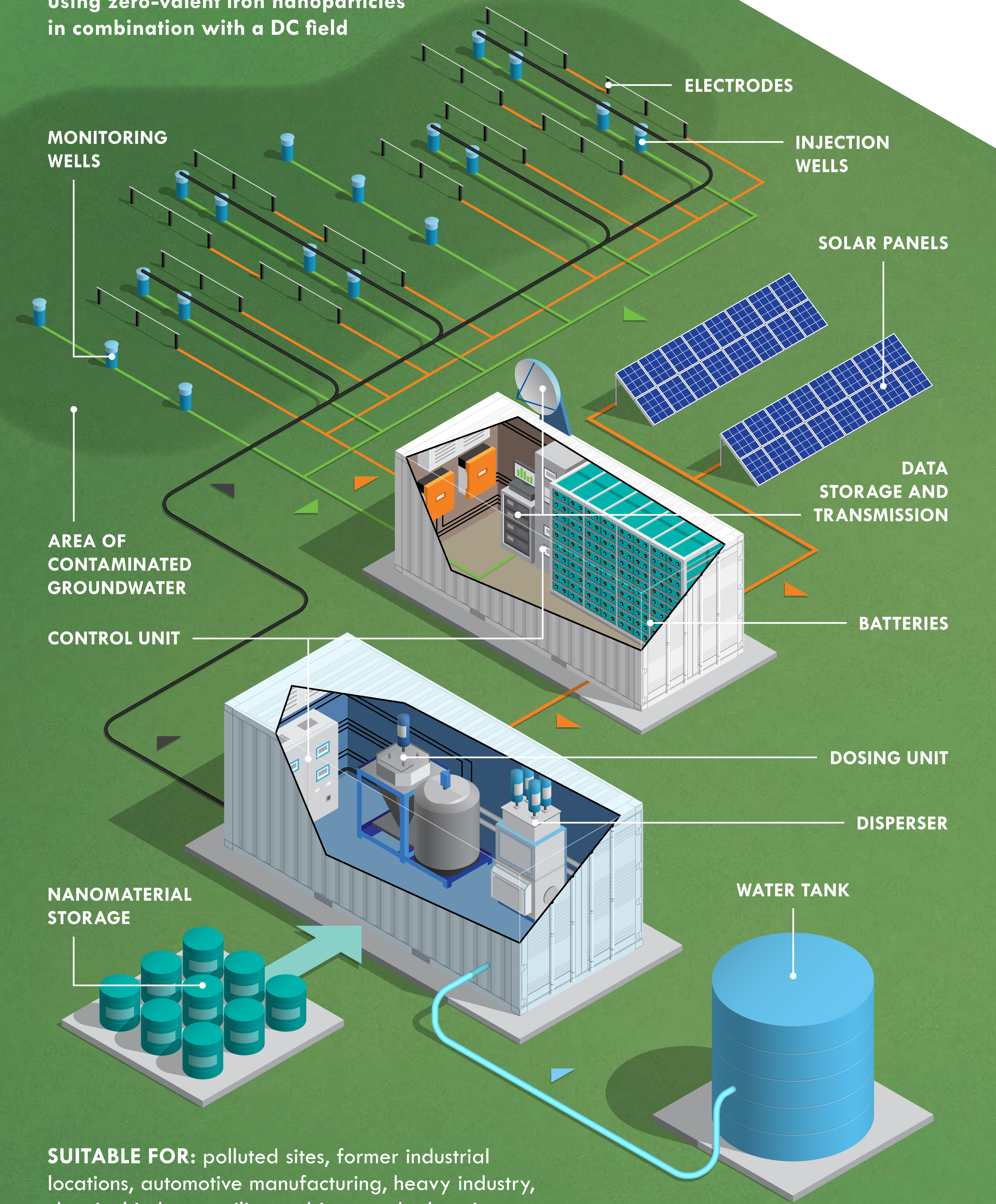
NANOREMEDIATION

In-situ ground water remediation using zero-valent iron nanoparticles in combination with a DC field



SUITABLE FOR: polluted sites, former industrial locations, automotive manufacturing, heavy industry, chemical industry, military objects and other sites

ABOUT NANOREMEDIATION

Nanoremediation relies on the use of zero-valent iron nanoparticles (nZVI) in reducing water contaminants. An additional electric field enhances the transport of nanoparticles in an aquifer environment and improves the remediation performance of nZVI as well as lowering overall costs substantially.

The applied electric field both reduces the adhesion force between nZVI particles and the surfaces of sedimentary rocks and enhances their reactivity and longevity in contaminated groundwater environments.

Large-scale demonstrations at real contaminated sites have confirmed the performance of Nanoremediation, especially in low permeability soils.

At the same time the overall costs are reduced substantially thanks to the transfer for chemical reduction from the cathodes to contaminants through nZVI and then increasing its longevity.

An additional means of reducing costs is the use of less reactive nanocomposite material of zero-valent iron.

Why use nanoremediation?

- **Method proven at multiple sites**
- **No costly specialised instruments needed**
- **Safe both in terms of environmental risk as well as health risks**
- **Advantages over normal nanoiron thanks to use of electric field:**
  - particles are protected from oxidation, leading to higher reactivity and longer lifespan
  - reduces amount of nanoparticles necessary
  - allows for use of DC optimised material: less reactive nanocomposite particles
  - DC field activates iron minerals located in ground matrix
- **DC field also supports the migration of iron particles:**
  - targeted use and migration of materials
  - efficient influence through complete aquifer body
  - fewer injection wells necessary

Economic advantages:

- In-situ technology is financially more competitive than other methods based on pure physical treatment
- Significantly higher effectivity in terms of use of reagents compared to oxidation methods
- Lifespan of reactive material prolonged thanks to DC electric field
- Lower costs thanks to lower amounts of reactive materials needed
- Lower costs thanks to use of optimised nanomaterial

Ecological advantages:

- Environmentally friendly technology: the material is non-toxic and close to naturally existing materials (e.g. magnetite)
- Compared to biotech methods, the use of nanoiron combined with a DC electric field produces a minimal amount of toxic degradation intermediates
- Suitable for locations close to potable water sources
- Small-scale injection wells, no extensive intervention needed
- DC field can be generated using renewable energy sources (e.g. solar energy)

Materials used:

- DC optimised nanocomposite material (depending on specific parameters with or without surface treatment)
- Nanocomposite materials containing ZVI nanoparticles are applied in a suspension depending on contaminants, soil type and type of application
- The nanocomposite is shipped either in a ready-to-use water suspension or in dry powder form, which can be stored indefinitely

Process:

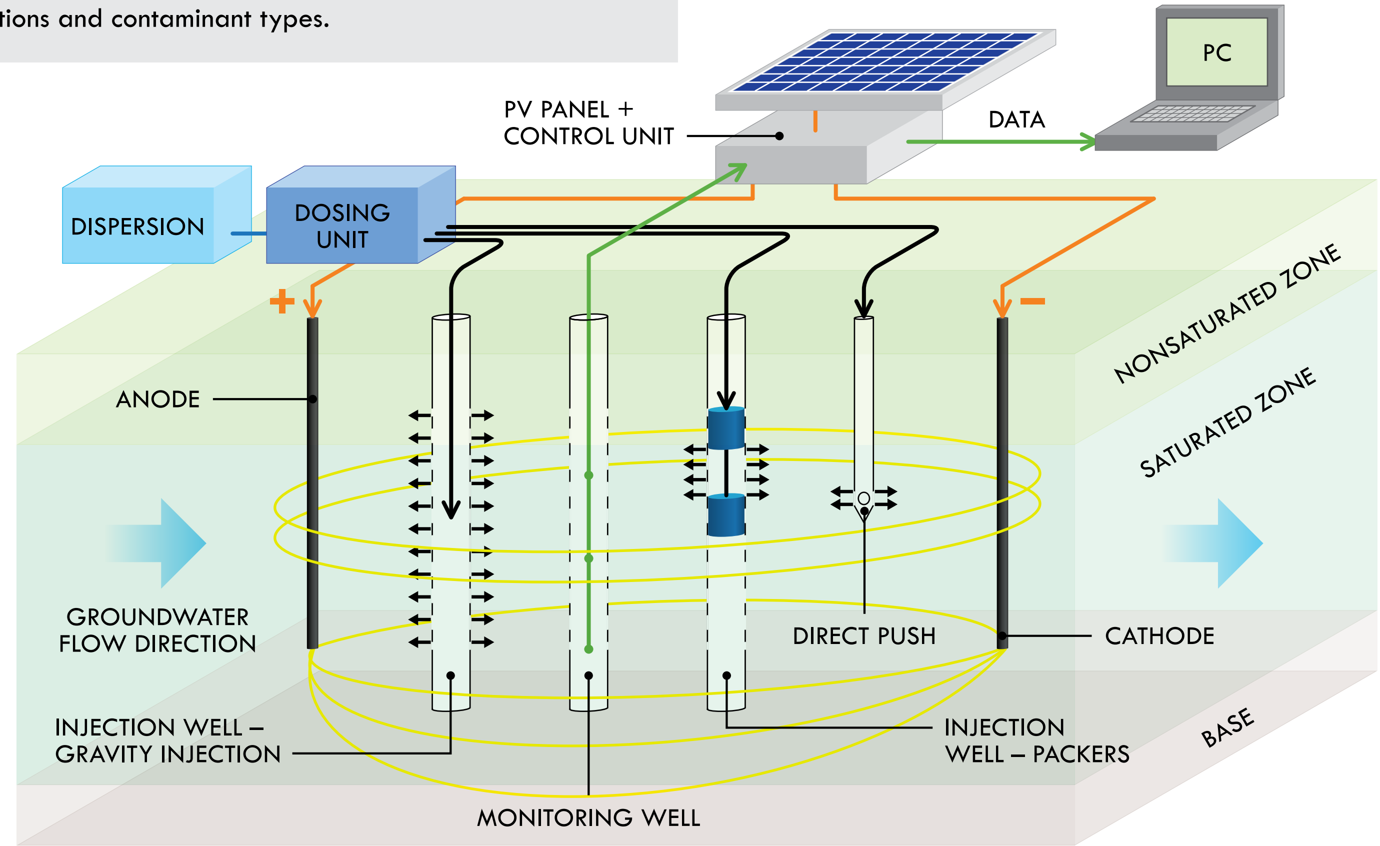
1 Dispersion and dosing

Two forms of nanomaterials are produced and used for site remediation. Nanoiron in powder form is more stable, allowing for long term storage, with the reactive suspension being prepared on site. A stabilised water suspension form of nanoiron is ready to use.

Dosing of nanomaterial is performed using an independent dosing unit and is dependent on local site conditions and contaminant types.

4 Monitoring

An integral part of the solution is the monitoring of the remediation progress, measuring main physical and chemical parameters. In the postmonitoring phase, the outcome of the remediation is confirmed. The remediation process is controlled and remotely optimised using a specially developed information system.



2 Nanomaterial injection

In-situ application of DC optimised nanomaterial is performed in the form of a water suspension applied directly into remediation injection wells or drains. The targeted injection is performed by gravity application, directly to contaminated soil layers using injection packers or direct push technology.

3 DC field system

The purpose of the DC field is to provide targeted application with controlled nanoiron migration through contaminated aquifers. The material is transported under the DC field by flowing water from injection well to the contaminated area where it reacts with the contamination. The power for the system is generated by an autonomous photovoltaic unit.

PHOTON WATER

Contaminants:

GROUP	CONTAMINANT
Chlorinated ethenes	Tetrachloroethene (PCE)
	Trichloroethene (TCE)
	1,2-cis Dichloroethene (c-DCE)
	1,2-trans Dichloroethene (t-DCE)
	1,1-Dichloroethene (DCE)
	Vinylchloride (VC)
Chlorinated ethanes	Hexachloroethane (PCA)
	1,1,1,2-Tetrachloroethane
	1,1,2,2-Tetrachloroethane (TeCA)
	1,1,1-Trichloroethane (1,1,1-TCA)
	1,1,2-Trichloroethane (1,1,2-TCA)
	1,1-Dichloroethane (1,1-DCA)
Chlorinated benzenes	Hexachlorobenzene (HCB)
	Pentachlorobenzene (PeCB)
	Tetrachlorobenzene
	Trichlorobenzene (TCB)
	Dichlorobenzene (DCB)
	Chlorobenzene (MCB)
Trihalomethanes	Bromoform
	Dibromochloromethane
	Dichlorobromomethane
Chlorinated methanes	Tetrachloromethane (Freon 10)
	Chloroform (TCM, Freon 20)
	Dichloromethane (DCM, Freon 30)
	Chloromethane (Freon 40)
Metals, metalloids	Arsenic
	Chromium
	Cadmium
	Copper

GROUP	CONTAMINANT
Metals, metalloids	Nickel
	Lead
	Mercury
	Selenium
	Silver
	Uranium
	Zinc
Organic dyes	Orange II
	Chrysoidine
	Tropaeolin
Other organic pollutants	Polychlorinated biphenyls (PCB)
	Dioxines
	Lindane (HCH)
	Nitrobenzene
	Trinitrotoluene (TNT)
	Trinitroglycerine (TNG)
	Dichlorodiphenyltrichlorethane (DDT)
	n-Nitrosomethylamide (DNMA)
	1,2-Dibromomethane (EDB)
	Trichlorofluoromethane (Freon 11)
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
	1,2-Dichloropropane
	1,2,3-Trichloropropane (TCP)
	2,3,4,5,6-Pentachlorophenole (PCP)
	Molinate (S-Ethyl azepane-1-carbothioate)
Other inorganic pollutants	Nitrates
	Sulphates
	Perchlorates
	Phosphates

Partners:

NANOIRON FUTURE TECHNOLOGY

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