Effect of initial water content on hydraulic conductivity in desalinization with slaking

スレーキングによる除塩における飽和透水係数への初期含水比の影響

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1. Introduction

The soil slaking has been considered as an unfavorable effect on aggregate stability and on saturated hydraulic conductivity (SHC) due to sealing of permeable pores by the slaked particles. In this respects, the SHC and slaking was measured after 24 hours immersion in water during desalinization from saline soil under different initial moisture contents with special attention to change in ESP after slaking. The objectives of the present research are (1) to assess the effects of slaking and drying on the status of soil conditions and (2) to identify the impact of drying and slaking on SHC.

2. Methods and materials

We collected a bulk amount of virgin soil block from 50-70 cm depth of Kojima Bay Polder. Some fundamental properties of studied soils are given in **Table 1.** The soil was mixed thoroughly and it was packed into the samplers (5.1 cm height and 5 cm diameter) by pushing them into the soil block. The samplers were kept in the incubators at 30°C for drying treatment to attain different soil moisture stages from water content of 60 to 10%. The weights of each sampler were monitored carefully until the desired moisture contents. There were 18 soil samples for 6 moisture conditions i.e., each moisture levels were replicated thrice. After completing moisture adjustment they were kept into the refrigerator. Finally, each adjusted soil sample was immersed into water in the pot (tap water; EC: 0.112 mS/cm, volume: 10980 cm^3) on the 4.75 mm sieve for slaking test. After 24 hours immersion, the slaked (fell down through the sieve) and the unslaked (remained on the sieve) soils were collected. The cations in extracts of soil: water = 1:5 from the slaked and unslaked soils were measured by atomic absorption spectrophotometer (AAS; Z 5300; Hitachi Ltd.). The exchangeable cations were also analyzed by the same method. We calculated the SAR by equation (1); then, the ESP was calculated from the SAR employing the equation (2) developed by Horneck et al., (2007).

Table 1: Some selected fundamental properties of studied soil.

Properties		Unit
Texture	Silty clay	
Clay	38.2	%
Silt	50.4	%
Sand	11.4	%
Soil pH (Soil:Water=1:2.5)	7.5	
Particle density	2.51	g/cm^3
Bulk density (In situ)	0.82	g/cm^3
Plastic limit	39.53	%
Liquid limit	72.9	%
Shrinkage limit	31.81	%
Saturated Hydraulic Conductivity	1.348×10^{-6}	cm/sec
Electrical Conductivity (Soil:Water=1:5)	2.92	mS/cm

$SAR = [Na^+]/\sqrt{0.5}\ ([Ca^{2+}] + [Mg^{2+}])$… (1)

$ESP = 1.475 \times SAR/1+ (0.0147 \times SAR)$… (2)

where, calcium, magnesium and sodium concentrations are expressed in units of meq/100 g soil.

Saturated hydraulic conductivity (SHC) was measured by Falling Head Method. The soil was packed into the samplers (5.1 cm height and 5 cm diameter) by pushing them into the soil. The soil cores were closed with lids on both open ends immediately after collection. The moisture content was adjusted to 60 to 10 % by the same method mentioned previously. The soil cores were saturated from the bottom with distilled water by raising water level up to the mark and left slaked for 24 hours. Finally, the SHC was measured.

3. Results and discussion

Fig. 1 shows the saturated hydraulic conductivity with slaking rate under different initial water contents in soil. The soil at lower water content shows the high SHC even at very dry condition (10 % water content). The SHC starts to increase after slaking started at water content lower than 40 %, showing prompt increase at the water contents of the maximum slaking (30 %). At further drying stage the SHC keeps increasing. This is accompanied by decrease in ESP. The SHC were increased with the decrease of ESP of the soil aggregates.

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Fig. 2 shows SAR of outer solution after 24 hours immersion against initial moisture contents. After 24 hours immersion in water, highest SAR were noted in outer solution under lower water content (30 %) which might be attributed due to the higher slaking rate and predominant release of sodium. The increasing in SAR started at the beginning of slaking at 40 % moisture content which coincides with that of beginning of slaking (**Fig. 1**). It means high proportion of Na shifted to outer solution from soil aggregate during slaking under lower water content below 30 %.

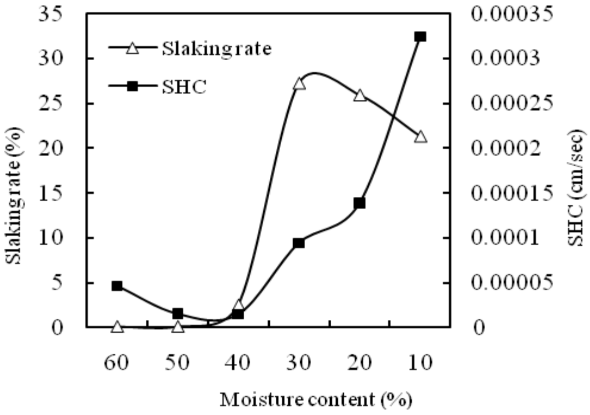

Fig. 1 Saturated hydraulic conductivity (SHC) and slaking rate of soil to moisture content.

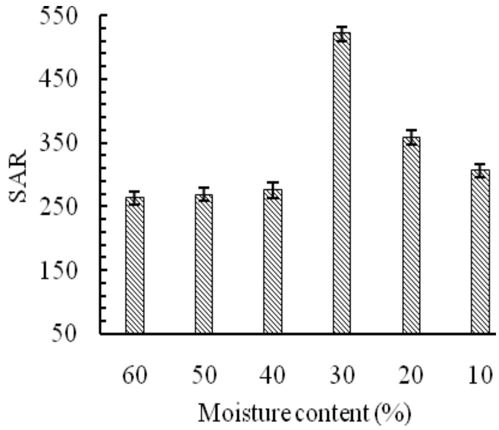

Fig. 2 The SAR of outer solution after 24 hours immersion. *Vertical bar* indicates ± SE of three replicates.

Fig. 3 shows ESP existing in (slaked + unslaked) soils after 24 hours immersion against various initial moisture contents. Significant reduction in ESP of the soil was noted in lower water content. Decrease in ESP of the soil was caused by releasing sodium into outer solution after 24 hours immersion. At lower water contents (30, 20 and 10 %) the soil was slaked and swelled well which helps to release the salt from the soil block. At the same time, water permeability characteristics of the soil was not decreased or degraded because the ESP were low than that of other moisture contents. That is why, the SHC is increased under the water content below 30 % and keeps to increase as the water content decreased in the soil.

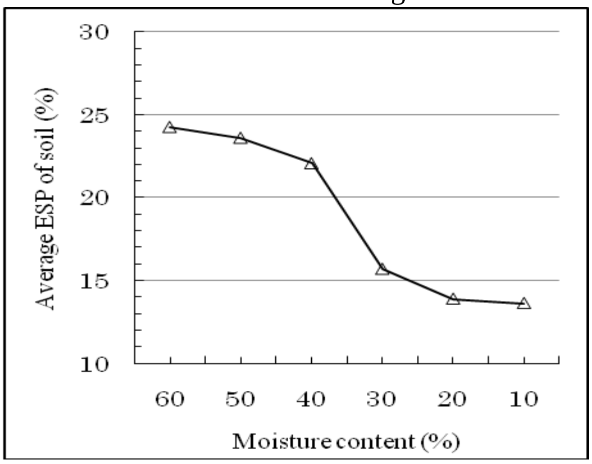

Fig. 3 The average ESP of soil against various initial water contents.

4. Conclusion

From the foregoing discussion, it can be concluded that after 24 hours immersion, higher SAR in outer solution was found under lower (30, 20 and 10 %) in compared to higher (60, 50 and 40 %) water content due to release of high proportion of Na into outer solution. In the soil, significant reduction in SAR and ESP of the soil was also found in the same moisture contents. The saturated hydraulic conductivity (SHC) started to increase under the water content below 30 % and kept to increase as the water content decreased. The results indicated that lower water content was more effective in decreasing the soil SAR and ESP under slaking in desalinization of the saline soil. The results also revealed that there were no harmful effects of slaking on SHC. But the further study and research in this challenging field is encouraged in order to find out the most effective and appropriate desalinization method.

References

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