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EXTENDED ABSTRACT

Canal Seepage Control by Soil Combined With Sodium Carbonate and Molasses

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Introduction

Seepage reduction in earth canals is a practical way for maintaining available water resources. The use of proper and inexpensive materials is a practical way for decreasing seepage losses in canals. Experiments showed that seepage in small channels and field canals is usually more than conveyance canals. One of the most important factors for determining seepage rate is permeability of constituent materials of bed and sidewall of canal, which depends on porosity size. Smaller porosity size results in less permeability, which is proportion to squared diameter of the porosity USBR (1963).

Garg and Chawla (1970) showed the seepage rate is high in unlined canals.

Aylward and Newton (2006) determined water losses rate to be 25% in an earth canal with 82 km length and found water losses volume to be 11.9 million cubic meter along a period of 210 days of irrigation season. The results showed that water losses decreased by 30% through 45% by controlling seepage and also water losses in the canal are directly proportional to permeability.

The purpose of this research is to introduce an economic lining in order to reduce seepage losses of four-degree irrigation canals and increase their water conveyance efficiency. Hence, it is recommended to use sodium carbonate and sugarcane and sugar beet factory waste instead of use of heavy machinery for compacting of soil.

Materials and Methods

According to previous researches, a proper soil for lining is one contains at least 15% clay with cationic exchange capacity 15 mEq gram in 100-gram soil. More clay percent causes fewer problems for performing this type of lining.

If exchangeable sodium amount in a clay soil is more than 15%, sodium ion, due to being monovalent and having positive charge, is involved in clay particles and diverges them. Thus sodium carbonate, due to having sodium ion, is added to the bed and sidewall soil to provide necessary conditions for divergence. In general, sodium salt, in the amount of 15% cationic exchange capacity of soil, is added to clay for diverging 100-gram clay.

Therefore, the amount of sodium carbonate for the canal length unit is calculated by equation (1) using geometric dimensions of canal, unit weight of soil and thickness of lining:

$$Na_2CO_3 = 0.055 \times P \times d \times \rho_S \times (0.15 \times C.E.C - E.S.P) \quad (1)$$

Where Na_2CO_3: the amount of sodium carbonate for the canal length unit (kg), P: wetted perimeter (m), d: the thickness of bed and sidewall of canal mixed with sodium carbonate (m), ρ_s: the soil bulk unit mass (g/cm^3), C.E.C: Cationic Exchange Capacity (mEq gram in 100 gram dry soil), E.S.P: Exchangeable Sodium Percentage (mEq gram in 100 gram dry soil).

It is necessary to use a cementing agent in order to prevent the soil erosion. In this regard, library reviews showed that sugarcane molasses is not utilized yet for canal sidewall soil stabilization. Therefore, in this research, the use of different percentages of sugarcane molasses was investigated.

Since main base of insecticide production is sulfur, the canal lining would be protected against invasive insects. Thus the lining is combined with different percentages of sulfur, including zero, two, four and six; and is ironed by a roller. The ironing of lining by hot roller results in a chain of sulfur layers on it. This action stabilizes the lining against water erosion in addition to repelling insects.

Dez Irrigation System was selected as a pilot study to investigate for the lining. After field observations, it was provided about ten samples from the different areas. The textures of samples soils are loam, silt-loam, and silt-clay-loam.

In this study, the saturated samples in falling head experiment for determining the permeability were used. According to the field environment, water flowing in canal leads to sidewall saturation, and after irrigation, the canal is dried, thus the operating conditions are such that it will change pore pressure of canal sidewalls. Wetting and drying of the canal sidewall may create its sliding conditions. Hence, determination of shear strength parameters is significant and necessary for all scenarios. Then, direct shear experiment was conducted. Finally, scour depth of all samples in the flume was measured.

Results and discussion

It was previously noted that the first priority of this study is to control seepage in earth canals using sodium salts. These salts, due to the environment alkalization, cause deactivation of calcium and magnesium cations and ultimately lead to the soil structure collapse. It was determined electric conductivity, sodium absorption ratio, exchangeable sodium capacity and cationic exchange capacity for all samples.

Four samples were selected as control samples among ten samples. The samples were with different percentages of sodium carbonate afterwards. And the hydraulic conductivity coefficient using falling head experiment for all of them was obtained. The results are shown in the table (1).

Table 1– Hydraulic Conductivity Coefficient Rates for Different Percents of Sodium Carbonate

Sodium Carbonate Percentages	hydraulic conductivity coefficient rates (cm/s×10^{-7})			
	No. 1	No. 2	No. 3	No. 4
0	0.067	1.49	1.79	9.38
2	0.056	1.27	1.03	9.25
4	0.053	0.99	0.84	8.11
6	0.048	0.72	0.66	7.24
8	0.041	0.63	0.57	6.30
10	0.039	0.53	0.51	5.54

Then the samples were mixed with 2 to12% by weight of sugarcane molasses and it was measured soil shear strength parameters. The results show cohesion coefficient and internal friction angle rates increase by increasing molasses percentages. The results give the maximum shear strength parameters for 10% molasses. While in sample No. 4, despite 30% clay, the maximum cohesion coefficient and maximum internal friction angle are obtained from the soil sample combination with 6% molasses.

According to instructions given in materials and methods section, a sulfur-heated layer was used to solve erosion problem. The chained membrane created by sulfur is rolled out by hot rollers on the soil surface, which increases the soil resistance against scouring like an armor layer. To evaluate the performance of this method, the surface layer of the soil was covered with various sulfur percentages. This procedure was performed by combining 2, 4 and 6% by weight of dry soil samples. The observations showed that sulfur addition to surface layer is effective and even with addition of the lowest possible (2%), erosion problem is controlled to a significant degree.

Conclusion

Based on the results obtained from all conducted experiments, the following results can be obtained:
In this study, the 10% increase in sodium carbonate reduces its permeability to zero. Increasing molasses in soil leads to an increase in shear strength parameters of the soil. The investigations showed that the combination 6 to 10% by weight of molasses in soil resulted in a significant increase in shear properties of the soil. The satisfactory results of experiments on permeability and erosion in a canal lining with mosaics made of soil with different percentages of sodium carbonate and sugarcane molasses and a small percentage of sulfur, showed that this material provides all necessary criteria for lining traditional irrigation canals. The construction cost of this lining type is very low compared to conventional linings.

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