International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 04, April 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Effect of Drainage in Sub-grade on the Performance of Highways

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ABSTRACT

Gathering of rain water spillover and injecting it into the groundwater is the need to revive the ground water table. However, the runoff contains physical, chemical and biological impurities. These impurities are necessarily removed to protect ground water from pollution and also from blockage of pores of the aquifer. However, cleaning(backwash) and maintenance is required at regular interval for this clogging problem. This needs performance evaluation of rain water harvesting filter unit consisting of coarse sand (CS) supported by gravels (G) and boulders (B) layers. Rectangular column of (Bx Wx H) was used in laboratory for evaluation which is having the provision of continuous water inflow and flows out freely. The effect of variable water head over the filter is evaluated. Different concentrations of clay in filtering water and algae clogged filter are used for performance evaluation. The performance is evaluated in terms of recharge rates and clogging time. The results show that the exclusion of suspended impurities from run-off water takes place mostly in the upper layers of this filter, irrespective of the overall removal efficiency of this filter. The recharge rate is increases with increase in the water head over the filter. Results indicates that increase in concentration of clay and algae in water, reduces its efficiency.

Keywords—Groundwater, clogging, run-off, rain water harvesting.

I.INTRODUCTION

Artificial recharge is the process by which water enters in to the groundwater storage. United States Environmental Protection Agency (USEPA) established the Underground Injection Control program for the purpose of safeguarding the underground drinking water sources. Under this program, injection wells are divided into five classes, primarily based on the types of fluids that are injected into the wells. Storm water injection wells are categorized as "shallow injection wells designed for the disposal of rain water and melted snow". Groundwater acknowledge a fundamental part in managing the water demand of Indian urban gatherings. Ground water is utilized as a bit of meeting ar ound 60% of irrigation needs and 80% of drinking water necessities in India. By virtue of silly utilize groundwater table is falling at very fast rate in around 15% of region expand of india. Water tables in new groundwater areas of the India’s northern-western conditions, especially in Punjab and Haryana, have

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

fallen at a yearly rate of 25 -75cm over the traverse of the last 2-3 decades and undermining the sensibility of development because of accelerating in pumping costs, disintegration in the quality of groundwater and related environmental and socio–economic factors. The groundwater decay rate can be supported off to some degree by updating groundwater reestablish utilizing rain water, which may also improve it's quality. Recharging a groundwater system by the excess water on the surface is injected at higher rate than the natural reestablish rate. The performance of filtration unit good enough to get potential central focuses from the displayed reestablish structures. The most basic issue concerning the effectiveness of the segregating unit is clogging, i.e. diminish in porousness of segregating medium thusly of addressing physical technique . Different alternatives for sustainable water supply in urban India are growth of water supply through rainwater harvesting, conservation and groundwater recharge. The fast recuperation of ground water table is possible by injection through rainwater harvesting. The injectable water may contain physical, chemical and biological impurities, these must be passed over filter so as to protect ground water from pollution. As the filter is prone to clogging cleaning and maintenance of filter is necessary. This needs performance assessment of filter. The aim of the study is to evaluate the performance of filter with different concentrations of clay in runoff under various degree of clogging of filter with algae. The main objective of this laboratory experiment is to calculate the efficiency of CS layer of the filter medium in rain water harvesting filter and its effect on quality of recharged water. Laboratory experiment was carried out under constant head condition because it was not easy to analyse under various sediment load of runoff water on clogging, recharge rate and sediment penetration under actual field conditions.

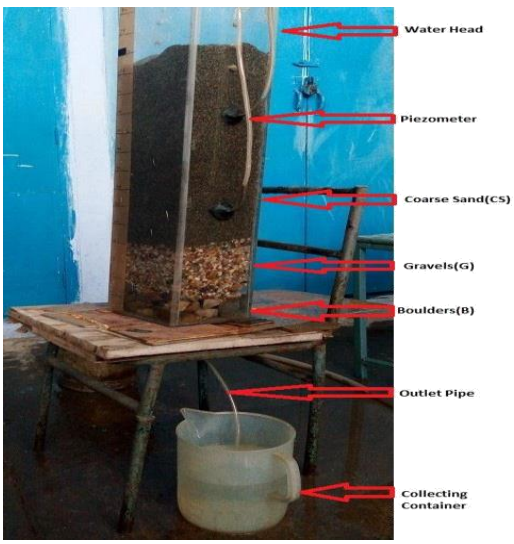
II.METHOD

A. Experimental Setup

Rectangular column of size: 20cm x 16cm x 120cm (B x W x

H) was used for laboratory experiment which is having the provision of continuous water inflow and flows out freely as shown in Fig. 1.

Fig. 1 Rectangular column used in the experimental study



IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

To maintain the constant hydraulic head manually during the test run, inlet is provided in the upper portion of the column. Drainage outlet is also provided for the filtered water at the bottom of column. Collecting container is to measure filtered water from the outlet which is provided at the bottom of the column. The column is then filled up to 10cm mark from bottom with boulders (passed from 40mm size IS sieve) and above that gravels (retained on 4.75mm size IS sieve; thickness = 10 cm) are filled up to 20cm mark of the scale from the bottom for free drainage of water. The coarse sand passing through IS sieve of 1.18mm size and retained on 600 microns size (Thickness = 50 cm) is filled up to 70cm mark of scale from the bottom. Thus, remaining 50cm height is left for the water height. In this set of study, aimed to calculate recharge rates and clogging time, the thickness of CS layer was kept higher to eliminate all physical, chemical and biological impurities present in the runoff.

The synthetic water having different concentrations of clay in runoff under various degree of clogging of filter with algae was prepared. This was done to ensure the real storm water run-off conditions was created. It was observed that the first storm generates more sediment load in run-off water than the succeeding ones. Synthetic water was prepared with sediment load of 5-20 mg/l using dried clay sieved through 0.075mm sieve and oven dried algae with different concentrations for the laboratory tests. Experiments were conducted with sediment load of 5, 10, 15, 20 mg/l clay and different combinations of clay and algae. The prepared synthetic water was passed through a rectangular column. Clear water was passed through filtering medium for 5 min before every experiment to drain out clogging materials.

B. Analysis

The experiments studies show that the recharge rate of this filter is dependent on the suspended solids from runoff recharge water. When the percent removal of solids increases, the recharge rate decreases. In the filtration process, water containing clay and algae is applied to the surface of this filter. The sand rapidly collects these impurities and soon clogged. Clogging may be defined as the head loss across the filter layer until it reaches some predetermined design limit. A filter is used until it gets partially clogged. The time taken between the starting of experiment and the recharging rate became constant is taken as clogging time.

III.RESULTS AND DISCUSSION

Effect of water head on impedance values is analyzed in the case of clear water, water containing different concentration of clay and algae and water containing mixture of both clay and algae. laboratory experiments are conducted to find out the relationship between recharge rate, water head over the filter, head loss through sand layer of filtration system in the form of impedance value. Experiment results are discussed below.

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IJARSE
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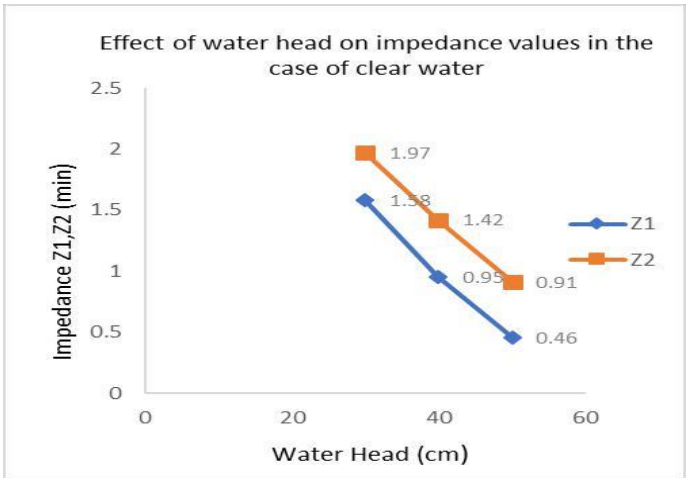
A. Estimation of Impedance Value Using Graph

Variation in recharge rate and different water head corresponding to varying sediment loads of runoff water during test run of 2 min was calculated in the terms of impedance values Z1 and Z2. The Z1 represents the impedance at 55cm mark of the apparatus and Z2 represents the impedance at 30cm mark of the apparatus where piezometers P1 and P2 is installed.

a) *Variation in the impedance values corrosponding to water head in the case of clear water:*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 2. This graph shows that the impedance value decreases with increase in water head over the surface of filter.

Fig. 2: Impedance versus water head curve for clear water



*Variation in the impedance values corrosponding to water head in the case of clay water having concentration 5gm/l:*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 3. This graph shows that the impedance value decreases with increase in water head over the surface of filter.

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*d) Variation in the impedance values corresponding to water head in the case of of clay water having concentration 15gm/l:*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 5. This graph shows that the impedance value decreases with increase in water head over the surface of filter.

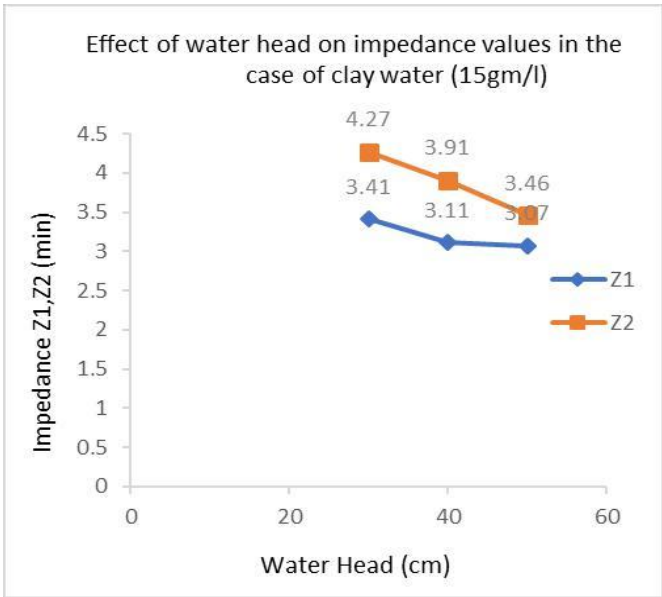

Fig. 3: Impedance versus water head curve for the clay water(5gm/l)

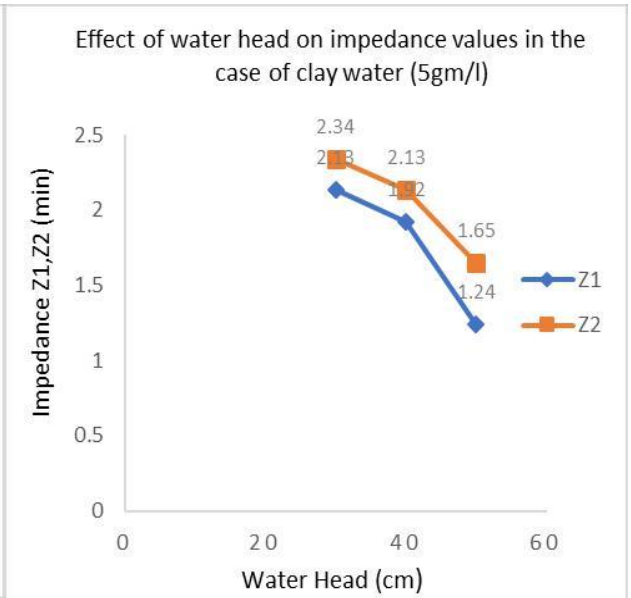

Fig. 5: Impedance versus water head curve for the clay water(15gm/l)

c) *Variation in the impedance values corresponding to water head in the case of of clay water having concentration 10gm/l:*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 4. This graph shows that the impedance value decreases with increase in water head over the surface of filter.

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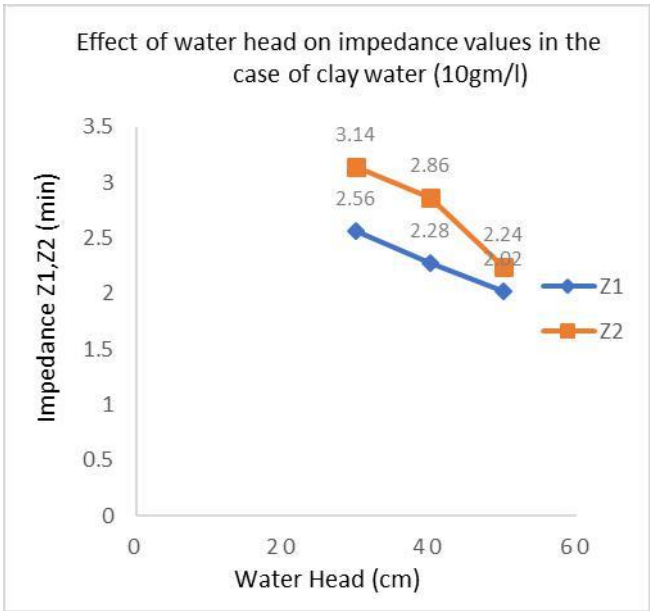


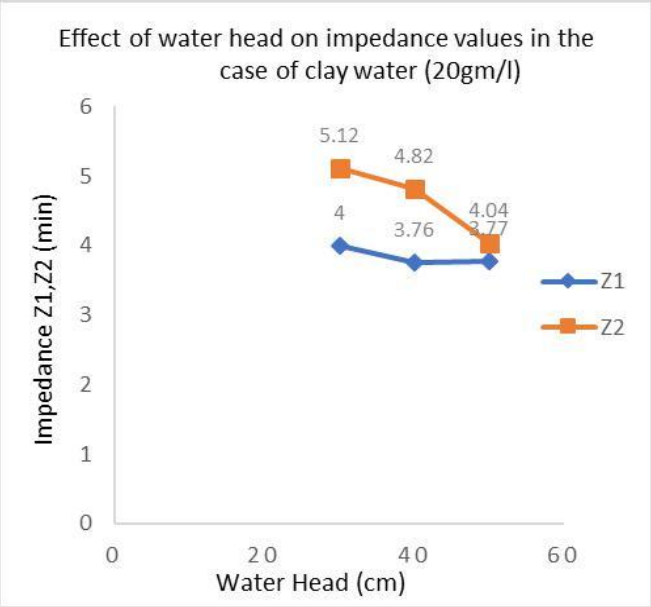
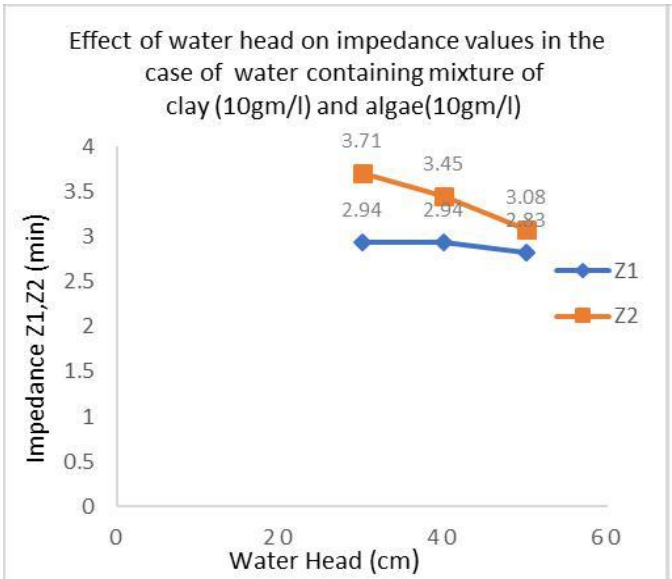


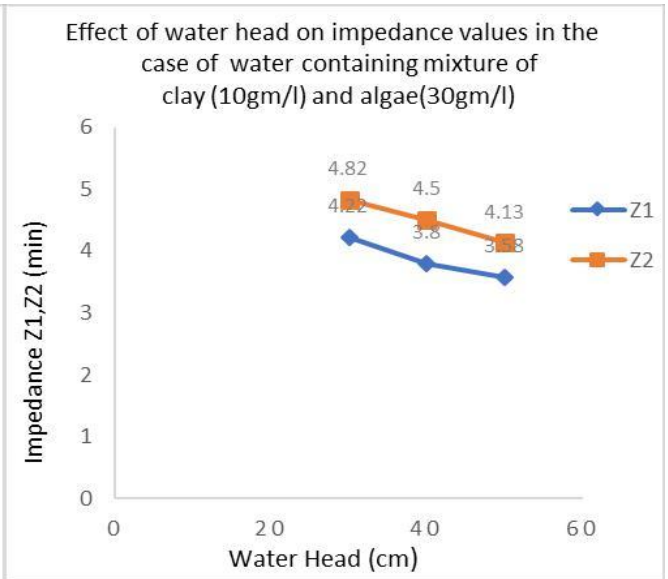
Fig. 4: Impedance versus water head curve for the clay water(10gm/l)

Fig. 6: Impedance versus water head curve for the clay water(20gm/l)

e) *Variation in the impedance values corresponding to water head in the case of of clay water having concentration 20gm/l:*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 6. This graph shows that the impedance value decreases with increase in water head over the surface of filter.

*f) Variation in the impedance values corresponding to water head in the case of water containing mixture of clay(10gm/l) and algae(10gm/l):*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 7. This graph shows that the impedance value decreases with increase in water head over the surface of filter.





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ISSN (O) 2319 - 8354
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Fig. 7: Impedance versus water head curve for the water containing mixture of clay (10gm/l) and algae(10gm/l)

h)

i) *Variation in the impedance values corresponding to water head in the case of water containing mixture of clay(10gm/l) and algae(30gm/l):*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 9. This graph shows that the impedance value decreases with increase in water head over the surface of filter.

*g) Variation in the impedance values corresponding to water head in the case of water containing mixture of clay(10gm/l) and algae(20gm/l):*The variation of impedance values w.r.t. varying water heads over the surface of filter is shown below in the Fig. 8. This graph shows that the impedance value decreases with increase in water head over the surface of filter.

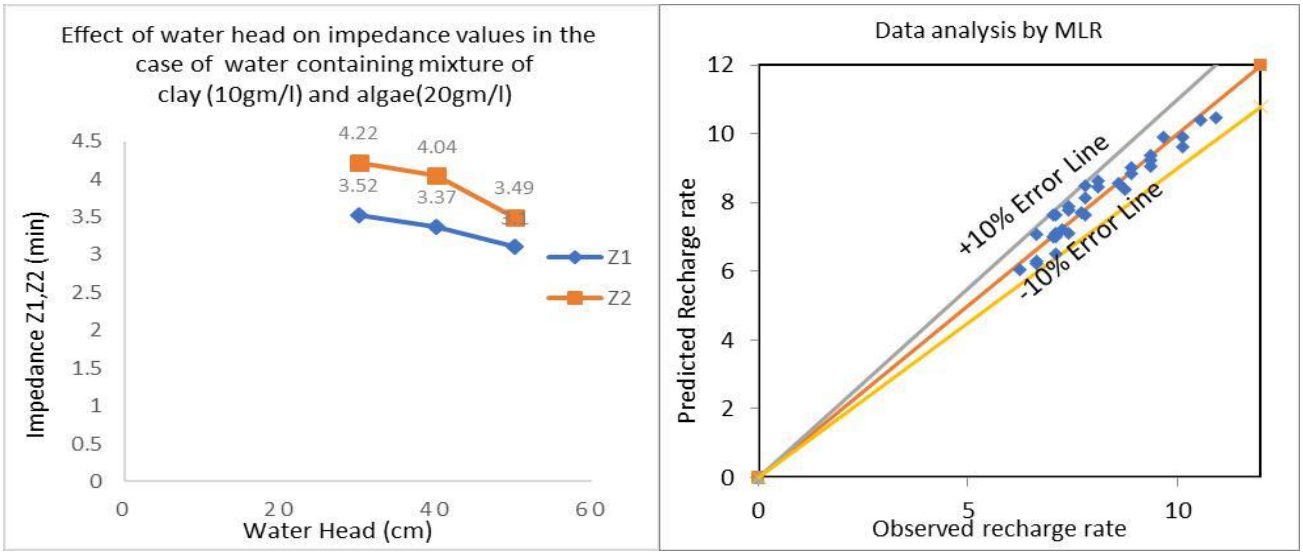

Fig. 8: Impedance versus water head curve for the water containing mixture of clay (10gm/l) and algae(20gm/l)

Fig. 10: Observed versus predicted recharge rate curve using MLR

B. Analysis using Multiple Linear Regression (MLR)

Using Recharge rate (Q in cm/min), Water head over the filter surface (H in cm), Impedance value (Z in min), amount of clay (C in gm/l) and amount of algae (A in gm/l), the empirical relationship has been derived as given below:

Q=10.98907+0.00289*H-0.73103*Z-0.06386*C+0.02002*A

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ISSN (O) 2319 - 8354
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IV. CONCLUSIONS

The following conclusions can be obtained from the experimental study:

- Impedance value decreases with increase in the water head over the surface of the filter.
- Impedance value increases with increase in sediment load i.e. increase in the concentration of clay because greater concentration of clay offers more resistance to flow.
- Higher percentage of algae offers higher resistance to the flow. Similarly, clay and algae mixed water offers even more resistance than clay mixed water having same concentration.
- R^2 for best fitted curve obtained is 0.9249 using Multiple Linear Regression.

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