Pre-assessment of clogging possibility in recharge wells and shallow aquifers in MAR region, South Korea

Chan-Ik Hwang[1)], Myoung-Rak Choi[2)], Gyoo-Bum Kim[3*)]

[1)] Industry-Academic Cooperation Foundation, Daejeon City, Republic of Korea,

[2)] Department of Disaster Prevention, Graduate School of Daejeon University, Daejeon City, Republic of Korea,

[3)] Department of Construction Safety and Disaster Prevention, Daejeon University, Daejeon City, Republic of Korea, geowater@dju.kr

Introduction

- During artificial recharge of groundwater, clogging of aquifers causes changes in injection rate and water quality, and physical, biological and chemical blockages act as factors that reduce groundwater withdrawal and clog wells.
- According to previous studies, a number of cases of clogging caused by chemical factors such as physical particles and oxidation of iron and manganese have been performed. In this study, the correlation between factors and clogging was analyzed using factors closely related to clogging, such as MFI, SDI, iron, manganese, turbidity, UV254, and DOC, through groundwater sampling and analysis of mineral saturation and Preliminary evaluation of the possibility of artificial recharge clogging.

Study area

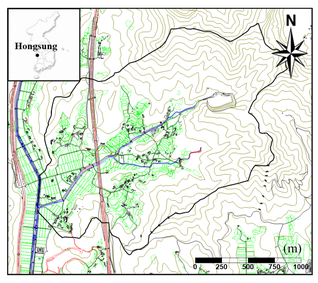

Fig. 1. Location map of research area.

- The area of this study is Ungok-ri (Singok Village), Galsan-myeon, Hongseong-gun, Chungcheongnam-do, Republic of Korea, with mountainous terrain in the northeast and lowlands in the southwest, and the 5~15 m wide Singok and Ungok Streams flow (Fig. 1).
- The geology of the study area consists of Cenozoic Quaternary alluvial and granite gneiss, and most of the land in the study area consists of field agriculture and paddy agriculture.

Contents of research

1. Mineral Saturation Analysis

- The saturation index of minerals was calculated as PHREEQC using the results of the physicochemical analysis of water samples. If the saturation index of a mineral is greater than 0, it means that there is a possibility of precipitation in a supersaturated state. If it is less than 0, it is unsaturated and it means that it is more likely to exist in a dissolved ion state.
- Alunite, Anhydrite, Anorthite, Barite, Calcite, Chlorite, Dolomite, Fluorite, Gypsum, Halite shows unsaturated state, Ca-Montmorillonite, Gibbsite, K-mica, Kaolinite (kaolinite), and Quartz (quartz) show a supersaturated state. In the case of Chalcedony and Illite, both supersaturated and unsaturated states coexist, but most are supersaturated.

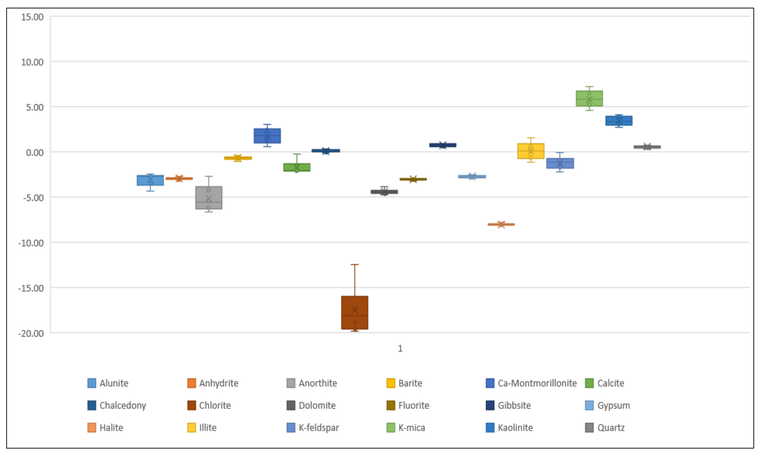

Fig. 2. Mineral saturation index by major chemical species

- The results calculated by PHREEQC by analyzing the mineral species of iron and manganese are shown in Box-Whisker Plot. In the case of iron mineral species, Fe(OH)2.7Cl0.3, Geothite (goethite), Hematite (hematite), and Magnetite (magnetite) are in a supersaturated state where the saturation index is greater than 0. Maghemite is a supersaturated state and an unsaturated state. There is a high possibility that the states coexist, and Fe3(OH)8, Greenalite, Melanterite, and Siderite show unsaturated states. In the case of mineral species of manganese, Manganite (manganese stone), Pyrochroite (manganese hydroxide), and Rhodochrosite (manganese stone) show an unsaturated state.

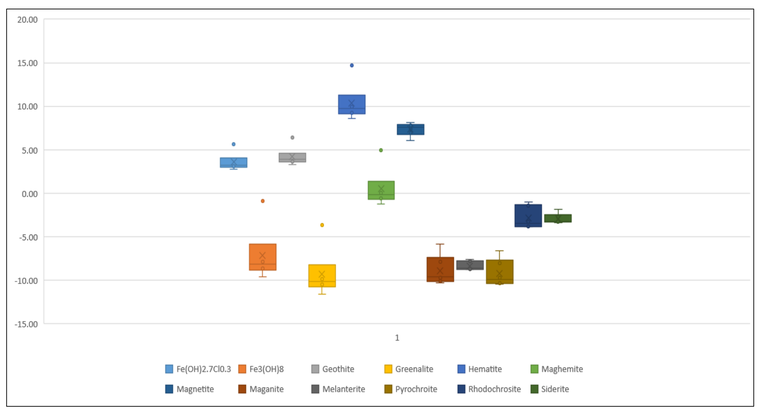

Fig. 3. Saturation Index by Iron Manganese Minerals

2. Modified Fouling Index and Silt Density Index Analysis

- MFI refers to 1) blocking filtration, 2) cake filtration without compression, 3) cake plugging and/or cake compression when the experiment is performed using a membrane with a pore diameter of 045 μm. cake curve. Cake refers to the accumulation of fouling on the membrane surface.
- According to the existing literature, when MFI exceeds 10 and SDI exceeds 5, it was evaluated that there is a risk of clogging.

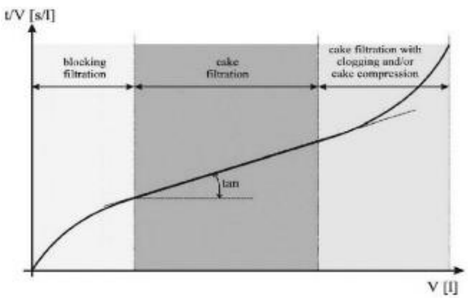

Fig. 4. Cake filtration curve(Javeed et al., 2009)

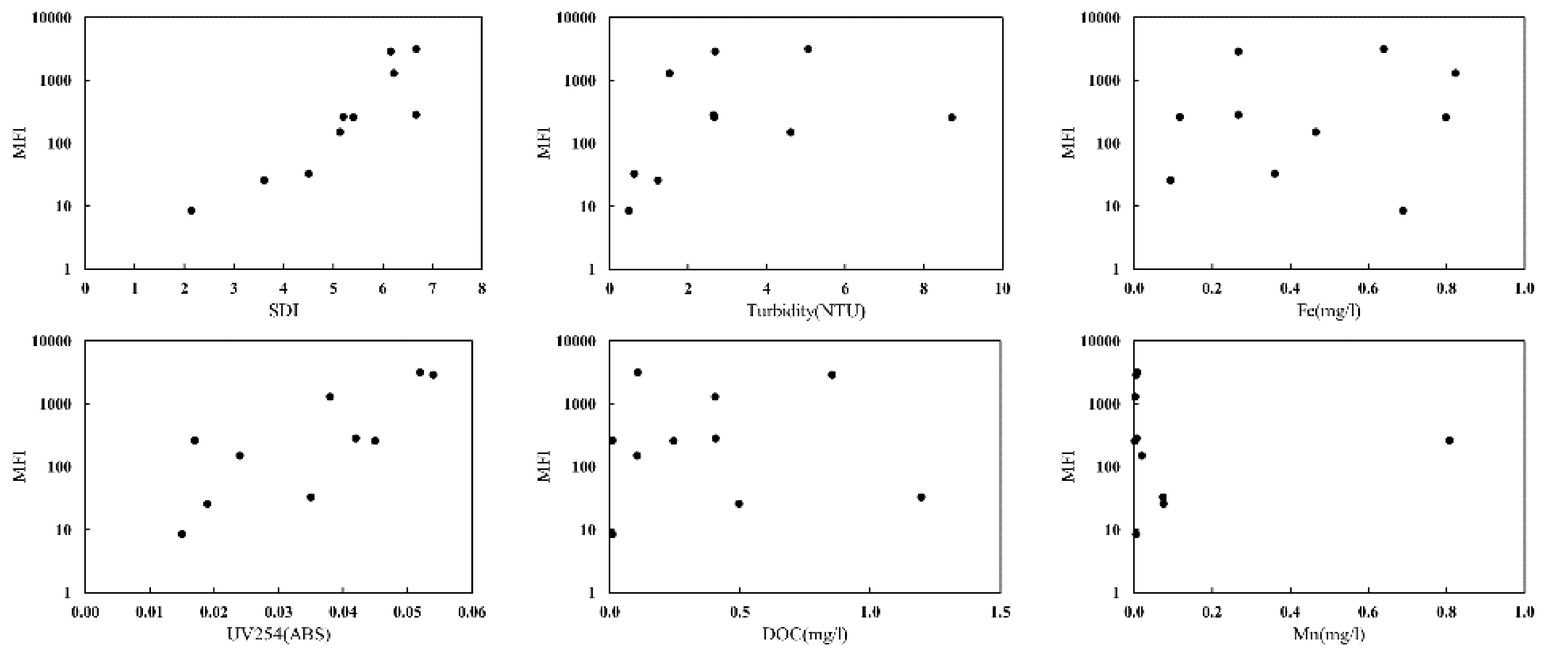

Fig. 5. Correlation by clogging factors.

- Looking at the relationship between MFI and SDI, the higher the SDI, the higher the MFI trend. In the case of three samples with SDI less than 5, the MFI also shows the smallest trend, indicating that the risk of clogging is relatively low compared to other samples.
- Although the correlation between turbidity and MFI is weak, the three samples with the lowest MFI all have the smallest turbidity, suggesting a relatively low probability of clogging.UV254 and MFI show a high correlation, but there is little correlation between DOC and MFI.
- In the case of iron and manganese, it appears that there is no correlation with MFI, but according to the existing iron-manganese clogging studies, it appears that in the long term, artificial cultivation will affect clogging.

Table 1. Water quality data for clogging evaluation.

Sample	MFI	SDI	Turbidity (NTU)	Fe (mg/l)	Mn (mg/l)	UV254 (ABS)	DOC (mg/l)	Sample	MFI	SDI	Turbidity (NTU)	Fe (mg/l)	Mn (mg/l)	UV254 (ABS)	DOC (mg/l)
PW	263.1±67.0	5.20	2.66	0.117	0.808	0.017	0.010	BH-4	1112.8±90.7	6.22	1.53	0.823	0.003	0.038	0.404
SG-1	152.8±24.8	5.14	4.61	0.466	0.020	0.024	0.105	BH-5	8.5±3.2	2.14	0.49	0.689	0.005	0.015	0.010
SG-27	2880.6±895.7	6.16	2.68	0.268	0.006	0.054	0.855	BH-6	3168.7±652.9	6.67	5.06	0.639	0.008	0.052	0.107
BH-1	33.1±3.17	4.51	0.62	0.361	0.074	0.035	1.197	BH-7	286.2±27.9	5.16	2.65	0.267	0.007	0.042	0.407
BH-2	25.9±13.1	3.61	1.23	0.093	0.076	0.019	0.497	Lab-madePure	-1.8±0.9	0.53	0	0	0	0	0.223
BH-3	260.5±26.9	5.41	8.71	0.799	0.001	0.045	0.246	tap water	295.8±35.5	5.34	0.12	0.315	0.030	0.058	1.570

- As a result of analyzing groundwater samples from 10 points in the artificial cultivation candidate site, 3 samples with SDI lower than 5 (BH-1, BH-2, BH-5) and no samples with MFI lower than 10 were found. Appears to have clogging potential when used. Since MFI and SDI tests tend to underestimate the effect of iron and manganese fouling, it seems that applying BH-2 groundwater to artificial replenishment without pretreatment has the lowest risk of clogging.

Conclusion

- In this study, the possibility of clogging in the aquifer was preliminarily evaluated by analyzing factors related to clogging during artificial cultivation using groundwater.
- As a result of analysis of the groundwater sample, it contains a lot of fine particles, but shows a low content of iron and manganese ions. However, there is a high possibility of clogging due to iron and manganese during long-term artificial cultivation. Therefore, it seems desirable to reduce iron and manganese, and to use raw water for enrichment through pretreatment of fine powder and turbidity of raw water.
- The saturation index of groundwater minerals using PHREEQC indicated that Ca-Montmorillonite, Gibbsite, K-mica, and Quartz were more likely to be supersaturated and precipitated, and Fe minerals such as Goethite, Hematite, and Magnetite could also precipitate. Membrane filtration indices (MFIs) for three groundwater samples were also analyzed, with MFI, NTU, and SDI ranges of 8.5 ± 3.2 to 33.1 ± 3.17, 0.49 to 1.23, and 2.14 to 4.51, respectively, implying the pretreatment requirements of the source. Clogging assessment is essential prior to MAR construction, but should be re-evaluated based on actual field data early in the injection operation.

Acknowledgement

- This work was supported by the Korea Ministry of the Environment (MOE) and the Korea Environmental Industry & Technology Institute (KEITI) through the “Demand Responsive Water Supply Service Program (#146523).”