CONTAMINANT REDUCTION BY USING NANOSCALE ZERO VALENT IRON (NZVI)

PRINCIPLE

The application of nanoscale zero valent iron (nZVI) is an innovative remediation technology, using the reducing power of elemental iron (Fe0) for the removal of organic and some inorganic contaminants from groundwater and soils.

The reaction of contaminants with nZVI includes either their reduction to harmless final products (e.g. in the case of chlorinated hydrocarbons) or reduction to non-toxic form.

The nZVI has a much higher specific surface and better migration capabilities than the macro/micro-particles of iron, and therefore is more effective in contamination removal.

Nanoiron can be delivered either in the form of a concentrated aqueous suspension (the most common form) or in the form of surface-stabilized nanoparticles, or if necessary as a pyrophoric nZVI nanopowder without surface stabilization. In this case, the nZVI is stored under the inert nitrogen atmosphere (nZVI reacts with air vigorously - it burns).

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DESCRIPTION

After the decision of the nZVI application, preparation works must be done. This involves either building a suitable situated system with application wells (where the suspension can be applied repeatedly) or securing technical background for the direct push application.

The suspension of desired concentration of nZVI (usually grams per litre) is prepared by diluting and mixing of concentrated nZVI suspension (event. nZVI powder with the surface stabilization) directly at the site in a suitable storage tank with deoxygenated pure water.

The suspension is immediately applied into the bedrock. Depending on the specific hydrogeological conditions it can be either a pressure injection (into the cased wells or temporary direct push probes) or the gravitational application (into the cased wells).

TECHNOLOGY APPLICABILITY

Reduction by nZVI is suitable for removing the wide range of organic contaminants, such as chlorinated hydrocarbons, PCBs, nitro derivatives, as well as some heavy metals (e.g. Cr (VI)).

The technology is usually applied in situ, when the suspension of nZVI is infiltrated into the cased wells (can be done repeatedly) or by direct injection (direct-push method).

Main advantages of the technology

- Good migration properties compared to macro/micro - particles of iron
- No formation of toxic products, Fe is a natural component of the environment
- Suitable for source zones of contamination (presence of phase, high content of contaminants)
- Fast kinetics of chemical process
- Easy application
- Relatively low investment costs of a remediation system

Potential limitations

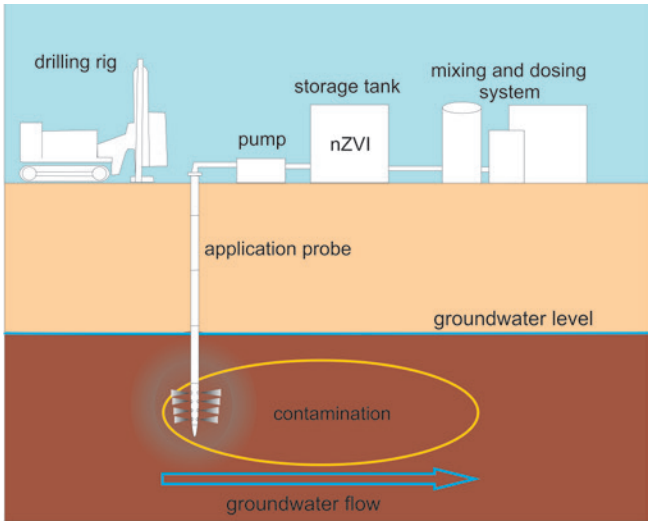
- Poor efficiency on sites with low permeability of the soil environment
- Fast nanoparticle surface oxidation during the preparation/application and subsequent aggregation of nanoparticles in the soil (the possibility to mitigate this phenomenon by using a suitable modification of nZVI)
- In the case of extensive contamination repeated injection is necessary (rebounding effect)
- Relatively high price of nZVI

Services and products

- Investigation and evaluation of the contaminated site
- Design of suitable remediation process
- Technological adjustment for the nZVI application
- Laboratory tests for verifying nZVI effectiveness and evaluation of its application on the site
- Supply service for chosen nZVI reagent
- Monitoring and supervision of the remediation

Data for technology design

- The type, extent and level of contamination
- Required target limits of remediation
- Geological and hydrogeological conditions of the site
- Space limitations on the site (buildings, engineering nets, structures)
- Manufacturing, operational and other limitations resulting from the character of the site
- The required time frame of the remediation



Direct-push application scheme

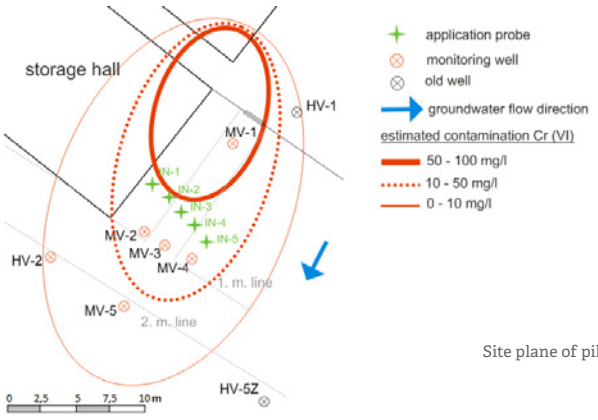
REFERENCE PROJECT

The demonstration project of the application of surface-modified iron nanoparticles into the saturated zone was implemented in the industrial area contaminated by hexavalent chromium. The detected concentration of dissolved Cr (VI) in groundwater reached values up to 60 mg/l; secondary contamination with chlorinated hydrocarbons (mainly TCE) was about 10 mg/l.

Hydrogeological collector was formed by quaternary fluvial sandy gravels (filtration coefficient in the order of 10 4 m/s) with isolating clay layers. The application suspension was prepared from the powder of nZVI with surface stabilization (commercial name NANOFER STAR, manufacturer NANO IRON, CZ). This product is much easier to handle (transport, storage, preparation) in comparison with other forms of nZVI.

The application of prepared suspension was carried out by direct injection through temporary probes (Direct-push method). Immediately after nZVI application the decrease in the concentration of Cr (VI) and ClU to the limit of detection appeared.

Although later on, the „Rebounding effect" appeared (repeated increase in contamination levels due to the release of sorbed contaminants from the soil), the effectiveness of this remediation action was confirmed to be about 90%.



Site plane of pilot test

DEKONTA, a.s.
Dretovice 109, 273 42 Stehelceves
Czech Republic

Phone: + 420 312 292 960 / + 420 235 522 252
Fax: + 420 235 522 254
info@dekonta.cz / www.dekonta.com

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