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In-situ remediation of the contaminated soils in Ostrava city (Czech Republic) by steam curing/vapor

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ABSTRACT

This study deals with an application of vapor in the remediation of soils in an extensive part of the Ostrava city center (Czech Republic) needed to be decontaminated from abundant tar (wash oil). The source of contamination was the Karolína Coking Plant (operating between 1842 and 1985), which was situated in the center of the Ostrava City, the largest industrial center of the Czech Republic and former Czechoslovakia. The problem was that a large part of the contaminated ground could not be remediated by extraction and soil treatment, but the area needed to be remediated without disrupting its structure by reason of impossibility of the changes to the important Road of 28 Října and Na Karolíně Street and historical buildings in the city center. The main scientific contribution of this article is to point at a possible application of this unique solution in localities where no soils/rocks can be extracted during remediation. The remediation process in this study was successfully completed and the monitoring results confirmed that the unsuitable conditions were improved. Successful application of the vapor in remediation of contaminated soils in this study may expand new horizons in applications for numerous contaminated city quarters world-wide.

1. Introduction

The conditions of a highly contaminated part of the locality in the vicinity of the Ostrava City center did not allow the soil remediation by extraction of soils because of the possible disruption of other parts of the locality as a bearing capacity failure and settlement of the existing buildings and roads. It was necessary to apply an in-situ method which would permit liquefaction, liberation and thus drawing of the contaminants to be disposed of. This was achieved by applying 180 °C hot vapor by means of horizontal bores. It should be pointed out that this method is crucial for the liberation of the contaminants but does not guarantee their in-situ disposal. This is implemented in the second stage, outside the premises in question and is a principal marginal condition of the application as well as its major advantage.

The study area is found in the properties of a former industrial complex Karolina in the Ostrava City center in the Moravia–Silesian Region in the north-east of the Czech Republic (Figure 1). The Karolina Locality is bordered by the Road of 28 Října in the north, a line of the Ostravice River bank in the east, heap of Žofie steelworks and Na Karolině Street. In the south and west, the border runs along the track of the Czech Railways between the stations of Ostrava – Centre and Ostrava – Main Train Station (Figure 1).

This case study of vapor application for remediation purposes was implemented in relatively complex natural conditions influenced by significant anthropogenic processes in the Ostrava City which can be found in the papers published by Marschalko et al. (2008, 2011, 2012a,b,c,d,e) in detail. All the mentioned studies state prominent anthropogenic impacts which are high above-average compared with other industrial regions in Europe.

In the study area, the volume of tars was calculated as 527 m^3 with 0.30–1.10 m thickness, and ground water contamination by predominant PAHs, phenols, AHs, NES, ammonium ions and CN was documented and measured on circa 6 ha. Besides, the soil air was contaminated by benzene.

The relationships between viscosity and variations in the temperature for remediation purposes have been clearly reported by Nobre and Thomson (1993), Wang et al. (2005), Henry and Smith (2006),

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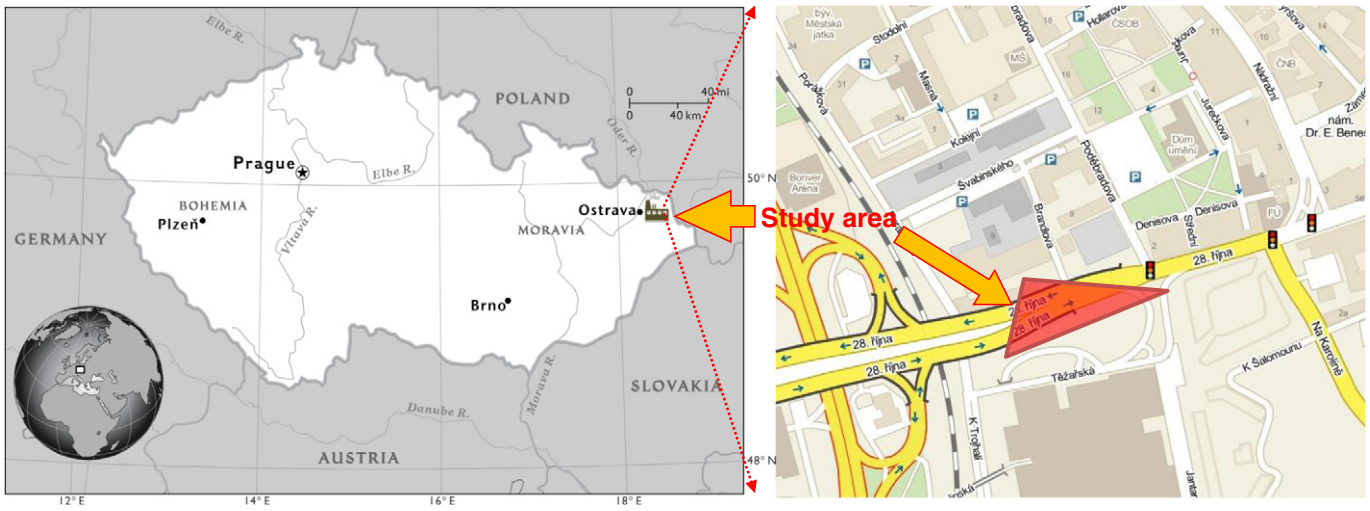

Fig. 1. Location of the study area.

Canizares et al. (2007). All the generally known characteristics of the contaminants point at their changing properties having increased the temperature. The applied method of hot vapor makes use of the above mentioned. This process causes significantly higher solubility. The water solubility in naphthalene is 17 mg/l at 11 °C, 69 mg/l at 45 °C, in benzene it is 1.630 mg/l at 10 °C and 2.500 mg/l at 60 °C. As for volatility, the partial pressure in naphthalene is 0.002 mm at 12 °C, 1 mm at 53 °C, in benzene it is 60 mm at 15 °C and 397 mm at 60 °C. The increased temperature also causes a very high mobility which is used in more efficient extraction of as much as mobile contaminant components. The changes in the contaminant properties are the essential information for the applied vapor method as well as the basic hypothesis of the carried out remediation.

2. Source of contamination

In order to understand the sources of contamination, it is important to learn about the history of the locality, which dates back to 1842 since when the Karolina Locality was used for coking, iron production, chemical production, coal mining and power generation purposes (Figure 2). The coking production was finished in 1985. In the localities near to the study area, there are the premises of Lower Vítkovice, which is among the industrial history candidates for the UNESCO World Heritage List. After 1985, the premises were left unused and decayed to become an old ecological load devaluing the center of the Ostrava City. As the city center is fully built over and used, not many suitable localities were available for the city and investors for further development of public

Fig. 2. Karolina Coking Plant in 1930 (source of contamination).