The feasibility of rice husk application as an envelope material in subsurface drainage systems

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Introduction

- In many irrigated areas, rising water tables have subsequently led to waterlogging, salinity and drainage problems.

- Smedema et al. (2000) estimate that: 10–20% of the irrigated land is already equipped with drainage,20-40% of the irrigated area is not need of any artificial drainage; while 40–60% is need of drainage but remains without drainage (FAO 61).

- In Iran: About 29% (2.1 million ha) of total irrigated area (7.2 million ha) is salinized but only 0.6% of irrigated area has surface and subsurface drainage (FAO 61).

Introduction

In order to proper and lasting performance of subsurface drainage systems:

The selection of appropriate materials (i.e. pipes and envelopes) and their adequate installation and maintenance are essential.

Review of envelope materials

- Envelope materials are divided to three groups:

  organic (like peat), mineral (like gravel) and synthetic materials.

- Organic envelopes have advantages like cheapness, ease of installation and no need for special design.
- In northwestern Europe (Belgium, Germany and The Netherlands) the most common organic envelopes are peat litter, flax straw and coconut fibres.
- Sawdust from coniferous trees is often used as envelope material in Scandinavian countries. 50% of sawdust is usually decomposed in Norway after 20 years. Also some of drains in Scandinavian countries are older than 30 years due to the low temperature.
- The results of a research that was done in 1994-98 in Lithuania shows that using the sawdust envelope resulted in the improvement of the performance of drainage system.

Targets of this research

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- **In many areas, properly graded gravel material is scarce or non-existent. For this reason, sand and gravel envelope constitutes the principal cost of drain installation. Moreover, handling and placement of gravel envelopes around the drainpipe is difficult that leading to increase the project cost (FAO 60).**
- **For example: In Khuzestan's sugar-cane development project (Iran), material carring distance is about 50 to 220 Kms.**
- **In practice, availability and cost strongly affect the selection of envelope material.**
- **On the other hand, rice production in Iran had been 2700000 tons with a potential for producing 0.5 millions tons of rice husk, annually.**

Targets of this research

Therefore

This research aims at finding a cheap envelope material such as rice husk that can be replace for conventional sand and gravel material and reducing drainage cost by using the local materials especially where sand and gravel envelope is not available.

For this purpose the following approaches was taken:

- Study of the hydraulic conductivity of rice husk.
- Study of the feasibility of rice husk application as an envelope material instead of sand and gravel.

Materials and methods

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Materials and methods of this research are divided to 3 parts:

1- **Physical properties of rice husk including gradation curve, porosity, bulk and particle densities and the percent of water absorption were measured.**

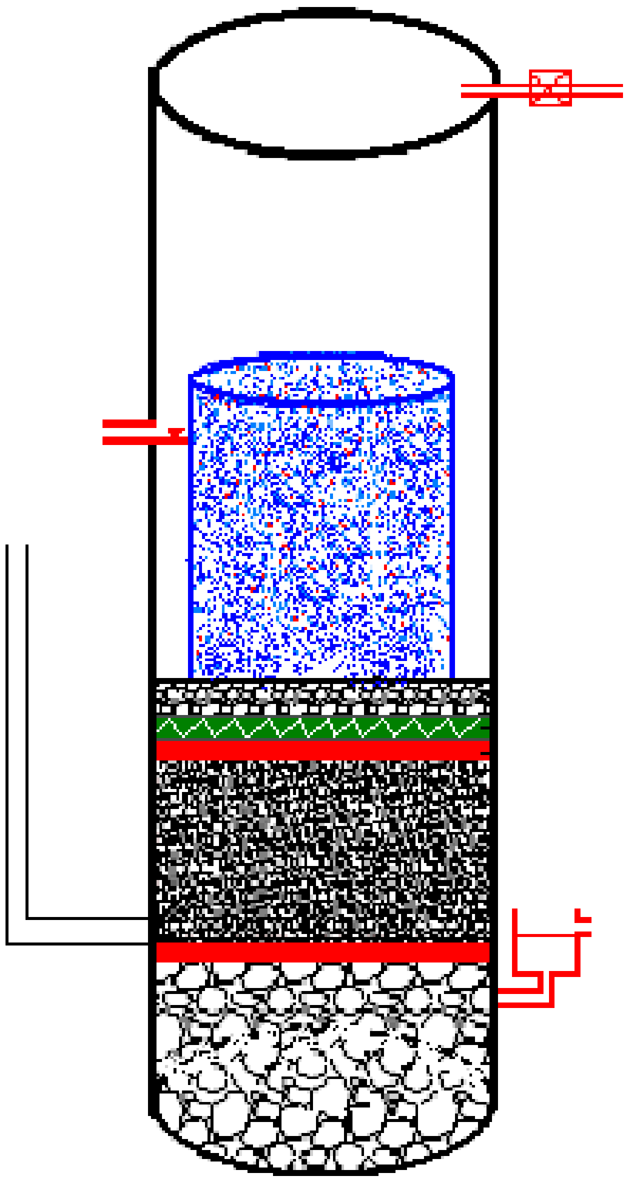
2- **Studying hydraulic conductivity of rice husk**

3- **Investigation of the rice husk as an envelope and comparison it with common mineral envelope in the laboratory.**

Materials and methods: Hydraulic conductivity

Hydraulic conductivity of organic envelopes, like rice husk, is dependent on the compaction resulting from the applied load of the overlying soil. In order to investigate this, a conductivity meter was made to measure change of the hydraulic conductivity of rice husk as a result of different static load applied.

To simulate the pressure of the soil column, a concrete cylinder with 15 cm diameter was used. The amount of load is increased in each step after measuring the hydraulic conductivity.

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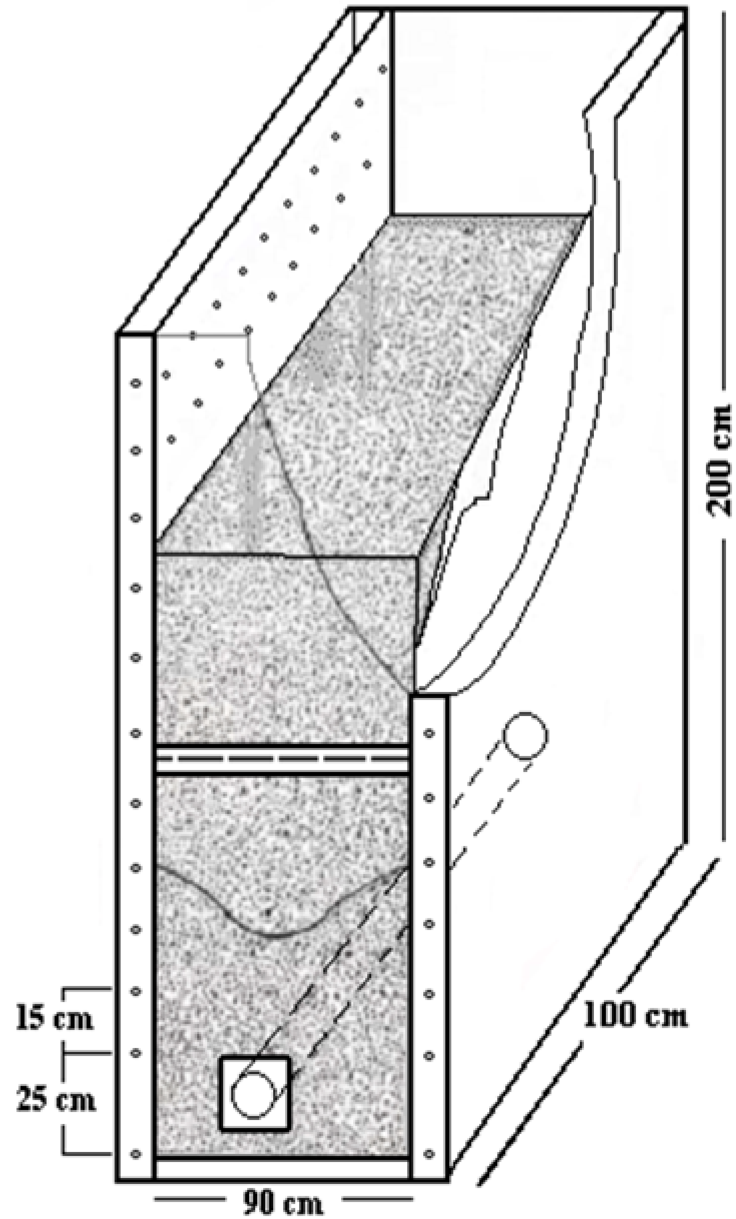
Materials and methods: Investigation of rice husk envelope

for studying rice husk envelope and comparing it with common envelope (sand and gravel) in the laboratory, a rectangular trenchlike physical model with the ability of water table regulation was used which simulate a part of drain trench.

Water table in the lateral walls is controlled by the weirs. Water flows into the soil from 4 mm diameter orifices that are placed at 10×10 cm distances in the lateral walls.



Materials and methods: Investigation of rice husk envelope

- **Experiments were conducted with two soils.**
- **Experiments were conducted with two water table at 45 and 90 cm above the drain pipe.**
- **In this research, a corrugated PVC drain pipe with a diameter of 10 cm and an envelope with 10 cm thickness were used.**
- **Soil is placed into this model to the height of 150 cm.**

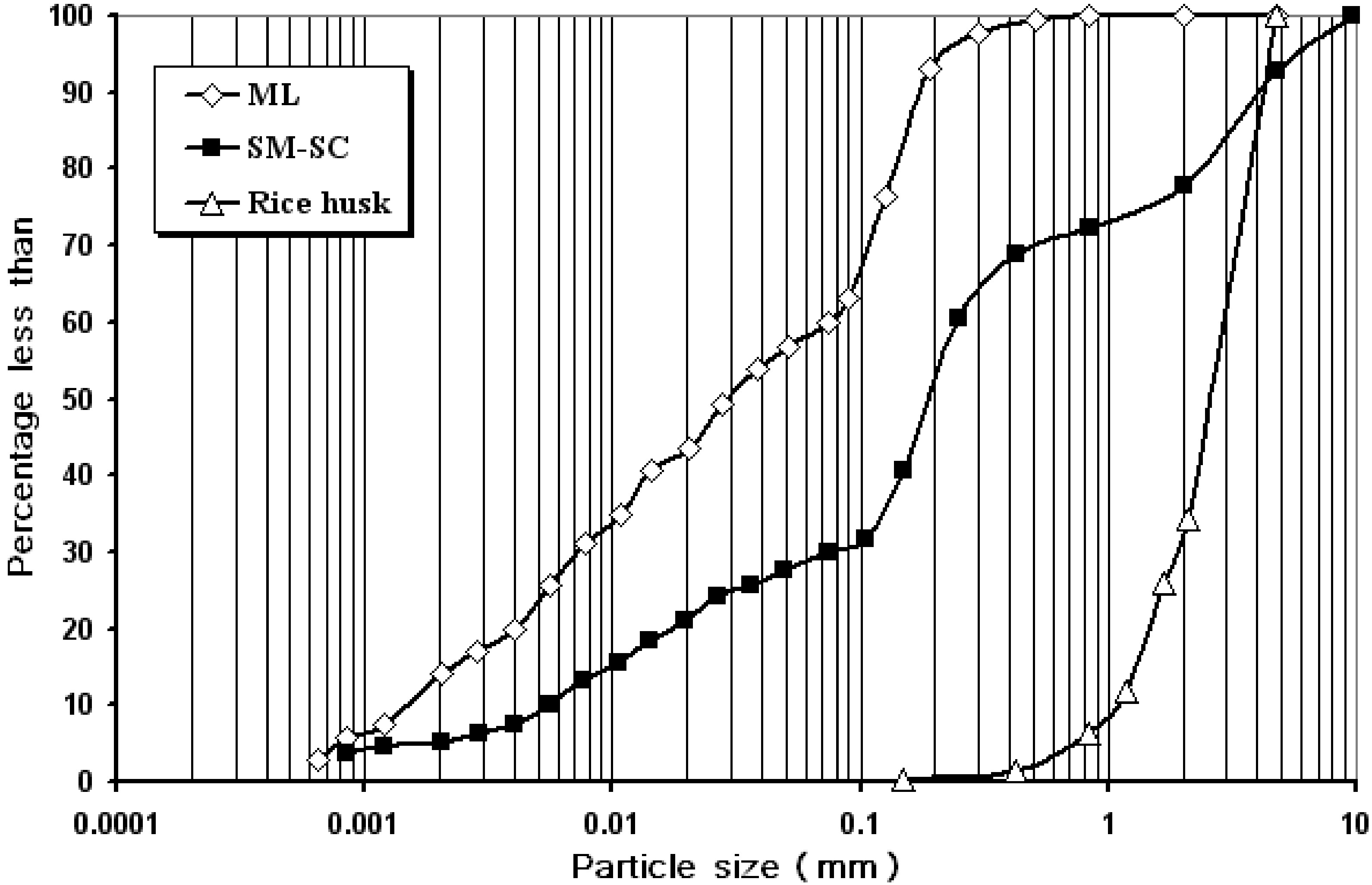
Measured parameters:

1- Discharge and temperature of drain flow was measured daily until the discharge was stable, which took few days.

2- The amount of discharged sediments and the amount that was deposited in the drain pipe were recorded at the end of each experiment.

Results

Results: Soils and rice husk gradation curve



- **Gradation curve of rice husk has low CU (Coefficient of Uniformity) that it means: particles size are approximately equal.**

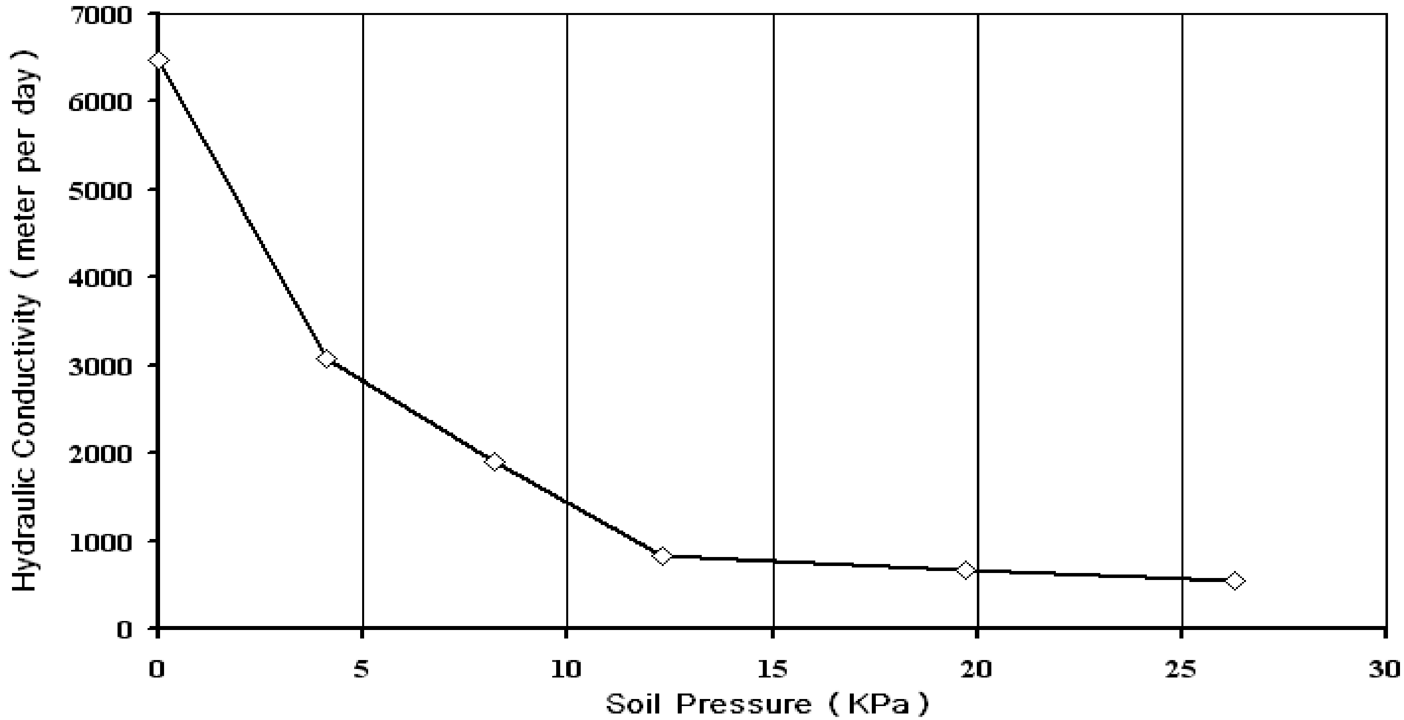
Results: Physical characteristics of rice husk

CC	CU	Porosity (%)	Water absorption (%)	Bulk density (gr/cm^3)	Particle density (gr/cm^3)
1.16	2.8	79	410	0.081	0.36

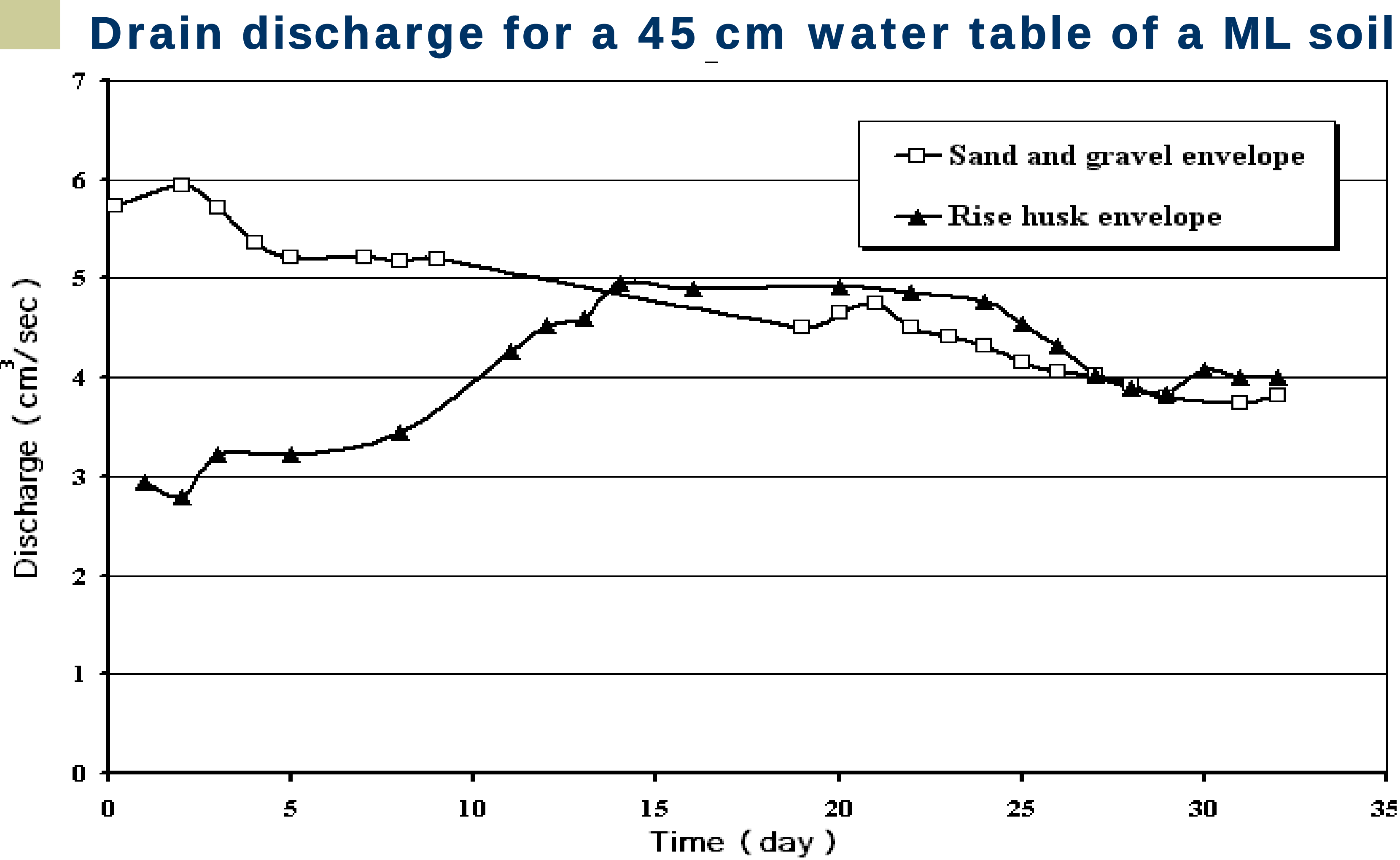
Porosity of rice husk is about 79%. The reason for high porosity of rice husk is its fusiform shape.

Results: *change of Hydraulic conductivity of rice husk under different load*

- **As shown, with increasing of soil pressure (or rice husk compaction), the hydraulic conductivity decreases, but it become stable at high soil pressure.**
- **Hydraulic conductivity of rice husk under 0-26 KPa pressure changes between 6500 to 500 m/day.**
- **Hydraulic conductivity of rice husk under high pressure is high which guarantees the hydraulic function of rice husk envelope.**

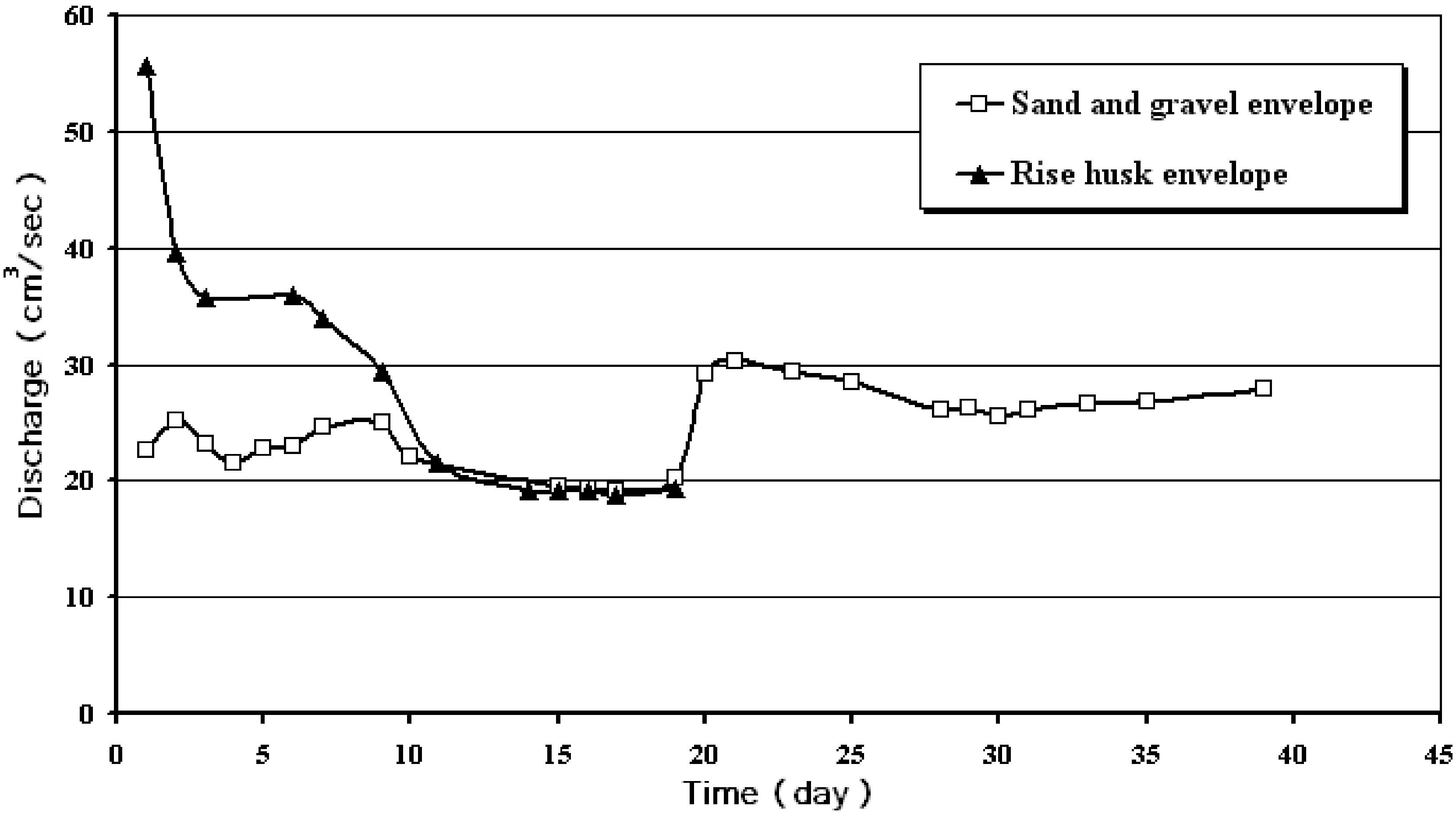


Results: Investigation of rice husk envelope and its comparison with common mineral envelope



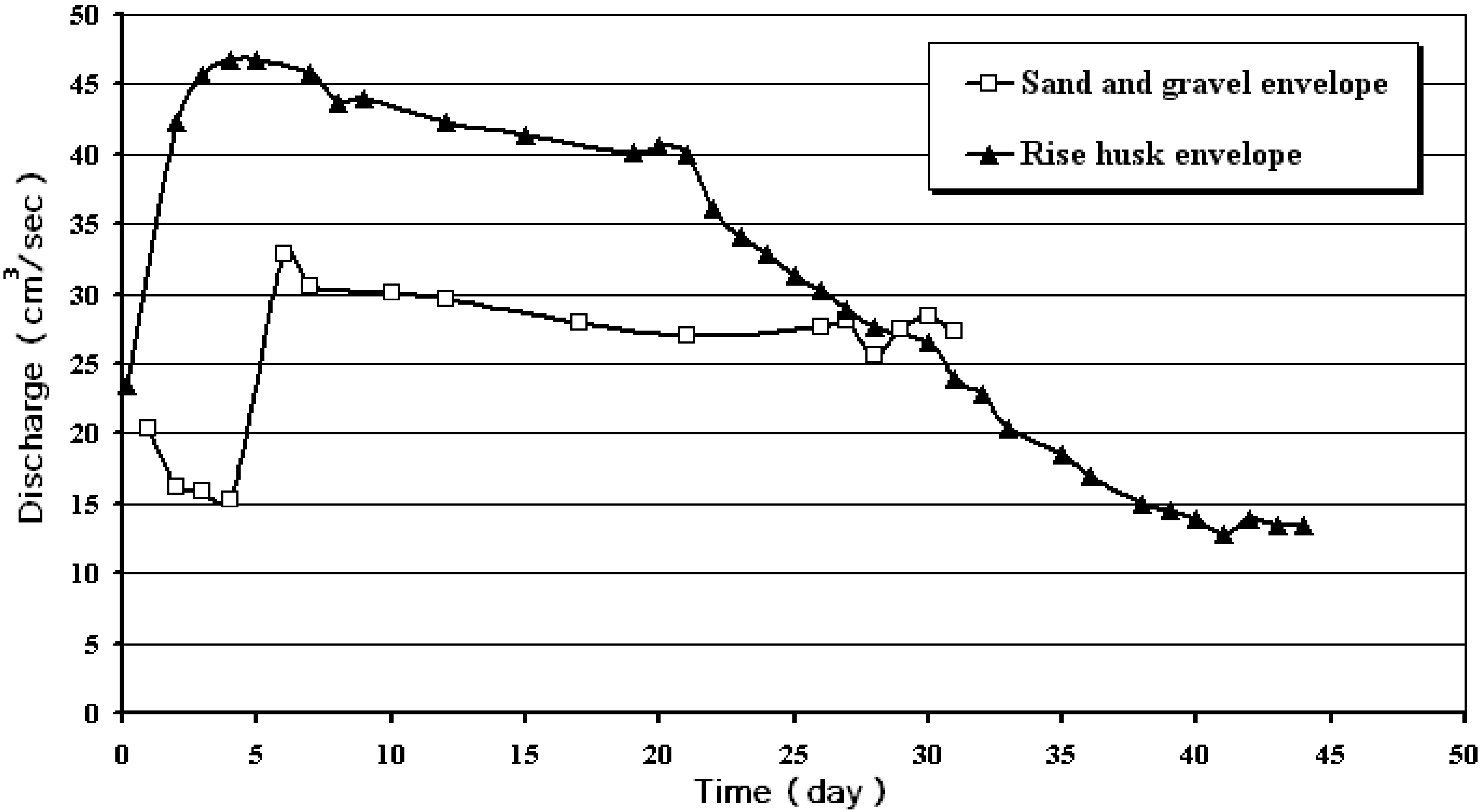
Results: Investigation of rice husk envelope and its comparison with common mineral envelope

Drain discharge for a 90 cm water table of a ML soil



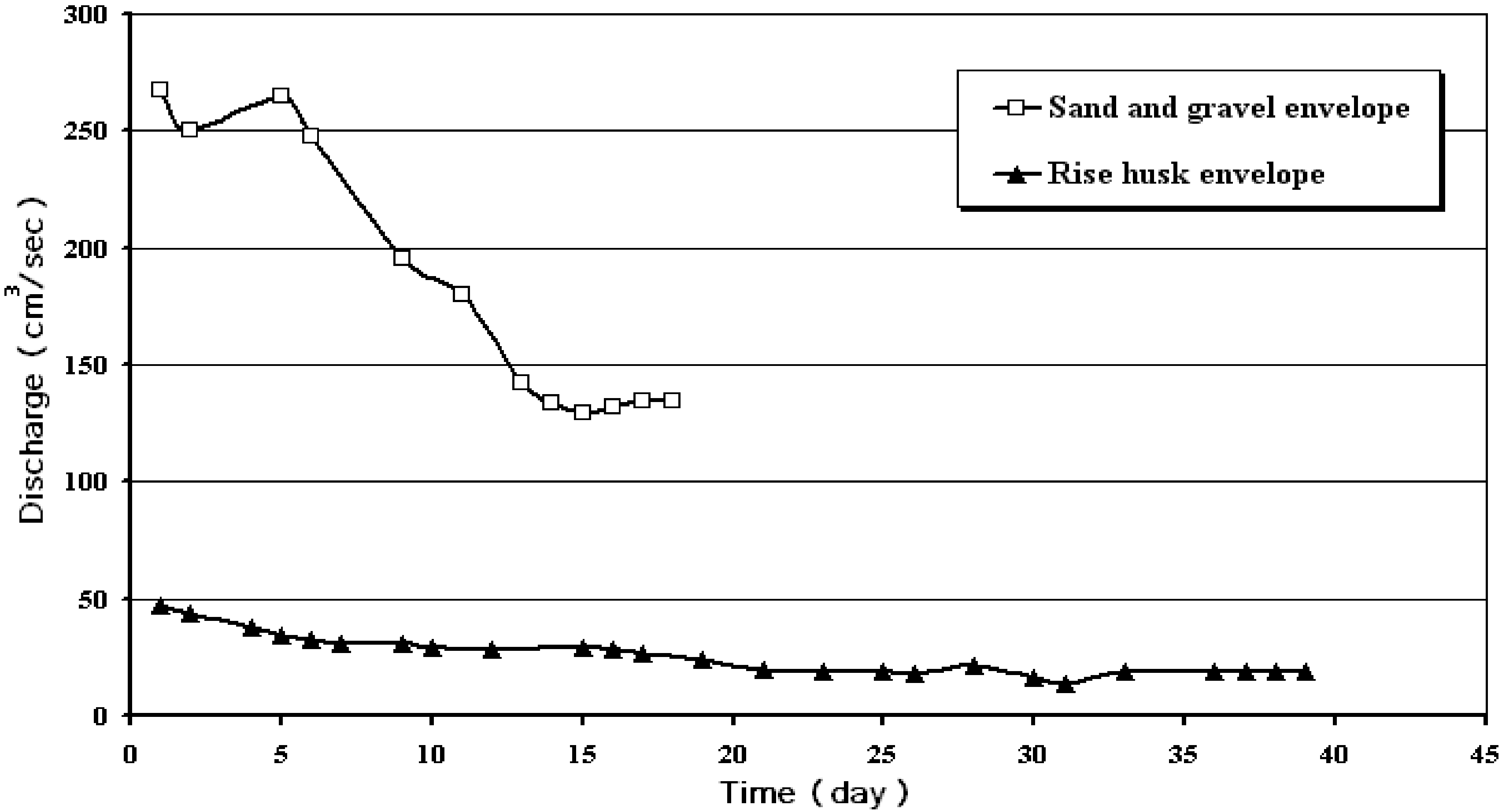
Results: Investigation of rice husk envelope and its comparison with common mineral envelope

Drain discharge for 45 cm water table of a SM-SC soil

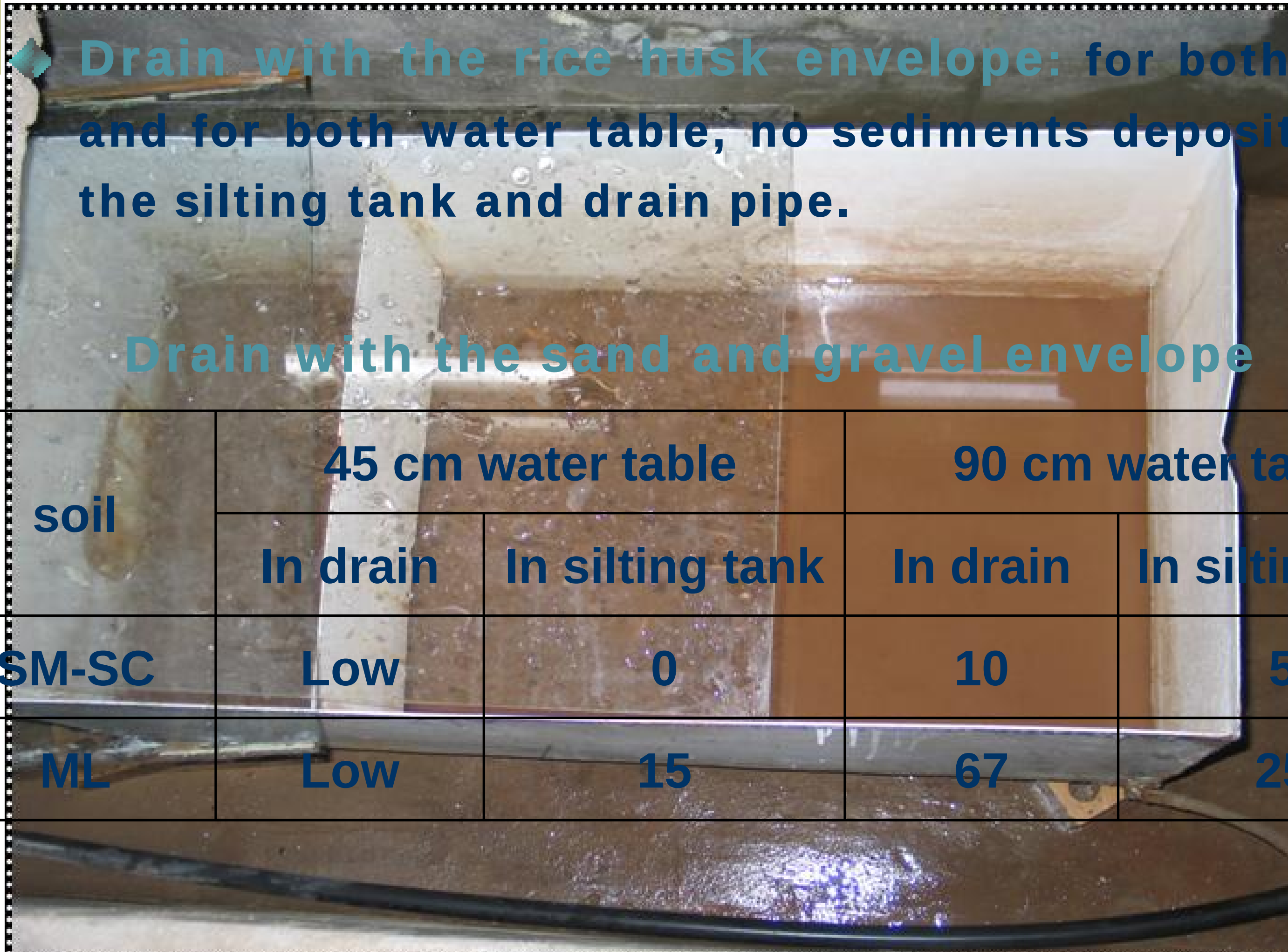


Results: Investigation of rice husk envelope and its comparison with common mineral envelope

Drain discharge for 90 cm water table of a SM-SC soil



Results: amount of sediments that silting in the drain and out of it



- **Drain with the rice husk envelope:** for both soils and for both water table, no sediments deposited in the silting tank and drain pipe.

Drain with the sand and gravel envelope

soil	45 cm water table		90 cm water table	
	In drain	In silting tank	In drain	In silting tank
SM-SC	Low	0	10	59
ML	Low	15	67	251

Conclusion

Recommendation

- ***Rice*** **husk envelope when compared with the common envelope resulted in a decreasing drain discharge.**
- **Using rice husk as an envelope is recommended in rice growing area, especially where other sources of envelope material are not available like northern parts of Iran.**
- **One reason behind this research was decreasing the cost of drainage projects by using the local sources of envelope material. Considering the amount of rice husk produced in Iran, which as said before is about 0.5 million tons annually, and using a thickness of 15 cm envelope around the pipe of 10 cm diameter, it is possible to lay more than 35 Kms of drain lines with this envelope material annually.**

- **The reason for discharge reduction from the drain with the rice husk envelope is the tiny texture, fusiform structure and low CU gradation curve of the rice husk that results in trapping of the soil particles in the envelope. This results in prevent of sediments entrying into the drain pipe. In this manner, although sediment silting risk in the drain pipe decrease, but trapped sediments in the envelope results in decreasing of the conductivity of envelope, gradually. The amount of final drain discharge confirms its.**
- **It seems that combination of rice husk and gravel preventing the risk of mineral clogging of the rice husk envelope, increasing hydraulic conductivity of envelope and decreasing the cost of drainage projects. Therefore, it is suggested that the performance of an envelope with different combination ratios of rice husk with gravel be evaluated in another research.**
- **Finally, field experiments under actual conditions of drains installation in the field is recommended in order to reach a conclusion about the use of this material as envelope.**

Thanks for your attention

conductivity meter

the conductivity meter was made with a transparent plexiglass cylinder of 8 mm thickness with a diameter of 20 cm and height of 120 cm which has two holes, one on top to keep a costant water level at the entrance and one at the bottom to act as an outlet. A piezometer was placed at the bottom for making the estimation of hydraulic gradient possible. The inlet is extended down whit a short pipe in order to prevent surface disturbance by inflowing water. Coarse gravel is filled from the bottom of conductivity meter to the piezometer installation place. Rice husk is then placed on top of the gravel layer to a specific height. Two thin metal screen plates are placed, one on top of the coarse gravel layer and one on the rice husk, to prevent the movement and washing out of the material. To simulate the pressure of the soil column on top as happens in the field, a concrete cylinder of 15 cm diameter was put on top. The amount of load is increased in each step after specifying the hydraulic conductivity. In order to spread the static load over all of the surface, an 8 mm thick netted plexiglass plate is placed on the metal screen. Because placing the concrete cylinder on this netted plate would result in obstruction of the holes on the plate and preventing the flow conduction from all of the rice husk surface, a large of coarse gravel is placed under the concrete cylinders.

physical model

Water table in the lateral walls is controlled by the weirs installed at distances of 15 cm from each other.

In order to simulate radial flow, the drain pipe is placed at a distance of 25 cm above the model bottom. Water entrance into the sides can be done by existing valves on the lowest part. With the entrance of water from this level and gradual raising of water table, entrapped air bubbles are displaced and a better saturation of soil is achived. Drain discharge is conducted to a silting tank placed behind the physical model for collecting the sediments.

physical model

$$CU = \frac{D_{60}}{D_{10}}$$

$$CC = \frac{D_{60} * D_{10}}{(D_{30})^2}$$

- The increasing drain discharge in the early days with the water table at 45 cm is due to the increasing level of water table from 0 to 45 cm. Reading the discharge with the water table at 90 cm is done when the water table is stablized at the level of 90 cm.
- In all cases, drain discharge was decreasing and finally reached in a nearly low frequency. The reason for decreasing discharge is that after filling the model with soil and during flow, soil particles around the pipe and envelope find new arrangement and smaller particles fill the free spaces between envelope particles which results in a decreasing discharge.