Control of Ochre Formation on Geotextile By Application of Lime

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Abstract- *Ochre is an amorphous, gelatinous substance rich in organic matter and with a high concentration of iron oxides resulting in its characteristic orange color. Ochre is found sticking to solid surfaces of drainage systems and its accumulation may ultimately cause a reduction in drain void spaces available for water percolation thus resulting in clogging. Ochre formation results from microbial colonization by bacterial consortia, which may include various iron bacteria and its affinity to iron compounds. This type of ochre forms on geotextile filter in earthen dams. This type of clogging due to ochre on geotextile can be prevented by application of lime. Lime of suitable thickness applied at a particular distance can reduce ochre formation on geotextile surface largely.*

Keywords- Geotextile, Lime, Ochre, Filtration

I. INTRODUCTION

Geotextiles are used in earth dams for the purpose of filtration. It retains the soil particles while it lets out clear water. In some cases there will be clogging on geotextiles due to formation of ochre. Ochre is an amorphous, gelatinous substance rich in organic matter and with a high concentration of iron oxides resulting in its characteristic orange color. Ochre is found sticking to solid surfaces of drainage systems and its accumulation may ultimately cause a reduction in drain void spaces available for water percolation thus resulting in clogging. Ochre formation results from microbial colonization by bacterial consortia, which may include various iron bacteria and its affinity to iron compounds. . Biofilm is a general term for a consortium of microbes and related extracellular substances that colonize an attractive surface due to their facility in obtaining nutrients. The cells stick firmly to the surfaces where they grow reproduce and produce extracellular polymer substances. Surfaces in aquatic environments are quite attractive for the colonization of bacteria due to their facility in obtaining nutrients from the liquid medium. The cells stick firmly to these surfaces where they grow reproduce and produce extracellular polymer substances. In order to prevent this ochre formation lime with a higher pH than that of soil can be **used.** Ochre can be considered to be the result of a Biofilm development related to high bacterial activity in iron compounds and organic matter in the soil. Biofilm is a general term for a consortium of microbes and related extracellular substances that colonize an attractive surface due to their facility in obtaining nutrients. The cells stick firmly to the surfaces where they grow reproduce and produce extracellular polymer substances. Surfaces in aquatic environments are quite attractive for the colonization of bacteria due to their facility in obtaining nutrients from the liquid medium. The cells stick firmly to these surfaces where they grow reproduce and produce extracellular polymer substances. In order to prevent this ochre formation lime with a higher pH than that of soil can be used.

II. OBJECTIVES

- To study the effect of lime on different types of geotextiles
- To find appropriate lime thickness to reduce clogging

Amount of lime to be applied in actual field and the type of geotextile that is best suited for use with lime will be known.

III. MATERIALS AND METHODOLOGY

Sand, Quicklime, Geotextile, Gravel, Iron bacteria, and Nutrient medium are the materials used. The soil was collected from IES College of engineering, Chittilappilly. Iron bacteria Acidithiobacilluswas used in this study. The bacteria was collected from Agharkar Research Institute, Pune.Column tests were performed with the purpose of modeling a drainage system under optimum ochre formation conditions. The main objective of the study is to find the effect of lime in controlling ochre formation on geotextile filters. The column tests were set up using a PVC permeameter with upstream soil, geotextile filters and drainage material i.e. gravel underneath. Both the ends of permeameter is closed with drainage caps. An inlet and outlet pipes are provided on top and bottom of the permeameter for the inflow and outflow of water. The test was performed under constant hydraulic head and fluid composition in the top reservoir. Water flows through inlet into the PVC permeameter and comes out through outlet, which is collected by a collection vessel.Sand was used. Collection vessels are provided to collect the water flowing out of permeameter. Three different types of geotextiles (Non-woven polyester, Non-woven polypropylene and Woven polypropylene) are used for this study. Non-woven polyester, non-woven polypropylene and Woven polypropylene were used. Effect of these geotextiles on permeability is studied. Lime layer is applied at a particular distance from the geotextile and at different thickness. In the first series of tests, effect with and without the application of lime layer is compared i.e. in the first test set up no lime layer will be provided while in other setups lime layer will be provided. Also different lime thickness (1 cm, 2 cm, and 3cm) is used to find its effect on ochre formation and permeability. Column tests were performed with the purpose of modeling a drainage system under optimum ochre formation conditions. The main objective of the study is to find the effect of lime in controlling ochre formation on geotextile filters. The column tests were set up using a PVC permeameter with upstream soil, geotextile filters and drainage material i.e. gravel underneath. Both the ends of permeameter is closed with drainage caps. An inlet and outlet pipes are provided on top and bottom of the permeameter for the inflow and outflow of water. Test was performed under constant hydraulic head.

Figure 3.1.Experimental set up

IV. RESULT AND DISCUSSION

The tests for Index properties and Engineering properties of *sand and gravel were determined by conducting laboratory* experiments. Properties of sand and gravel were tabulated in table 4.1 and 4.2.

Table 4.1.Basic Properties of sand

PROPERTIES	VALUES	IS CODE
Specific gravity	2.64	IS 2720 Part III -1980
Effective sizes,		IS 2720 Part IV -1985
D_{10} (mm)	0.16	
D_{30} (mm)	0.33	
D_{60} (mm)	0.8	
Uniformity coefficient, C_u	5	
Coefficient of curvature, C_c	0.85	
Gradation of sand	SP	
Max. dry density (g/cc)	1.801	IS 2720 Part 14-1983
Min. dry density (g/cc)	1.68	
Soil friction angle	39°	IS 2720 part 14-1983
Permeability (cm/s)	8.20×10^{-4}	IS 2720 Part 17-1986

Table 4.2.Basic properties of gravel

BASIC PROPERTIES OF GRAVEL	VALUES
Aggregate Crushing value	24%
Aggregate Impact value	15.75%
Water absorption	2.41%
Coefficient of curvature (Cc)	4.75
Uniformity coefficient (Cu)	2.433
Hardness	31.44%

Various parameters that effect ochre formation was studied. Major parameters studied are types of geotextile and lime thickness. The effects of lime on different types of geotextiles are investigated. Appropriate lime thickness to reduce clogging effect is determined.

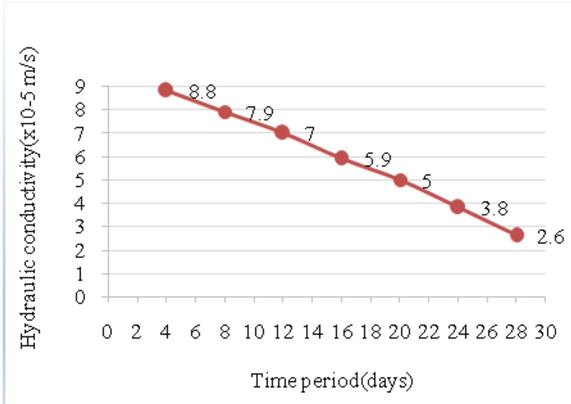

Figure 4.1. Hydraulic conductivity when no lime is Used

Hydraulic conductivity when no lime is used decreased considerably with respect to time. This decrease is due to gradual ochre formation that took place throughout the test. Hydraulic conductivity decreased from 8.8 x 10^{-5} to 2.6 x 10^{-5} m/s by the end of 28 days. Hydraulic conductivity values are noted for every 4 days. Higher permeability is observed during the start of test and by the end of 28 days, permeability decreased considerably. Hydraulic conductivity is expressed in m/s and time period is expressed in terms of days. Ochre is found sticking to the surface of geotextile thereby causing clogging. Ochre fills the pores of geotextile fabric. Thus, we need a remedy to reduce ochre formation on geotextile surface. Severe clogging is to be prevented so as to increase the permeability.

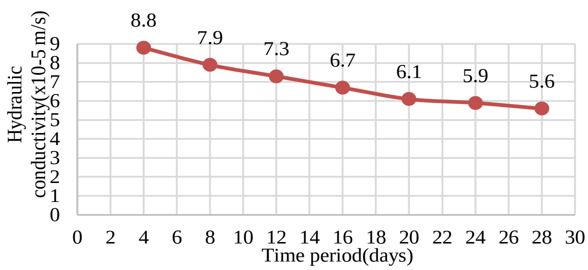

Figure 4.2.Hydraulic conductivity when lime of 1 cm thickness is used

Hydraulic conductivity when lime of 1 cm is used decreased with time.Hydraulic conductivity decreased from 8.8 x 10^{-5} to 5.6 x 10^{-5} m/s by the end of 28 days. Higher permeability is observed during the start of the test while it reduced over the course of 28 days. Lime of 1cm thickness proved to reduce clogging as the permeability the end of 28 days is higher than the case where no lime is used. Hydraulic conductivity in the initialdays had greater difference compared to the negligible difference in values toward the end of the test.Little ochre formation has taken place over the course of time. Halfway during the test lime was capable of maintaining smaller difference in values towards the end of test.Thus lime of 1 cm thickness was not enough to bring considerable changes in the values.

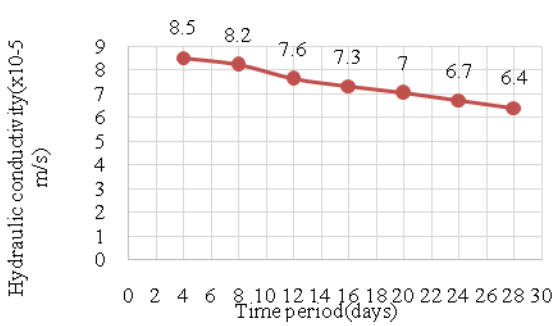

Figure 4.3.Hydraulic conductivity when lime of 2 cm thickness is used

Hydraulic conductivity when lime of 2 cm is used decreased with time.Hydraulic conductivity decreased from 8.8 x 10^{-5} to 6.4 x 10^{-5} m/s by the end of 28 days. Hydraulic conductivity values are noted for every 4 days.

Hydraulic conductivity when lime of 2 cm is used, it had negligible difference in values throughout the test Lesser ochre formation is observed in this case. Lime was capableof maintaining almost negligible values of permeability from start to end of the test. Lime of 2cm thickness proved to reduce clogging as the permeability at the end of 28 days is higher than all other cases Thus, lime of 2 cm thickness is found satisfactory to bring considerable changes in values of hydraulicconductivity.

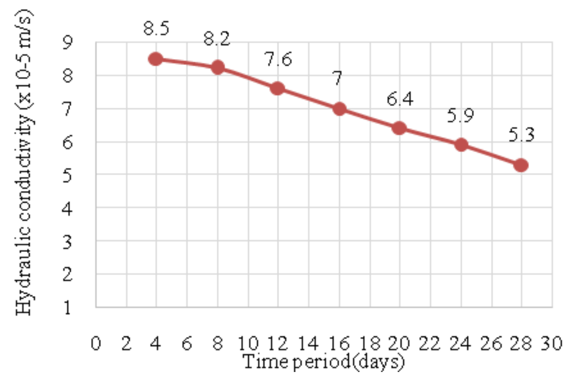

Figure 4.4. Hydraulic conductivity when lime of 3 cm thickness is used

Hydraulic conductivity when lime of 3 cm is used decreased with time.Hydraulic conductivity decreased from 8.5 x 10^{-5} to 5.3 x 10^{-5} m/s by the end of 28 days. Hydraulic conductivity values are noted for every 4 days. Higher permeability was observed during the start of the test while itreduced over the course of 28 days. This is due to little ochre formationthat has taken place throughout the test. Lime of 3cm thickness also proved to reduce clogging as the permeability at the end of 28 daysis higher than the case where no limeis used. Greater difference in hydraulicconductivity towards the end of test is due to lime clogging.

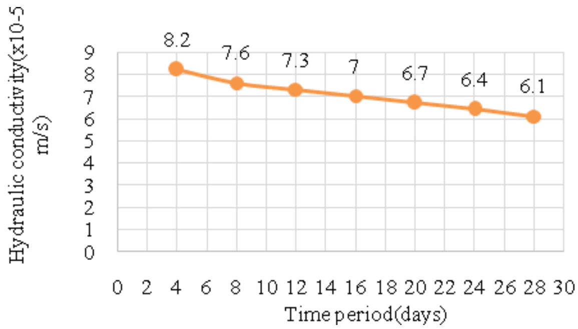

Figure 4.5. Hydraulic conductivity when Non-woven polypropylene geotextile is used

Hydraulic conductivity when Non-Woven PPgeotextile is used decreased with time. Hydraulic conductivity decreased from 8.2 x 10^{-5} to 6.1 x 10^{-5} m/s by the end of 28 days. Hydraulic conductivity values are noted for every 4 days. Non-woven PP geotextile performed almost similar to woven geotextile though there is small difference in values of permeability. Almost similar ochre formation is observed for this case. Lower permeabilityof non-woven geotextile compared to woven geotextile is due to its lower apparent opening size.

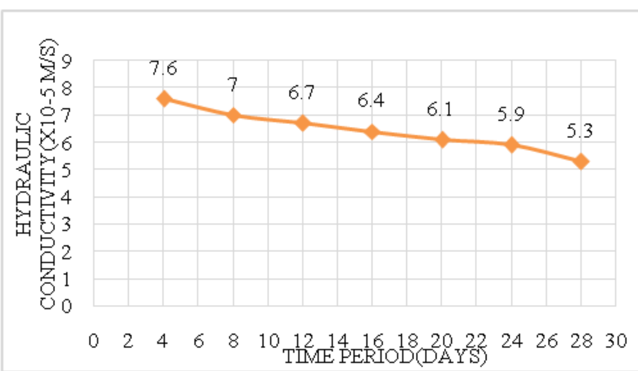

Figure 4.6. Hydraulic conductivity when Non-woven polyester geotextile is used

Hydraulic conductivity when Non-Woven Polyester geotextile is used decreased with time. Hydraulic conductivity decreased from 7.6 x 10^{-5} to 5.3 x 10^{-5} m/s by the end of 28 days. Hydraulic conductivity values are noted for every 4 days. Permeability value for this case is much lower than for other types of geotextiles at the end of 28 days. Non-woven polyester is not found suitable compared to other types of geotextiles. Lower permeability compared to other types of geotextile is due to lower apparent opening size. Ochre formation observed is greater than other two cases.

V. CONCLUSIONS

The conclusions made from the study are as follows.

- Lime of 1cm thickness proved to reduce clogging as the permeability at the end of 28 days is higher than the case where no lime is used.
- Hydraulic conductivity when lime of 2 cm is used, it had negligible difference in values throughout the test.
- However, lime of 1 cm, 2 cm and 3 cm is able to reduce clogging, lime of thickness 2 cm is suggested for higher permeability.
- Non-woven pp geotextile performed almost similar to woven geotextile.
- Non-woven polyester is not found suitable compared to other types of geotextiles.

REFERENCES

[1] L.G.C.S.Correia,M.Ehrlich,M.B.Mendonca(2016)"The effect of submersion in the ochre formation in geotextile filters" *Geotextiles andGeomembranes, Elsevier ,Vol 45,Issue 1,pp 1- 7*

[2] Marcos Barreto de Mendonca, Mauricio Ehrlich, and Magali Christe Cammarota(2003) "Conditioning factors of iron ochre biofilm formation on geotextile filters", Canadian *Geotechnical Journal,40(6),pp 1225-1234*

[3] Marcos barreto de mendonca and Maurício ehrlich(2006) "Column test studies of ochre biofilm formation in geotextile filters",*Journal of geotechnical and geoenvironmental engineering ,ASCE,Volume 132,Issue 10*

[4] K. R. Legge , Pr. Eng(2016) "Composite Filters of Geotextiles and Natural Materials for Critical Applications in Dam Engineering", *ASCE,GSP 275*

[5] K. Y. Wei and T. L. Vigo(1985) "Permeability of Soil-Geotextile Systems", *Textile Research Journal*

[6] Lava Kumar Reddy Palle, Arti Sudam, Madhav Madhira(2019) "Estimating Optimal Geotextile Type for Controlling Soil Erosion", *International Journal of Innovative Technology and Exploring Engineering ,Vol 8,Issue 10*

[7] A.B. Fourie and S.M. Kuchena(1995) "The influence of tensile stresses on the filtration characteristics of geotextiles", *Geosynthetics International,Vol 2,N.o 2,pp. 455-471*

[8] Anirudh,Dr Sanjay K Sharma,Er Rakesh K Goel,Jyothi (2016)"Analysis of discharge rate through conventional and geotextile based filter", *Indian Research Journal ofEngineering and Technology,Vol 3,Issue 8,August*

[9] Anna Miszkowska, Eugeniusz Koda, Anna Sieczka, and Piotr Osinski(2019) "Laboratory Tests of the Influence of Clogging on the Hydraulic Properties of non-woven geotextiles *,6th European geosynthetics conference, pp - 686-691*

[10] Anna miszkowska, Eugeniusz koda (2017)"Change of water permeability of nonwoven geotextile exploited in earth fill dam" , *24th International PhD Students Conference,Vol 24, pp 790-795*

[11] Anna Miszkowska,Stanislav Lenart and Eugeniusz Koda(2017) "Changes of permeability of non-woven geotextiles due to clogging and cyclic water flow in laboratory conditions" , *Water Resource Journal,Vol 9,Issue 9*

[12] Anna Miszkowska (2019) "A study on soil-geotextile interaction using gradient ratio tests", *Engineering and Environmental Sciences,28(2),pp 235 – 243*

[13] Anna Miszkowska (2019) "Evaluation of soil-geotextile filtration behaviour using the gradient ratio test", *Geosynthetics International, 25th international Conference*

[14] C. Yaman1, J. P. Martin2 and E. Korkut(2006) "Effects of wastewater filtration on geotextile permeability", *Geosynthetics International,13(3) ,pp 87-97*

[15] D. Vaughan (1994) " Inhibition of iron precipitation from field drainage water", *The Journal of Agricultural Science,Vol 123,Issue 2,pp 253-256*

[16] E. M. Palmeira, M. G. Gardoni and D. W. Bessa da Luz(2005) "Soil–geotextile filter interaction under high stress levels in the gradient ratio test" , *Geosynthetics International,12(4),pp 162-175*

[17] E.M. Palmeira and M.G. Gardoni(2000) "The influence of partial clogging and pressure on the behaviour of geotextiles in drainage systems", *Geosynthetics international,Vol 7,Issue 4-6,pp 403-431*