



Doctoral Dissertation
Doctoral Program in Energy Engineering (33rd Cycle)

Electrokinetic delivery of reactants for groundwater remediation

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RESPONSE TO REVIEWERS

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I would like to thank the reviewers for the time dedicated to the evaluation of this manuscript and their helpful comments, both general and specific, that will help to improve the manuscript quality. I also would like to thank them for their words of appreciation for the project discussed in this work.

I did my best in modifying the manuscript accordingly to such comments, below I report the detailed answers to the specific comments.

REVIEWER: Professor Pietro Paolo Falciglia

- 1- *Page 2, line 6: please check “(see)”*.
The entire manuscript was checked for typos.
- 2- *Page 5, please give an adequate space after “many fields”. Check typos for all the document.*
The entire manuscript was checked for typos.
- 3- *Page 6, use “.” at the end of each points*
The correction was applied through all the bullet points in the manuscript.
- 4- *Please give more details in the schematics of the experimental setups (Figures 16, 35, 53).*
The schematics were integrated with additional details in the figures.
- 5- *Please give schematic details on the monitoring system (camera, panel, light,...) also with referring the EK setup (relative positioning, distances, dimensions,...).*
I would like to thank the reviewer for the comment; an additional paragraph was added in appendix covering the monitoring system set-up in greater detail.
- 6- *Please include a table summarizing the scenarios adopted. This will help to better understand the results and their interpretation.*
I thank the reviewer for the helpful comment, a table summarizing the main parameters for the scenarios adopted was added for Chapter III and the two sub-section of Chapter IV.
- 7- *Please include a graphic scale in all the figures showing the plume evolution images (i.e.: figures 24, 27, 28, 30, 55-60).*
All images obtained from the photos collected with the monitoring system were added with a scale.
- 8- *In general, figure captions should be more descriptive of the figures including more details. For instance, captions of figures 30 and 37 are not clear.*
Figure captions were checked in the entire manuscript and integrated with more details.
- 9- *Figure 33, change “filed” with “field” and add include the significance of the colors used.*
The manuscript has been modified accordingly, adding details to the caption and a more comprehensive description in the text.
- 10- *Figure 36, please also include a zoom of the reactor is possible.*
A close-up of the column was added.

11- Page 82, check spaces between table 7 and 8 citations in the text.

The typo was corrected, and entire manuscript was checked.

REVIEWER: Professor Massimiliano Fabbicino

1- I have found several editing mistakes. I have marked some of those that I've noted in this chapter (see attached file), but I suggest the author to check carefully throughout the whole manuscript.

The manuscript was checked for editing mistakes such as spelling and spaces.

2- Please check the third sentence in section 2.1, which is not clear to me.

The sentence was modified to add more clarity.

3- Most of symbols are not listed. Please check.

The symbols have been checked and harmonized in the entire manuscript. A table listing all the symbols used was also added before Chapter 1.

4- I do not understand the choice of the author to use the units, instead of dimensions, when defining any parameter. I do understand that it is important to indicate the units in empirical equations, but this is generally not the case in this work.

I would like to thank the reviewer for the insightful comment. I do agree that parameters definition is often approached using dimensions rather than units. However, in the case of the present study an opposite approach was preferred since some parameters presents different values using different units, whereas the dimensions do not change. For example, the gas constant R [$M^1 L^2 T^{-2} K^{-1}$] has 16 different values each using different units. Lastly, units were preferred to harmonize the theoretical and experimental section.

5- After Equation 8 there are two sentences with the same meaning. Please check.

The section was checked, and the two sentences unified.

6- Please better explain equation 14

I thank the reviewer for the helpful comment, the text was modified to provide better context and explanation for Equation 14.

7- I do not understand why the aim of the study is reported at the end of the chapter.

Thanks for the useful comment. This was a typo from an old version of the manuscript. This section is now at the end of Chapter I.

8- The aim of this chapter is not clearly linked to the literature study (this is very well done in chapter IV, instead).

Thanks for the useful comment and the appreciation for the work in the following chapter. The study performed in this chapter was driven by the lack of studies exploring a true bidimensional

transport using electrokinetics, specifically investigating transport in the transversal direction under different boundary conditions. Two phrases were added to better convey the aim of the study “This focus is aimed to add to the current literature on the mathematical modeling of electrokinetic assisted delivery, to account for multidimensional process so far only marginally investigated. This is of paramount importance in the design of field-scale applications, specifically to optimize the injection well geometry and strategy (e.g., concentration of amendment, volume injected)”.

9- Any reason for the chosen concentration of permanganate (3mM)?

Thanks for the insightful question. The concentration of choice for permanganate was selected pondering different aspects. Firstly, the detection method using a DLSR camera required a good color intensity, which means not too dark or too light in comparison with the glass beds background. Secondly, the concentration was dictated by the ‘EK equal’ scenario background electrolyte concentration, for which we arbitrarily defined the concentration to fall in a plausible groundwater range. Lastly, we accounted for the preparation procedure (weighing of the salt) to reduce wastes production (permanganate solution has a short shelf-life). The concentration of choice is about 1/10th of the lowest value found in scientific literature presenting pilot- or field-scale tests and was found to have been used in some of the laboratory-scale tests cited in the manuscript.

10- Is there any possibility of adding a scale to the photos?

Thanks for the helpful comment. A scale was added for all the images obtained from the monitoring system.

11- In this chapter too many things are given as known. A more detailed description would be required. For example: i) evaluation of terms in Table 3; ii) normalization; iii) model equations and used values of the parameters (Figure 23 and others).

Thanks for the helpful comment. Regarding Table 3 additional details were added both in the main manuscript and in appendix, explaining the image analysis process; details on parameters (area, concentration, etc.) normalization were also added. Principal model equations, spatial moment analysis, parameters values and additional details on the COMSOL-Phreeqc coupling and outputs were added in Appendix.