# Permeable zerovalent-iron reactive barrierfor the reclamation of an area contaminated by chlorinated solvents

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The landfill, authorised in 1991 as disposal area for foundry slag, is located in the Dora Riparia Valley, about 10 km West of Torino.

Water monitoring tests carried out by ARPA (regional environmental protection agency) on August 99 detected the contamination of the shallow groundwater, for the presence of chlorinated solvents, and specifically of trichloroethylene.

The contamination was probably originated by drums abandoned at the end of '80s in a depression of the ground, within the disposal area, few ten meters from the river bed. The barrels were then probably damaged, during the earth movement preliminary to the foundry slag disposal.

For the reclamation of the area, on the base of the ascertained pattern of the flow lines, and on the results of comprehensive laboratory tests specifically carried out, the design was prepared detailing type, location, extension, depth and thickness of the permeable barrier.

The permeable reactive barrier, made up of zerovalent iron, is located between the landfill and the river, with an alignment parallel to the river bed, at few meters from the bank.

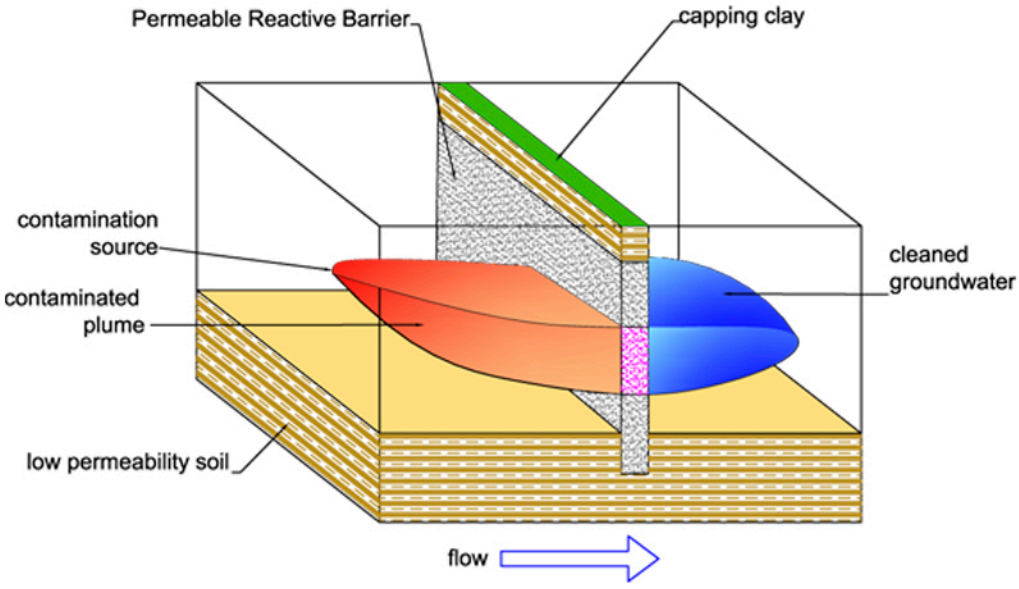
Overall, 1510 m2 of barrier have been constructed, 60 cm thick, with a linear extension of 120 m and an average depth of 13 m.

The trench was excavated within a sandy-gravelly soil, turning to silty-sand at depth, and keyed 1.0 m in the bottom clay.

Into the trench were cast 1700 tons of zerovalent iron; the iron was in particles, with a grain-size in the range 0.2-3.0 mm, absolutely free from oil or other impurities.

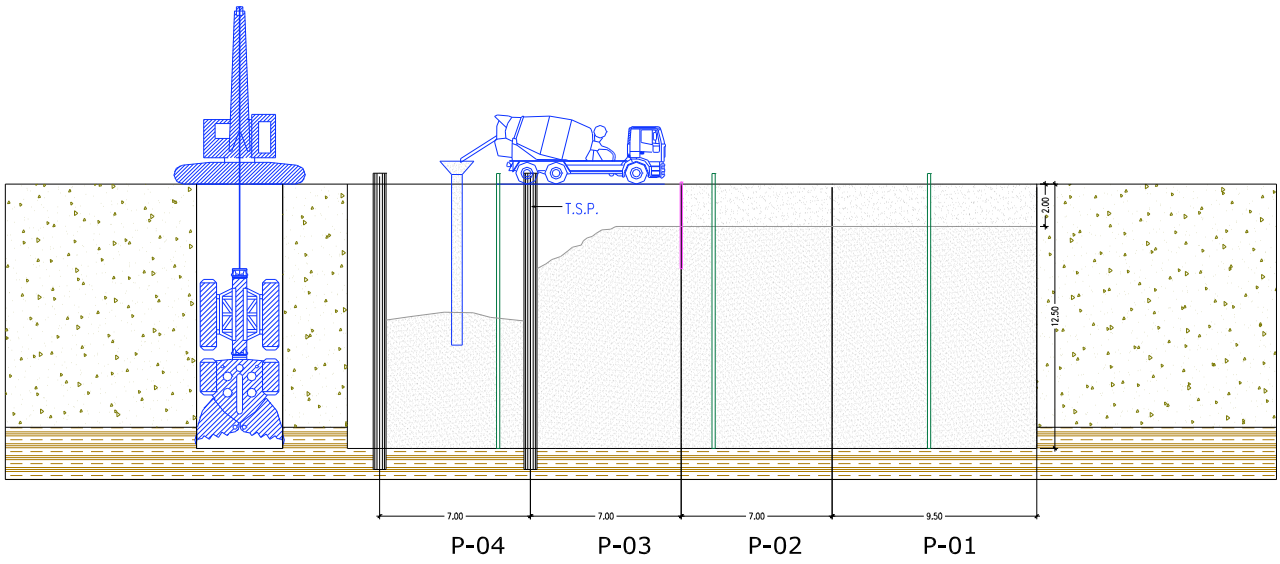
Inside the barrier, five piezometers have been installed, to monitor the chemical and physical groundwater parameters, in order to evaluate the evolution of the barrier performance in the time.

The project, completed in November 2004, represents the first case of permeable reactive barrier, with zerovalent iron, constructed in Italy.

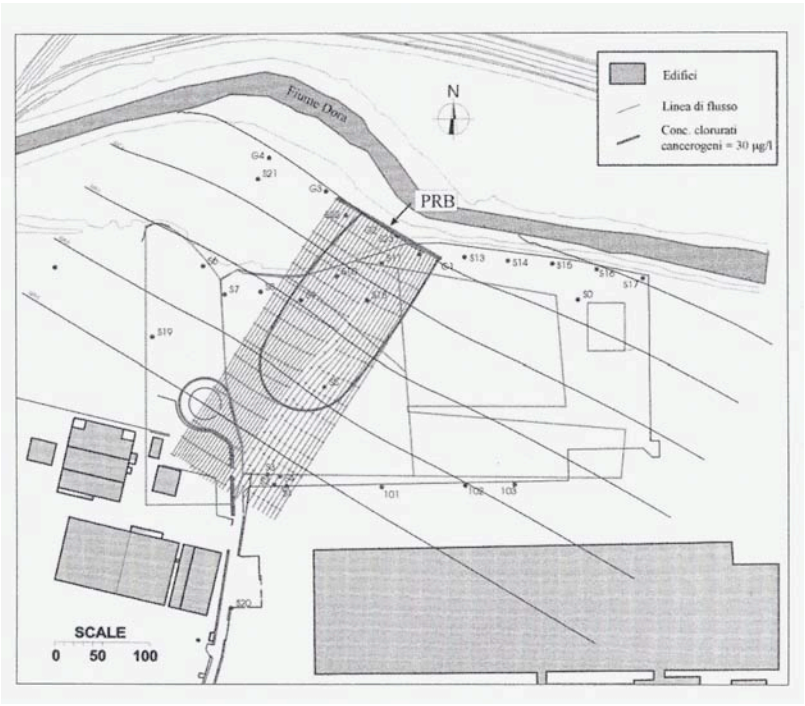



*The principle of the Permeable Reactive Barrier is the interception of the contaminated water flow with a material able to remove, by chemical reaction, precipitation or absorption processes, the contaminants dispersed in the water, in order to avoid their diffusion.*

*The continuous permeable reactive barrier intercepts the groundwater flow without significantly alter the local hydrologic regime. This system is able to prevent the migration of the contaminants beyond the barrier, and allows the reclamation of the aquifer in the time.*




*Construction procedure for a Permeable Reactive Barrier with zerovalent iron*
*The trench is excavated by a rope suspended clamshell, operated by a suitable crawler crane. The trench is excavated to the full depth, using a biodegradable mud, in a sequence of primary and secondary excavation bit.*
*The reactive material is cast in panels (P), having depth and length variable as per the construction design. During the casting activity, each panel is confined at the two ends by TSP (temporary separation pipes), characterised by a shape apt to confine the cast iron from the adjacent excavation. The upper part of the barrier is filled with sand, or other inert material, and capped at the top by clay.*
*At the site subject of the present case history, the barrier was constructed by 17 PRB panels, 7 m long and 13 m deep in average.*




*In the figure, the capture area of the permeable barrier.*

*The flow-net geometry, location and development were studied and defined by a numerical model, to define location and extension of the permeable barrier for the site reclamation (Di Molfetta 2005).*

*Passing through granular zerovalent iron, the chlorinated solvents are decomposed, with a velocity that is function of the iron specific surface. The process that leads to the degradation of the chlorinated hydrocarbons in presence of zerovalent iron is related to a redox reaction that develops at the surface of the metal: when the contaminant pass through the iron grains in the barrier, an electro-chemical process occurs, and the contaminant is decomposed, releasing chlorine.*

*The permeable reactive barrier is almost parallel to the river. To construct the working platform, along the trench to be excavated, boulders were preliminarily removed and two tracks were prepared to bear the weight of the utilised equipment. Guide walls, made of slightly reinforced concrete, were constructed to support the upper portion of soil immediately adjacent to the excavation, to provide a permanent alignment, to drive the grab and to provide a temporary support for casting stand. Furthermore, a reinforced concrete slab was created to allow the installation of silos, mixing plant and other site equipment.*

*The trench, maintained full of biodegradable mud, was excavated continuously. The biodegradable mud, made of water and natural polymers (poly-saccharide), was batched at site using an apposite mixing plant.*

*The excavation depth, defined by the design drawing, was precisely checked by sounding.*

*The trench was backfilled with reactive material up to the max elevation reached by the groundwater table excursion (2 m from working platform). The zerovalent iron was imported from Germany in big bags (2 ton). It is constituted by 0.2-3.0 mm particles, absolutely free from oils or other impurities. At all times during the work activities, great care was paid to avoid/reduce its contact with air, in order to prevent the iron oxidation.*

*The casting was performed by tremie-pipes and truck-mixers. During casting, the iron level was checked and recorded at frequent intervals, by sounding, to control the actual panel volume versus the theoretical volume. On the top of the iron reactive barrier, sand was poured to create a covering stratum up to the working level.*

*At the completion of the casting works, the degradation of the polymeric mud remaining in the trench was accelerated, by circulating specific enzymes through pipes installed in the trench on purpose.*

*Piezometers were installed, in pre-designed position, within the barrier. These piezometers will be utilised to monitor the level of the groundwater table within the barrier and to obtain water-samples for chemical tests, in order to evaluate the behaviour of the contaminant degradation process in the time.*

*At the completion of all the works, on the top of the barrier and in the adjacent area, three clay-strata were placed by rolling, to create a protective capping.*

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