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CHEMICAL STABILIZATION OF BAIJI SAND DUNES IN IRAQ
1. EFFECT OF SOME SOIL STABILIZERS ON THE INFILTRATION RATE OF SAND

By

NAIF B. AHMED
University of Mosul, Mosul - Iraq

التثبيت الكيميائي للكثبان الرملية في بيجي بالعراق
١ - تأثير بعض مثبتات التربة على معدل ترشح الرمل

نايف بكر أحمد

تمت دراسة تأثير المثبتات الكيميائية للتربة ، كحول عديد الفينيل (٠,٢٪ ، ٠,٤٪) ، والمستحلب الراتنجي فيركوتاك RB - 50 (٠,١٤ ، ٠,١٨ ، ٠,٢ ، ٠,٤ لتر/م٢) ومستحلب البيتومين A1-35 (٠,٣ ، ٠,٤ ، ٠,٥ ، ١,٠ لتر/م٢) ، وراتنج اكوابول 0019 - 35 (٠,٣٣٪ ، ٠,٥٪ ، ٠,٦٦٪) ، وراتنج اكوابول 0031 - 35 (١٥٠ ، ١٧٥ ، ٢٠٠ ، ٢٥٠ لتر .م٢) على معدل ترشح رمل الكثبان الرملية لمنطقة بيجي .

وقد أظهرت النتائج عن ارتفاع معدل ترشح عينات الرمل بإضافة كحول عديد الفينيل وانخفاضه مع بقية المواد ، وقد ازداد معدل الترشح مع زيادة تراكيز بقية المواد . التراكيز (٠,٢ ، ٠,٤ لتر/م٢) من الفيركوتاك ، و(٠,٥ ، ١,٠ لتر/م٢) من البيتومين ، و(٠,٦٦٪) من اكوابول 35-0019 ، و(٢٥٠ غم/م٢) من اكوابول 35-0031 جعلت من عينات الرمل غير نفاذة للماء ، الا ان معدل المغاض تحت بقية التراكيز من هذه المواد زاد عن أقل حد مقبول لمغاض التربة (٠,٢٥ سم/ساعة) .

Key Words : Bitumen, Erosion, Fixation, Infiltration rate, Sand dunes, Stabilizers.

ABSTRACT

In this study, the effect of soil chemical stabilizers including polyvinyl alcohol 125,000 (PVA) (0.2% and 0.4%); ferquatac resin emulsion RB-50 (F.E.) (0.14, 0.18, 0.2 and 0.4 $1m^{-2}$); bitumen emulsion Al-55 (B.E.) (0.3, 0.4, 0.5 and 1.0 $1m^{-2}$); aquapol resin 35-0019 (Aq1) (0.33% and 0.66%) and aquapol resin 35-0031 (Aq2) (150, 175, 200 and 250 gm m^{-2}) on the infiltration rate of Baiji dunes sand was investigated. The results indicated that, both PVA concentrations increased the infiltration rate; whereas, the remaining chemicals reduced it. The reductions in the infiltration rate caused by F. E. (0.2 and 0.4 m^{-2}); B. E. (0.5 and 1.0 1 m^{-2}); Aq1 (0.66%); and Aq2 (250 gm m^{-2}) rendered the samples impermeable. While, the infiltration rates under the remaining concentrations of these chemicals were in excess of the minimum acceptable rate of 0.25 cm hr^{-1}.

INTRODUCTION

Sand dunes at Baiji site (central Iraq) form one of the most important fields in Iraq. They cover more than 220,000 donums (1 Iraqi donum = 2500 m^2), with large expenses of currently active dunes. Moreover, they represent a typical example of dune formations in the rest of Iraq.

The instability of the surface layer of the sand dunes renders sand vulnerable to losses through wind and water erosion. Since vegetation cover is effective in stabilizing the aeolian sand dunes, soil chemical stabilizers in the form of

emulsions or solutions have been used to stabilize the soil structure and hence prevent or slow down water erosion or wind erosion while the vegetation cover is being established [1,2].

Despite of being a major producer of oil, using of oil products and other chemical materials for the fixation of sand dunes in Iraq is still very limited [3,4]. Thus, it is important to carry out some more tests on the effect of various soil chemical conditioners and oil minerals on the stabilization of Iraqi sand dunes.

The effectiveness of any chemical mulch as sand dune stabilizer can be assessed on the following criteria: permeability, non-toxicity to seeds or seedlings, ability to produce stable aggregates, and prolonged resistance to both wind and water erosion. These properties were tested in Druridge Bay (UK) for 12 chemical materials by means of extensive laboratory, greenhouse, wind tunnel and field trials [1]. From the results of these chemicals, PVA, F. E., B. E. Aq1, and Aq2 were selected for the present study that aims at finding out the effect of these 5 chemicals on the infiltration rate of Baiji sand dunes.

MATERIALS AND METHODS

This study was conducted using air-dry samples obtained from the surface 30 cm of Baiji sand dunes. The chemical and physical characteristics of the sand are given in Table 1. The stabilizers used were : PVA (0.2% and 0.4%); F. E. (0.2 and 0.4 1 m^{-2}); B. E. (0.5 and 1.0 1 m^{-2}); Aq1 (0.33% and 0.66%) and Aq2 (200 and 250 gm m-2) [5]. All (%) were on the basis of air-dry sand. Preliminary experiments showed that these treatment reacted differently with the Baiji sand in comparison with the Druridge Bay sand, and apart from PVA, they rendered the samples impermeable or at best drastically reduced the infiltration rate. As a consequence the experiment was repeated using lower concentrations of the chemicals:

- F.E. 0.14 and 0.18 1 m^{-2},
- B.E. 0.3 and 0.4 1 m^{-2},
- Aq1 0.33% and 0.50%

Table 1
Some chemical and physical characteristics of Baiji sand dunes

Character	Value
EC (mmhos / cm)	0.221
pH	7.4
Alkaline - Earth Carbonates (%)	10.46
Gypsum (meq / 100 gms soil)	1.49
Organic Matter (%)	0.088
Sand (Coarse, Medim and Fine) (%)	0.1; 16.5; 78.3
Silt (Coarse, Medium and Fine) (%)	1.9; 0.3; 0.4
Clay (%)	2.5
Texture	Sandy
C.E.C. (meq / 100 gms soil)	3.40
Soluble Ions (meq / 100 gms soil)	
Na^+	0.018
K^+	0.020
Ca^{+2}	0.157
Mg^{+2}	0.020
$C1^-$	0.020
$C03^{-2}$	0.000
$HC03^-$	0.150
Total N (%)	0.013
Available P (mg / 100 gms soil)	1.250
S. A. R. (meq / 1)*	0.191
Exchangeable Cations (meq/100 gms)	
Na^+	0.032
K^+	0.230
$Ca^{+2} + Mg^{+2}$	3.138
E. S. P. (%) **	0.941
Bulk Density (gm / cm3)	1.51
Sand Particles Density (gm / cm3)	2.68
Porosity (%)	44.00

* S.A.R (Sodium Absorption Ratio) = Na+ / [(Ca+2 + Mg+2) / 2]1/2
** E.S.P. (Exchangeable Sodium Percent) = (Na+ / C.E.C.) x 100%
C.E.C. = Cation Exchange Capacity (meq / 100 gms soil)

- Aq2 150; 175; 200 and 225 gm m^{-2}

all chemicals were prepared or diluted with water to obtain the stated concentrations [when applied at a rate of 6.0 1 m^{-2}] and each treatment was tested in triplicate. The experiment involved adding these chemicals to 65 gm of air-dry sand in glass leaching columns of surface area 3.465 cm^2, these then placed in a leaching rack and water added at the top. Control samples using untreated Baiji sand were included. Input water volumes as a function of time were measured. The data were later used for the calculation of the infiltration rates using the procedure described by Michael [6].

RESULTS AND DISCUSSION

The results indicate, as in the case of Druridge Bay dunes sand [1], the application of PVA as surface mulch increased the infiltration rate of Baiji sand when compared with the control (Fig. 1), its effect increased as the chemical concentration increased. The remaining chemicals, F.E. (140 and 180 ml m^{-2}); B.E. (0.3 and 0.4 l m^{-2}); Aq1 (0.33% and 0.50%) and Aq2 (150; 175; 200 and 225 gm m-2) reduced the infiltration rate of the sand in proportion to their concentrations (Figures 2-5).

The increase in the infiltration rates with PVA treatments, confirms the results obtained by [7 and 8], and may be due to the production of a stable surface layer with large number of macropores. Reduction in the infiltration rates in the sand samples treated with B.E., F.E., Aq1 and Aq2 chemical materials (Figures 2 - 5) may be due to the hydrophobic character of the sand surfaces treated with these chemicals [9 and 10]. Gabriels [8] suggests that the infiltration rate can be blocked by a high contact angle, especially when small aggregates are treated with a waterproofing material. The high contact angle causes water repellency and prevents water entering the pores between the small aggregates. Similar infiltration tests carried out by Al-Debagi [11] on two Iraqi soils (sandy clay loam and clayey) treated with bitumen emulsions and crude oil, showed close agreement with the angle values determined by Gabriels [9]. The reduction in the infiltration rates could be due to the filling and blocking of some pores between sand particles in the treated layer by the chemical materials [12].

The infiltration rate in both control and treated sand samples was reduced with the time. The rate of reduction was greatest at the start of the test and decreased with time. The time taken to reach a steady state varied with various chemical treatments, but in all cases it was less than 12 minutes. The initial rapid reduction in infiltration has been attributed by Michael [6] to three possible causes. First, the antecedent soil moisture content has a considerable effect on the initial rate and total amount of infiltration (both decrease as the soil moisture content rises). Second, transfer of the fine particles from the surface layer results in the clogging of pores in the lower layers, and the reorientation of particles with in the sand column, thus reducing water movement [3, 14 and 6]. Third, the expansion of 2:1 lattice clay minerals and any humus present will rapidly reduce water movement.

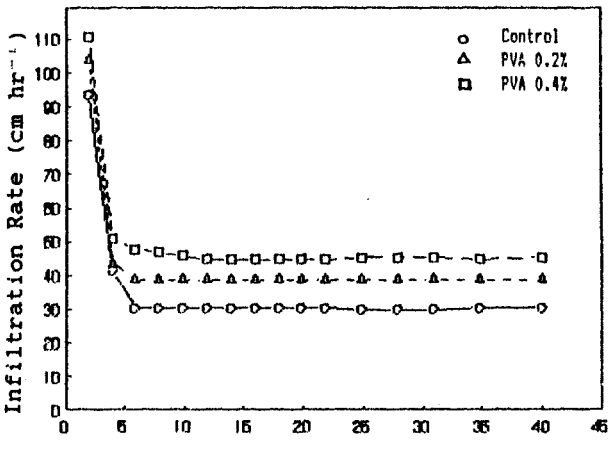

Fig. 1 . Effect of PAV on the Inf. Rate of Baiji Dunes Sand

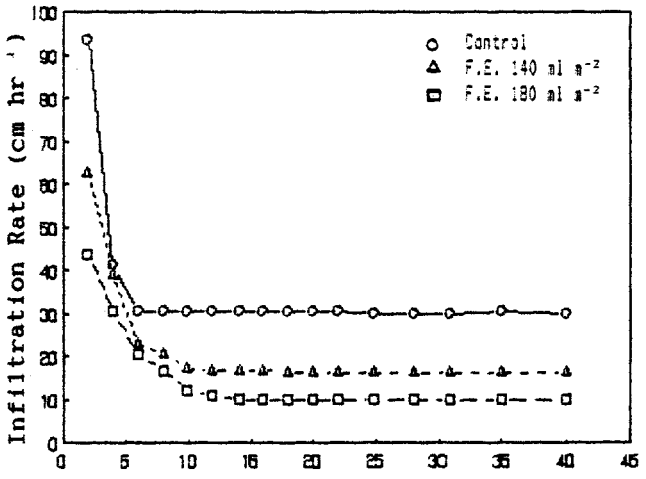

Fig. 2: Effect of F.E. on the Inf. Rate of Baiji Dunes Sand.

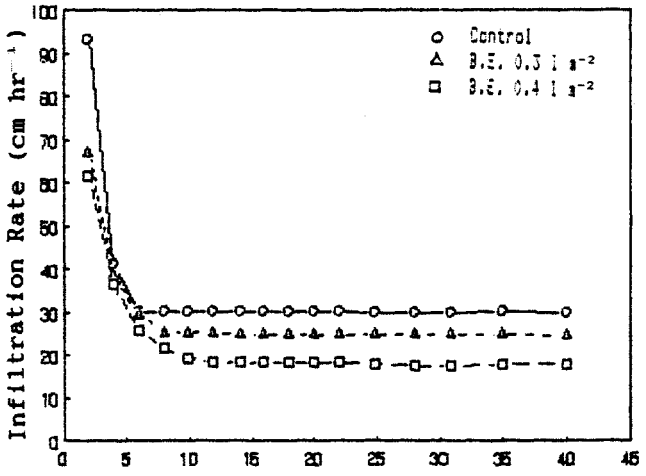

Fig. 3: Effect of B.E. on the Inf. Rate of Baiji Dunes Sand

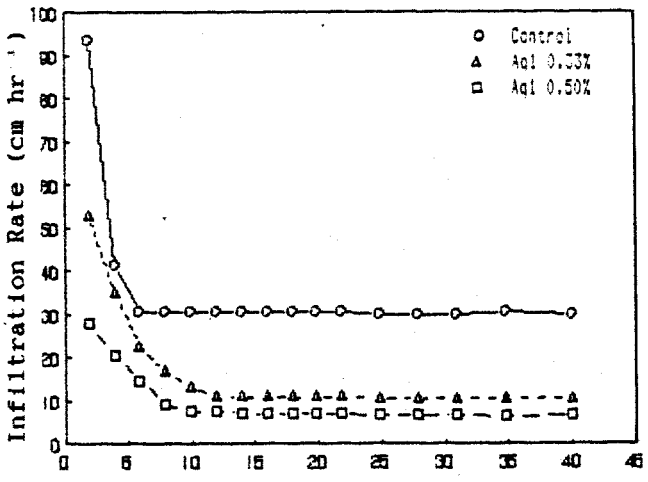

Fig. 4: Effect of Aq1 on the Inf. Rate of Baiji Dunes Sand

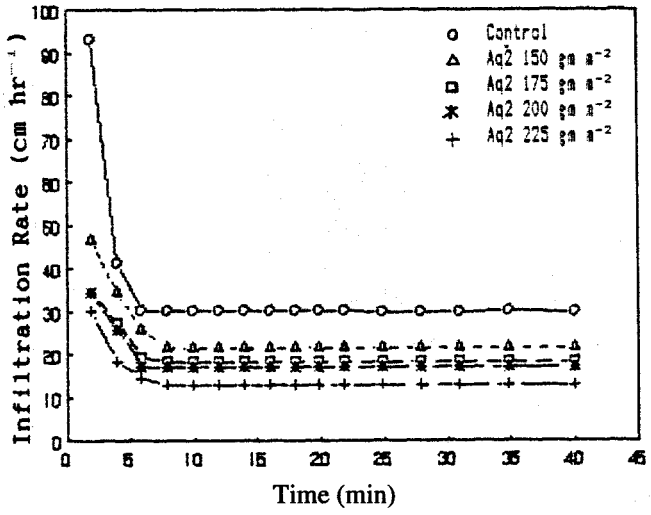

Fig. 5: Effect of B.E. on the Inf. Rate of Baiji Dunes Sand

Whilst the results from Baiji sand experiments are in agreement with those of Druridge Bay sand experiments [5], the actual infiltration rates of all Druridge Bay samples were much higher than those of Baiji sand samples. This was almost certainly due to the coarser sand particles of Druridge Bay sand in comparison with those of Baiji sand. With the reduced concentrations of the chemical used, the effect of the stabilizers can be ranked as follows : PVA 0.4% > PVA 0.2% > Control > B.E. 0.3 $1m^{-2}$ > Aq2 150 gm m^{-2} > Aq2 175 gm m^{-2} > B.E. 0.4 1 M^{-2} > Aq2 200 gm m^{-2} > F.E. 140 ml m^{-2} > Aq2 225 gm m^{-2} > Aq1 0.33% > F.E. 180 ml m^{-2} > Aq1 0.50%. It is worth mentioning that, all the results of Baiji sands treated with these concentrations were in excess of the minimum acceptable infiltration rate of 0.25 cm hr-1 [15].

CONCLUSIONS

1. The application of PVA increased the infiltration rate as compared with the control. The rate of increase was related to the concentation of PVA applied.

2. F.E.; B.E.; Aq1 and Aq2, reduced the infiltration rate of the sand. In all these cases, increased chemical concentration caused a further decrease in infiltration rates.

3. F.E.; B.E.; Aq1 and Aq2 concentrations, that were used successfuly with Druridge Bay sand, either rendered Baiji samples impermeable or drastically reduced their infiltration rate.

4 The increases or decreases in infiltration rates differ with various chemicals. However, all the results were in excess of the minimum acceptable rate of 0.25 cm hr-

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