COMPARISON OF DIFFERENT LINING MATERIALS FOR FIELD CHANNELS BASED ON SEEPAGE CHARACTERISTICS

By

ANNIE S S

SUKANYA S

Department of Land & Water Resources & Conservation Engineering

Kelappaji College of Agricultural Engineering & Technology

Tavanur-679573, Kerala, India

January 2014

COMPARISON OF DIFFERENT LINING MATERIALS FOR FIELD CHANNELS BASED ON SEEPAGE CHARACTERISTICS

By

ANNIE S S

SUKANYA S

PROJECT REPORT

Submitted in partial fulfilment of the

requirement for the degree

Bachelor of Technology

in

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Land & Water Resources & Conservation Engineering

Kelappaji College of Agricultural Engineering & Technology

Tavanur-679573, Kerala, India

January 2014

DECLARATION

We hereby declare that this project entitled "**COMPARISON OF DIFFERENT LINING MATERIALS FOR FIELD CHANNELS BASED ON SEEPAGE CHARACTERISTICS**" is a bonafide record of project work done by us during the course of project and the report has not previously formed the basis for the award to us for any degree, diploma, associateship, fellowship or other similar title of any other university or society.

Place: Tavanur **Annie S S**

Date: 25/01/2013 **(2010-02-005)**

Sukanya S

(2010-02-030)

CERTIFICATE

Certified that this project report entitled "**COMPARISON OF DIFFERENT LINING MATERIALS FOR FIELD CHANNELS BASED ON SEEPAGE CHARACTERISTICS**" is a record of project work done independently by Annie S S and Sukanya S under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

Priya, G. Nair

Asst. Professor

Department of Land & Water

Resources & conservation Engineering

KCAET, Tavanur

Place: Tavanur

Date: 25/01/2014

ACKNOWLEDGEMENT

We would like to express our deep sense of gratitude, utmost indebtedness and heartfelt thanks to our guide **Er. Priya, G. Nair**, Assistant professor, Department of Land and Water Resources and Conservation Engineering, KCAET Tavanur for her valuable guidance, profound suggestions, constant backing, prolific encouragement and advice throughout the project work.

We are thankful to **Dr. M. Sivaswami**, Dean, KCAET Tavanur for his support and co-operation during the course of work.

With deep respect we express our heartfelt gratitude to **Dr. Abdul Hakkim, V. M**, Head of the Department of LWRCE, KCAET Tavanur for his immense guidance and support during this work.

Words do not suffice to express our gratitude to all our classmates especially **Wilson D'souza., Harikrishnan R., Dhanasree B., Anjali V.L** and **Bhavya Francis** and and all our juniors especially **Saroop C.L., Sanal Joseph., Ajay Jayakumar** and **Arjun,P** who have helped us immensely during the period of our study and the project work for their support.

We extent our extreme gratitude to **Mr. Harris. K.** and **Mrs. Pankajam. T.** of Library for their timely help for collecting the literature for the documentation of this work.

We express our deep sense of gratitude to our loving parents and our entire friends for their stable support and inspiration throughout our study.

Above all we bow our head before The Almighty, whose blessings empowered us to complete this work successfully.

Annie S S

Sukanya S

Dedicated to

The Almighty,

Loving parents

And Teachers

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

ºC	degree Celsius
/	per
%	percentage
ASTM	American standards for testing of materials
BS	British standards
cc	cubic centimetre
cm	centimetre
cumecs	cubic meter per second
D	particle size
Dept.	department
et al.	and other people
etc	etcetera
g	gram
ha	hectare
hr	hour
IS	Indian standards
I_{avg}	average infiltration
IWASRI	International Waterlogging and Salinity Research Institute.
J.	journal
JGT	jute geotextile
K	hydraulic conductivity
KCAET	Kelappaji College of Agricultural Engineering and Technology

kg	kilogram
km	kilometer
ln	natural logarithm
log	logarithm
l/s	litres per second
lph	litres per hour
LWRCE	Land and Water Resources and Conservation Engineering
m	meter
mg	milligram
min	minutes
mm	millimeter
m^2	square meter
m/s	meter per second
Mm^2	Million square meter
Mft^2	Million square feet
N	cumulative percentage finer
No.	number
sec	second
UV	ultra violet
V	volume
W	water content

INTRODUCTION

CHAPTER I

INTRODUCTION

Water is nature's most important gift to mankind and is also the most essential. It is the critical input for the development of agriculture and for the sustenance of life. The water resources which could be tapped for irrigation are very limited and its conservation is very important. Although a substantial progress have been made in the recent yeas in the development of water resources for irrigation, a good amount of potential thus developed is lost in its conveyance towards the area to be irrigated. It is lost in the main canal, branches, distributaries, water courses and the field channels as well as in the field.

India is rich in water resources, being endowed with a network of rivers and blessed with snow cover in the Himalayan range that can meet a variety of water requirements of the country. The catchment areas of these rivers are divided into 20 river basins. Of the major rivers, the Ganga - Brahmaputra – Meghna system is the largest with catchment area of about 11 lakh sq km. The other major rivers with catchment area about one lakh sq km or more are: Indus, Godavari, Krishna, Mahanadi and Narmada. However, with the rapid increase in the population of the country and the need to meet the increasing demands of irrigation, human and industrial consumption, the available water resources in many parts of the country are getting depleted and the water quality has deteriorated. Indian rivers are polluted due to the discharge of untreated sewage and industrial effluents.

Irrigation is known to consume nearly 75% of all freshwater used by humans. Yet, the availability of exclusive irrigated area maps, which provide sub-national, national, continental, and global level statistics, are rare and inconsistent from one country or region to another. Irrigated areas are sometimes part of Land-Use/Land-Cover (LULC) maps with a single class or two. The biggest limitation of the existing irrigated area maps and statistics has been the failure to account for: (a) irrigation intensity, (b) irrigation source, (c) irrigated crop types, and (d) precise location of irrigated areas.

Irrigation intensity and irrigation crop types have a huge influence in the quantum of water consumed. The irrigation source is a must to determine patterns of resource use and environmental impacts from major versus minor irrigation, and in determining the quantum of groundwater use and its overdraft issues.

Irrigation water is expensive commodity and as such there should not be any wastage during its flow from the head end to the fields. The losses that occur from the head end of the canal up to the outlets are usually called conveyance or transmission losses. The transit losses may also occur from wastage due to irregular distribution of water on the field where by some parts are oversaturated and others are left insufficiently irrigated. However, the main transit losses are due to seepage, evaporation and percolation.

Also, the losses in a new canal are very great in initial stages. But they slowly diminish in time due to saturation of the surrounding soil and due to stanching of banks and canal section by deposition of silt from canal water. The other factors affecting the transit losses are nature of soil, its condition and size of the canal, depth of water, temperature and position of sub soil water level. A property designed water distribution system for surface irrigation is easy and efficient. Farm irrigation distribution system for surface irrigation methods can be classified into two groups-surface channels and underground pipe lines. Field channels may be either unlined earth channels or lined channels.

Earthen irrigation channels in permeable soils can lose a lot of water through seepage. Large losses through the bed and sides of canal lead to low conveyance efficiency; that is, (the ratio of water reaching farm turnouts to that released at the source of supply from a river or reservoir). Earthen canals also get clogged up with weeds which reduce the water-carrying capacity.

Two factors combine to disadvantage of the tail end farmers. Therefore unlined canals are inefficient, inadequate from the point of view of equitable performance.

Total losses from unlined watercourses are known to be more than those from the main system, but they don’t get the same attention during a lining programmed. Lining programmers are divided into main system lining and watercourse lining. The main system canals (main, distributaries, and minors) are large channels supplying several watercourses. The transmission losses are 17% for main canals and branches, 8 per cent for distributaries and 20% for water courses which gives a total loss of 45 per cent of the water entering the canal head for the unlined irrigation channels.

Unlined earth channels are frequently used in water conveyance on the farm. Through they are of low cost and can be built and maintained by unskilled persons, they cause wastage of water by evaporation and seepage.

Infiltration, seepage and redistribution of water within soil profile are of significant importance to present day water conservation and ground water contamination problems. The rates at which these processes occur depend on water transmission characteristics of the soil profile. Excessive seepage losses contribute to water logging, deterioration of agricultural land and increased drainage problems. Maintenance of unlined channels is also difficult especially in sandy soils.

Lining irrigation canal is recognized as an effective barrier to the transmission of water. Earthen channels are lined with impermeable materials to prevent excessive seepage and weeds in channels. Lining can significantly reduce conveyance losses. Lined channels have a smaller surface area for a given discharge than unlined channels. Typically a lined channel will have 40% of the unlined surface area for a given discharge. Therefore even at the same loss rate per unit area there will be a saving in water. When estimating the reduction in losses from a lining programme, this should be based on the combination of a reduced cross-section and a reduced seepage rate per unit area.

Specific objectives of this study are:

1. To study the physical properties of the soil
2. To study the seepage characteristics of different lining materials under field condition
3. To study seepage pattern for different lining materials
4. To study about the weed growth in different lining materials.

REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

An important reason for lining a canal is to reduce the water losses, as water losses in unlined irrigation canals are high. Canals that carry from 30 to 150 l/s can lose 10 to 15% of this flow by seepage and water consumption by weeds. Lining a canal will not completely eliminate these losses, but roughly 60 to 80% of the water that is lossed in unlined irrigation canals can be saved by a hard-surface lining. Possible benefits of lining a canal include water conservation, no seepage of water into adjacent land or roads, reduces the change in canal dimensions and maintenance.

2.1. Losses in Unlined Earthern Canals

Unlined earth channels are frequently used in water conveyance in the farm. The advantages of earth lined channels are that they are accepted by the farmers. They can be built and maintained by unskilled persons and require no special equipments or materials. But a large portion of water that is harvest at a high cost, through the canal irrigation network or through water courses and field channels is lost by seepage.

Sharma and Sehgal (1971) studied the assessment of seepage from unlined irrigation channels and concluded that the seepage losses were 1.8 cumec/Mm^2 against the assumed losses of 2.4 cumec/Mm^2. Percentage of water lost from main branch of canal system was found to be 19 percent as against 18 percent usually assumed. Total seepage from both sides of canal was found to be 6/5 times the maximum intensity of seepage at the bottom.

Luthra (1980) found that the conveyance losses in the unlined canals varying between 25-60 percent and the seepage losses in case of lined canal system were restricted depending on type of material used for lining.

Bihari and Patel (1986) studied the conveyance losses in earthen channel and concluded that apart from steady state seepage, there could be a significant transit loss component that is not measured in steady state measurements. These include rapidly infiltrated water to wet up dry channel banks, water seepage and leakage during the time water was being transferred from one field to another, dead storage losses resulting from water course breaches and due to growth of grasses in the channel.

Rajput and Ashwani Kumar (1988) studied conveyance losses in the field water courses. The loss from field water courses alone was measured to be about 20 percent of canal discharge.

Sur. *et.al* (1989) reported that conveyance losses and efficiency in unlined field channels in the command area of Bhavani Distributory in South Western Punjab is less. Overall losses from the studied channels were 24.2%. Conveyance efficiency decreased exponentially with increase in the length of channel. The results suggested that additional 18 minutes per hour per kilometer of channel length will be required to receive same amount of water at different field outlets along the channel.

Achanta Rao (1994) conducted experiments to find effects of seepage on inflow over a sand bed in a straight rectangular flume. Effects of both injection and suction caused by seepage flow into and out of the channel bed were studied. Quantitative relationships giving the ratio of bed shear stresses with and without seepage were presented.

2.2 Studies on seepage losses.

Determination of water lost due to seepage is an important parameter that has to be considered for lining of channels. Studies have been conducted in India in several places to determine the seepage losses. Most of the data available in water losses are from large sized canals and are very little information on water losses from small channels is available. It is however reported that a major percent of losses occur in water courses and field channels through seepage of the order of 20% and above. Average seepage losses in lined and unlined canals were 0.836 to 7.063 cumec/Mm^2 respectively. If lining is provided the seepage losses could be reduced by nearly 88.16%(Mahesh M. Karad *et al*).

Siddique et al. (1993) measured seepage losses in Chashma Right Bank Canal canal by inflow-outflow method and were reported to be 126, 121, 100, 84 and 63 mm/day during 1990, 1991 1992, 1993 and 1994 respectively for the upper reach of the canal.

Bankar *et.al* (1995) estimated seepage losses of irrigation water through minor and field channels by inflow outflow method under On Farm Water Management Studies in Mula Command during kharif, rabi and summer seasons of the year 1991 – 92 and 1992 – 93. The study revealed that by simple cleaning the sediments of field channel the seepage losses could be reduced by 40 percent over unclean channel. Due to lining of field channel the seepage losses could be further reduced by 36 to 61 percent over cleaned and unclean filed channels, respectively, During kharif season there were comparatively more seepage losses of water (21.44 1ph/m^2) than in rabi (18.79 1ph/m^2) comparison of seepage losses amongst lined. Cleaned and unclean field channels in various seasons indicated that lining of field channel resulted into minimum loss of water (11.65 lph/m^2) through seepage followed by cleaned field channel and maximum was due to unclean field channel (3024 1ph/m^2)

Dhotre *et.al* (1996) studied the field evaluation of seepage losses through field channel at College of Agricultural Engineering M.P.K.V.Rahuri. Seepage losses in lined and unlined field channels were 1.64 and 3.62 cumec / Mm^2 respectively. He also suggested that if lining was provided the losses could be reduced to 1.64 cumec / Mm^2 which is 54.70 percent less compared to unlined field channels.

Ittfaq et al. (1998) applied modeling approach to estimate seepage losses in Chashma Right Bank Canal. The losses were estimated to be 46.8 mm/day during the period of March 1995.

Basharat and Hafeez (2002) also applied MODFLOW groundwater model for seepage estimation from the most seepage prone reach of Pat Feeder canal in Balochistan province and estimated it to be 35 mm/day (1.336 cfs/msf) for a canal discharge of 142 cumecs. Groundwater level in this case was 3 meter below the canal bed

Karad *et.al*. (2013) studied on seepage losses through canals and minors and concluded that velocities of flowing water were found to be maximum in lined canal and minor as compared to unlined canal and minor and Average seepage losses in lined and unlined canal were 0.836 to 7.063

cumec/Mm2 respectively. If lining is provided the seepage losses could be reduced by nearly 88.16%.

2.3 Canal Lining

Canals are lined with impervious materials to overcome the problems of seepage through it.

Advantages of canal lining

1. Reduces seepage loss considerably thereby water can be saved
2. Stabilization of channel bed and banks thereby reduces erosion
3. Avoid piping through and under channel banks
4. Decreases hydraulic roughness (flow resistance)
5. Promote easy movement, rather than deposition, of sediments
6. Avoid water logging of adjacent land
7. Decreases maintenance costs and facilitates cleaning
8. Control of weed growth
9. Reduces movement of contaminated groundwater plumes

Nagarkar *et.al* (1979) used fly ash to supplement the fines in concrete to minimize cost of concrete lining. They found that the concrete tiles of proportion (1:3:6:9) could be manufactured satisfactorily and this concrete was economical to the extent of 25 to 30 percent.

Gwinn and Ree (1980) conducted experiments on grass lined channel and observed that the stability and capacity of channel were related to changes in cover. They conducted flow tests of channels with natural encroachment of bush and trees and found that encroachment of bush reduced the flow capacity by 29 percent.

Atre and Sarap (1988) studied seepage losses for different channel lining materials. They concluded that the velocity of flow was maximum in polyethylene channel (91.99) cm/sec) Manning’s roughness coefficient was found to be minimum in case of polyethylene channel (0.008). The seepage losses were maximum in earthen channel to the tune of 1.57 m/day and minimum in polyethylene channel as 0.014 m/day.

Nema (1988) conducted experiments to evaluate the effectiveness of different channel lining materials. Analysis revealed that by compacting the channel surface up to a bulk density of 1.9 g/cc seepage losses can be checked up to 74.89 percent as compared to that in an unlined channel. This treatment was found most economic and feasible amongst other lining material tried in the study.

Michael *et.al* (1991) investigated the feasibility of use of unconventional materials like lime, Surkhi, plaster of pairs, fly ash, cement, sand, gravel for precast channels. The study revealed that the minimum seepage of 2 lit/m^2/day was found in lime – fly ash – gravel (1:1:2) mixture and maximum seepage rate of 16 lit/m^2 day was found in case of lime – surkhi gravel (1:3:3) mixture.

Ahmad *et al* (1993) conducted studies on the performance of various lining materials. Brick lining has many site specific field problems. Local bentonites have shown rapid deterioration in the field. Soil sealants/emulsions need a lot of improvements in their sealing properties under varied local conditions. Polyethylene sheets are damaged by weed growth, and animal damage. Synthetic rubber membranes, under protective covers, gave fairly good results, except for some problems with bonding.

Ehsan *et al* (1993) conducted a study on recent experience of lining on small channels in Punjab province. Lining has been done with concrete, stone masonry or brick masonry giving channels rectangular or brick masonry giving channels rectangular or trapezoidal in cross section. Experiences gained in the irrigation systems rehabilitation project of the Pakistan Punjab indicate that these channel lining are giving satisfactory hydraulic performance and are contributing towards giving water supplies to farmers.

Biswas (1997) studied on the application of low cost non-conventional lining materials for seepage control in small irrigation channels and concluded that the precast bamboo-reinforced concrete slabs of breadths 40 cm, 30 cm and 20 cm and the thickness 5 cm, 5 cm or 4 cm and 4 cm or 3 cm reduced the water losses by 91.68, 93.45 and 87.93%, respectively.

Hojyaz *et.al.* (2013) studied on canal lining to increase water use efficiency and remediate groundwater levels in Khorezm Uzbekistan and found that on a monthly basis, the largest increase from 47 to 91% (control to lined section) took place during June. The unlined, control section lost almost three times the amount of flow as compared with the lined plastic section of canal.

2.4 Lining materials

2.4.1 Concrete

During the past several years it has become popular to install concrete linings in small canals at the same time as final excavation and finishing, often using a laser to control the alignment and longitudinal slope. Small concrete-lined canals are usually non-reinforced Steel reinforcement (rebar or steel mesh) is also not commonly used on large canals anymore unless there are compelling structural reasons The elimination of steel reinforcement from concrete canal linings saves about 10 to 15% of the total cost. the concrete was popular material for canal lining as excellent hydraulic properties were attained by its use (Varshney et al). by lining the unlined channels with concrete 50 percent of the present losses can be saved (Yazdani et.al).

Laliberte *et al*. (1967) studied on Seepage control in concrete-lined irrigation ditches. They found seepage loss from and irrigation ditch was reduced by more than 90% by installing an unreinforced concrete lining with a subgrade-guided slip form. After 3 years of service the seepage reduction was still greater than 70%.

Worsteel (1969)conducted the tests on various lining materials to study the seepage losses and found the range of seepage losses through different lining materials as Concrete (0.009 to 0.29) m/day), compacted earth (0.003 to 0.29 m/day), Asphalt membrance (0.003 to 0.92 m/day.), Soil cement (100 : 5) (0.009 to 0.06 m/day.), Chemical Sealant (0.1 to 2.53 m/day), Sediment Seal (0.12 to 0.40 m/day), Unlined (0.003 to 5.37 m/day)

Kemper *et al*. (2005) studied on Reducing Water Losses from Channels Using Linings. To evaluate the effectiveness of various types of linings in reducing the seepage losses from field channels, 10 conventional and 12 low cost test sections were constructed. The conventional test sections included six rectangular brick masonry sections and four trapezoidal concrete sections with varying thickness of walls and bed lining materials. The low cost sections consisted of six rectangular brick masonry sections and six trapezoidal sections with brick masonry, pre-cast concrete slab and tile lining having different thickness of wall and bed linings. Economic analyses showed that low cost linings were a better investment than the conventional linings. Low cost lining with 11 cm thick brick masonry in vertical walls, or 2:1 sloped walls, plastered on the inside, without lining in the bed, is recommended. Lining walls, with 2:1 slope, using fired tile or pre cast concrete slabs were also good investments when the joints were plastered.

Meijer *et al*. (2006) studied on impacts of concrete lining of irrigation canals on availability of water for domestic use in southern Sri Lanka. From the measurements it was determined that canal seepage provides an important contribution to groundwater recharge. It was estimated that after concrete lining the annual groundwater recharge in the irrigated areas will be reduced by approximately 50%. This saves a substantial amount of water that can be used to extend the irrigation area so more people can benefit from the available irrigation water.

Abu-Khashaba (2013) studied on innovating impermeable concrete appropriate for canal lining using a specific mixing ratio and applying it to a pilot reach. This research was initiated with the objective of innovating impermeable concrete appropriate for canal lining (i.e. to improve their function, as they lose water through evaporation, seepage and leakage) using a specific mixing ratio. The results proved that the permeability/microstructure of EN-1 mixes (i.e. consisting of mortar, limestone powder and a chemical engineering admixture "EN-1 RBS", mainly defined as a permeability reducing admixture), as well as its long-term performance, was satisfactorily improved.

2.4.2 Coir Geo-textiles

Geo-textiles are natural or synthetic fibres used for covering the earth. The fibres are woven or non-woven in the form of matt with standard weaving procedure, some are also knit. They are porous and can allow filtration of specific size particles only through them and are also porous to allow water to flow within their plane. Coir geotextiles can be used either as an overlay or an interlay – the former protecting the surface from run-off and the latter performing the functions of separation, filtration and drainage.

Cammack (1988) reported the use of coir geotextiles in Noora basin in Australia, for causeway protection to prevent wave-lap erosion in saline water condition. He also reported that the accuracy of Coir geotextiles, with a density of 500g/m^2, in reducing the water velocity and soil loss was reported to be 77% and 98.4% respectively relative to bare soil conditions.

Sotir and Simms (1991) illustrated case studies of river bank stabilisation using coir geotextiles in USA. In Longfellow Creek Bypass Channel, Coir geotextiles with selected plants were used to stabilise trapezoidal channel slopes. Results show that use of coir geotextiles in and along streams and river bank protection, and for the establishment of healthy riparian zones for aquatic enhancement appears to be a viable alternative.

White *et al*. (1991) reported various control techniques adopted by Illinois department of conservation for the control of stream bank erosion of the Crow Creek. He reveals that coir geotextiles were found to be the most effective and environmentally sound biotechnical application to effectively enhance our environment.

Schurholz (1992) reported the durability of coir geotextile. According to him the coir geotextile retained 20 % of their original tensile strength after one year in incubator test with high fertile soil. He further observed that when natural fabrics kept wet for 167 days with conditions to simulate the traction effect while flooding, coir had almost no damage.

Schurholz *et al.* (1992) illustrated various field trials using coir geotextiles in Germany. It includes stabilisation of a creek bed and its bank using woven geotextiles, river bank stabilisation and re-vegetation of shore lines by sedimentation.

Theisen (1992) studied and concluded that the use of geosynthetic erosion and sediment materials continues to expand at a rapid pace. Geosynthetic components are an integral part of erosion and sediment materials ranging from temporary products such as hydraulic mulch geofibers, plastic erosion control meshes and nettings, erosion control blankets and silt fences to high performance turf reinforcement mats, geocellular confinement systems, erosion control geotextiles and fabric formed revetments.

Sudhakaran (1994) shown that coir geotextiles are effective in riverbank protection and also that it is economical in its use with 50% reduction in cost compared to the conventional gravel lining process.

Ogbobe *et al.(*1998) studies the effectiveness of geotextiles in decreasing soil erosion which depended mainly on several properties, such as percentage of open area, mass per unit area, thickness, tensile strength, mass of geotextiles per unit area when wet, design and drapability. It was also suggested that the use of geotextile mats on bare soil significantly reduced soil splash height by 51% and splash erosion by 90%.

Babu *et al*. (1999) had reported the results of exhaustive study carried out to explore the behaviour of coir geotextile reinforced subgrade soils in terms of California Bearing Ratio. From the studies, it is clear that the presence of coir geotextiles influences the strength of subgrade due to the interaction between soil and coir geotextile in soaked and unsoaked condition.

Swihart and Haynes. (2002) studies and reported that all geomembrane materials, like HDPE, Linear low density polyethylene (LLDPE), Polyvinylchloride (PVC), Flexible polypropylene (fPP), Chlorosulphonated polyethylene(CSPE), Ethylene-propylene diene monomer (EPDM), bituminous geomembrane (BGM)), and Polyurea (PU), are effective in reducing water seepage/ leakage and allow increased flow rates. However, in practice, they may not be totally leak-tight. They differ in their abilities to lay and remain flat as temperatures change, in their abilities to conform to rough sub grades and differential settlement without impacting durability, in their tolerance of installation damage, UV radiation and oxidation, and in their abilities to be easily installed and repaired

Venkatappa and Dutta (2005) conducted monotonic and cyclic load test on Kaolinite sand bed with geotextile placed at the interface of the two soils. It was found bearing pressure of the soil improved by about 33% when reinforced with coir geotextiles.

Shaheem S and Tomy Cyriac (2013) studied on performance evaluation of coir geo-textiles as earth reinforcement in soil structures and found that Coir Geotextiles offer a major solution for subgrade improvement and soil structure protection. Based on the performance evaluation studies conducted on coir geotextiles laid reinforced roads, it is found that H2M5 grade (700g/m2) laid reinforced roads perform better than H2M6 grade (400g/m2) coir geotextiles. The study conducted using coir geotextiles for embankment protection shows that the coir geotextile laid embankments perform very good in terms of functional and structural evaluation.

2.4.3 Jute Geotextiles

Use of jute geotextile is the emergent technology in the field of geotechnical engineering. Jute geotextile is manufactured from raw jute fibres in the jute mills. Cellulose, hemicelluloses, alpha cellulose, lignin are the main components of the jute fibers. Environment sustainability is the most important issue in the modern development strategy. In case of jute geotextile it is needless to say that it is environment friendly. So selection of jute geotextile to improve the soil for any project in geotechnical engineering is also beneficial to environment.

Thomson & Ingold, (1986) studied on synthetic and jute geotextile on erosion control and concluded that JGT reduced erosion with lower rainfall intensity to 9% and 27% than that of an unprotected soil for initially dry and wet soil conditions respectively and tha comparable figures for Enviromat were 6% and 25%.

Fifield *et al* (1988) reported a yield factor (ratio of soil loss from soil covered by an erosion control system to soil loss from bare soil) of as high as 0.3, whereas after about one year with the establishment of good grass cover a value of 0.01 was recommended.

Parikh and Shroff (1989) studied on grouted geosynthetic mattresses have been used as canal lining under flowing water conditions to prevent erosion of the canal bed in the Kakrapar canals in Gujarat. Mattresses were laid in lengths of 15 cm in the canal bed as well as on the side slopes and then filled with a cement-sand slurry and found that it is effective.

Ramaswamy and Aziz (1989) have conducted some studies on jute geotextiles and their applications. The laboratory test results conclusively showed that the stress- strength characteristics of the soil are better with the jute fabric than without it. The study also showed the beneficial effects of natural jute geotextiles for subgrade stabilisation.

Ingold and Thomson (1990) carried out studies which indicates that JGT installed in sandy loam soil on 1:2 slope reduced the soil loss to about 1.3 g/mm compared to 8.8 g/mm from control.

Ingold *et al*. (1990) studied on the performance of Jute geotextile in surficial erosion control and found that Jute and enviromat are very effective in reducing erosion for the soil tested. The entire product reduced erosion at the higher intensity rainfall where jute proved to be the most effective. At lower intensity rainfall jute and enviromat gave similar performances, although the jute tended to become more effective with time throughout the tests.

Sanyal *et al*. (1992) studied on control of bank erosion naturally- a pilot project in Nayachara island (West Bengal) - in the river Hugli and they concluded that the undisturbed bank even after 11 years of study JGT performed its designated functions as river bank protection and helped in natural consolidation of the bank soil and durability of JGT beyond 1½ years, even under continuing adverse conditions, proved to be redundant due to catalytic function of JGT.

Choudhury *et al.* (2008) studied on lining of open channel with jute geotextile and its performance in seepage control and concluded that Jute non-woven geo-textile of 250 g/m² and 300 g/m² fabric weight were coated with polyethylene sheet on one side and both sides and were experimented to assess the seepage loss through open channels. 300 g/m² fabric with both sides coated controlled seepage most efficiently. Single side coated sheets also performed well in seepage control, but allowed more water to seep compared to double side coated sheets. However, 250 g/m² fabric with both sides laminated yielded optimum performance.

Ganguly *et.al.* (2008) studied on Lining of open channel with jute geo-textile and its performance in seepage control, and found that jute non-woven geo-textile of 300g/m^2 fabric with both side coated with polyethylene sheet controlled seepage most efficiently.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

A field study was conducted to compare different lining materials based on seepage characteristics. Various methods and techniques used in the data generation and validation are described in this chapter.

3.1. Description of study area

3.1.1 Location of the study

Field experiment were conducted in the farm of KCAET campus, Tavanur, at 10° 52' 09.97" North Latitude and 75° 58' 34.20" East Longitude. The total area of the KCAET is 40.99ha, out of which total cropped area is 29.65ha. Agronomicaly the area falls within the border line of Northern Zone and Central Zone of Kerala. The major part the rainfall received in this region is from South West monsoon. The average rainfall of the region varies from 2500 to 2900mm. The soil type of study area is sandy loam. The area is under cultivation for more than 30 years.

3.1.2 Climate

Agro-climatically the area falls within the border line of northern zone, central zone and kole lands of Kerala. The average annual rainfall received in the area is about 2900 mm and has a humid climate. Medium to high rainfall zones are available within 10-15 km of the area. The area receives the rainfall mainly from south-west monsoon and north-east monsoon. The average maximum temperature of the study area was 31 °C and the average minimum temperature was 26 °C.

Table 1: Climatological data of experimental area

Mean Maximum temperature	31ºC
Mean Minimum temperature	22.4ºC
Average Relative humidity	85%
Average annual rainfall	2900mm
Pan evaporation	7mm/day
Mean solar radiation	87w/m^2/day
Number of rainy days	125

3.2. Soil properties

3.2.1 Specific gravity

Specific gravity of soil was determined by pycnometer method. Pycnometer of about 900 ml capacity, with a conical brass cap screwed at its top was used. The mass of empty dry pycnometer with brass cap and washer (M_1) was first taken. A sample of oven dried soil, cooled in desiccators, put in the pycnometer and the mass M_2 was taken. The pycnometer was then filled with distilled water gradually and stirred well with glass rod. The mass M_3 of the pycnometer, soil, and water (full up to the top) was taken. Finally, the pycnometer was emptied completely and thoroughly washed, and clean water was filled to the top, and the mass M_4 was taken. Based on these four observations, the specific gravity can be computed as:

$$G= \frac{M_2-M_1}{(M_4-M_1)-(M_3-M_2)}$$

Where

G = Specific gravity

M_1 = Mass of dry pycnometer with brass cap and washer (g)

M_2 = Mass of dry pycnometer with dry soil (g)

M_3 = Mass of dry pycnometer with soil and water filler up to the top (g)

M_4 = Mass of pycnometer and clear water filled up to the top (g)

3.2.2 Particle size distribution

The percentage of various sizes of particles in the dry soil sample was found by particle size analysis or mechanical analysis. Mechanical analysis was meant for the separation of soil into its different size fractions. The IS sieves selected where 4.75, 2, 1, 0.60, 0.425, 0.3, 0.212, 0.150, 0.075 mm.

Sieve analysis

In the BS and ASTM standards, the sieve sizes are given in terms of the number of openings per inch. The number openings per square inch are equal to the square of the number of sieve. The sieves used for fine sieve analysis are: 2.0 mm, 1.0 mm, 600 µm, 425 µm, 300 µm, 212 µm, 150 µm, & 75 µm IS sieves. For this purpose about 1 kg of soil was collected from site after removing a top layer of 5 cm depth. The oven dried soil of about 500 g soil was taken for analysis each time.

Sieving was performed by arranging the various sieves one over the other in the order of their mesh openings-the largest aperture sieve being kept at the top and the smallest aperture sieve being kept at the bottom. A receiver was kept at the bottom and a cover was kept at the top of the whole assembly. The weighed oven dried soil sample was put on the top sieve, and whole assembly was fitted on a sieve shaking machine the amount of shaking depends upon the shape and the number of particles. At least 10 minutes of shaking was done for soils with small particles. The portion of the soil sample retained on each sieve was weighed. The percentage of soil sample retained on each sieve was calculated on the basis of the total mass of the soil sample taken and from these results percentage passing through each sieve was calculated.

Particle size distribution curve

The results of the mechanical analysis are plotted to get a particle size distribution curve with the percentage finer (N) as the ordinate and the particle diameter as the abscissa, the diameter being plotted on a logarithmic scale.

3.2.3 Moisture content

The moist sample was kept in clean container. The mass of the soil and container with lid was determined. With the lid removed, the container was then placed in the oven and maintains the temperature of the oven between 105°C - 110 °C for about 16-24 hours. After drying the container was taken from oven and allows for cooling. The lid was then removed and the mass of the container and dry soil was found. The water content was calculated by the following equation:

$$W = \frac{M_2 - M_3}{M_3 - M_1}$$

Where,

M_1 = mass of container with lid, g

M_2 = mass of container with lid and wet soil, g

M_3 = mass of container with lid and dry soil, g

3.2.4 Saturated hydraulic conductivity

Soil sample were collected using cylindrical core. Then, the sample was kept for saturation. After saturation it was placed in the permeameter mould assembly in the bottom tank and the bottom tank was filled with water up to its outlet. The water inlet nozzle of the mould was connected to the stand pipe filled with water. Water supply was given to the constant head permeameter. The soil column length (L); the head of the water over the soil column, h (cm) etc were noted. A measuring cylinder was placed below the soil column to collect discharge. The water was allowed to infiltrate and discharge was measured once in 5 minutes and the process was repeated till the consecutive values were reached.

Saturated hydraulic conductivity was calculated by using the Darcy's law

$$K_S = \frac{Q}{t} \times \frac{L}{h} \times \frac{1}{A}$$

Where,

Q = Quantity of flow (cm^3/sec)

t = Time interval (s)

L = Length of sample (m),

h = Hydraulic head (cm)

A = Cross sectional area of the sample (m^2)

The mean value of K_s was found out.

3.2.5 Infiltration

Infiltrometer is the device used to measure the rate of water infiltration into soil or other porous media. Commonly used infiltrometer are single ring or double ring infiltrometer and disc permeameter.

In this study infiltration rate was studied using double ring infiltrometer. The experimental set up used in infiltration measurement is illustrated in plate 10. 25cm deep cylinders of diameter 30cm and 20cm were used for experiment. The cylinders were installed about 10cm deep in the soil. The cylinders were driven into the ground by a falling weight type hammer. Then water was added to both cylinders. The water level in the inner cylinder was read with steel rile placed in the inner cylinders. A stop watch started at the instant of the addition of water begins. The total quantity of water added to the inner cylinder was determined by counting the number of full containers of water and the fractional volume in the jar, which was added last. The difference between the quantity of water added and the volume of water in the cylinder at the instant it reach the desired point was taken as the quantity of water that infiltrates during the time interval between the start of filling and the first measurement. After the initial reading the water level measurements were made at frequent intervals to determine the amount of water that has infiltrated during the time interval. Water was added quickly after each measurement so that a constant average infiltration head could be maintained. The buffer pond was filled with water immediately after filling the inner cylinder to have an equal water level. The experiment was followed till considerable readings were obtained. Then the readings (water level) at regular intervals were taken and tabulated and infiltration rate was determined.

Using the data an equation of following form was developed to find functional relationship

$$Y = at^{\alpha} + b$$

Where:

Y= accumulated infiltration (cm)

t= elapsed time (min)

a, b, α= constant

3.3 Properties of lining materials

3.3.1 Bulk density

A 50×30cm material was taken and the weight and thickness was measured using weighing balance and metallic scale. The volume was calculated.

$$\text{Bulk density} = \frac{Weight\ (kg)}{Length \times Width \times Thickness\ (cm^3)}$$

3.4 Experimental details

A field experiment was conducted to find out which low cost lining material possesses good lining quality. The experiment was conducted at the instructional farm, KCAET, Tavanur. The size of the experimental field was 30×12m . The layout of the experiment field is shown in Fig.1

3.4.1 Field preparation

The field was levelled first. After levelling, four trapezoidal channels having the dimensions length 8m, top width of 2.2m, Bottom width of 0.8m, Height of 0.7m side slope of 1:½ and bed slope of 1:1000 was prepared in the field with a minimum spacing of 4m between the channels. The cross-sectional view of one channel is shown in Fig.2. After the construction of four channels, the lining materials such as coir geo-textile, gunny cloth and plastic sheet material made from plastic sack were laid. The plastic sheet material was fixed to the channel with metallic pegs. The two ends of the channels were blocked with impervious material. The experimental set up of different channels before ponding is shown in Plate 1 to 4. The experiment was conducted during the months of September 2013 to January 2014

3.4.2 Experimental layout

The statistical design was a randomised block design with five replications. Three different lining materials were used. The treatments are as follows:

T1- Channel with coir geo-textile as lining material

T2- Channel with gunny cloth as lining material

T3- Channel with plastic sheet material as lining material

T4- Channel without any lining material (control)

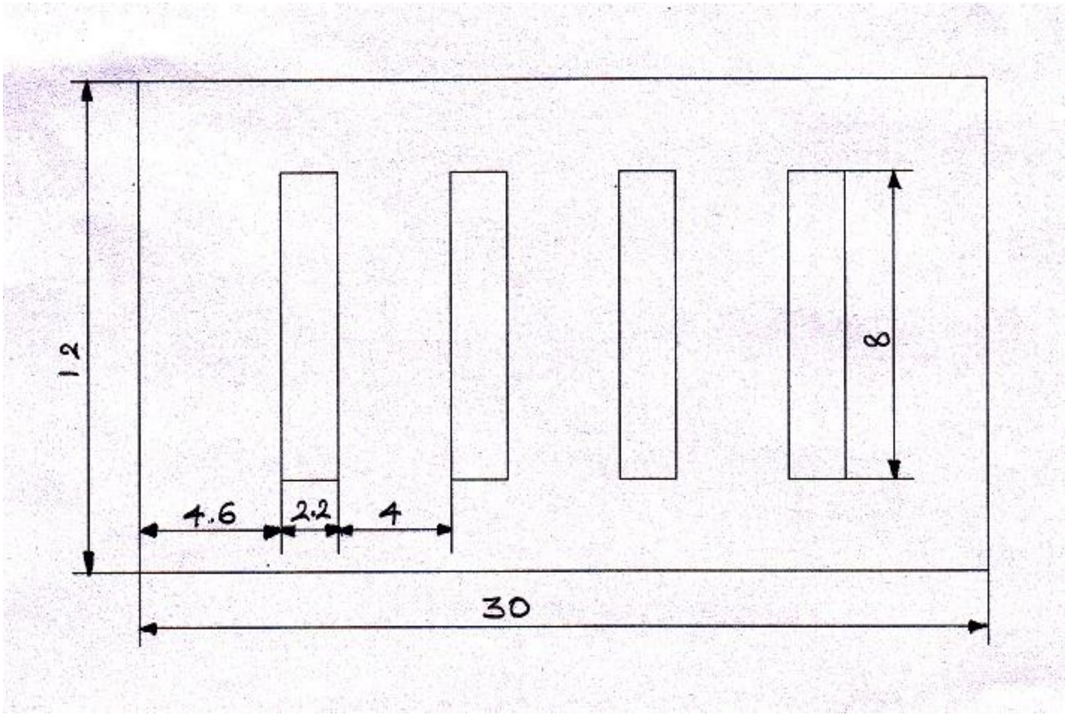


Fig 1: Layout of the experimental plot

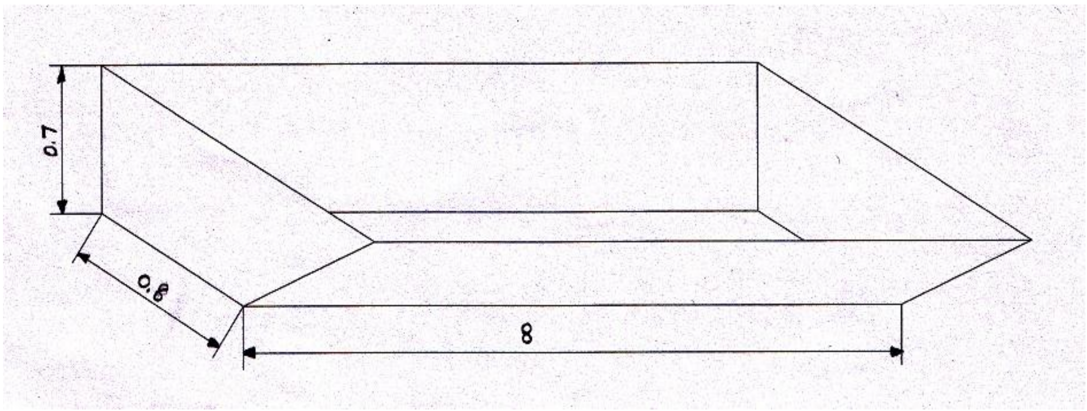


Fig 2: Cross section of single channel

All dimensions are in metres.

Plate 1: Coir Geo-textile lined channel before ponding

Plate 2: Gunny cloth lined channel before ponding

Plate 3: Plastic sheet material lined channel before ponding

Plate 4: Control channel before ponding

3.4.3 Seepage rate

The seepage through different lining material was found out by filling the channel up to a height of 30cm from the bottom and the depth of water at different time intervals i.e., 0, 15, 45, 90, 150, 225, 315, 420, 540 minutes were taken from the four channels using metallic ruler. Readings were taken from 1m and 7m from the upstream side. And the average was taken for calculations. The view of the field channels at the time of ponding is shown in Plate 5 to 8. With this, the depth of water lost due to seepage was found out and with that the volume of water lost was calculated. Depth of water lost due to seepage at any interval is found out by,

$$Y = Y_1 - Y_2$$

Where,

Y = Difference in depth (cm)

Y_1 = Initial depth (cm)

Y_2 = Final depth (cm)

$$\text{Seepage rate} = Y/t$$

Where t = time in hrs

3.4.4 Soil moisture distribution pattern

The moisture lost due to seepage was determined by measuring the moisture content in horizontal distance and at several depths within the sides of each channel. From the moisture content data obtained, soil moisture distribution due to seepage was obtained. This provides a basis for deciding the suitable lining material.

Soil moisture content was taken before and after the experiment. The observation was taken at 20, 40, and 60cm horizontal distance from the edge of the channel. The measurements were taken at different depths of 20, 30, and 60cm from each horizontal distance in every treatment before and after the experiment. The soil moisture measurements were done by gravimetric method since it is most accurate

Plate 5: Coir Geo-textile lined channel at the time of ponding

Plate 6: Gunny cloth lined channel at the time of ponding

Plate 7: Plastic sheet lined channel at the time of ponding

Plate 8: Control channel at the time of ponding

one. Soil samples were taken from different depths and horizontal distances using spade and tube type soil augers. After taking the soil samples, they were kept in moisture boxes and covered immediately with lids. The samples are weighed along with the moisture box (W_2) and placed in the oven at 105ºC for 24 hours until the moisture was driven off. It was weighed again and the weight (W_3) was noted. Soil moisture content is expressed as percentage dry basis.

Moisture content was calculated using the formula:

$$\text{Moisture Content (\%)} = \frac{(W2-W3)\times 100}{(W3-W1)}$$

Where,

W_1 = Weight of empty container (g)

W_2 = Weight of container and moist soil (g)

W_3 = Weight of container and dry soil (g)

Soil moisture distribution pattern was drawn by noting the moisture content values in horizontal and vertical distance from the channel before and after the experiment by using software.

3.6 Weed Count

As the channels are constructed in farming land, there are possibility for the growth of weeds in the channel bed and sides. Since the weeds grown in the channels will reduce the velocity of flow, it should be considered. The weed count is taken three months after the channels are formed.

The weed count was determined by using a 10×10cm square. The square was placed on four places in the channel randomly and the number of weeds inside the square was counted.

3.7 Analysis of the data observed

Statistical analysis of the data obtained was done using RBD analysis in the computer package. Analysis of variance was done to find out the significant difference in the treatments. The level of significance used was 5%. Critical differences in treatments were also calculated for all the treatment means. The result is presented in the next chapter.

3.8. Cost of different lining materials

The costs of each lining material are collected from the market to compare the total costs.

RESULT AND DISCUSSION

CHAPTER IV

RESULT AND DISCUSSION

The study was conducted to compare different lining materials on the basis of their seepage characteristics. The soil characteristics as specific gravity, moisture content, infiltration and permeability were studied. The seepage characteristics were studied by ponding method and analyzed the flow net pattern for each lining material.

The results obtained from this study were analyzed to provide better lining material which is locally available and cheap. The results of the study were described in this chapter.

4.1 Soil Properties

4.1.1 Specific Gravity

Specific gravity of the field sample is determined using pycnometer method and the experimental data is given in APPENDIX I. The result shows that the specific gravity of the experimental plot soil was 2.4.

4.1.2. Evaluation of soil Physical Properties

The result of the mechanical analysis is plotted to get particle size distribution curve. In this curve percentage finer 'N' is taken as ordinate and particle diameter (mm) as the abscissa on logarithmic scale. The resulting curve is shown in Fig 3. The figure showed that the soil sample consisted of 60.86% sand having size ranging from 2 to 0.05mm, 36.82% silt (0.05 to 0.002mm) and the remaining part 1.59% clay. As per the USDA classification chart, the textural class of the soil was found to be sandy loam. The result of soil textural analysis is shown in APPENDIX II.

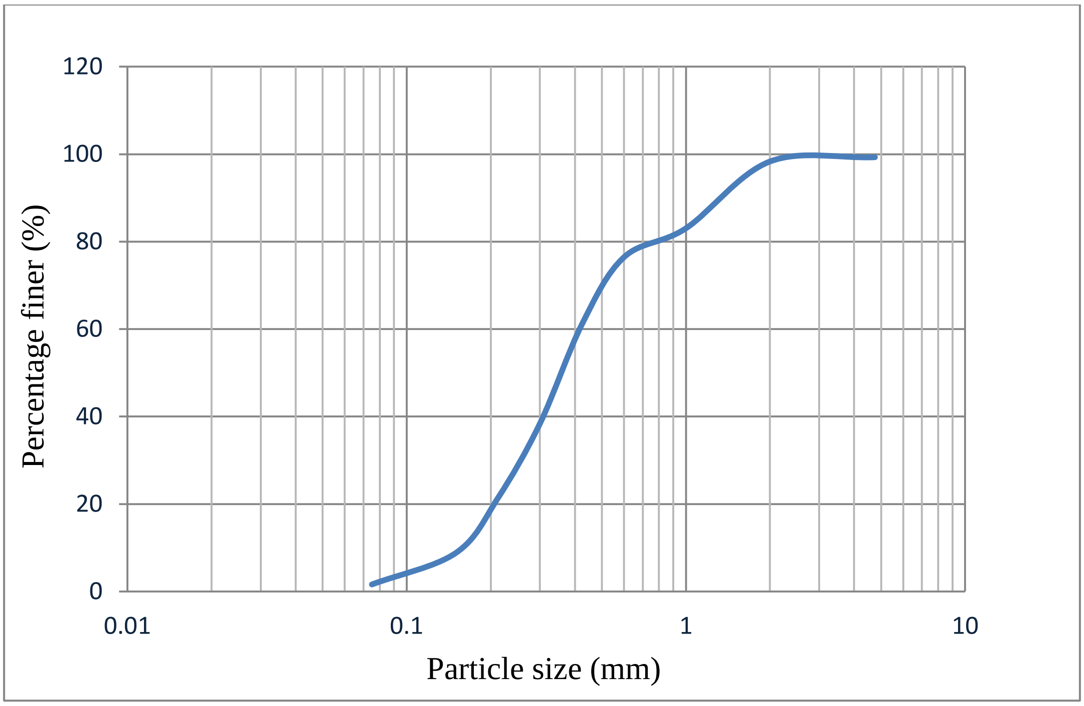


Fig 3. Particle size distribution curve

4.1.3. Moisture Content

The moisture content from the experimental plot was found by gravimetric method. Table 2 shows the moisture content of the experimental field before starting the experiment. The samples were collected randomly from 3 different places and the field data on moisture content determination is given in APPENDIX III.

Table 2: Moisture content of the soil in the experimental plot

Can No.	**Weight of wet soil (g)**	**Weight of dry soil (g)**	**Moisture content (%)**
1	41.5	36	15.71
2	46	40.5	14.29
3	59	50	19.15

The average moisture content in the experimental field was found as 15.62 %

4.1.4. Saturated Hydraulic conductivity

Quantity of flow was obtained at a particular time interval of 5 minutes. The experimental values are given in APPENDIX IV. The hydraulic conductivity was calculated using Darcy's law.

Average saturated hydraulic conductivity of the soil was 1.517×10^{-3} cm/sec

4.1.5. Infiltration rate

Cylinder infiltrometer test was conducted in the field to determine the infiltration rate of the soil.

The variation of average infiltration rate with elapsed time is shown in Fig 4. The curve indicates that the infiltration rate decreases with increase in the elapsed time and finally reaches a constant value. This value termed as infiltration capacity or basic infiltration rate of the soil. As water moves through deeper layer, hydraulic gradient decreases and thereby infiltration rate also decreases. The functional relationship between accumulated infiltration (Y) and elapsed time (t) is represented by the empirical equation

$Y = at^{\alpha} + b$ where

a, α, b are constants.

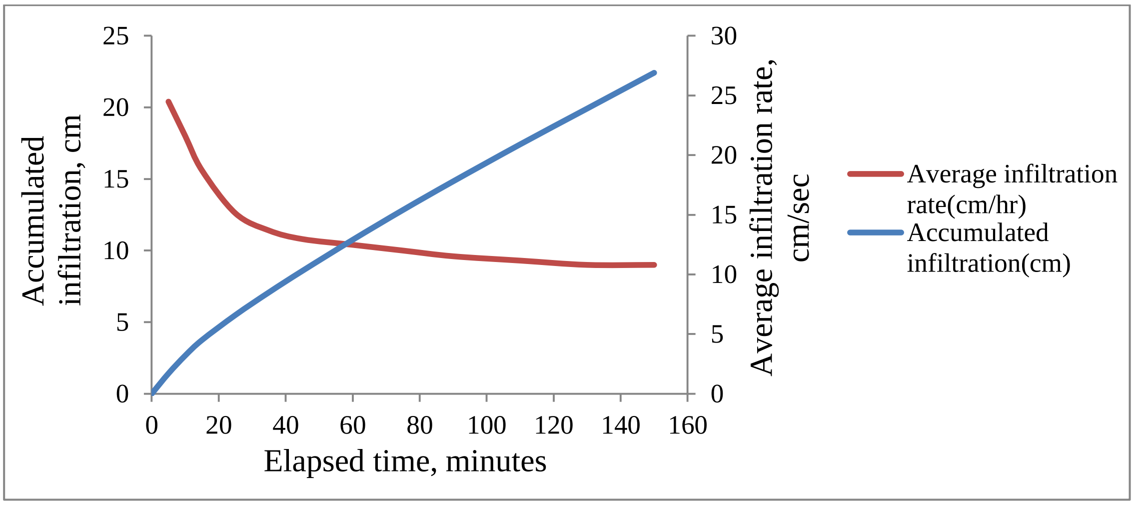


Fig 4: Variation of accumulated infiltration and average infiltration rate with elapsed time

From the observations obtained in this test the value of a, α and b are determined by the method of averages and is shown in APPENDIX V. The functional relationship connecting the infiltration rate and time is given by

$$Y= 0.49\ t^{0.8} + 0.077$$

The basic infiltration rate for sandy loam soil ranges between 6.5 to 12.5 cm/h. The average basic infiltration rate obtained for the soil, i.e., 9 cm/h is within this range.

4.2 Properties of lining materials

4.2.1 Bulk density

Bulk density of Coir geo-textile = 0.2 g/cc

Bulk density of gunny cloth = 0.23 g/cc

Bulk density of plastic sheet = 0.18 g/cc

4.3 Seepage rate

Determination of seepage rate was done. The average evaporation rate from the experimental area was 7mm/day. As this value is very small, it is not considered for the calculation of the actual seepage rate. The curves showing the variation of seepage rate with elapsed time for different lining materials lined channels and also for the channel without any lining material (control) are shown in Fig 5 to 8. Ponding was done in the channel up to a height of 30 cm. Fig. 5 shows that in coir geo-textile laid channel (T1), after 15 minutes, the average seepage rate observed was 9.04cm/hr. After 225 minutes and 420 minutes, it was 3.12 cm/hr and 2.35cm/hr. In T2, gunny cloth lined channel, initially it was 12.44cm/hr and after 225 min and 420 min it was 2.846and1.99 cm/hr. The channel lined with plastic sheet material (T3), it was 12.8, 3.03and 1.94cm/hr. In case of channel without lining material (T4) it was18.64, 3.608 and 1.308 cm/hr. In all cases, initially the seepage rate was maximum. After 15 minutes, the maximum rate was observed in channel without lining. The least was observed in coir geo-textile. Fig. shows that in between 15 and 225 minutes (i.e., for 45, 90 and 150 minutes), there is a notable variation in seepage rate in all cases, and in case of coir geo-textile (T1) it was less compared to other treatments and gunny cloth and plastic sheet material (T2 and T3) shows almost same trend and control (T4) shows maximum variation. After 225 minutes also, maximum seepage rate was observed in control. There is no significant difference in seepage rate between coir geo-textile, gunny cloth and plastic sheet material. After 420 minutes also, there is no significant difference in seepage rate between coir geo-textile (1.5cm/hr), gunny cloth (1 cm/hr) and plastic sheet material (0.75 cm/hr). After 420 minutes also, some water is available in coir geo-textile lined channel. The least was observed in control. The statistical analysis was done by using ANOVA and is shown in Table 3 to 5. It shows that there is no significant difference between replications 15 minutes after ponding but significant difference was observed among treatments with 5% significance level. After 225 minutes, analysis shows that there was no significant difference in both treatments and replications (Table 4) with 5 % significance level. After 420 minutes also, there was no significant difference among treatments with 5 % significance level (Table 5). As the time passes the seepage rate reduces and becomes zero as the depth of water becomes zero.

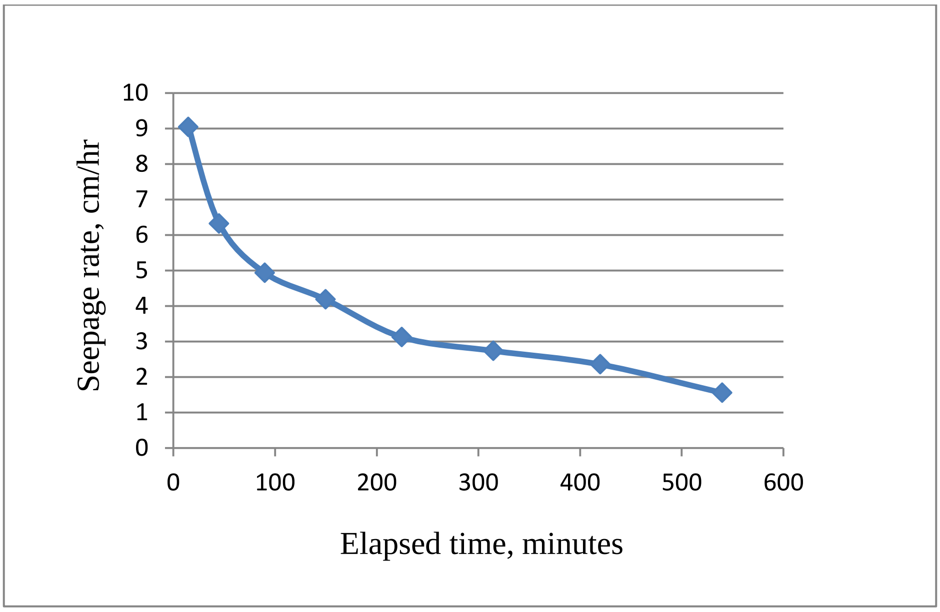


Fig 5: Variation of seepage rate with elapsed time for coir geo-textile lined channel

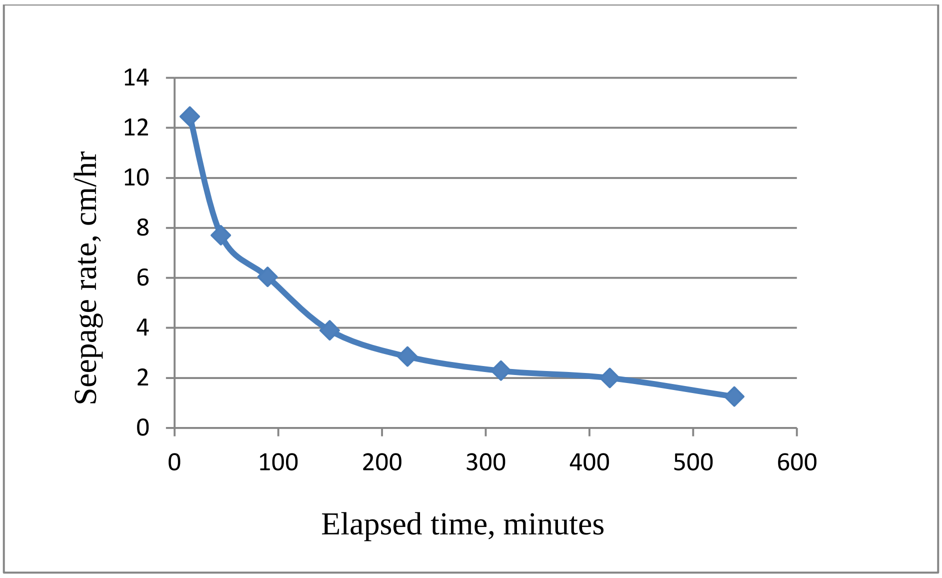


Fig 6: Variation of seepage rate with elapsed time for gunny cloth lined channel

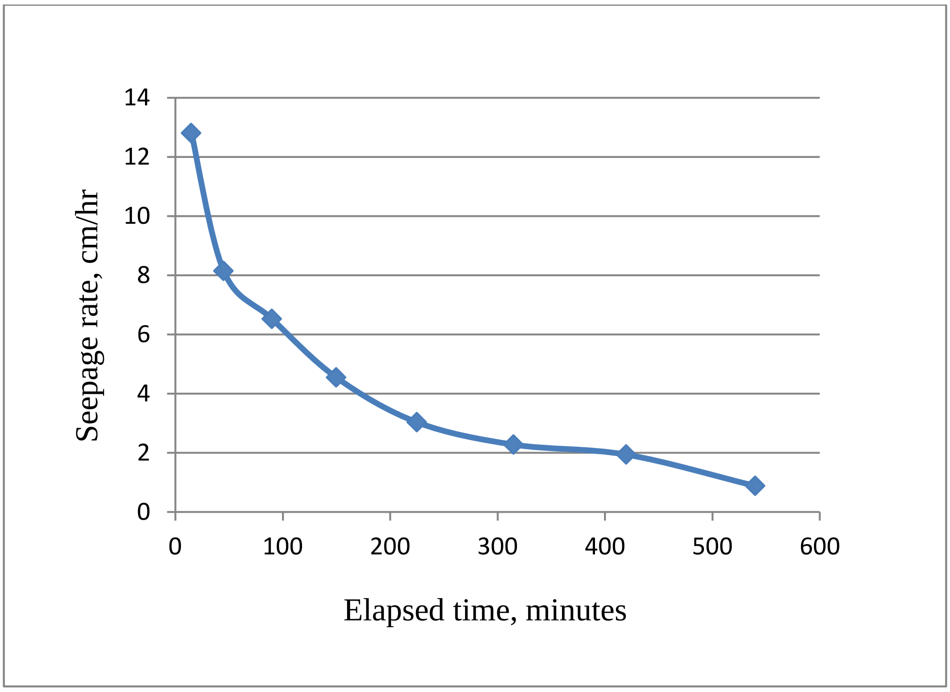


Fig 7: Variation of seepage rate with elapsed time for plastic sheet material lined channel

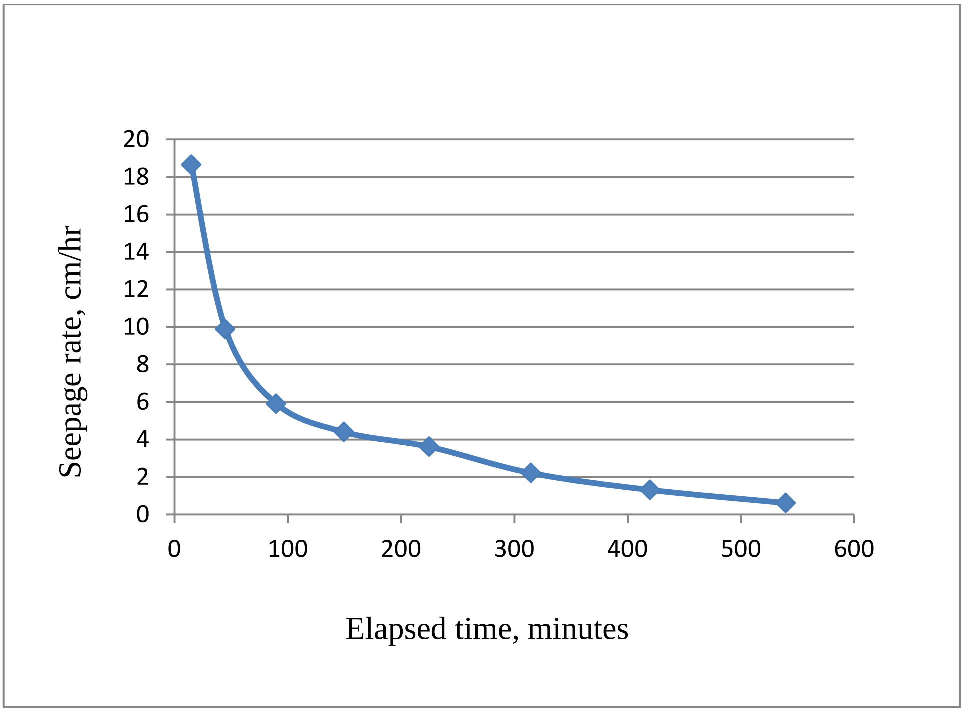


Fig 8: Variation of seepage rate with elapsed time for channel without lining (control)

Table 3: Anova table for seepage rate after 15 minutes ponding

Source	df	ss	Ms	F-ratio	Tab value	Remarks
Blocks	4	60.65	15.16	0.96	3.26	NS
Treatments	3	230.17	79.39	5.04	3.49	*
Error	12	188.96	15.75			
Total	19	487.78				
						CD=5.47

Table 4: ANOVA table for seepage rate after 225 minutes ponding

Source	df	ss	Ms	F-ratio	Tab value	Remarks
Blocks	4	1.67	0.42	1.41	3.26	NS
Treatments	3	2.35	0.75	2.64	3.49	NS
Error	12	3.56				
Total	19	7.57				

Table 5: ANOVA table for seepage rate after 540 minutes ponding

Source	df	ss	Ms	F-ratio	Tab value	Remarks
Blocks	4	2.81	0.7	1.91	3.26	NS
Treatments	3	2.82	0.94	2.55	3.49	NS
Error	12	4.41	0.37			
Total	19	10.04				

4.4 Soil moisture distribution pattern

The data obtained from the field study was analysed to understand the soil moisture distribution pattern due to seepage from the channels. The data was taken before ponding and 540 minutes after ponding for five replications. The soil samples were collected from different depths and horizontal distances. Gravimetric method was used to evaluate the soil moisture regime in the sides of the channels, which helps in monitoring the distribution of soil moisture as a function of depth as well as horizontal distance from the channel. The data also provide information regarding the characteristics of the soil moisture distribution as a function of elapsed time and type of lining material used.

The soil samples were taken from three different depths in the sides i.e., 20, 40 and 60cm and lateral distances of 20, 40 and 60cm from the edge of the channel. The analysis of data of moisture content before ponding and 540 minutes after ponding was done and moisture contour maps were plotted by using computer software package of windows version. The moisture distribution patterns hence obtained are shown in Fig 9 and Fig 10. The field used for this is given in APPENDIX VII.

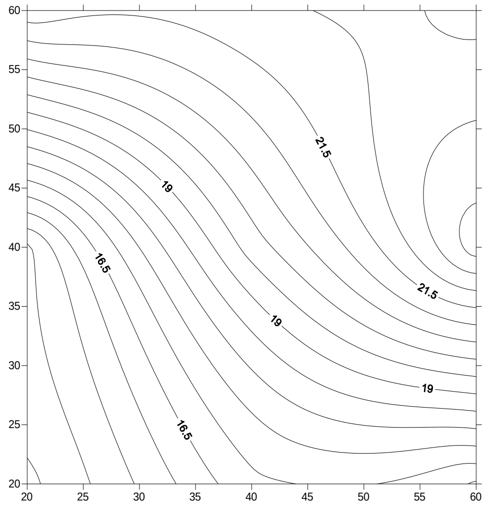
The moisture content before ponding in channels with different lining materials shows that at 20 cm vertical and horizontal distances it ranges between 13.5 to 15.5%. The moisture content in channels with different lining materials shows significant change in moisture content 540 minutes after ponding. The maximum moisture content 540 minutes after ponding for horizontal and vertical distance of 20, 40 and 60 cm was observed for channels lined with different materials. At 20 cm vertical and horizontal distance, the maximum moisture content observed was 20.72% for control, followed 18.55 % for coir geo-textile and gunny cloth (18.4%). The moisture content observed was 17.72% for plastic sheet material. At 40 cm vertical and horizontal distance, the maximum moisture content observed was 25.56% for control, followed by 23.48 % for gunny cloth and plastic sheet material (23.38%). The moisture content observed was 22.88% for coir geo-textile. At 60 cm vertical and horizontal distance, the maximum moisture content observed was 28.5% for control, followed by 25.38 % for gunny cloth and coir geo-textile (24.04%). The moisture content observed was 23.3% for plastic sheet material. In all cases, the maximum moisture content was observed in control. For all lining materials, the moisture content was observed less in 20 cm horizontal distance and vertical distance. This may because the ponding depth kept was 30 cm so that the quantity of water available and the contact time for water was less for 20 cm distance. As this layer is very near to the surface layer due to high rate of evaporation, percolation and uneven distribution of moisture, the moisture content was found less compared to 40 and 60 cm depths. For all lining materials, the moisture content increases with depth. The maximum moisture content observed for coir geo-textile and plastic sheet material was at 40cm horizontal distance and 60cm vertical distance. But for gunny cloth lined channel and in control, the maximum moisture content was observed at 60 cm vertical and horizontal distances. This implies that the seepage (lateral movement of water) is less in coir geo-textile and plastic sheet material compared to gunny cloth and control channel. The accumulated infiltration and seepage depths will be high in the deeper layer. The moisture contour maps revealed that there is a distinct variation in moisture content between the points with respect to horizontal distance as well as vertical distance. The contour maps also show that there is a uniform distribution of moisture in coir geo-textile, followed by gunny cloth. The least uniformity was found in channel without any lining material (control).

The statistical analysis was done using ANOVA shown in Table6. The result of the analysis shows that there is significant difference among treatments and no significant difference in replications.

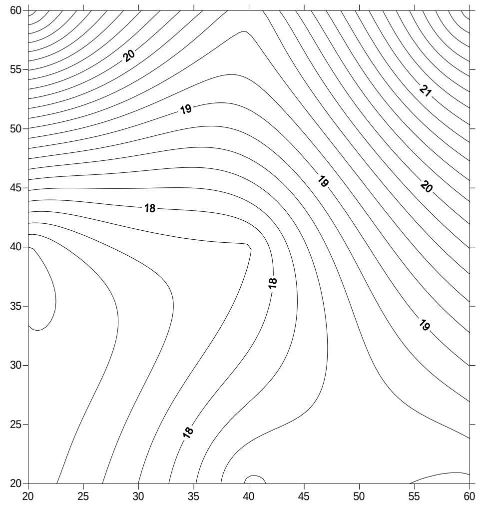
From the observed moisture content values shows that maximum moisture content at different horizontal and vertical distance was more for channel without lining material (control) and the minimum moisture content was observed for coir geo-textile. The soil moisture contour maps also revealed that uniform distribution of soil moisture after 540 minutes ponding is observed in coir geo-textile lined channel. Hence coir geo-textile is a better lining material compared to other lining materials used in the study.

Table 6: ANOVA table for moisture distribution at 60cm horizontal and vertical after 540 minutes ponding

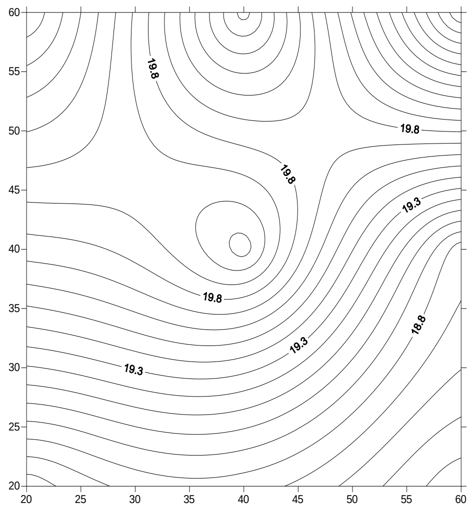
Source	**df**	**ss**	**ms**	**F-ratio**	**Tab value**	**Remarks**
Blocks	4	64.55	16.14	2.63	3.26	NS
Treatments	3	73.96	24.65	4.02	3.49	*
Error	73.5	4.41	6.13			
Total	80.5	10.04				



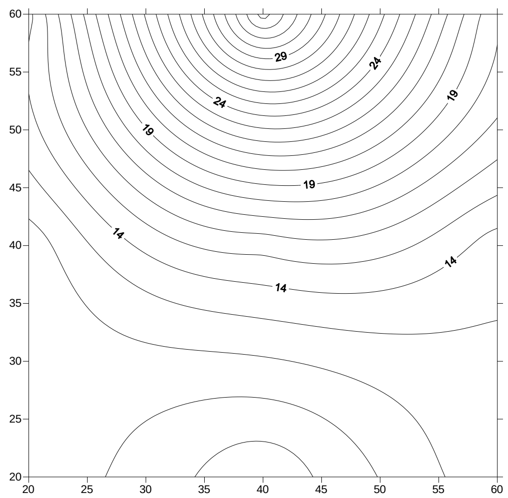
Treatment 1



Treatment 2



Treatment 3



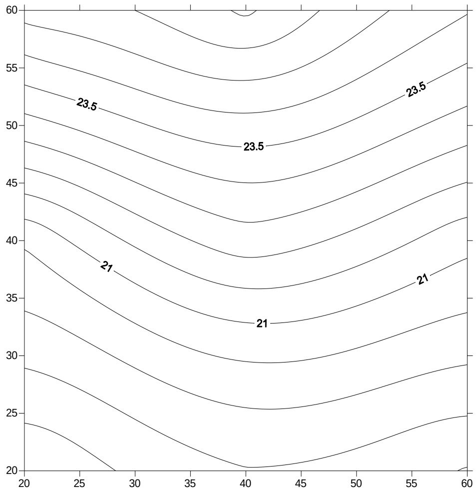
Treatment 4

Fig 9. Soil moisture distribution pattern– Before ponding

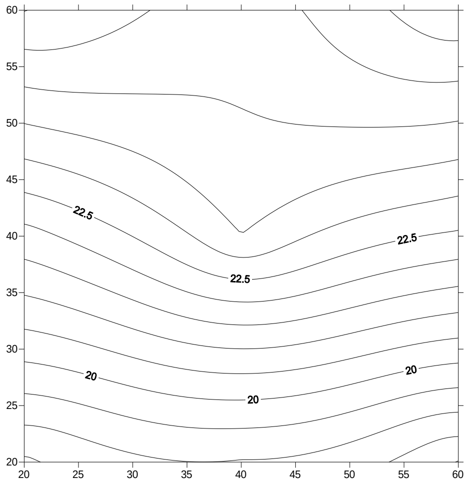
X-axis- Horizontal Distance (cm) Depth -60 cm

Y-axis- Vertical Distance (cm) Grid size - 5×5

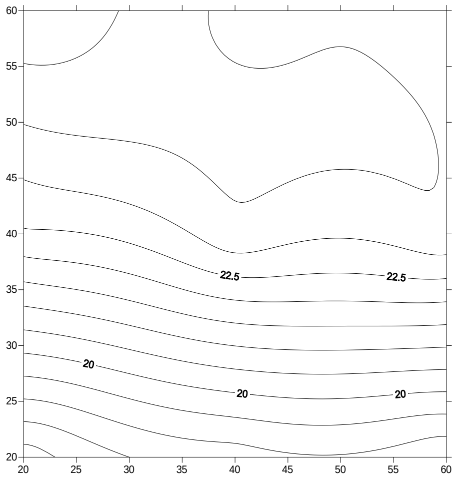
Z-axis- Moisture content (%)



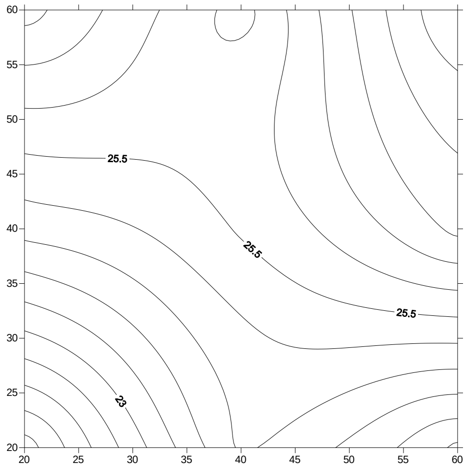
Treatment 1



Treatment 2



Treatment 3



Treatment 4

Fig 10. Soil moisture distribution pattern– after 540 minutes ponding

X-axis- Horizontal Distance (cm) Depth – 60cm

Y-axis- Vertical Distance (cm) Grid size - 5×5

Z-axis- Moisture content (%)

4.5 Weed Count

Weed count was taken from the field. The average weed counts from each channel are:

TREATMENT 1 = 0.1275/cm^2

TREATMENT 2 = 0.0775/cm^2

TREATMENT 3 = 0.0075/cm^2

TREATMENT 4 = 0.15/cm^2

It shows that density of weeds is more in control (T4) followed by coir geo-textile lined channel (T1), gunny cloth lined channel (T2) and least in plastic sheet material lined channel (T3). The weed density in coir geo-textile lined channel is better compared to other lining materials. The data is given in APPENDIX VIII.

4.6 Cost of different lining materials

Total cost for coir geo-textile : Rs. 1706

Total cost for gunny cloth : Rs. 270

Total cost for Plastic sheet material : Rs. 54

The results show that initially after 15 minutes, there is a drastic change in the seepage rate between the treatments, from 45 to 150 minutes variation in seepage rate was maximum in control (T4) and in case of coir geo-textile (T1) variation in seepage rate was less compared to other treatments. Jute gunny cloth and plastic sheet material (T2 and T3) shows almost same trend. After 225 and 420 minutes, maximum seepage rate was observed in control. There is no significant difference in seepage rate between coir geo-textile, jute geo textile and plastic sheet material. After 420 minutes seepage rate observed for coir geotextile lined channel (T1) was 1.5cm/hr, 1 cm/hr for gunny cloth lined channel (T2), 0.75 cm/hr for plastic sheet material (T3) and for control (T4) it was almost zero. After 420 minutes also, some water is available in coir geo-textile lined channel. The least was observed in control. The result implies that variation in seepage rate was less in coir geo-textile compared to other treatments. In all cases, the maximum moisture content was observed in control. For all lining materials, the moisture content was observed less in 20 cm horizontal distance and vertical distance. For all lining materials, the moisture content increases with depth. The maximum moisture content observed for (T1 and T3) coir geo-textile and plastic sheet material was at 40cm horizontal distance and 60cm vertical distance. But for gunny cloth lined channel (T2 and T4) and in control, the maximum moisture content was observed at 60 cm vertical and horizontal distances. This implies that the seepage (lateral movement of water) is less in coir geo-textile and plastic sheet material compared to gunny cloth and control channel. The contour maps also show that there is a uniform distribution of moisture in coir geo-textile (T1), followed by gunny cloth (T3). The least uniformity was found in channel without any lining material (T4).

As far as the cost is concerned, plastic sheet material is more cheaply available compared to other treatments, but it should be fixed to the soil well. Because of its light weight, there is a chance to float. Its life is also very short. The variation in seepage rate is minimum, uniform moisture distribution and minimum lateral movement of water was found in coir geo-textile (T1).The weed count in the coir geo-textile lined channel (T1) was also observed high after a prolonged time compared to jute gunny cloth(T2) and plastic sheet lined one(T3). For the purpose of channel slope stabilization and long durability, geo-textiles lined channels are better. As the time passes they act as vegetated waterways.

SUMMARY AND CONCLUSIONS

CHAPTER V

SUMMARY AND CONCLUSIONS

The study entitled “Comparison of different lining materials for field channels based on the seepage characteristics” was aimed to assess the seepage characteristics of locally available low cost lining materials such as coir geo-textile, gunny cloth, and plastic sheet material which were used to line the earthen channels. The study was conducted at instructional farm of KCAET, Tavanur in the month of September 2013 to January 2014.The experiment set up consists of four treatments including one control and five replications. The plot was of 30×12 m size and four channels of trapezoidal cross section with dimensions top width 2.2m bottom width of 0.8m, depth of 0.7m and a side slope of 1:½ bed slope of 1:1000 and length 8m were constructed and lined with coir geo-textile, jute gunny cloth, plastic sheet and without any lining material(control). The soil properties like texture, moisture content, specific gravity, hydraulic conductivity, infiltration etc. were studied. The bulk density of the different lining materials was also studied. The textural analysis revealed that soil type in the area was sandy loam in nature. At normal condition, the moisture content was randomly distributed in the area because of evaporation and difference in infiltration rate through the soil layers. The seepage through different lining material was found out by filling the channel up to a height of 30cm from the bottom and the depth of water at different time intervals i.e., 0, 15, 45, 90, 150, 225, 315, 420, 540 minutes were taken. Soil moisture content was taken before and after ponding. The observation was taken at 20, 40, and 60cm horizontal distance from the edge of the channel. The measurements were taken at different depths of 20, 30, and 60cm from each horizontal distance in every treatment before and after the ponding. The soil moisture measurements were done by gravimetric method since it is most accurate one. The soil moisture contour maps were prepared for each channel before ponding and 540 minutes after ponding. Weed count was taken from each channel 3 months after construction.

For Treatment 1, i.e. coir geotextile lined channel, (T1), after 15 minutes, the average seepage rate observed was 9.04cm/hr. After 225 minutes and 420 minutes, it was 3.12 cm/hr and 2.35cm/hr. For Treatment 2, i.e. gunny cloth lined channel, seepage rate is high at initial time as in all cases. In T2, jute geo-textile lined channel, initially it was 12.44cm/hr and after 225 min and 420 min it was 2.846and1.99 cm/hr. For Treatment 3, i.e. plastic sheet material lined channel, (T3), it was 12.8, 3.03and 1.94cm/hr. In case of channel without lining material (T4) it was18.64, 3.608 and 1.308 cm/hr.

In all cases, initially the seepage rate was maximum. After 15 minutes, the maximum rate was observed in channel without lining. The least was observed in coir geo-textile. In between 15 and 225 minutes (i.e., for 45, 90 and 150 minutes), there is a notable variation in seepage rate in all cases, and in case of coir geo-textile (T1) it was less compared to other treatments and gunny cloth and plastic sheet material (T2 and T3) shows almost same trend and control (T4) shows maximum variation. After 225 minutes and 420 minutes, maximum seepage rate was observed in control. There is no significant difference in seepage rate between coir geo-textile, jute geo textile and plastic sheet material. After 420 minutes also, some water is available in coir geo-textile lined channel. The least was observed in control.

The statistical analysis was shows that there is no significant difference between replications 15 minutes after ponding but significant difference was observed among treatments with 5% significance level. After 225 and 420 minutes, analysis shows that there was no significant difference in both treatments and replications with 5 % significance level. As the time passes the seepage rate reduces and becomes zero as the depth of water becomes zero.

The moisture content in channels with different lining materials shows significant change in moisture content 540 minutes after ponding. The maximum moisture content 540 minutes after ponding for horizontal and vertical distance of 20, 40 and 60 cm was observed for channels lined with different materials. At 20 cm vertical and horizontal distance, the maximum moisture content observed is 20.72% for control, followed 18.55 % for coir geo-textile and gunny cloth (18.4%). The moisture content observed was 17.72% for plastic sheet material. At 40 cm vertical and horizontal distance, the maximum moisture content observed was 25.56% for control, followed by 23.48 % for gunny cloth and plastic sheet material (23.38%). The moisture content observed was 22.88% for coir geo-textile. At 60 cm vertical and horizontal distance, the maximum moisture content observed was 28.5% for control, followed by 25.38 % for gunny cloth and coir geo-textile (24.037%). The moisture content observed was 23.3% for plastic sheet material.

In all cases, the maximum moisture content was observed in control. For all lining materials, the moisture content was observed less in 20 cm horizontal distance and vertical distance. This may because the ponding depth kept was 30 cm so that the quantity of water available and the contact time for water was less for 20 cm distance. As this layer is very near to the surface layer due to high rate of evaporation, percolation and uneven distribution of moisture, the moisture content was found less compared to 40 and 60 cm depths.

For all lining materials, the moisture content increases with depth. The maximum moisture content observed for coir geo-textile and plastic sheet material was at 40cm horizontal distance and 60cm vertical distance. But for gunny cloth lined channel and in control, the maximum moisture content was observed at 60 cm vertical and horizontal distances. This implies that the seepage (lateral movement of water) is less in coir geo-textile and plastic sheet material compared to gunny cloth and control channel

The contour maps also show that there is a uniform distribution of moisture in coir geo-textile, followed by gunny cloth. The least uniformity was found in channel without any lining material (control).

The statistical analysis shows that there is significant difference among treatments and no significant difference in replications.

The performance of plastic sheet material lined channel (T3) is better than jute gunny cloth lined channel in seepage rate and moisture content aspects. This channel was very less in weed count. The lining material is also have less cost and is more cheaply available compared to other materials, but it should be fixed to the soil well in a proper way. Because of its light weight, there is a chance to float. Its life is also very short.

The weed count was observed high in control channel (T4) followed by the coir geo-textile lined channel (T1) after three months after construction and it was about 0.15/cm^2 and 0.1275/cm^2 respectively. The variation in seepage rate was minimum, uniform distribution of moisture and minimum lateral movement of water was found in coir geo-textile (T1) lined channel compared to all other treatments. For the purpose of channel slope stabilization and long durability also, geo-textiles lined channels are better. As the time passes they act as vegetated waterways.

REFERENCES

REFERENCES

Abu Khashaba, M. I. 2013. Innovating impermeable concrete appropriate for canal lining using a specific mixing ratio and applying it to a pilot reach, *J.of Engng Sci.*Vol.41(3): 900 – 918.

Achanta Rao. 1994. Seepage effects on sand –bed channels. *J.of irrig. and Drainage Engineering* Vol.120 (1): 60-79.

Ahamad,I., Ahamad,C.B., Butt,H.N., Zuberi,F.A. and Bodia,M.A. 1993. Studies on the performance of various lining materials. Zuberi,F.A. (ed.). *Proc. of the International Workshop on canal lining an seepage*, Lahore, Pakistan, 18-21 October, 1993, 301-321.

Atre A.A. and Sarap A.S. 1988. Seepage losses for different channel lining materials, *Proc. of XXIV ISAE Annual Convention*; January,1988; pp. 21-23.

Aziz,Y.A., Zuberi,F.A. and Bodia,M.A. 1993. A country paper on canal lining – The Egyptian experience. Zuberi,F.A. (ed.). *Proc. of the International Workshop on canal lining and seepage*; 18-21 October,1993; Lahore, Pakistan; pp.137-143.

Babu., K.S.Beena And A.K. Raji. (2008). Design Of Coir Geo-Textile Reinforced Roads Using IRC Methods, *Highway Research Journal*, Special Issue , 113p.

Bankar M.C., More T.A., Pol P.S. and Khade K.K. 1995. Estimation of seepage losses through different conveyance systems[Abstr].In:*Abstracts,National Symposium on managing water resourses for sustainable agriculture and environment*; 5-7 October, 1995. ,GAU, Navsari. pp. 73.

Bihari and Patel 1986. Studies on the conveyance loss in earthen irrigation channels. *Proc. of XXIV Annual Convention ISAE.* 21-23, January,1986.

Cammack, A. _1988_. A role for coir fiber geofabrics in soil stabilization and erosion control. *Proc. of Workshop on Coir Geogrids and Geofabrics in Civil Engineering Practice,* Coimbatore, India, 28–31.

Dhotre R.S., Pawar D.D. and Kumakar J.K. 1996. Field evaluation of seepage losses through field channels. *Proc. of International Agricultural Engineering Conference*; 9-12 Dec,1996; Pune (India); pp. 547-552.

Ehsan,M., Dodhy,N.L., Sali,M.S., Zuberi,F.A. and Bodia,M.A. 1993. Recent experience of lining on small channels in punjab province with particular reference to irrigation systems rehabilation project. *Zuberi,F.A.* (ed.), *Proc. of the International Workshop on canal lining an seepage*; 18-21 October 1993; Lahore, Pakistan; pp. 145-170.

Fifield, J. S.; Malnor, L.K.; Ritcher, B and Dezman, L.E. (1988), Field testing erosion control products to control sediment, *Proc. 19th IECA Conf*, New Orleans, 1988, pp.327-341.

Gwinn W.R. and Ree W.O. 1980. *Maintenance effects on the hydraulic properties of a vegetation lined channel* (trans), ASAE. 23 (3): 636-642.

Hansen, V.E., O.W. Israelsen and G.E. Stringham. 1980. *Irrig. Principles and Practices,* (4th Ed)., John Wiley and Sons.

Ingold, T.S. and Thomson, J.C. 1990, A design approach for performed erosion control systems, *Proc. 4th International Conf. on Geotextiles, Geomembranes and related Products,* Den Hang,pp.375-380.

Ittfaq M., Bashir M.S., Bhutta M.N. and Niazi M.F.K. 1998. *Interceptor Drain Performance at Sump 38, Chashma Right Bank Canal*. IWASRI Publication No. 196.

Jabbarov Hojyaz., Ruzimboy Eshchanov., Jamshid Nurmetov., Alexandra Lutz., Margaret Shanafield.,John P.A. Lamers. (2013). Canal lining to increase water use efficiency and remediate groundwater levels in Khorezm Uzbekistan, Central Asia. *International J. of Agric.: Research and Review.* 3 (4): 742-750. Available online at http://www.ecisi.com.

Karen Meijer., Eline Boelee., Denie Augustijn., and Irna van der Molen. 2006. Impacts of concrete lining of irrigation canals on availability of water for domestic use in southern Sri Lanka. *Agric. Water Management,* Vol 83(3), 16 June 2006: 243-251.

Kemper, W.D., and Muhammad Akram Kahlown. 2005. Reducing Water Losses from Channels Using Linings. *Agric. Water Management* Vol:74(1), May 30 2005: 57-76.

Laliberte, G.E., Rapp,E., and Paziuk, N. 1967. Seepage control in concrete-lined irrigation ditches. *Canadian agricultural engineering*: 71-73.

Lee M, H. Soil bioengineering - The Korean Experience, *Proc. of the India International Coir Fair and seminar*, 2001; Coir Board, India.

Luthra, S.D.L.1980. Conveyance losses in lined irrigation canal systems. *J.Irrig. Power.* 37 (3): 329 -336.

Mahesh M. Karad, R.A. Panke, P.A. Hangargekar 2013. Seepage losses through canals and minors. *International J. of Engng Research & Technology* 2(11):1125- 1134.

Mclaughlin N.B., Dyck F.B. and Sommerfeldt T.G. 1976. An asphalt is corporator and packer for lining irrigation ditch [abstract]. *In Abstracts, 4th International Conference*, 1976, U.S.A.

Michael. A.M., Rajput T.B.S. and Ashwani Kumar. 1981. Use of unconventional materials for pre-cat channels. *J.Agic. Engng. XVIII* (3-4): 56-63.

Muhammad Basharat and Muhammad Saeed. 2002. Research : *Modelling the seepage from chashma jhelum link canal and rehabilitaion of the waterlogged areas*[Lecture notes]. International Waterlogging and Salinity Research Institute, WAPDA, Lahore.

Nagarkar K.L.S. Dotihal and Soni, S.M. 1979. Fly Ash Concrete tiles for canal lining. *J.irrig. Power 36* (2): 116-117.

Nema A.K. 1988. Evaluation of different channel lining materials. *Proc. of XXIV Annual convention ISAE* ;21-23 January,1988.

Ogbobe, O., Essien, K.S., Adebayo, A., 1998. A study of biodegradable geotextiles used for erosion control. Geosyn. Inter. 5, 545–553.

Parikh, P. and Shroff, A.V. (1989), Use of grouted mattresses for canal bed/slope protection- In use of Geosynthetics in India : Experiences and Potential, Report No. 207, Central Board of Irrigation and Power, New Delhi, India, pp. 310-20.

Rajput, T.B.S. and Ashwani Kumar. 1988. Minimization of conveyance losses in the field water courses. *Proc. of XXIV Annual convention ISAE;* January 21-23, 1998.

Raju, K.C. 1980. Groundwater resources of Lower Bhavani Canal Command Area in Noyil Bsin. *Proc. of Third Afro-Asian Regional Conferenc;*1980; New Delhi, pp. 247-262.

Ramaswamy, SD, Aziz, MA. 1989. Jute geotextile for roads, *Proc. of a Workshops on Geotextiles;*1989; *Bangalore, India;* pp.*1*259-266.

Roy Choudhury, M., Chatterjee, P., Dey ,P., Nag D., Debnath S., Ghosh S.K. and Ganguly P.K. 2008, Lining of Open Channel with Jute Geotextile and its Performance in Seepage Control **,** *J.of Agric. Engng. ISAE vol.45. No. 4 (2008)*: 83-86.

Sangram Ganguly., Arindam Samanta., Mitchell A. Schull., Nikolay V. Shabanov., Cristina Milesi., Ramakrishna R. Nemani., Yuri Knyazikhin and Ranga B. Myneni. (2008). Generating vegetation leaf area index Earth system data record from multiple sensors. Part 2: Implementation, analysis and validation. *Remote Sensing of Environment.* 112 (2008):4318–4332

Sanyal, T. 2006, Jute Gotextile in erosion control & strengthening of sub-grades. *Proc. IGS-CBIP*; 2006; New Delhi, Publication No. 298: 206-215.

Schurholz, H.1992. Use of woven coir geotextiles in Europe. *Proc. of the United Kingdom Coir Geotextile Seminar*, 1992; West Midlands.

Siddique,M., Parsha,F.H., Choudari.A.M., Zuberi,F.A. and Bodia,M.A. 1993. In: Zuberi,F.A.(ed.),*Proc. of the International Wokshop on canal lining and seepage*, 18-21 October 1993; Lahore, Pakistan, pp.197-221.

Shaheem S and Tomy Cyriac. (2013). Performance evaluation of coir geo-textiles as earth reinforcement in soil structures. *American Journal of Engineering Research (AJER).* Vol.1, pp.49-53

Sharma R.P. and Sehgal S.R. 1971. Assessment of seepage losses from unlined field channels. *J. irrgi Drain.* Div. (28): 325p.

Sotir, R, B., Simms, A, P. 1991. North American coir geotextiles experiences in combination with soil bioengineering, *Proc. of the North American Coir seminar*; 1991; Coir Board, India.

Sudhakaran, P.1994. Protection to the side slopes of Kabini Canal, *Proc. of fifth International conf. on Geotextiles, Geomembrane related products*; 1994; Singapore.

Sur. H.S., Rachhpal Singh and Gill J.S. 1989. Conveyance losses of water from unlined field channels. *J. of Agric. Engng.* ISAE vol. 26. No. 1 (1989): 29-32.

Swihart J, Haynes J. 2002. Canal-Lining Demonstration Project year 10 Final Report[online]. US Bureau of Reclamation.
Available:http://www.usbr.gov/pn/programs/wat/pdf/finalcanal/fr ont.pdf.

Tapabrata Sanyal. 1992. Control of Bank Erosion Naturally. *Proc. National Workshop on Role of Geosynthetics in Water Resource Projects*, New Delhi, pp.131-137.

Terence S. Ingold an., James, C. Thomson. 1999. Results of current research of synthetic and natural fibre erosion control systems. ITC – UNCTAD/GATT.

Theisen M.S (1992). The role of geo synthetics in erosion and sediment control : an over view. Geotextiles and Geomembranes II (1992), pp.535-550.

Thomson, J.C. and Ingold, T. S. 1986, *Use of Jute Fabrics in Erosion Control*, Report of the International Trade Centre, UNCTAD/GATT.

Tiwari, K.N. and Pant N. 1991. Performance evaluation of lining materials for seepage control from farm ponds. *Agril. Engng. Abstr. (16)* : 1-12.

Varshney, R.S., Gupta S.C. and Gupta R.L. (1969).*Theory and design of Irrigation structures.* New Chand and Brothers, Roorkee.

Venkatappa Rao, G and Dutta, R.K. ,Coir products in unpaved roads – a comparative study. *Proc. International Conf. on Structural and Road Transportation Engineering*, Kharagpur, 2005, pp. 533-541.

White, W.1991. Flood plain dynamics and available erosion control techniques, *Proc of the North American Coir seminar*; 1991;Coir Board, India.

Worstell, R.V. 1976. Estimating seepage losses from canal systems. *J. of the Irrig. and Drain. Division, Society of Civil Engineers* 102 (IR1):137-147.

Yazdani. B. (1972). *Possibilities of supply of proper use of water in Grassmar area*; In: ENTO seminar on agricultural concepts of arid and semiarid zones.pp. 212 -224.

APPENDICES

APPENDIX I

Specific gravity of the soil using Pycnometer.

Mass of pycnometer M_1	425
Mass of pycnometer + Soil sample, M_2	726
Mass of pycnometer + Soil + Water, M_3	1655
Mass of pycnometer + Water, M_4	1476
Specific gravity, G	2.47

APPENDIX II

Grain size distribution of the soil (coarse fraction)

Sl. No.	IS Sieve	Particle Size D (mm)	Mass Retained (g)	% Retained	Cumulative % Retained	Cumulative % finer(N)
1	4.75	4.75	3.5	0.70	0.70	99.3
2	2	2	4.8	0.96	1.66	98.34
3	1	1	76	15.28	16.95	83.05
4	600	0.6	32.8	6.59	23.54	76.46
5	425	0.425	75.7	15.22	38.76	61.24
6	300	0.3	113.4	22.80	61.56	38.43
7	212	0.212	84.9	17.07	78.64	21.36
8	150	0.15	62.3	12.53	91.17	8.83
9	75	0.075	35.9	7.22	98.39	1.61
10	Pan	<0.075	8	1.61	99.99	0.01

APPENDIX III

Determination of Moisture content by gravimetric method.

Can No	Mass of can (g)	Mass of wet soil + can (g)	Mass of dry soil + can (g)	Water content w (%)
1	15	56.5	51	15.28
2	13.5	59.5	54	13.58
3	14	73	64	18

APPENDIX IV

Saturated hydraulic conductivity.

	Sample 1	Sample 2	Sample 3
Hydraulic head, (cm)	115	115	115
Length of sample, (cm)	12	12	12
Cross sectional area of the sample, (cm^2)	78.53	78.53	78.53
Time interval, (sec)	300	300	300
Quantity of flow, (cm^3)	347.5	338.5	342
Coefficient of permeability, (cm/sec)	1.54×10^{-3}	1.5×10^{-3}	1.51×10^{-3}

APPENDIX V

Infiltration

Observations on double ring infiltrometer.

Elapsed time	Distance of water surface from ref. Point		Infiltration during period		
(min)	Before filling (cm)	After filling (cm)	Depth (cm)	Average rate (cm/hr)	Accumulated infiltration (cm)
0		11			0
5	9.3	11	1.7	20.4	1.7
10	9.5	11	1.5	18	3.2
15	9.7	11	1.3	15.6	4.5
25	8.9	11	2.1	12.6	6.6
35	9.1	11	1.9	11.4	8.5
45	9.2	11	1.8	10.8	10.3
60	8.4	11	2.6	10.4	12.9
75	8.5	11	2.5	10	15.4
90	8.6	11	2.4	9.6	17.8
110	7.9	11	3.1	9.3	20.9
130	8	11	3	9	23.9
150	8	11	3	9	26.9

Derivation of infiltration equation

From the plot y against t

For t_1 = 5 minutes y_1 = 1.7cm and

t_2 = 150 minutes y_2 = 26.9cm.

Adopting the procedures suggested by Davis (1943), The rectifying value of t is found from the following relationships;

$$t = \sqrt{(t_1 t_2)} = \sqrt{(5 \times 150)} = 27.39 \text{ minutes}$$

The corresponding y3 was determined from the figure 2 is 6cm. the value of constant b was obtained as follows.

$$b = y_1 y_2 - {y_3}^2 / y_1 + y_2 - 2y_3 \quad = 1.7 \times 26.9 - (6^2)/1.7 + 26.9 - 2 \times 6 = 0.077$$

The value of 0.77 of b is subtracted from each value of y. the logarithms of (y-0.77) and t are taken. The variables are related by the expression

$$y - 0.11 = at^{\alpha}$$

The logarithmic form of which is log(y-11) = log a+ α log t

Substituting the data on average infiltration y and elapsed time t presented in table in the equation log (y-11) = log a+ α log t yields the following equations:

$$0.2103 = \log a + 0.6990\alpha$$

$$0.4945 = \log a + 1.0000\alpha$$

$$0.6457 = \log a + 1.1761\ \alpha$$

$$0.8144 = \log a + 1.3979\ \alpha$$

$$0.9255 = \log a + 1.5441\ \alpha$$

$$1.0096 = \log a + 1.6532\ \alpha$$

$$1.1080 = \log a + 1.7782\ \alpha$$

$$1.1853 = \log a + 1.8751\ \alpha$$

$$1.2485 = \log a + 1.9542\ \alpha$$

$$1.3185 = \log a + 2.0414\ \alpha$$

$$1.3770 = \log a + 2.1139\ \alpha$$

$$1.4285 = \log a + 2.1761\ \alpha$$

Adding the fix six and last six equations:

$$4.1000 = 6 \log a + 7.4703\, \alpha$$

$$7.6658 = 6 \log a + 11.9389\, \alpha$$

Solving simultaneously,

$$\alpha = 0.8$$

$$\log a = -0.31017$$

$$a = 0.49$$

APPENDIX VI

Properties of lining materials: Bulk density

Material	Weight	Volume	Bulk density
	g	cm^3	g/cm^3
Geotextile	300	1500	0.2
Gunny bag	345	1500	0.23
Plastic sack	162	900	0.18

APPENDIX VII

Seepage rate.

Treatment 1

Time	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
min	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr
0						
15	9.6	12.2	8.2	6.2	9	9.04
45	6.2	7.2	6.6	5.2	6.4	6.32
90	4.33	5.06	6.53	4.2	4.533	4.93
150	3.65	4.6	4.25	4	4.4	4.18
225	2.8	2.32	2.52	3.76	4.2	3.12
315	2.4	2.27	2.4	3.4	3.2	2.73
420	2.27	2.14	2.2	3.09	2.06	2.35
540	2.25	2.08	2.08	0.75	0.6	1.55

Treatment 2

Time	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
min	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr
0						
15	10	14.4	14.4	7.4	16	12.44
45	7.7	10.9	9.8	6	4.1	7.7
90	5.87	6.93	7.8	5.73	3.8	6.03
150	4.2	2.95	4.8	4.05	3.45	3.89
225	2.47	2.88	2	3.88	3	2.85
315	2.26	2.1	1.7	2.63	2.7	2.28
420	1.25	1.66	1.97	2.43	2.66	1.99
540	0	1.45	1.05	1.5	2.23	1.245

Treatment 3

Time	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
min	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr
0						
15	14.6	8.2	10	15.2	16	12.8
45	12.9	6.1	5.3	7.8	8.6	8.14
90	6.2	5.4	7.07	6.4	7.53	6.52
150	4.35	5.05	5.35	4.75	3.2	4.54
225	3.6	3.64	2.64	2.67	2.6	3.03
315	1.87	2.57	2.5	2.23	2.2	2.27
420	1.54	2.46	2.43	1.57	1.68	1.94
540	0.325	0.55	0.5	1.47	1.55	0.88

Treatment 4

Time	Replication 1	Replication 2	Replication 3	Replication 1	Replication 5	Average
min	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr	cm/hr
0						
15	16.4	26.2	10.6	20.2	19.8	18.64
45	15.9	11.6	6.9	7.2	7.8	9.88
90	6.26	5.6	5.53	6.13	6	5.90
150	4.9	5.3	4.1	3.65	4	4.39
225	4.04	3.88	2.96	3.68	3.48	3.61
315	1.93	1.6	2.97	2.43	2.1	2.21
420	0.1	0.31	2.43	1.77	1.94	1.31
540	0	0.05	1.5	0.75	0.75	0.61

APPENDIX VIII

Soil moisture distribution pattern

Before ponding

TREATMENT 1						
Moisture content (%)						
Distance (X,Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
20 20	13.89	21.5	15.49	11.11	9.92	14.38
20 40	12.38	19.85	16.67	14.29	11.32	14.90
20 60	22.97	20.55	19.18	25.67	20.69	21.81
40 20	16.85	15.38	15.73	17.99	18.45	16.88
40 40	18.18	15.56	15.56	27.27	22.07	19.73
40 60	22.32	20.54	20.54	24.11	21.89	21.88
60 20	16.09	15.12	15.96	20.69	14.25	16.42
60 40	23.81	18.18	17.05	40.48	16.85	23.27
60 60	21.1	20.18	20.75	26.6	20.44	21.81

TREATMENT 2						
Moisture content (%)						
Distance (X.Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
20 20	17.24	18.26	17.09	18.1	15.84	17.31
20 40	17.86	17.78	17.14	19.05	14.06	17.18
20 60	22.03	19.75	21.25	23.73	22.87	21.93
40 20	17.86	19.51	16.67	19.05	20.14	18.65
40 40	18.92	18.18	17.65	21.62	12.53	17.78
40 60	19.28	20.48	20.24	20.48	16.75	19.45
60 20	17.89	18.75	16.33	22.11	16.67	18.35
60 40	18.48	19.77	20.93	19.57	20.31	19.81
60 60	22.22	20.37	21.49	24.07	24.53	22.54

TREATMENT 3						
Moisture content (%)						
Distance (X,Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
20 20	19.4	16.67	16.9	22.39	17.3	18.53
20 40	20	19.72	18.7	24.44	15.88	19.75
20 60	20.83	20.83	20.83	19.17	20.83	20.5
40 20	18.6	19.52	15.38	27.9	12.33	18.75
40 40	19.3	20.69	18.03	26.31	16.44	20.15
40 60	20	17.39	20	24.44	13.92	19.15
60 20	18.97	17.86	16.42	24.14	14.24	18.33
60 40	19.05	20.99	17.5	21.43	14.68	18.73
60 60	21.01	21.01	21.01	22.69	18.8	20.90

TREATMENT 4						
Moisture content (%)						
Distance (X,Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
20 20	12.12	12.41	10.96	15.15	8.82	11.89
20 40	11.59	14.18	8.33	17.39	5.48	11.39
20 60	14.14	12.12	14.68	16.16	11.44	13.71
40 20	6.67	14.28	10	11.67	3.22	9.169
40 40	15.28	12.16	12.16	18.61	18.57	15.36
40 60	12	12.12	10.1	13.4	10.89	33.50
60 20	13.58	9.64	13.5	15.8	11.38	12.78
60 40	15.27	6.94	10	19.16	15.96	13.47
60 60	20.65	15.62	13.27	22.6	18.09	18.04

After 540 minutes

TREATMENT 1						
Moisture content (%)						
Distance (X,Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
2020	19.23	17.8	16.88	19.44	19.44	18.5586
2040	20.3	20.19	19.81	20	22.54	20.57
2060	25	25.49	25.24	21.87	25.84	24.69
4020	19.23	18.55	22.47	18.18	18.94	19.47
4040	20.94	20.89	20.29	27.27	22.05	22.29
4060	27.06	24.44	24.72	25.88	25.84	25.59
6020	20	16.07	18	20	20.75	18.96
6040	21.21	20.96	20.97	21.21	21.43	21.16
6060	27.19	22	24.1	23.73	23.17	24.04

TREATMENT 2						
Moisture content (%)						
Distance (X,Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
20 20	20	18.85	18.75	17.07	17.39	18.41
20 40	21.67	19.64	24.07	20.37	23.25	21.80
20 60	29.17	23.93	27.35	22.41	22.22	25.012
40 20	17.26	19.64	20.47	18.97	18.48	18.96
40 40	25	20.98	23.28	27.5	20.68	23.49
40 60	22.34	24.69	26.43	25	22.04	24.1
60 20	17.54	16.16	19.81	19.3	17.07	17.98
60 40	23.015	21.59	22.22	23.01	22.22	22.41
60 60	28.33	23.28	25.35	24.6	25.33	25.38

TREATMENT 3						
Moisture content (%)						
Distance (X,Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
20 20	16	17.39	17.39	18.75	19.05	17.72
2040	24.64	21.43	24.55	21.21	20.35	22.44
2060	27.03	22.73	24.42	25.71	22.22	24.42
4020	17.7	19.65	18.8	18.58	19.01	18.75
40 40	25	22.22	24.7	22.5	22.5	23.38
4060	24.32	23.33	22.05	23.65	23.26	23.32
6020	19.84	17.07	16.26	20.79	18.75	18.54
6040	24.07	25	23.26	23.21	21.59	23.42
60 60	22.22	23.58	23.58	23.46	23.71	23.31

TREATMENT 4						
Moisture content (%)						
Distance (X,Y)	Replication 1	Replication 2	Replication 3	Replication 4	Replication 5	Average
20 20	20.49	19.86	21.01	21.43	20.83	20.72
2040	26.5	21.95	25	25.88	24.07	24.68
2060	27.27	27.37	27.37	26.67	27.37	27.21
4020	22.53	25.4	23.27	26.36	25.4	24.59
40 40	29.9	25.88	26.32	21.77	23.94	25.56
4060	22.92	26.02	27.16	27.01	23.33	25.29
6020	19.6	23.15	23.53	21.49	26.67	22.89
6040	30	26.67	24.7	29.32	25	27.14
60 60	37.86	25.53	26.6	26.29	26.23	28.50

APPENDIX IX

Weed count

	Place 1	Place 2	Place 3	Place 4	Average	Area of square	Weed count
	weeds	weeds	weeds	weeds	Weeds	cm²	weeds/cm²
Channel 1	14	16	9	12	12.75	100	0.1275
Channel 2	9	12	6	4	7.75	100	0.0775
Channel 3	0	2	0	1	0.75	100	0.0075
Channel 4	15	18	11	16	15	100	0.15

APPENDIX X

Cost Economics

Raw material	Quantity required/m²	Total Quantity required	Cost/unit quantity (Rs.)	Total cost
Geotextile	1 m²	17.96	95	1706
Gunny bag	1nos.	27	10	270
Plastic sack	1nos.	27	2	54

COMPARISON OF DIFFERENT LINING MATERIALS FOR FIELD CHANNELS BASED ON SEEPAGE CHARACTERISTICS

By

ANNIE S S

SUKANYA S

ABSTRACT OF THE PROJECT REPORT

Submitted in partial fulfilment of the

Requirement for the degree

Bachelor of Technology

in

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Land & Water Resources & Conservation Engineering

Kelappaji College of Agricultural Engineering & Technology

Tavanur-679573, Kerala, India

January 2014

ABSTRACT

Agricultural productivity is based on the availability of required at proper time. As water is becoming a limited resources its effective utilization is important. The water resources which could be tapped for irrigation are very limited and its conservation is very important. Also, the losses in a new canal are very great in initial stages. But they slowly diminish in time due to saturation of the surrounding soil and due to stanching of banks and canal section by deposition of silt from canal water. The other factors affecting the transit losses are nature of soil, its condition and size of the canal, depth of water, temperature and position of sub soil water level.

The study entitled "Comparison of different lining materials for field channels based on the seepage characteristics" was aimed to assess the seepage characteristics of locally available low cost lining materials such as coir geotextile, gunny cloth, and plastic sack which were used to line the earthern channels. The study was conducted at instructional farm of KCAET; Tavanur in the month of September 2013 to January 2014.The experiment set up consists of four treatments including one control and five replications. The plot is of 30×12 m size and four channels of trapezoidal cross section with dimensions bottom width of 0.8m, depth of 0.7m and a side slope of 1:½ were constructed. The textural analysis revealed that soil type in the area is sandy loam in nature.

For coir geotextile lined channel, variation in seepage rate was observed less compared to other treatments, and reduces with time and ceases to a constant rate. The maximum moisture content observed for coir geo-textile and plastic sheet material was at 40cm horizontal distance and 60cm vertical distance. But for gunny cloth lined channel and in control, the maximum moisture content was observed at 60 cm vertical and horizontal distances. This implies that the seepage (lateral movement of water) is less in coir geo-textile and plastic sheet material compared to gunny cloth and control channel. The contour maps also show that there is a uniform distribution of moisture in coir geo-textile, followed by gunny cloth. The vegetation in the coir geo-textile channel after 3 months of construction is $12.75\times10^{-2}/cm^2$. This implies that the channel will act as a vegetated water way after a long time of running.