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Sulfuric acid as a chemical amendment for increasing efficiency of reclamation process of salt affected soils of Iraq

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ABSTRACT

Diluted solutions of sulfuric acid were evaluated, as a leaching solution, in comparison with water for reclamation of salt affected soils of Iraq. Sulfuric acid was used to liberate Ca^{2+} of the native soil lime so as to replace Na^{+} on the exchange sites. Solutions of 0.05 and 0.1 N sulfuric acid resulted in remarkable increase in the hydraulic conductivity (HC) of both soils over when water was used as a leaching solution. Electrical conductivity of the leachate of both soils leached with water was less than that when the two soils were leached with either 0.05 or 0.1 N acid solutions. Total salts which remained in soils leached with water were markedly higher than that leached with the acid. Amount of Na^{+} removed as an average of both soils was 62, 50 and 42% under 0.1 N, 0.05 N H_2SO_4 and distilled water, respectively. Thus leaching of such soils by appropriate solution of sulfuric acid is highly efficient in removing sodium salts out of soil profile. And for that matter it is highly recommended for use in reclamation projects in Iraq.

Keywords: Leaching solution, Na, Ca, Mg.

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INTRODUCTION

Salt affected soils occupy about 70% of agricultural land of the Lower Mesopotamian Plain of Iraq (Al-Taie, 1970). These soils are of saline and saline alkali type either with a white salt crust on the surface or of a dark brown color with a high content of deliquescent salts (Buringh, 1960). The first one is locally known as a Shura soils while the second is known as a Sabakh soils, Salt accur naturally within soil and water.

Intensive reclamation projects for these soils were initiated in the early seventies. Reclamation process involved lowering the depth of water table and applying enough volume of water on the surface to remove the excess salts. These projects, however, encountered real problems of slow reclamation process, re-salinization of the reclaimed area and the considerable loss of land productivity. Salination can be caused by natural processes like mineral weathering and can also come about through (Shahbaz and Ashraf, 2013).

Low efficiency of reclamation process may be attributed to leaching with a high quality water or with a water of low electrolyte concentration which had been reported to induce a considerable decrease in soil permeability and consequently hydraulic conductivity (HC) (Quirk and Schofield, 1955; McNeal et al., 1968; Shainberg et al., 1981; Shainberg et al., 1989). Resalinization of reclaimed soils may arise from inefficient removal of exchangeable sodium (Miyamoto et al., 1975; Kirda et al., 1974; Papadopoulos, 1985).

Therefore this work was designed to investigate the possibility of increasing the efficiency of reclamation process by using an appropriate concentration of sulfuric acid to liberate Ca through reaction with native calcium carbonate to the leaching solution.

MATERIALS AND METHODS

The soils used are alluvial clay texture of salt affected area of Salman project 20 km south eastern of Baghdad, Iraq. Soils were sampled from 0 to 60 cm depth in two layers of equal depth, some of soil properties are shown in Table 1. The homogenized soil of each depth was packed on a depth wise in aplexiglass columns of 70 cm length and 12 cm inner diameter. The bulk density of the soil in the columns was 1.48 + 0.05 g/cm^3.

Six columns were prepared from each soil. Two replicate (columns) of each soil were assigned to one of the following leaching solutions; Distilled water (DW); 0.05 N H_2SO_4 and 0.1 N H_2SO_4 solution. Continuous ponding of 5 cm depth of either leaching solution on the surface of the soil for the entire leaching period was employed as a leaching method.

Effluent was daily collected for which volume, EC, Na, Ca and Mg, were determined. The hydraulic conductivity of the soil was also determined throughout the leaching period. All measurements were conducted according to Page (1982).

Table 1. Properties of the soils used in the study.

Property	Shure soil		Sabakh soil	
	Depth (cm)			
	0-30	30- 60	0-30	30-60
EC 1:1 dSm^{-1}	38.4	19.56	62.48	18.0
pH 1:1	6.58	7.04	6.35	7.06
$CaCO_3$ gkg^{-1}	302.2	311.4	308.46	317.46
Gypsum gkg^{-1}	0.54	0.36	0.41	0.28
CEC $cmolkg^{-1}$	21.8	24.65	24.6	23.28
Sand	109.6	89.6	249.6	89.6
Silt	280	300	280	320
Clay	610.4	610	470.4	590.4
Texture	Clay	Clay	Clay	Clay
Na $mmolL^{-1}$	268.12	154.77	333.07	129.25
Ca $mmolL^{-1}$	29.45	7.69	117.42	19.12
Mg $mmolL^{-1}$	88.53	33.81	166.78	33.68

RESULTS AND DISCUSSION

Solutions of 0.05 N and 0.1 N H_2SO_4 (Figure 1) had a remarkable effect in maintaining HC of both soils above that of water. The HC of Shura soil when 1 pore volume of either D.W, 0.05 or 0.1 N H_2SO_4 passed was 0.078, 0.082 and 0.09 cm/h respectively. Hydraulic conductivity of Sabakh soil was less than that of Shura soil. An exponential decrease in hydraulic conductivity was observed with the amount of D.W passed through. Hydraulic conductivity of Sabakh soil when either 0.05 or 0.1 N solution used was markedly higher than that when leaching solution was distilled water. The greatest the salt content of the leaching solution, the greatest the hydraulic conductivity of soil. This is in agreement with Shainberg (1981) who reported that high electrolyte content of soils during the reclamation was very important for maintaining high hydraulic conductivity.

Efficiency of H_2SO_4 in reclamation process of Shura and Sabakh soils of Iraq was also evaluated against the amount of salt removed by a unit volume of leaching solutions. Amount of Na removed from Shura soil by one pore volume of D. W, 0.05 N and 0.1 N H_2SO_4 (Figure 2) was 48, 60 and 70% of total sodium, respectively. However, amount of sodium removed from Sabakh soil was 36.5, 40 and 54% of the total sodium respectively. Moreover, for both soils, Excess amount of leaching solution percolating through resulted only in a slight increase in Na leached. This may indicate that remaining amount of Na in soils takes fairly long time to be removed (Amezketa et al., 2005; Lopez-Aguirre et al., 2007).

Amount of Ca^{2+} leached from Shura and Sabakh soils (Figure 3). The greatest amount of Ca removed was under 0.1 N H_2SO_4 while the least amount was under the D.W. However, in Sabkh soil only 85 to 90% of Ca was leached under 0.1 and 0.05 N H_2SO_4 while < 80% was leached under D.W. Increasing the period of leaching to 3 pore volumes passed through resulted in only minute increase in the amount of Na^+,Ca^{2+} or Mg^{2+} leached.

Amount of Mg^{2+} leached from Shura and Sabakh soil (Figure 4) was relativity equal. Amount of Mg^{2+} leached from shura soil was 98, 86 and 75% under leaching with 0.1N H_2SO_4, 0.05N H_2SO_4 or D.W respectively. This may again confirm the previous conclusion that solution of sulfuric acid is more effective in replacing Na^+, Ca^{2+} and Mg^{2+} ions than the D.W (Amezketa et al., 2005; Lopez-Aguirre et al., 2007). Amount of Na remained may behave as a seed for resalinization process.

In the conventional reclamation process of salt affected soils the electrical conductivity of the leached and that of saturation paste are considered as the main parameter for efficient reclamation. In this study, EC of the leachate was <4 dS/m yet there was >50% of total Na^+ that remained in both soils under the leaching with D.W. However, amount of Na^+ that remained in both soils was <30% under the leaching with the acidified water (Ahmad et al., 2013). This

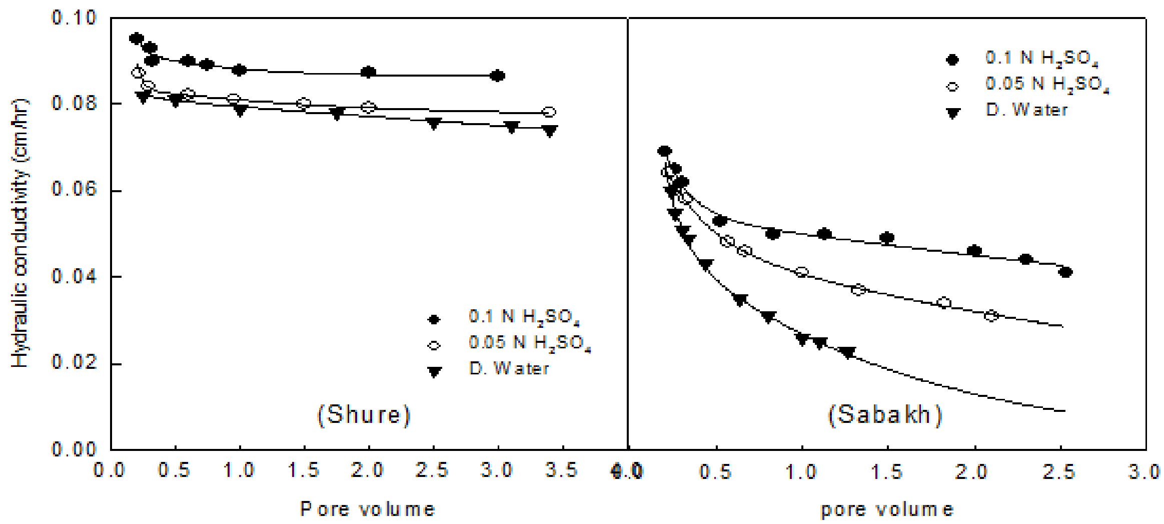

Figure 1. Effect of leaching process on the hydraulic conductivity of soils specified.

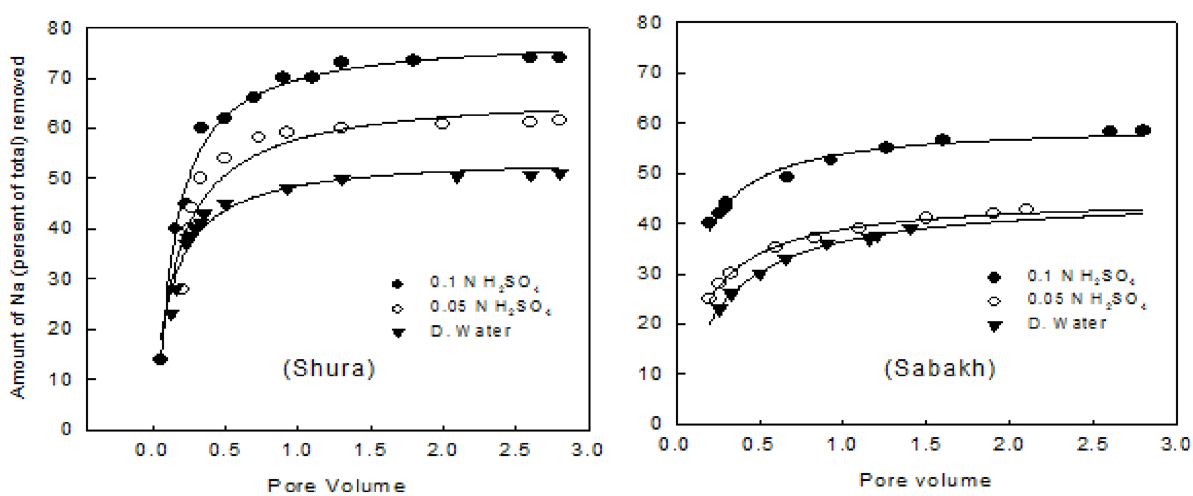

Figure 2. Amount of Na (as a percentage of the total) removed by different leaching solutions.

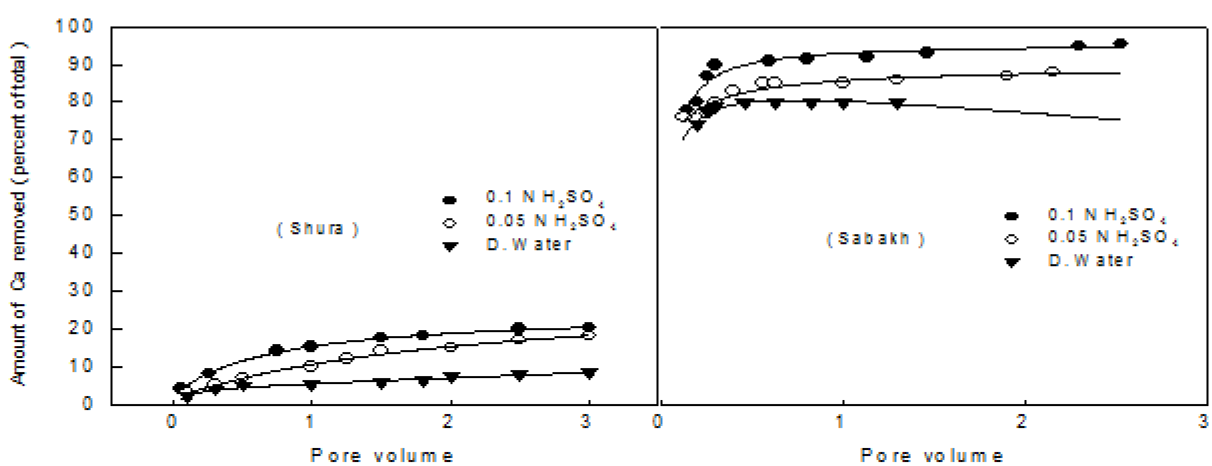

Figure 3. Amount of Ca (as a percentage of the total) removed by different leaching solutions.

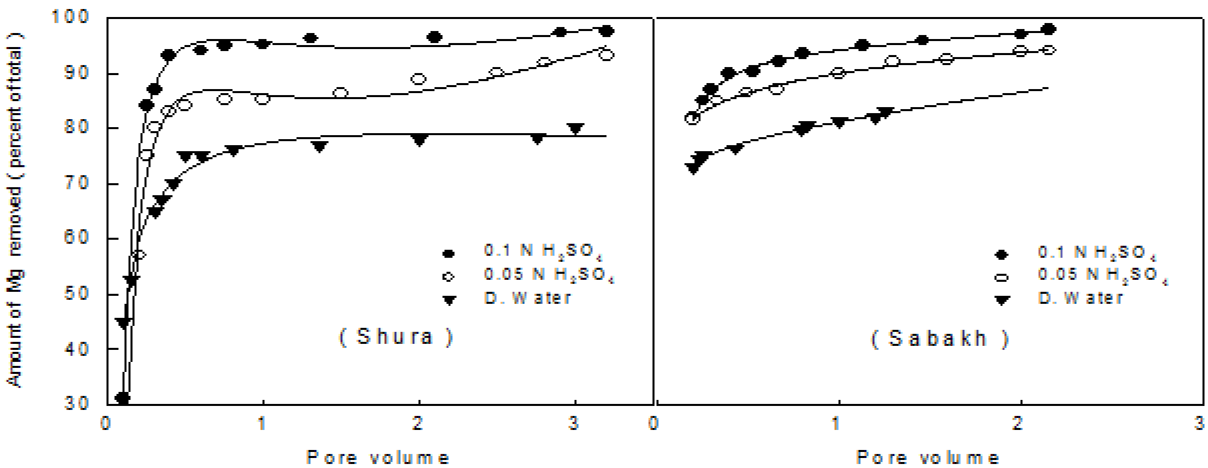

Figure 4. Amount of Mg (as a percentage of the total) removed by different leaching solutions.

may again confirm the superiority of using H_2SO_4 as reclaiming aid over that of water. Moreover, leaching with acidified water may prevent reclaimed soils of being resalinized again.

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