Thermal treatment : in-situ and ex-situ applications

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Thermal treatment methods for contaminated soil remediation are common practice since the 90th of the last century. Depending on the achieved temperatures, different processes dominated the remediation process for organic contaminants like vaporisation and steam distillation (< 100℃), gasi fication and hydrolysis (> approx. 120℃), steam cracking in the case of benzene deriv atives and linear alkanes (> approx. 180℃), torrefication (in the case of hi gh carbon content) and anaerobic pyrolysis (> approx. 250℃) or aerobic cracking or pyrolysis (> approx. 500℃).

Ex-situ thermal methods are used to treat heavily contaminated soils with complex contaminant cocktails. Contaminated soil is excavated and transported to the treatment plant. Here, soil is selected partwise (e.g. large stones) and homogenised. Depending on the contamination, the temperatures in the oven can be varied and as well organic contaminants with high boiling points like PAH can be treated at high temperatures > 250℃.

To avoid excavation and transport expenditure, in-situ thermal treatment (ISTT) became more popular during the last decade. As subsurface structure is not homogeneous and water saturation or groundwater flux might limit the window for economical applications, the interaction of site-specific dominating in-situ remediation processes can be complex. Based on several research projects, steam-air-injection (TUBA® method), electrical driven thermal wells (THERIS® method), radio frequency heating and resistance heating are the most common heating methods.

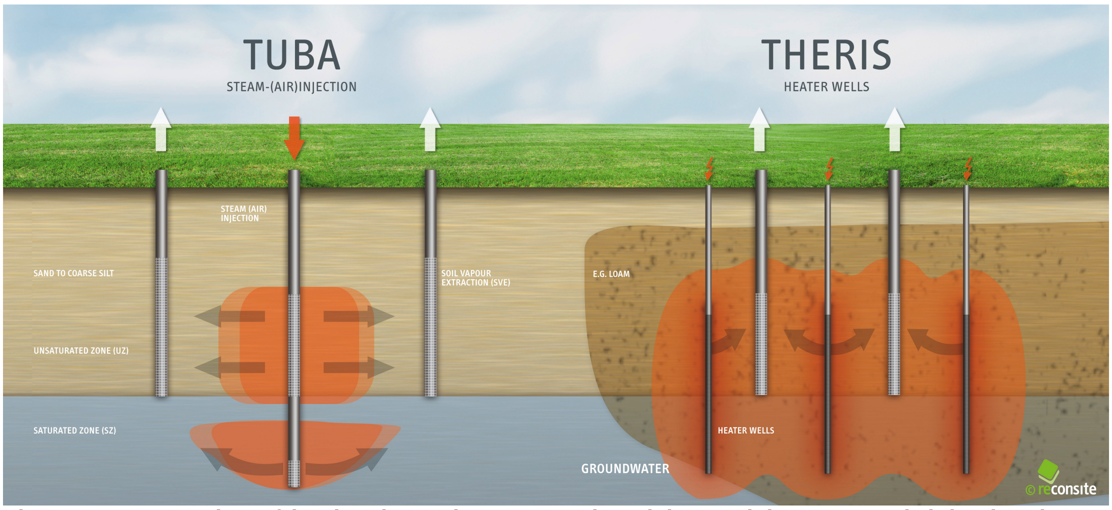

Figure 1.1. Examples of in-situ thermal treatment (ISTT) by applying steam-air-injection (TUBA method) or thermal wells (THERIS method) to remove source zones like CHC or BTEX.

Even the application of the methods can differ due to the site-specific boundary conditions, for the most applications the vaporisation of liquid contaminants by steam distillation is one of the major processes to treat source zones with volatile to semi-volatile organic contaminants like CHC, BTEX. Due to the co-boiling with water, contaminant phase is vaporised below the boiling point of the specific substance. ISTT methods like TUBA and THERIS have shown to be more cost effective and to consume less energy than ‘cold’ soil vapour extraction (SVE) or pump-and-treat (P&T) and are presented by Eurodemo as feature technologies. Major remediation processes, operating windows and fields of application are summarized in the Guidelines for ISTT (Hiester et al., 2012). Within the lecture, additionally a few examples from more than 20 field applications throughout Europe will be presented. The focus will be on more complex sites and technologies like the remediation beneath a building during its continued usage, recovery of explosive compounds or the combination of different thermal in situ remediation methods.

Table 1.1. Fields of application of ISTT (excerpt from Hiester et al., 2012).

Especial field of application		Steam-air-injection (TUBA)	Thermal wells (THERIS)	Radio-frequency-energy (RF)
Unsaturated Zone				
Soil type				
NON-COHESIVE	Gravel	++	○	+
NON-COHESIVE	Sand	++	○	++
NON-COHESIVE	silty sand, sandy silt	+	++	++
COHESIVE	Silt	○	++	++
COHESIVE	loam, marl	-	++	+
COHESIVE	Clay	-	++ to +	+
Contaminants				
CHC		++	++	++
BTEX		++	++	++
Petroleum Range Organics		○	+ to ○	+ to ○
PAH		-	○ to -	○
Saturated Zone				
Soil type				
AQUIFER	Gravel	+ to ○	-	○ to -
AQUIFER	Sand	++	-	○ to -
AQUIFER	silty sand, sandy silt	+	+ to ○	+
AQUITARD	Silt	-	+	++ to +
AQUITARD	loam, marl	-	++ to +	+
AQUITARD	Clay	-	++ to +	+
Contaminant				
CHC		++ to+	++ to +	++ to +
BTEX		++ to +	++ to +	++ to +
Petroleum Range Organics		○	+ to ○	+ to ○
PAH		○	○	○

++ very good + good ○ partly possible / individual examination
- inappropriate boundary conditions due to an economic application. Individual examina. necessary

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