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Effect of different water quality parameters on acid requirement to lower the pH of water in drip irrigation

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Abstract
Drip irrigation system has been widely used as an efficient application method. But performance of a drip irrigation system using poor quality water is mainly limited by emitter clogging and this discourages farmers to use drip irrigation system as emitter clogging reduce irrigation efficiency. This paper gives the result of laboratory study conducted to determine the amount of acid required to lower pH of water to desired level to prevent emitter clogging. Three ground samples of different pH and chemical composition were used. Three acid HCL (36.5%conc) H_2SO_4 (98.08% conc.) and H_3PO_4 (88% conc.) were used to bring the pH to 4.0. Amount of acid required depends on strength of acid used, buffering capacity of irrigation water, pH of irrigation water and on target pH of water. Functional relationships are developed to determine the amount of different acids required per 1000 litre of water.

Keywords: Drip irrigation, acid, clogging

Introduction
Drip irrigation is a technology which is very useful in agriculture, landscape, greenhouses and nurseries to apply water directly in plant root. Drip irrigation minimizes the use of water and enables the use of fertilizer through drip irrigation system. But most of the advantages regarding drip irrigation system are nullified by emitter clogging which is directly related to water quality parameters like high pH, soluble salts and concentration of calcium manganese and iron ions. The emitter clogging can be reduced by lowering water pH to a desired level acidification. The different acids needed to bring source water pH to desired level can be determined by titration test. So emitter clogging problem can be reduced by acidification and drip irrigation can be utilized by reducing emitter clogging.

Chemical clogging is caused by mineral precipitation. The most common deposits are calcium or magnesium carbonates and iron oxide. Precipitation occurs more readily in water with a pH above 7.0. Acidification can reduce chemical clogging of emitters. Precipitation of these compounds can be prevented by continuous injection (whenever the system is operating) of a small amount of acid to maintain water pH just below 7.0. A more popular control method is to remove deposits they are formed by periodic injection of a greater volume to acid. Enough acid should be injected continuously for 45 to 60 minutes to reduce the water pH to 4.0or 5.0. Phosphoric acid (which also supplies phosphate to the root zone), sulphuric acid, or hydrochloric (muriatic) acids are commonly used. The selection of a specific acid depends on cost and availability, water quality, the severity of clogging, and nutrient needs of the crop.

The amount of acid required to treat a system depends on (1) the strength of the acid being used, (2) the buffering capacity of the irrigation water and (3) the pH of the irrigation water.The required pH of the irrigation water (target0020xxxpH) depends on the severity of mineral deposits. Volume of acid required to bring pH of irrigation water to target level can be estimated by titration test. So emitter clogging problem can be reduced to some extent by acidification.

Review of Literature
Emitter clogging is one of the most serious problems faced by user of drip irrigation system using poor irrigation water. It can affect irrigation system performance and crop yield.

Various studies have been carried out by different researchers to investigate physical, chemical and biological clogging of emitters and related measures.

Adin (1978) studied emitter clogging as a function of particulate removal by granular filtration screen filtration of waste water stabilization pond effluent. The result showed the deep bed granular media controlled suspended particle with large particle (10µm) removed at a higher rate than smaller particles. Particulate removal efficiency increased to 0.45m. Screen filter (80 µm&130µm) performed very poorly with only about 1% removal efficiency, which was sufficiently to cause surface clogging filter.

Buck *et al.* (1979) conducted a field study of water quality and preventive maintenance procedure to reduce clogging using a variety of treatment methods and emitter system. They recommended water filtration chemical treatment and pipeline flushing.

Cararo *et al.* (2006) studied clogging in drip irrigation emitters during wastewater irrigation. Experiments were conducted using 15 different types of emitter models to identify emitter's susceptibility and techniques to mitigate the potential for clogging. The result of three experimental trials concluded that partial clogging caused by biofilm build up and particles accumulated in corners of torturous pathways is the main mechanism of emitters clogging. Self-cleaning membrane and short pathways are desirable characteristics of emitters in use of water. Chlorination by using 0.5 g/m^3 of free chlorine residual at high pressure diminishes biological clogging.

David *et al.* (1982) studied the effect of chemical clogging on drip tape irrigation uniformity. In their study they discussed the four management schemes: 1) above ground day-time water application, 2) above ground night- time water application, 3) subsurface placement of drip tape, and 4) lowering the pH of irrigation water which are evaluated for reducing the chemical clogging effect of high calcium content water in drip- tape. It was concluded that the water quality is a critical factor in chemical clogging. Water relatively high in multivalent cations, high pH and high temperature were found to be conducive to chemical precipitation.

Gilbert *et al.* (1982) concluded that water quality and emitter design are important consideration for successful long drip irrigation. A combination of screen and sand filters was recommended to remove suspended solids, acid treatment to reduce chemical precipitation and flushing of laterals to eliminate sediments.

Materials and Methods

Groundwater samples of different pH and chemical composition were received from Soil and Water Testing Laboratory of Department of Soil Science, CCS HAU, Hisar.

Preparation of acid solution

To determine the amount of acid required to lower pH to a desired level. Acid solution of hydrochloric acid, Sulphuric acid and phosphoric acid of 0.01N were prepared.

For preparation of 0.01 N HCL solution following methodology was adopted

- 86.27 ml of concentrated HCL (36.5%) was taken and distilled water was added to make 1000 ml (1N HCL)
- 100 ml 1N HCL and distilled water was added to make 1000 ml (0.1N HCL)
- 100ml 0.1N HCL and distilled water was added to make 1000ml (0.01N HCL)

For preparation of 0.01N H_2S0_4 following methodology was adopted

- 27.17ml of concentrated H_2S0_4 (98.08%) was added in distilled water to make 1000 ml (1N H_2S0_4)
- 100 ml 1N H_2S0_4 and distilled water was added to make 1000 ml
- 100 ml 0.1N H_2S0_4 and distilled water was added to make 1000 ml (0.01N H_2S0_4)

For preparation of 0.01N H_3PO_4 following methodology was adopted

- 21.21ml of concentrated H_3PO_4(88%) and distilled water was added to make 1000 ml (1N H_3PO_4)
- 100 ml 1N H_3PO_4 and distilled water was added to make 1000 ml
- 100 ml 0.1N H_3PO_4 and distilled water was added to make 1000 ml (0.01N H_3PO_4)

Estimation of acid requirement

As different water samples have different chemical composition, pH and electric conductivity, so volume of acid used is also different. Three acids Hydrochloric (HCL), sulphuric (H_2S0_4) and Phosphoric acid (H_3PO_4) were used to bring pH to 4.0.

Titration for pH reduction

To determine the acid required to bring the pH of ground water sample to the desired level. The following methodology was used

- 50 ml of water sample of known pH was taken in titration flask.
- 2ml of 0.01N HCL, H_2S0_4 and H_3PO_4 solution was added to water sample and stirred to completely mix the solution in water sample.
- The sample was kept for 30 minutes, stirred and then pH determined.
- Above steps were repeated till the pH of water sample was lowered to 4.0.

Volume of acid required for pH reduction

Volume of acid required for pH reduction of ground water depends on pH, normality of acid solution used for titration and also on the initial and target pH of water. A titration curve was prepared to determine the volume of acid required to bring the pH up to target level for 1000 litre of irrigation water.

Volume of HCL (36.5% conc.) required for 1000 litre of water was estimated as:

$V_{1000} = 86.27 \times N_p \times V_t / V_s$

Results and Discussions

Chemical analysis of the 15 water samples was performed in the laboratory. The pH values of sample ranged from 7.92 to 8.91.

Amount of HCL

The amount of acid required to lower the pH of water samples to the desired level (pH = 4) was estimated with the help of HCL (36.5%conc.), H_2SO_4 (98.08% conc.) and H_3PO_4 (88% conc.). The amount of HCL (35.5% conc.) required to lower the pH of three sample (having different pH). The volume of HCL acid added varied from 14 ml for sample having pH 8.6 to 3.6 ml for water havingpH 7.62. The empirical relationship fitted between initial pH of water and amount of acid HCL

(35.5% conc.) required to lower pH to 4.0 has been plotted in Figure 1.

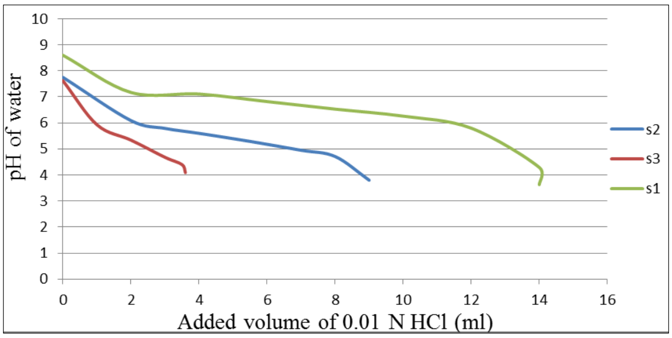

Fig 1: Relationship of HCL requirement for 1000 litre of water with initial pH of water

Amount of H_2SO_4

The amount of H_2SO_4 (98.8% conc.) required to lower the pH of three sample (having different pH) has been presented. The volume of HCL acid added varied from 109 ml for sample having pH 8.8 to 110ml for sample having pH 7.62. The empirical relationship fitted between initial pH of water and amount of H_2SO_4 (98.8% conc.) required to lower pH to 4.0 has been plotted in Figure 2.

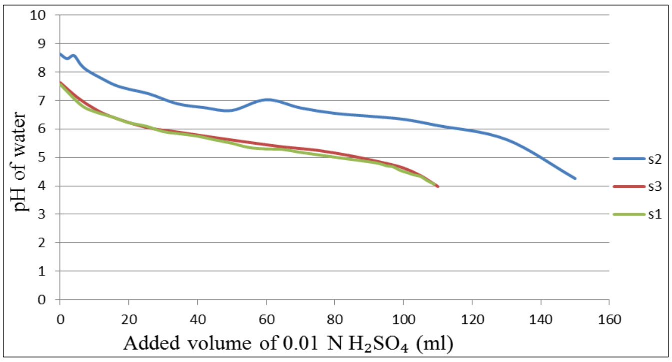

Fig 2: Reduction of pH of 50 ml sample on addition of H_2SO_4 (0.01N)

Amount of H_3PO_4

The amount of H_3PO_4 (88% conc.) required to lower the pH of fifteen water sample (having different pH) has been presented. The volume of H_3PO_4 acid added varied from 156.1 ml for sample having pH 8.89 to 51.6 ml for sample having pH 7.92. The empirical relationship fitted between initial pH of sample and amount of H_3PO_4 (88% conc.) required to lower pH has been plotted in Figure 3.

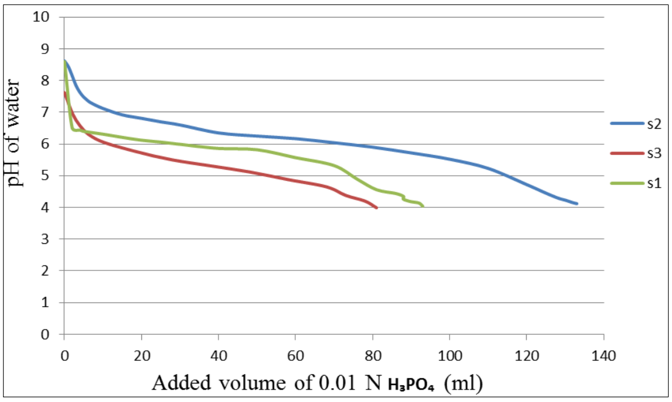

Fig 3: Reduction in pH of 50 ml of water sample using H_3PO_4 (0.01N)

Conclusion

The amount of HCL (35.5%conc.) required to bring down the pH of water sample has a strong correlation coefficient with initial pH. The amount of H_2SO_4 (98.8% conc.) required to bring down pH of water sample also depends upon the initial pH. The effect of other water quality parameters on acid requirement is found to be negligible. The amount of H_3PO_4 (88% conc.) required to bring down the pH of water sample depends upon initial pH and as well as on other water quality parameters. In HCL (35.5%conc.), H_2SO_4 (98.8% conc.) and H_3PO_4 (88% conc.) phosphoric acid is most economical to use.

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