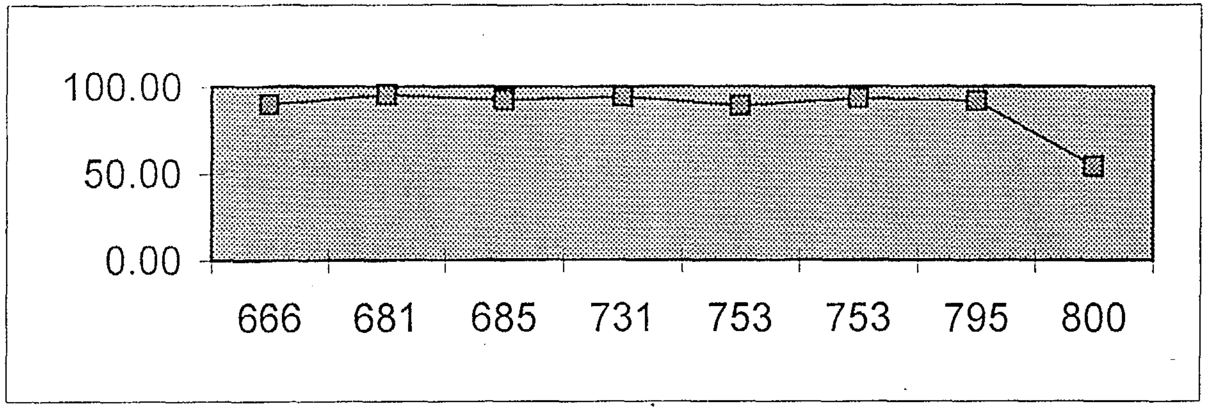
Month	Mean Input m³/d	Mean Output m³/d	Inlet Mean COD mg/l	Inlet Mean COD kg/d	Outlet Mean COD mg/l	Outlet Mean COD kg/d	Reduction of COD %	Specific Reduction of COD g/m²/d
Aug-99	54.0	46.6	1808.0	97.63	1063.0	49.54	49.26	77.08
Sep-99	51.4	44.3	1720.0	88.41	407.0	18.03	79.61	112.79
Oct-99	37.8	32.6	1667.0	63.01	293.0	9.55	84.84	85.67
Nov-99	39.8	34.3	2044.0	81.35	415.0	14.23	82.50	107.56
Dec-99	53.7	46.3	1866.0	100.20	557.0	25.97	74.26	119.25
Jan-00	55.2	47.5	2186.0	120.67	619.0	29.40	75.63	146.26
Feb-00	39.8	34.5	2014.0	80.16	553.0	19.08	76.20	97.88
Mar-00	24.5	21.2	2270.0	55.62	606.0	12.85	76.90	68.54
Mean	**44.5**	**38.4**	**1946.9**	**85.88**	**564.13**	**22.31**	**74.90**	**101.88**



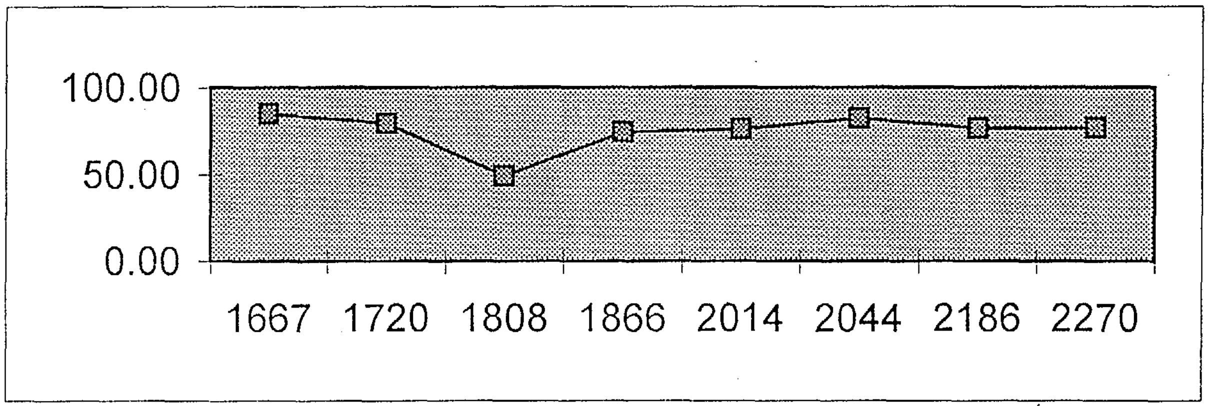
Graph 6.1 Rate of reduction of BOD against BOD:COD ratio



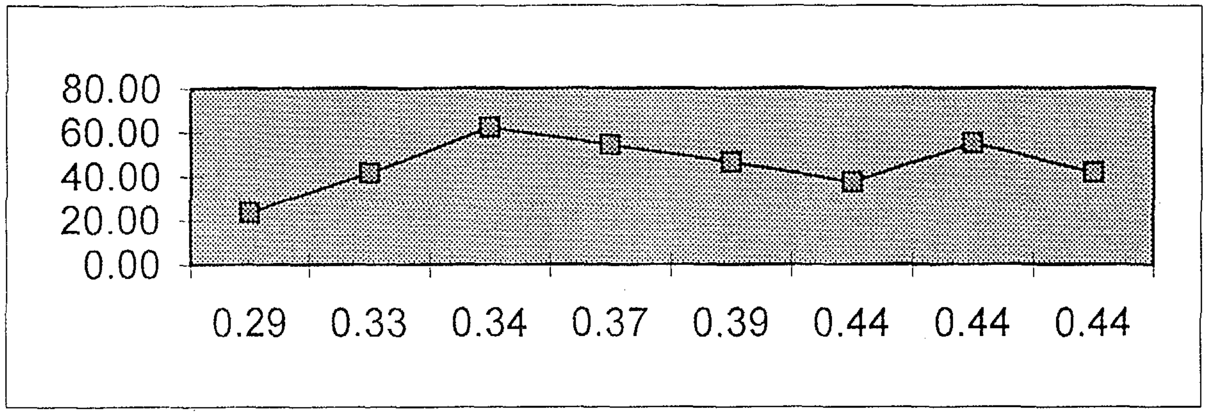
Graph 6.2 Rate of reduction of BOD against BOD:COD ratio



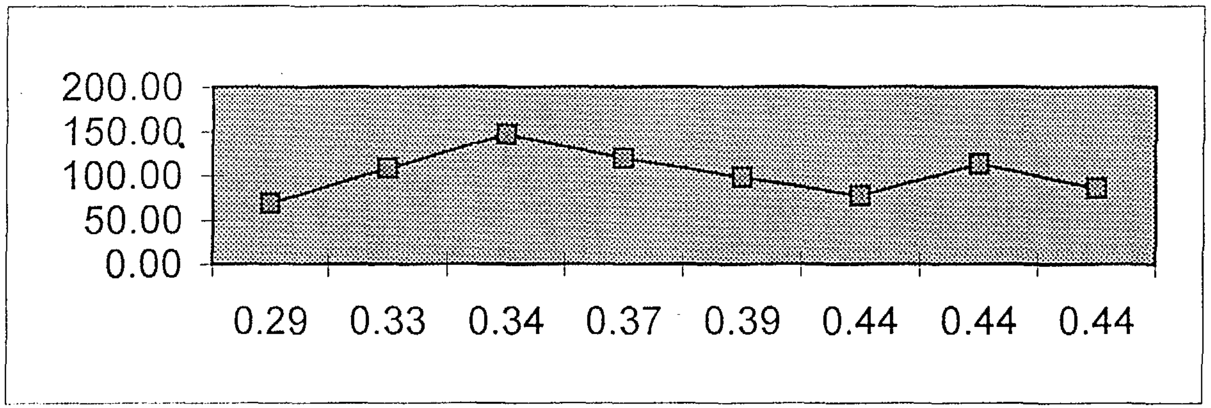
Graph 6.3 Rate of reduction of BOD against Influent BOD



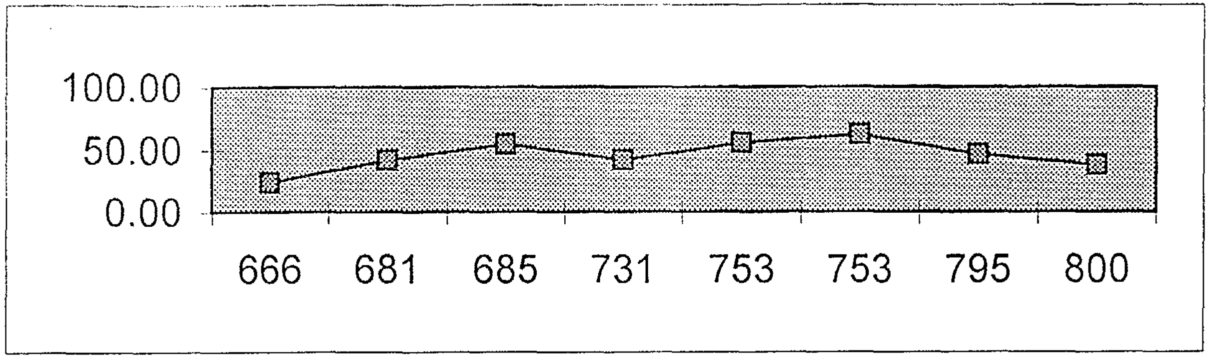
Graph 6.4 Rate of reduction of COD against Influent COD



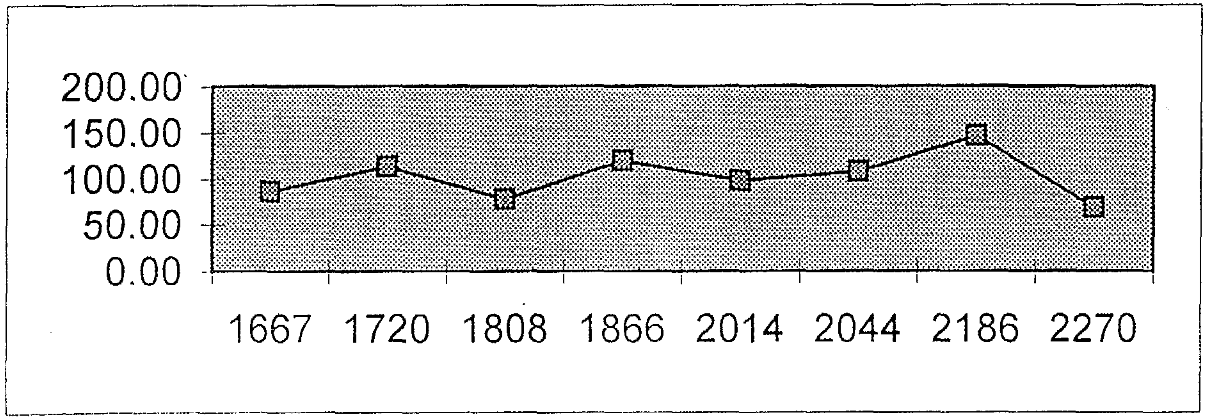
Graph 6.5 Specific Reduction of BOD against BOD:COD ratio



Graph 6.6 Specific Reduction of COD against BOD:COD ratio



Graph 6.7 Specific Reduction of BOD against influent BOD



Graph 6.8 Specific Reduction of COD against influent COD

Annexure 7

Performance of Experimental Reed Bed at TALCO RANITEC

7.1 Introduction

TALCO RANITEC is a CETP located at V. C. Mottur in Walajah taluk. The CETP has been established for the treatment of effluent discharged by 76 tanneries in the cluster, mostly processing raw to finished leather, largely by vegetable tanning. The CETP employs physical, chemical & biological treatment and a tertiary treatment unit to treat the effluent. The purpose of tertiary treatment is reduction of colour and BOD/COD. Though the efficiency of this tertiary treatment is generally satisfactory, the cost of operation was found prohibitively high. Hence the proposal for establishing an experimental unit for the purpose.

7.2 Implementation of the project

The small bed was made as a horizontal reed bed, operating with continuos feeding. The feeding to the bed was started by 03 August, 1998. The system was put into operation with regular monitoring from September, 1998.

Main experiments planned with the reed bed were to find out the optimum BOD, COD and colour reduction.

7.3 Details of the system

The bed made had the following specifications:

Dimensions : 5 m x 8 m x 0.5 m, Construction : 200 micron LDPE sheet in bottom 10 cm gravel (10-20 mm size) and 0.40 m sieved sand (0.5-1 mm size) on top.

7.4 Reeds

The reed bed was planted with Typha, Phragmites (local species), Scirpus and Trema. The survival/propagation of Typha was found to be better than that of Scirpus while the Phragmites could not survive.

7.5 Performance of reed bed

The system had produced good BOD/COD reduction and very good reduction in colour. When operated with lower retention times too, the system produced good performance. The overall performance of the system is given in Table 7.1 and performance after stabilisation at 5 day retention time is presented in Table 7.2 given below:

Table 7.1

Characteristics of influent and effluent of the experimental Reed Bed at TALCO RANITEC

Sl.No.	Parameter	10/98		11/98		1/99		2/99		3/99	
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1	pH	7.1	7.2	7.0	7.1	7.1	7.1	7.0	7.0	7.0	7.0
2	COD	298	85	412	178	385	260	372	235	345	206
3	BOD	29	9	24	9	19	14	26	15	25	11

Table 7.2

Parameter	Feed water	Final outlet	% reduction
pH	7.1	7.0	---
COD mg/l	304	165	46
BOD mg/l	24	9	62

7.6 Fill and draw system

To check the impact of feeding pattern on the performance of reed bed, the continuous feeding maintained from the beginning till end of Dec, 98 was changed to fill and draw system for a month from 1 Jan, 99 to 3 Feb 99. The performance reported during this period was given in Table 7.3

Table 7.3

#	Parameter	Influent	Treated effluent	% reduction
1.	pH	7.1	7.1	
2.	COD mg/l	385	260	26%
3.	BOD mg/l	19	14	27%

As the performance of the system has come down by feeding modification to fill and draw, it was decided to revert to continuous feeding. Nevertheless, the experiment with fill and draw system was informative and useful.

7.7 Modifications in feeding rate

in order to find out the changes in efficiency of reed bed, the retention time was reduced to 3 days and the performance of the system observed during this period is given in Table 7.4.

Table 7.4

#	Parameter	Influent	Treated effluent	% reduction
1.	pH	7.0	7.0	
2.	COD mg/l	345	206	40
3.	BOD mg/l	25	11	56

7.8 Evaluation of performance

To compare the efficacy of reed bed as a replacement of existing tertiary treatment, the efficiency reported by existing tertiary treatment was compared with the reed bed performance. Further, the same inlet water let into the reed bed was collected and subjected to tertiary treatment using chemical oxidation. The results of these experiments is given in Table-7.5

Table-7.5

Reed bed vs conventional tertiary treatment systems

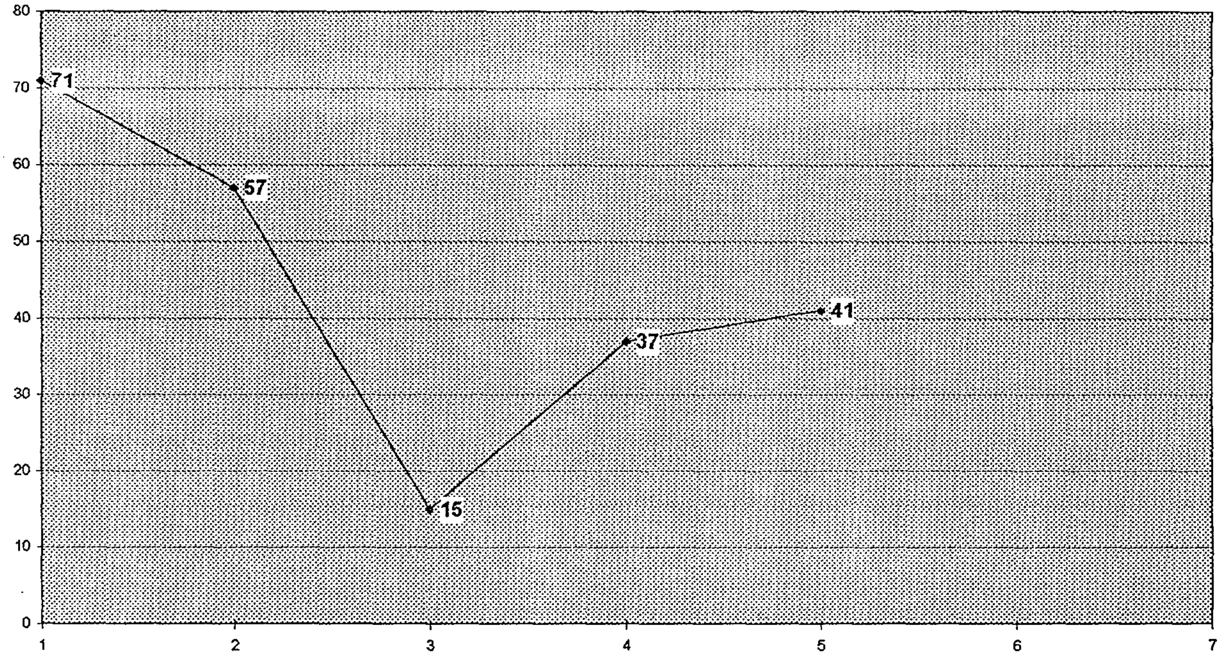
% Reduction

Parameter	Chemical precipitation*	Chemical oxidation**	Reed bed
BOD	30-40	15-25	45-55
COD	45-60	35-40	55-65
TSS	55-70	---	40-50
Colour	25-40	35-40	50-55

* Result obtained from existing tertiary treatment - one year data

** Using sodium hypo chlorite (50 - 500 ppm) - 5 trials

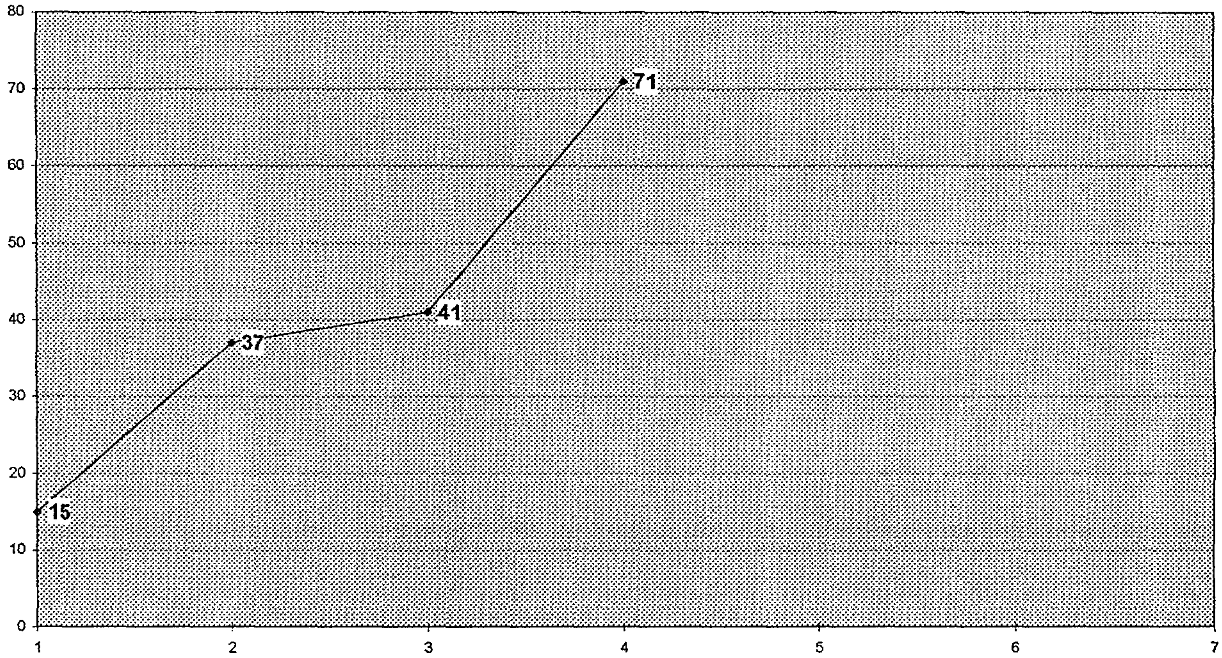
X axis 2.5 cm = 1 month
Y axis 1 cm = 10%



Graph 7.1

RATE OF REDUCTION OF COD AGAINST TIME

X axis 2.5 cm = 10×10^{-3}
Y axis 1 cm = 10%



Graph 7.2

RATE OF REDUCTION OF COD AGAINST BOD : COD RATIO

Annexure 8

Performance of Experimental Reed Bed at SIDCO CETP

8.1 Introduction

Sidco the CETP, situated in SIPCOT Industrial area of Ranipet, treats effluent generated from 'nn' tanneries located in the SIPCOT area most of them processing semi finished to finished leather. The treatment system adopted in the CETP consists of physio-chemical and biological treatment. The CETP is successful in achieving all standards except COD commitment; high colour in the treated effluent is also a problem for the CETP management.

To evaluate the suitability of reed bed system for tertiary treatment of the effluent for removal / reduction of colour and COD, it was planned to try a reed bed on an experimental basis. To limit the expenditure, it was decided to utilise an unused experimental sand filter bed available with the CETP for the purpose.

8.2 Implementation of the project

The experimental Reed Bed at SIDCO CETP has set up by converting the sand filter available by adding necessary piping system for feeding the treated effluent. A fill and draw method was adopted by replacing 1/5th of the contents of the bed every day. The PSRT adopted initially was 5 days ie. a feeding rate of 5 m^3/d considering the filter tank volume and porosity of the media.

Main experiments planned with the reed bed was to find out the optimum BOD, COD and colour reduction and the optimum hydraulic retention time to achieve the mandatory COD limit of 250 mg/l.

8.3 Details of the system

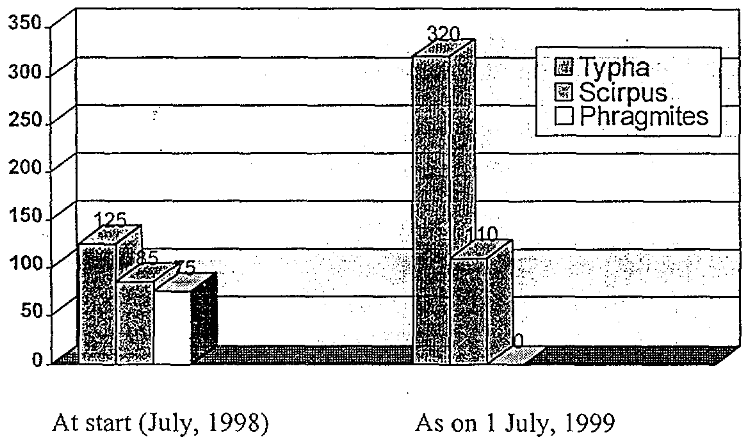
The converted bed had the following specifications:

Dimensions : 11 m x 5 m x 1.15 m, Media : 0.2 m gravel (10-20 mm size) in the bottom and 0.95 m sieved sand (0.5-1 mm size) on top.

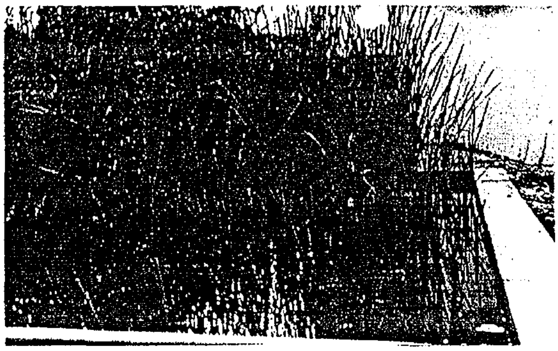
8.4 Reeds

The reed bed was planted with Typha, Phragmites (local species) and Scirpus. The survival/ propagation of Typha was found to be better than Scirpus while the Phragmites could not survive.

The data regarding survival and growth of reeds are presented in the graph below.



Graph .8.1 Survival and growth pattern of reeds



Picture 8.1

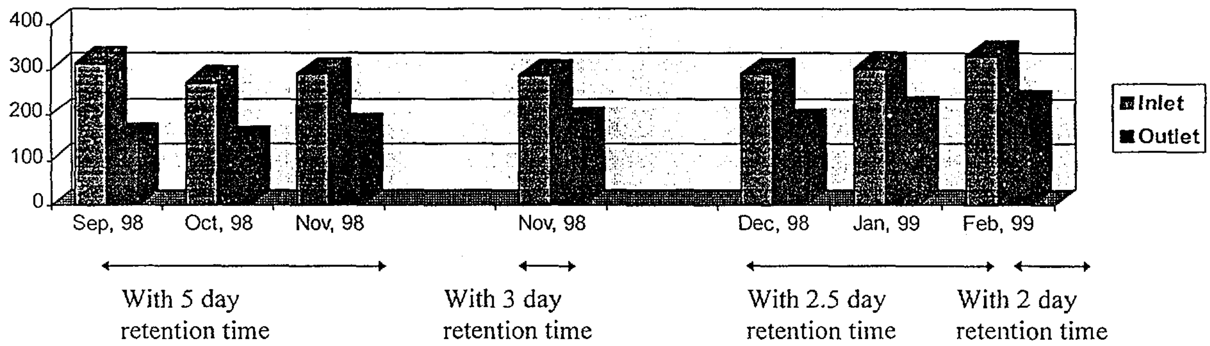
Reed bed developed at Sidco

Picture-8.2

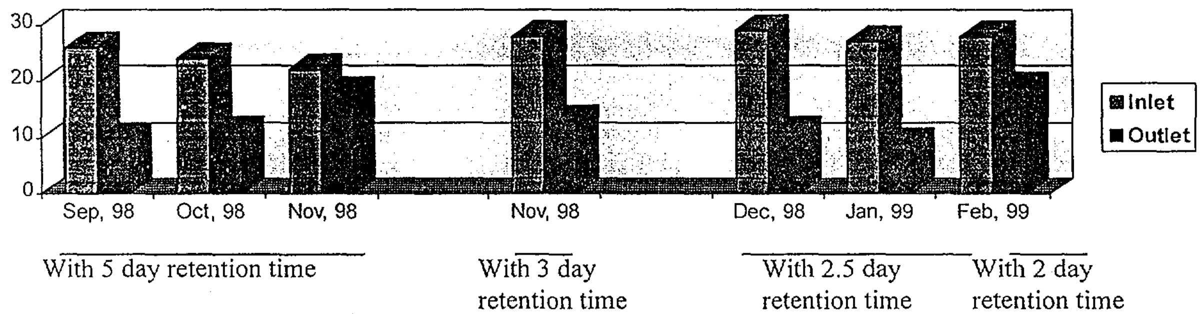
Chemist demonstrating clarity of treated effluent from reed bed

8.5 Experiments with the reed bed

The system had produced good BOD/COD reduction and very good reduction in colour. When operated with lower retention times too, the system produced good performance. Step by step the feeding was increased to reduce the hydraulic retention time from five days to 2.5 days. The overall performance of the system in terms of BOD/COD are presented in the graph below.

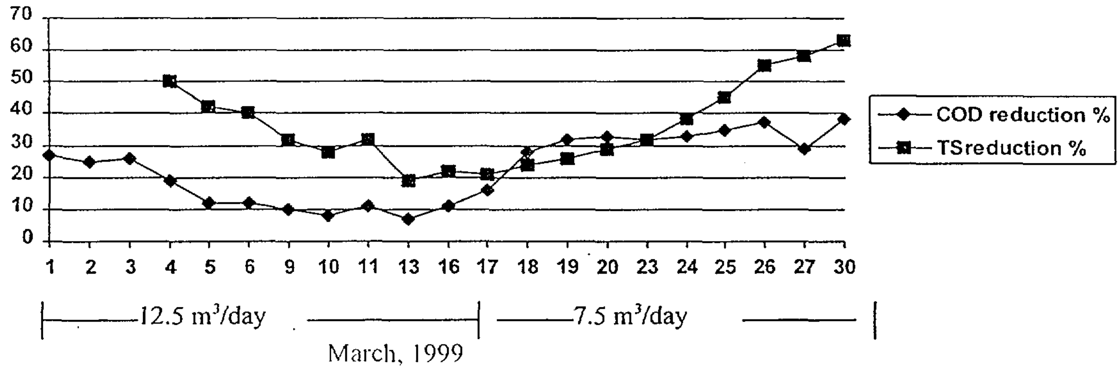


Graph 8.2 COD values in inlet & outlet of reed bed



Graph 8.3 BOD values in inlet & outlet of reed bed

When the feeding was increased to 12.5 m^3/day (equivalent to 2 days retention time), the system performance steadily declined and at one point the system collapsed. Immediate withdrawal of feeding increase restored the performance of the system to some extent. This change performance can be seen in the graph below:



Graph 8.4. COD Reduction as indicator of performance with different feeding rates

The overall performance of the reed bed with different feeding rates are given in table 8.1. Performance of the system @ 7.5 m^3/day feeding (equivalent to 3 days retention time) with more or less consistent performance as seen in Table 8.2.

Table 8.1

Characteristics of influent and effluent of the experimental Reed Bed at SIDCO CETP

Sl.No.	Parameter	10/98		11/98		1/99		2/99		2/99		3/99	
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1	Feeding rate (m^3/d)	5	-	5	-	7.5	-	7.5	-	10	-	10	-
3	pH	7.9	7.2	7.8	7.2	7.7	7.4	7.6	7.5	7.1	7.1	7.2	7.1
2	TDS mg/L	4210	4105	3890	3830	3870	3870	3860	-	-	-	-	-
4	SS mg/L	145	60	150	65	135	50	120	40	115	55	145	60
5	Chlorides mg/L	575	574	460	465	462	-	-	-	-	-	-	-
6	Sulphates mg/L	1120	1135	1120	1135	1085	1010	-	-	-	-	-	-
7	COD mg/L	272	138	292	167	287	182	291	178	304	205	330	220
8	BOD mg/L	24	11	22	11	-	-	29	11	27	9	28	19

Table 8.2

Parameter	Feed water	Final outlet	% reduction
pH	7.3	7.6	---
TSS mg/l	135	65	52
Colour Pt- Co unit	765	85	88
TDS mg/l	4750	4355	8
COD mg/l	345	228	40
BOD mg/l	27	13	52

8.6 Evaluation of performance

To verify the efficacy of reed bed as a tertiary treatment, the same inlet water let into the reed bed was collected and subjected to tertiary treatment using various methods. Several set of repeated experiments were done for each trials at various dosages. The results of these experiments are given in Table-8.3

Table-8.3

Reed bed vs. conventional tertiary treatment systems

% Reduction

Parameter	Activated carbon*	Chemical oxidation**	Chemical precipitation***	Reed bed
BOD	50-60	12-20	15-20	65-70
COD	60-65	15-20	20-25	50-60
TSS	50-60	---	70-80	40-50
COLOUR	40-50	10-15	40-50	30-40

* Using powdered carbon added to aeration tank MLSS - 0.2-5 g/l - 16 trials, packed bed - contact time 30 minutes to 4 hours- 4 trials

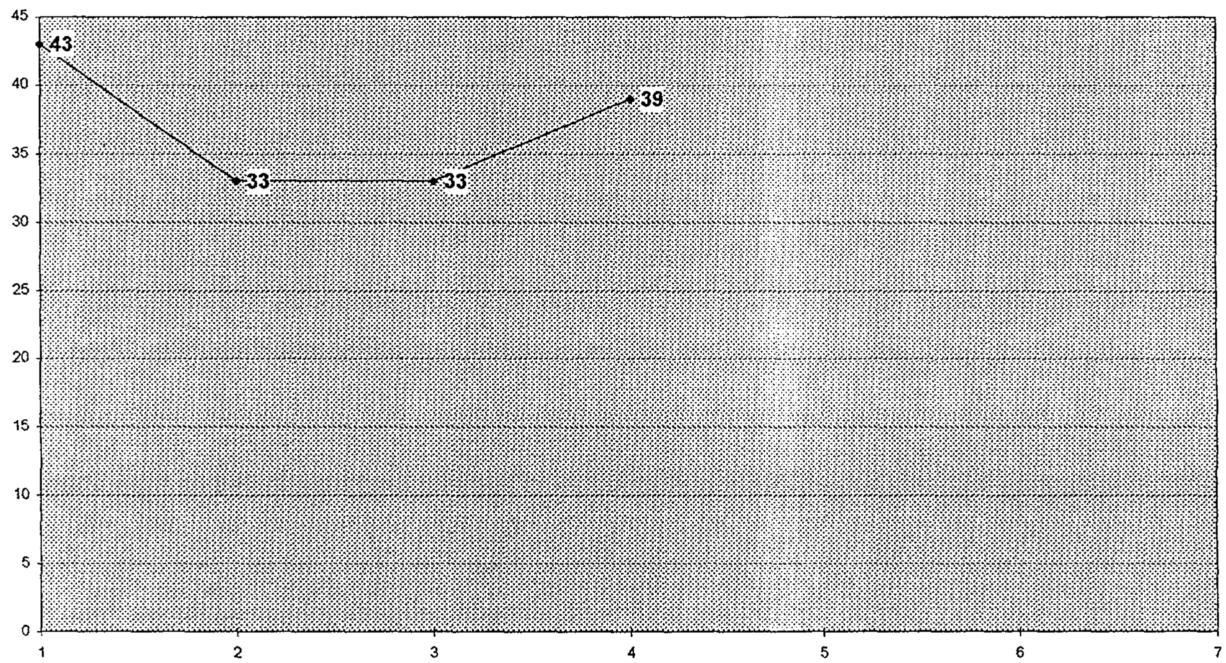
** Using sodium hypo chlorite (50 - 500 ppm) - 12 trials and hydrogen peroxide (100-500 ppm) - 6 trials

*** Alum dosage (100-250 mg/l), Lime (100-300 mg/l) and PE (1-2 ppm) - 26 trials

Various parameters like pH, TDS, SS, Chlorides, Sulfates, BOD and COD were monitored. The average values for the month of Oct. 98 indicate a reduction of 49.5% of COD and 54% of BOD. The COD: BOD ratio was 11:33. The negligible variation of Chloride, sulfates & TDS validated the assumption that the evapotranspiration rate will be low in this type of operation. There was considerable removal of SS and turbidity. Encouraged by the results, the feed was increased to 7.5m^3/d. There was reduction in efficiency of the bed on increase of the feeding in terms of reduction of colour and COD. SS removal remained almost constant at 53%. Further increase of feeding rate to 10m^3/d reduced the COD removal to 33%, and the effluent from the bed started turning turbid and turning darker in colour. On reduction of the feeding rate in March, the system was found to recover and achieve previous levels of performance.

8.7 Since all data required by UNIDO has been collected and consolidated, no further activity is proposed to be undertaken in this project.

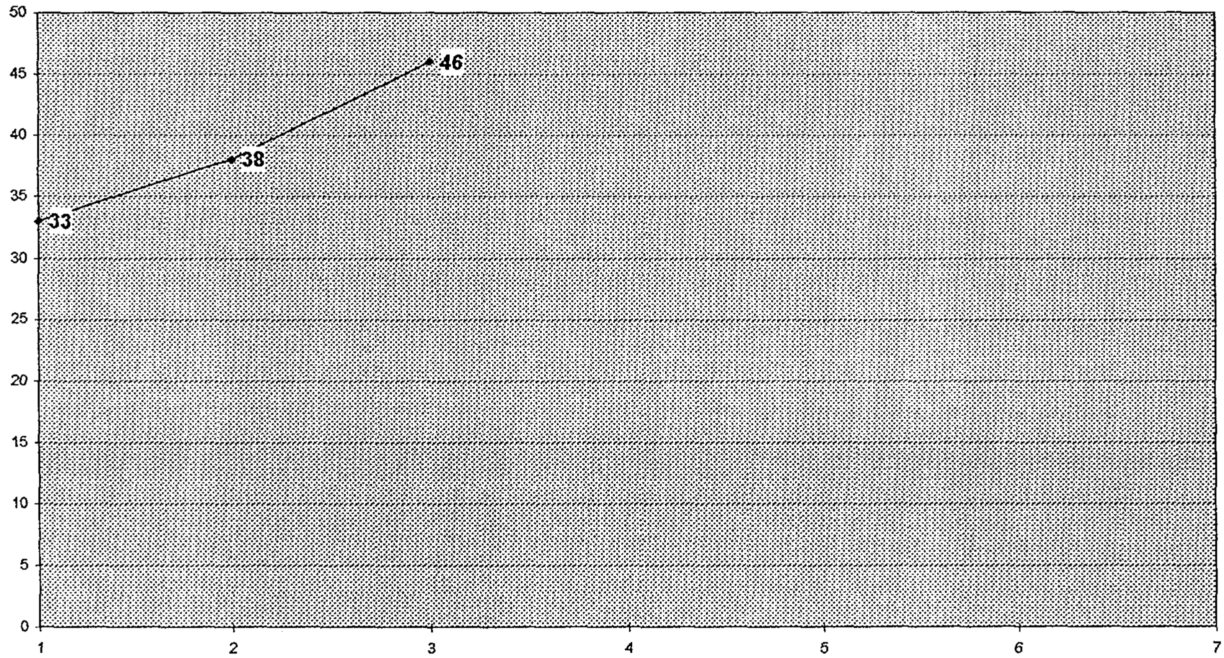
X axis 2.5 cm = 10×10^{-3}
Y axis 1 cm = 10%



Graph 8.1

RATE OF REDUCTION OF BOD AGAINST BOD : COD RATIO

X axis 2.5 cm = 0.5d
Y axis 1 cm = 10%



Graph 8.2

RATE OF REDUCTION OF COD AGAINST RETENTION TIME

Annexure 9

DRAWINGS

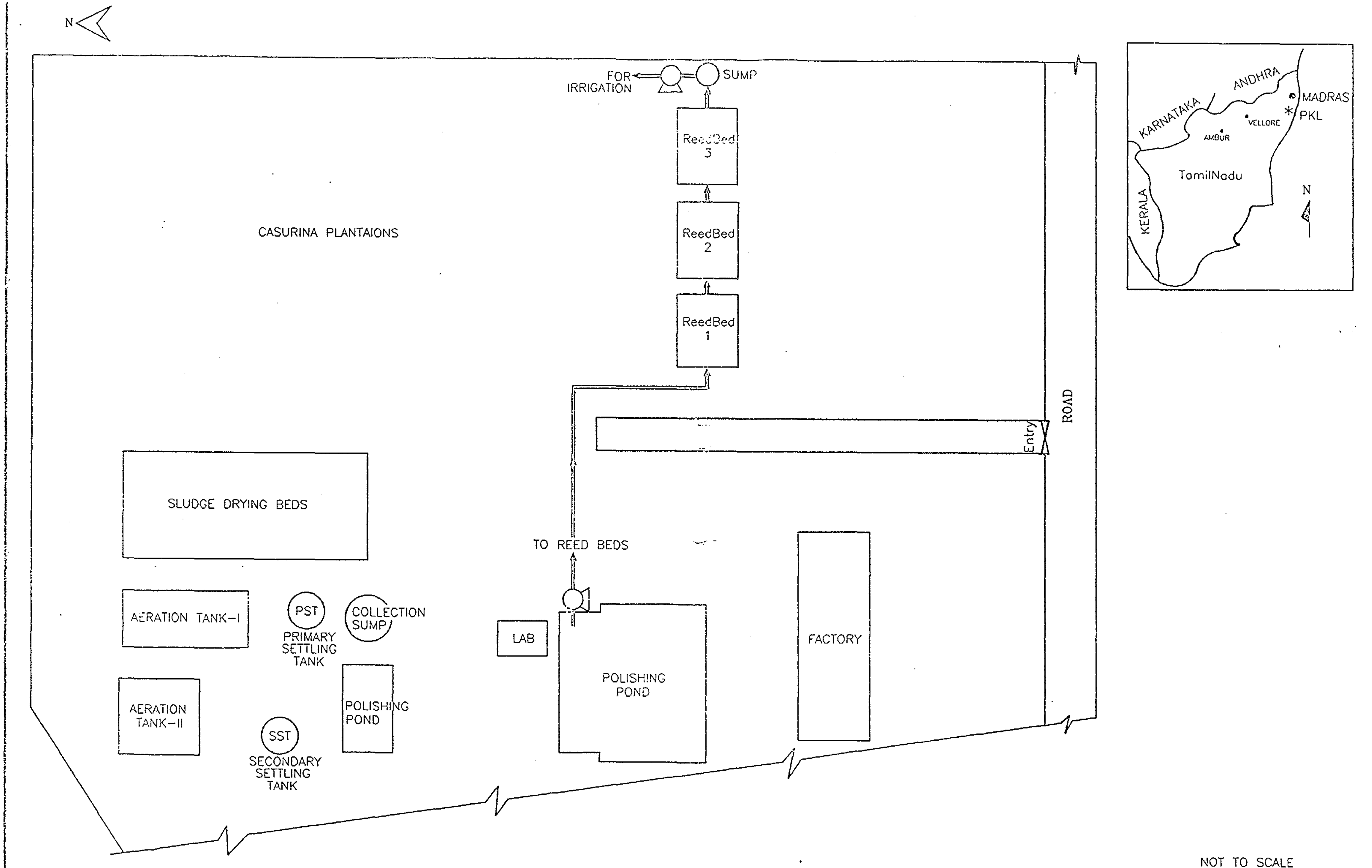


FIG 1 LAYOUT ETP,PRESIDENCY KID LEATHERS LIMITED,MADRAS,INDIA.

US/RAS/92/120/PDU1/SR1

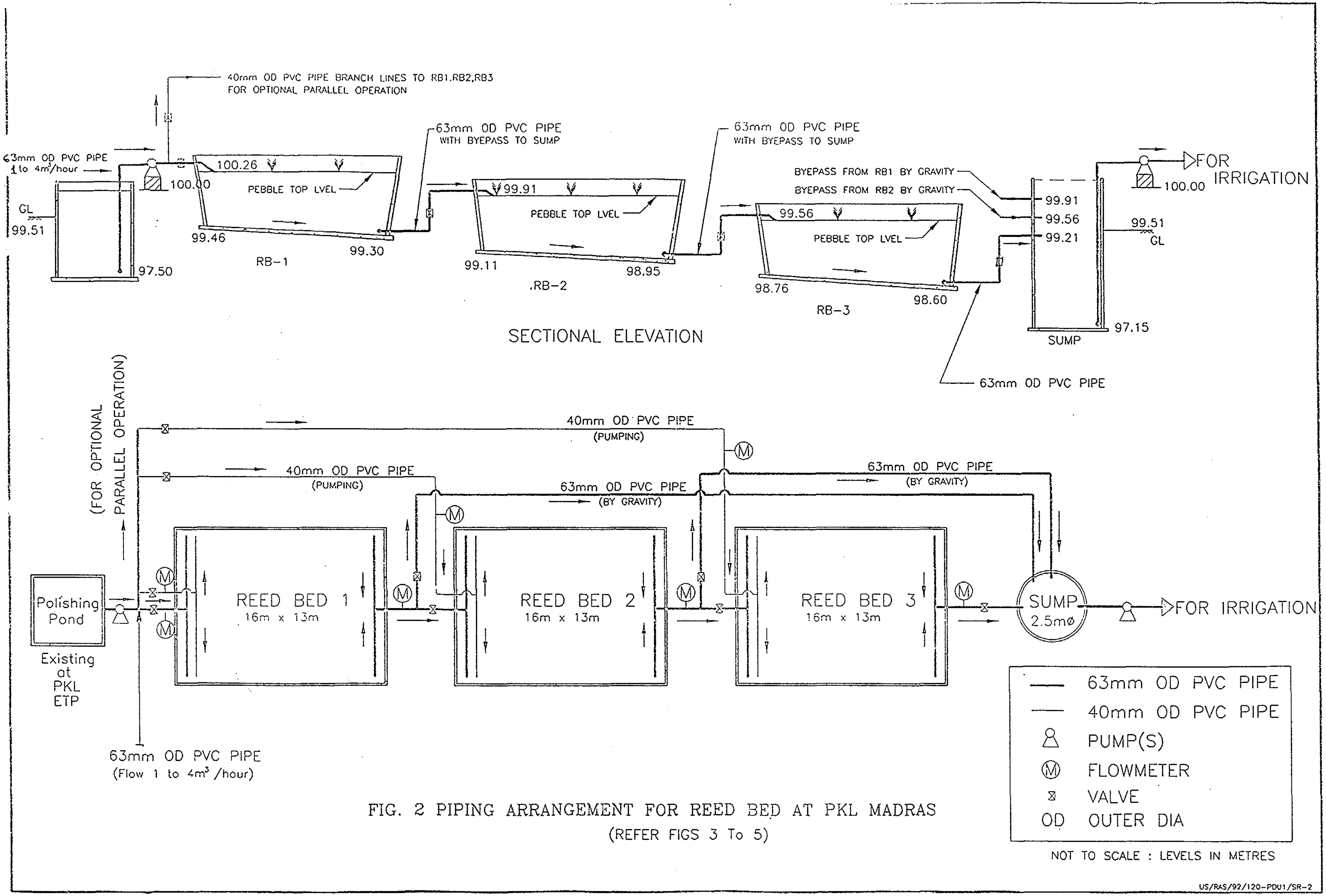


FIG. 2 PIPING ARRANGEMENT FOR REED BED AT PKL MADRAS

(REFER FIGS 3 To 5)

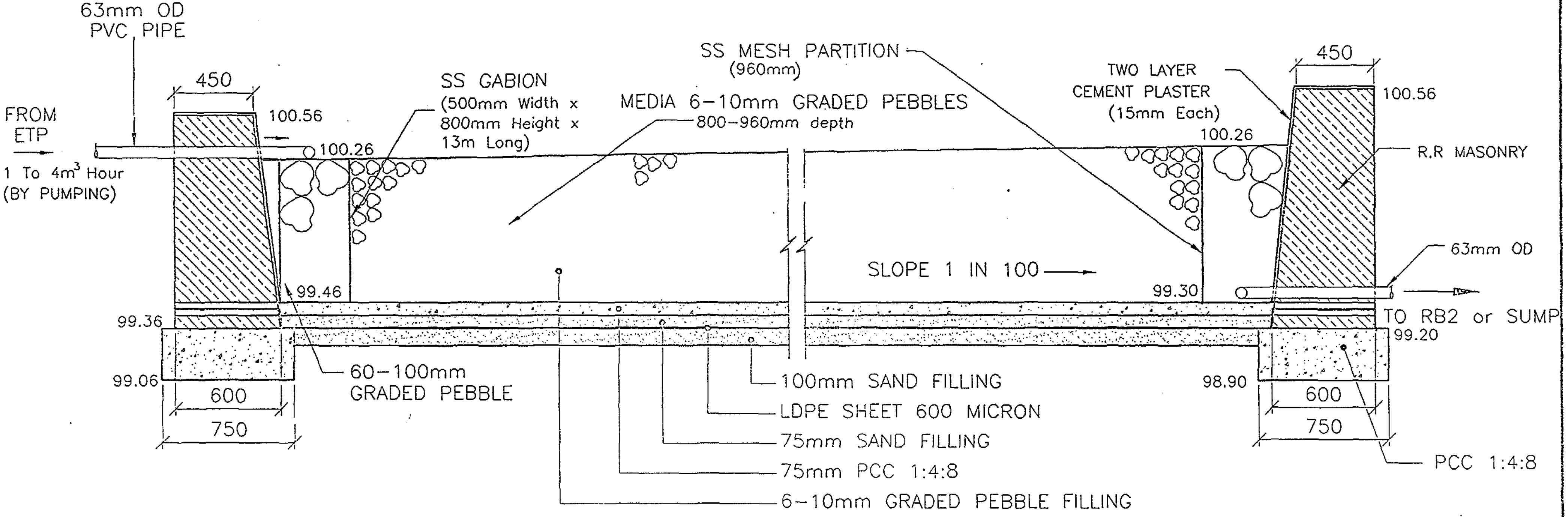


FIG.4A CROSS SECTION OF REED BED NO:1

(REF. FIGS. 2, 3 & 5)

NOT TO SCALE
DIMENSIONS IN 'mm'
LEVELS IN METERS
P.C.C : PLAIN CEMENT CONCRETE

US/RAS/92/120/PDU1/SR-4A

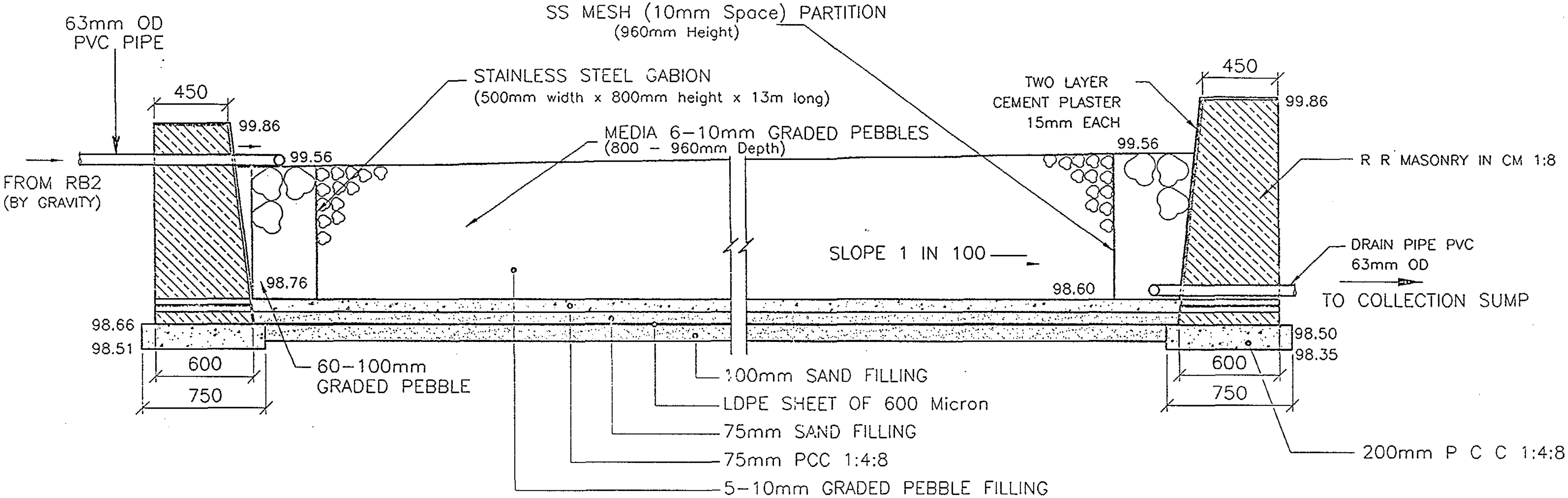


FIG.4C CROSS SECTION OF REED BED NO:3

(REF. FIGS. 2, 3 & 5)

NOT TO SCALE

DIMENSIONS IN 'mm'

LEVELS IN METERS

P.C.C : PLAIN CEMENT CONCRETE

US/RAS/92/120/UDPI/SR-3

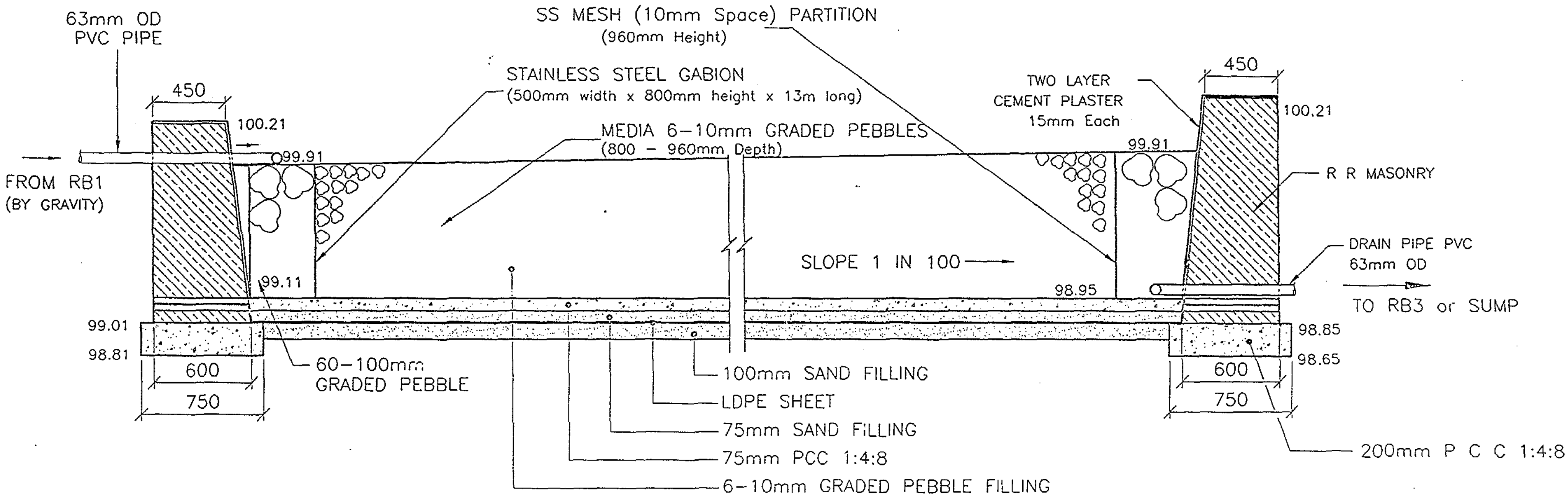


FIG.4B CROSS SECTION OF REED BED NO:2

(REF. FIGS. 2, 3 & 5)

NOT TO SCALE
DIMENSIONS IN mm
LEVELS IN METERS
P.C.C PLAIN CEMENT CONCRETE

US/RAS/92/120/PDU1/SR-4B

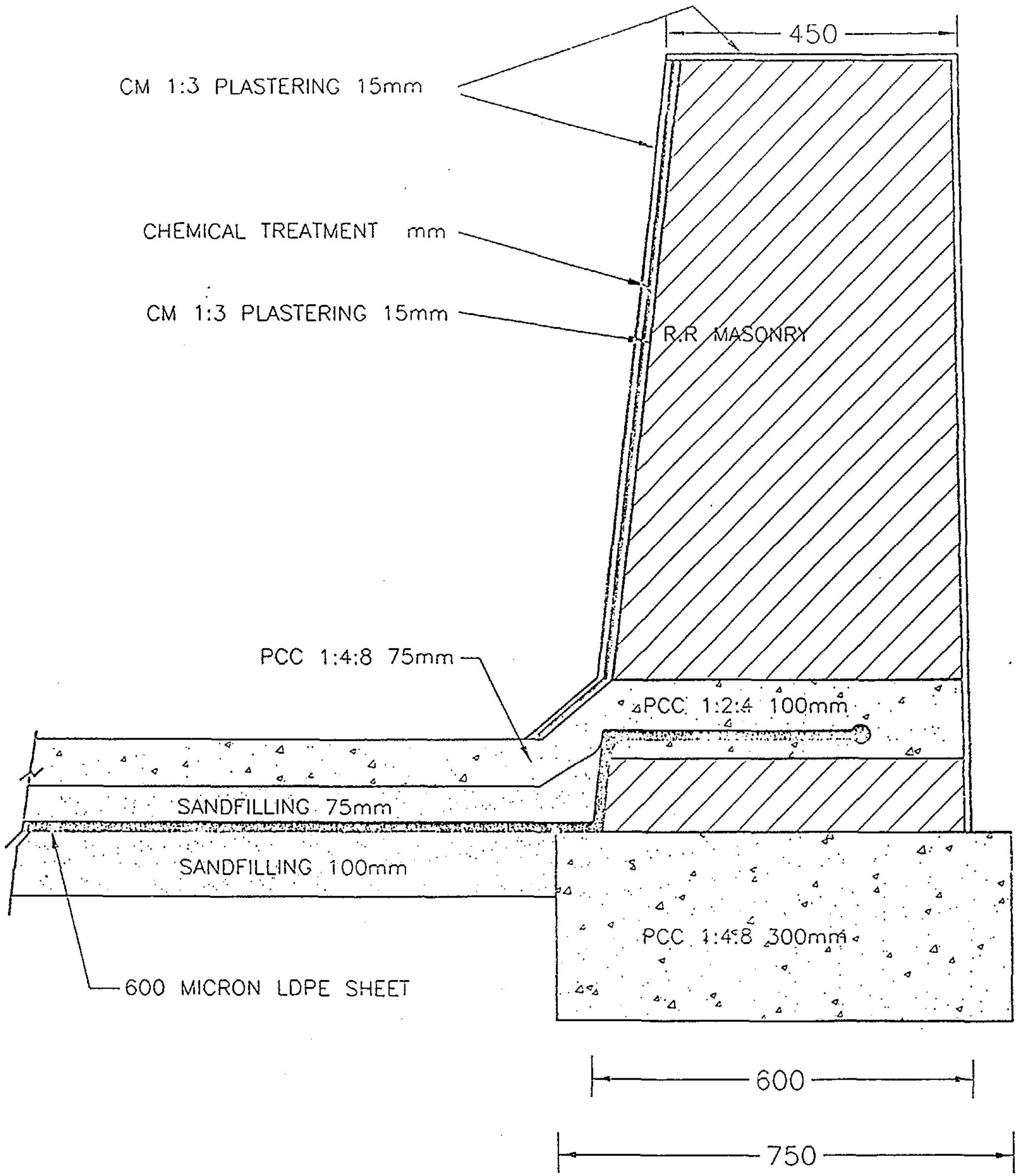


FIG. 5A CONNECTION DETAILS OF LDPE SHEET

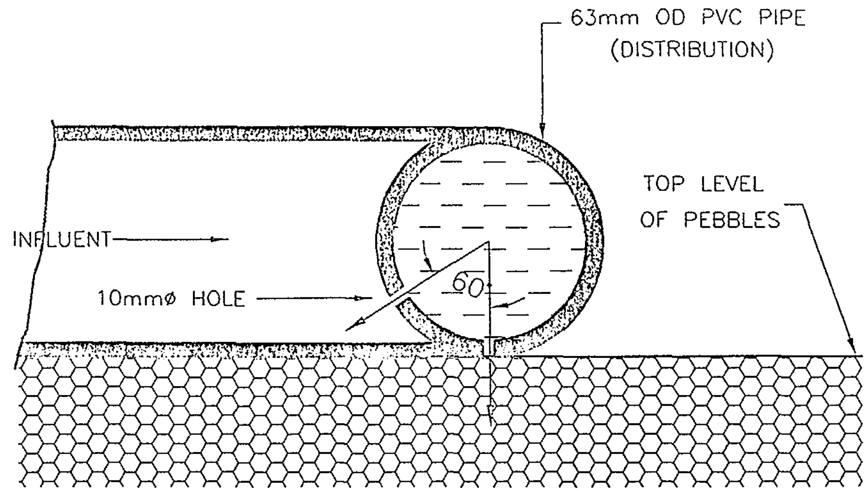
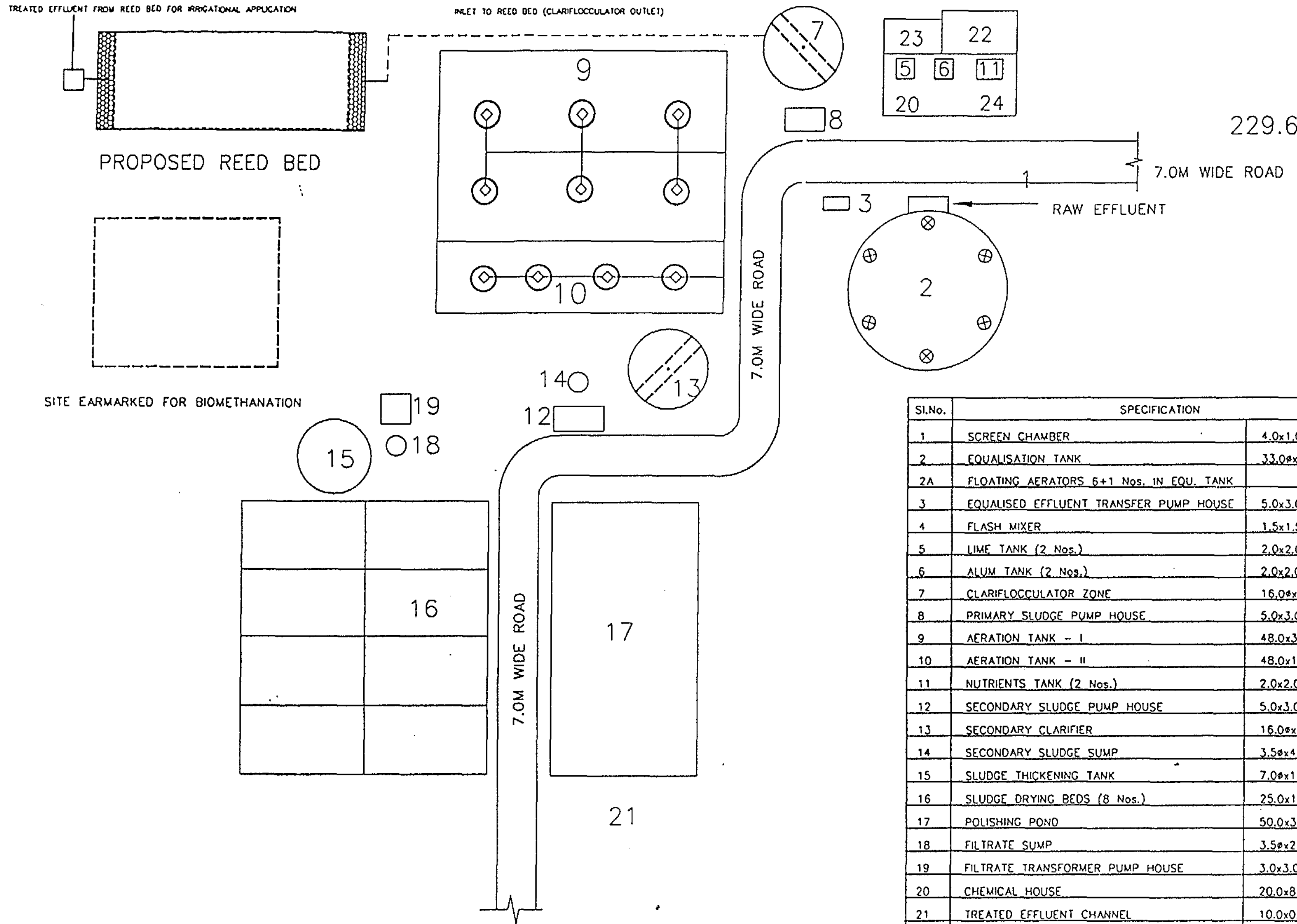


FIG. 5B DETAILS OF INLET PIPE AT TOP OF PEBBLES

NOT TO SCALE

ALL DIMENSIONS ARE IN mm.

US/RAS/92/120/PDU1/SR/5-AB.



Sl.No.	SPECIFICATION	
1	SCREEN CHAMBER	4.0x1.0x1.0m SWD (1.3m TD)
2	EQUALISATION TANK	33.0øx3.0m SWD (3.5m TD)
2A	FLOATING AERATORS 6+1 Nos. IN EQU. TANK	
3	EQUALISED EFFLUENT TRANSFER PUMP HOUSE	5.0x3.0x3.0m HT
4	FLASH MIXER	1.5x1.5x1.0m SWD (1.5m TD)
5	LIME TANK (2 Nos.)	2.0x2.0x1.2m SWD (1.8m TD)
6	ALUM TANK (2 Nos.)	2.0x2.0x1.5m SWD
7	CLARIFLOCCULATOR ZONE	16.0øx3.5m SWD
8	PRIMARY SLUDGE PUMP HOUSE	5.0x3.0x3.0m HT
9	AERATION TANK – I	48.0x32.0x3.5m SWD (4.0m TD)
10	AERATION TANK – II	48.0x12.0x3.2m SWD (3.8m TD)
11	NUTRIENTS TANK (2 Nos.)	2.0x2.0x1.5m SWD (1.8m TD)
12	SECONDARY SLUDGE PUMP HOUSE	5.0x3.0x3.0m HT
13	SECONDARY CLARIFIER	16.0øx3.0m SWD
14	SECONDARY SLUDGE SUMP	3.5øx4.25m SWD (4.75m TD)
15	SLUDGE THICKENING TANK	7.0øx1.5m SWD (4.8m TD)
16	SLUDGE DRYING BEDS (8 Nos.)	25.0x15.0x1.0m TD
17	POLISHING POND	50.0x30.0 (1.2–1.0 m TD)
18	FILTRATE SUMP	3.5øx2.5m SWD (4.3m TD)
19	FILTRATE TRANSFORMER PUMP HOUSE	3.0x3.0x3.0m HT
20	CHEMICAL HOUSE	20.0x8.0x7.0m HT IN TWO FLOOR
21	TREATED EFFLUENT CHANNEL	10.0x0.8x(0.8–0.45m TD)
22	TRANSFORMEY YARD	
23	D.G.ROOM	6.0x8.0x3.5m HT
24	INSTRUMENTATIO' NTROL ROOM	

LAYOUT OF CETP AT FIG 1: MELVISHARAM INCLUDING PROPOSED REED BED

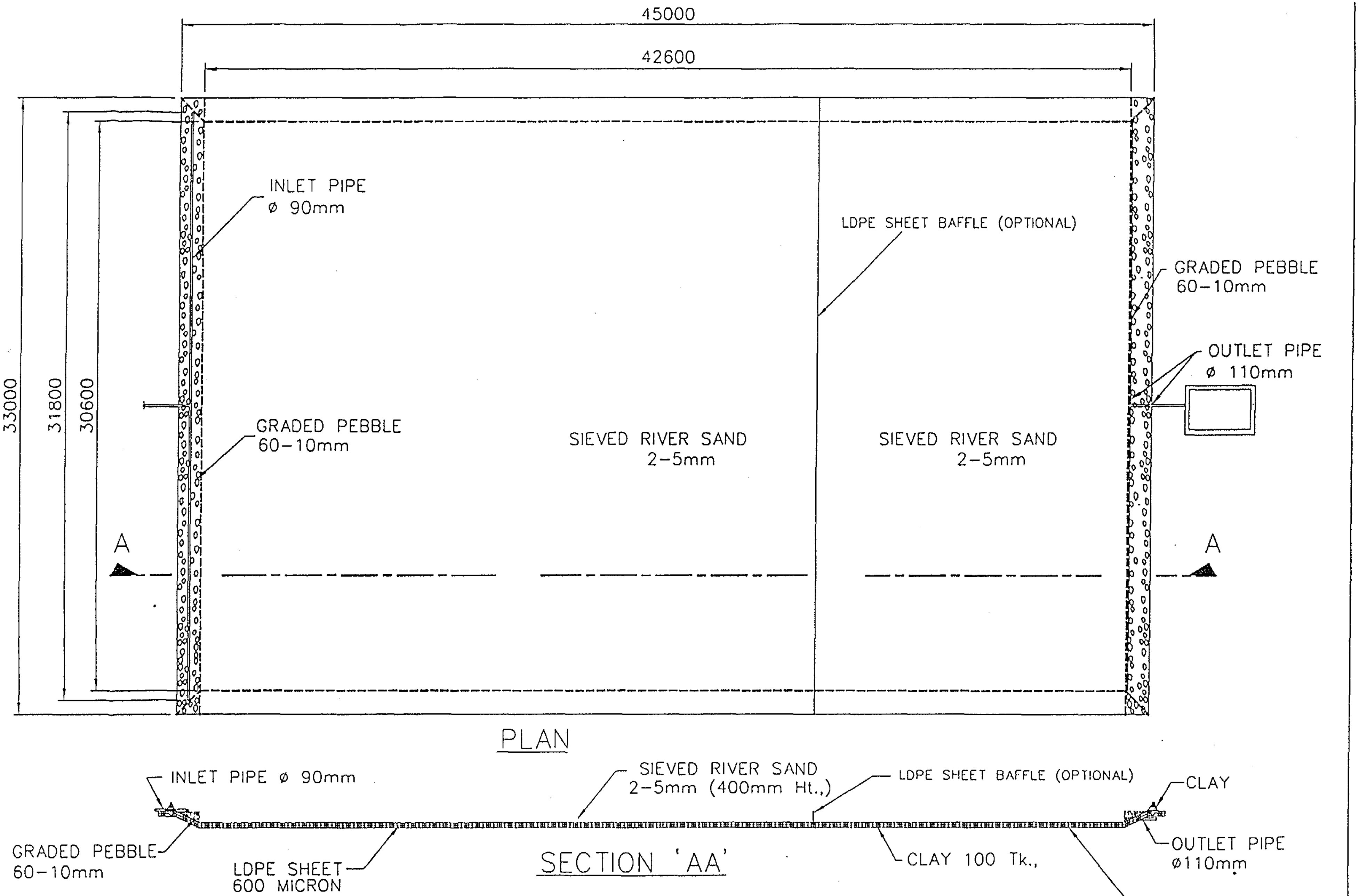
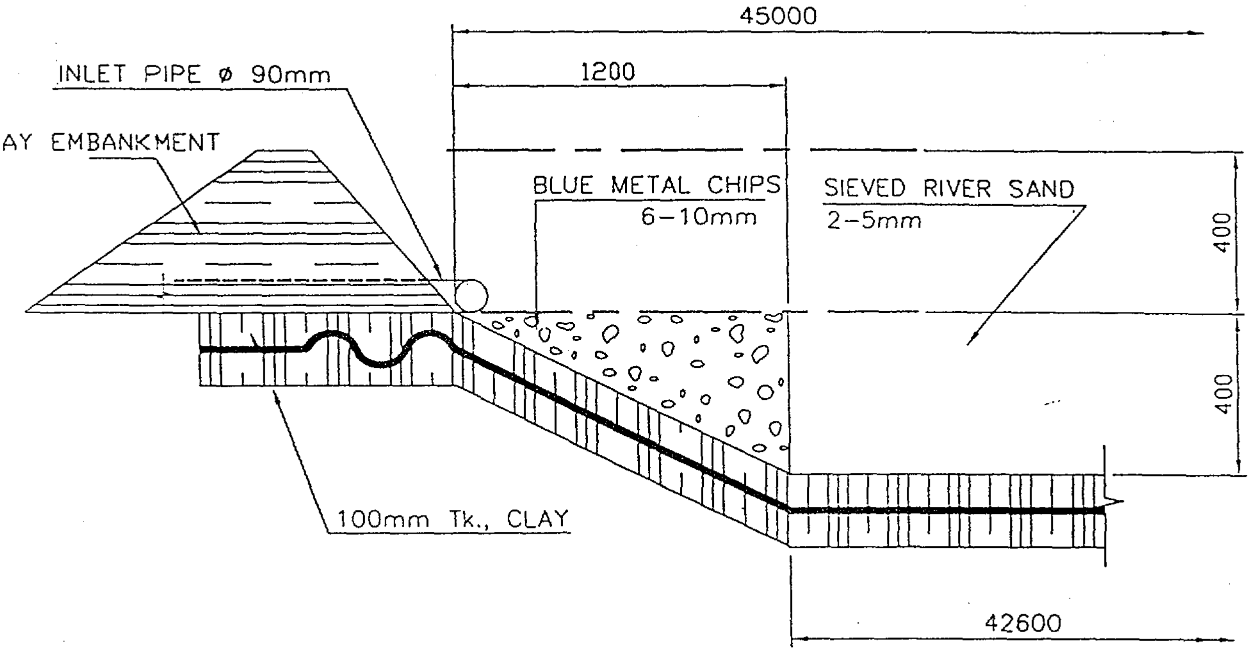
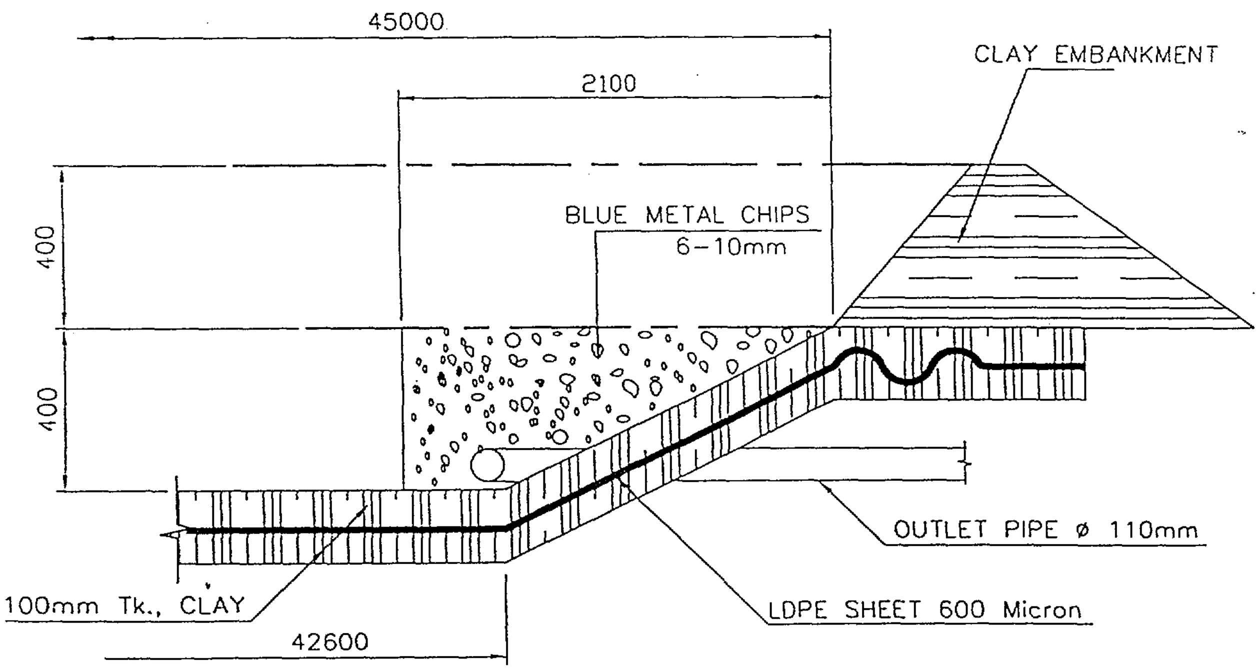


FIG 2 REED BED AT VISTHEC CETP, MELVISHARAM



DETAILS OF REED BED
INLET



DETAILS OF REED BED
OUTLET

FIG. 3 DETAILS OF INLET & OUTLET OF REED BED

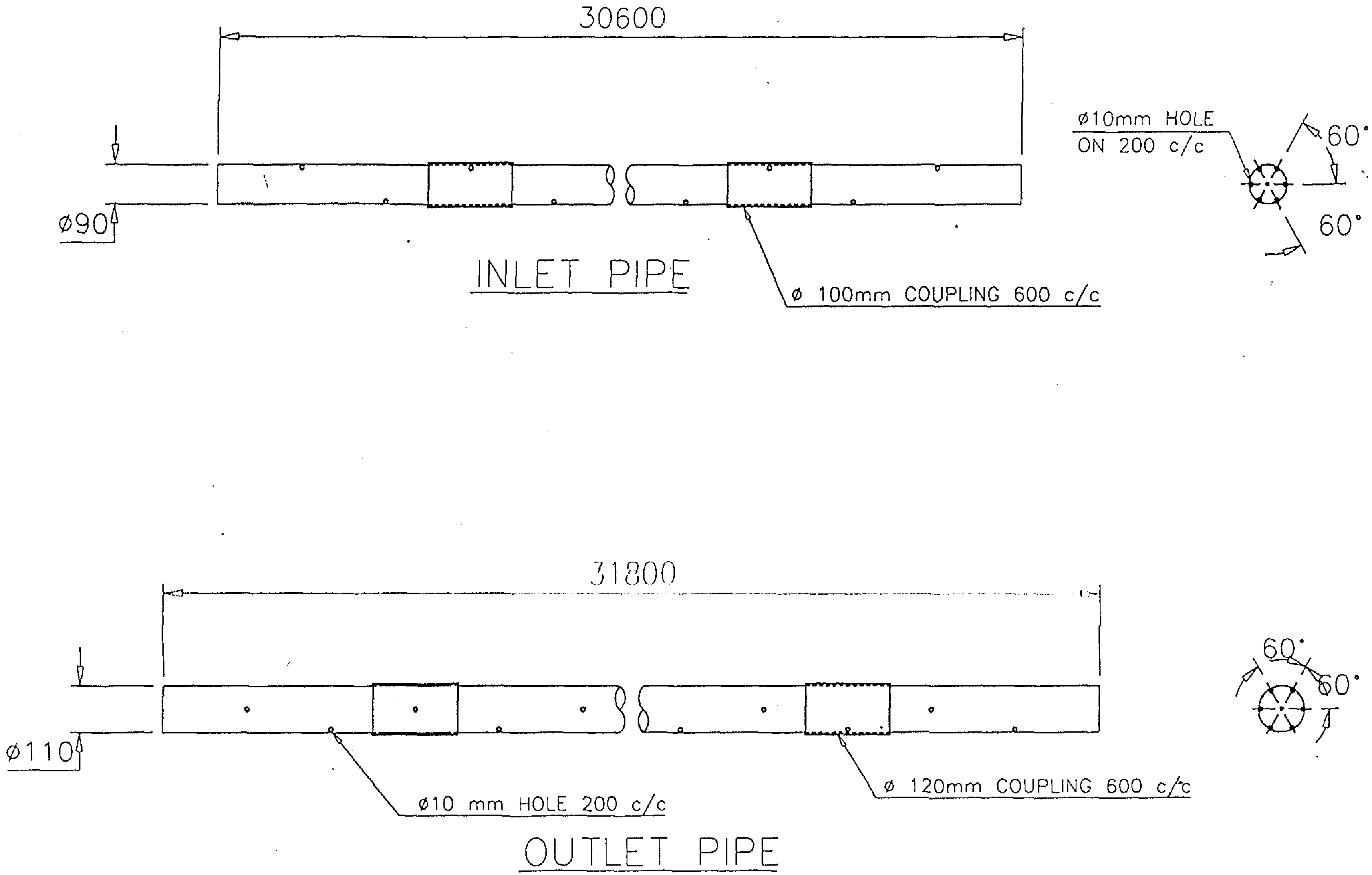
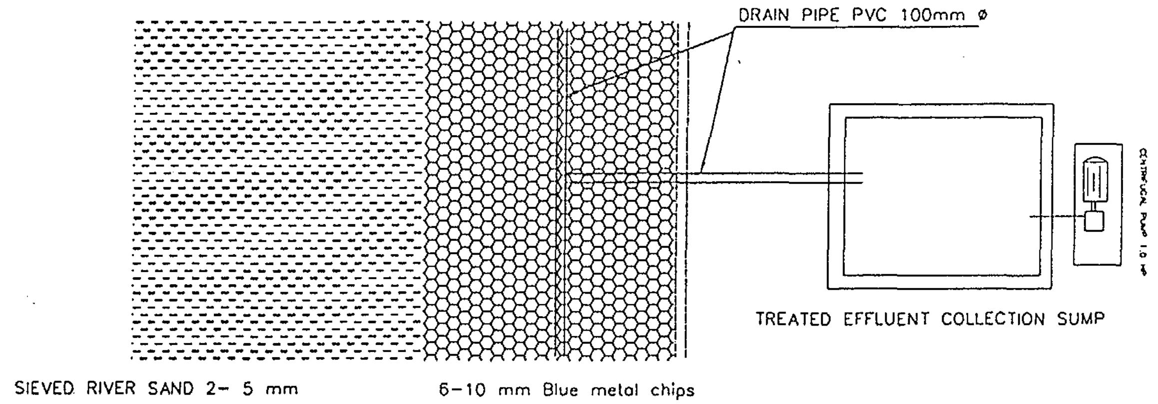
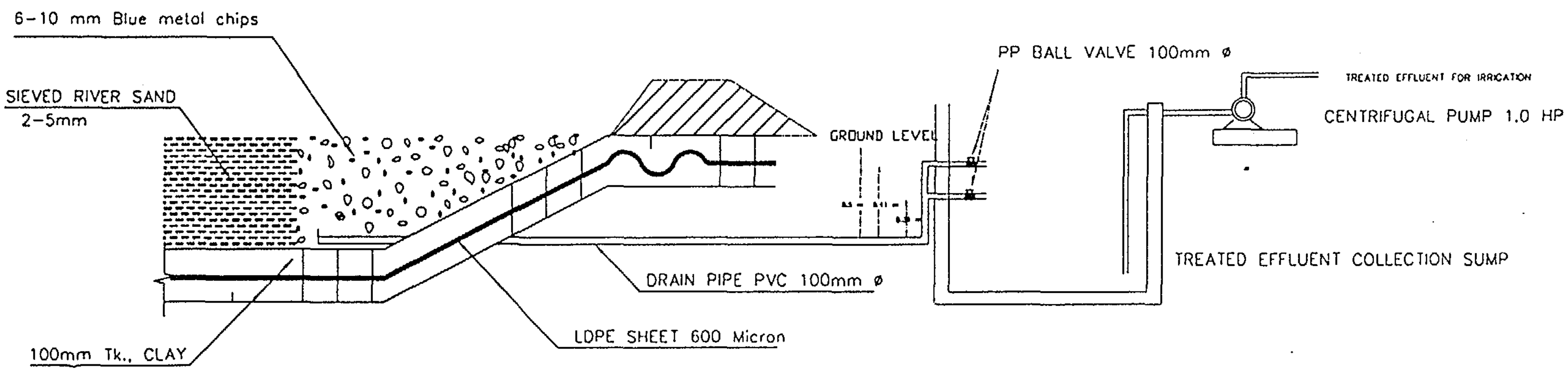


FIG 4 : DETAILS OF PERFORATIONS IN PIPES

FIG. 5 DETAILS OF TREATED EFFLUENT COLLECTION



DETAIL OF OUTLET (PLAN)



DETAIL OF OUTLET (SECTION)