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USE OF GEOSYNTHETICS IN WATER HARVESTING

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***Abstract*—The excess rainwater in monsoon is drained-off by the storm water drain with negligible water recharge . The various water harvesting methods incorporating geosynthetics have been proposed to save the water. The geogrid, geotextile can be incorporated in the geotechnical applications to improve the ground water table. These materials are water preamble and easy to apply in the conventional drainage system. Water recharge test rig has been constructed using RCC pipes at various locations having different soil type. The water recharge rate has been measured at regular interval. It is mainly applicable in residential area of urban regions and certain industrial area. 'Water recharge pit' also have been constructed using sand, locally available aggregate materials and nonwoven fabric. The location of pit should such that accumulated rainwater available to maximize water recharge. The amount of water recharged has been measured through the pit. The study shows that the needled nonwoven fabric in combination of geogrid filters the rain water and accelerates water recharge rate. The water harvesting using geosynthetics is cost effective way for the ground water recharge. It also help in resolving the water logging in heavy rains.**

***Keywords*— Geosynthetics, rainwater, water harvesting, recharging, stram water drain, water logging, recharge-pit.**

PREAMBLE

The rainwater is the main source of the water for human life. As forecasted by the environmentalist, geo-climatic experts that there will be water crisis in many parts of the world, which can even induce a water war. In India, water conservation at some extent is being done through various water harvesting-works such as check dams, minor irrigation schemes (MIS), medium dams, percolation tanks, recharge wells, spreading canals. The water conservation has increased the soil humidity and yield of agriculture products contributing in raising the GDP.

Government of India have launched SEZ scheme for large industrial zones and various housing projects. During monsoon season, the rainwater collected from all these areas can be prevented from flowing off as waste. It will prove a boon for the water conservation to meet with huge water requirement. Certain water logging spots especially in open and uneven grounds are often troublesome for public health, sports activities, and even physical training of defense, police, and security personals etc. The water recharge schemes can save the water and ease the problem of water logging providing easy commuting and better health conditions especially in urban area. The physical training and sport activities can also be carried out smoothly during monsoon as water evacuates much faster.

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OBJECTIVE

Water for irrigation is required to pump up and transported through pipelines. It involves capital cost, cost of water pumping and maintenance cost of water works. In India there are several regions, where the water network systems yet to be made and some of these regions even face the problem of drinking water especially in lean year of rainfall. In such cases domestic water harvesting is amicable solution to meet the water requirements. Due to increase in the population and the industrial development, various town development is in progress leading to expansion of urban regions. In these areas storm water drains are required to be laid using the network of underground RCC hume pipes. These pipes are normally connected using a traditional RCC collar joint and spigot joint in case of NP2 pipes and NP3 pipes respectively. These joints are supposed to be sealed properly so that it does not allow water to leak through. If the aforesaid joints can be replaced by the joints which neither allow the silt, suspended particles etc. of storm water to drain in to the surrounding ground nor the outside clay enter inside the drain then it can allow the inside rainwater from the drain pipe to ooze and recharge the ground water. A newly designed permeable geo-fabric-grid joint can be incorporated in to the drain pipes which are laid below the ground level. The objective of this project is to device efficient and cost effective water harvesting systems and to measure water recharge rate using in-situ field conditions.

STORM WATER RECHARGE DRAIN

A. *Experimental Methods*

A drain set-up has been prepared using water tank and drain pipes. As shown in Fig. 1 two NP2 60mm RCC hume pipes, 2.5m in length have been laid in series, having one end of each pipe sealed completely, 1 m below the ground level. A water tank kept at suitable height from which a water inlet pipe is connected to one of the covered faces of the pipe.

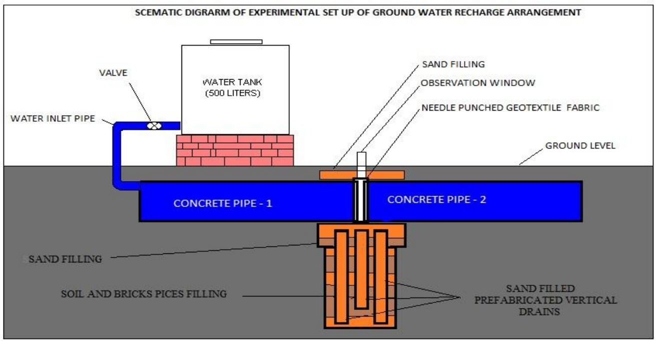

Figure 1. Schematic diagram of water recharge test rig

The pipes have been laid with normal slope to allow the water to flow from one end to other, such that open ends facing each other with a gap of 190mm. The gap is covered using a geosynthetics joint made from HDPE geogrid and Polypropylene needle- punched nonwoven geotextile. The overlapped portion of the fabric is sealed with mortar for the stability of the joint (Fig. 2). The surrounding of the joint has been covered with 150mm thick sand filling, which acts as a media for the water to be recharged. The filling can also be comprised of coarse sand, remains of sand screening, small size gravel etc. Prefabricated vertical drains filled with sand also have been used below the joint. The pipe set up was filled with water daily once for 3 successive days for conditioning the soil. Thereafter, it was filled completely with water and then measured quantity of water has been added every hour for maintaining the level for the next period of 8 hours, for 5 successive days in each case.

B. *Results and discussion*

The water recharge depends on the area of the joint exposed to the recharge media i.e. surrounding soil and sand filling. The area is a function of width of the joint and circumference of the pipe. The net water recharge R can be given as: $R \propto AP$, i.e. $R \propto wdP$

Where, R = Recharge of water
A = Area of joint exposed to water
w = Width of gap in the joint
d = diameter of pipe
P = Permeability of soil

The study is carried out at two different sites having different type of soil. At site A, the soil permeability is greater than 100 x 10^{-6} cm /sec whereas at site B, black cotton soil is available.. The recharge could be even more in case of highly permeable soil in certain regions of India. The total full capacity of the drain set-up is 1441 liters. The water intake during the conditioning period was more than the full capacity of the drain set-up. During the test days at the start, first water intake was higher however it was found reducing every next day. Excluding the first water intake amount of everyday which is higher due to comparatively dry condition of the soil, the average intake of water have been calculated in the range of 310 to 350 liters per hour in case of Site A. However for the estimation of total water recharge of the season, lower limit is considered. Data of the region show on average, total rainfall recorded for about 22 days in every monsoon. (Table 1).

Figure 2. RCC pipes connected using geosynthetic joint

TABLE 1 RECHARGE BY STORM WATER DRAIN A MONSON

Sr. No.	*Level of water flowing in drain pipe*	*Number of days*	*Recharge per day(liters)*	*Rechar ge per monson (liters)*
1.	Storm water pipe if running full	11	24 x 310	81840
2.	Storm water pipe if running half	6	24 x 155	22320
3.	Storm water pipe if running one forth	5	24 x 55	6600
Total		22		110760

Considering the variation in the intensity of rain, on average the storm water pipe running full for about 11 days, at half the depth for 6 days and one forth depth for 5 days, the total recharge has been calculated on volume fraction base that will be available per joint of 190 mm width.

The statement of water intake every hour 11 a.m. onward during the daytime is given for the period of the experiment conducted at two different sites. In both the cases it is observed that total water intake of 8 hours in daytime observed higher on day 1 which gradually decreases marginally for successive days. During the each day also water intake varies depending on the temperature and moisture content of the surrounding soil filling. The test has been carried out during 4th week of May at site A and during 2nd week of May at site B prior to monsoon.

The average recharge rate for the duration of each hour has been calculated from the data of water intake for 4 days to estimate the net average water recharge rate. The average water recharge rates of each hour from 11 am to 6 pm have been compared for both the types of soils (Fig. 3). It may be noted that type of soil available at site B is black cotton soil having poor permeability of about 0 to 1.0 x 10^{-6} cm /sec, as a result average water recharge rate is lower as compared to that of site A.The other design parameters such as width of the preamble portion in the joint and the number of such joints per unit drain length also can be appropriately selected for the actual field condition. Depending on the rainfall and soil conditions, the suitable joint can be designed by selecting the width of joint and permeability of geotextile. The frequency of the joint also can be decided base on the availability of water, type of soil receiving recharge etc.

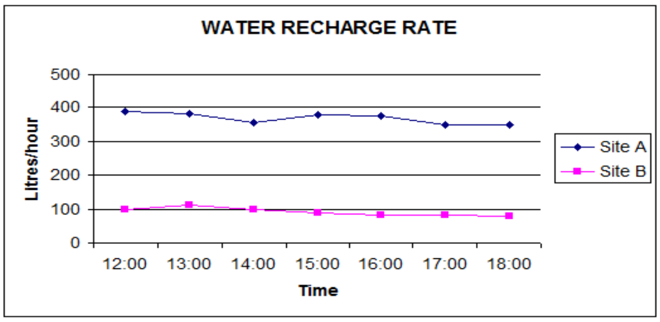

Figure 3. Average water recharge rate at various sites

C. *Cost Comparison of Joints*

The picture of recharging of water is rosy and quite encouraging. The storm water drain is normally constructed laying the RCC hume pipes using the RCC collar joints. The same drain system is required to be modified by geosynthetics joint for recharging of rain water. Economically viability of proposed technique has been checked by comparing the cost of conventional RCC collar joint and the new geosynthetics joint. The total cost of each of these joints has been estimated considering the material and labour costs at current rates. designed for two affiliations.

1) *Rate Analysis of RCC Collar Joint*

The details of cost of providing and laying in position NP2 RCC pipe as per drawing with collar ends including filling the joint with cement mortar (1:1) etc. have been given Table 2(A)

2) *Rate Analysis of Geosynthetics Joint*

The details of cost providing and fixing in position Geotextile fabric with HDPE geogrid for 600 mm NP2 RCC pipe as per drawing with welcrow fixture have been given in Table 2(B) .

The total cost of RCC collar joint works out to (INR) 950 per joint and that of new geosynthetics joint is (INR) 730 with net saving of (INR) 220 per joint; And in terms of economics the externality will be recharging the water more than one lac litres per joint per year.

The geosynthetics joint also can be used in sewage water lines after confirmation from health department about safety of the users. This micro-recharge system is applicable mainly in the urban area where storm water drain is required to be laid.

WATER RECHARGE PIT

Proposed water harvesting system viz. 'Recharge Pit' can be implemented in any region where collected rain water is available. The pit can be made by first digging out the soil below the ground level and then filling it with various materials such as coarse/fine sand, coarse/medium aggregate and other waste materials such as wastage pieces of hume pipes, brickbats, plastic bottles, tin cartoons etc. in the appropriate layers. The pit dimensions can be decided depending on availability of rainwater at the site.

The Fig. 4 shows the sectional view of the pit along with the details of various filling layers in the pit. At the bottom of the pit 30cm thick layer of coarse sand is first laid; and another 60cm thick layer is made using aggregate size of 2 to 3cm. After filling major layer of the pit using coarse aggregate size of 10 to 15cm, the waste pieces of hume pipes and brick bats etc. so as to get minimum of 10% voids, a 30cm thick layer of coarse sand is made; on top of this sand layer, a non woven geotextile of 2m X 2m is placed. Another layer of coarse sand 30cm thick is made on the geotextile.

TABLE 2(A) RATE ANALYSIS FOR RCC COLLAR JOINT

Description	Qty.	Unit	Rate (INR)	Amount (INR)
(A) Material:				
Collar (600 mm dia)	1	--	185	185
Cement	0.05	T	5500	275
Sand	0.04	M^3	750	30
Total				**490**
(B) Labour:				
Mason	0.25	Each	500	125
Labour	0.50	Each	250	125
Bhisti	0.25	Each	200	50
	Total			**300**
Total (A)+(B)				**790**
Add, 2% Water charges				15
Add, 3% Sundries and T&P				25
Add, 13% Contractor profit and OH charges				120
Grand Total				**950**

TABLE 2(B) RATE ANALYSIS FOR GEOSYNTHETICS JOINT

Description	Qty.	Unit	Rate (INR)	Amount (INR)
(A) Material:				
HDPE Geogrid	1.0	M^2	150	150
Polypropylene Nonwoven Geotextile	1.0	M^2	200	200
Sand filling around Geosynthetic joint	0.5	M^3	750	375
Total				**725**
(B) Labour:				
Fixing Geosynthetics belt joint				50
Total (A)+(B)				**775**
Add, 15% Contractor profit and OH charges				125
Total				**900**
Less, Saving of pipe length 190 mm @ 900 (INR)/Rm				**-170**
Grand Total				**730**

A final layer of 30cm is made using earth filling with light compacting such that its level is kept about 25mm below the surrounding ground level. The composite layered structure comprising sand/nonwoven geotextile/sand provides efficient filtration of water to be recharged giving higher recharge rate and longer recharge life of the pit. The experiment of water recharge measurement has been carried out in the first week of during the monsoon. The measured quantity of water has been supplied continuously for 8 hours a day for 5 consecutive days. The average water intake was observed about 2000 liters per hour on account of 10% voids. After considering the 10% normal recharge, the net water recharge rate obtained about 1800 litres per hour.

The quantity of recharge will entirely be depending on the availability of water and the location of its construction viz. i) water availability during the actual rain (streets of residential area and societies having local, small catchment), ii) water availability even after the rain fall (check dam basin, bed of village tanks, field drains etc.). In the first category, the rainfall duration of 100 hours can be assumed during the entire monsoon which gives the water recharge of 1,80,000 litres per year. In case of second category, it may be even much more. Considering the availability of water for the total period of 100 days including the monsoon, water recharge is expected to the tune of 43,20,000 litres per year. The estimated cost of the pit is only around INR 6000, which is quite economical considering the output in terms of ground water recharge and evacuation of logged water providing safety and comfort as the case may be. The irrigation department, Government of Gujarat has constructed 90000 check dams, 14600 boarder ponds, 9529 village ponds and 173805 small structures. It has a total storing capacity of 76888 million cubic feet which is almost 15% of the 200 major dams and minor dams. This has raised the water table hence in spite of shortfall of rain in the current season; farmers will be provided irrigation water assuring the saving of the crops.

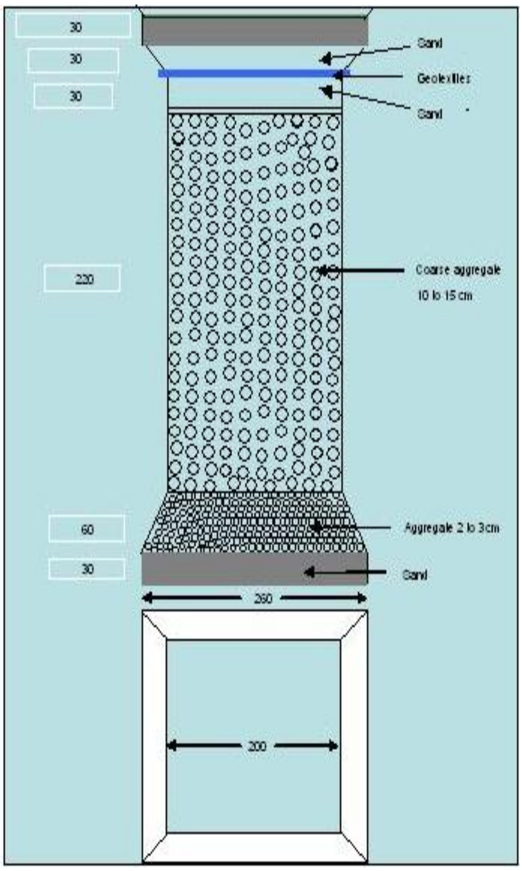

Figure 4. Sectional view of water recharge pit

CONCLUSION

Field trials show encouraging results indicating high potential for ground water recharge by both the methods proposed in the present study. In case of storm water drain comprised of geosynthetics, the water recharge rate depends on the type of the soil. The water recharge is observed much higher in case of semi pervious soil as compared to that of black cotton soil. The geosynthetics belt-joint is easy to install and having longer life with outstanding filtering characteristics needed for storm water. The cost comparison for replacement of geosynthetics joint show that ground water recharge is economically viable. The above practical was carried out for short duration by using limited resources. We recommend that the similar study may be extended further using different specifications of hume pipes and geosynthetics for longer duration so that not only cost may be lowered but the recharge of water may be enhanced with proper design of geosynthetics/soil system to perform as optimum recharge media in case of storm water drain. The water recharge pit also shows intake of huge amount of water supplied in its basin showing very high potential of ground water recharge. The selection of location for the pit can play important role on the total quantity of water that can be recharged. We recommend to implement the proposed methods for the ground water recharge as these methods are easy to implement and also economical to use for the social cause.

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