

Study on radius of influence of groundwater circulation well in the field experiment

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Abstract. In recent years, groundwater circulation wells (GCW) have gradually become a research hotspot as an In-situ remediation technology. This technology reduces the construction of gas phase extraction wells and saves underground space compared to the traditional Air sparging (AS) remediation technology, the remediation process involves both volatile removal and microbial degradation. This study fully combines the background conditions of an organic contamination site and designs a positive circulation airflow lift circulation well. By analyzing the diffusion law of chloride tracer with aeration time and the changes of water level and water pressure of the monitoring well, it is known that the influence radius of the circulation well can be stabilized at 5.00 m when the aeration volume is 10 L/min. It not only has an essential demonstration significance for the development of groundwater circulation well remediation technology, but also provides reference process parameters for subsequent applications in type site remediation engineering applications.

1. Research Area and Methodology

1.1 Overview of the research site

The research site is located in the alluvial plain of the Yangtze River Delta, with elevations ranging from 3.50 to 5.80 m. Hu et al [1] used the high-density resistivity method to analyze the resistivity differences to conclude that the area is made up mainly of pulverized clay layers, silty pulverized clay layers, and locally pulverized fine sand layers. The groundwater flow direction in the study area shows a trend from southeast to northwest.

1.2 GCW circulation well design and well laying

1.2.1 Design of GCW circulation wells

Groundwater circulation well technology, as an in situ remediation technique, has shown great promise for application in actual site remediation [2-5]. The key to recirculating well rehabilitation technology is the circulation of water. In order to ensure that the purpose of continuous groundwater circulation is effectively achieved, the appropriate internal structure of the GCW and related connection fittings are designed, and a series of parameters such as the length of the wellbore, the size of the well diameter, and the location of the floral tube are determined.

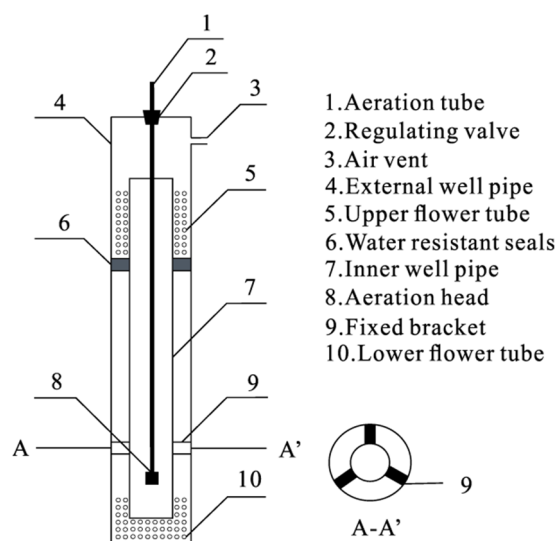


Fig1. Circulation well design drawing

- ① 6.00 m length and 245.00 mm inner diameter for the outer well pipe and 5.00 m length and 150 mm inner diameter for the inner well pipe;
- ② After the outer well pipe is ready, the inner well pipe is installed into it, and the upper top surface of the inner well pipe is 5.00 cm above the upper floral pipe, and the bottom end of the inner well pipe is 25.00 cm from the bottom surface of the outer well pipe;
- ③ The tip of the inner well pipe is 20.00 cm from the top surface of the outer well pipe;

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- ④ Upper floral tube 50.00 cm long, lower floral tube 50.00 cm long, venting hole 5.00 cm in diameter;
 - ⑤ In the inner part of the outer well pipe, the lower part of the upper floral pipe is equipped with a water barrier seal with a thickness of 2.00 cm; the upper part of the lower floral pipe is equipped with a fixed bracket. The inner well pipe is fixed inside the outer well pipe by the upper water barrier seal and the fixing bracket, and after the inner and outer well pipes are ready, the inner well pipe is lowered into the circulation well hole with the outer well pipe;
 - ⑥ The aeration head is lowered into the inner well pipe together with the aeration tube, the aeration tube is connected to the aeration pump through the regulating valve, and the exhaust hole is connected to the VOCs pollution gas monitor;
 - ⑦ The upper floral pipe and the lower floral pipe need to be wrapped with non-woven fabric or copper wire mesh to prevent the aquifer media from entering the circulation well with the groundwater flow causing operational blockage.
- GCW for this research uses seamless galvanized steel pipe (material grade: Q235) to make the outer well pipe and inner well pipe, with floral holes on the pipe, and uses 220V air pump to provide the power source.

1.2.2 GCW and surrounding monitoring well placement

The GCW was located in the center of the demonstration site, and several monitoring wells at different distances were set upstream and downstream of the circulation wells. The monitoring wells are distributed in a cross shape with the distances of 5.00 m and 15.00 m from the circulation wells, which are shown in Figure 2 and Table 2.

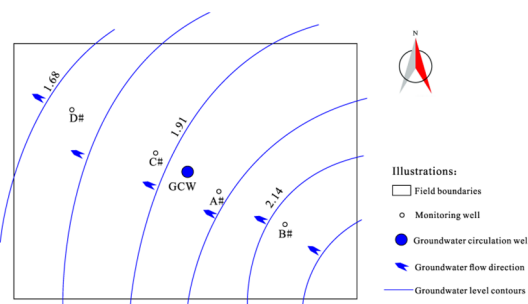


Fig 2. Distribution of GCW and surrounding monitoring wells

Table 2. List of the distance between the monitoring well and GCW

Well No.	Distance from GCW(m)
A#	5.00
B#	15.00
C#	5.00
D#	15.00

1.3 Tracer experimental method

Due to the high solubility of chloride ions in water and their stable nature, they do not participate in oxidation-

reduction reactions in the groundwater environment and do not adsorb on the surface of organic matter, chloride ions were selected as tracer for the tracer experiments. Samples were taken to measure the background values of chloride ions in the circulation wells and monitoring wells, while the appropriate sodium chloride solution was then configured and added to the wells, and the measured background value of chloride ion concentration at the site was approximately 82 ppm, as shown in Table 2.

Table 2. Background value of chloride ion concentration in each well

Well No.	Concentration/ppm
GCW	72
A	98
B	107
C	104
D	109

A total of two groups of tracer experiments were conducted.

In the first group, 5L of 274 ppm NaCl solution was added to the circulation wells, and samples were taken at 30 minute intervals in the circulation wells and each monitoring well to determine the chloride ion concentration using a Bante321-CL chloride ion meter (measuring range: 1.8-35500 ppm; measuring accuracy: ± 0.5% F.S.).

In the second group, 5 L of 228 ppm NaCl solution was added to monitoring well #C, 5.00 m from the circulation well, and samples were taken every 30 minutes in the circulation well to determine the chloride ion concentration using a Bante321-CL chloride ion tester.

1.4 Experimental method of water level change

In order to monitor the water level change more accurately, the PCM260B LCD cable type level transmitter is placed in four layers in each monitoring well, and the outer well is divided into three sections from the partition between the inner and outer wells to the bottom of the well, and the two junctions are recorded as A and B. The A upward to the partition is divided into two sections, and the junction is recorded as C. The B downward to the bottom plate is divided into two sections, and the junction is recorded as D. The distance of A, B, C, and D from the well cover are 3.62 m, 4.76 m, 3.03 m and 5.35 m respectively.

The position of the aeration head in the circulation well will have a large impact on the radius of influence. Taking C# as the research object, air was introduced into the circulation well at a rate of 10 L/min, and the aeration head was placed at five positions of 5.75 m, 5.65 m, 5.55 m, 5.45 m, and 5.35 m, and recorded every 20 minutes, and finally, by analyzing the water level change of the circulation well under the same time magnitude.

2. Analysis and Discussion

2.1 Tracer analysis

The background values of chloride ions in the circulation wells and monitoring wells were first measured, and then

274 ppm NaCl solution was added to the circulation wells, and samples were taken every 30 minutes, and the chloride ion concentration was plotted in Figure 3 and Figure 4. It can be seen that the chloride ion in the groundwater of the study area is relatively stable moment, and the concentration influence range is about 5.00 m.

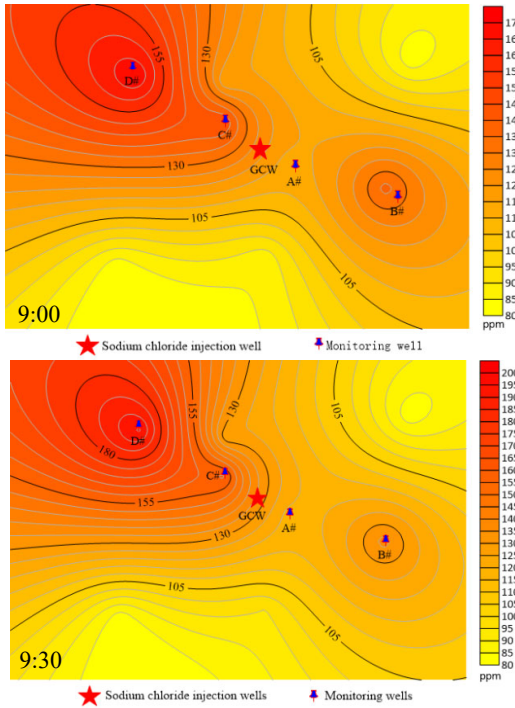


Fig 3. The first group of tracer experiment chloride ion concentration graph

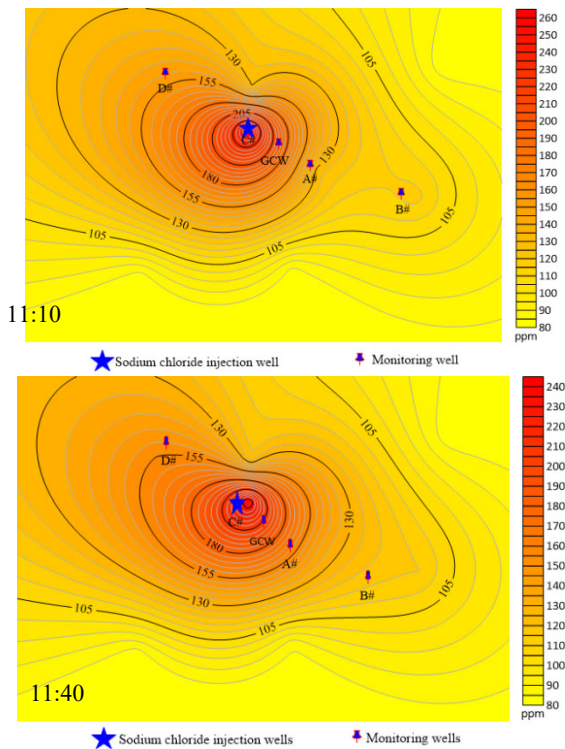


Fig 4. The second group of tracer experiment chloride ion concentration graph

2.2 Analysis of water level change

In this study, water level changes in the surrounding monitoring wells were used as a basis in order to determine the radius of influence of the circulation wells. Air was introduced into the circulation wells at a rate of 10 L/min, and the water level was recorded every 20 minutes or so, and the groundwater levels at four levels in each monitoring well were plotted as a line graph, with the water level changes in well C shown in Figure 5 below.

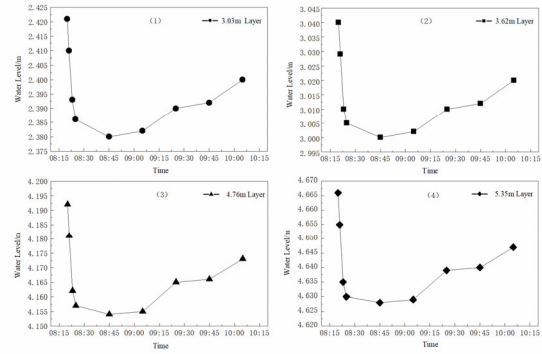


Fig 5. Water level change graph in C#

As can be seen from Figure 6, the groundwater level as a whole showed a trend of first falling and then rising, with all four layers reaching their lowest values 30 minutes after aeration. At the end of the experiment, the water level recovered to 3.02 m; at the groundwater level of 4.76 m layer, the lowest value of 4.154 m was reached 30 minutes after aeration, and the water level recovered to 4.173 m at the end of the experiment; at the groundwater level of 5.35 m layer, the lowest value of 4.628 m was reached 30 minutes after aeration, and the water level recovered to 4.647 m at the end of the experiment; the trend of groundwater level at 3.03 m layer was more significant than the other three layers. The trend of groundwater level at 3.03 m is more significant than the other three layers, and the trend of the same layer at 5.35 m is the least, which is mainly due to the non-homogeneity of the site, and may also be caused by the existence of preferential flow channels in the site.

3. Conclusion & Outlook

3.1 Conclusion

Groundwater circulation wells can reach a remediation radius of 5.00 m under the geological conditions of this study site with aeration at a rate of 10 L/min.

3.2 Outlook

Groundwater recycling well is a very in-situ groundwater remediation technology with great potential for development, and there are still large gaps in domestic research on its site, and the development of groundwater recycling well remediation equipment and process parameters system suitable for China's national conditions requires more practical site accumulation. For this site, additional research on precise aeration locations and optimal aeration rates can be added before restoration

work is carried out. For other site conditions, when carrying out GCW applications, in addition to the first detailed exploration of the process parameters, attention should be paid to the collection and treatment of VOCs on the ground during the GCW remediation process to avoid secondary pollution. Strengthen research on the development evolution and material change characteristics of the surrounding impact areas, focusing on the changes in the contribution of biodegradable pollution remediation after the operation and stabilization of the circulating wells, to provide a basis for the large-scale application of engineering remediation.

Acknowledgments

This work was financially supported by 2020 Langfang science and technology research and development plan (the second batch of self funded projects) (2020013159) and Innovative Ability Training Project for Postgraduate Students in Hebei Province (CXZZSS2022161) funds.

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