Optimization of electrode layout and verification of pilot effect for electric enhanced microbial dechlorination

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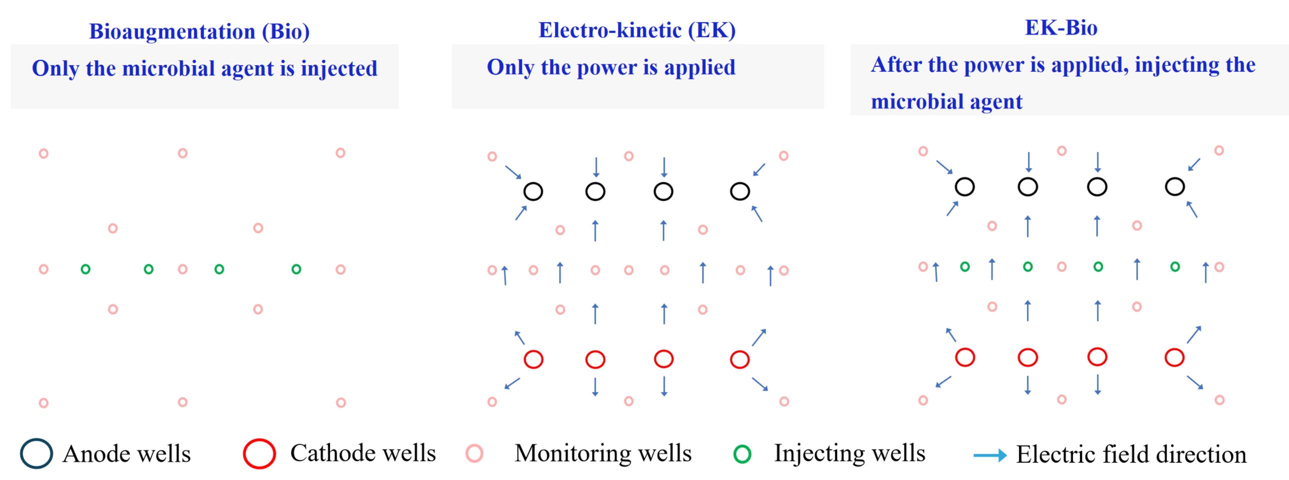
Motivation The electric coupling microbial remediation of trichloroethylene pollution in low-permeability media has been proven to be an effective technical method. However, the relevant parameters for its site application have not been explored, nor has its practical application effect in actual sites. This study determined the optimal electrode array arrangement for electrically enhanced microbial remediation of trichloroethylene pollution through laboratory reactor simulations and subsequently verified its effectiveness in engineering remediation at low-permeability sites.

Experiment Setup

In the laboratory, we selected one-dimensional unidirectional, one-dimensional bidirectional, and two-dimensional triangular electrode arrays, employing a rotating operation mode to mitigate the impact of pH fluctuations during a 60-day intermittent electrification process. At the site, 3 types of well clusters were established: electric-only, bio-enhanced, and electric-coupled microbial communities, with pH balance achieved through the use of exchange electrodes. Regarding microbial agents, NPC adjuvants and CE40 microbial agents were utilized.

Figure 1



Results and Discussion

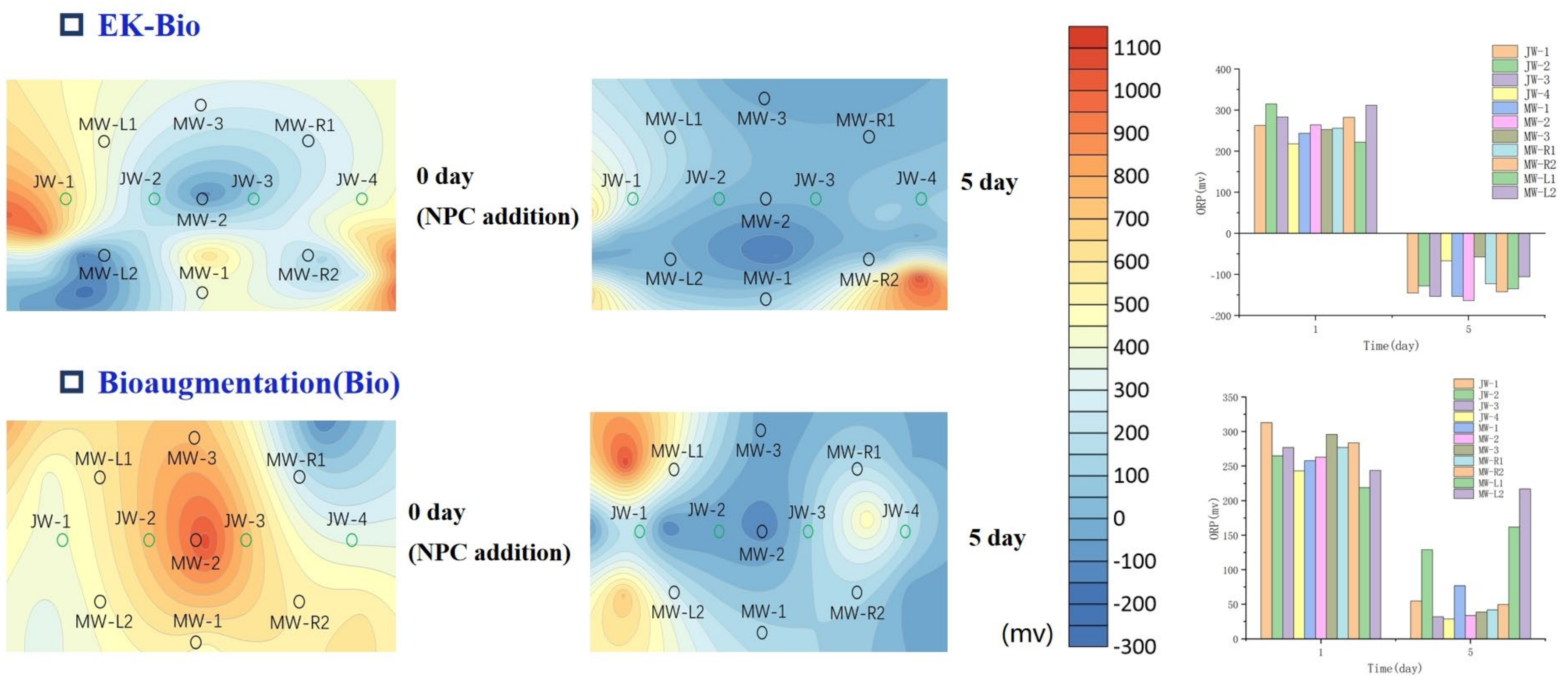


Figure 2

The system has maintained stable for 110 days under a voltage gradient of ~0.2 V/cm. In field experiments, NPC adjuvants have been instrumental in creating a conducive environment for the proliferation and maturation of dechlorinating bacteria. They have effectively lowered the redox potential and facilitated the field colonization of these adjuvants through electric stimulation, thereby achieving a more rapid ORP degradation rate.

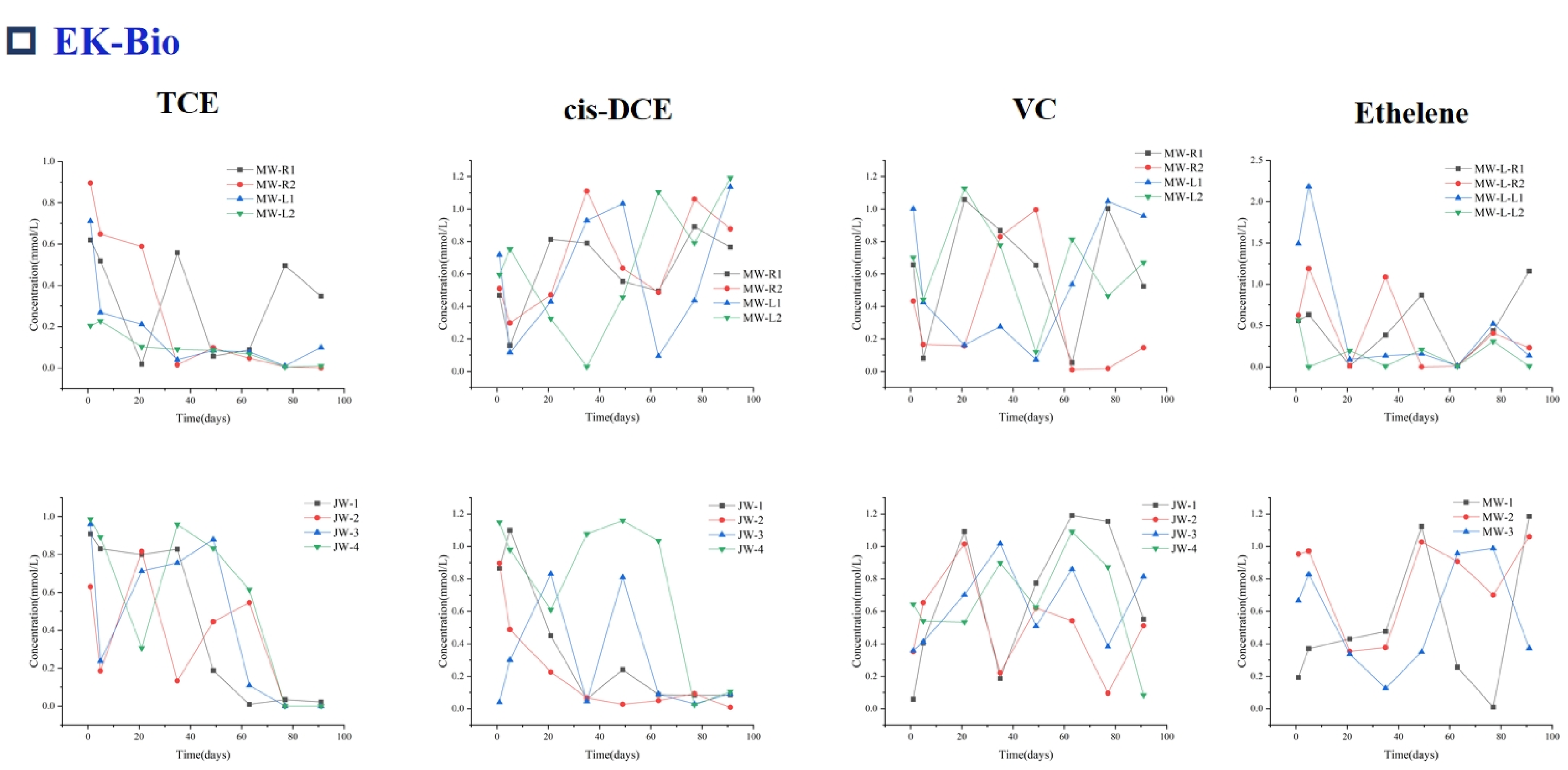


Figure 3

In comparing the degradation rates of trichloroethylene, the EK-Bio group demonstrated the highest efficiency, essentially completing the degradation process on-site within 40 to 50 days, with a degradation rate of 70-80%. After 60 days, changes in the water table due to a rainstorm led to the migration of some pollutants. This can be attributed to the redistribution of contaminants resulting from the hydraulic gradient and the silting of wells.

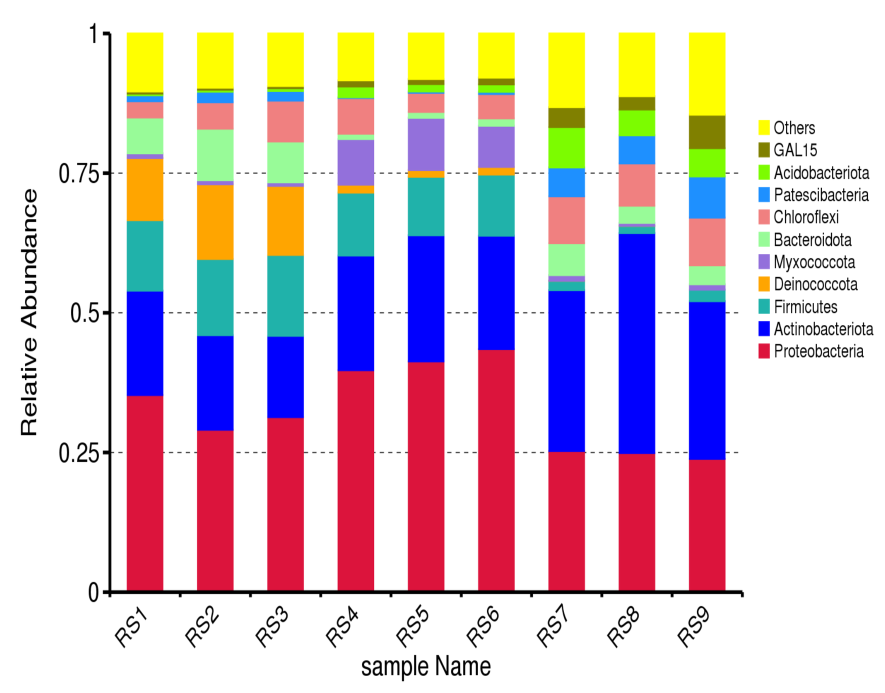


Figure 4

Figure 5

In the EK-Bio group, the phylum Actinobacteria is the dominant phylum. During the electric colonization by microbial agents, ***Dhc*** showed the best colonization effect in the electric group, but it was not the dominant bacterial genus, which can be attributed to the ecological niche characteristics of ***Dhc***.

Conclusion

- The effectiveness of EK-Bio at the site is influenced by the hydraulic gradient, and it is recommended to employ it in conjunction with a waterproof curtain to optimize its performance.
- Electric colonization of microorganisms can improve the growth efficiency of dechlorinating bacteria ***Dhc*** and alter their ecological niche.

Acknowledgement:
This project has received funding from the National Natural Science Foundation of China (32061133002) and the European Union's Horizon 2020 research under grant agreement N°965945. This presentation reflects only the author's view. The NSFC and the European Commission are not responsible for any use that may be made of the information it contains.