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Determination of acid requirement for preventing chemical clogging in a drip irrigation system

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Abstract
Problem of clogging is frequently observed in emitters of drip irrigation systems, which is directly linked with quality of water and effectiveness of filtration system. Acidification can reduce biological as well as chemical clogging of emitters as it reduces pH of water. In this study fifteen water samples collected from different locations having diverse quality parameters with their pH ranging between 8.14 to 9.26 were used. From these samples 50 ml of solution was taken and pH of the water sample was reduced to a desired level (=4) by titrating it against three different acids HCl (35.5% conc.), H_2SO_4 (98.8% conc.) and H_3PO_4 (88% conc.). Acid solutions of 0.01N were prepared to determine the amount of acid require to lower down the pH to a target level (4.0). Functional relationships were developed to determine the amount of different acids required for bring down pH 1000 litre of water to a desired level (4.0). It was found that the amount of HCl, H_2SO_4 and H_3PO_4 required to bring down the pH of water sample has a strong correlation with initial pH. The effect of other water quality parameters on acid requirement is found to be non-significant. Among HCl (35.5% conc.), H_2SO_4 (98.8% conc.) and H_3PO_4 (88% conc.), the phosphoric acid is most economical to use for acidification treatment.

Keywords: Drip irrigation, clogging, water quality, acid requirement and acidification

Introduction

Drip irrigation also known as trickle irrigation is one of the most efficient method of irrigation in comparison with currently existing irrigation methods. It requires least amount of water over the growing season in comparison to other irrigation methods. Proper management and maintenance are required for efficient working of drip irrigation system, these systems are affected by emitter clogging which is directly related to quality water in used and reduce the efficiency of the system (Cararo *et al.*, 2006) [4]. Emitter clogging results in reduced discharge along lateral, uneven pressure distribution, decreased distribution uniformity and irrigation efficiency. It is mainly classified is classified into three categories -: (1) physical (2) chemical (3) biological clogging (Bucks *et al.*, 1979) [3]. Physical clogging is caused by suspended particles of inorganic material like sand, silt, clay and plastic material. Physical clogging can be prevented by introducing a filtration system like using screen filters which are simple, economical and easy to manage. Biological clogging is caused by biological and bacterial growth in the pipeline which in turn disturb discharge and pressure in the pipeline. It can be prevented by chlorination. Chemical clogging is caused by precipitation of mineral compounds like deposits of calcium or magnesium carbonates and iron oxide which occurs more readily in water with a pH above 7.0. Acidification can be used as means to reduce chemical clogging of emitters and which is also effective controlling biological clogging to some extent. Acids like Sulfuric (H_2SO_4), hydrochloric (HCl), phosphoric (H_3PO_4) and nitric (HNO_3) acid can be used to lower the pH of water and reduce the potential risk of chemical precipitation (Pitts *et al.*, 2003) [7]. Previous studies suggest that relatively low concentrations like 2 mg L^{-1} given intermittently and 1 mg L^{-1} or 0.4 mg L^{-1} given continuously are effective in preventing chemical clogging (Ribeiro *et al.*, 2008) [8]. Although the chlorination method can be efficient for the preventing clogging but there is no general agreement between researchers in relation to amount, frequency and best way of application (Airoldi, 2007) [1]. The amount of acid required for chemical treatment of clogging depends on (1) the strength of the acid, (2) the buffer capacity of the irrigation water and (3) the pH of the irrigation water (Bo *et al.*, 2016) [2]. The pH of the irrigation water (target pH) required to be maintained depends on the severity of chemical clogging and concentration of mineral deposits (Pei *et al.*, 2014) [6]. Titration test can be used determine the volume of acid required to bring the pH of irrigation water to a desired (target) level. This study was conducted with aim of achieving the following objectives i.e. Determination of amount of acid required to lower water pH to given target level and identify the effect of different water quality parameters on acid requirement to lower the pH of water.

Material and Methods

Groundwater samples collected from various locations having different pH and quality parameters were received from Departments of Soil Science, COA and analysed in Soil and Water Engineering Laboratory, COAE&T, CCSHAU, Hisar. Determination of acid requirement for treatment of chemical clogging in drip irrigation system was carried by titrating water samples against the following acids: HCl (35.5% conc.), H_2SO_4 (98.8% conc.) and H_3PO_4 (88% conc.). The concentration of acids used was based on recommendations previous researches on the subject (Keller & Bliesner, 1990) [5] and were prepared according to standard procedure of preparation.

Estimation of acid requirement

As groundwater samples were collected from different locations, there pH and chemical composition was different. So, the volume of acid required to bring down the pH of water sample to a desired level used is also different. For estimation of acid requirement 50 ml of water sample of known pH was taken in titration flask then 2 ml of 0.01N solution of acid ($HCL/H_2SO_4/H_3PO_4$) was added to water sample and stirred to properly mix the solution. The sample was kept undisturbed for 30 minutes then it was stirred and its pH was determined. The Above procedure was repeated till the pH of water sample was lowered to 4.0 and further calculations were done.

Volume of acid required for pH reduction

Required volume of acid reduction of pH reduction of ground water sample depends on pH, concentration of acid used and also on the initial and target pH level. A titration curve was prepared for determining the volume of acid required to bring the pH down to a desired level for 1000 litre of irrigation water. Volume of acid required for 1000 litre of water was determined based on the formulas given in Table 1.

Table 1: Volume of acid required for 1000 liter of water

Name of Acid	Volume of acid required for 1000 litre of water
HCL (35%conc.)	$V_{1000} = 86.81 \times N_P \times V_t / V_S$
H_2SO_4 (98.08%conc.)	$V_{1000} = 27.17 \times N_P \times V_t / V_S$
H_3PO_4 (85%conc.)	$V_{1000} = 22.80 \times N_P \times V_t / V_S$

Where,

V_{1000} = volume of acid required for lowering pH of 1000 litre of irrigation water to desired level (ml).

N_P = Normality of acid solution used

V = Volume of acid solution used in titration, ml

V_s = Volume of Water sample used, ml

Results and Discussion

Chemical analysis of the 15 water samples was performed in the laboratory for EC, pH, CO_3, HCO_3, Cl, SO_4, NO_3, Total Anion, $Ca^{+2} + Mg^{+2}$, Ca^{+2}, Mg^{+2}, Na^+, K^+ and Total Cation. The pH values of groundwater samples ranged from 8.14 to 9.26. Acid requirement for different samples was determined based on by titrating it against different acids.

Volume of acid required

The amount of acid required for reduction pH of 1000 litre of water to target level (4.0) for different acids was determined using formulae from Table 1. A graph was plotted between the acid requirement to bring down pH of 1000 litre of water to a desired level (4.0) and initial pH of the water and a curve of best fit was determined. The relationship between initial pH of water and amount of HCl (35% conc.) required to lower pH to desired level (4.0) is shown in Fig. 4.1. The relationship between initial pH of water and amount of H_2SO_4 (98.08% conc.) required to lower pH to desired level (4.0) is shown in Fig. 4.2. The relationship between initial pH of water and amount of H_3PO_4 (85% conc.) required to lower pH to desired level (4.0) is shown in Fig. 4.3.

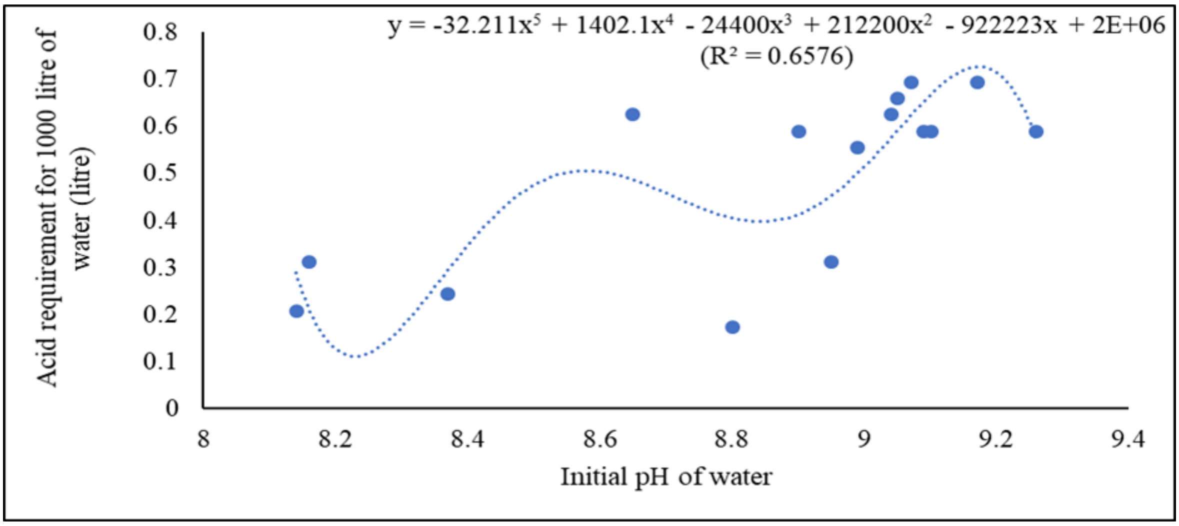

Fig 1: Relationship of HCL requirement for 1000 litre of water and initial pH of water

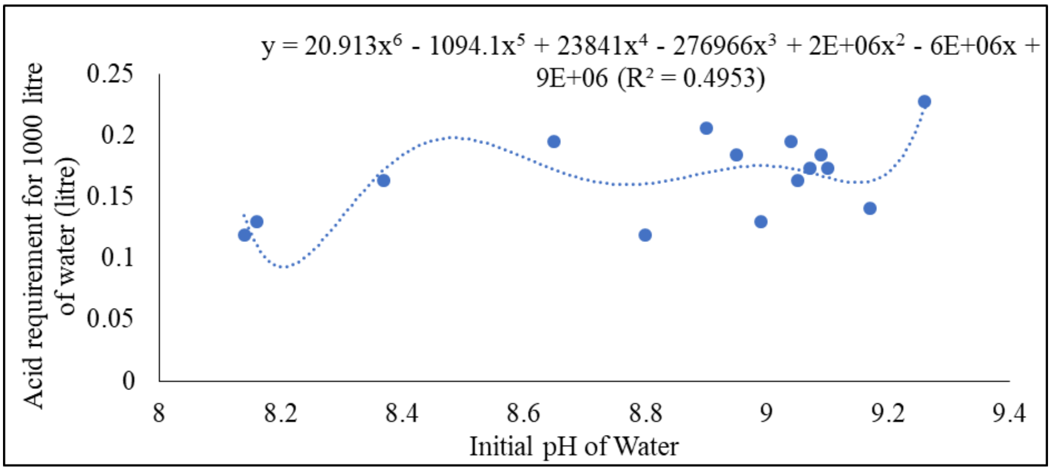

Fig 2: Relationship of H_2SO_4 requirement for 1000 litre of water and initial pH of water

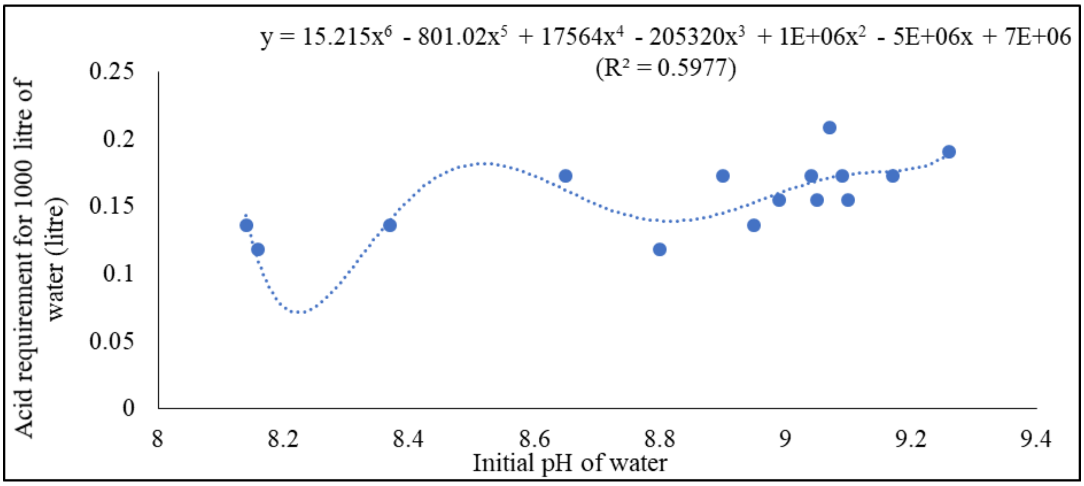

Fig 3: Relationship of H_3PO_4 requirement for 1000 litre of water and initial pH of water

Effect of water quality parameters on acid requirement

Correlation and regression analysis were used to determine the effect of different water quality parameters (EC, pH, CO_3, HCO_3, Cl, SO_4, NO_3, Total Anion, Ca^{+2} + Mg^{+2}, Ca^{+2}, Mg^{+2}, Na^+, K^+ and Total Cation) on acid requirement. There was strong correlation between the amount of HCl (35.5% conc.) or H_2SO_4 (98.8% conc.) or H_3PO_4 (88% conc.) required to bring down the pH of water sample with initial pH of the water sample, effect of other water quality parameters on acid requirement was found to be insignificant.

Empirical relationships

The empirical relationship between initial pH of water and acid requirement for 1000 litre of water for different acids have been tabulated in Table 2.

Table 2: Empirical relationship between the acid requirement and pH of water

Name of Acid	Volume of acid required for 1000 litre of water	Coefficient of determination (R^2)
HCL (35% conc.)	$y = -32.211x^5 + 1402.1x^4 - 24400x^3 + 212200x^2 - 922223x + 2E+06$	0.6576
H_2SO_4 (98.08% conc.)	$y = 20.913x^6 - 1094.1x^5 + 23841x^4 - 276966x^3 + 2E+06x^2 - 6E+06x + 9E+06$	0.4953
H_3PO_4 (85% conc.)	$y = 15.215x^6 - 801.02x^5 + 17564x^4 - 205320x^3 + 1E+06x^2 - 5E+06x + 7E+06$	0.5977

Conclusion

Three acid H_3PO_4 (85%conc.), H_2SO_4 (98.08% conc.) and HCl (35% conc.) were used to lower down the pH of 50ml of water sample to the desired level (=4). Acid solution 0.01N were prepared to determine the amount of acid require to lower down the pH. Acid requirement to bring the pH of water to target level of 4.0 depends on the initial pH of the water. The amount of acid required also depends on the strength and types of acid. The amount of HCl (35% conc.) required to bring down the pH of water sample has a strong correlation coefficient with initial pH, the effect of other water quality parameter on acid requirement is found to be negligible. The amount of H_2SO_4 (98.08% conc.) required to bring down the pH of water sample has a strong correlation coefficient with initial pH, effect of other water quality parameter on acid requirement is found to be negligible. The amount of H_3PO_4 (85%conc.) required to bring down the pH of water sample has a strong correlation coefficient with initial pH, the effect of other water quality parameter on acid requirement is found to be negligible. Empirical equations have been developed to predict the amount of acid as a function of pH of water to be injected per 1000 liter of water to bring the pH to target level of 4.0.

References

1. Airoldi RPS. Análise do desempenho de gotejadores e da prevenção do entupimento em irrigação com água residuária. Piracicaba: USP/ESALQ Tese (Doutorado), 2007, 139.

2. Bo Z, Yunkai L, Peng S, Tianzhi W, Yinguang J, Honglu L. Formulation of an Emitter Clogging Control Strategy for Drip Irrigation with Reclaimed Water. Irrig. and Drain. 2016; 65(45):1-460.
3. Bucks DA, Nakayama FS, Gilbert RG. Trickle irrigation water quality and preventive maintenance. Agri. Water Mngmt. 1979; 2(2):149-162.
4. Cararo DC, Botrel TA, Hills DJ, Leverenz HL. Analysis of clogging in drip emitters during wastewater irrigation. Appl. Eng. Agric. 2006; 22(2):251-257.
5. Keller J, Bliesner RD. Sprinkle and trickle irrigation. New York: Van Nostrand Reinhold, 1990, 652.
6. Pei YT, Li YK, Liu YZ, Zhou B, Shi Z, Jiang YG. Eight emitters clogging characteristics and its suitability evaluation under on-site reclaimed water drip irrigation. Irri. Sci. 2014; 32(2):141-57.
7. Pitts DJ, Haman DZ, Smajstla AG. Causes and prevention of emitter plugging in micro irrigation systems. Gainesville: University of Florida, Florida Cooperative Extension Service, 2003, 258.
8. Ribeiro TAP, Paterniani JES, Coletti C. Chemical treatment to unclogging dripper irrigation system due to biological problems. Sci. Agric. 2008; 65(1):1-9.