การใช้โพลีไวนิลแอลกอฮอล์ในการแก้ไขดินเค็มภาคตะวันออกเฉียงเหนือ ตอนที่ 1 : การทดลองในห้องปฏิบัติการ

Utilization of PVA for Reclamation of the Salt-affected Soils in Northeast Thailand. Part 1 : Laboratory Experiments

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ABSTRACT

Surface layers of the salt-affected areas in Northeast Thailand were usually thin, sandy and underlain by a dark colored impermeable layer which inhibited desalinization in rainy season. In laboratory, PVA was confirmed to be effective in stabilizing aggregates of layers and was found to suppress capillary rise of saline water and to promote leaching of both saline and fresh waters. Thus, PVA was expected to help desalinization and suppress erosion in the salt-affected areas.

Keywords : Saline Soil, Northeast, PVA

บทคัดย่อ

ดินเค็มในภาคตะวันออกเฉียงเหนือชั้นบนจะเป็นชั้นบาง ๆ ของทรายอยู่เหนือชั้นของดินเนื้อละเอียดสีดำที่เรียกว่า impermeable layer ซึ่งเป็นชั้นที่ยับยั้ง desalinization ในช่วงฤดูฝน การศึกษาในห้องปฏิบัติการพบว่าโพลีไวนิลแอลกอฮอล์ได้ผลดีในการคงไว้ซึ่งความคงทนของการเกิดเม็ดดิน (stabilizing aggregates) ในดินทั้ง 2 ชั้นและยังหยุดยั้งการเคลื่อนที่ขึ้นของน้ำใต้ดินที่เค็ม นอกจากนี้ยังช่วยให้การชะล้างของทั้งน้ำจืดและน้ำเค็มเป็นไปได้ดีขึ้น ดังนั้นจึงคาดว่าโพลีไวนิลแอลกอฮอล์จะสามารถช่วยลดความเค็มและลดการเกิดกษัยการในบริเวณพื้นที่ดินเค็มได้

คำหลัก : ดินเค็ม ภาคตะวันออกเฉียงเหนือ PVA.

INTRODUCTION

One of the soil problems in the Northeast Thailand was the salt-affected soil (Arunin 1984). In general, desalinization was the first priority in reclaiming of this kind of soil. However, the desalinization process was rather difficult eventhough most of the salt-affected soils were sandy. For instance, the use of a drainage canal was inappropriate as it was easily filled up by eroded sandy materials (Puengpan *et al.* 1991 a). The dark colored impermeable layer near the soil surface suppressed

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desalinization in the rainy season by inhibiting infiltration of rain water (Puengpan *et al.* 1990) and enhanced erosion of saline materials resulting in expansion of salt patches (Puengpan *et al.* 1991 b). In the dry season, salt accumulated on and near the soil surface due to the strong evaporation and quick cappillary rise of the saline ground water (Katawatin *et al.* 1987. Nakano and Sugi 1987).

It was proposed that these desalinization factors would be overcome, at least partly, when stable aggregates were to be formed in the sandy salt-affected soil, especially in the impermeable layer.

In a reviewed report (Patcharagreecha *et al.* 1993), polyvinyl alcohol (PVA) was shown to be remarkably effective in stabilizing the aggregates of sandy soils in Northeast Thailand. Thus, PVA had been considered to be useful for reclaiming the salt-affected soils due to its ability to aggregate soil particles which were unaffected by salinity (Carr and Greenland 1975).

The objectives of this experiment were to clarify the abilities of PVA in

1) stabilizing aggregates of the sandy salt-affected soils with the impermeable layer in Northeast thailand,

2) enhancing percolation of water through the aggregated impermeable layer and

3) suppressing evaporation and/or cappillary rise.

MATERIALS AND METHODS

Soil sample and polyvinyl alcohol

Two soil samples were collected from a well developed salt patch at the foot of a slope which was located at the South of Phra Yun District, Khon Kaen Province.

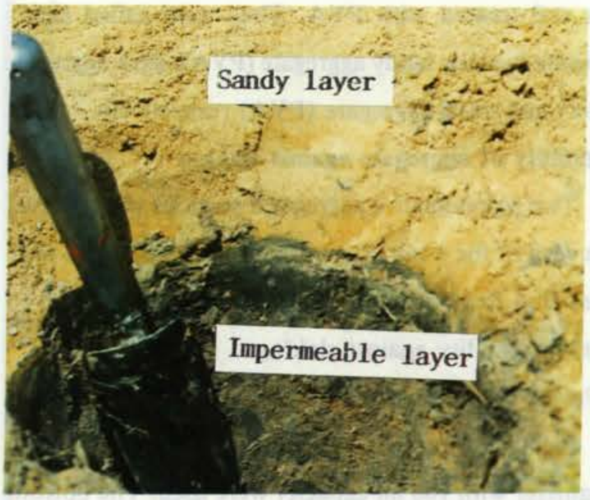

Fig.1 A profile from which soil samples were collected

The first sample was from the sandy surface layer (0-5 cm) and the second was from the dark colored impermeable layer (5-15 cm) (Fig. 1). They were air dried and passed through a 2 mm sieve. Their particle size distribution and textural classes were shown in Table 1 and identified as Satuk series saline variant.

The PVA used in the experiment was with molecular weight (MW) of 100,000 and saponification degree of 86.5-89% obtained from Japan.

1. Preparation of aggregate

Each of the soil samples was non-treated and treated with addition of PVA (0.2% w/w) in order to make aggregates as shown by Patcharapreecha *et al.* 1993. Thus, the total of 4 kinds of aggregated soil were yielded: (1) surface sandy layer soil treated with water, (2) surface sandy layer treated with PVA, (3) dark impermeable layer soil treated with water and (4) dark impermeable

Table 1 Particle size distribution and textural classes of the study soils

	Sand	Silt	Clay	Textural Class
	◄―――	%	―――►	
Sandy cover	87.8	10.6	1.6	Sand
Impermeable layer	58.3	34.2	7.5	Sandy loam

layer soil treated with PVA. They were called sandy aggregate (water), sandy aggregate (PVA), dark aggregate (water) and dark aggregate (PVA) respectively.

2. Stability of aggregate against slaking

Two representative aggregated particles were selceted from each of the 4 soil preparations. These particles were placed in a Petri dish and distilled water was added to test their stability against slaking.

3. Weight of soil in the column

Eight stainless steel cores of 5.1 cm in height and 5 cm. in diameter with 100 ml capacity were used. The bottom of the steel cores was covered with a piece of cloth. Then, each core was completely filled with one of the soil preparations and the weight of the soil inside the core was measured. For each soil preparation, 2 soil columns were prepared.

4. The rate of capillary rise of water through soil column

The cores containing the soil columns were carefully immersed in 1N NaCl solution of about 3 cm depth in a tray. The soil columns were wetted from bottom bottom through capillary rise and saturated with the NaCl solution. The rate of capillary rise through the soil column was roughly estimated by measuring the time when the surface of the soil column became wet.

5. Change in height of the soil column

Before and after immersing the soil column in the NaCl solution for 24 hrs. the soil columns were measured for height, since the decrease in height of the soil columns was expected by solution immersion.

6. Percolation rate through the soil column

After saturation with 1 N NaCl solution, the soil column was percolated firstly with 100 ml of 1N NaCl solution, then with 100 ml of distilled water using a falling head permeameter obtained from Japan. Soil column height as well as percolation rates of the soil columns for both the NaCl solution and distilled water were measured.

7. Slaking test of the soil column

The air dried soil columns were submerged in distilled water for slaking and measured for decrease in their heights.

RESULTS AND DISCUSSION

1. Preparation of aggregate

Preparation of small aggregates was very difficult for the sandy surface layer soil. Therefore, the size of the aggregate became large, e.g., with diameter of about 5 mm. The same size aggregates were prepared from the dark impermeable layer soil, though much smaller aggregates could have been prepared from this soil.

2. Stability of aggregate against slaking

Sandy aggregates (water) were immediately and completely disintegrated when distilled water was added. Sandy aggregates (PVA) were somewhat disintegrated by slaking. Observations under a binocular microscope revealed that slaked sandy aggregates (water) and sandy aggregates (PVA) produced individual soil particles and small aggregates, respectively. This demonstrated that PVA could not stabilize the aggregates of the sandy surface layer if their size was as large as 5 mm but could stabilize small aggregates.

On the contrary, dark aggregates (water) were gradually disintegrated when they were added with distilled water and dark aggregates (PVA) were completely intact against slaking.

3. weight of soil in the column

The weight of soil in the column was shown in Table 2. The weight in Table 2 varied from greater weight to smaller weight in the following order, dark aggregate (water) dark aggregate (PVA) .sandy aggregate (water) sandy aggregate (PVA). This must be a reflection of difference in the agrregates sizes.

Table 2 Weight of aggregates in cores (100 ml)

	Core 1 (g)	Core 2 (g)	Average (g)
Sandy aggregate (Water)	94.03	93.21	93.62
Sandy aggregate (PVA)	88.95	87.79	88.37
Dark aggregate (Water)	114.70	113.49	114.10
Dark aggregate (PVA)	103.26	106.96	105.11

4. The rate of cappillary rise through the soil column

The rate of capillary rise (Table 3) was decreased in the following order; sandy aggregate (water) > sandy aggregate (PVA) = dark aggregate (water) > dark aggregate (PVA) (Fig.2).

Fig.2 Wetting of soil column by capaillary rise and change of column height (1 2 = 3 4)

There are three conceivable factors that could have caused this result: (1) decrease in height of the soil column, (2) development of capillary pores and (3) size of capillary pores. The height of the soil culumn was decreased by immersion in the saline water due to disintegration of the aggregate. Disintegration of the aggregates, in turn, might produce new capillary pores. Sizes of both original and newly produced capillary pores were considered to depend on soil texture.

Table 3 Rate of capillary rise of NaCl solution

	Rate of capillary rise (mm/min.)*
Sandy aggregate (Water)	0.7
Sandy aggregate (PVA)	0.13
Dark aggregate (Water)	0.14
Dark aggregate (PVA)	0.02

* period of wetting of surface soil column divided by height of soil column in NaCl solution

5. Change in height of the soil column

When the soil columns were immersed in 1N NaCl solution, their height were reduced as shown in Table 4 and could be arranged in the following decreasing order: sandy aggregate (water) sandy aggregate (PVA) dark aggregate (water) dark aggregate (PVA). Actually, the soil column of dark aggregate (PVA) did not show any height decrease.

Table 4 Height of soil column

	Height (cm.)	
	After immersion in NaCl	After permeability test
Sandy aggregate (Water)	3.5	2.8
Sandy aggregate (PVA)	4.4	3.3
Dark aggregate (Water)	4.8	4.4
Dark aggregate (PVA)	5.1	5.1

This must be mainly caused by difference in disintegration of the aggregates by slaking. For instance, if the submerged aggregates were quickly disintegrated by slaking, the overlying aggregates sinking in the solution were also slaked. This was te case of sandy aggregate (water). On the contrary, if the aggregates were slowly disintegrated, the aggregates above the solution might be safe against slaking. Probably, this was the case of dark aggregate (water).

6. Percolation rate through soil column

Percolation rate of the NaCl solution (Table 5)

Table 5 Percolation rate of NaCl solution

	1 N NaCl Ksat. (cm/sec.)	Distilled H_2O Ksat. (cm/sec.)
Sandy aggregte (Water)	$2.78x10^{-3}$	$3.92x10^{-3}$
Sandy aggregate (PVA)	0.036	0.036
Dark aggregate (Water)	Very quick*	$9.40x10^{-4}$
Dark aggregate (PVA)	Very quick*	very quick

* too quick to be measured

decreased in the following order: dark aggregate (PVA) > dark aggregate (water) > sandy aggregate (PVA) > sandy aggregate (water).

This percolation rate order seemed to be the reversed order of the decrease in the soil solumn. It supported the consideration and discussion on slaking of the aggregates indise the cores mentioned previously.

Percolation rates of water were similar to those of the NaCl except that the dark aggregate (water) became somewthat impereable.Change in percolation solution form the NaCl solution to water must generate osmotic pressure inside the aggregates. This was remarkable only for dark aggregate (water). The reasons might be due to

1) dark aggregate (water) remained large in size at the time of percolation with water and since it contained clay, it made the aggregate susceptible to the osmotic pressure

2) sandy aggregate (water) was already more or less completely disintegrated by slaking in NaCl solution

3) sandy aggregate (PVA) became small in NaCl solution by slaking and contained less clay than dark aggregate (water). PVA helped the small size aggregate from dispersion by the osmotic pressure and 4) dark aggregate (PVA) could stand against the osmotic pressure.

7. Slaking test of soil column

Heights of almost all the soil columns were further decreased by percolation (Table 4). This indicated that not only osmotic pressure but also mechanical impact of the percolating solutions distintegrated the aggregates. This consideration was supported by observation that the surface of the soil column be came flat after percolation, especially that of the dark aggregate (water).

Characteristics of salt-affected areas

As discussed above, in the salt-affected area, the dark colored impermeable layer was usually covered with a sandy layer of varying thickness. The sandy layer was fully permeable even if no aggregates were present (Puengpan *et al.* 1990 a). On the contrary, the dark colored impermeable layer must be treated to increase both intake and percolation rates of the soil. This could feasibly be accomplished through the impermeable layer destruction by mechanical means such as ploughing (Subhasaram *et al.* 1992 b) However, the effect of ploughing tends to be easily and quickly nullified in the field. Mulching and/or incorporation of organic fertilizers appeared to effectively prolong the effect of ploughing or help extention of plant roots to the subsurface horizons before restoration of the impermeable layer (Subhasaram *et al.* 1992 a, 1993).

The results of these present experiments have thus demonstrated that utilization of PVA may be an alternative and more advanced technology for solving the problem of the dark colored impermeable layer. For instance, if the dark colored impermeable layer was successfully aggregated with PVA, not only would intake and percolation rates be increased but also the rate of erosion, another serious problem in the salt-affected area, would be decreased

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