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Physico-Chemical Studies on Treatment of some Divalent Elements in Ground Water

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PHYSICOCHEMICALSTUDIESONTREATMENTOFSOMEDIVALENTELEMENTSINGROUNDWATER

Strictly as per the compliance and regulations of:

"Physico-Chemical Studies on Treatment of some Divalent Elements in Ground Water"

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Keywords: groundwater; iron and manganese treatment, aeration, chlorination, KMnO4.

I. Introduction

Groundwater is an important resource to act as a natural storage that can buffer against shortages of surface water. However, due to the stratum composition, the groundwater often contains iron and manganese ions.

While the concentrations in excess, the water becomes red-brown, and endues the scaling problems in pipeline system. Thus, the water quality standards have specified their limitations, where Fe is less than 0.3 mg L-1 and Mn is less than0.05 mg L-1.

In the traditional process, Fe and Mn in groundwater are initially oxidized using aeration and/or chemical oxidant such as chlorine, hypochlorite, chlorine dioxide, ozone or potassium permanganate following the remove by filtration.

The selection of various oxidants depends on which kinds of pollutants in water, as well as their effects on the water quality. Capital cost is also an important consideration. After the oxidation process, the Fe and Mn oxides are then removed through the sand filter. Moreover, previous studies have indicated that the presence of Mn oxide particles accelerates the formation of Fe-Mn oxide, contributing to the removal of Fe and Mn from groundwater [1].

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Granular activated carbon is often used to enhance the adsorption of Mn^{2+} in filtration process [2-5]. However, the drawback is frequent regeneration or new carbon replacement.

In recent years, membrane process has been applied in water and wastewater treatment. Compared to the traditional physical/chemical treatment, membrane process illustrates more advantages in water quality enhancement, including space saving, and reduced amounts of chemicals used and sludge produced [6].

However, high capital and maintenance costs are considered to be major drawbacks. Due to the dramatic improvements of membrane science and technology, the manufacturing cost of membranes has been decreased significantly. Many water treatment plants in US have used membrane process as one of major treatment units [7].

Meeting the water treatment standards using the existing equipment is considered to be the major problem for many water treatment plants. Membrane separation technology has been utilized to remove metal oxide particles and to improve the performance of the existing process [8].

II. Materials and Methods

a) *Forms of Occurrence of Iron and Manganese in Water*

Iron and manganese occur in dissolved forms as single ions (Fe^{2+}, Mn^{2+}) or in undissolved higher forms mainly as $Fe(OH)_3$ or $Mn(OH)_4$, respectively. They can also be present in colloid form (bound to humic substances). The form of their occurrence depends on oxygen concentration, solubility of Fe and Mn compounds in water, pH value, redox potential, hydrolysis, the presence of complex-forming inorganic and organic substances, water temperature, and water composition (e.g. CO_2 content).

b) *Effect on Water Quality*

Adverse effects of higher Fe and Mn concentrations in drinking water can be summarized as follows:

- iron (II) and manganese (II) ions are oxidized to higher forms in a water distribution system and this results in the formation of hydroxide suspensions causing undesirable turbidity and colour of water,

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- the presence of iron and manganese bacteria in water supply system causes change in water quality (smell) and bacterial growth in pipes,
- in the case of the occurrence of iron (II) and manganese (II) ions at the consumer's point, iron and manganese are oxidized and precipitated under suitable conditions (e.g. in washing machines, boilers).

Following the above-mentioned facts, higher concentrations of iron and manganese in water cause technological problems, failure of water supply systems operation, water quality deterioration and, in water with slightly higher concentrations of oxygen, they form undesirable incrustations that result in the reduction of pipe flow cross-section.

c) Methods of Iron and Manganese Removal

The principle of most methods used for iron and manganese removal is that originally dissolved iron and manganese are transformed into undissolved compounds that can be removed through single-stage or two-stage separation.

Oxidation and hydrolysis of these compounds is done under strict conditions with respect to water properties and type of equipment for iron and manganese removal.

Single-stage water treatment (filtration) is designed for iron and manganese concentrations to 5 mg·l-1, and the two stage treatment (settling tanks or clarifiers and filters) is used for water with iron and manganese concentrations higher than 5 mg·l-1. In case water contains higher concentrations of Ca, Mg, and CO_2 (eventually H_2S), aeration is done before settling or filtration.

Removal of Fe and Mn from groundwater and surface water can be done by several methods:

- oxidation by aeration,
- removal of Fe and Mn by oxidizing agents (O_2, Cl_2, O_3,$KMnO_4$),
- removal of Fe and Mn by alkalinization (by adding thelime),
- contact filtration for removal of Fe and Mn,
- removal of Fe and Mn by ion exchange,
- removal of Fe and Mn using membrane processes,
- removal of Fe and Mn using biological filtration,
- removal of Fe and Mn using in situ method.

Fe^{2+} and Mn^{2+} oxidation rate as well as hydrolysis of emerging oxides of higher iron and manganese oxidation forms in groundwater depends on the pH value.

Various graphic dependencies of these relationships with respect to oxidation time are listed in literature. The pH value should be equal or greater than 7 in removal of iron from groundwater.

For removal of manganese without catalyst, the pH value should be equal to or greater than 8 [3].

Removal by using the oxidized film on grains of filter medium is one method for elimination of dissolved manganese.

The film is formed on the surface of filter medium by adding permanganate potassium (not only KMnO4 but also other strong oxidizing agents).

The film serves as a catalyst for the oxidation process. Grains of filter medium are covered by higher oxides of metals. In such a case, it is related to special filtration so-called "contact filtration" – filtration by using manganese filters. The oxidation state of the film of MnOx(s) filter medium is important in removal of dissolved manganese.

Manganese removal efficiency is a direct function of MnOx(s) concentration and its oxidation state. The films with different ability to remove dissolved manganese from water are formed on the surface of various filter media [10-14].

III. Results and Discussion

Aeration

Groundwater passing through different layers of soil and due to its water properties and its high solubility, contain elements and minerals of material in the soil that sometimes can be dangerous for the health of consumers or at least undesirable in terms of cognitive beautiful. Iron and manganese are from constitutive of the soil and rocks of the Earth's surface. Water penetration through soil and rock can minerals such as these elements have dissolved and bring them into solution. The problems of iron and manganese in groundwater in domestic installations, commercial, industrial and refineries are created, and because much of the community water supply from underground water supplies will be removed where iron and manganese concentrations exceeded it is necessary.

Table 1 : Results obtained from ground water aeration

	PARAMETERS	UNITS	EGYPTIAN STANDARDS	BEFORE TREAT.	AFTER TREAT.
1	RES. CHLORINE	PPM	5	0	0
2	TURBIDITY	NTU	1	0.85	0.25
3	PH		6.5-8.5	7.53	7.72
4	IRON	PPM	0.3	0.282	0.041
5	MANGANESE	PPM	0.4	0.963	0.602

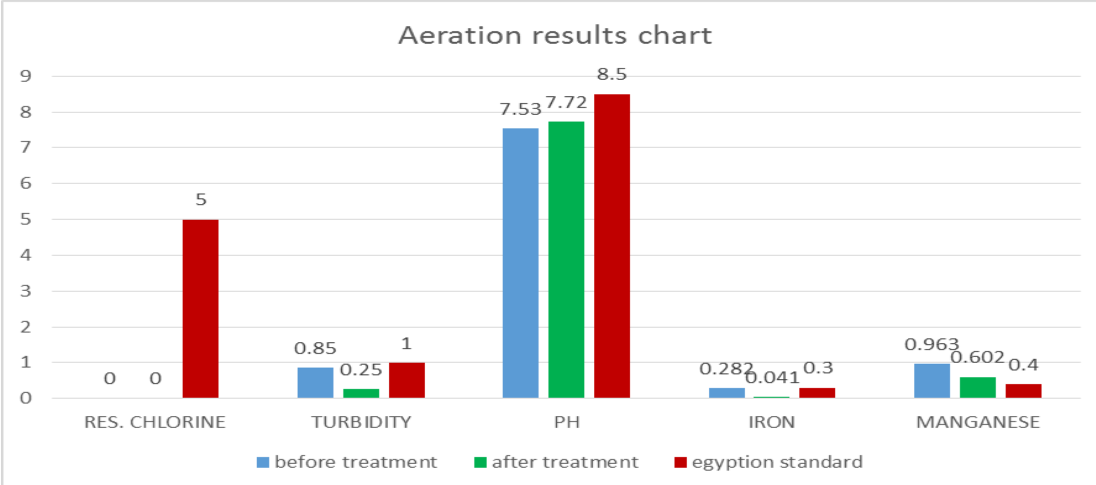

Fig. 1 : Results obtained from ground water aeration

1-we don't use chlorine [26]
2- reduce of turbidity come from filtration[15] .
3- increase of pH come from volatility of CO_2 [16]
4- aeration high effect on Iron than manganese as the second need chemical treatment[17].

a) Chlorination

Chlorine is the most commonly used disinfectant employed for killing bacteria in water. In addition chlorine, as an oxidizing agent, is used to remove undesired inorganic species such as ammonia, iron and manganese[18]:

Table 2 : Results obtained from ground water chlorination

	PARAMETERS	UNITS	EGYPTIAN STANDARDS	BEFORE TREAT.	AFTER TREAT.
1	RES. CHLORINE	PPM	5	0	2
2	TURBIDITY	NTU	1	0.68	0.51
3	PH		6.5-8.5	7.62	7.55
4	IRON	PPM	0.3	0.281	0.242
5	MANGANESE	PPM	0.4	0.614	0.561

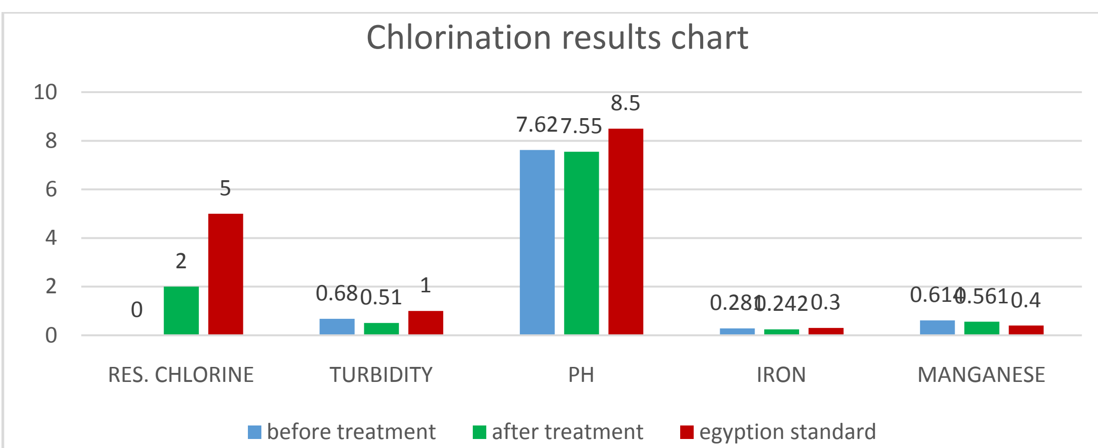

Fig. 2 : Results obtained from ground water chlorination

1-turbidity decrease after filtration [26]
2- PH decrease under the acidic effect of chlorine[19] .
3- the decrease of IRON and MANGANESE is little because that chlorine is a weak on oxidation of them[20] .

b) *Chemical treatment by $KMnO_4$*

Potassium permanganate ($KMnO_4$) is used primarily to control taste and odors, remove color, control biological growth in treatment plants, and remove iron and manganese.

In a secondary role, potassium permanganate may be useful in controlling the formation of THMs and other DBPs byoxidizing precursors and reducing the demand for other disinfectants [(21).]

c) *Iron and Manganese Oxidation*

A primary use of permanganate is iron and manganese removal. Permanganate will oxidize iron and manganese to convert ferrous (+2) iron into the ferric (+3) state and +2 manganese to the +4 state.

The oxidized forms will precipitate as ferric hydroxide and manganese hydroxide [(22).]

The precise chemical composition of the precipitate will depend on the nature of the water, temperature, and pH.

The classic reactions for the oxidation of iron and manganese are:

$$3Fe^{+2} + KMnO_4 + 7H_2O \longrightarrow 3Fe(OH)_3(s) + MnO_2(s) + K^+ + 5H^+$$

$$3Mn^{+2} + 2KMnO_4 + 2H_2O \longrightarrow 5MnO_2(s) + 2K^+ + 4H^+$$

Table 3 : Results obtained from groundwater chemical treatment by $KMnO_4$

	PARAMETERS	UNITS	EGYPTIAN STANDARDS	BEFORE TREAT.	AFTER TREAT.
1	RES. CHLORINE	PPM	5	0	0
2	TURBIDITY	NTU	1	0.67	0.24
3	PH		6.5-8.5	7.66	7.23
4	IRON	PPM	0.3	0.184	UDL
5	MANGANESE	PPM	0.4	0.943	0.291

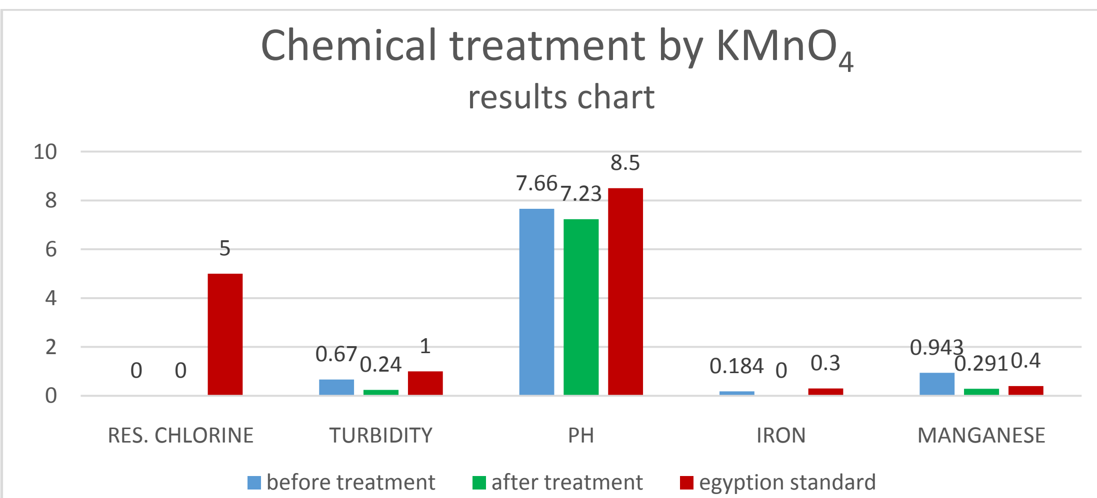

Fig. 3 : Results obtained from groundwater chemical treatment by $KMnO_4$

IV. Chemical Treatment by KMnO4 Discussion

1- turbidity decrease under the effect of filtrations.[(26)]

2- pH decrease because that the $KMnO_4$ is consumed alkalinity[(23)] .

3- IRON decrease under the effect of oxidation by $KMnO_4$ [(24).]

4- MANGANESE decrease under the effect of oxidation by $KMnO_4$ [.(25)]

V. Conclusion

Underground drinking water treatment difficult but when mastery will provide a lot and we will get a rich mineral salts drinking water and conform to the specifications aeration will help in getting rid of iron, chemical treatment, help in getting rid of iron and manganese.

References Références Referencias

1. The authors would like to acknowledge the Taiwan Water Corporation and Water Resources Agency (MOEAWRA0990004) for their financial support, the Sumitomo Electric Interconnect Products (Japan) Inc. for providing PTFE hollow fiber module, and the Changhua water treatment plant for providing the research field and conducting related analysis.
2. Teng, Z., J.Y. Huang, K. Fujito and S. Takizawa, Manganese removal by hollow fiber micro-filter. Membrane separation for drinking water. Desalination, 139(1-3), 411-418 (2001).
3. Okoniewska, E., J. Lach, M. Kacorzak and E. Neczaj, The removal of manganese, iron and ammonium nitrogen on impregnated activated carbon. Desalination, 206(1-3), 251-258 (2007).
4. Mondal, P., C.B. Majumder and B. Mohanty, Effect of adsorbent dose, its particle size and initial arsenic concentration on the removal of arsenic, iron and manganese from simulated ground water by Fe3+ impregnated activated carbon. J. Hazard. Mater., 150(3), 695-702 (2008).
5. Xia, S., J. Nan, R. Liu and G. Li, Study of drinking water treatment by ultrafiltration of surface water and its application to China. Desalination, 170(1), 41-47 (2004).
6. Jusoh, A.B., W.H. Cheng, W.M. Low, A. Nora, M. Mega and M.J. Noor, Study on the removal of iron and manganese in groundwater by granular activated carbon. Desalination, 182(1-3), 347-353 (2005).
7. Munir, C., Ultrafiltration and Microfiltration Handbook. CRC Press, Boca Raton, FL (1998). US Environmental Protection Agency (EPA), Membrane Filtration Guidance Manual. USEPA, Cincinnati, OH (2003).
8. Kimura, K., Y. Hane, Y. Watanabe, G. Amy and N. Ohkuma, Irreversible membrane fouling during ultrafiltration of surface water. Water Res., 38 14-15), 3431-3441 (2004).
9. ILAVSKف J., BARLOKOVء D., BISKUPIČ F. Chémia vody a hydrobiolٌgia, STU Bratislava, ISBN 978-80-227-2930-7, pp. 303, *2008.*
10. DOULA, MARIA K. Removal of Mn2+ Ions from Drinking Water by Using Clinoptilolite and Clinoptilolite-Fe Oxide System. Water Research, *40,* (17), 3167, *2006.*
11. KNOCKE W.R., VAN BENSCHOTEN J.E., KEARNEY M. J., SOBORSKI A. W., RECKHOW D. A. Kinetics of Manganese and Iron Oxidation by Potassium Permanganate and Chlorine Dioxide. Jour. AWWA **6**, 80, *1991.*
12. KNOCKE W.R., OCCIANO S. C., HUNGATE R. Removal of Soluble Manganese by Oxide-Coated Filter Media: Sorption Rate and Removal Mechanism Issues. J. AWWA **8**, 64, *1991.*
13. KNOCKE W.R., HAMON J.R., THOMPSON C.P. Soluble Manganese Removal on Oxide-Coated Filter Media. Jour. AWWA *12,* 65, *1988.*
14. MERKLE P.B., KNOCKE W.R., GALLAGHER D. Characterizing Filter Media Mineral Coatings. Jour. AWWA, *12,* 62, *1996.*
15. *-j. M. Montgomery, consulting engineers (1985). Water treatment principles and design. New york, ny, usa, john wiley. P. 510-512.*
16. *-american water works association committee on aeration (1975). 'aeration of water'. 1n: journal american water works association, vol.47, no 5, p. 873-893.*
17. *-h., p.d. (1932). 'theoretical principles of aeration'. In: journal of the american water works association, vol. 24, no. 62.*
18. *Us epa: (1999). Alternative disinfectants. (http://water.epa.gov/lawsregs/rulesregs/sdwa/mdbp/Upload/2001_07_13_mdbp_alternative_disinfectants_guidance.pdf)*
19. *-white's handbook of chlorination and alternative disinfectants, 5th edition, by black &veatch corporation copyright © 2010 john wiley & sons, inc.-*
20. *-j.c.morris. Health perspective in the oxidative treatment of water for potable supply. National institute for water supply, leidschendam, the netherlands (1982).*
21. *H. And s. 1992. Disinfection alternatives for safe drinking water. Van nostrandreinhold, new york, ny.*
22. *Awwa (american water works association). 1991. Guidance manual for compliance with the filtration and disinfection requirements for public water systems using surface water Sources.*
23. *Y. M.t., t.m. straub, and c.p. gerba. 1990a. Inactivation of poliovirus type 1 by potassium permanganate. University of arizona preliminary research report, tucson, az.*
24. *Y. M.t., et al. 1989. "evaluation of potassium permanganate for the inactivation of ms-2 in water systems." J. Environ. Sci. Health. A34(8):979-989.*
25. *W. W.j., jr., and h.s. posselt. 1972. "disinfection." Physicochemical processes in water quality control. W. J. Webber (editor). John wiley & sons, new york, ny.*
26. *.f.,1993. Iron and manganese filtration systems. A technical discussion.*

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