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Study of groundwater filtration system by sand-mix method

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Abstract— The present paper discusses the analysis of groundwater recharge into the porous medium for the need to sustain the ground water table. However, the runoff through the different porous medium entraps various types sediments and other floating objects whose removal are necessary to avoid pollution of groundwater and blocking pores of aquifer. For evaluate the performance of filter system consisting of coarse sand (CS), gravel (G), marble chips and Boulders (B) layers, a laboratory experiment was conducted in a rectangular column (200mm×160mm×1200mm). The effects due to variable thickness of Cs, G, marble chips and B were observed and sediment concentration of effluent water was evaluated. Coarse sand (CS) of three particle size i.e.150, 300 and 600 micron as the top layer of recharge filter for influent sediment concentration of 250mg/l-3000mg/l. the performance was evaluated in terms of spatial movements of sediments, removal efficiency, recharge rates and clogging time. The results indicated that more than 60% suspended solids, were entrapped in the top 10 cm layer of CS, the removable efficiency improved with the increasing thickness of CS layer and the recharge rate of influent concentration declined sharply for influent concentration more than 1000mg/l. For the interpretation of the results various physical and chemical properties of the effluent water is evaluated.

Keywords— filtration system, sand-mix, groundwater recharge

1. INTRODUCTION

In nature, Groundwater is a key element in many geological and hydrological chemical processes, which sustains Groundwater, is used in meeting about 60% of irrigation demand and 80% of drinking water requirement in India. Due to excessive use groundwater table is declining at an alarming rate in about 15% of India's geographical area. Water tables in fresh groundwater regions of the north-western states of India, particularly in Haryana and Punjab, have fallen at an annual rate of 25-70cm over the past 2-3 decade and threatening the sustainability of agricultural due to escalation in pumping costs, deterioration in groundwater quality and associated socio-economic and environmental factors (Taneja and Khepar,1996).The rate of groundwater decline can be slowed down to some extent by enhancing groundwater recharge(GR) using rainwater, which may also lead to improvement in groundwater quality. Artificial groundwater recharge is a process by which the groundwater reservoir is augmented at a rate higher than the rate of natural recharge.

The non-linear, partial-differential equation characterizing the unconfined aquifer receiving uniform vertical recharge from a rectangular spreading basin is solved numerically. The method of solution consists of the alternating-direction implicit scheme with inhomogeneous grid spacing. The numerical solution is compared with an available linearized solution for a flow system in which the rate of recharge is much smaller than the hydraulic conductivity of the underlying aquifer. The comparison shows that the values of the maximum scheme are always higher than those calculated from the linearized solution.

They argue that the community or otherwise of a mathematical model to Hurst's empirical law is determined by its asymptotic properties but rather by its behaviour over the relevant interval of finite n-value, says100 years < n < 1000 years. They show that for gamma distributed inflows with appropriate shape parameter the adjusted range of cumulative sums has local Hurst exponent in the neighbourhood of 0.75 over the desired time interval (confirming in detail an earlier note of Moran's on this topic), and draw attention to the desirability of investigating whether a similar result might hold for the rescaled range for these inputs. Artificial groundwater recharge is of increasing importance as an essential component of water-management programs. The fluctuation of the water table in response to recharge depends on the size and shape of the recharging area, on the duration and the type of the recharge rate, and on the hydraulic and geometric parameter of the underlying and geometric parameters of the underlying aquifer. In order to tackle the twin hazard of de-saturation of aquifer zones and consequent deterioration of groundwater quality, there is an urgent need to augment the groundwater resources through suitable management interventions.

2. OBJECTIVES

i. The field operation indicates there is need for through investigation of the use of filtering media to achieve high infiltration rates in recharging well.
ii. The filtration unit must perform effectively to get potential benefits from the installed recharge structures.
iii. The most critical issue with regard to the efficiency of the filtering unit is clogging, i.e. decrease in permeability of filtering medium as a result of governing physical processes.

iv. In additional, there are no well-defined criteria for designing the thickness of different layers of filter materials and is exposed first to runoff water for retaining particulates suspended in it. The particle size of CS or MS, therefore, plays an important role, but it is not standardized.

3. METHODOLOGY OR EXPERIMENTAL SETUP

As it is difficult to study the impact of a large number of treatments involving different media size and sediment load of influent water on clogging, removal efficiency, recharge rate and sediment penetration under actual field conditions, therefore laboratory study is conducted under uniform flow conditions.

The laboratory study is conducted in a rectangular column of (B×W×H) 200mm×160mm×1200mm and having provision of regulated water inflow and free outflow. Inlet is provided in the upper portion of the column to maintain a constant hydraulic head manually during the test run. Sampling ports, consisting of PVC pipes of 12.5mm size and perforated in the upper half portion are fitted horizontally at different depths in the column to collect sample of flow through water and spatial movement of sediments in the filtering medium. Outlet is provided at the bottom of column to drain out filtrate water. Measuring bucket is provided at the bottom of the column to measure the filtrate water from the outlet. One concentric gallon is provided at the bottom of the column in such a way that only the flow through water is collected in the gallon. The filtrate collected in the gallon is utilized for further analysis. In total nine sampling ports are installed: The first three being 5cm apart and remaining six at 10cm distance from each other. These sampling pipes are not perforated upto 5cm on both sides near to the column walls to ensure that the water moving along the side of the column is not mixed with the flow-through water. Two concentric collectors were provided at the column in such a way that only the flow through the water was collected in the inner collector and the water flowing along the sides of the column was collected in the outer collector.

Figure 3.1: Module used for testing

Gravel (size 10-20mm and 300mm thickness) and boulders (size-20-40mm and 300mm thickness) are used as supportive layers below CS. Experiments are conducted with varied concentration of sediment load in the recharging water to simulate field condition of runoff. Gravels and boulders sizes as well as thickness are kept constant for all treatment combinations. A cloth net is used at the top of the coarse sand to dissipate the impact of inflow sand mixed runoff water to minimize the displacement of CS particles. Clean tap water is passed through filtering medium for 10 minutes before each experiment run to drain any soluble materials. Experiments runs are performed with sediment load of 250mg/l and replicated three times: scheme of experimentation is summarized.

a. Details of Materials Used

Table 1- Detail of materials used

Materials	Passed through Is sieve	Retained on Is sieve	Height of material in test apparatus
Coarse sand	1.81mm	600,300,150micron	30cm
Marble chip	4.75mm	2.36mm	10cm
Gravel	12.5mm	10mm	30cm
Boulder	40mm	20mm	30cm

b. PHYSICAL PROPERTIES:

Table: 2 Physical Test results

S.N.	Parameter	For 600 micron soil (Syntheti		For 300 micron soil (River water)		micron soil (River water)		Allowable values by Is codes
		Before experiment	After experiment	Before experiment	After experiment	Before experiment	After experiment	
1	Colour	Light yellow	colourless	yellowish	Colourless	Yellowish	colourless	5 (unit of platinum cobalt scale)
2	Turbidity	27.6 NTU	4NTU	12NTU	3NTU	12NTU	3NTU	1-5 NTU
3	Odour	Earthy Scent	Earthy scent	Pungent smell	Earthy scent	Pungent smell	Earthy scent	Un-objectable
4	pH	6.7	6.8	6.4	6.7	6.4	6.7	6.5-8.5

c. CHEMICAL PROPERTIES:

Table: 3 Chemical test results

S.N.	Parameter	micron soil (Syntheti c water)		micron soil (River water)		micron soil (River water)		Allowable values by Is codes
		Before experiment	After experiment	Before experiment	After experiment	Before experiment	After experiment	
1	Alkalinity	164.53	120.25	588	196.5	588	185.4	200
2	Acidity	4.6	4	6	5.2	6	4.9	
3		8	7	57	24.6	57	23.6	
4	ry	118.6	116.7	278	176.6	278	168.3	
5	Hardne	126.6	123.7	335	293.5	335	284.8	

4. RESULT & DISCUSSION

The performance is evaluated in terms of recharge rate and clogging time. From the experiment carried out the following conclusions are obtained:

i. More than 60% of the suspended solids were solids were entrapped in the top 10 cm layer of CS the level of accumulation in the upper layer increased with the turbidity of influent water.

ii. Maximum retention of sedimentation is the top10cm layer was observed in T3 having larger intrinsic pores and its recharge rate also reached a constant level later than in T1 and T3 regardless of influent sediment concentration. These results suggest that the performance of CS media can be improved by using the higher sizes of CS particle in the filtering media.

iii. The recharge rates through all CS beds were substantially high at inflow concentration of 1000ppm or less. A sharp decline in recharge rate was observed at higher sediment concentration of all sizes due to quick clogging of flow pathways of recharging water. These results suggest that the performance of CS beds in the field can be improved by making some provision to reduce higher sediment load of inflow water to a lower level before it approaches the filter bed.

iv. Treatments with the higher thickness of CS media indicated that the recharge rate is slightly more than of treatment with lower thickness of CS media.

5. CONCLUSION

Data collection and their interpretation is a very important work in any groundwater recharge study .The present study evaluates the performance of the module in terms of recharge rate and clogging time. The experiment was carried out in the laboratory for the influent and effluent water to evaluate their physical and chemical characteristics. It was observed that more than 60% of the suspended solids were entrapped in the top 10cm layer of CS, the level of accumulation depend upon the amount of turbidity present in the influent water. On another hand, the treatment with higher thickness of CS media indicates the recharge rate is little bit more than that of treatment with lower thickness of CS media. The maximum retention of sediment was observed in the top 10cm layer was observed which suggests that the performance of CS media can be improved by using higher size of CS particle in the filtering system. The relationship is observed higher will be the sediment load and higher will be clogging in the filtering media.

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Abbreviations and Acronyms

Abbreviations	Descriptions
CS	coarse sand
G	Gravel
B	Boulders
NTU	Nephelometric turbidity unit
GR	groundwater recharge