RDP – A New On-site Soil Remediation Method

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BACKGROUND

Ranator AB, an environmental chemistry research and development company, has recently developed a new on-site soil remediation method, referred to as RDP (Ranator Detoxification Process), in collaboration with the Wallenberg Laboratory at the University of Stockholm and with support from the Swedish Environmental Protection Agency (SNV).

In 1994 a RDP pilot plant (50–100 kg/hour production scale) was developed and successfully tested on soil samples contaminated with creosote and polychlorinated biphenyls (PCB). A full scale RDP pilot plant, completed in May 1995, was also successfully tested in June – July 1995 (2 ton/hour production scale) on creosote contaminated soil from Stockholm City. Industrial soil remediation operations are planned to commence in late 1995. The project is carried out in collaboration with the construction and real estate company Skanska AB and the waste management company Ragn-Sells AB.

PRINCIPLES OF RDP

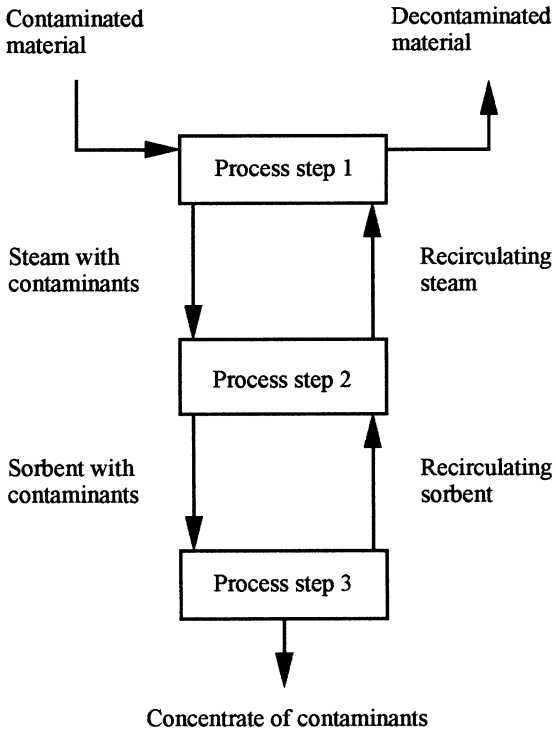
RDP is designed for efficient decontamination of soil, sediments, sludge, etc. with regard to lipophilic and water insoluble chemical substances such as PCB, creosote, chlorinated phenols, dioxins or other persistent environmentally hazardous substances, and oil and other petroleum products.

RDP is a mobile, non-destructive process. The chemical substances, here referred to as contaminants, are separated from the material as a concentrate for external treatment, e.g. by high temperature incineration.

The RDP process is carried out by three consecutive low temperature process steps, executed at atmospheric pressure. Each step takes advantage of the special physical and chemical properties of the contaminants in the material. The contaminants are transferred in a stepwise manner, while gradually being concentrated, from the material to steam in the first process step, from the steam to a special chemical agent in the second step and finally, in the third process step, from the chemical agent into a concentrate.

No condensation of the steam is required. After removal of the contaminants from the steam by the chemical agent, the steam is recirculated to the first process step. After removal of the contaminants from the chemical agent into a concentrate, the chemical agent is recirculated to the second process step. These three basic RDP process steps are schematically illustrated in Figure 1.

Figure 1. The basic three process steps of the Ranator Detoxification Process, RDP



Process step one. Separation of the contaminants from the material

The first process step is based on the principle of codistillation with water. In order to make this possible the contaminants should, as noted earlier, be lipophilic and water insoluble. In addition, the contaminants should have measurable and thus usable vapour pressures in the process. The chemical substances mentioned above meet these requirements and therefore, despite their relatively high molecular weight and boiling point, are suitable for water codistillation.

The first process step is carried out as follows. The contaminated material is heated (continuously or batchwise) and treated with steam. During this treatment, the contaminants are removed from the material by codistillation. Due to the water codistillation efficiency, the process steam temperature is relatively low. The process steam temperature depends on the material type, composition, grain size, and the type of contaminant or contaminant group present in the material. In 'normal' treatments, the steam temperature ranges between 150^{o}C and 250^{o}C, but in extreme cases it may be as high as 300^{o}C.

Fine grained, clayey materials are treated as a slurry while coarse material is treated in a dry state. During the treatment the contaminants are codistilled from the material, whereby the low molecular weight and low boiling contaminants are removed first, followed by the heavier components. When the contaminant concentration, i.e. the total concentration of the remaining high molecular contaminants, is reduced to a preselected level, the process step is completed.

Process step two. Transfer of the contaminants from the steam to sorbents

In the second step the contaminants are transferred directly from the steam to a special chemical agent. The steam is then returned to the first process.

The steam, containing the gaseous contaminants in the first process step, is brought into contact with a special chemical agent, referred to as a sorbent, which takes up the contaminants directly from the steam. This is the second process step. Thus, the contaminants are removed from the steam, without a conventional steam condensation step, and is recirculated in a closed circuit to the first process step.

The sorbent is one of a series of water undistillable solid or liquid polymers, selected on the basis of its capability to take up the individual or type groups of gaseous contaminants directly from the steam, or structurally designed in order to obtain such unique properties.

Process step three. Separation of the contaminants into a concentrate

In the third step the contaminants are isolated from the sorbent as a concentrate. The sorbent is then returned to the second process.

The sorbent is regenerated when a sufficient amount of contaminants has been taken up from the steam. This is done in a third separation process step, by conventional solvent extraction or by thermal desorption. The separation method used depends on the type of sorbent selected for process step two. When solvent extraction is preferred, the solvent is separated (in an additional fourth process such as conventional distillation and condensation) from the contaminants and recirculated to the third process step in a closed circuit. The contaminants remain as a concentrate due to their solubility in the solvent.

Environmental impact

RDP produces decontaminated material and concentrates of contaminants only. The chemicals involved, such as the sorbents etc., most of which are non-toxic, are used and recirculated within closed circuits within the process system. Due to the low process temperature and the closed process system, there is no secondary formation of other toxic chemical substances, nor any release of exhaust gas or hazardous chemical substances to the environment during the process. This makes RDP a 'clean' soil remediation method.

Degree and rate of decontamination

The degree of contaminant removal from soil can be regulated during the RDP process step one treatment and thus reach as close to 100% as is required. The decontamination rate depends on the composition of the material, mainly the content of organic components, and the contaminant type, property and concentration.

In a series of RDP pilot plant tests, initial concentrations of PCB and creosote, ranging between 1000 and 5000 ppm in soil from different contaminated industrial sites, were reduced to required final levels, in some cases 10 ppm, in others 1 ppm. Tests on PCP (pentachlorphenol) contaminated soil, as well as on soil containing up to 25 000 ppm creosote gave similar results.

RDP cost of operation

An industrial RDP plant is mobile and modular in design in order to facilitate the transport and set up of the plant at the contaminated site for on-site soil remediation. When the material is decontaminated, it can be returned directly to the excavation site after treatment. Thus, no extensive and expensive material transportation is required. Only the isolated contaminant concentrate, a minute fraction of the material volume, may be transported to the site of treatment or disposal.

The RDP cost of operation depends largely on the rate and extent of the decontamination required as noted above. From a theoretical point of view the RDP is a very complex process but its practical application is relatively simple, which, in combination with the continuously recirculated, non-condensing process steam makes RDP very cost efficient. The project results also strongly indicate that RDP may indeed be a low cost and thus highly competitive soil remediation method.