The ‘HCH in EU’ project: part 2
Conceptual Site Models (CSM), environmental and health risks of HCH-contaminated sites

Introduction

In the previous article we introduced the legacy of former pesticide and anti-parasitic drug Lindane (gamma-hexachlorocyclohexane or γ-HCH) in Europe. This time we will provide background information on how to understand HCH-contaminated sites and the related potential environmental and health risks.

What is a Conceptual Site Model?

A conceptual site model (CSM) helps in understanding and identifying potential environmental and health risks. A CSM is a representation of a site that describes the distribution, release mechanisms, exposure pathways and migration routes and potential receptors of contaminants of concern. This is usually visualized by organizing and presenting data in such a way that it is easy to understand (Figure 1).

The first step in creating a CSM is to gather general and site-specific information during a preliminary investigation. Topics of interest when constructing a CSM, in our case HCH-impacted sites, include:

- Site use history;
- Geology and hydrology of the site and surrounding area;
- Soil type, structure and heterogeneity;
- Contaminant types and properties – in this case, HCH and its isomers;
- Contaminant situation: load, location, state and extent of the HCH-contaminant situation;
- Fate, transport and migration of HCH contamination;
- Geochemistry and redox conditions;
- Natural attenuation potential (the natural process of transforming contaminants to less harmful forms or immobilizing contaminants).

Building a CSM involves different experts and disciplines, such as soil scientists, hydrologists, toxicologists, and remediation engineers. With regard to environmental and health risks, important aspects of a CSM are the source(s) of contamination, the source receptor pathway(s) and the receptor(s).

A CSM is built in various stages, with the first stage being an Initial CSM (ICSM) made with the information available. The second stage is the update of the Initial CSM to an updated CSM. This is based on a gap analysis of the ICSM and the data collection and interpretation for bridging the gaps. This results in an updated CSM. The update / completion of a CSM is often a process of various cycles, especially when it involves a complex site.

An updated CSM must provide at least enough information to assess ecological and human health risks and migration risks of the contaminants. A completed CSM also provides all information necessary for designing the risk reduction measures.

Thus, with respect to environmental and health risks, the CSM is a tool that sets the basis for understanding the source, different pathways and receptors of contaminants, and facilitates further investigation and remediation assessments. The CSM also assists in supporting decision-making and reduces uncertainty in managing.

Environmental risk of HCH

The production of Lindane generated larger volumes of waste, including the inactive isomers and liquid production waste (chlorinated solvents). For a long time, the environmental impact of dumping this HCH waste was grossly underestimated (Figure 2).

Figure 2: Soil horizon with a white layer of dumped HCH material (Photo by B.H.F. Boudewijn)

Moreover, properties of certain HCH isomers, including Lindane, have been shown to have a water solubility and volatility that is higher than other pesticides. In addition, HCH, like other chlorinated pesticides, is easily soluble in non-polar substances (such as fat). All these factors must be considered when constructing the CSM and assessing the risk.

A phenomenon that needs to be incorporated in the CSM, when present, is waste with chlorinated solvents that sink down towards and in the groundwater and form a sunken liquid layer, also referred to as dense non-aqueous phase liquid layers (DNAPL; Figure 1) at the bottom of an aquifer. Recent studies have shown that this phenomenon occurs frequently under HCH landfills sites. So far, very little

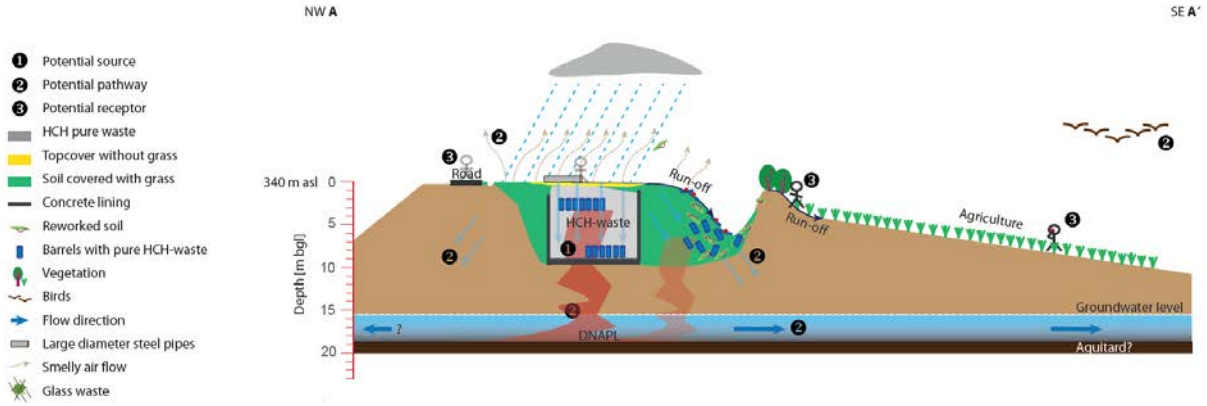

Figure 1: Example of graphical designs belonging to the ICSM of HCH-Lindane contaminated site (Source: TAUW)

attention has been paid to this. The EU Life Surfing Project[1] is one of the first projects to address this issue.

The properties described above facilitate the spread of HCH contamination. Lindane migrates in the environment and accumulates at the top of the food chain and, like other Persistent Organic Pollutants (POPs), has been found in the Arctic.[2] Exposure to high levels of HCH can result in dizziness, skin irritation, hallucinations, diarrhea, convulsions and even death.[3] Furthermore, Lindane and other HCH isomers are carcinogenic and mutagenic.[4]

Health risk of HCH

In order to outline a potential health risk for humans we need to understand the four routes of exposure: (1) inhalation, (2) dermal contact, (3) direct and (4) indirect ingestion. The first route involves the inhalation of contaminated fine soil particles that float in the air as a result of, for example, earthmoving in HCH-contaminated soil. The second exposure route involves direct skin contact with Lindane(-based pesticides). The third route is direct ingestion and is most common for small children (0-4 years) due to their 'hand-mouth' behavior. The fourth and most important route of exposure is indirect ingestion, the consumption of contaminated animal products and crops, produced on HCH-contaminated soil.

An example of indirect ingestion concerns the story of farmer Herman Peterman from Weerselo in the Netherlands. In the late 1970s, his cows became inexplicably sick. Family members also developed health problems. Only later was it discovered that the pastures where these cows had grazed were seriously contaminated with HCH. Research showed that the CH percentages in the fat of these cows were 4 to 16 times higher than allowed.[5]

The 'HCH in EU' project

The objectives of the 'HCH in EU' project are to obtain a detailed picture of Lindane and HCH-production sites, waste deposits, landfills and treatment centers in all EU member states and to help the authorities deal with the legacy of these POPs. Identifying all possible HCH-contaminated sites, environmental and health risks is the first step in gaining sustainable control of HCH-contaminated sites.

More information about the project

In the following article (part 3) in this series on HCH, we will dive into more of the projects on HCH-contaminated sites. For more information and the milestones in the 'HCH in EU'- project, please visit the project page on our website.

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[1] http://www.lifesurfing.eu/en/life-surfing-project/

[2] USEPA, (2006), Lindane and Other HCH Isomers--EPA Risk Assessment Fact Sheet, https://archive.epa.gov/pesticides/reregistration/web/html/lindane_isomers_fs.html

[3] CEC, (2013) Commission for Environmental Cooperation. North American Regional Action Plan on Lindane and Other Hexachlorocyclohexane Isomers. Final Evaluation Report. http://www.cec.org/pubs_docs/documents/index.cfm?varlan=english&ID=1821 http://www3.cec.org/islandora/en/item/11389-north-american-regional-action-plan-lindane-and-other-hexachlorocyclohexane-isomers-final

[4] IARC, (2016). Carcinogenicity of lindane, DDT, and 2,4-dichlorophenoxyacetic acid. Volume 113 of the IARC Monographs. http://monographs.iarc.fr/ENG/Monographs/vol113/index.php

[5] Boerderij boer Peterman wordt na tien jaar strijd nu toch geveild. Trouw, 19-03-1992, https://www.trouw.nl/nieuws/boerderij-boer-peterman-wordt-na-tien-jaar-strijd-nu-toch-geveild~be745682/