

Environmental remediation

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Generally, remediation means providing a remedy, so environmental **remediation** deals with the removal of pollution or contaminants from environmental media such as soil, groundwater, sediment, or surface water for the general protection of human health and the environment or from a brownfield site intended for redevelopment. Remediation is generally subject to an array of regulatory requirements, and also can be based on assessments of human health and ecological risks where no legislated standards exist or where standards are advisory.



Sustainable development Portal

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Remediation standards

In the USA the most comprehensive set of Preliminary Remediation Goals (PRGs) is from the Environmental Protection Agency (EPA) Region 9. A set of standards used in Europe exists and is often called the Dutch standards. The European Union (EU) is rapidly moving towards Europe-wide standards, although most of the industrialised nations in Europe have their own standards at present. In Canada, most standards for remediation are set by the provinces individually, but the Canadian Council of Ministers of the Environment provides guidance at a federal level in the form of the *Canadian Environmental Quality Guidelines* and the *Canada-Wide Standards/Canada-Wide Standard for Petroleum Hydrocarbons in Soil*.

Site assessment

Once a site is suspected of being contaminated there is a need to assess the contamination. Often the assessment begins with preparation of a Phase I Environmental Site Assessment. The historical use of the site and the materials used and produced on site will guide the assessment strategy and type of sampling and chemical analysis to be done. Often nearby sites owned by the same company or which are nearby and have been reclaimed, levelled or filled are also contaminated even where the current land use seems innocuous. For example, a car park may have been levelled by using contaminated waste in the fill. Also

important is to consider off site contamination of nearby sites often through decades of emissions to soil, groundwater, and air. Ceiling dust, topsoil, surface and groundwater of nearby properties should also be tested, both before and after any remediation. This is a controversial step as:

1. No one wants to have to pay for the clean up of the site;
2. If nearby properties are found to be contaminated it may have to be noted on their property title, potentially affecting the value;
3. No one wants to pay for the cost of assessment.

Often corporations

which do voluntary testing of their sites are protected from the reports to environmental agencies becoming public under Freedom of Information Acts, however a "Freedom of Information" inquiry will often produce other documents that are not protected or will produce references to the reports.

Funding remediation

In the US there has been a mechanism for taxing polluting industries to form a Superfund to remediate abandoned sites, or to litigate to force corporations to remediate their contaminated sites. Other countries have other mechanisms and commonly sites are rezoned to "higher" uses such as high density housing, to give the land a higher value so that after deducting clean up costs there is still an incentive for a developer to purchase the land, clean it up, redevelop it and sell it on, often as apartments (home units).

Remediation technologies

Remediation technologies are many and varied but can be categorised into ex-situ and in-situ methods. Ex-situ methods involve excavation of impacted soils and subsequent treatment at the surface, In-situ methods seek to treat the contamination without removing the soils.

The more traditional remediation approach (used almost exclusively on contaminated sites from the 1970s to the 1990s) consists primarily of soil excavation and disposal to landfill "dig and dump" and groundwater "pump and treat".

Excavation or dredging

Excavation processes can be as simple as hauling the contaminated soil to a regulated landfill, but can also involve aerating the excavated material in the case of volatile organic compounds (VOCs). If the contamination affects a river or bay bottom, then dredging of bay mud or other silty clays containing contaminants may be conducted.

SEAR - surfactant enhanced aquifer remediation

Also know as Solubilization and recovery, the *Surfactant Enhanced Aquifer Remediation* process involves the injection of hydrocarbon mitigation agents or specialty surfactants into the subsurface to enhance desorption and recovery of bound up otherwise recalcitrant non aqueous phase liquid (NAPL).

In geologic formations that allow delivery of hydrocarbon mitigation agents or specialty surfactants, this approach provides a cost effective and permanent solution to sites that have been previously unsuccessful utilizing other remedial approaches. This technology is also successful when utilized as the initial step in a multi faceted remedial approach utilizing SEAR then In situ Oxidation, bioremediation enhancement or soil vapor extraction (SVE).

Pump and treat

Pump and treat involves pumping out contaminated groundwater with the use of a submersible or vacuum pump, and allowing the extracted groundwater to be purified by slowly proceeding through a series of vessels that contain materials designed to adsorb the contaminants from the groundwater. For petroleum-contaminated sites this material is usually activated carbon in granular form. Chemical reagents such as flocculants and sand filters may also be used to decrease the contamination of groundwater. Air stripping is a method that can be effective for volatile pollutants such as BTEX compounds in gasoline.

Depending on geology

and soil type, pump and treat may be a good method to quickly reduce high concentrations of pollutants. It is more difficult to reach sufficiently low concentrations to satisfy remediation standards, due to the equilibrium of absorption/desorption processes in the soil.

In situ oxidation

New in situ oxidation

technologies have become popular, for remediation of a wide range of soil and groundwater contaminants. Remediation by chemical oxidation involves the injection of strong oxidants such as hydrogen peroxide, ozone gas, potassium permanganate or persulfates.

Oxygen

gas or ambient air can also be injected as a more mild approach. One disadvantage of this approach is the possibility of less contaminant destruction by natural attenuation if the bacteria which normally live in the soil prefer a reducing environment. The injection of gases into the groundwater may also cause contamination to spread faster than normal depending on the site's hydrogeology.

Soil vapor extraction

Soil vapor extraction

(SVE) is an effective remediation technology for soil. "Multi Phase Extraction" (MPE) is also an effective remediation technology when soil and groundwater are to be remediated coincidentally. SVE and MPE utilize different technologies to treat the off-gas volatile organic compounds (VOCs) generated after vacuum removal of air and vapors (and VOCs) from the subsurface and include granular activated carbon (most commonly used historically), thermal and/or catalytic oxidation and vapor condensation. Generally, carbon is used for low (<500ppmV) VOC concentration vapor streams, oxidation is used for moderate (up to 4,000 ppmV) VOC concentration streams, and vapor condensation is used for high (>4,000 ppmV) VOC concentration vapor streams. Below is a brief summary of each technology.

1. Granular Activated Carbon (GAC) is used as a filter for air or water. Commonly used to filter tap water in household sinks. GAC is a highly porous adsorbent material, produced by heating organic matter, such as coal, wood and coconut shell, in the absence of air, which is then crushed into granules. Activated carbon is positively charged and therefore able to remove negative ions from the water such as organic ions, ozone, chlorine, fluorides and dissolved organic solutes by absorption onto the activated carbon. The activated carbon must be replaced periodically as it may become saturated and unable to absorb (i.e. reduced absorption efficiency with loading). Activated carbon is not effective in removing heavy metals.

2. Thermal oxidation (or incineration) can also be an effective remediation technology. This approach is somewhat controversial because of the risks of dioxins released in the atmosphere through the exhaust gases or effluent off-gas. Controlled, high temperature incineration with filtering of exhaust gases however should not pose any risks. Two different technologies can be employed to oxidize the contaminants of an extracted vapor stream. The selection of either thermal or catalytic depends on the type and concentration in parts per million by volume of constituent in the vapor stream. Thermal oxidation is more useful for higher concentration (~4,000 ppmV) influent vapor streams (which require less natural gas usage) than catalytic oxidation at ~2,000 ppmV.

1. Thermal oxidation which uses a system that acts as a furnace and maintains temperatures ranging from 1350°F to 1500°F (730°C-815°C).
2. Catalytic oxidation which uses a catalyst on a support to facilitate a lower temperature oxidation. This system usually maintains temperatures ranging from 600°F to 800°F (315°C-430°C).

3. Vapor condensation

is the most effective off-gas treatment technology for high (>4,000 ppmV) VOC concentration vapor streams. The process involves cryogenically cooling the vapor stream to below 40 degrees C such that the VOCs condensate out of the vapor stream and into liquid form where it is collected in steel containers. The liquid form of the VOCs is referred to as dense non-aqueous phase liquids (DNAPL) when the source of the liquid consists predominantly of solvents or light non-aqueous phase liquids (LNAPL) when the source of the liquid consists predominantly of petroleum or fuel products. This recovered chemical can then be reused or recycled in a more environmentally sustainable or green manner than the alternatives described above. This

technology is also known as cryogenic cooling and compression (C3-Technology).

Other technologies

The treatment of environmental problems through biological means is known as *bioremediation* and the specific use of plants for example by using phytoremediation. Bioremediation is sometimes used in conjunction with a pump and treat system. In bioremediation, either naturally occurring or specially bred bacteria are used to consume contaminants from extracted groundwater. This is sometimes referred to as a bio-gac system. Many times the groundwater is recycled to allow for continuously flowing water and enhanced bacteria population growth. Occasionally the bacteria can build up to such a point that they can affect filtration and pumping. The vessel should then be partially drained. Care must be taken to ensure that a sharp change in the groundwater chemistry does not kill the bacteria (such as a sudden change in pH).

Dual-phase extraction utilizes a soil vapor extraction system that produces a high vacuum resulting in the extraction of both contaminated vapors as well as a limited amount of contaminated groundwater. This method is somewhat inefficient due to large amount of energy required by pulling water by vacuum compared to pushing water with a submersible pump.

Community consultation and information

In preparation for any significant remediation there should be extensive community consultation. The proponent should both present information to and seek information from the community. The proponent needs to learn about "sensitive" (future) uses like childcare, schools, hospitals, and playgrounds as well as community concerns and interests information. Consultation should be open, on a group basis so that each member of the community is informed about issues they may not have individually thought about. An independent chairperson acceptable to both the proponent and the community should be engaged (at proponent expense if a fee is required). Minutes of meetings including questions asked and the answers to them and copies of presentations by the proponent should be available both on the internet and at a local library (even a school library) or community centre.

Incremental health risk

Incremental Health Risk is the increased risk that a receptor (normally a human being living nearby) will face from (the lack of) a remediation project. The use of incremental health risk is based on carcinogenic and other (e.g., mutagenic, teratogenic) effects and often involves value judgements about the acceptable projected rate of increase in cancer. In some jurisdictions this is 1 in 1,000,000 but in other jurisdictions the acceptable projected rate of increase is 1 in 100,000. A relatively small incremental health risk from a single project is not of much comfort if the area already has a relatively high health risk from other operations like incinerators or other emissions, or if other projects exist at the same time causing a greater cumulative risk or an unacceptably high total risk. An analogy often used by remediators is to compare the risk of the remediation on nearby residents to the risks of death through car accidents or tobacco smoking.

Emissions standards

Standards are set for the levels of dust, noise, odour, emissions to air and groundwater, and discharge to sewers or waterways of all chemicals of concern or chemicals likely to be produced during the remediation by processing of the contaminants. These are compared against both natural background levels in the area and standards for areas zoned as nearby areas are zoned and against standards used in other recent remediations. Just because the emission is emanating from an area zoned industrial does not mean that in a nearby residential area there should be permitted any exceedances of the appropriate residential standards.

Monitoring for compliance against each standards is critical to ensure that exceedances are detected and reported both to authorities and the local community.

Enforcement is necessary to ensure that continued or significant breaches result in fines or even a jail sentence for the polluter.

Penalties must be significant as otherwise fines are treated as a normal expense of doing business. Compliance must be cheaper than to have continuous breaches.

Transport and emergency safety assessment

Assessment should be made of the risks of operations, transporting contaminated material, disposal of waste which may be contaminated including workers' clothes, and a formal emergency response plan should be developed. Every worker and visitor entering the site should have a safety induction personalised to their involvement with the site.

Impacts of funding remediation

The rezoning is often resisted by local communities and local government because of the adverse impacts on the local amenity of the remediation and the new development. The main impacts during remediation are noise, dust, odour and incremental health risk. Then there is the noise, dust and traffic of developments. Then there is the impact on local traffic, schools, playing fields, and other public facilities of the often vastly increased local population.

Example of a major remediation project

Homebush Bay, New South Wales, Australia has been the subject of a controversial remediation project.[1] (<http://rhodesnsw.org>)

In this case the proposed rezoning, remediation and redevelopment has a wealth of material available through the internet from <http://rhodesnsw.org>:

1. Numerous investigations and reports by Australian and International consultants
2. For the former Union Carbide site, a previous remediation by excavation and containment in a clay capped sarcophagus, separated from the Bay by a bentonite wall.
3. A Parliamentary Inquiry by the Upper House of the Parliament of New South Wales, a state of Australia;
4. Two Commissions of Inquiry, one for each of the major dioxin contaminated sites, both contaminated by the operations of Union Carbide;
5. Resolutions by the relevant local government bodies (originally Concord council and after the Municipality of Concord was merged with Drummoyne Council to form the City of Canada Bay, by that Council);
6. Campaigns by local residents' groups, Greenpeace Australia, Nature Conservation Council of NSW, and Inner West (of Sydney branch of the) Greens
7. published submissions by Planning NSW and Environmental Protection Agency of NSW;
8. Comprehensive Environmental Impact studies published in digital format and available on CD from Planning NSW.

This rezoning, remediation and redevelopment of land contaminated by Union Carbide, ICI and others also involves the remediation of a strip of dioxin contaminated sediments in Homebush Bay, New South Wales. The Homebush Bay area was home to the main events of the Sydney 2000 Summer Olympics. The soil contamination was addressed in the Commission of Inquiry into the Lednez site formerly owned by Union Carbide, but not to the satisfaction of local community activists.

The remediation of Homebush Bay is important because of its impact on the food chain which extends through benthos not only to local protected and threatened species of birds, but also to JAMBA and CAMBA protected species and species which use other Ramsar-protected wetlands. Ultimately human health is impacted through the food chain. Homebush Bay has a complete fishing ban, there is a commercial fin fishing ban west of the Gladesville Bridge, and based on submissions of the remediator and NSW Waterways and EPA the complete fishing ban ought be extended to the whole of the Parramatta River west of Homebush Bay and at least as far East as the Ryde Traffic Bridge.

See also

General links

- Biodegradation
- Degradation
- Environmental restoration
- Natural attenuation
- Mold Remediation

- Phase I Environmental Site Assessment
- Phytoremediation
- Soil contamination
- In Situ Oxidation

Legislation about remediation

- Superfund (United States)
- Contaminated Land Management Act (New South Wales, Australia)
- *Contaminated Sites Act 2003* (Western Australia, Australia)
- 'Wet Bodembescherming' (*Soil Protection Act*, Netherlands)
- 'Wet Verontreiniging Oppervlaktewater' (*Surfacewater Pollution Act*, Netherlands)
- 'Environmental Management Act' ([Canada])

Environmental groups with information

- CHEJ (US - Grew out of Love Canal controversy)
- Greenpeace (International organisation with National sites)

Environmental protection agencies

- United States Environmental Protection Agency
- NSW EPA (NSW, Australia)
- Environment Canada
- Canadian EPA Summary Table

External links

- U.S. EPA's clean-up information web site, primarily devoted to remediation technologies (<http://www.clu-in.org>)
- U.S. EPA's database of innovative remediation and characterization technologies (<http://www.epareachit.org/>)
- U.S. EPA's Brownfields (<http://www.epa.gov/brownfields>)
- U.S. EPA's Superfund (<http://www.epa.gov/superfund>)
- USGS (<http://toxics.usgs.gov/index.html>)
- Odours In Remediation (<http://odour.au.com>)

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Categories: Pollution | Soil contamination

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