HCH-polluted soils in highly populated areas in "O Porriño" (Galicia, Northwest Spain)

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Background

In 1939 a leading chemical company (ZELTIA) set up a phytosanitary plant in the residential area of Torneiros situated in the town of Porriño, in the SW of Galicia (NW Spain).

Figure 1. Galicia location

Figure 2. Torneiros location

During the aftermath of the civil war, faced with scarce resources, closed commercial frontiers and a series of poor harvests, it was considered that the way forward could be achieved by improving agricultural production together with the certainty of obtaining a quick profit by supplying badly needed agrochemical products practically without any competition. And so in the early 40's the production of phytosanitary products began followed by DDT in 1942 and other pesticides containing organochlorine compounds, such as lindane (gamma-HCH) from which further pesticides for household use were produced (such as ZZ).

Later, in the 50's and the first half of 60's, pesticides containing lindane (gamma-HCH) were manufactured here, by using benzene and chlorine as raw materials.

In addition to gamma-HCH, other isomers without practical application were obtained. These by-products were considered as waste and a total of approximately 1,000 tonnes was dumped near the factory.

The lindane production was stopped in the mid 60`s but the closure and sale of the original company producing lindane and the creation of new companies stemming from the parent company hampered the task of defining the contaminated area and one can only assume a process of dispersal of the waste throughout the area.

The waste was probably moved from its original dumping site in order to create room for expansion for the new factories and carried out without security measures to prevent the dispersal of its pollutants. It is very likely that PV-1 was one of the areas were the waste was taken and mixed with other materials and used as filling for the subsequent urban development. The rest of the waste served a similar purpose in other building sites around the area. This has lead to the spread of the contamination over an area of nearly 1 km^2.

When the Galician Autonomous Government was alerted about this chemical waste problem, they studied the ways to determine the extent of the problem and its possible solution and in 1998 this investigation began. The preliminary studies concluded that the main zone of HCH-polluted soil was assumed to be located in an area of 136,000 m^2 (PV-1 zone) of which about 41,000 m^2 were the result of anthropogenic land refilling. The whole site is highly populated and includes recreational facilities.

Location of contamination

An investigation consisting of 41 rotary drillings confirmed the existence of dispersed pollution, especially in the areas as a result from anthropogenic activity. Values up to 1,000 mg/kg were detected, with a decreasing rate down to 6 meters below ground level (Figures 3-4).

Thereafter, in order to determine the exact extent of the contaminated area, other neighbourhoods were investigated (specially sensitive areas, such as cycle track, schools and residential areas). High levels of surface pollution were detected at the cycle track, no pollution was found in the educational centre areas, whereas on residential sites polluted areas were detected corresponding to unused soils during the construction works.

At the same time, analysis of different water samples were carried out from wells and springs and also from piezometers installed during the investigation. Concentrations of HCH-isomers, over 1 ppb (sometimes over 50 ppb) were detected, which indicated the existence of different sources of pollution, both inside and outside the investigated area.

Figure 3. Soil isolines with concentrations of HCH>2mg/kg

The results obtained, made it necessary to carry out new investigations, in order to define the vertical and horizontal extent of the contamination and to make a medical analysis of the inhabitants. A strategy based on a step-by-step investigation away from the area with the main contamination source was adopted. In the first stage (40,000 m^2, zone PV-4), only low concentrations of the investigated soil contaminants (except, one plot of land, with superficial filling) were detected. Nevertheless, the groundwater was polluted and therefore a further step was necessary.

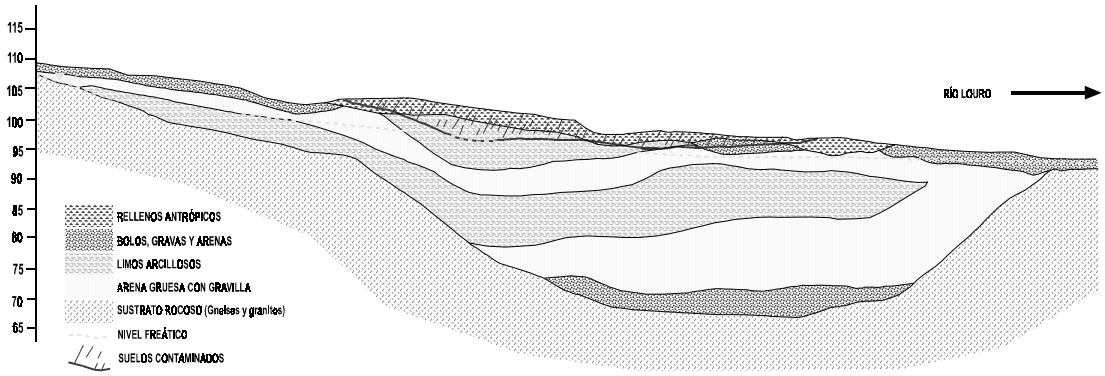

Figure 4. Geological profile and contaminated soils

In the second step, an area of 140,000 m^2 (called PV-3) was studied. Except for one point, with a high concentration of HCH-isomers (affected by changes in the groundwater table), high levels of pollutants did not affect any points, inside this area. An industrial source, located in this area, might be the origin of these high levels.

At this point we also detected high levels of pollutants, associated with surfaces altered by anthropogenic landfills (Figure 5). Groundwater was particularly affected with concentrations of HCH-isomers in the order of hundreds of ppb (Figure 6). The water used in this industrial site also presents a certain degree of pollution, so new sources of pollution should be identified which was included with the main aims of the present investigations.

Medical tests made on the residents, only detected low levels of β-HCH-isomer (the most persistent). The intake of this pollutant, through the usual pathways has occurred for many years, but did not cause any personal damage.

Concurrent with this investigation, the hydrogeology of this area has also being assessed in more detail, revealing the existence of an aquifer of complicated behaviour due to the following causes:

- Continuous recharge due to frequents rains.
- Layers of materials of different permeability sitting on an altered granite layer.
- Discharge towards several superficial watercourses.

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Figure 5. Results of the step-by-step investigation

Conclusions

The results of the investigation have given clear evidence of the lindane waste pollution in soil and its spread to groundwater. The waste in soil is dispersed over a highly populated area and this is due to its use as filling material at different locations, over a period of 40 years. The health of the residents does not appear to have been affected by this dumping.

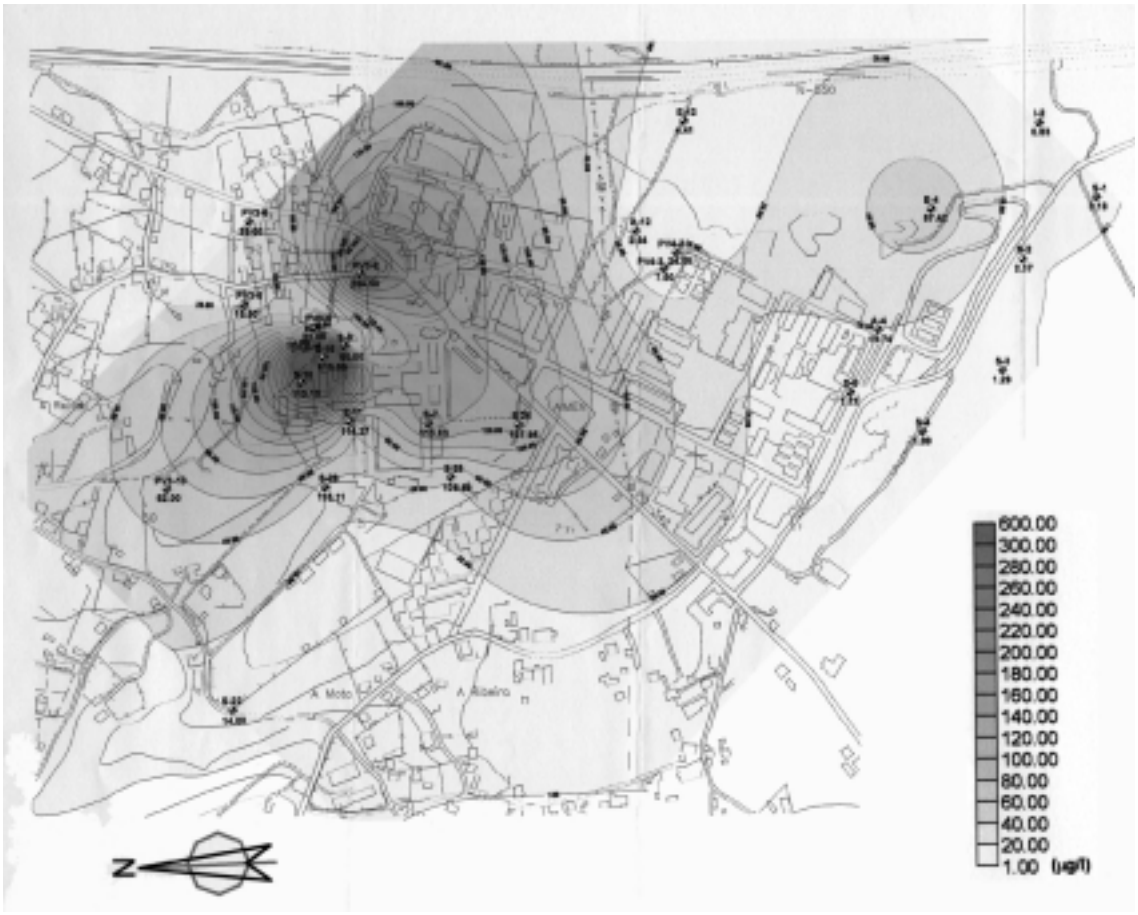

Figure 6. HCH distribution in groundwater

Actions taken

We must distinguish between two types of actions:

- actions taken in order to limit human health risk
- actions for the containment and remediation of contaminants.

Among the most urgent actions was the fencing of the fields with a concentration of 2 ppm or higher of HCH-contamination, the closure of the wells in the area and the restriction on agricultural use of the fields.

It should be noted that the Xunta de Galicia has passed a law, which established that soils with a HCH-concentration higher than 2 ppm should be declared contaminated independent of their use.

The use of off-site techniques for the remediation and/or encapsulation, in the first area investigated, was too expensive in the given circumstances (dispersion of contaminants in large quantities of soil). Besides, the possible dispersion caused by the movement of soil would increase the health risk for the population. This situation and the knowledge of the behaviour of groundwater pollution recommended the encapsulation of the principal source, with vertical panels of bentonite-cement, 30 m maximum depth (to embed them into the granite mother rock). With this method contaminants are isolated from groundwater (Figure 7).

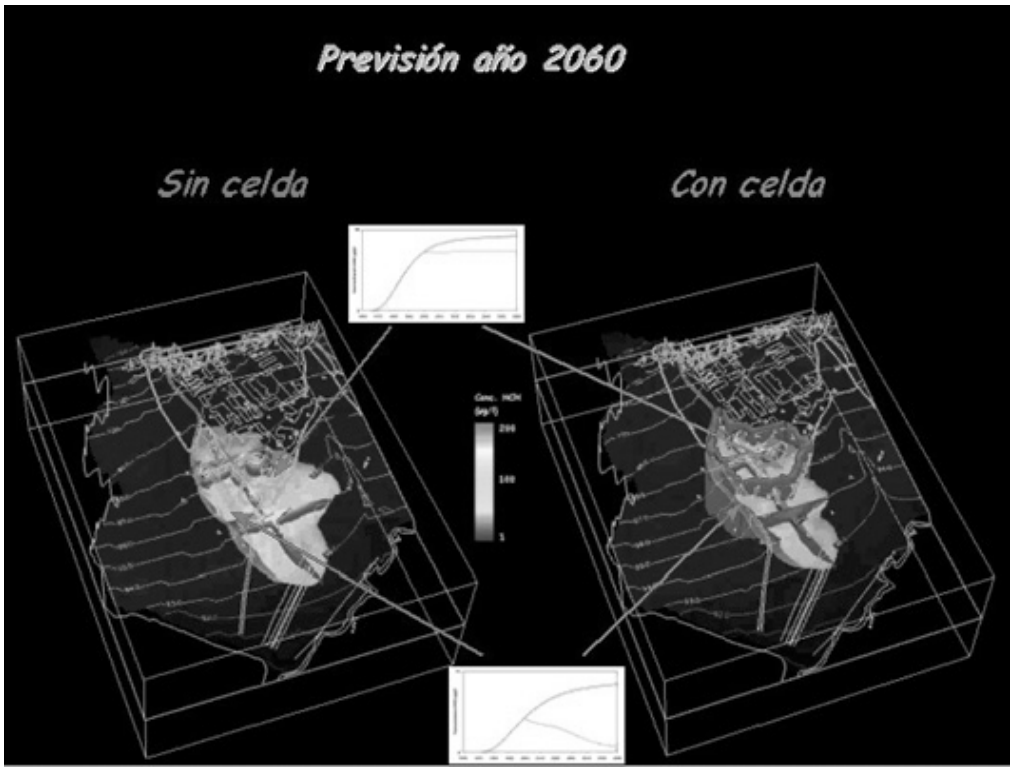

Figure 7. Bentonite-cement panels and their effect

On the surface of 3.2 ha in the isolated area, soils with a concentration between 2 - 5 ppm (from the nearest source of contamination with lower concentration levels) were deposited, and finally sealed (rain water could not reach the polluted area inside the panels, see Figure 8). The soil from the area with a concentration of HCH higher than 5 ppm was excavated and disposed in hazardous waste landfills. (Figure 6).

According to the Spanish waste law 10/1998, the person or industry that causes any soil contamination has to repair the damage. If the responsible person was not found, then the owners or at last the tenant would have the responsibility to repair the damage and this is why, in the Porrino case, the Administration of Galicia, as owner of the land, is already cleaning up to repair the damage caused by lindane contamination. When pollution affects industrial land the industries should remediate the soil using the best available technique BATNEEC (Best Available Technique Not Entailing Excessive Cost). In any case, the remediation technique used must be previously authorised by the Consellería de Medio Ambiente, who supervises and controls the execution of the remediation works.

For the polluted public land outside the encapsulated volume, in-situ biodegradation is considered the best technique, depending on the conditions and the pollutant if the appropriate technology is available. The Galician Autonomous Government is backing the investigation of these techniques, in co-operation with different research groups, who have at their disposal the plot of land with surface contamination within PV-4. This investigation will take place over a period of 2 years and cover aspects such as phytoremediation, degradation of pollutants by lignolitic fungi and landfarming. The results of this research could be applied equally to other public and private land polluted by HCH and they may also help to solve the problem in Porriño.

The main data about the on-going work for the investigation and the treatment of the HCH-contamination and about the extent of the pollution are as follows:

- Total area of contaminated site 1 km^2
- Polluted area 90,000 m^2
- Area encapsulated 32,056 m^2
- Total volume of polluted soil 375,000 m^3
- Total encapsulated volume 864,000 m^3
- Total volume of encapsulated polluted soil 150,000 m^3
- Cost for encapsulation and removal of polluted soil to a safe deposit is 4,947,500 €
- Investigation costs are 472,401 €
- Cost of bioremediation techniques research is 381,745 €

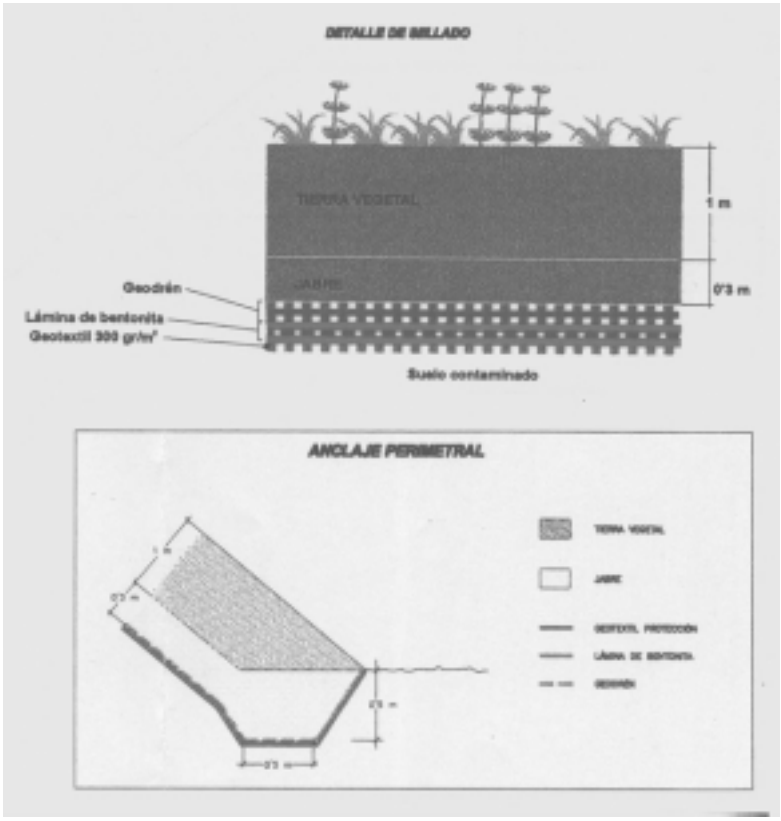

Figure 8. Detail of sealing cover