Remote monitoring of hydrocarbons in groundwater through sensor data fusion

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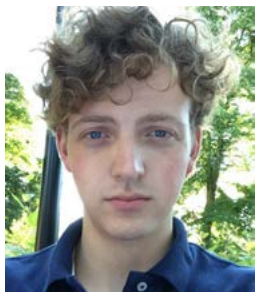

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Motivation

Industrial activities can lead to contamination of groundwater near industrial sites, for example by petroleum hydrocarbons [1]. They can form pollution plumes of which BTEX (Benzene, Toluene, Ethylbenzene, Xylene) compounds are one of the most damaging for public health [2] (figure 1).

Natural attenuation processes are able to decrease hydrocarbon concentrations in groundwater. Microorganisms can aerobically and anaerobically degrade hydrocarbons using a terminal electron-accepting process (TEAP) [3]. Currently hydrocarbon concentrations are measured on a yearly basis by sampling and lab analysis.

Current sensors that can measure BTEX in situ in aqueous conditions need either frequent recalibration or maintanance due to their measuring principles. Instead of monitoring BTEX concentrations directly, water quality indicators that give an indication of the hydrocarbon degradation will be monitored.
The goal is to develop a cheap in situ sensoring method for BTEX in groundwater that is reliable for over a year.

Technological challenge

Instead of measuring BTEX concentrations directly, changing water quality indicators could provide information on BTEX concentrations. It is hypothesized that changes in ORP (Oxidation Reduction Potential), pH and temperature correlate with hydrocarbon concentrations and degradation processes. Finding the correlation between water quality parameters and BTEX concentrations is the biggest challenge.

Furthermore, sensors that will be used for the remote monitoring should be low-cost and reliable for a long time. A degree of autocalibration should be developed in the sensors.

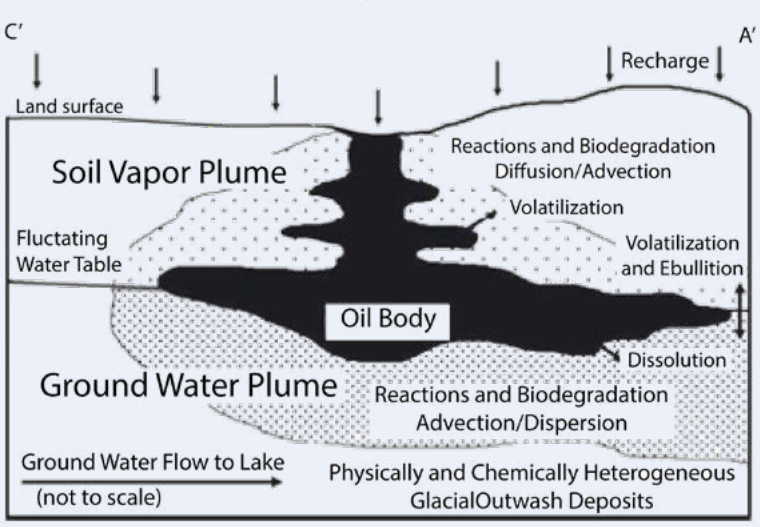

Fig 1. Cross sectional view of multiple natural attenuation processes of light non-aqueous phase liquid (LNAPL) in the subsurface [4]

[1] Contamination of ground water by toxic organic chemicals. 1981
[2] Delin, G. 1998: US Department of the Interior, US Geological Survey.
[3] Haack, S.K. and B.A.J.H.J. Bekins. 2000. Hydrogeology Journal. 8(1): p. 63-76.
[4] Essaid, H.I., et al., 2011. Groundwater. 49(5): p. 706-726.

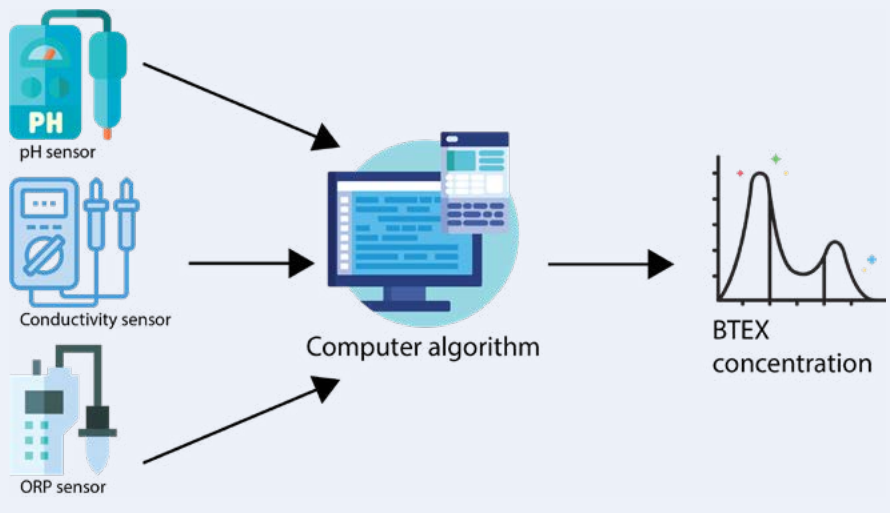

Fig 2. Schematic sensor data fusion through pH, conductivity and temperature to determine BTEX concentration.

Research goals

The goal of the research is to use reliable and low-cost multi-sensor system together with a computational sensor fusion framework to enable remote monitoring of hydrocarbons in groundwater under varying conditions (figure 2). This is done by measuring water quality indicators that are affiliated to the natural attenuation of hydrocarbons in groundwater. To do this, multiple questions need to be answered first (figure 3):

- Which measurable water quality parameters can be correlated to hydrocarbon contamination by analyzing model produced and historical datasets?
- Can sensor drift and stability for low-cost sensors be controlled for an extended period of 1+ years?
- Can the amount of BTEX in a laboratory setup be approximated by using the measurable variables that correlate to the contaminants concentrations?
- Can BTEX concentrations in the field be approximated by using the measurable variables that correlate to BTEX concentrations?

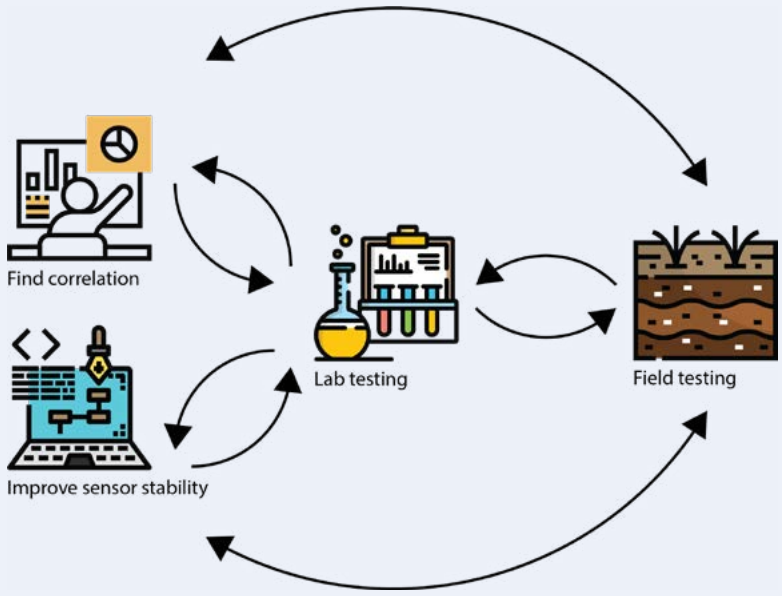

Fig 3. Plan of approach to solve the research goals

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