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Decontamination of a dumpsite of waste from mineral oil refineries in the Czech Republic, locality of Ostrava

Oil lagoons in Ostrava contribute significantly to environmental contamination in the Czech Republic. In the lagoons, liquid and solid waste from a mineral oil refinery was deposited for a long time. In the contribution, the authors are concerned with the description of a procedure for removing the content of the lagoons, remedial measures and use of decontaminated areas.

Keywords: waste from mineral oil, decontaminated area, drainage system, methods to remedy environmental damage

Introduction

There are places that would be best forgotten. Localities that seem to have never existed. These areas are many times referred to as old damage. People put off their preparation and tried not to see, not to handle, to forget. But they remained, the problem did not go away, it only slowly and inevitably grew bigger. Such old damage includes among other places also places located in the Moravian-Silesian Region. In this part of the Region on the cadastral territory of Ostrava-Mariánské Hory and cadastral territory Ostrava-Prívoz, City of Ostrava, District of Ostrava-Mesto there is a waste dumpsite. It is known as a waste disposal site of s.p. DIAMO, from the past better known as so-called Ostramo lagoons in Ostrava (Fig.1).

1. Characteristics of the locality

The waste dump is located within the range of lagoons marked R0. This is the oldest lagoon, in which semi-solid waste was detected under the landfill. It is not separated with an underground supporting wall ("Milan" wall). Lagoons R1, R2, R3 located at with "Milan" underground walls on the perimeter. Their purpose was to isolate the surrounding environment and function as a seal. Insulation function of Milan walls, like other man-made works, is limited in time and therefore requires reconstruction, separation of the lagoon, (Fig.2). The lagoons are located in an industrial zone on the right-bank side of the alluvial plain of the river Odra and border on Mariánskohorská

Fig.1 General view of the locality of Ostramo lagoons in Ostrava

expressway. From the north-west the locality adjoins a shunting yard, from the south-west it borders on a concrete plant and from the south-east it adjoins a construction debris dumpsite. From the north-east the lagoons border on dumpsite water treatment plant of s.p. DIAMO.

The area of this territory spreads over ca 7 ha and it was used to dump waste from a mineral oil refinery. Solid and liquid waste had been deposited there at least since World War II. Lagoons as old damage were selected as a locality requiring implementation of emergency remedial measures. Their purpose was to limit possible spreading of pollution and protect

Fig.2 General layout of the locality Ostramo lagoons in Ostrava

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groundwater. In the past the use of this locality was always a burdening factor to the City of Ostrava and its citizens. [1]

2. Basic problems of the decontaminated area

The lagoons are filled with mostly mushy and liquid stuff containing used mineral oils, acid resins, lyes and sludge, oil sludge and waste whitening limewash. There were also construction waste and dichloroethane with benzene or trichlorethylene and heavy metals like lead. These substances had negative impact on the surroundings mainly by smell, which it gave out at higher temperatures.

The basic problems of solution consist in cleaning the groundwater, cleaning the contaminated soil and removing the contents of the lagoons - acid tars, using remedial measures of the Ostramo Lagoons (NOLO).

3. Water pollution

Hazardous waste dumps represent a permanent risk of pollution of groundwater and surface water. This risk may be called also a possibility of accidental pollution of the neighborhood and surrounding terrains. The character and extent of soil contamination were subject to survey and also sampling. An output monitoring profile was made by the company KAP, spol. s r. o. Infiltration drill holes were used and the samples were further tested to find out the extractability of loose cyanides and to find contaminants in solids. The limiting line for the extent of contamination was supposed to be the outside border of the extent of contamination in the area of interest and it was not established as a line connecting points with established limiting value. Higher contamination was found mostly in soils in the area of trackage. These soils were made of backfill whose thickness was up to 3 meters. Here the contamination came mainly from leaks through the heel of dam in a period before the peripheral cutoff wall was built. Results of laboratory analyses confirmed contamination of soils represented namely by the presence of NEL (non-polar extractable substances). Then contamination with organic substances of the BTEX group was found. This was less significant and represented benzene, toluene, ethylbenzene and xylene. NEL contamination was concentrated over 2 meters under the terrain, mainly on the base of backfill, gravels and diluvial soil. Thanks to the presence of NEL we can representatively establish contamination of groundwater with oil substances. Another contaminant was sulphonic acids in the contents of the lagoons. These were a product of technological processes of acid refining of oils. Contamination with heavy metals was evidenced in the CD trackage.

The origin of contamination is seen also in a period before the peripheral cutoff walls were built, especially in the area by the trackage prevailing along the direction of groundwater flow in a distance of up to 80 meters. It was assumed that it was a stationary contamination, which remained limited to the top of the gravel collector and in the nearest vicinity of the lagoons. Collected groundwater at the position of the landfill had a character of unconnected local aquifers. There is shallow groundwater on top of less permeable diluvial soils. These largely contributed to lateral spreading of contamination, mainly before the peripheral walls were built. A decontamination station was made on the lagoon territory of interest. It was situated on a panel surface inside a fence and constructed in a modular way. Since 2003 its operation was possible thanks to simple and operative possibility of configuration change leading to required functionality and keeping economy operation. This enabled disconnection and gradual replacement of obsolete or malfunctioning technological levels with new ones. It was initially designed for a maximum output of 3 l/s.

3.1 Water treatment methods

Water treatment in this decontamination station was possible using methods of filtration, absorption on activated charcoal, gravitational separation and aeration [2].

A mobile contaminated water treatment plant was successfully used in decontamination of the lagoons. It was built on a panel surface in the south-west part of the lagoons. All pumped groundwater from the drain was drained to that place. A retention tank was also built for sufficient capacity. The retention tank was connected to the station via a delivery main from the pumping station of dumpsite water on the lagoons to the dumpsite water treatment station. Pumping pontoons were used. Water treatment methods used were graded in levels.

The first level represented gravitational separation. Separation of substances with specific weight different from specific weight of water was used, whose concentration reached values of a supersaturated solution, i.e. they make a loose phase. Mostly mechanical impurities were deposited and iron hydroxides were partially removed. Four steel tanks were used. In the loose phase the contaminant can be gradually pumped off the water surface or heavier one from the bottom.

The second level was aeration. A fan of 2.3 kW was used in this method. Water kept flowing to the retention-transfer tank. The exhaust air was further cleaned through sorption filters with activated charcoal in the filling of 300 kg.

The third level included filtration. Mechanical impurities were removed by filtration of water in a sand filter. This method had to be included before absorption in activated charcoal because of protection from unwanted degradation by mechanical impurities and iron deposition. After going through individual levels the water contains remaining dissolved contaminants in low concentrations.

The fourth level included a sorption method using activated charcoal during which two sorption filters, engaged one after the other, were successfully used. It was useful to have a spare filter prepared to replace for example a worn-out one and thus to prevent possible interruption of decontamination work. When using filters for work of the same nature the filters have to be replaced regularly too. The filter medium contained 2,500 kg of activated charcoal. When using similar methods, electrical or mechanical protection is appropriate. It is necessary to train the staff and timely check the functionality of individual elements, namely check the status of filters, connection of parts and possibly arrange for filter replacement.

During the decontamination the retention tank was connected to the station via a delivery main from the pumping station of dumpsite water on the lagoons to the dumpsite water treatment station. It included the use of a thin-wall shell, which was welded of metal plates to form a cylinder. The inner surface of the tank was painted with a coat resistant enough to pumped water. Joints were sealed using flexible sealing cement. The cylindrical retention tank was anchored at the bottom by an anchor strip. It was provided with inspection manholes at the bottom and on the upper part. Overflow piping was built, which led to a protective retention tub. Sludge from the tank was discharged to a retention sump, which was built in the protective tub. It is feasible to insulate the tanks from weather conditions, using for example mineral wool, which was used in thickness of 100 mm. During the operation of the decontamination station, a pumped and separated loose phase of oil substances formed and it was stored in watertight steel barrels and taken to an incineration plant for subsequent liquidation.

3.2 Drainage system

A drainage system for decontamination of the territory, (Fig.3), was built at the lagoons during implementation of emergency remedial measures. This system was efficient and it was necessary during the construction of the drainage rib to comply with safety measures in connection with detected presence of methane [3]. It was necessary to have specialized safety supervisors present and get informed about the methane risk in the given locality. It was necessary to observe and comply with the quality of backfill material used, its compacting during the construction of the rib. Then lowering of groundwater level was monitored during decontamination pumping to prevent movement of contamination further down to less contaminated terrace gravel. Extraction was done in decks (levels) and soil was closely monitored all the time from the contamination point of view. Heavily contaminated soil was separated from less contaminated soil. The process of pumping water from the pit was monitored to prevent spreading of contamination by water. After the backfill of the drainage rib, contaminated soil was extracted from a strip between the rib and the CD trackage. The contaminated soil was accumulated at the decontamination plate for liquidation.

Paved area was built on the land of the area of interest so that the excavation machinery could travel there and this area was also used for disposal and transport of excavated soil and delivery of backfill material for the drainage layer. Traffic in this area had to be one-way only. Before exiting the area of interest it was necessary to make sure that the machinery was clean, or otherwise clean it mechanically. Paved areas were built on a total of 3,600 m^2. Panel access and service roads were built in the area of interest that was to be decontaminated. They are used namely because of good interlocking, possible quick use, good strength and subsequent easy manipulation. Considering

Fig.3 Construction of excavation for a drainage rib supported by sheet pile walls

possible contamination, the panels used in the area were cleaned on the surface and deposited in the area of the lagoon marked R0. The subbase material was extracted and visually checked, eventually tested in a laboratory and based on the outcome it was decided about its further use. When contamination was found the material had to be subsequently taken to an area designated for biodegradation. During decontamination work it was necessary to make sure that the contamination did not leak into the surrounding ecosystems. Clay-cement cutoff walls were used, which were built at the top of dam and were embedded in impermeable clay subsoil. Inside this underground cutoff wall it was necessary to place an above-ground storage tank, which was used when extracting and separating the liquid phase of oil sludge. From the technological point of view the trench was supported with walls of sheet piles to lay the drainage by means of pile ramming and vibrating. Sheet pile elements prepared beforehand were driven to the soil. Through them the strain was transferred to the soil base and earthwork support structures were built. The prepared element was driven to the soil using transfer of energy of a battering ram to the head of the element; it was also possible to drive it in using vibrations and vibration ram. Soil properties are affected in contact with the element driven in by the vibration ram. The sheet pile enters the soil thanks to its own weight and also the weight of the vibration ram. The limiting factor for entry of the element into the soil is resistance at the foot of the element. When working on the rammed structure in the locality it was necessary to make sure that the ground plan is complied with and secure breaking points and height points. Verticality of the structures being built was also constantly checked. If it deviated from the required direction the element would have to be pulled out and driven again into the right position.

Work was performed in six sections, which were prepared beforehand according to work schedule and each was closed by a transverse wall. Maximum level of excavation was always 0.5 meters under then installed level of spreading structure. One spreading structure was installed at one level and subsequently excavation at the lower level was performed. On the other hand the spreading structure was removed, which was done upon completion of backfill up to the next level. By building the sheet pile walls it was possible to build a drain for which a trench was made. Excavation of the trench using earthwork support and levelling of the trench bottom enabled subsequent installation of drainage pipes at two levels. The drainage pipes were subsequently controllably covered with drainage material. The drainage rib was filled with crushed aggregate (gravel) of 32 - 63 mm fraction at two levels of height. Pumping and inspection manholes were built under the protection of walls. Inspection pumping concrete sumps were spaced 60 meters apart and placed in the line of the rib. They were made of pre-fabricated parts equipped with a ladder on the inside. The prefabricated parts were 800 mm in diameter. The height of the tops of sumps had to be aligned with the surrounding terrain and they were covered with steel lids, which were lockable. Larsen-type sheet piles were used in the locality. Pipe spreaders were used for strutting, which through a strap anchor enabled gradual excavation of the trench. Rams were diesel-powered, high-frequency non-resonant and vibration type. High-frequency types are conveniently used namely for redevelopment work in built-up areas.

Within the framework of emergency remedial measures drilling was made by a mobile drilling set to prevent spreading of contamination. The line of monitoring drill holes was located in the trackage. The drilling set was transported to the location by rail. The line was situated in a strip ca 10 meters wide from the axis of adjacent tracks. The set was placed on a belt on which it moved independently. There was a traffic closure during drilling. Thanks to these drill holes of required depth and diameter, groundwater and its chemical composition was monitored. Infiltration drill holes were made, which enabled continuous soaking of decontaminated water back in groundwater. The goal was to minimize the volume of discharged wastewater and to get a chance to gradually flush the center of contamination, first of all on the south-west edge of the lagoons area. The disadvantage included limited functionality of the drill hole, thus the effectiveness and efficiency of the pumping was reduced. Implementation project documentation, prepared by OKD, Doprava, akciová spolecnost, and with the date of trial operation in 2003, was provided for the implementation of emergency remedial measures to prevent spreading of contamination from the waste dump. Within the framework of remedial measures the drainage system was extended along the existing cutoff wall of the lagoons in the north-west direction and subsequently an independent section oriented to the south-west was built. When the rib was being built, pumping and also soaking of decontaminated water was checked and cleanliness of groundwater was monitored. The trench for the construction of the drainage rib was supported on both sides with temporary sheet pile walls, which were embedded in impermeable clay subsoil. Suitable distance between wall axes was 1.6 meters. Excavated soil was gradually removed in order not to interrupt or compromise the work flow. Work was performed in sections, where each had two transverse fronts of sheet piles and thus made an independent closed sump. Ramming of sheet piles was done from the existing terrain without compacting because the terrain had sufficient bearing capacity. Then steel pipe spreaders were used during excavation. They were spread over steel strap anchors of tubular sections. Thanks to this, sufficient stability of the supporting structure was achieved. Excavation was done in sections by individual decks, 0.5 meters under a strap anchor, then the strap anchors and spreaders were installed, which was checked and subsequently spreaders were activated through supporting metal sheets and wedged out. When excavation work was performed for the rib samples of soil were taken and effect on stability of the dam of the waste dump and tracks of the railway siding was monitored. Upon completion of excavation for the rib, sumps were made for pumping and they were provided with immersion pumps to pump water. To clean this pumped water, the pumps were connected to a pipeline leading to the decontamination station. Total distance between the end-points of the contamination drainage after extension and decontamination station was 825 meters. 9 wells were made and immersion pumps of 2 l/s were used and 1 decontamination drill hole. A total of 10 pumping points were suitable.

4. Soil contamination

Priority of the used solution was controlled for prevention of spreading of possible contamination in the direction of groundwater flow. Excavated soil and pumped loose phase of oil substances from the excavation pit created waste, which originated during implementation work when excavating for the drainage rib. Excavated soil was contaminated with hazardous substances and biodegradation ex-situ was used for it. A contamination method of biodegradation technology of TALPA-RPF, s.r.o. was applied upon approval by the State Health Institute in Prague. It was possible to make use of present microflora in the contaminated soil and also implant in that environment other strains with sufficient activity. This biotechnology was applied in a biodegradation area in Dolní Benešov on a dumpsite premises [5].

5. Remedial measures of the Ostramo lagoons

Equipment for remedial measures applied to the Ostramo lagoons (NOLO) was used to process acid tars. The equipment was operated in two stages, on site until a trial operation (fuel mixing) permit was issued and in the newly built area in the lagoon from the date a trial operation permit was issued until the contamination was completed. Waste that was found in the lagoons was classified as hazardous waste. It includes acid tars. A long-rage excavator (CAT 345, CAT 330) was used, equipped with special attachment, for example rake. Pre-processed waste was of loose consistency, it was collected and thus the threat to water or rocks was reduced.

The long-range excavator equipped with special attachment had a maximum working depth of 5 meters. Equipment ALLU PM 500 was used, which was designed particularly for increasing possible bearing capacity of areas that were subsequently used for construction or from the technical point of view. For reinforcement of salinized soil and insulation of contaminated soil, for fixation this equipment was suitably used. Burnt lime (CaO) was gradually dosed and mixed in the contents of the lagoons. Lime container ALLU PF on caterpillar chassis was necessary and also equipment for control and possible monitoring of ALLU DAC data. Then these pre-processed contents of the lagoons were extracted using an assorting shovel ALLU SC, ALLU SM. Further transport was possible by trucks. Extracted liquid phase from the container was lead by gravity drainage through a pipeline to lagoon R3. The outfall of the pipeline in the container was at the bottom level, ca 15 cm. Trapped sediments were taken back to lagoon R2. A separation and catching sump was placed in lagoon R3. Liquid phase from the surface of this lagoon flew in there and the oil and water phases separated. The oil phase was pumped to the above-ground tank and a tank of 30 m^3 was used. This tank was located inside the cutoff wall, which was provided with a lid to prevent the release of emissions into the surroundings. Before adding lime, pumps in individual lagoons were placed on mobile pontoons and suspension gears. This enabled their operative positioning during pumping of the liquid phase. Equipment for processing of acid tars in NOLO was used for activities like extraction and necessary separation of liquid phase of sludge. It was followed by pre-processing of mushy and solid phase of sludge connected with checkup of pre-processed contents of lagoons and subsequent extraction of these contents. The contents of added lime were ca 10%. A pier was used when moving to the lagoons. The piers had to be made in numbers sufficient enough to be in a distance where the machinery spreading lime could reach them. The piers were built thanks to pre-treatment with lime, subsequent compacting and use of separating layers of geotextiles and distributing geo grating in one to two layers. Soil from the area of lagoons could be used for filling. In the process of building such piers, the area of the lagoons got also re-cleaned and homogenized. The pre-processed contents were extracted to trucks using a caterpillar excavator and transported to an interim dumping area, which was first at the lagoon R1, possibly later on the shore and in the extracted areas of R2 and R3 lagoons. Homogenization could be done in two stages and in the course of it the extracted material separated and the inhomogeneous ingredients were sorted out and new fuel was mixed. Thanks to the mixing of pre-processed waste and coarse coal dust (input substances) in required proportion in a mobile mixer, input fuel could be obtained as demanded by end users [6,7].

In waste received we have to observe the weight of:

- pre-processed waste, acid tars treated with lime
- lime applied
- separated waste formed during pre-processing of mushy and solid phase of sludge, extraction of pre-processed contents of the lagoons
- water evaporated during the lime application process (laboratory analyses of acid tars before and after lime application were used).

Conclusions

For the whole time of decontamination work it is very important to comply with safety and health-protection regulations given by the legislation. As it is a location very close to the center of Ostrava, namely dust and smell could deteriorate living conditions for people in nearby housing estates during the decontamination process.

Because of shortage of available land mainly close to the center, the decontamination of contaminated land is highly desirable. Appearance of the city gets improved as well as the environment, and also a locality is created that could be used for various civic activities, development of culture and that could bring employment opportunities.

Successful completion of decontamination work in the given location resulted in improvement and improved quality of the condition and equilibrium in the ecosystem, therefore successful decontamination work is at the end a benefit to the whole neighborhood.

Acknowledgement

The article was prepared thanks to support from the grant project GACR No 105/09/0089.

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Printed by Pradip Kumar Chanda at The Indian Press Pvt. Ltd. 93A Lenin Sarani, Kolkata 700 013 and published by him for Books & Journals Pvt. Ltd. from 6/2 Madan Street, Kolkata 700 072.