Characterization of contaminated site using electrical resistivity and induced polarization methods

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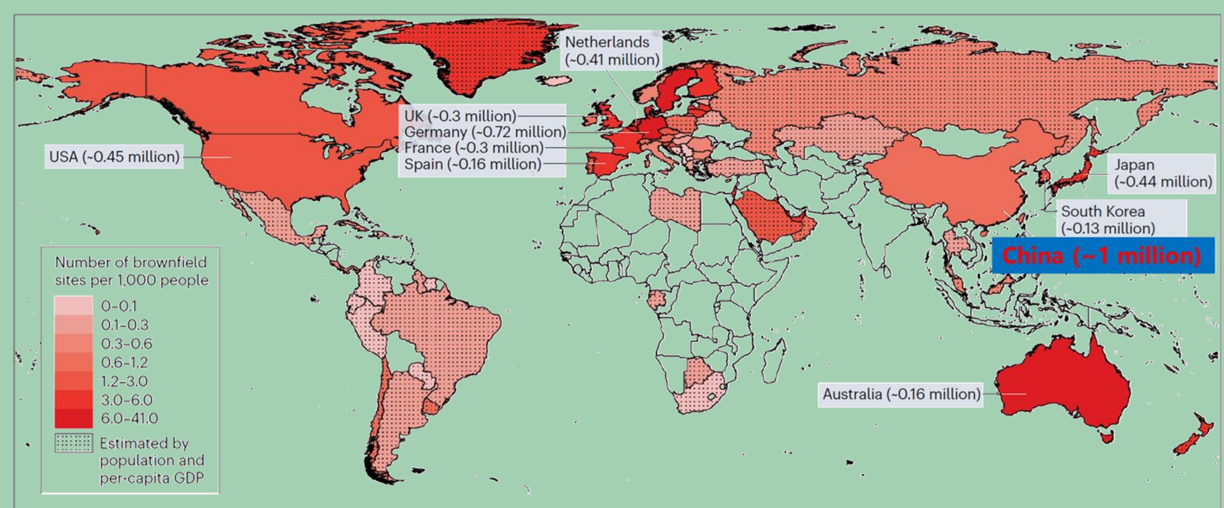
1 Introduction & Objectives

Soil and groundwater contamination has been widely concerned because of its impact on **industrial**, **agricultural** production, and even **human health**. **Accurate delineation of contaminant distribution** is the basis for successful remediation strategies. Traditional drilling based methods are **costly** and **less efficient**. **Geophysical methods**, particularly **electrical resistivity (ERT)** and **induced polarization (IP)**, are sensitive to soil and groundwater contamination and have been proven very effective. However, there were still some **pressing issues** to be resolved, such as **IP mechanism of contaminants**, **data acquisition**, **inversion strategies** and **result interpretation**.



O1 Relationship and mechanism of IP signal and contaminants

O2 High IP data quality for contaminated site survey

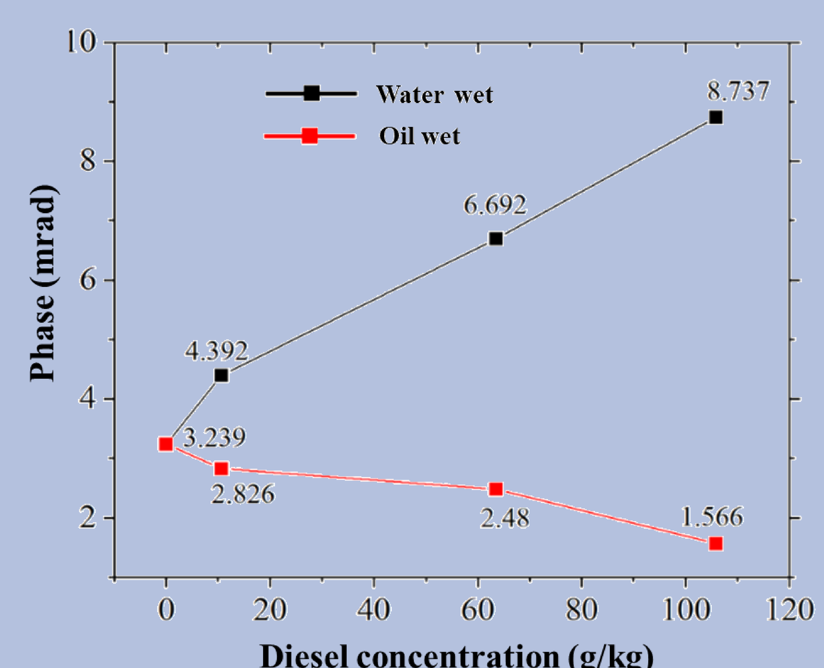
O3 Fusion of borehole and ERT information during inversion

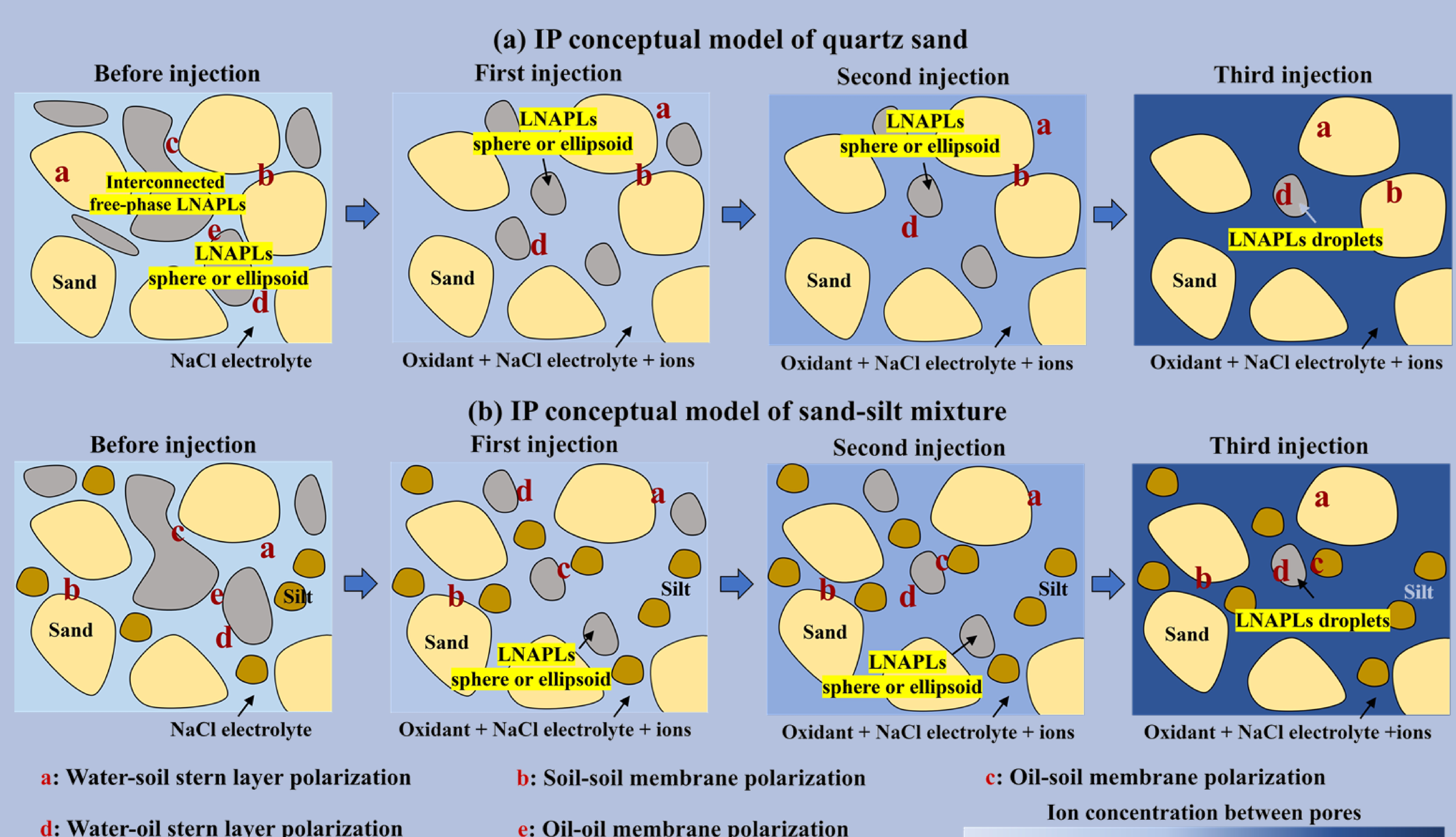
O4 Joint interpretation of multi-source data at contaminated site

2 IP response and conceptual model

The IP column experiments were conducted to quantify the relationship of IP parameters and contaminant concentrations. The resistivity and phase increase with the increase of diesel saturation in water-wet condition. The resistivity and phase amplitude decrease as the saturation of diesel fuel increases in oil-wet condition.

The sandbox experiments were conducted to monitor the remediation of organic contamination by IP, CT scanning and hydrochemistry. Accordingly, we propose a conceptual model for the IP response during the oxidation process based on the phase and resistivity results. The three-phase distribution morphology is referenced to the CT scanning slice.



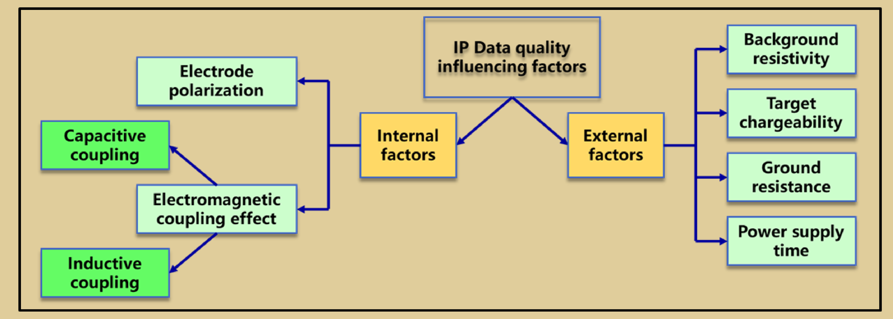


3 IP data acquisition for contaminated site

The quality of IP data in **contaminated sites** is poor. Through **theoretical derivation** and **field experiments**, the influencing **mechanism and factors** of the IP data quality are revealed.

IP data acquisition system for different contaminated site conditions is proposed with **high signal-to-noise**.

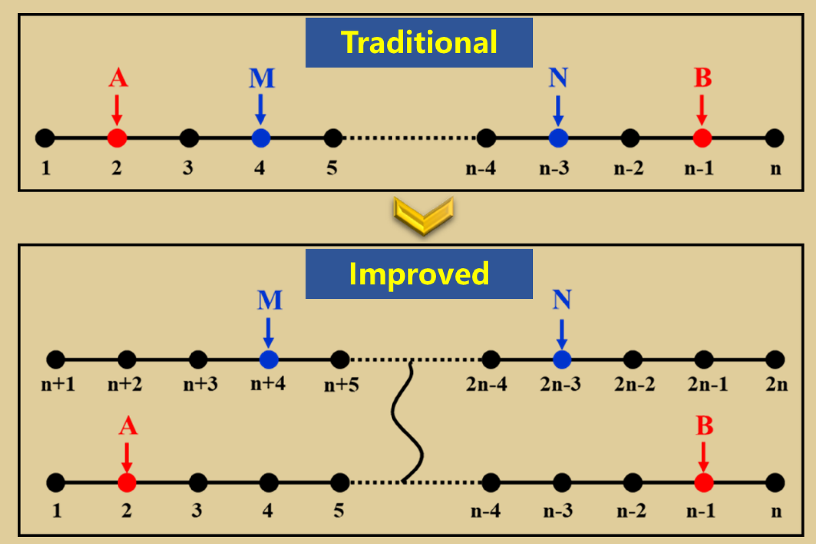
In contaminated sites where the resistivity **is less than 10 Ω·m**, reliable IP data can **only** be obtained using **separate current and potential cables method**.

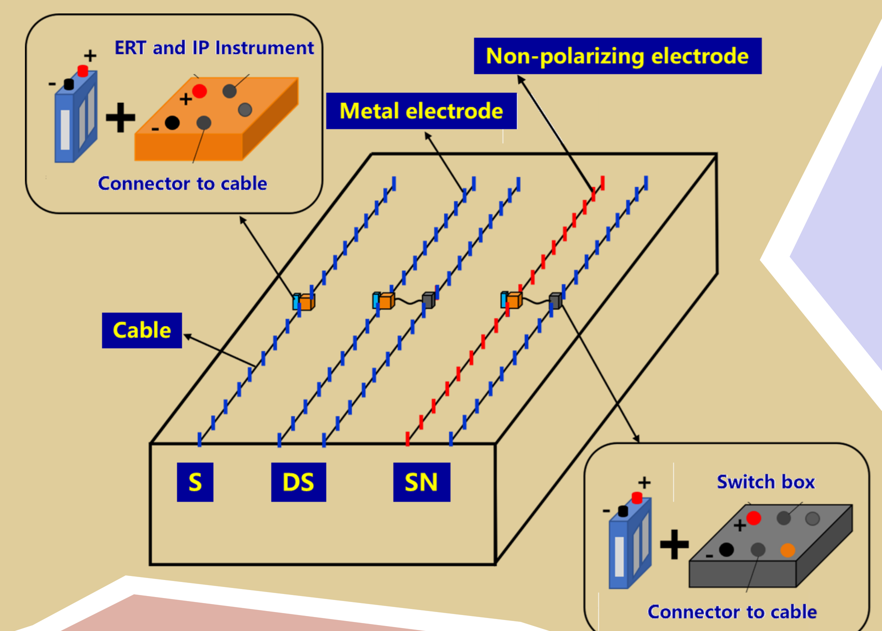


Apparent resistivity $\rho_a = k\frac{V_{DC}}{I}$

Apparent chargeability $M_0 = \frac{V_{IP(t=t_0)}}{V_{DC}}$

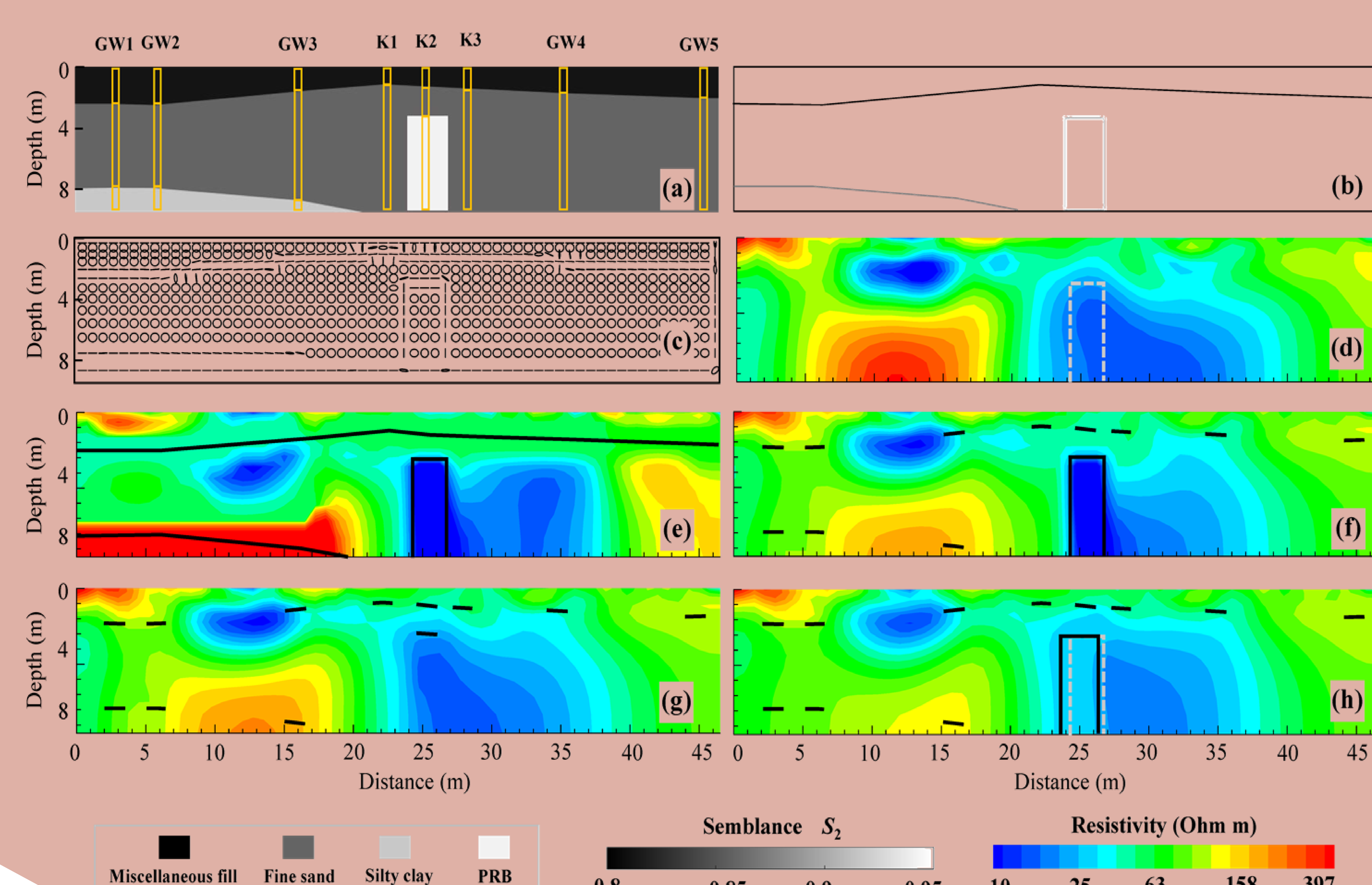
$V_{IP(t=t_0)} = \frac{\rho_a \cdot M_0 \cdot I}{k}$ Measured voltage





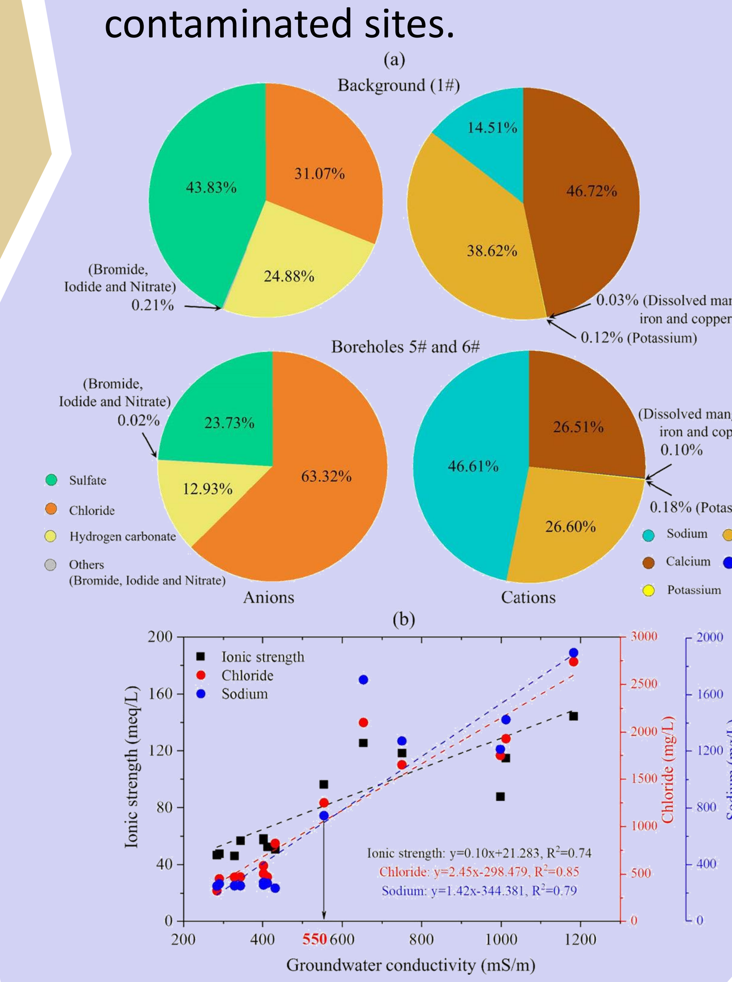
4 Image-guided structure-constrained inversion

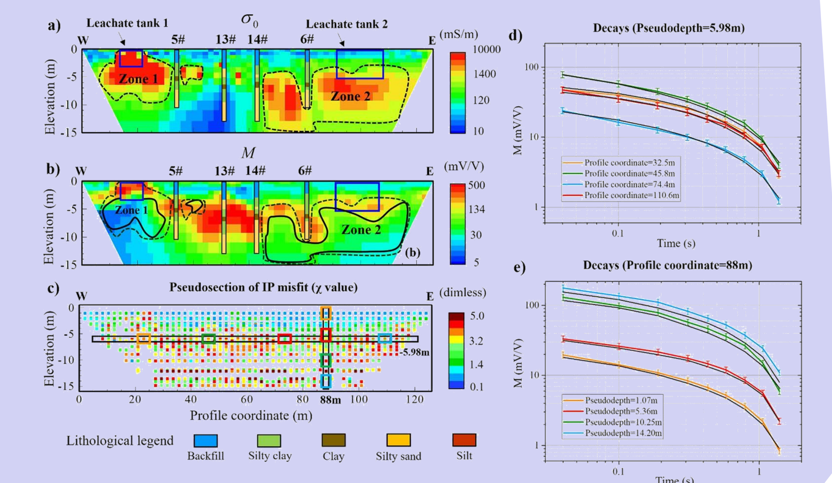
Utilizing available **prior information** is crucial for **enhancing geological plausibility**. **Without knowing the boundary exactly**, we propose a method to obtain **local constraints** from borehole logs by **improved structure-constrained method** that updates the smooth weights of **all eight elements** surrounding a boundary element using **three different magnitudes**, which is verified by **both numerical and field data**. This method **reduces the interference** from **uncertain structural boundaries** and **enhances the inversion robustness**. Correct boundary information even with **scattered constraints** can **increase the identification** of the abnormal contamination resistivity.

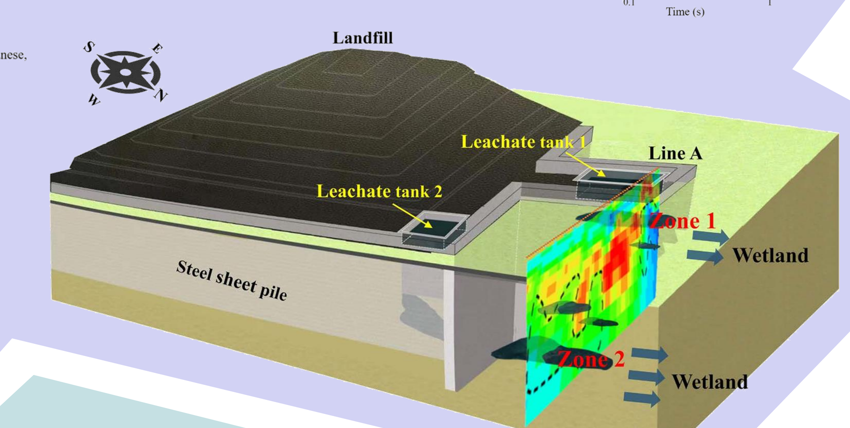


5 Joint interpretation of multi-source data

Based on **ERT, IP and borehole sampling** analysis, the **correlation** between the **multi-source data** of contaminated site, including **hydrochemistry** data, **soil sample** information, **contaminant concentration** data and **electrical parameters** is strengthened. The integration of multi-source data is an excellent way to **locate contaminated zones** and **monitor the behaviors of contaminants transport** in the contaminated sites.

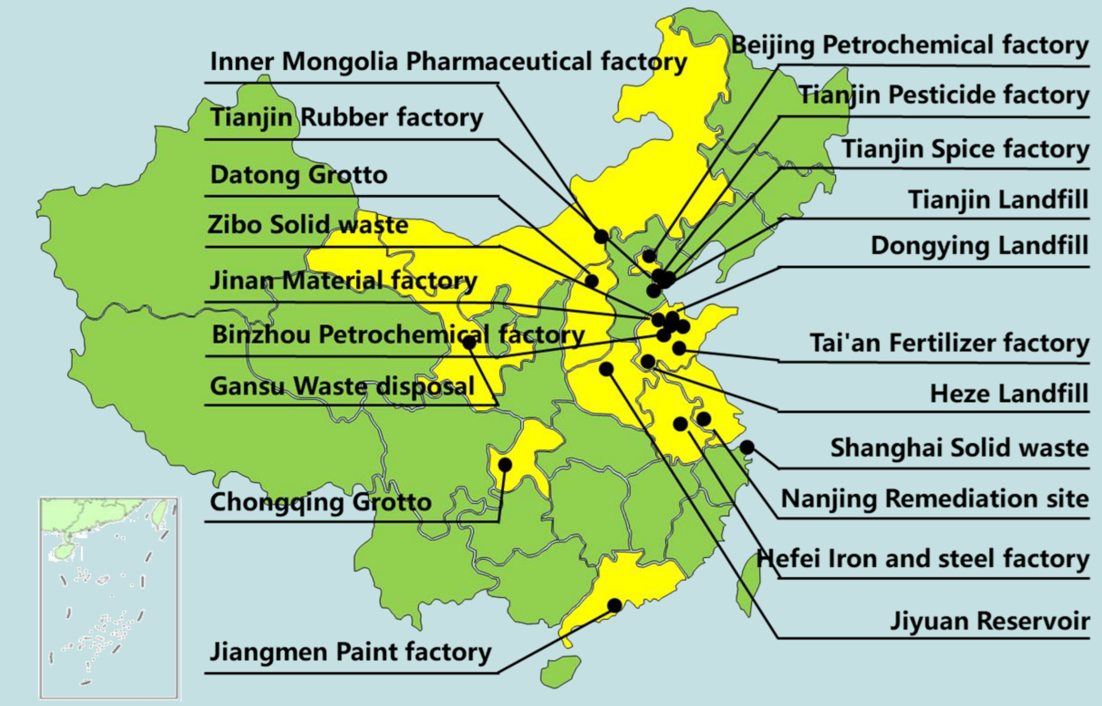






6 Application to field contaminated site

Those methods has been applied to more than **20 sites in 12 provinces** across China, covering **chemical factory**, **landfills, solid waste deposits**, etc., and contaminant types include **organic, inorganic, heavy metal**, and **compound** contaminants.



Conclusion & Outlook

- **Non-invasive geophysical methods** make contamination survey results more **in line with ground truth**, **reducing the uncertainty** of contamination localization.
- IP reflects the characteristics of porous media, sensitive to contaminants in pore scales
- With the **upgrading** of **geophysical instruments** and the improvement of **interpretation technology**, **automatic** geophysical **monitoring** technology will characterize contaminant sites more efficiently.

References

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[2] Xia T, Ma M, Huisman JA, Zheng C, Gao C, Mao D (2023) Monitoring of in-situ chemical oxidation for remediation of diesel-contaminated soil with electrical resistivity tomography, Journal of Contaminant Hydrology, 10.1016/j.jconhyd.2023.104170.

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