A fresh solution for the lindane problem

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At the UPV/EHU's Department of Analytical Chemistry Itxaso San Roman has studied whether iron nanoparticles can be applied to eliminate lindane, and how far they are capable of achieving this. Credit: UPV/EHU

For many years two companies located in Bizkaia, Bilbao Chemicals

(Barakaldo 1947-1987) and Nexana (Erandio 1952-1982), had been manufacturing lindane and dumping it into the environment with no control whatsoever. Today we have become aware of the need to solve the problems caused by this dumping and the difficulty in achieving this since there is no viable process that will safely destroy the lindane mixed with the soil. A study by the UPV/EHU's Department of Physical Chemistry and Analytical Chemistry in collaboration with Tecnalia has confirmed the hypothesis of the high reactive capacity of iron nanoparticles to degrade lindane. The study has been published in the prestigious journal *Chemosphere*.

Lindane has been routinely used among farmers as an insecticide and pesticide, and although its use has now been banned, the consequences of lindane manufacture and use have not disappeared. The risk posed by lindane lies in the fact that it is not only toxic, it can be accumulated in living organisms. From an environmental point of view, it has low solubility, high stability and high persistence and resistance to degradation in the environment.

Although there is as yet no viable process for safely destroying lindane, an innovative, efficient alternative is to use iron nanoparticles. Iron nanoparticles have shown themselves to be very effective as a decontaminating agent when it comes to handling various families of highly toxic compounds like lindane. However, they have a number of drawbacks that limit and hamper their application, since they oxidize easily in the presence of air and their tendency to agglomerate limits their mobility in the medium in which one is seeking to apply them. So the need to protect them is done by using Carboxymethyl cellulose (CMC), polyaspartate (PAP) and poly (acrylic acid) (PAA) as biodegradable polymer coatings.

From the laboratory to the land

"The main aim of our study was to validate on a laboratory scale whether these iron nanoparticles can be applied and whether they have the capacity to eliminate the lindane," explained Itxaso San Román, member of the UPV/EHU's Department of Analytical Chemistry. This requires advanced analytical techniques capable of monitoring the degradation process, which will take place in the presence of the various nanoparticles, determining the speed of the reaction and likewise detecting the possible by-products that are formed in the course of that reaction.

The process to degrade the contaminant itself was evaluated by analysing samples of water containing lindane using the technique called solid-phase extraction (SPE). That way the lindane remaining in the solution was measured over time. Likewise, the technique involving solid-phase microextraction (SPME) was used to detect the gas by-products generated during the degradation at each moment in the study by means of gas chromatography with a mass spectrometry (GC-MS) detector.

Through the techniques employed it was possible to compare and study the effectiveness of the various types of nanoparticles used to degrade the lindane and to find out the reaction speed in each case. The study showed how the lindane gradually disappeared in the presence of the nanoparticles over time (between 1 and 72 hours), revealing various reaction tendencies and speeds. "The protection of the nanoparticles increases the effectiveness of the degradation of the lindane and also prevents the agglomeration of the nanoparticles; the result is a greater reaction surface," pointed out Itxaso San Román. However, "as the lindane concentration in water diminished over time, other less harmful by-products were seen to appear; as time passes these will probably be transformed into more innocuous compounds," she said. That way "both the coated and uncoated nanoparticles have been shown to be capable of transforming the lindane into other less harmful products," stressed San Román. "This fact provides valuable information for applying them in

the future as a decontaminating tool in real environmental matrices," she added.

More information: I. San Román, M.L. Alonso, L. Bartolomé, A. Galdames, E. Goiti, M. Ocejo, M. Moragues, R. M, Alonso, J.L. Vilas. Relevance study of bare and coated zero valent iron nanoparticles for lindane degradation from its by-product monitorization. *Chemosphere*. ISSN:0045-6535 DOI: 10.1016/j.chemosphere.2013.07.050 www.sciencedirect.com/science/ … ii/S0045653513010345

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