

Iron and Manganese Removal from groundwater using ozonation and nanofiltration process as a water treatment solution

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Abstract

Groundwater is an important resource of drinking water that act as a compliment resources against shortages of surface water particularly during dry period. Although the use of groundwater in Malaysia is lesser compared to surface water, but it is quite significant usage for industry activities and domestic needs, mostly people living in rural area. Iron and manganese are common metallic elements found in the earth's crust (Oram, 1995). Water percolating through soil and rock can dissolve minerals containing iron and manganese and hold them in solution (Jusoh et al, 2005). However, iron and manganese are the two naturally common contaminant found in tropical region, which are usually present in groundwater as divalent ions (Fe^{2+} and Mn^{2+}), are considered as contaminants mainly because of their organoleptic properties (Ellis et al., 2000). The concentration of iron sometimes goes up to tens of mg/L where laterisation is dominant mechanism of chemical weathering. Groundwater containing iron and manganese is usually anoxic. Iron and manganese often occur together in groundwater but manganese usually occurs in much lower concentration than iron. Both iron and manganese are readily apparent in drinking water supplies (Alex Colter & Mahler, 2006). The iron and manganese concentrations in excess, the water becomes red-brown, and endues the scaling problems in pipeline system.

The maximum recommended levels of Fe^{2+} and Mn^{2+} in drinking water are 0.3 mg/L and 0.1 mg/L, respectively (Department of Standards Malaysia, 2010) and (WHO, 2008), but these are not health related and not enforceable. Conventional treatment for iron and manganese removal from groundwater consists of oxidation and sand filtration. Strong oxidants such as chlorine and potassium permanganate (KMnO_4) are generally used for Fe^{2+} and Mn^{2+} oxidation. An aeration step may precede oxidation for oxygenation and removal of carbon dioxide (pH increase), sulphur and other volatile substances. The conventional process works fairly well if Fe^{2+} and Mn^{2+} concentration below 5 mg/L and in the absence of dissolved organic matter. However, for higher concentrations, excessive amounts of solids tend to shorten filtration cycles and render the overall process unprofitable. The selection of various oxidants depends on which kinds of pollutants in water and their effects on the water quality.

The aim of this study is to examine the removal of Fe^{2+} and Mn^{2+} from groundwater. The pilot-scale experiments were executed in mini water treatment plant at NAHRIM Complex, Seri Kembangan, Selangor. The methods applied were aeration by internal circulation, ozonation and nanofiltration. The removal effects of iron and manganese under the different conditions were investigated. The raw water containing iron and manganese ions were firstly oxidized in raw water tank by internal circulation through mechanical action followed by ozonation and nanofiltration process. All the groundwater sample were filtered with 0.45 μm filter paper except groundwater sample passing through nanofiltration. Ozone as a powerful oxidizing agent, which was used in this study to oxidize iron and manganese converting ferrous ions (Fe^{2+}) iron to ferric state (Fe^{3+}) and (Mn^{2+}) to (Mn^{4+}) state. The Fe^{2+} and Mn^{2+} concentration

was gradually decreased from raw water of 3.9 to 0.03 mg/L after completed treated cycles. By increasing contact time of raw water aeration, the concentration of Fe^{2+} and Mn^{2+} is reduced tremendously, the accumulated sludge of Fe and Mn oxide will also increase. The accumulated sludge of Fe and Mn due to aeration will be removed by sand filtration. The remaining Fe^{2+} and Mn^{2+} in groundwater were reduced by passing through the ozonation injection. After going through ozonation and nanofiltration process, the iron and manganese concentrations came down from 0.08 to 0.03 mg/L and 0.30 to 0.17 mg/L respectively. For optimum removal of iron and manganese ion, the ozone dose has been noted as 3 mg/L or (30% of maximum ozone output) at optimum temperature of 28°C which improved removal of Fe^{2+} and Mn^{2+} to more than 50% and 43% respectively. Therefore, this study can be concluded that ozone application can be applied for improving groundwater quality to meet water quality standards without chemical usage.

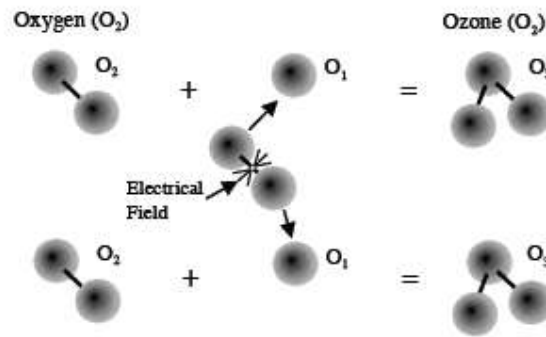


Figure 1: Ozone generation from oxygen atoms then recombine with other oxygen molecules in the air stream, forming ozone (O_3)

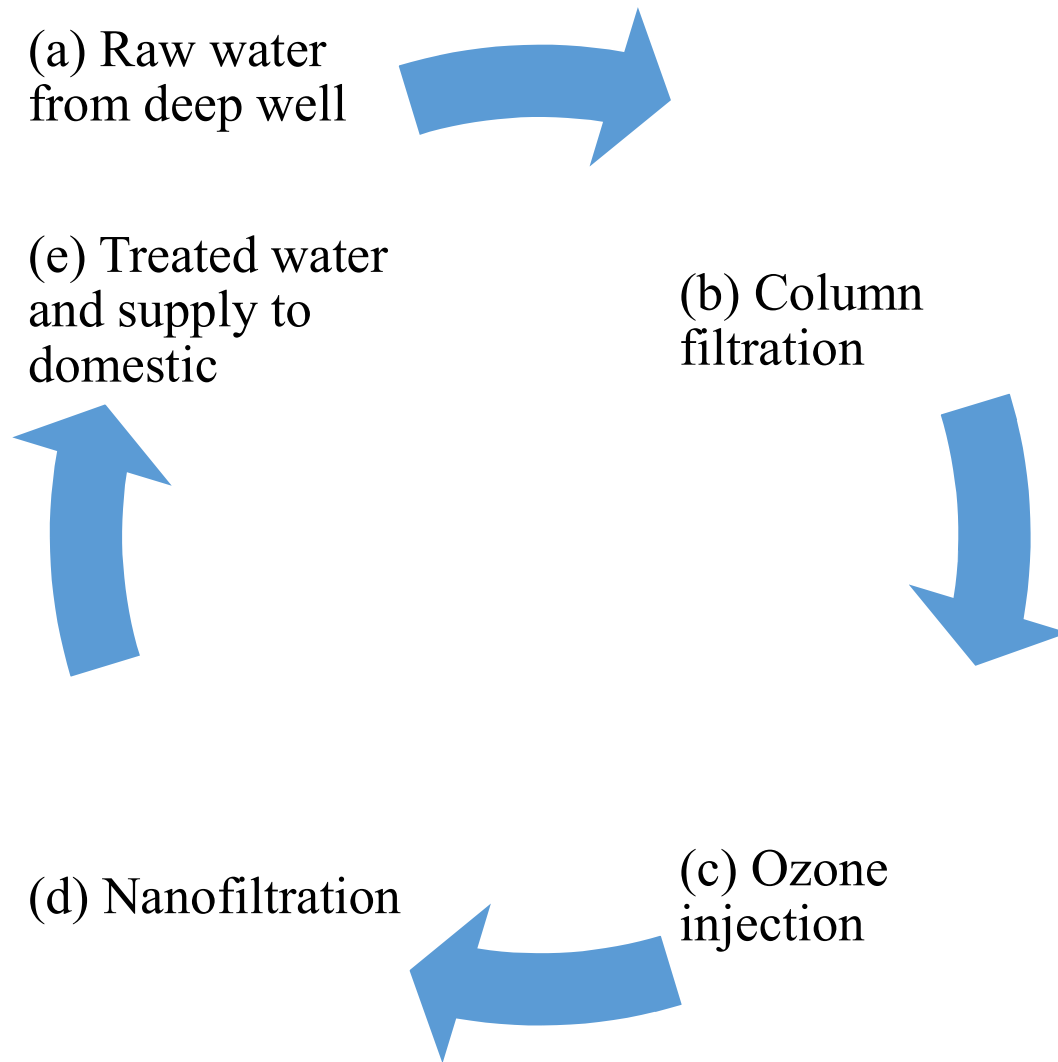


Figure 2: The schematic diagram of the groundwater treatment

Table 1: The Fe^{2+} and Mn^{2+} removal at different sampling point.

Sampling point	pH	Fe^{2+} (mg/L)	Mn^{2+} (mg/L)
S1 (raw water)	5.01	3.90	0.60
S2 (aeration)	5.43	0.08	0.32
S3 (sand filtration)	5.45	0.08	0.30
S4 (ozone)	6.12	0.04	0.17
S5 (nanofiltration)	5.82	0.03	0.15

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