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Removal of Iron and Manganese from Underground Water Using Cement Dust

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Different qualities of water and the necessary treatment processes vary widely and sometimes have little in common [1]. Many authors have reviewed processes and factors affecting the removal of iron and manganese [2,3].

Cement dust contains basically a mixture of raw materials used in the cement production, clinker nearly amorphous and some volatile components [4,5]. Many reports have revealed that cement dust can be utilized as fertilizer [6,7], bituminous filler, lime replacement and an additive in clay brick industry [4]. Salem [8] has reported that cement dust can be used to purify a highly contaminated water with the aim of evaluating the possibility to attenuate the toxicity given by the presence of heavy metals.

The aim of present work is to investigate the possibility of utilizing cement dust to remove iron and maganese from water used for both domestic and industrial purposes.

Fe and Mn solutions of different concentrations were prepared using demineralized water. Two levels of Fe (5 & 25ppm) and three levels of Mn (7,20 & 30ppm) were used. Each of the prepared solutions were treated with different doses of cement dust (0.5, 1, 1.5 & 2 gm/lit of prepared solution). Samples of the solution were taken before the addition of cement dust and every 15 min intervals after the addition of cement dust. Both pH and total dissolved solids were monitored during sampling to detect any changes. Fe and Mn levels in the collected samples were measured using atomic absorption spectrophotometer (Perkin Elmer).

It was clear from the results that salts of Fe & Mn when dissolved in demineralized water showed an appreciable degree of acidity (pH 3.7). The reason was reported to be due to the following reactions [1,8].

$$Fe^{2+} + HOH \rightleftharpoons Fe(OH)^{+} + H^{+} \quad \ldots\ldots(1)$$
$$Fe(OH)^{+} + HOH \rightleftharpoons Fe(OH)_2 + H^{+} \quad \ldots\ldots(2)$$
$$Mn^{2+} + HOH \rightleftharpoons Mn(OH) + H^{+} \quad \ldots\ldots(3)$$
$$MN(OH)^{+} + HOH \rightleftharpoons MN(OH)_2 + H^{+} \quad \ldots\ldots(4)$$

It is primarily dependent on both pH and oxidition-reduction potential [1] and that the dissolved forms (Fe^{2+}, Mn^{2+}, $FeOH^{+}$, $MnOH^{+}$) can be changed to precipitated forms ($FeCO_3$, $MnCO_3$, $Fe(OH)_2$, $Fe(OH)_3$ $Mn(OH)_2$] by raising either the potential or the pH or both together. It was clear that Fe in the prepared solutions is precipitated at all the different treatment doses used (Fig. 1). On the other hand, Mn was not removed at lower pH (around 9), but at pH above 10.5 it is removed efficiently (Fig. 1).

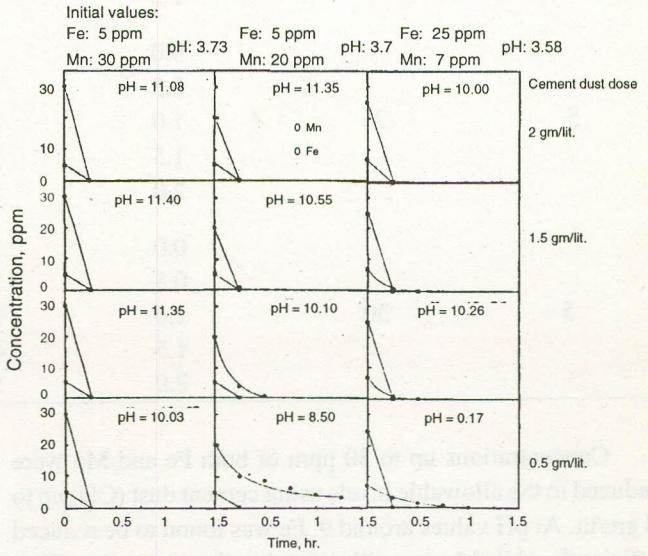

Fig. 1. Effect of cement dust dose on the removal of Fe & Mn.

Application of cement dust causes both increase in pH (Table 1) and possibily an increase of soluble carbonate. Accordingly Fe can be removed in both forms as hydroxide and carbonate, while Mn is removed according to the following mechanisms:

1. At lower pH around 9.2 as carbonates according to the following reactions [8].

$$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^{-} + OH^{-} \quad \ldots\ldots(5)$$
$$Mn^{2+} + HCO_3^{-} \rightleftharpoons MnHCO_3^{+} \quad \ldots\ldots(6)$$
$$MnHCO_3^{+} + OH^{-} \rightleftharpoons MnCO_{3(S)} + H_2O \quad \ldots\ldots(7)$$
$$MnOH^{+} + HCO_3^{-} \rightleftharpoons MnCO_{3(S)} + H_2O \quad \ldots\ldots(8)$$
$$Mn^{2+} + CO_3^{2-} \rightleftharpoons MnCO_{3(S)} \quad \ldots\ldots(9)$$
$$MnCO_{3(aq)} \rightleftharpoons MnCO_{3(S)} \quad \ldots\ldots(10)$$

2. At higher pH around 11.5 by the formation of hydroxide as indicated by reactions (3) & (4).

As indicated in Table 1 the total hardness of the prepared solutions increased by the addition of cement dust, which can be removed by softening unit. On the other hand the increase in the total dissolved solids was found to be within the allowable limit for drinking water or ever for the industrial use.

TABLE 1. EFFECT OF CEMENT DUST DOSE ON SYNTHETIC SOLUTION PROPERTIES.

Iron concentration (ppm)	Manganese concentration (ppm)	Cement dust dose (gm/lit.)	Total dissolved solids (ppm)	Solution pH	Total Hardness ppm after 0 (hrs)	0.25 (hrs)	1.25 (hrs)
		0.0	190	3.58	20	20	20
		0.5	200	9.17	45	155	178
25	7	1.0	205	10.26	45	168	188
		1.5	275	10.92	45	180	210
		2.0	307	10.96	45	210	248
		0.0	132	3.7	20	20	20
		0.5	175	8.5	60	120	155
5	20	1.0	221	10.1	60	150	162
		1.5	271	10.55	60	190	225
		2.0	357	11.35	60	200	232
		0.0	191	3.73	20	20	20
		0.5	231	10.93	70	140	190
5	30	1.0	271	11.35	70	160	212
		1.5	495	11.4	70	189	236
		2.0	528	11.68	70	220	270

Concentrations up to 30 ppm of both Fe and Mn were reduced to the allowable levels using cement dust (CD) up to 2 gm/lit. At pH values around 9, Fe was found to be reduced efficiently while Mn was still above the allowable value. With increasing pH value above 10, both Fe and Mn were found to be reduced to the allowable levels. The total hardness of the treated water was found to be increased while total dissolved solid was acceptable from the industrial point of view.

Keywords: Water treatment, Cement dust, Iron, Manganese.

References

1. Degremont, *Water Treatment Handbook,* (Firmin-Didot S.A., Paris, France, Distributed by: Halsted Press, N.Y., Toronto, 1979) 5th ed.
2. M.L. Beardsley, Paper presented at the 38th Annual Meeting of the Int. Water Conf., Pittsburgh, Pennsylvania, November (1977).
3. C.R. Peters and W.R. Hollingshad, Paper presented at the Annual Meeting of the Amer. Power Conf., April, (1984).
4. A.A. Gamal El-Din, M.Sc. Thesis, Engineering Department, American University in Cairo (1990).
5. S. Mikhail, Y. Barakat and A. El-Naggar, 1st Regional Symp. on Material Sci. in Arab States, December, Instit. of Graduate Studies and Research, Alexandria Univ., Alexandria, Egypt, (1987).
6. A.H. Khater, Egypt J. Appl. Sci., **7**, 61 (1992).
7. S. Khader and N. Abu-Rub, Dirasat, **13**, 51 (1987).
8. N. Salem, Agrochimica, **34**, 352 (1990).