Additional Equipment for Soil Biodegradation

Terezie Vondráčková 1, Michal Kraus 1, Jiří Šál 1

1 Institute of Technology and Business in České Budějovice, Okružní 10, 370 01
České Budějovice, Czech Republic

terezie.vondrackova@centrum.cz

Abstract. Intensification of industrial production, increasing citizens' living standards, expanding the consumer assortment mean in the production - consumption cycle a constantly increasing occurrence of waste material, which by its very nature must be considered as a source of useful raw materials in all branches of human activity. In addition to strict legislative requirements, a number of circumstances characterize waste management. It is mainly extensive transport associated with the handling and storage of large volumes of substances with a large assortment of materials (substances of all possible physical and chemical properties) and high demands on reliability and time coordination of follow-up processes. Considerable differences in transport distances, a large number of sources, processors and customers, and not least seasonal fluctuations in waste and strong price pressures cannot be overlooked. This highlights the importance of logistics in waste management. Soils that are contaminated with oil and petroleum products are hazardous industrial waste. Methods of industrial waste disposal are landfilling, biological processes, thermal processes and physical and chemical methods. The paper focuses on the possibilities of degradation of oil pollution, in particular biodegradation by bacteria, which is relatively low-cost among technologies. It is necessary to win the fight with time so that no ground water is contaminated. We have developed two additional devices to help reduce oil accident of smaller ranges. In the case of such an oil accident, it is necessary to carry out the permeability test of contaminated soil in time and, on this basis, to choose the technology appropriate to the accident - either in-situ biodegradation - at the site of the accident, or on-sit - to remove the soil and biodegrade it on the designated deposits. A special injection drill was developed for in-situ biodegradation, tossing and aeration equipment of the extracted soil was developed for on-sit biodegradation.

1. Introduction
The paper deals with the logistic solution of soil decontamination from petroleum products. Oil is a mixture of natural substances that have been produced by physicochemical processes over many millions of years, and its origin is organic, as evidenced by the findings of recent years' research. Currently, world oil reserves are estimated at 1.65 trillion barrels (1 barrel = 0.159 m3). The world is mining and processing about 3 billion tonnes per year (1 tonne of oil is about 6 ÷ 10 barrels). It plays a decisive role in world energy production. In automotive and air transport, petroleum products are an absolutely privileged position that will undoubtedly hold for several more decades. Unfortunately, in all phases of oil contact, starting with exploration wells and ending with the use of petroleum products, gaseous, liquid and, in some cases, solid wastes are formed. Oil wastes cause ground water pollution, soil leakage, eventually surface water pollution, gas and vapour leakage into the atmosphere, atmospheric pollution by flue gases and liquid waste arising from production and use, [1].
Removing the consequences of an accident associated with the release of extraneous substances into the environment is usually a very complex, technically, time and costly process. The problem of leakage of contaminants to the external environment and the elimination of their consequences is a multi-criteria discipline. Leakage occurs when oil is extracted, processed, and during petroleum products usage.

The paper deals with the solution of oil accidents that arise from the use of petroleum products, mainly in the construction industry, automotive and aviation sectors, where oil leaks occur as a result of, for example, leakage of pipelines, collisions of cars and other means of transport, eventually of repair and maintenance of mobile devices. It is always a minor range of an accident, but it should be remembered that every time such oil leak occurs, there is a struggle with time and we must try to prevent the penetration of oil into the ground water. This of course depends on the permeability of the given subsoil, i.e. how fast the leak will continue, [2].

The aim of the paper is to familiarize the professional public with our proposed facilities for the most rapid removal of the oil accident.

2. Subsoil permeability

Subsoil permeability characterizes whether the pumping of petroleum products is physically possible. The outcome of the assessment of the survey of the affected area should be a report of the amount of water the soil can take per unit of time. Permeability is determined on the basis of the absorption test or grain analysis. The permeability of the medium \([\text{m.s}^{-1}]\) expresses the coefficient of filtration \([-]\) - Table 1.

| Earth             | Permeability in m/s | Coefficient of permeability |
|-------------------|---------------------|----------------------------|
| Coarse-grained gravel | 0.1 to 0.005        | 10^{-1} to 5 x 10^{-3}     |
| Fine to medium-grained gravel | 0.03 to 0.0005      | 3 x 10^{-2} to 5 x 10^{-4} |
| Sandy gravel      | 0.01 to 0.0001      | 10^{-2} to 10^{-4}        |
| Coarse-grained sand | 0.004 to 0.0001     | 4 x 10^{-3} to 10^{-4}    |
| Medium grained sand | 0.001 to 0.00006    | 10^{-3} to 6 x 10^{-5}    |
| Fine-grained sand | 0.0004 to 0.000006  | 4 x 10^{-4} to 6 x 10^{-5}|
| Aluminium sand, Sandy clay | 0.000075 to 0.00000005 | 7.5 x 10^{-2} to 5 x 10^{-8} |
| Clay (Earth)      | 0.000005 to 0.0000000001 | 5 x 10^{-9} to 10^{-10} |
| Loam              | 0.0000004 to 0.0000000001 | 4 x 10^{-9} to 10^{-10} |
| Aluminium clay    | 0.00000001 to 0.0000000001 | 10^{-8} to 10^{-10} |

3. Remediation procedures

The right sequence and scope of work must minimize the extent and severity of environmental pollution and typically includes:

- rapid accident analysis, risk identification and quantification, short-term (immediate) action to eliminate the accident,
- quickly eliminate the source of pollution (if it is still active),
- protection of surface and groundwater,
- after accident stabilization, investigation of the extent of contamination, introduction of monitoring of surface and groundwater pollution, detailed analysis of the contaminant,
- designing long-term remediation measures;
- launch of groundwater and soil remediation.

The remediation procedures for soil decontamination can be distinguished according to the basic technical approach to in-situ and ex-situ remediation, i.e. the remediation takes place either at the site of the accident or the soil is removed and the remediation takes place outside the affected area, either in a
given location on a paved substrate or taken to the site for such purposes established (incinerator, landfill, degradative areas). The paper deals with the remediation process of soil biodegradation. Biodegradation is a process of degradation of oil and organic contamination from contaminated surfaces. This process uses natural bacterial strains that allow the natural decomposition of the contaminant. These are special bacteria that are capable of treating undesirable organic compounds as a source of carbon and energy for their growth, [3].

The advantages of biological decontamination processes are that they do not disturb the physical and chemical composition of the soil, but their disadvantage is that they are slow and to a great extent depended on ambient conditions (temperature, humidity, nutrient supply).

3.1. In-situ biodegradation
Biodegradation processes are cheaper than other degradation processes, especially in situ biodegradation. This method is carried out by discharge the bacterial solution into the surface of the places that are polluted with oil, the run with time begins, if bacteria will prevent oil from entering the ground water in time. Because the rate of bacterial infiltration into the soil depends on the amount of leaked oil and soil properties, for bulk soils where oil penetration is faster, it will be more favourable to supply bacteria in a certain depth. This will speed up the breakdown of oil and reduce the risk of penetration into the ground water. That is why we designed a drilling rig, the main part of which is a grouting auger drill which, when blasted into the soil, destroys and dips it, and delivers a mixture of water and bacteria at a certain depth with the hollow shaft. Bacteria can be delivered even when the drill stops. The whole drilling device is designed as a universal group that can be used with multiple types of carriers. According to logistic principles, we prefer a carrier such as the HOLDER C 270 PowerDrive (where they have older vehicle fleet egg PRAGA UV 80 carrier is suitable). These vehicles are versatile for both the terrain and the road for carrying interchangeable working devices (drills) and permanent bodies (the biological solution tank). This carrier complies in all directions with the intention of remediation of contaminated soil according to the logistics aspects.

3.2. On-situ biodegradation
In the on-situ method, the contaminated soil is extracted and treated either in the contaminated site in mobile decontamination units or the extracted soil is weighed for processing in a stable processing enterprise – figure 1. Decontamination can be done using land forming technology, which is the use of the original bacterial cultures in the soil and the optimization of conditions for their activity, or the use of special bacterial strains again, i.e. using special bacterial strains next to the original soil microflora. The digested soil is maintained in a moist state by sprinkling and the supply of air oxygen required for bacterial activity is ensured by hacking, loosening and tossing the material on the biodegradation surface using appropriate mechanization. Aeration intervals depend on the rate of oxygen consumption by bacteria. We have also developed an additional device for this method to allow soil spreading and aeration, [4].

4. Results and discussions
It is necessary to assess individual options according to the logistics aspects in order to prepare and dispose of the contaminated environment, remediation facilities, workers and decontaminated soil in the required quantity and quality on a designated place at a specified time (in order to avoid pollution of the ground water) at optimal prices, without further pollution of the environment. This is also the case with the two above-mentioned biodegradation equipment for oil products. Immediate measures to prevent the spread of environmental pollution by oil are usually critical to the success of the disaster disposal. Timeliness and speed of action is a key factor in crash elimination management.
References

[1] V. Voštová, V. Altman, J. Fries and K. Jeřábek, “Logistics of waste management,” Monograph CTU Prague, 2009, 350 p., 2009.

[2] V. Voštová and J. Fries, “Processing of solid waste,” CTU Prague, 2005, 157 p., 2005.

[3] T. Vondráčková, J. Míkyška and V. Voštová, “Machines maintenance in making and control of building work”. Technical Diagnostics, vol. XXIII, number. 1, pp. 43, 2014.

[4] V. Voštová and T. Vondráčková, “The influence of the building industry, building machinery, and modern methods of management of building machinery on the environment,” Proceedings of the 4th Int. Conference TECHSTA 2007, pp. 43-47, 2007.