AERATION, CHLORATION AND pH CONTROL FOLLOWED BY FILTRATION IN THE TREATMENT OF THE EXCESS OF ÍONS OF IRON AND MANGANESE IN WATER FOR ENDS OF IRRIGATION

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ABSTRACT: This work had the purpose to evaluate the efficiency of artificial aeration processes done isolated and/or together with chlorination and pH control, followed by filtration for treatment of Fe^{++} and Mn^{++} ions excess in irrigation water. At aeration system it was used a Venturi injector to capture atmospheric air injecting it into the water. In this process it was used a system of perforated PVC pipes to put the air captured by the injector into the water. The water was stored in two reservoirs made of polyester reinforced with glass fiber with capacity of 5000 l each one. The water samples were obtained at interval of times equal to 0; 30; 60; 90 and 120 minutes and sent to laboratory. It was determined Fe^{++}, total iron, Mn^{++} and total manganese concentrations. At field, it was determined oxygen values of the water, water temperature, ambient temperature, electric conductivity and pH of the water. The chlorination was made using sodium hypochlorite (NaOCl) and the pH control using sulfuric acid. At filtration process were used two sand filters, one filter of disks and one screen filter (200 mesh). The aeration done with pH control of the water was more efficient for treatment of iron than manganese. At chlorination and in the treatment using sulfuric acid for pH control there was an increase on the electric conductivity of the water. The aeration system using Venturi injector and perforated PVC pipes was highly efficient about of proposed objectives.
KEYWORDS: emitter clogging, aeration, pH control, filtration, microirrigation.

INTRODUCTION: Pipelines and emitters clogging are frequent when it is used low quality water for drip and microirrigation systems. Those obstructions have as causes agents of physical nature, chemistry and biological. The chemistry agents are associated with high concentrations of soluble solids and/or excess of Fe^{++} and Mn^{++} ions. When soluble solids react with oxygen existent in the air or in the water it is oxidized for insoluble forms. These forms precipitate and accumulate along the pipelines causing obstruction partial or total of pipelines and of emitters. Pizarro (1987), Rogers et al (2003), Zinati (2005) recommend to cause oxidation of those elements on purpose, so that they precipitate in a decant container and doesn't reach water distribution lines. By this way it is expected to reduce the problems of emitter clogging of the irrigation systems. Although that process is technically justified the literatures doesn't inform like it should be done on practice. Pereira (2004) evaluated the efficiency of aeration using Venturi injector and he obtained excellent results of artificial aeration for the control of excess iron and manganese ions of irrigation water. Authors that evaluated problems of pipelines and emitters clogging concluded that isolated water treatment rarely is effective for all conditions (Nakayama & Bucks, 1991; Gilbert et al., 1981; Hernandez et al., 2007). Besides aeration, it was usually used chlorination and pH control of irrigation water. About these aspects, this research had the purpose to compare the artificial aeration made alone and/or together with chlorination, with pH control for treatment of iron and manganese ions excess of irrigation water.

METHODOLOGY: The experiment was made at Departamento de Engenharia Rural of Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba-SP. The water used at experiment was pumped from a dam to two reservoirs made of polyester reinforced with glass fiber, with capacity of 5000 liters each one. In the aeration system a Venturi injector was used to capture the atmospheric air. The air was injected into the water through perforated PVC pipes. The used PVC pipes had diameter of 25 mm creating a closed circuit similar to aeration system developed by Feitosa Filho et al. (1997) and used by Pereira (2004). At work there were assessed three treatments followed by filtration: T1: Artificial Aeration + Filtration; T2: Artificial Aeration + Chlorination + Filtration; T3: Artificial Aeration + pH Control + Filtration. The water samples were obtained on interval of times equal to: 0; 30; 60; 90 and 120 minutes. At laboratory it was determined the concentrations of Fe^{++}, total iron, Mn^{++} and total manganese.

By using portable meters it was determined pH of reservoirs' water, electric conductivity and temperature being also determined ambient temperature. For reduce the mistakes and to facilitate the comparison of efficiency in each way of water treatment, the treatment with aeration and filtration just served as witness, was always repeated. So, it was made the combinations T_1 x T_2 and T_1 x T_3. Sodium hypochlorite (NaOCl) was used at chlorination with concentration of free chlorine from 10 to 12%. It was used a volume of 2,0 l of solution for each 5000 l of water (40 mg.l-1). This solution was putted into water two hours before initializes the aeration and gathering data. The water pH was maintained near to 7,0 with sulfuric acid addition two hours before the beginning of gathering samples. Initially a main solution was prepared being added 5 ml of sulfuric acid with 95 to 98% of purity in the water contained in each one of the two beckers of glasses, 1000ml. At the time initial zero the volume of 500 ml from the main solution was added in the reservoir of 5000 l. After 30 minutes, the remained of 500ml of solution was added in the water. After 1,5 hours from first application a new volume of solution equal to 1000 ml was added in the water in order to keep pH around 6,5. The electric conductivity of water on each treatment was determined considering a depth of 20 cm from the water surface. For this measure it was used a digital equipment previously adjusted. The values about oxygen concentrations in the water, pH, Fe^{++}, total iron, Mn^{++} and total manganese, it was assessed by regression considering its values in function of aeration times of reservoir and application times. Soon after, there were determined regression equations that more adjusted to each function.

4. RESULTS AND DISCUSSION: For data presented at Table 1 it was verified that aeration system was efficient for water oxygen. It was clear considering the increment of oxygen from 1,8 to 4,1 at the operation time of 120 minutes. It was also verified the value increment of electric conductivity of the water on treatment with Aeration + Chlorination(AR+CL). Comparing data of Aeration + Chlorination(AR+CL) with just Aeration(AR) it indicates an efficiency of aeration system with behavior that resemble each other results of Pereira(2004).

Table 1. Ambient temperature (AT), Water temperature (WT), Water oxygen concentration (O_2), Electric Conductivity of water (EC) and pH of the water, at treatments with Aeration(AR) and Aeration + Chlorination (AR+CL), at times of operation equal to 0; 30; 60; 90 and 120 minutes.

Time	AT(°C)		WT(°C)		O_2(mg.l^{-1})		EC(dS.m^{-1})		pH	
(min)	AIR	AR+Cl	AIR	AR+CL	AIR	AR+CL	AIR	AR+CL	AIR	AR+CL
0	21,7	28,1	22,3	23,3	1,8	3,3	0,05	0,27	7,7	7,5
30	23,0	28,9	22,3	23,3	2,8	3,5	0,05	0,29	7,5	7,7
60	25,0	34,0	22,6	23,7	3,9	3,2	0,05	0,29	7,6	7,6
90	28,0	34,0	23,0	23,9	3,9	3,4	0,05	0,29	7,3	7,7
120	28,2	38,0	23,2	24,6	4,1	3,3	0,05	0,28	7,6	7,7
Average	25,2	32,6	22,7	23,8	3,3	3,3	0,05	0,28	7,5	7,6
%Variation	+29,9	+35,2	+4,0	+5,6	+27,8	-	-	+3,7	-1,3	-2,7

Analyzing the data of Table 2 it was observed larger concentrations of iron at ferrous state or soluble iron (Fe^{++}) than soluble manganese (Mn^{++}) and total manganese. These results were similar with others obtained by Pereira (2004), which found values of (2,7-0,6); (3,9-2,3) for Fe++ and total iron before and after the aeration respectively; and of (0,2-0,07); (0,4-0,2) for Mn++ and total manganese.

Table 2. Concentration of soluble iron, iron total, soluble manganese and total manganese of treatments with Artificial Aeration (AR) x Artificial Aeration (AR) + Chlorination (CL) at times of operation equal to 0; 30; 60; 90 and 120 minutes.

Time	Fe^{++}		Total Fe		Mn^{++}		Total Mn	
(min)	AIR	AR+Cl	AIR	AR+CL	AIR	AR+CL	AIR	AR+CL
0	1,1	1,1	1,6	1,6	0,03	0,03	0,04	0,04
30	0,8	0,7	1,6	1,2	0,03	0,01	0,03	0,02
60	0,8	0,7	1,3	1,2	0,02	0,02	0,03	0,03
90	0,8	0,8	1,2	1,4	0,02	0,02	0,03	0,03
120	0,7	0,8	1,2	1,4	0,02	0,01	0,03	0,03
Average	0,84	0,82	1,38	1,36	0,024	0,018	0,032	0,030
%Variation	-36,36	-27,27	-25,00	-12,5	-33,33	-66,67	-25,00	-25,00

The data acquired also approach of presented data presented by Testezlaf et al. (2001), who verified that iron and manganese concentrations varied between 0,01 and 6,2 mg.l-1 and from

0,01 to 0,30 mg.l^{-1}, respectively. Water with these levels of iron and manganese can already present risks for the irrigation according to the classification for water proposed by Ford & Tucker (1975). It is verified that the process of artificial aeration was more efficient for reduction of Fe^{++} ions (soluble) and iron total than for reduction of manganese ions, results also verified by Pereira (2004). The data about manganese are suitable with information of Rump & Krist (1992) when they mention that manganese comes in low concentrations in the water being of difficult removal if compared to iron. Efficiency of aeration was verified for reduction of total iron already passing of 1,6 mg.l-1 for 1,2m.l^{-1} at time of operation equal to 90 minutes. For data of Table 3, the treatment of aeration + chlorination was more efficient for reduction Fe++ ions and of total iron in comparison with isolated aeration. This information was similar with Imhoff & Imhoff (1986) who mention that the simple aeration has limited effect because the water can only dissolve the air oxygen up to saturation point around 10mg.l^{-1}. It is important to reinforce the chlorination or other processes of water treatment. For data presented at Table 3, the artificial aeration was less effective for manganese removal than removal of iron, corroborating with statements of Hallberg & Johnson (2007). These authors affirmed that manganese is more problematic than iron for demanding conditions of high pH (near to 8,0).

Table 3. Concentration of soluble iron, iron total, soluble manganese and total manganese of Aeration Artificial (AR's united treatments) x (Artificial Aeration + Chlorination(CL) + pH(pH Control)), at times of operation equal to 0; 30; 60; 90 and 120 minutes.

Time (min)	Fe^{++}		Total Fe		Mn^{++}		Total Mn	
	AIR	AR+Cl+ pH	AIR	AR+Cl+ pH	AIR	AR+Cl+ pH	AIR	AR+Cl+ pH
0	1,0	1,0	1,5	1,5	0,04	0,04	0,05	0,05
30	1,4	0,7	1,6	1,1	0,05	0,04	0,05	0,05
60	1,4	0,7	1,7	1,2	0,05	0,05	0,06	0,08
90	1,1	1,1	2,2	1,6	0,05	0,05	0,06	0,08
120	1,1	0,7	2,0	1,3	0,05	0,05	0,05	0,05
Average	1,2	0,84	1,8	1,34	0,05	0,046	0,054	0,062
%Variation	+10,0	-25,0	+25,0	-13,33	+25,0	+25,0	-	-

CONCLUSION: Uniting aeration, chlorination and pH control of water, it was observed a better efficiency for removal of ions of iron and manganese when compared to treatment with isolated aeration. Manganese, although in smaller concentration than iron, had removal more dependents of pH control of the water. The artificial aeration made together with other practices was efficient for control the excess of iron and manganese of irrigation water.

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