Catena 92 (2012) 172–178

Contents lists available at SciVerse ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Studying some hydro-physical properties of two soils amended with kaolinite-modified cross-linked poly-acrylamides

Rashad A. Hussien [a,*], Ahmed M. Donia [b], Asem A. Atia [b], Osama F. El-Sedfy [a], Azza R. Abd El-Hamid [a], Rama T. Rashad [a,*]

[a] Soil, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt
[b] Department of Chemistry, Faculty of Science, Menoufia University, Menoufia, Egypt

ARTICLE INFO

Article history:
Received 28 April 2011
Received in revised form 20 December 2011
Accepted 22 December 2011

Keywords:
Swelling degree
Hydro-physical properties
Pore size distribution
Hydraulic conductivity
Sandy soil
Cross-linked hydrogel

ABSTRACT

A poly[(acrylic acid)-*co*-acrylamide] hydrogel was prepared in the laboratory through polymerization of partially neutralized acrylic acid (AA) in the presence of N,N′-methylene bisacrylamide (MBA) as a crosslinker. The polymer was prepared without an additive (H1) or with 5% (w/w) kaolinite clay mineral added during the polymerization (H2). The swelling of the hydrogel in distilled water as well as within the soil matrix was studied. Some hydro-physical properties of two different soil samples amended with the hydrogel were also studied. The S1 soil was sandy and non-saline; and the S2 soil was sandy clay loam and slightly saline. The swelling degrees (S) in distilled water were 97.8 and 282.8 g/g of the hydrogel dried at 70 °C, for the non-modified H1 and kaolinite-modified H2 hydrogels, respectively. The S values of H1 and H2 hydrogels, within the S1 soil were 85.45 and 81.25 g/g, respectively. While within the S2 soil, the S values of H1 and H2 hydrogels were 31.17 and 16.32 g/g, respectively. The change in the studied hydro-physical properties of soil treated by the hydrogel was more dependent on the soil texture and salinity and the hydrogel concentration in soil than on the swelling degree of the hydrogel. The change in the bulk density values of the soil–hydrogel mixture was in the range 90.1%–71.43% relative to the soil sample free of hydrogel. While the change in the total porosity values were in the range of 98.83%–132.64%. The effect of presence of the hydrogel on the hydraulic conductivity of the soil samples was discussed.

© 2011 Elsevier B.V. All rights reserved.

1. Introduction

Reclamation and land utilization of the desert areas, often sandy, are faced by several difficulties (Abed et al., 1981 and El-Hady et al., 1990). To a large degree, the soil quality depends on the size, shape and arrangement of solids and voids (Abdel-Mawgoud et al., 2006; Abd El-Hamid, 2004). In the arid and semiarid regions, water availability is often the limiting factor determining the size of cultivated area (El-Hady et al., 2006). High sodium in sodic soils or $CaCO_3$ content in some soils causes some difficulties such as reduced infiltration and poor drainage. Also, it causes the crop damage due to standing water or inadequate aeration in the root zoon and in alga growth on the soil surface (Abu-Hamdeh, 2004).

Both linear and cross-linked polymers have been widely used as soil conditioners for different application purposes (Anagnostopoulos, 2005; Hayat and Ali, 2004; Orts et al., 2000). Some commercially available conditioners were used in many studies (Ajwa and Trouts, 2006; Bhat et al., 2006). Two types of polymeric soil conditioners are known: (i) cross-linked polymers (hydrogels) that are used to improve the water holding capacity of the soil and (ii) linear polymers that are used to for stabilizing the soil aggregates and structure in order to minimize crust formation, runoff and soil erosion. They may change the mean diameter of the soil pores which sometimes enhances water transmitting properties (Bhardwaj and Mclaughlin, 2007; Bhat et al., 2009; Jhurry, 1997; Tayel and El-Hady, 1981). Poly-acrylamide (PAM) is a synthetic polymer that degrades in the soil environment at rates less than 10% per year (Orts et al., 2000).

Hydrogels are loosely cross-linked, highly hydrophilic, organic polymers. They can absorb and retain aqueous fluids up to 500 times of their own weight (Guilherme et al., 2005; Li et al., 2005). In the field application, such absorbents exhibited a limited swelling capacity within the soil matrix. Their swelling efficiencies decrease with increasing the water salinity (Akhter et al., 2004; Kazanskii and Dubrovisky, 1992). Free swelling of some hydrogel polymers was in the range 200–500 g/g of the polymer, but when mixed with the sandy soil it was 40–140 g/g. Mixing the suitable hydrogel with the organic material applied to soil (natural soil conditioners like organic manures and composts) is sometimes more effective and economic than using each of them alone (El-Hady and Abo-Sedera, 2006; El-Hady and Camilia, 2006). The yield, uptake of nutrients and both water and fertilizers use efficiency may decrease by the use of a concentration higher than the critical (over dose) of the applied hydrogel (El-Hady and Camilia, 2006). Better understanding of the interaction

* Corresponding authors. Tel.: +20 106 2856224.
E-mail address: rtalat2005@yahoo.com (R.A. Hussien).

0341-8162/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.catena.2011.12.010

among hydrogel, soil and water quality may produce an efficient and economic technology for the soil management.

Clay/polymer composites are very attractive because small amount of clay (<5 wt.%) can lead to a great improvement in many properties of the polymer such as swellability of the hydrogels and renders it biodegradable and environment friendly (Atia et al., 2009; Weian et al., 2005; Xia et al., 2003).

In the present study a poly[(acrylic acid)-*co*-acrylamide] hydrogel was prepared in the laboratory. The swelling degree *S* (g/g) of the hydrogel was increased by adding 5% (w/w) of kaolinite clay mineral during polymerization. The main objectives of this study is to assess the hydrogel swelling in distilled water as well as within the soil matrix and to evaluate the role of the difference in the swelling degree between the clay-modified and the non clay-modified hydrogel in changing some hydro-physical properties of soil. The soil–hydrogel interaction mechanism was also discussed.

2. Methods

2.1. Soils

Two disturbed soil samples, S1 and S2 (0–30 cm depth) were obtained from two different locations in Egypt, El-Esmailyia and El-Nubaryia Agric. Res. Stations, respectively. Both samples were air-dried, ground, sieved with a 2 mm sieve and kept for the study. The particle size distribution, $CaCO_3$% and concentration of the soluble ions (in the soil paste extract) were measured according to Page et al. (1982) and presented in Table 1. The S1 soil was sandy with a high content of coarse sand, non-calcareous and non-saline (Abbas, 2003); While the S2 soil was sandy clay loam with a high content of the fine particles as fine sand, silt and clay, calcareous and slightly saline.

2.2. Hydrogels

Fresh samples of poly[(acrylic acid)-*co*-acrylamide] hydrogel (Fig. 1), H1 and H2, were prepared following the previously published method (Atia et al., 2009). Acrylic acid (AA) was partially neutralized by ammonia solution (neutralization degree ND = 63%—ratio of acrylic acid:acrylamide (AA:AAm) is 1:1.7). N,N′-methylene bisacrylamide (MBA) was added as a cross-linker to obtain the H1 hydrogel sample.

The H2 sample was prepared following the same procedure in the presence of 5% (w/w) kaolinite clay as filler. A synthetic commercial poly acrylic acid hydrogel (Aqua keep, Aquakeep Industrial Grade SAP, ALCHEMY substances, India) was used as a model (HA) for comparison with the two laboratory prepared hydrogel samples. It was applied in the form of solid powder, to help in the assessment of the laboratory prepared hydrogel, applied in the form of gel.

2.2.1. Swelling of the hydrogels

The swelling degree (water absorbing capacity of the hydrogel) was estimated as follows:

a) In distilled water: A 0.25 g of air-dried sample of each hydrogel was placed in 25 mL distilled water (1% concentration) at 25 °C for 18 h as equilibrium time. The swollen samples were then removed from water, blotted with a filter paper to remove non-absorbed water and weighed. All experiments were carried out in duplicate and the swelling values were the average of two data points. The swelling ratio *S* (g/g) was calculated using the formula (Weian et al., 2005):

$$S = \frac{Wt - Wo}{Wo} \quad (1)$$

Where W_o is the weight (g) of the dried hydrogel at 70 °C and W_t is the weight (g) of swollen gel at time t = 18 h.

b) In soil: a homogeneous mixture of a 100 g of air dried soil and a 2 g H1, H2 or 0.2 g HA hydrogel was prepared (on the air-dried basis: 2% for H1 and H2; each contain 94% water of preparation, 0.2% for HA). The mixture was packed by gentle manual vibration in a cylindrical metallic tube (core, 5 cm height and 5 cm diameter) with two open ends. One end has been sealed by a Wattman filter paper supported by a stronger filter tissue. The packed core was weighed then immersed in distilled water to the half of its height and left for 18 h equilibrium. The samples of soil/hydrogel mixtures were removed from water, left for minutes on a sieve to drain excess water, blotted with a filter paper to remove non-absorbed water and weighed. Compared with control soil samples without addition of the hydrogel, the swelling ratio *S* (g/g) values for H1, H2 and HA hydrogels, within the S1 and S2 soils, were calculated using the formula (1) and listed in Table 2.

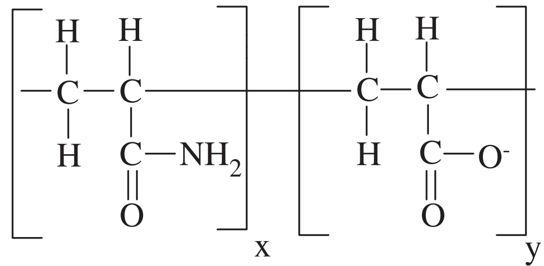

Fig. 1. PAM: Poly[(acrylic acid)-*co*-acrylamide] Hydrogel.

2.3. Procedures

Different hydrogel concentrations were examined for suitable handling and mixing with soil. On the basis of the *S* values in distilled water and within the soil, the selected concentrations were found to be the smallest possible weights which are suitable for handling and mixing with the soil; and can give a readable change.

Each hydrogel (H1 or H2) was added (in the form of gel containing water of preparation) to each soil (S1 or S2) individually at the rates of 0.5, 1.0 and 2.0% (wt/wt) on the air-dried basis (0.03, 0.06 and 0.12% wt/wt on the oven dried basis, respectively). One smaller concentration of HA was used (0.2%) because it is free of water of preparation. The studied soil samples (treatments) were listed in Table 3. Each treatment reading was an average of three replicates, i.e. 8 amendment treatments × 2 soils = 16 treatments, with 3 reps each. Analysis of variance among treatments was carried out at 95% confidence interval.

Table 1
Some properties of the studied soil samples.

	Particle size distribution (g kg^{-1})					$CaCO_3$ (%)	pH (1:2.5)	EC_e (dS m^{-1})	Soluble ions (meq L^{-1})						
	Coarse sand	Fine sand	Silt	Clay	Texture class				Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3^-	Cl^-	SO_4^-
S1 soil	768.2	92.0	57.8	79.7	Sandy	0.22	7.43	0.77	2.57	3.32	1.62	0.22	3.11	1.62	3.0
S2 soil	174.9	343.3	267.7	214.1	Sandy clay loam	23.0	7.50	4.36	9.0	7.2	26.54	0.58	9.61	18.84	14.91
($CaCO_3$ (%) in fraction)[a]	(7.98)	(3.55)	(0.52)	(11.11)											

[a] For S2 soil.

Download English Version:

https://daneshyari.com/en/article/4571900

Download Persian Version:

https://daneshyari.com/article/4571900

Daneshyari.com