Lindane

Title	**Assembly of root-associated microbiomes of typical rice cultivars in response to lindane pollution**
Author Name	Jiayin Fenga, Yan Xua, Bin Ma, Caixian Tang, Philip C. Brookes, Yan He & Jianming Xu
Journal Name	Environment International
Year	2019
Volume and Issue	131, 104975
Abstracts	Organochlorine pesticides have been extensively used for many years to prevent insect diseases of rice (Oryza sativa L.), but little is known about their residual impacts on the underground micro-ecology in anaerobic environment. In this glasshouse study, we characterized the lindane effects on the assembly of root-associated microbiomes of commonly used indica, japonica and hybrid rice cultivars, and their feedback in turn, in modifying lindane anaerobic dissipation during 60 days' rice production. The results showed that rice growth inhibited the anaerobic dissipation of lindane, but was not affected apparently by lindane at initial spiked concentration of 4.62 and 18.54 mg kg−1 soil. Suppressed removal of lindane in rice planted treatments as compared with that in unplanted control was likely due to inhibited reductive dechlorination induced by a comprehensive effect of radial O2 secretion of rice root and co-occurring Fe (III) reduction that consumed electron competitively in rice rhizosphere. However, the hybrid cultivar exhibited a less suppression than the conventional cultivars in high polluted soils. Bacteria was more sensitively responded to lindane pollution than fungal taxa, and Actinobacteria, Chloroflexi, Verrucomicrobia and Proteobacteria were the main different phyla between hybrid and conventional cultivars, with a more stable community structure exhibited in the hybrid rice under lindane stress. Our study highlights the assembly and variation of root-associated microbiomes in responses of lindane pollution, and suggests that hybrid rice cultivar might be most competent for cultivation in paddy fields polluted by lindane and other organochlorine pesticides, especially in the area with high residual levels.
Keywords	Lindane; glasshouse; anaerobic; dechlorination; rhizosphere; microbiomes; organochlorine

Title	Testing different strategies for the remediation of soils polluted with lindane
Author Name	J.Vidal, M.Carvela, C.Saez, P.Cañizares, V.Navarro, R.Salazar, M.A.Rodrigo
Journal Name	Chemical Engineering Journal
Year	2019
Volume and Issue	381, 122674
Abstracts	This work attempts to clarify the remediation processes involved in the treatment of soil spiked with non-soluble species like lindane. To achieve this goal, the remediation of spiked soil is evaluated coupling electro-kinetic soil flushing (EKSF) with three types of permeable reactive barriers (PRB) which consist of soil merged with nanoparticles of ZVI (n-ZVI), granular particles of ZVI (m-ZVI) or granular activated carbon (GAC). Likewise, the effect of reverse polarity in EKSF will be assessed. Results show that, for a given electric field applied, the intensity reached depends on the size and materials of the reactive particles contained in the PRB and decreases in the sequence EKAB-EKmZVIB-EKnZVIB. Additionally, water content and pH and conductivity profiles between rows of electrodes are also affected by the presence of PRB, mainly because ZVI particles can behave as bipolar electrodes and, thus amend current lines and water flux. In terms of lindane mobilization, the differences are even more remarkable since iron particles promote lindane dehalogenation and activated carbon shows a very good adsorption capacity for lindane. After 720 h of operation, the percentage of lindane extracted is below 2% in all EK-strategies while the percentage retained in soil depends on the strategy used: REKSF seems to prevent lindane removal while EKSF and EKAB lead to higher removal. Results are significant for the design of full-scale applications for the remediation of soils polluted with non-soluble species.
Keywords	Soil remediation; Electrokinetic soil flushing; Permeable reactive barriers; Lindane

Title	Lindane Bioremediation in Soils of Different Textural Classes by an Actinobacteria Consortium
Author Name	Enzo E. Raimondo, Juan D. Aparicio, Gabriela E. Briceño, María S. Fuentes, Claudia S. Benimeli
Journal Name	Journal of Soil Science and Plant Nutrition
Year	2019
Volume and Issue	19, 1
Pages	29-41
Abstracts	Lindane is a highly chlorinated and recalcitrant insecticide, capable to accumulate in soil and groundwater. Despite lindane has been banned in many countries, numerous sites still remain contaminated. The present work studies the bioremediation of soils of different textures contaminated with lindane by bioaugmentation with a quadruple Streptomyces consortium. In the three evaluated soils, silty loam soil (SLS), sandy soil (SS), and clayey soil (CS), heterotrophic microbial populations increased during the 14 days of the assay and CFU counts were higher in bioaugmented than in non-bioaugmented soils. Lindane removal was detected in all contaminated treatments, with higher removal percentages in the bioaugmented microcosms (SS 70.3%, SLS 36.3%, and CS 30.7%), than in non-bioaugmented ones (SS 40.4%, SLS 9.3%, and CS 12.2%). The pesticide half-life decreased by 77.3, 50.3, and 10.7 days, in bioaugmented SLS, CS, and SS, respectively. Lindane had an inhibitory effect on soil enzyme activities such as dehydrogenase, fluorescein diacetate hydrolysis, acid and alkaline phosphatases and increased the catalase activity, in non-bioaugmented controls; however, no effect on urease activity was observed. Bioaugmentation of soil microcosms with actinobacteria increased all enzymatic activities. Finally, the survival of the four strains of the consortium was demonstrated at the end of the bioremediation assay. Bioremediation using the Streptomyces sp. A2-A5-A11-M7 consortium represents a promising tool to restore different types of soils contaminated with organochlorine pesticides.
Keywords	Pesticide; Streptomyces consortium; Bioaugmentation; Soils Enzymes

Title	Perspectives of lindane (γ-hexachlorocyclohexane) biodegradation from the environment: a review
Author Name	Dharmender Kumar and Rochika Pannu
Journal Name	Bioresources and Bioprocessing
Year	2018
Volume and Issue	5:29
Abstracts	This review describes the biodegradation of Lindane *(γ-hexachlorocyclohexane*, γ-HCH) from the diverse sources. Environmental degradation of γ-HCH has been described in terms of integrated biological approaches such as *metagenomics*, cloning, *phytoremediation, nanobiodegradation*, and *biosrfactants*, genes and enzymes responsible for γ-HCH degradation and exploration of new strains of γ-HCH-degrading microbes from different environmental sources. *Metagenomics-based* approaches help in the identification and isolation of new genes from the uncultivable sources and provide insights for future research. There is potential in the elucidation of pathways of degradation of persistent organic pollutants (POPs) from environment by the microorganisms. This is possible by means of new/improved microbial species. The *behavior* of isolated strains and the microorganisms when present in community is altogether different. Therefore, there is a need to develop new technology which will identify the minor component of the microbial community involved in degradation because the minor part might have profound effect on degradation. This is mediated by the biological activity of the microbial system.
Keywords	Microbial degradation; Metagenomics; Phytoremediation; Microbial Community; Lindane (γ-hexachlorocyclohexane, γ-HCH)

Title	**Lindane dissipation in a biomixture: Effect of soil properties and bioaugmentation**
Author Name	Juliana M.Saez, Ana L.Bigliardo, EnzoE.Raimondo, Gabriela E.Briceño, Marta A.Polti&Claudia S.Benimeliae
Journal Name	Ecotoxicology and Environmental Safety
Year	2018
Volume and Issue	Volume 156
Pages	97-105
Abstracts	The *biomixture* is the major constituent of a *biopurification* system and one of the most important factors in its efficiency; hence the selection of the components is crucial to ensure the efficient pesticides removal. Besides, *bioaugmentation* is an interesting approach for the optimization of these systems. A mixed culture of the fungus *Trametesversicolor* SGNG1 and the *actinobacteria Streptomyces* sp. A2, A5, A11, and M7, was designed to inoculate the *biomixtures*, based on previously demonstrated *ligninolytic* and pesticide-degrading activities and the absence of antagonism among the strains. The presence of *lindane* and/or the *inoculum* in the *biomixtures* had no significant effect on the development of *culturable* microorganisms regardless the soil type. The consortium improved *lindane* dissipation achieving 81–87% of removal at 66 d of incubation in the different *biomixtures*, decreasing *lindane* half-life to an average of 24 d, i.e. 6-fold less than t1/2 of *lindane* in soils. However, after recontamination, only the *bioaugmentedbiomixture* of *silty* loam soil enhanced *lindane* dissipation and decreased the t1/2 compared to *non-bioaugmented*. The *biomixture* formulated with silty loam soil, sugarcane *bagasse*, and peat, inoculated with a *fungal-actinobacterial* consortium, could be appropriate for the treatment of *agroindustrial* effluents contaminated with *organochlorine* pesticides in *biopurification* systems.
Keywords	Biomixture; Pesticides; Bioaugmentation; Biopurification system; Actinobacteria; Fungi

Title	**Microbial-enhanced lindane removal by sugarcane (Saccharumofficinarum) in doped soil-applications in phytoremediation and bioaugmentation**
Author Name	Jaseetha Abdul Salam, Mohammed A.A.Hatha&Nilanjana Das
Journal Name	Journal of Environmental Management
Year	2017
Volume and Issue	193
Pages	Pages 394-399
Abstracts	The aim of this study was to examine the effect of *lindane*-degrading yeast on the growth and lindane uptake by *Saccharum* sp., in doped garden soils. The rhizosphere of *Saccharum* plant was amended with yeast Candida VITJzN04 by root-inoculation. The bio-augment yeast was applied in two different forms viz., *planktonic* form and cells immobilized on sugarcane-bagasse, in the pot experiments. Garden soils (lindane~100 mg/kg) exposed to various treatments were monitored for a period of 30 days, for residual *lindane* by gas-chromatography analysis. The *lindane*-removal rates in soil were expressed in terms of half-life period and were recorded as 13.3 days (yeast), 43.3 days (*Saccharum),* 9.8 days (free yeast-plant) and 7.1 days (immobilized yeast-plant). Additionally, Candida sp., was also identified as a plant growth promoting yeast due to its ability to produce growth hormone and *solubilize* insoluble phosphates in the soil for better uptake by the plant species. Bio-stimulation of the soil with yeast immobilized on sugarcane *bagasse* further enhanced the total yeast activity in the soil which in turn had a positive influence on *lindane*-removal. Combined treatment with *bagasse* immobilized yeast and plant showed the best *lindane* degradation. Results suggested that the synergistic activity of plant and yeast resulted in fast and efficient degradation of *lindane*. Thus, it can be concluded that *Saccharum* plant in combination with Candida VITJzN04 is an effective alternative for the conventional remediation strategies.
Keywords	Bioaugmentation; Candida VITJzN04; Immobilization; Lindane; Phytoremediation; Saccharum sp.

Title	**Targeting of detoxification potential of microorganisms and plants for cleaning environment polluted by organochlorine pesticides**
Author Name	M.V.Kurashvili, G.S.Adamia, L.L.Amiranashvili, T.I.Ananiasvili, T.G.Varazi, M.V.Pruidze, M.S.Gordeziani&G.A.Khatisashvili
Journal Name	Annals of Agrarian Science
Year	2016
Volume and Issue	14,3
Pages	222-226
Abstracts	The goal of presented work is the development phytoremediation method targeted to cleaning environment polluted with organochlorine pesticides, based on joint application of specially selected plants and microorganisms. Initial degradation of pesticides carry out by microorganisms; the forming dehalogenated products easily uptake by the plants and undergo oxidative degradation via plant detoxification enzymes. This approach can complete degradation of toxicants and their mineralization into nontoxic compounds. In the presented work the results of using selected strains from genera Pseudomonas and plants phytoremediators in the model experiments are given. It has been shown that the using developed technological approach effectively decreased degree of pollution in artificially polluted soil samples.
Keywords	Detoxifidation potential; Organochlorine pesticides; Persistent organic; Pollutants; Phytoremediation technologies; Microorganisms

Title	**Is Vigna radiata (L.) R. Wilczek a suitable crop for Lindane contaminated soil?**
Author Name	Vishal Tripathi, Rama Kant Dubey, H.B. Singh, Nandita Singh, P.C. Abhilash
Journal Name	Ecological Engineering
Year	2014
Volume and Issue	Volume 73
Pages	219 - 223
Abstracts	Lindane (γ-hexachlorocyclohexane) is an organochlorine pesticide recently included in the Stockholm list of persistent organic pollutants for global elimination. However, India is still allowed to use Lindane for combating vector borne diseases. Because of its large scale utilization during the last few decades, Lindane residue is reported from almost all agricultural soils of India. So there is an immediate need to monitor the accumulation of Lindane residue in crop plants growing in contaminated systems and suitable strategies should be taken to prevent the possible entry of Lindane in food chain. Therefore, in the present study, we studied the accumulation and translocation of Lindane in Vigna radiata (L.) R. Wilczek (Mung bean), a widely grown legume in India as a cheap source of protein. The test plant was grown in four different concentrations of Lindane viz. 5, 10, 15 and 20 μg g−1 soils and harvested at 15 and 45 days and at maturity. The experimental results showed that irrespective of the exposure days, the accumulation of Lindane in plant parts were linearly correlated (r2 = 0.915) with the Lindane concentration in soil. However, the Lindane concentration in soil significantly reduced the growth and yield (number of pods, pod length, number of seeds and seed weight) of the test plants at 95% confidence level (α = 5). At maturity, the concentration of Lindane in whole plant (root + shoot + leaf + seed) growing at four different concentrations were reached up to 3.8, 9.4, 13.5 and 17.79 μg g−1 dry matter, respectively. Worryingly, Lindane residue was found in the seeds of test plants grown at 10, 15 and 20 μg g−1 soils and the concentrations were detected as 0.2, 0.4 and 0.89 μg g−1 dry seed, respectively. Most importantly, the residue level detected in the edible part was higher than the maximum residue limit set by WHO and Codex Alimentarious Commission (0.1 μg g−1). Thus our study suggests that Mung bean is not a suitable crop for medium to high level Lindane contaminated soil.
Keywords	Persistent organic pollutants; Organochlorine pesticide; Lindane; Vigna radiata (L.) R. Wilczek; Phytoaccumulation; Maximum residue limit

Title	Phytoextraction and dissipation of Lindane by Spinacia oleracea L.
Author Name	Rama Kant Dubey, Vishal Tripathi, Nandita Singh, P.C. Abhilash
Journal Name	Ecotoxicology and Environmental Safety
Year	2014
Volume and Issue	Volume 109
Pages	22 - 26
Abstracts	Remediation and management of organochlorine pesticide (OCPs) contaminated soil is becoming a global priority as they are listed in the Stockholm list of persistent organic pollutants (POPs) for global elimination. Lindane is a OCPs candidate recently included in the Stockholm list. However, India has an exemption to produce Lindane for malaria control. Because of its widespread use during the last few decades, Lindane contaminated soils are found in almost all parts of India. Since phytoremediation is widely acknowledged as an innovative strategy for the clean-up of contaminated soils; the present study was aimed to evaluate the phytoextraction and dissipation of Lindane by a leafy vegetable Spinacia oleracea L (Spinach). The test plant was grown in different concentrations of Lindane (5, 10, 15 and 20 mg kg−1) and harvested at 10, 30 and 45 days. At 45 days, the concentrations of Lindane in root and leaf of Spinach growing in four different concentrations were reached up to 3.5, 5.4, 7.6 and 12.3 mg kg−1 and 1.8, 2.2, 3 and 4.9 mg kg−1, respectively. There was a significant difference ($p<0.01$) in the dissipation of Lindane in vegetated and non-vegetated soil. Moreover, the residual Lindane in four experiments was reduced to 81, 76, 69 and 61 percent, respectively. The experimental results indicate that Spinach can be used for the phytoremediation of Lindane. However, more studies are required to prevent the toxicity of harvested parts.
Keywords	Persistent organic pollutants; Organochlorine pesticide; Lindane; Vigna radiata (L.) R. Wilczek; Phytoaccumulation; Maximum residue limit