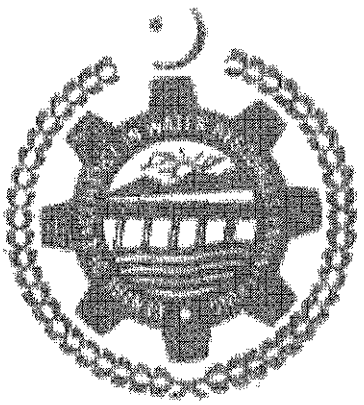
THESIS

INFILTRATION CONTROL AND IMPROVE ROOT ZONE WATER DISTRIBUTION EFFICIENCY IN COARSER SOIL BY USING BENTONITE AMENDMENT



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ABSTRACT

Demand of food is increasing day by day in Pakistan due to population growth thus marginally available land is increasingly being brought under irrigation as Thal, Cholistan, Thar deserts and vast barren areas of Balochistan in Pakistan, where soils are predominately coarser. An extensive irrigation system is being developed in Greater Thal Canal area and surface irrigation method (Basin) is likely to be used. The infiltration characteristic of the soil is the most important factor for the performance of surface irrigation. The Greater Thal Canal (GTC) area soils are predominately coarser which results to deep percolation losses much higher than the losses in other cultivated land. Infiltration may be described by the Kostiakov Equation. Soil amendments like bentonite could be used to reduce infiltration rate. The objective of the study is to control the infiltration in the coarser soil by the use of bentonite admixture to improve water distribution uniformity.

For experimental study the soil sample, having hydraulic characters identical to the soil of GTC area, was collected from the River Ravi flood plain area. Infiltration tests were conducted by using single ring infiltrometer arrangements ensuring complete vertical flow in the soil sample. To prepare soil-bentonite admixture 1 and 2% bentonite by weight was mixed in 2.54, 5.04, 7.62 and 30 cm soil depth. Infiltration readings were obtained without and with mixing of bentonite. Then graphs were drawn between infiltrated water depths and time for various combinations of soil-bentonite mixtures and admixture depths. Curve matching method was used to determine Kostiakov infiltration parameters **a, b** and $\mathbf{f_o}$. These parameters were then used in SIRMOD model to determine irrigation application performance for a typical irrigation field without and with bentonite

admixture. Best admixture ratio and depth combination determined from lab results was tested in GTC area (Near Adhikot). Infiltration tests were conducted in filed soil and irrigation performances were evaluated by SIRMOD.

It was observed for lab test the curve fitting parameters of Kostiakov eq. without using bentonite ware; a = 0.016, b= 0.655 & f_o= 0.0004. Using 1 % bentonite amendment the curve fitting parameters resulted; a = 0.011, b = 0.59 & f_o = 0.0004 for 2.54 cm mix depth, a = 0.0097, b = 0.56 & f_o = 0.0004 for 5.08 cm mix depth, a= 0.0099, b= 0.565 & f_o = 0.0004 for 7.62 cm mix depth and a= 0.0095, b= 0.538 & f_o= 0.0004 for 30 cm mix depth. For 2 % bentonite amendment it resulted a = 0.0064, b = 0.4 & f_o = 0.00038 for 2.54 cm mix depth, a= 0.0052, b= 0.37 & f_o= 0.00038 for 5.04 cm mix depth, a = 0.0065, b = 0.38 & f_o = 0.00039 for 7.62 cm mix depth and a = 0.0056, b = 0.35 & f_o = 0.00038 for 30 cm mix depth.

The cumulative one hour infiltrated water depth without using bentonite was 21cm. Using 1 % bentonite it reduced to 13.5 cm for 2.54 cm mix depth, 13 cm for 5.04 cm mix depth, 12.5 cm for 7.62 cm mix depth and 12.25 cm for 30 cm mix depth. Using 2 % bentonite it resulted 5.4 cm for 2.54 cm mix depth, 4.75 cm for 5.04 cm mix depth, 5.5 cm for 7.62 cm mix depth, and 4.25 cm for 30 cm mix depth.

Kostiakov parameters were then entered into SIRMOD model along with following typical field data: Field Length = 60 m, as area acre size is 60×67m, Field width = Half Acre (33.5 m), Discharge (1.5 cfs) = 1.25 lps/ m of width, Roughness coefficient = 0 .04, Targeted Infiltration Depth = 0.05 m, Time of Cut off = 50 min. SIRMOD results shows that water traveled only 19 m along the field for no amendment case because all the water deep percolated before reaching at the field end. Using 1 %

bentonite mixing result shows that water did not reach at field end and water traversed only 32 m for 2.54 cm mix depth, 38 m for 7.62 cm mix depth, 39m for 5.04 cm mix depth and 37 m for 30 cm mix depth. Using 2 % bentonite water will reach the tail end of field with Distribution Uniformity 80% for 2.54 cm mix depth, 84.5% for 5.04 cm mix depth, 90.9% for 7.62 cm mix depth and 84.9% for 30 cm mix depth. The best combination observed in lab tests was 2 % bentonite in any depth (2.54 cm – 30 cm), which gives satisfactory results for lowering infiltration rate in coarser soil and achieving better water distribution.

Best combination of soil-bentonite admixture was then tested in coarser soil of GTC area. Kostiakov curve fitting parameters for field (GTC) tests before mixing bentonite was a= 0.012, b= 0.9 & f_o= 0.0004. It resulted a= 0.0066, b= 0.383 & f_o= 0.00038 for 2% bentonite mixing in 5.08 cm depth. It was observed that the cumulative one hour infiltrated water depth without using bentonite was 50 cm and it reduced to 5.5 cm for 2% bentonite mix. Without bentonite amendment the SIRMOD results shows that water traveled only 10 m along the field. When 2% bentonite mix the resulted Distribution Efficiency was 80.5%.

It is concluded that adding of bentonite decreases the infiltration rate of coarser soil and improves the irrigation water distribution. The Kostiakov infiltration equation parameters **a, b** and $\mathbf{f_o}$ decrease when percentage of bentonite increases. For 1 % bentonite mixing the 1 hr infiltrated water depth is 13.5, 13.0, 12.5 and 12.25 cm for mix depth of 2.54, 5.04, 7.62 and 30 cm respectively. For 2 % bentonite mixing the 1 hr infiltrated water depth is 5.4, 4.75, 5.5 and 4.75 cm for mix depth of 2.54, 5.04, 7.62 and 30 cm respectively. The percentage of bentonite mix is more significant than the depth of

mix in reducing infiltration rate. For 1 % bentonite mixing the irrigation water does not reach end of field and advance distance is limited to 30 to 40 m only for various mix depth. For 2 % bentonite mixing the water reaches to tail end of field and distribution uniformity varies as 80 to 85% for various mix depth. 2 % bentonite by weight mixing in any depth of soil produces satisfactory results for lowering infiltration rate in sandy soil of Greater Thal Canal area. The cost of amendments of 2 % bentonite mixing is Rs: 21,600, 43,200, 64,800 and 2,55,100 per acre for mixing depth of 2.54, 5.08, 7.62 and 30 cm respectively and is prohibitive for farmers' adoption.

Study recommends that 2 % sodium bentonite may be used to improve water distribution uniformity in sandy soil of GTC area. Bentonite should be mixed before planting of the crop. Uniform spreading and mixing in soil should be ensured to achieve the desired results. Rotavator or tine cultivators can be used for bentonite mixing, with mixing restricted mixing to selected soil depth only. Soil bentonite admixture amendment is costly, so government should encourage the farmers in adopting soil-bentonite admixture technique by subsidizing the bentonite cost at least 75%. SIRMOD model only consider single uniform soil layer within the root zone. While mixing of bentonite results in two layers in the root zone which have different infiltration rate. It is recommended that modification be made in SIRMOD model to model the two layer flow.