

Nanotechnology – *in situ* remediation in a contaminated area by diesel in the Brazilian legal Amazon

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In situ Chemical Oxidation (ISCO) using Nano technology was applied to decontaminate a site along the railway Estrada de Ferro Carajás – EFC – Legal Amazon, Brazil. The contamination was around a traffic-controlling house due leaks in its generator diesel tanks. In 2013, a diesel free-phase was identified on the groundwater (LNAPL- Light non-aqueous phase liquid) and a “pump and treat” system remediation, installed between 2014 and 2017, was not able to remove completely the contaminant. In 2019, the free phase from 2 up to 9 cm of thickness was detected in some monitoring wells, in addition of a film (or iridescence) identified in some other wells, characterizing the expansion of the contamination. Figure 1 shows the hydrocarbon 36 m² plume having 9 cm of maximum thickness. After the diagnosis, the Nano *in situ* oxidation was applied in order to treat such plume.

GROUNDWATER PLUME MAP - BEFORE FIRST INTERVENTION



Figure 1 Distribution of the LNAPL hydrocarbons in the groundwater, 2019

GROUNDWATER PLUME MAP - AFTER SECOND INTERVENTION

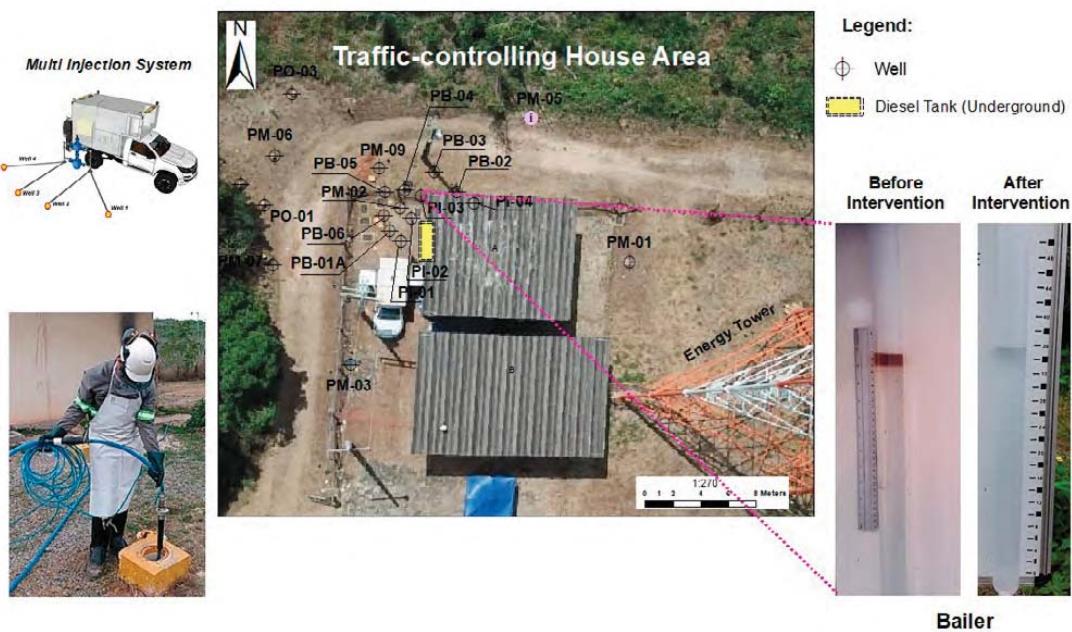


Figure 2 DNAPL completely remediated after the first intervention

Nano *in situ* oxidation – REDEMTIS® – consists of the injection of a Nano fluid – Meta liquid – in order to oxidise the hydrocarbon chain of the pollutants. This fluid is a meta fluid constituted by Nano bubbles or aqueous Nano particles which, besides to be electrically charged, can impress discontinuity to the fluid, generating an exponential increment on its contact surface, allowing an unmatched reaction kinetics and a substantial ($>1/20$) reduction in the amount of reagents (oxidants) if compared to the conventional ISCO.

The REDEMTIS® remediation encompasses the injection of an atomized Nano oxidation solution in a well. The contact of the Nano oxidant with the adsorbed or free phase contaminant, has the ability to break the surface tension by transferring the contaminant mass to the dissolved phase, generating nano oil emulsions, whose, immediately, organic chain is readily broken down into CO₂ and water, without any residue generation. Besides to be environmental sustainable it shows low consume of energy and water, high levels of safety and it is able to provide complete control of the reaction temperature. Such *in situ* nano oxidation is also able to remove not only the free phase of the organic contaminants, but also all the phases, including the dissolved and the adsorbed.

Two intervention period, 7 days each one, were carried on to perform the remediation. Twenty-three wells, 11 m depth, were used in order to inject the Nano oxidant, 19 of them from the pre-existent monitoring net and 4 additional, exclusively drilled for the remediation

After the Nano oxidation, all concentrations remained below the normative values established by Brazilian Environmental Regulatory Agency – Resolution 420/2009 – CONAMA. Nowadays the site monitoring is in progress, on the way to enclose, legally, the remediation process, what is supposed to happen after 2 hydrological cycles.