ACCELERATED PHYSICAL RIPENING OF PAH AND OIL CONTAMINATED SEDIMENT TO DISTINGUISH CRITICAL STEPS IN REMEDIATION

Johan Vermeulen[1], Suzanne van Dijk[1], Tim Grotenhuis[1], Jan Joziasse[2], Wim Rulkens[1]

[1]Sub-department of Environmental Technology, Wageningen University (WU)
P.O. Box 8129, 6700 EV Wageningen, The Netherlands
[2]Dutch Organisation for Applied Scientific Research (TNO)
Apeldoorn, The Netherlands

Key words: diffusion, disposal sites, dredged material, microbial activity, mineral oil, PAH (polycyclic aromatic hydrocarbons), remediation, sediments, soil

1 Processes in a temporary disposal site

Most dredging activity in the Netherlands takes place in the western parts of the country where clayey sediment is predominant. Much of this sediment is polluted with PAH and mineral oil which are biodegradable under aerobic conditions. When clayey dredged sediments are brought into a temporary disposal site, ripening starts, which irreversably converts sediments into soil.

Ripening of sediments consists of physical, chemical, and biological processes. The physical part of ripening consists of dehydration and shrinkage, increase of permeability, change from a soft consistency to friable or hard, and subsidence of the surface of the sediment, resulting in the formation of soil prisms separated by shrinkage cracks. Continuing water loss causes a breaking up of the prisms into blocks. The aggregates produced by this ongoing desiccation process usually remain quite large (> 50 mm). The stage of physical ripening can be described with a quantitative ripening index (Pons and Van der Molen 1973). This n-value is a measure of the waterbinding capacity of the material at a certain ripening stage and is therefore closely related to the total porosity of the material. Aggregates formed by desiccation can be further broken down by applying mechanical stresses, externally by tillage, internally by weathering processes (wetting and drying) or by a combination of the two (Dexter 1988).

Intensive landfarming can change a 1 meter thick layer of dredgings into an oxygenated soil within one summer (Harmsen et al. 1998), thus creating favourable conditions for PAH and oil degradation. However, within this layer anoxic sites are likely to occur, depending on the level of aggregation of the dewatered dredgings.

2 Accelerated physical ripening

To our knowledge the extend of anoxic microsites in dredgings at a certain ripening stage has not yet been studied. Because we assume that oxygenation of anoxic microsites is a critical step in remediation of PAH and oil contaminated dredgings during temporary disposal, a laboratory method was developed to study this step. To accelerate physical ripening at well-defined conditions, freshly dredged material was brought onto fine porous plates of sintered glass (P 1.6) and subjected to an external gas pressure (100-1000 mbar N_2) in specially designed pressure cells, hereafter referred to as micro-depots (Fig. 1).

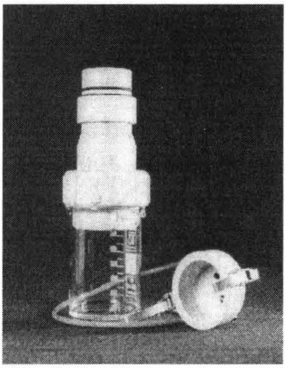

Fig. 1. Picture of a micro-depot

Below the plate water is discharged into a beaker at atmospheric pressure. This simulation of physical ripening results in circular synthetic aggregates with a controlled porosity and n-value, hereafter referred to as pellets (diameter ≈ 50 mm, height ≈ 10 mm). Their size was chosen in the order of the size of the aggregates that remain after natural desiccation. Physical ripening is realised in the micro-depots within one week, which is fast compared to physical ripening under field conditions.

Microelectrodes as described by Van Gemerden (1989) were used to measure oxygen profiles in the pellets. Within 1 day equilibrium was reached between the rates of oxygen diffusion into the pellets and oxygen consumption in the pellets. Oxygen penetrated about 5 mm into pellets with microbial activity. Control pellets deactivated with NaN_3 were fully oxygenated within this day. The measurements indicate that the high oxygen consumption rate within the pellets is the main cause for the anoxic microsites and not the low oxygen diffusion rate. Therefore, we conclude that critical steps in remediation can be studied very well in pellets of dredged material after accelerated physical ripening in a micro-depot.

References

Dexter, A.R. (1988) Advances in characterization of soil structure. Soil and Tillage Research 11: 199-238

Gemerden, H. van, C.S. Tughan, R. de Wit, Herbert, R.A. (1989) Laminated microbial ecosystems on sheltered beaches in Scapa Flow, Orkney Islands. FEMS Microbiology Ecology 62: 87-102

Harmsen, J. (1998) Natural biological treatment of polluted sediments. Contaminated Soil '98. In: Proceedings of the Sixth International FZK/TNO Conference on Contaminated Soil, 17-21 May 1998, Edinburgh, UK. pp. 805-806

Pons, L.J., van der Molen, W.H. (1973) Soil genesis under dewatering regimes during 1000 years of polder development. Soil Science 116: 228-235