Lindane uptake and translocation by rice seedlings (*Oryza sativa L.*) under different culture patterns and triggered biomass re-allocation (2021)

Table 1: The physico-chemical characteristics of the experimental soils.

Soil	S1	S2
Soil texture[a]	silt loam	sand
Sand (%)	41.5	99.4
Silt (%)	58.5	0.6
Clay (%)	-	-
pH (H_2O)	7.7	7.0
TOC (mg g^{-1})	6.50±0.42	3.45±0.20
CEC (cmol kg^{-1})	9.74±0.98	2.74±0.43
Pesticide residues	not detected	not detected

[a] as defined by the USDA

Table 2: The initial lindane concentration in the culture matrices.

Group		Culture matrix[a]	Lindane conc. in aqueous phase (μg L^{-1})	Lindane conc. in solid phase (μg kg^{-1})
Hydroponic experiments	H-0	nutrient solution	0	/
	H-i	nutrient solution	449.8±9.3	/
	H-ii	S1 extract	454.8±0.3	/
	H-iii	S2 extract	453.1±10.6	/
Soil-based culture experiments	S-0	S1	0	not detected
	S-i	S1	444.7±12.5	756.0±22.1
	S-ii	S1-S2 2:1 mixture	450.8±8.2	671.0±28.2
	S-iii	S1-S2 1:1 mixture	452.7±3.8	541.7±16.1
	S-iv	S1-S2 1:2 mixture	445.6±14.5	452.4±13.3
	S-v	S2	442.1±2.0	200.1±6.8

[a] In soil-based culture experiments, the soil matrices were submerged and surrounded by the nutrient solution.

Table 3: Summary of regression parameters for the allometric relationships between Ms and Mr of each experimental group.

Group	α (regression slope)	logβ (y intercepts)	r^2	F-value*
H-0	0.9791 ± 0.0261	0.3496 ± 0.0299	0.9866	1408.5
H-i	0.5979 ± 0.0288	0.7654 ± 0.0305	0.9635	503.0
H-ii	0.5245 ± 0.0288	0.8569 ± 0.0333	0.9458	332.7
H-iii	0.5503 ± 0.0244	0.8264 ± 0.0281	0.9639	509.1
S-0	1.101 ± 0.055	0.224 ± 0.062	0.9544	399.3
S-i	2.350 ± 0.125	-1.114 ± 0.137	0.9486	351.7
S-ii	2.264 ± 0.117	-1.028 ± 0.129	0.9513	372.5
S-iii	2.312 ± 0.159	-1.094 ± 0.176	0.9171	211.3
S-iv	2.035 ± 0.013	-0.766 ± 0.143	0.9265	240.8
S-v	2.130 ± 0.149	-0.894 ± 0.166	0.9142	203.5

* In each case, the scaling relationships were highly significant ($p<0.001$ or less).

Source: https://www.sciencedirect.com/science/article/abs/pii/S0045653520320269

Successful remediation of soils with mixed contamination of chromium and lindane: Integration of biological and physico-chemical strategies (2021)

Table 1: **Hexavalent chromium and lindane concentration in soil.** Treatments: Non-treatment (co-contaminated soil without treatments); Biological treatment (BT); Nanoremediation (nZVI); Nanoremediation + Biological treatment (nZVI + BT); Unamended soil (U); Amended soil (A). Conditions: Non-contaminated soil (NCS); Soil co-contaminated with 100 mg kg^{-1} of chromium and 15 mg kg^{-1} of lindane (Cr100 + Lin15); Soil co-contaminated with 300 mg kg^{-1} of chromium and 15 mg kg^{-1} of lindane (Cr300 + Lin15).

		Cr(VI) (mg kg^{-1})		**Lindane (mg kg^{-1})**	
		U	**A**	**U**	**A**
Non-treatment	NCS	ND	ND	ND	ND
	Cr100 + Lin15	19.6 ± 1.1^{c}	1.1 ± 0.1^{d}	5.6 ± 0.2$^{c'}$	9.9 ± 0.2$^{a'}$
	Cr300 + Lin15	123.1 ± 4.0^{a}	2.4 ± 0.03^{d}	5.5 ± 0.4$^{c'}$	9.9 ± 0.2$^{a'}$
BT	NCS	ND	ND	ND	ND
	Cr100 + Lin15	2.3 ± 0.2^{d}	0.8 ± 0.03^{d}	3.5 ± 0.2$^{f'}$	4.6 ± 0.3$^{d'}$
	Cr300 + Lin15	45.4 ± 2.1^{b}	1.0 ± 0.1^{d}	3.5 ± 2.3$^{ef'}$	4.5 ± 0.1d$^{e'}$
NZVI	NCS	ND	ND	ND	ND
	Cr100 + Lin15	0.3 ± 0.1^{d}	0.9 ± 0.1^{d}	5.6 ± 0.1$^{c'}$	9.4 ± 0.5$^{ab'}$
	Cr300 + Lin15	0.9 ± 0.1^{d}	1.8 ± 0.1^{d}	5.5 ± 0.6$^{c'}$	9.5 ± 0.5$^{a'}$
nZVI + BT	NCS	ND	ND	ND	ND
	Cr100 + Lin15	0.3 ± 0.1	0.9 ± 0.0	1.3 ± 0.1	8.6 ± 0.1
	Cr300 + Lin15	0.4 ± 0.0^{d}	1.10 ± 0.1^{d}	1.38 ± 0.2$^{g'}$	8.6 ± 0.1$^{b'}$

ND: non-detected. Values are presented as mean ± SD. Values sharing the same letter were not significantly different ($p < 0.05$).

Table 2: **Total chromium and lindane concentration in earthworms.** Treatments: Biological treatment (BT); Nanoremediation (nZVI); Nanoremediation + Biological treatment (nZVI + BT); Unamended soil (U); Amended soil (A). Conditions: Non-contaminated soil (NCS); Soil co-contaminated with 100 mg kg^{-1} of chromium and 15 mg kg^{-1} of lindane (Cr100 + Lin15); Soil co-contaminated with 300 mg kg-1 of chromium and 15 mg kg^{-1} of lindane (Cr300 + Lin15).

		Cr (mg kg^{-1})		**Lindane (mg kg^{-1})**	
		U	**A**	**U**	**A**
BT	NCS	ND	ND	ND	ND
	Cr100 + Lin15	30.5 ± 1.4^{a}	3.3 ± 0.5^{de}	0.09 ± 0.01$^{a'}$	0.08 ± 0.01$^{a'}$
	Cr300 + Lin15	*	12.6 ± 0.3^{c}	*	0.09 ± 0.01$^{a'}$
nZVI + BT	NCS	ND	*	ND	*
	Cr100 + Lin15	12.7 ± 0.6	2.2 ± 0.5	0.09 ± 0.01	0.10 ± 0.02
	Cr300 + Lin15	21.6 ± 1.7^{b}	5.5 ± 1.2^{d}	0.09 ± 0.01$^{a'}$	0.09 ± 0.01$^{a'}$

ND: non-detected. * non-survival. Values are presented as mean ± SD. Values sharing the same letter were not significantly different ($p < 0.05$).

Table 3: **Seed germination (G) and survival (S) of Brassica napus plants.** Treatments: Biological treatment (BT); Nanoremediation (nZVI); Nanoremediation + Bio- logical treatment (nZVI BT); Unamended soil (U); Amended soil (A). Condi- tions: Non-contaminated soil (NCS); Soil co-contaminated with 100 mg kg-1 of chromium and 15 mg kg-1 of lindane (Cr100 + Lin15); Soil co-contaminated with 300 mg kg-1 of chromium and 15 mg kg-1 of lindane (Cr300 + Lin15). Values sharing the same letter were not significantly different (p <0.05). G: seed germination. S: survival.

		G (% ± SD)		S (% ± SD)	
		U	**A**	**U**	**A**
BT	NCS	96 ± 3ab	95 ± 3ab	96 ± 3a’	95 ± 3a’
	Cr100 + Lin15	99 ± 1a	95 ± 3ab	*	95 ± 3a’
	Cr300 + Lin15	81 ± 5bc	98 ± 4a	*	98 ± 4a’
nZVI + BT	NCS	97 ± 3a	37 ± 8d	97 ± 3a’	*
	Cr100 + Lin15	99 ± 1a	35 ± 7d	99 ± 1a’	4 ± 1c’
	Cr300 + Lin15	67 ± 7c	73 ± 8c	67 ± 7b’	73 ± 8b’

* non-survival. Values are presented as mean ± SD. Values sharing the same letter were not significantly different (p < 0.05).

Source: https://www.sciencedirect.com/science/article/abs/pii/S0013935120315632

Bioremediation of lindane contaminated soil: Exploring the potential of actinobacterial strains (2021)

Table 1: Phytotoxicity assay of bioremediated soil on *Lactuca Sativa* seeds.

Treatments	Germination Percentage (%)	Mean Hypocotyl Length (cm) (Mean ± SD)	Mean Root Length (cm) (Mean ± SD)	Vigor Index (VI)
Sterilized Soil				
UCS Uncontaminated Soil (No Lindane and no bacteria)	65	5.99 ± 0.71	1.74 ± 0.36	50.25
CS1 (Contaminated Soil)(55 mg kg^{-1} Lindane and no bacteria)	20	3.43 ± 2.37	1.23 ± 0.82	9.32
CS2 (Contaminated Soil)(155 mg kg^{-1} Lindane and no bacteria)	15	4.08 ± 2.31	1.03 ± 0.77	8.15
CS3 (Contaminated Soil)(255 mg kg^{-1} Lindane and no bacteria)	10	5 ± 2.83	1 ± 0.28	6
Thermobifida cellulosilytica				
TC1 (55 mg kg^{-1} Lindane bioremediated by T. cellulosilytica)	55	4.14 ± 1.71	1.03 ± 0.37	28.44
TC2 (155 mg kg^{-1} Lindane bioremediated by T. cellulosilytica)	50	3.80 ± 1.97	1.02 ± 0.56	24.05
TC3 (255 mg kg^{-1} Lindane bioremediated by T. cellulosilytica)	40	3.34 ± 2.09	1.1 ± 0.78	17.76
Thermobifida halotolerans				
TH1 (55 mg kg^{-1} Lindane bioremediated by T. halotolerans)	55	3.76 ± 1.94	1.21 ± 0.79	27.34
TH2 (155 mg kg^{-1} Lindane bioremediated by T. halotolerans)	30	4.63 ± 2.15	0.97 ± 0.41	16.8
TH3 (255 mg kg^{-1} Lindane bioremediated by Thermobifida halotolerans)	25	3.56 ± 2.48	1.38 ± 0.41	12.35
Streptomyces coelicolor				
SC1 (55 mg kg^{-1} Lindane bioremediated by Streptomyces coelicolor)	40	2.97 ± 1.72	1.27 ± 0.56	16.96
SC2 (155 mg kg^{-1} Lindane bioremediated by Streptomyces coelicolor)	35	3.75 ± 1.19	1.14 ± 0.72	13.09
SC3 (255 mg kg^{-1} Lindane bioremediated by Streptomyces coelicolor)	30	2.6 ± 1.46	1.09 ± 0.67	11.07
Non-Sterilized Soil				
UCNS Uncontaminated Soil (No Lindane and no bacteria)	90	4.61 ± 1.06	1.68 ± 0.61	53.45
NCS1 (Contaminated Soil) (55 mg kg^{-1} Lindane and no bacteria)	25	3.12 ± 0.58	1.12 ± 0.49	10.56
NCS2 (Contaminated Soil) (155 mg kg^{-1} Lindane and no bacteria)	20	3.06 ± 1.17	0.5 ± 0.16	7.12
NCS3 (Contaminated Soil) (255 mg kg^{-1} Lindane and no bacteria)	15	2.83 ± 2.31	0.9 ± 0.53	5.6
Thermobifida cellulosilytica				
NTC1 (55 mg kg^{-1} Lindane bioremediated by Thermobifida	80	4.58 ± 1.55	1.53 ± 0.69	48.8

cellulosilytica)				
NTC2 (155 mg kg^{-1} Lindane bioremediated by Thermobifida cellulosilytica)	50	5.17 ± 0.87	1.10 ± 0.27	31.35
NTC3 (255 mg kg^{-1} Lindane bioremediated by Thermobifida cellulosilytica)	35	3.87 ± 1.14	1.40 ± 0.29	18.45
Thermobifida halotolerans				
NTH1 (55 mg kg^{-1} Lindane bioremediated by Thermobifida halotolerans)	40	5.36 ± 0.58	1.65 ± 0.71	28.04
NTH2 (155 mg kg^{-1} Lindane bioremediated by and Thermobifida halotolerans)	45	3.78 ± 1.84	2 ± 0.53	25.97
NTH3 (255 mg kg^{-1} Lindane bioremediated by Thermobifida halotolerans)	35	4.79 ± 1.55	1.4 ± 0.52	21.67
Streptomyces coelicolor				
NSC1 (55 mg kg^{-1} Lindane bioremediated by Streptomyces coelicolor)	60	4.04 ± 1.68	1.12 ± 0.54	30.96
NSC2 (155 mg kg^{-1} Lindane bioremediated by Streptomyces coelicolor)	55	3.49 ± 1.82	1.27 ± 0.78	26.18
NSC3 (255 mg kg^{-1} Lindane bioremediated by Streptomyces coelicolor)	30	3.87 ± 1.54	1.1 ± 0.33	14.91

UCS: Uncontaminated sterilized soil; UCNS: Uncontaminated non-sterilized soil; CS: Contaminated sterilized soil: NCS: Non-sterilized Contaminated soil.

Source: https://www.sciencedirect.com/science/article/pii/S0045653521009383#tbl1

Lindane degradation in wet-dry cycling soil as affected by aging and microbial toxicity of biochar (2021)

Table 1: Variations of FA saturation degree (SFA/UFA) in soils.

Treatments	SFA/UFA		
	Day 2	Day 40	Day 89
CK	3.06 ± 0.12	1.82 ± 0.20##	2.48 ± 0.39#
3% BP	1.77 ± 0.39*	1.12 ± 0.07**, #	1.72 ± 0.20*
1% BC400	4.51 ± 0.01**	2.13 ± 0.11##	5.15 ± 0.44**, #
1% BC600	3.65 ± 0.02*	2.06 ± 0.07##	4.65 ± 0.50**, ##
5% BC400	6.08 ± 0.46*	3.25 ± 0.64*, #	7.47 ± 1.13**, #
5% BC600	5.46 ± 0.01**	2.75 ± 0.36*, ##	6.03 ± 0.28**, ##
1% WBC400	3.87 ± 0.93*	3.01 ± 0.65*	3.62 ± 0.14**
1% WBC600	3.27 ± 0.33	2.53 ± 0.30*, #	3.09 ± 0.41
5% WBC400	8.95 ± 0.52**	7.19 ± 1.09**	4.84 ± 1.22*, ##
5% WBC600	4.13 ± 0.81	4.65 ± 0.47**	3.66 ± 0.09**

*indicates difference between control group and treated groups at $0.1 < p < 0.05$;

**indicates significant difference at $p < 0.01$;

#indicates significant difference between each treated group and its day 2 group at $p < 0.05$;

##indicates significant difference at $p < 0.01$.

Table 2: Abundance and diversity indices of soil microorganisms.

Sample	Chao1 index		Shannon index		Simpson index（%）	
	D2	D89	D2	D89	D2	D89
CK	2069.06	1702.78	5.58	5.87	0.80	0.94
3% BP	1737.96	2061.53	5.89	6.49	0.93	0.94
1% BC_{400}	2808.82	1923.81	8.69	6.75	0.99	0.96
1% BC_{600}	2821.67	2412.88	8.81	7.11	0.99	0.96
5% BC_{400}	2865.30	2751.31	8.89	7.27	0.99	0.97
5% BC_{600}	2811.75	2189.28	9.03	7.12	0.99	0.97
1% WBC_{400}	1887.08	2564.37	3.95	8.75	0.63	0.99
1% WBC_{600}	2138.03	2395.82	4.78	8.43	0.75	0.99
5% WBC_{400}	1806.85	2400.91	4.46	8.00	0.74	0.98
5% WBC_{600}	2121.76	2525.26	4.98	8.99	0.74	0.99

Source: https://www.sciencedirect.com/science/article/pii/S0147651321004863

Assessment of the Streptomyces-plant system to mitigate the impact of Cr(VI) and lindane in experimental soils (2021)

Table 1: Volatile organic compounds isolated from headspace of Streptomyces sp. Z38 strain.

Compound	RI	Mean±SD	Identification/EIMS (70 eV): m/z (rel. Int. %)	Cited in
2(3H)-Furanone, 5-ethyldihydro	1043	3.49±1.49	MS, RI	
Benzoic acid, methyl ester	1083	5.38±1.81	MS, RI	Pollak and Berger (1996)
MW 164	1212	3.38±0.42	67 (47), 79 (53), 81 (73), 93 (56), 109 (70), 123 (48), 149 (100), 164 (47)	Similar to Mass 164 B reported in Wilkins and Schöller (2009)
Geosmin	1391	13.18±0.85	MS, RI	Jiang et al. (2007); Wilkins and Schöller (2009)
Germacrene D	1473	4.55±0.83	MS, RI, S	Pollak and Berger (1996); Jiang et al. (2007)
MW 169	1519	3.55±3.49	43 (65), 57 (84), 71 (100), 85 (80), 99 (25), 113 (20), 127 (15), 155 (15)	
Mass 196, Thiophene derivative	1538	5.53±2.10	43 (45), 57 (60), 71 (55), 85 (40), 153(100), 181 (20), 196 (23)	
2-Oxepanone, 7-hexyl-MW 222	1610	6.17±1.08	MS, RI	Wu et al. (2015)
sesquiterpenoid	1641	3.19±4.24	43 (35), 57 (87), 71 (100), 84 (40), 112 (20), 207 (8)	
MW 222 sesquiterpenoid	1726	8.63±2.06	41 (40), 43 (20), 55 (75), 70 (45), 85 (95), 91 (100), 113 (38), 122 (20), 165 (10), 207 (10)	
Oleamide	2380	22.94±8.25	MS, RI	Kwon et al. (2001)

RI Kovats retention index determined according to n-alkanes on a DB-5MS capillary column. Identification based on mass spectra (MS), retention index and authentic standards (S). *MW* molecular weight

Source: https://link.springer.com/content/pdf/10.1007/s11356-021-14295-6.pdf

Table 1: Contaminant content in soil from which microorganism associations were isolated.

Pollutant	Soil samples/Content, mg/kg							
	No 1	No 2	No 3	No 4	No 5	No 6	No 7	No 8
γ-HCH	–*	1.8	4.2	53.4	0.4	5.5	–	–
DDT	–	0.9	–	–	–	–	–	–

*– not found

Table 2: Phylogenetic similarity of the lindane-degrading bacteria, association ‘‘A’’—with typical strains (EzBioCloud Database)

Strain	Identification based on the 16 S rRNA gene analysis		
	Similarity, %	Top-hit taxon	Top-hit strain
As3-127	100.00	*Pseudomonas putida*	NBRC 14,164
As 2-134	100.00	*Pseudomonas monteilii*	NBRC 103,158
As 2-116A	97.98	*Pseudomonas sichuanensis*	WCHPs060039
As 6-126	99.73	*Pseudomonas putida*	NBRC 14,164
As 5-145b	99.86	*Rhizobium pusense*	LMG 25,623
As 2-153A	99.00	*Ochrobactrum anthropi*	ATCC 49,188
As 4-147	99.00	*Ochrobactrum anthropi*	ATCC 49,188
As 6-140C	100.00	*Ochrobactrum tritici*	SCII24
As 4-132	93.10	*Mesorhizobium wenxiniae*	WYCCWR 10,195

Table 3: Phylogenetic similarity of the DDT degrading bacteria, association ‘‘D’’—with typical strains (EzBioCloud Database)

Strain	Identification based on the 16 S rRNA gene analysis		
	Similarity, %	Top-hit taxon	Top-hit strain
As7-D 1	99.75	*Brevibacillus parabrevis*	NRRL NRS 605
As7-D 2	100.00	*Paracoccus yeei*	ATCC BAA-599
As7-D 3	100.00	*Paracoccus yeei*	ATCC BAA-599
As7-D 4	100.00	*Stenotrophomonas lactitubi*	M15
As7-D 9	99.88	*Stenotrophomonas rhizophila*	DSM 14,405
As7-D 10	99.88	*Stenotrophomonas rhizophila*	DSM 14,405
As8-D 7	100.00	*Mycolicibacterium tokaiense*	ATCC 27,282
As8-D 8	99.84	*Pseudomonas xanthomarina*	DSM 18,231
As8-D 13	98.00	*Paracoccus acridae*	SCU-M53

Table 4: Pesticide decrease in the experiment, %

Sl.No.	Experimental variants	DDT loss, %	Lindane loss, %
1	Mineral medium ? ‘‘D’’ association	0	0
2	Mineral medium ? ‘‘A’’ association	38.02 ± 3.01	25.00 ± 2.16
3	Moistened soil	0.16 ± 0.02	26.05 ± 2.12
4	10 plants, moistened soil without bacteria introduction	1.57 ± 0.03	27.37 ± 1.27
5	100 plants, moistened soil without bacteria introduction	18.94 ± 0.04	39.79 ± 4.64
6	Soil ? ‘‘D’’ association, no plants	9.88 ± 0.83	46.82 ± 6.10
7	10 plants ? ‘‘D’’ association	35.73 ± 1.09	61.89 ± 11.63
8	100 plants ? ‘‘D’’ association	45.09 ± 4.91	63.87 ± 5.61
9	Soil ? ‘‘A’’ association, no plants	55.82 ± 2.36	75.17 ± 5.69
10	10 plants ? ‘‘A’’ association	32.08 ± 0.67	58.40 ± 2.54
11	100 plants ? ‘‘A’’ association	32.49 ± 2.88	65.57 ± 4.50

Table 5: Abundance, total biomass and total length of clever seedlings roots in experimental variants.

Number of plants in the weighing bottle	Total plant root mass, mg/10 g of soil	Total root length, cm/10 g of soil
100 plants, control	18.2 ± 2.2	310.1 ± 2.1
10 plants, control	2.2 ± 0.2	28.2 ± 0.2
10 plants, simple wetting	1.6 ± 0.1	22.3 ± 2.2
100 plants, simple wetting	17.0 ± 2.1	240.1 ± 2.2
100 plants + ‘‘D’’ association	15.1 ± 2.2	200.4 ± 5.3
10 plants + ‘‘D’’ association	1.5 ± 0.5	22.3 ± 2.3
100 plants +‘‘A’’ association	22.2 ± 2.1	190.2 ± 5.2
10 plants + ‘‘A’’ association	1.0 ± 0.2	18.1 ± 2.2

Table 6: Average length and mass of shoots and roots of clover seedlings in experimental variants.

Number of plants in the bu	Average seedling length, cm	Average seedling mass, mg	Average root length, cm	Average root mass, mg
100 plants, control	4.4 ± 0,2	0.82 ± 0.20	3.2 ± 0.2	0.22 ± 0.02
10 plants, control	4.2 ± 0,2	0.78 ± 0.15	2.8 ± 0.2	0.18 ± 0.02
100 plants, simple wetting	3.4 ± 0,8	0.78 ± 0.22	2.4 ± 0.8	0.17 ± 0.03
10 plants, simple wetting	4.2 ± 0,8	0.78 ± 0.20	2.2 ± 0.8	0.17 ± 0.05
100 plants + ‘‘D’’association	3.2 ± 0,8	1.03 ± 0.23	2.0 ± 0.5	0.15 ± 0.02
10 plants + ‘‘D’’association	3.4 ± 0.8	0.75 ± 0.18	2.4 ± 0.8	0.17 ± 0.03
100 plants + ‘‘A’’association	3.9 ± 0.6	0.97 ± 0.15	1.9 ± 0.6	0.22 ± 0.05
10 plants + ‘‘A’’association	2.4 ± 0.7	0.97 ± 0.18	1.8 ± 0.5	0.10 ± 0.02

Table 7: Similarity coefficient of the ‘‘A’’ association DGGE profiles.

	1	**2**	**3**
1	100	63.5	47
2	63.5	100	64.4
3	47	64.4	100

Table 8: Similarity coefficient of the ‘‘D’’ association DGGE profiles.

	1	**2**	**3**
1	100	84.6	36.4
2	84.6	100	42.1
3	36.4	42.1	100

Source: https://link.springer.com/content/pdf/10.1007/s10653-021-00821-5.pdf

Insights into the Biodegradation of Lindane (γ-Hexachlorocyclohexane) Using a Microbial System (2020)

Table 1: Lindane degradation by various microorganisms.

Species	Microorganism	Concentration of lindane	Degradation rate	Sources	References
Bacteria	Microbacterium sp. P27	50 mg/L	82.7% in 15 days	Phragmites karka	Singh and Singh, 2019b
	Paracoccus sp. NITDBR1	100 mg/L	90% in 8 days	Agricultural field	Sahoo et al., 2019
	Achromobacter sp. strain A3	50 mg/L	88.7% in 15 days	Acorus calamus	Singh and Singh, 2019a
	Burkholderia sp. IPL04	100 mg/L	98% in 8 days	Soil	Kumar, 2018
	Rhodococcus wratislaviensis Ch628	200 mg/L	32.3% in 5 days	Soil	Egorova et al., 2017
	Chromohalobacter sp. LD2	50 mg/L	89.6% in 7 days	Soil	Bajaj et al., 2017
	Kocuria sp. DAB-1Y	10 mg/L	94% in 8 days	Soil	Kumar et al., 2016
	Staphylococcus sp. DAB-1W	10 mg/L	98% in 8 days	Soil	Kumar et al., 2016
	Streptomyces sp. M7	1.66 mg/L	45% in 7 days	Sediment	Sineli et al., 2016
	Arthrobacte fluorescens	100 mg/L	40% in 72 h	Soil	De Paolis et al., 2013
	Arthrobacter giacomelloi	100 mg/L	56% in 72 h	Soil	De Paolis et al., 2013
	Azotobacter chroococcum	10 mg/L	Almost complete in 6 days	Farm fields	Anupama and Paul, 2009
	Sphingomonas sp. NM05	100 mg/L	90% in 7 days	Soil	Manickam et al., 2008
	Xanthomonas sp. ICH12	100 mg/L	100% in 8 days	Soil	Manickam et al., 2010
	Pseudomonas aeruginosa ITRC5	2 mg/kg of soil	76% in 15 days	Soil	Kumar et al., 2011
	Microbacterium sp. ITRC1	200 mg/kg of soil	96% in 28 days	Soil	Manickam et al., 2006
	Pseudoarthrobacter sp.	5 mg/L	50.7% in 7 days	Soil	Nagpal and Paknikar, 2006
	Pseudomonas sp.	5 mg/L	52.2% in 7 days	Soil	Nagpal and Paknikar, 2006
	Klebsiella sp.	5 mg/L	51.2% in 7 days	Soil	Nagpal and Paknikar, 2006
	Arthrobacter citreus B1-100	100 mg/L	100% in 8 h	Soil	Datta et al., 2000
Fungi	Ganoderma lucidum GL-2	4 mg/L	75.5% in 28 days		Kaur and Kaur, 2016
	Pleurotus ostreatus	2.03 mg/L		Rotten wood	Dritsa and Rigas, 2013
	Fusarium verticilliodes AT-100	50 mg/L	30% in 7 days	Leaves	Guillén-Jiménez et al., 2012
	Rhodotorula sp. VITJzN03	600 mg/L	100% in 10 days	Soil	Salam et al., 2013
	Fusarium poae	100 mg/L	56.7% in 10 days	Soil	Sagar and Singh, 2011
	Fusarium solani	100 mg/L	59.4% in 10 days	Soil	Sagar and Singh, 2011
	Conidiobolous 03-1-56	5 mg/L	100% in 5 days	Soil	Nagpal et al., 2008
	Bjendera audusta	100 mg/kg of soil	69.1% in 30 days	Soil	Quintero et al., 2007
	Cyathus bulleri,	5 µM	97% in 28 days		Singh and Kuhad, 2000

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7119470/pdf/fmicb-11-00522.pdf

Development of artificial consortia of microalgae and bacteria for efficient biodegradation and detoxification of lindane (2020)

Table 1: Comparison of lindane degradation reported in different studies.

	Genera	Incubation time (in days)	% degradation of lindane	Reference
Bacteria	Paenibacillus sp. ISTP10	3	61	This study
	Streptomyces sp. M7	7	79	Sineli et al. (2016)
	Sphingobium strains	5	79.7	Zheng et al. (2011)
	Sphingomonas sp.	5	90	Manickam et al. (2008)
Algae	Scenedesmus sp.	3	68	This study
	Scenedesmus intermedius	60	99	González-Fernández et al. (2012)
	Synechococcus sp. Q2	7	89	El-Bestawy et al. (2007)
	Oscillatoria sp. R12	7	98	El-Bestawy et al. (2007)
	Nostoc sp. SH	7	97	El-Bestawy et al. (2007)
Bacto-algal consortium	Paenibacillus sp. ISTP10 and Scenedesmus sp.	3	100	This study

Table 2: MTT EC_{50} values of untreated and treated samples along with the corresponding EROD activity.

Treatments[a]	MTT EC_{50}[b]	R^2 (EC_{50})
UT	13.79	0.99
A168	21.10	0.97
B168	18.03	0.99
AB168	26.15	0.99

UT - untreated; A168 - 168 h algal treated; B168 - 168 h bacterial treated; AB168 - 168 h bacto-algal treated.
[a]HepG2 cell lines were treated with different test samples (dilutions, 5% to 20% v/v test samples) for 24 h in MTT assay.
[b]EC_{50} was derived using global curve fitting model with four parameters logistic non-linear regression equation, expressed in terms of % test samples.

Source: https://www.sciencedirect.com/science/article/abs/pii/S2589014X20300360

Table 1: Soil physicochemical properties.

	Unamended soil	Amended soil
Texture class (USDA)	Loam	Loam
Coarse sand (%)	17.9	14.5
Fine sand (%)	21.3	25.1
Total silt (%)	37.5	44.0
Total clay (%)	23.4	15.7
Carbonates (%)	54.7	44.0
Organic Matter (%)	1.0	19.5
Total C organic (% DW)	0.6	7.3
Total N (% DW)	0.1	0.9
C organic/N organic	6.7	8.6
Total S (% DW)	<0.05	<0.05
pH (1:2.5)	7.9	8.0
[Cr] (C) (mg kg^{-1})	25.2	25.5
[Cr] (M) (mg kg^{-1})	125.2	124.9
[Cr] (H) (mg kg^{-1})	325.9	324.9
[Lindane] (C) (mg kg^{-1})	0	0
[Lindane] (M) (mg kg^{-1})	13.6	15.3
[Lindane] (H) (mg kg^{-1})	14.0	13.3

Pollution level: control (C), moderate (M), high (H).

Table 2: Plant parameters. Shoot dry biomass (DW), total chlorophyll (Chl a+b), ratio of antheraxanthin + zeaxanthin: violaxanthin + antheraxantin + zeaxanthin (AZ:VAZ), and total carotenoid content (Carot).

	type	Treatment	C	M	H
Shoot DW (g)	U	Bn	1.2 ± 0.1 b	Ø	Ø
		Ac + Bn	1.4 ± 0.1 b1	0.61 ± 0.03 2	Ø
		Ac + Bn + Ef	2.1 ± 0.2 a	Ø	Ø
	A	Bn	3.2 ± 0.2 c3*	7.4 ± 0.2 a1	5.29 ± 0.23 a2
		Ac + Bn	6.1 ± 0.2 a2*	8.0 ± 0.1 a1*	5.31 ± 0.06 a3
		Ac + Bn + Ef	4.5 ± 0.2 b1*	4.7 ± 0.2 b1	4.64 ± 0.02 b1
Chl aþb (pmol mm^{-2})	U	Bn	103.9 ± 11.8 a	Ø	Ø
		Ac + Bn	104.2 ± 11.5 a2	344.4 ± 20.8 1	Ø
		Ac + Bn + Ef	157.7 ± 3.13 a	Ø	Ø
	A	Bn	196.6 ± 9.8 a2*	301.8 ± 35.9 a1	311.09 ± 15.89 a1
		Ac + Bn	220.2 ± 27.1 a1*	258.3 ± 60.8 a1*	169.63 ± 6.24 b1
		Ac + Bn + Ef	258.2 ± 20.2 a1*	300.5 ± 23.5 a1	296.63 ± 43.41 a1
AZ:VAZ	U	Bn	0.37 ± 0.03 a	Ø	Ø
		Ac + Bn	0.25 ± 0.03 b1	0.04 ± 0.00 2	Ø
		Ac + Bn + Ef	0.20 ± 0.04 b	Ø	Ø
	A	Bn	0.15 ± 0.04 a*	0.13 ± 0.04 a	0.11 ± 0.03 b
		Ac + Bn	0.10 ± 0.01 a2*	0.08 ± 0.03 a2	0.27 ± 0.02 a1
		Ac + Bn + Ef	0.10 ± 0.01 a*	0.09 ± 0.02 a	0.11 ± 0.01 b

Carot (pmol mm^{-2})	U	Bn	35.1 ± 3.9 a	Ø	Ø
		Ac + Bn	36.3 ± 2.1 a2	101.6 ± 6.7 1	Ø
		Ac + Bn + Ef	51.5 ± 8.1 a	Ø	Ø
	A	Bn	63.03 ± 2.6 a2∗	92.9 ± 9.8 a1	93.9 ± 5.8 a1
		Ac + Bn	72.2 ± 7.8 a12∗	82.7 ± 17.1 a1	53.2 ± 1.8 b2
		Ac + Bn + Ef	78.6 ± 5.7 a1∗	90.2 ± 6.9 a1	91.8 ± 12.3 a1

Soil types: unamended (U), amended with organic matter (A).
Pollution level: control (C), moderate (M), high (H).
Treatments: *Brassica napus* (Bn), actinobacteria + *B. napus* (Ac + Bn), actinobacteria + *B. napus* + *Eisenia fetida* (Ac + Bn + Ef).
Ø indicates that no specimen survived the treatment.
Different letters indicate statistical significance (P < 0.05) between biological treatments, and numbers indicate statistical significance (P < 0.05) between pollution levels.
∗ indicates statistical significance (P < 0.05) between homologous treatments with and without organic amendment.

Table 3: Weight loss of *Eisenia fetida* worms in the pots during the experiment.

Soil type	Treatment	C	M	H
U	Ef	44.2 ± 0.7 b2	77.2 ± 0.9 a1	Ø
	Ac + EF	42.5 ± 2.8 b2	61.4 ± 2.3 b1	Ø
	Ac + Bn + Ef	54.8 ± 1.6 a2	63.3 ± 2.5 b1	Ø
A	Ef	34.5 ± 0.9 a2∗	34.4 ± 2.1 a2∗	52.6 ± 2.0 b1∗
	Ac + Ef	8.35 ± 2.0 b3∗	19.4 ± 2.2 b2∗	38.2 ± 1.5 c1∗
	Ac + Bn + Ef	38.8 ± 0.6 a2∗	38.9 ± 3.7 a2∗	64.9 ± 1.9 a1∗

Soil types: unamended (U), amended with organic matter (A).

Pollution level: control (C), moderate (M), high (H).

Treatments: *Eisenia fetida* (Ef), actinobacteria + *E. fetida* (Ac + Ef), actinobacteria + *Brassica napus* + *E. fetida* (Ac + Bn + Ef).

Ø indicates that no specimen survived that treatment.

Different letters indicate statistical significance (P < 0.05) between biological treatments, and numbers indicate statistical significance (P < 0.05) between pollution levels.

* indicates statistical significance (P < 0.05) between homologous treatments with and without organic amendment.

Source: https://www.sciencedirect.com/science/article/pii/S2405844020313943

Bioremediation of Lindane-contaminated soils by combining of bioaugmentation and biostimulation: Effective scaling-up from microcosms to mesocosms. (2020)

Table 1: Physicochemical characteristics of the three different soils and sugarcane filter cake.

Parameters	Soil #1	Soil #2	Soil #3	Parameters	Sugarcane filter cake
pH[a]	7.6	7.3	6.2	pH[f]	5.8
Totalorganiccarbon(%)[b]	0.80	0.61	0.58	Total organic carbon(%)[g]	42.60
Oxidizableorganicmatter(%)[b]	1.30	1.05	1.00	Total organic matter(%)[g]	73.40
Available phosphorus(%)[c]	0.002	0.004	0.002	Total phosphorus(%)[h]	0.880
Totalnitrogen(%)[d]	0.10	0.07	0.04	Total nitrogen (%)[d]	2.43
C/N ratio	8.0	8.7	14.5	C/N ratio	17.5
Clay(%)[e]	14.3	62.5	2.5	Ashes (%)	25.3
Silt(%)[e]	59.8	13.8	4.0	Potassium (%)[h]	0.73
Sand (%)[e]	25.9	23.7	93.5	Calcium (%)[i]	3.36
Texture[e]	Silty Loam (SLS)	Clayey (CS)	Sandy (SS)	Magnesium (%)[i]	0.21
				Iron(ppm)[j]	17.0
				Zinc(ppm)[j]	40.5

a =Soil to distilled water ratio of 1:2.5.
b =Walkley-Black method.
c =Bray-Kurtz method.
d =Kjeldahl method.
e =Analysis by hydrometer: modification of the Bouyoucos method.
f =Chemical reaction by potentiometry in saturated paste and extract.
g =Calcination.
h =Spectrophotometry.
i =EDTA titration method in hydrochloric acid extract of carbonated ashes.
j =Atomic absorption spectrometry.

Table 2: Experimental conditions employed to study the bioremediation of Lindane-contaminated soils.

Treatments	Mesocosms	Soil(g)	SCFC(g)	SP(mm)	MC(%)	Consortium	Lindane
Bioremediated SLS mesocosm	SLS-BA-BS	980	20	0.5	20	2 g kg^{-1} soil	2 mg kg^{-1} soil
Contaminated SLS mesocosm	SLS-Cont	1000	–	–	20	–	2 mg kg^{-1} soil
Natural SLS mesocosm	SLS-Nat	1000	–	–	20	–	–
Bioremediated SLS mesocosm	CS-BA-BS	900	100	0.5	20	2 g kg^{-1} soil	2 mg kg^{-1} soil
Contaminated SLS mesocosm	CS-Cont	1000	–	–	20	–	2 mg kg^{-1} soil
Natural SLS mesocosm	CS-Nat	1000	–	–	20	–	–
Bioremediated SLS mesocosm	SS-BA-BS	980	20	0.5	30	2 g kg^{-1} soil	2 mg kg^{-1} soil
Contaminated SLS mesocosm	SS-Cont	1000	–	–	30	–	2mg kg^{-1} soil
Natural SLS mesocosm	SS-Nat	1000	-	–	30	–	–

SCFC: Proportion of sugarcane filter cake; MC: Moisture content; SP: Size of sugar cane filter cake particles; SLS: Silty loam soil; CS: Clayey soil; SS: Sandy soil; BA: Bioaugmented; BS: Biostimulated; Cont: Contaminated; Nat: Natural.

Table 3: First-order kinetic parameters for lindane removal. Different letters indicate significant differences between treatments (contaminated and bioremediated mesocosms) for each type of soil ($p < 0.05$, Tukey test). (a, b) and (a', b') were used for comparisons among treatments for removal constant (k) and half-life time ($T_{1/2}$), respectively.

Mesocosms	**First-order kinetic parameters**			
	Equation	R^2	$k(d^{-1})$	$T_{1/2}$**(d)**
SLS-Cont	y=-0.007x+0.797	0.961	0.007 ± 0.001^{a}	$99.0 \pm 0.1^{a'}$
SLS-BA-BS	y=-0.027x+0.834	0.974	0.027 ± 0.002^{b}	$25.7 \pm 0.1^{b''}$
CS-Cont	y=-0.007x+0.829	0.970	0.007 ± 0.001^{a}	$99.0 \pm 0.1^{a'}$
CS-BA-BS	y=-0.016x+0.838	0.961	0.016 ± 0.001^{b}	$43.3 \pm 0.1^{b'}$
SS-Cont	y=-0.007x+0.413	0.930	0.007 ± 0.001^{a}	$99.0 \pm 0.1^{a'}$
SS-BA-BS	y=-0.030x+0.747	0.974	0.030 ± 0.002^{b}	$23.1 \pm 0.1^{b'}$

SLS: Silty loam soil; CS: Clayey soil; SS: Sandy soil; BA: Bioaugmented; BS: Biostimulated; Cont: Contaminated.

Table 4: Germination percentages (G) and vigor indexes (VI) of *L. sativa*, *R. sativus*, and *L. esculentum* on mesocosm samples taken at 63 days of incubation. Different letters indicate significant differences between treatments (natural, contaminated, and bioremediated mesocosms) for each type of soil ($p < 0.05$, Tukey test). (a, b, c), (a', b',c'), and (a'', b'', c'') were used for comparisons among treatments for *L. sativa*, *R. sativus*, and *L. esculentum*, respectively.

Mesocosms	*L.sativa*		*R.sativus*		*L.esculentum*	
	G	VI	G	VI	G	VI
SLS-Nat	93±2^{a}	55.1±0.8^{a}	93±7$^{a'}$	123.7±6.3$^{a'}$	92±2$^{a''}$	106.1±3.9$^{a''}$
SLS-Cont	90±2^{a}	45.9±1.7^{b}	91±5$^{a'}$	98.2±6.2$^{b'}$	91±4$^{a''}$	71.9±5.0$^{b''}$
SLS-BA-BS	90±1^{a}	52.5±2.1^{a}	97±3$^{a'}$	119.4±4.8$^{a'}$	92±5$^{a''}$	93.2±5.8$^{c''}$
CS-Nat	93±1^{a}	63.6±1.2^{a}	94±2$^{a'}$	122.8±5.5$^{a'}$	99±2$^{a''}$	141.7±3.9$^{a''}$
CS-Cont	90±4^{a}	54.7±2.2^{b}	96±2$^{a'}$	104.7±6.0$^{b'}$	94±4$^{a''}$	77.4±3.8$^{b''}$
CS-BA-BS	93±2^{a}	61.1±2.0^{a}	94±2$^{a'}$	117.2±5.2$^{a'}$	97±0$^{a''}$	112.5±0.8$^{c''}$
SS-Nat	93±2^{a}	64.4±2.5^{a}	96±2$^{a'}$	124.0±3.1$^{a'}$	94±2$^{a''}$	123.2±3.6$^{a''}$
SS-Cont	93±2^{a}	57.3±1.4^{b}	90±6$^{a'}$	97.7±4.4$^{b'}$	94±5$^{a''}$	84.4±4.0$^{b''}$
SS-BA-BS	97±3^{a}	68.5±3.0^{a}	92±2$^{a'}$	112.4±2.8$^{c'}$	98±2$^{a''}$	115.9±4.9$^{a''}$

SLS: Silty loam soil; CS: Clayey soil; SS: Sandy soil; BA: Bioaugmented; BS: Biostimulated; Cont: Contaminated.

Source: https://sci-hub.hkvisa.net/10.1016/j.jenvman.2020.111309

Enhanced bioremediation of lindane-contaminated soils through microbial bioaugmentation assisted by biostimulation with sugarcane filter cake (2020)

Table 1: Physico-chemical characteristics of soils and sugarcane filter cake employed in the study.

Parameters	Soil #1	Soil #2	Soil #3	Sugarcane filter cake
pH	7.6	7.3	6.2	-
Organic carbon (%)	0.80	0.61	0.58	73.40
Oxidizable organic matter (%)	1.30	1.05	1.00	42.60
Total phosphorus (%)	0.002	0.004	0.002	0.880
Total nitrogen (%)	0.10	0.07	0.04	2.43
Clay (%)	14.3	62.5	2.5	-
Silt (%)	59.8	13.8	4.0	-
Sand (%)	25.9	23.7	93.5	-
Texture	Silty Loam (SLS)	Clayey(CS)	Sandy(SS)	-

Table 2: Twenty four runs of the factorial designs for optimization of lindane bioremediation process by the bioaugmentation with an actinobacteria consortium, in different soils biostimulated with sugarcane filter cake.

Conditions	A	B	C	Lindane removal (%): SLS		Lindane removal (%): CS		Lindane removal (%): SS	
				Exp	Pred	Exp	Pred	Exp	Pred
1	2	20	0.5	63.0	61.4	48.7	49.1	63.2	69.5
	2	20	0.5	58.9	61.4	50.4	49.1	74.6	69.5
	2	20	0.5	62.2	61.4	48.1	49.1	70.6	69.5
2	10	20	0.5	44.2	49.0	73.1	70.8	45.9	47.1
	10	20	0.5	54.8	49.0	69.0	70.8	52.7	47.1
	10	20	0.5	48.0	49.0	70.5	70.8	42.8	47.1
3	2	30	0.5	53.7	54.7	22.5	21.5	86.1	86.3
	2	30	0.5	58.9	54.7	22.0	21.5	85.9	86.3
	2	30	0.5	51.6	54.7	19.9	21.5	87.0	86.3
4	10	30	0.5	37.8	37.8	32.8	38.8	71.5	68.7
	10	30	0.5	38.2	37.8	41.1	38.8	66.6	68.7
	10	30	0.5	37.3	37.8	42.4	38.8	67.9	68.7
5	2	20	5.0	47.6	49.2	49.0	48.2	67.4	71.7
	2	20	5.0	53.4	49.2	47.4	48.2	72.3	71.7
	2	20	5.0	46.4	49.2	48.2	48.2	75.5	71.3
6	10	20	5.0	21.9	20.0	66.7	68.7	49.0	48.0
	10	20	5.0	20.2	20.0	71.6	68.7	46.9	48.0
	10	20	5.0	18.1	20.0	67.8	68.7	48.0	48.0
7	2	30	5.0	48.8	45.0	34.8	36.4	82.2	82.9
	2	30	5.0	40.8	45.0	37.6	36.4	83.6	82.9
	2	30	5.0	45.4	45.0	36.9	36.4	83.1	82.9
8	10	30	5.0	39.6	35.8	39.9	36.9	60.8	58.6
	10	30	5.0	29.7	35.8	40.6	36.9	56.5	58.6
	10	30	5.0	38.2	35.8	30.0	36.9	58.6	58.6

A: Proportion of sugarcane filter cake (%); B: Moisture content (%); C: Size of sugarcane filter cake particles (mm); SLS: Silty loam soil; CS: Clayey soil; SS: Sandy soil; Exp: Experimental values; Pred: Predicted values.

Table 3: Analysis of variance and estimated effects of factors on lindane removal (%) in bioaugmented and biostimulated microcosms, at 14 days of incubation.

Source	BABS SLS						BABS CS						BABS SS					
	ANOVA			Estimated effects			ANOVA			Estimated effects			ANOVA			Estimated effects		
	DF	F-value	p-value	Effect	t-value	Remarks	DF	F-value	p-value	Effect	t-value	Remarks	DF	F-value	p-value	Effect	t-value	Remarks
Model	7	35.58	0.000				7	85.47	0.000				7	57.65	0.000			
Linear	3	66.86	0.000				3	181.33	0.000				3	130.20	0.000			
A	1	123.82	0.000	−16.90	−11.13	S	1	136.37	0.000	15.00	11.68	S	1	263.66	0.000	−22.03	−16.24	S
B	1	1.07	0.317	−1.57	−1.03	I	1	403.80	0.000	−25.81	−20.09	S	1	123.30	0.000	15.06	11.10	S
C	1	75.69	0.000	−13.21	−8.70	S	1	3.82	0.068	2.510	1.95	I	1	3.64	0.075	−2.59	−1.91	I
2-Way Interaction	3	10.72	0.000				3	15.05	0.000				3	4.02	0.026			
A*B	1	6.42	0.022	3.85	2.53	S	1	22.94	0.000	−6.153	−4.79	S	1	0.58	0.458	1.03	0.76	I
A*C	1	2.14	0.163	−2.22	−1.46	I	1	12.45	0.003	−4.533	−3.53	S	1	2.21	0.157	−2.02	−1.49	I
B*C	1	23.59	0.000	7.37	4.86	S	1	9.74	0.007	4.010	3.12	S	1	9.27	0.008	−4.13	−3.04	S
3-Way Interaction	1	16.32	0.001				1	9.20	0.008				1	0.92	0.351			
A*B*C	1	16.32	0.001	6.14	4.04	S	1	9.20	0.008	−3.896	−3.03	S	1	0.92	0.351	−1.30	−0.96	I
Error	16						16						16					
Total	23						23						23					

SLS: Silty loam soil; CS: Clayey soil; SS: Sandy soil; BABS: Bioaugmented and Biostimulated; DF: Total degrees of freedom; A: SCFC proportion (%); B: Moisture content (%); C: Size of SCFC particles (mm); S: Significant; I: Insignificant.

Table 3: Optimal conditions for lindane removal in bioaugmented and biostimulated microcosms, obtained through factorial designs after run the response optimizer (Minitab 17).

Microcosms	SCFC proportion (%)	Moisture content (%)	Size of SCFC particles (mm)
BABSSLS	2	20	0.5
BABSCS	10	20	0.5
BABSSS	2	30	0.5

SCFC: Sugarcane filter cake; SLS: Silty loam soil; CS: Clayey soil; SS: Sandy soil; BABS: Bioaugmented and Biostimulated.

Source: https://www.sciencedirect.com/science/article/abs/pii/S0147651319314745

Assembly and variation of root-associated microbiota of rice during their vegetative growth phase with and without Lindane pollutant (2020)

Table 1: Soil basic properties

Soil type	pH	OM (%)	TC (%)	TN (%)	AP (mg kg^{-1})	AK (mg kg^{-1})	SO42– (mg kg^{-1})	Fe(II) (mg kg^{-1})	Clay% (%)	Silt% (%)	Sand % (%)
Soil 1	6.76	5.44	1.95	0.21	3.28	2.15	15.78	910.3	36.3	45.3	18.4
Soil 2	4.54	1.56	1.51	0.19	1.38	4.58	4.45	139.8	17.8	63.9	18.3

Abbreviations: OM, organic matter; TC, total carbon; TN, total nitrogen; AP, available phosphorus; AK, available potassium.

Table 2: The impacts of variables on the microbial community described by PERMANOVAa.

	df	SS	MS	F. Model	R^2	P value[c]	
Growth time	1	4.491	4.4906	32.225	0.12473	0.001	***
Pollution	1	0.156	0.1561	1.120	0.00433	0.326	
Compartment	2	4.043	2.0215	14.507	0.11230	0.001	***
Soil type	1	1.328	1.3285	9.533	0.03690	0.001	***
Growth time × pollution[b]	1	0.166	0.1657	1.189	0.00460	0.270	
Growth time × compartment	2	1.194	0.5968	4.282	0.03315	0.001	***
Pollution × compartment	2	0.388	0.1939	1.391	0.01077	0.138	
Growth time × soil type	1	3.686	3.6860	26.451	0.10238	0.001	***
Pollution soil × type	1	0.170	0.1698	1.219	0.00472	0.260	
Compartment × soil type	2	1.382	0.6911	4.960	0.03839	0.001	***
Growth time × pollution × compartment	2	0.348	0.1741	1.250	0.00967	0.195	
Growth time × pollution × soil type	1	0.191	0.1912	1.372	0.00531	0.167	
Growth time × compartment × soil type	2	2.271	1.1353	8.147	0.06307	0.001	***
Pollution × compartment × soil type	2	0.212	0.1061	0.761	0.00589	0.767	
Growth time × pollution × compartment × soil type	2	0.231	0.1156	0.830	0.00642	0.695	
Residuals	113	15.747	0.1394	0.437			
Total	136	36.003	1				

PERMANOVA, permutational multivariate analysis of variance; df, degree of freedom; SS, sums of squares; MS, mean square; “,” interactions between environment variables; Adjusted-P value: *, P < 0.05; **, P < 0.01; ***, P < 0.001.

Table 3: Concentrations of environmental variables in different treatments

Treatment	Date day	Root accumulation (mg kg^{-1})	Soil residual lindane (mg kg^{-1})	p^H	DO (μmol L^{-1})	DOC (mg kg^{-1})	DON (mg kg^{-1})	NH_4^+-N (mg kg^{-1})	Fe(II) (mg kg^{-1})	SO_4^{2-} (mg kg^{-1})
CK-S1-UP[a]	10	/[b]	/	7.21±0.05	5.47±0.86	535.3±73.6	109.4±17.9	204.8±25.6	1172.5±170.3	2.75±0.60
	30	/	/	7.24±0.07	5.82±0.92	144.6±44.6	12.1±4.1	184.3±12.1	2152.0±232.6	0.45±0.11
	60	/	/	7.49±0.10	5.68±0.65	188.5±2.9	8.4±0.3	146.8±10.8	2460.3±440.0	0.30±0.08
CK-S1-P	10	/	13.13±1.09a[c]	6.86±0.57	5.62±0.85	452.7±96.9	82.0±14.5	163.8±12.4	974.1±189.5	3.58±0.32
	30	/	1.13±0.18b	7.27±0.09	6.30±0.93	227.3±28.9	20.5±2.6	148.8±23.1	2309.1±178.7	1.04±0.33
	60	/	0.87±0.01c	7.67±0.04	5.67±0.66	232.9±8.9	10.4±0.6	103.8±7.7	2490.6±382.5	0.70±0.91
CK-S2-UP	10	/	/	5.67±0.06	5.41±0.70	354.6±77.0	49.7±4.9	94.7±4.9	224.3±21.7	1.84±0.3
	30	/	/	5.54±0.12	6.20±0.87	135.3±41.9	22.1±5.1	63.9±10.1	398.6±44.3	0.72±0.14
	60	/	/	5.20±0.08	5.92±0.89	115.6±52.8	18.2±6.6	56.9±8.1	484.9±70.4	0.42±0.18
CK-S2-P	10	/	21.90±0.34a	5.62±0.06	5.97±0.54	291.6±56.1	42.8±3.0	85.9±3.3	152.9±30.5	2.17±0.45
	30	/	1.84±0.09b	5.60±0.10	6.04±0.72	101.5±4.4	19.2±1.6	54.0±9.8	425.3±80.4	0.86±0.48
	60	/	1.07±0.05c	4.95±0.11	6.20±0.48	80.4±25.0	14.5±3.9	39.4±9.9	492.2±67.9	0.24±0.12
Ri-S1-UP	10	/	/	6.87±0.02	65.6±22.8	321.1±407.1	103.5±9.4	223.9±32.2	1003.3±260.6	2.61±0.42
	30	/	/	6.89±0.07	111.6±16.1	197.7±46.6	14.1±6.5	20.7±18.9	2773.9±318.0	0.58±0.16
	60	/	/	7.29±0.03	140.5±24.4	143.1±7.7	3.2±0.3	19.7±3.5	2298.3±188.9	0.19±0.02
Ri-S1-P	10	0.08±0.01a	11.94±0.84a	6.91±0.05	80.4±10.5	240.2±117.2	81.3±19.5	209.0±2.1	654.2±34.0	3.73±1.02
	30	0.55±0.05b	1.24±0.05b	7.06±0.13	121.1±18.1	189.8±28.2	11.4±3.7	16.4±4.7	2304.5±314.6	0.86±0.33
	60	1.02±0.13c	0.92±0.01c	7.31±0.08	137.7±16.6	275.2±13.3	4.4±0.5	18.9±4.1	2275.1±117.1	0.22±0.01
Ri-S2-UP	10	/	/	5.55±0.09	83.1±7.7	105.2±152.1	47.1±3.6	85.9±21.5	2275.1±117.1	1.75±0.38
	30	/	/	5.11±0.04	119.2±17.2	73.2±11.7	8.8±1.6	7.6±2.0	319.5±66.1	0.69±0.49
	60	/	/	4.96±0.08	139.8±18.5	98.4±8.2	11.9±0.7	13.9±3.4	359.6±33.4	0.13±0.05
Ri-S2-P	10	0.10±0.01a	19.97±0.40a	5.16±0.04	75.2±13.3	95.0±66.7	45.1±3.1	102.5±7.5	186.3±34.6	1.84±0.46
	30	0.57±0.19b	2.14±0.23b	5.07±0.05	102.2±15.1	58.7±7.5	8.0±1.0	9.0±3.2	365.7±73.4	0.90±0.33
	60	1.21±0.30c	1.12±0.14c	4.90±0.03	143.2±12.1	77.4±3.4	9.9±0.3	12.7±0.9	428.8±119.3	0.19±0.02

Abbreviations: CK-S1, the unplanted control in soil 1; CK-S2, the unplanted control in soil 2; Ri-S1, the rice planted treatment in soil 1; Ri-S2, the rice planted treatment in soil 2; UP, unpolluted treatment; P, polluted treatment. DO, dissolved oxygen; DOC, dissolved organic carbon; DON, dissolved organic nitrogen. /, not applicable. Values are means±standard errors of three replications; Values within a column followed by a common letter are not significantly different (P< 0.05).

Source: https://link.springer.com/content/pdf/10.1007/s42832-020-0063-1.pdf

Assembly of root-associated microbiomes of typical rice cultivars in response to lindane pollution (2019)

Table 1: The height and biomass of different rice cultivars, and their accumulation amount for lindane.

Cultivars[a]	**Pollution dose**[b]	**Root**			**Shoot**		
	($mgkg^{-1}$)	Length (cm)	Biomass(g FW plant^{-1})	Lindane (μg kg^{-1})	Height (cm)	Biomass (g FW plant^{-1})	Lindane (μg kg^{-1})
	0	19.6 ±1.2cd[c]	5.04 ± 0.65bc	nd[d]	69.7 ± 0.9e	24.7 ± 2.81 cd	nd
	5	18.2 ± 2.4d	5.00 ± 0.37bc	59.1 ± 13.5b	66.4 ± 1.4f	25.2 ± 0.75 cd	16.5 ± 6.81ab
	20	19.1 ± 1.5 cd	4.12 ± 0.19c	164.0 ±40.0a	68.0 ± 1.5ef	20.8 ± 1.05d	31.2 ± 10.1a
	0	23.3 ± 1.6a	6.75 ± 0.58a	nd	83.2 ± 1.1bcd	34.4 ± 2.80ab	nd
	5	22.5 ± 1.3ab	6.09 ± 0.36ab	64.7 ± 49.6b	87.5 ± 1.2ab	36.0 ± 5.50ab	nd
	20	23.1 ± 1.6a	4.12 ± 0.60c	137.4 ±43.2a	88.1 ± 4.9a	32.2 ± 0.43bc	26.7 ± 15.4a
	0	20.2 ±1.8bcd	5.97 ± 0.29ab	nd	80.5 ± 1.9d	42.0 ± 3.65a	nd
	5	21.3 ±1.0abc	6.09 ± 0.71ab	72.3 ± 16.1b	81.3 ± 2.1 cd	40.1 ± 1.89a	6.4 ± 2.62b
	20	**21.5 ±0.7abc**	**6.75 ± 1.25a**	**167.3 ± 28.8a**	**85.7 ± 0.8abc**	**37.2 ± 7.20ab**	22.3 ± 14.7ab

a Abbreviations: XS, japonica cultivar XS519; HHZ, indica cultivar HHZ; YY, hybrid cultivar YY12.

b Lindane spiked concentration (mg kg^{-1}).

c Values are means ± standard errors of three replications; values within a column followed by a common letter are not significantly different ($P < 0.05$).

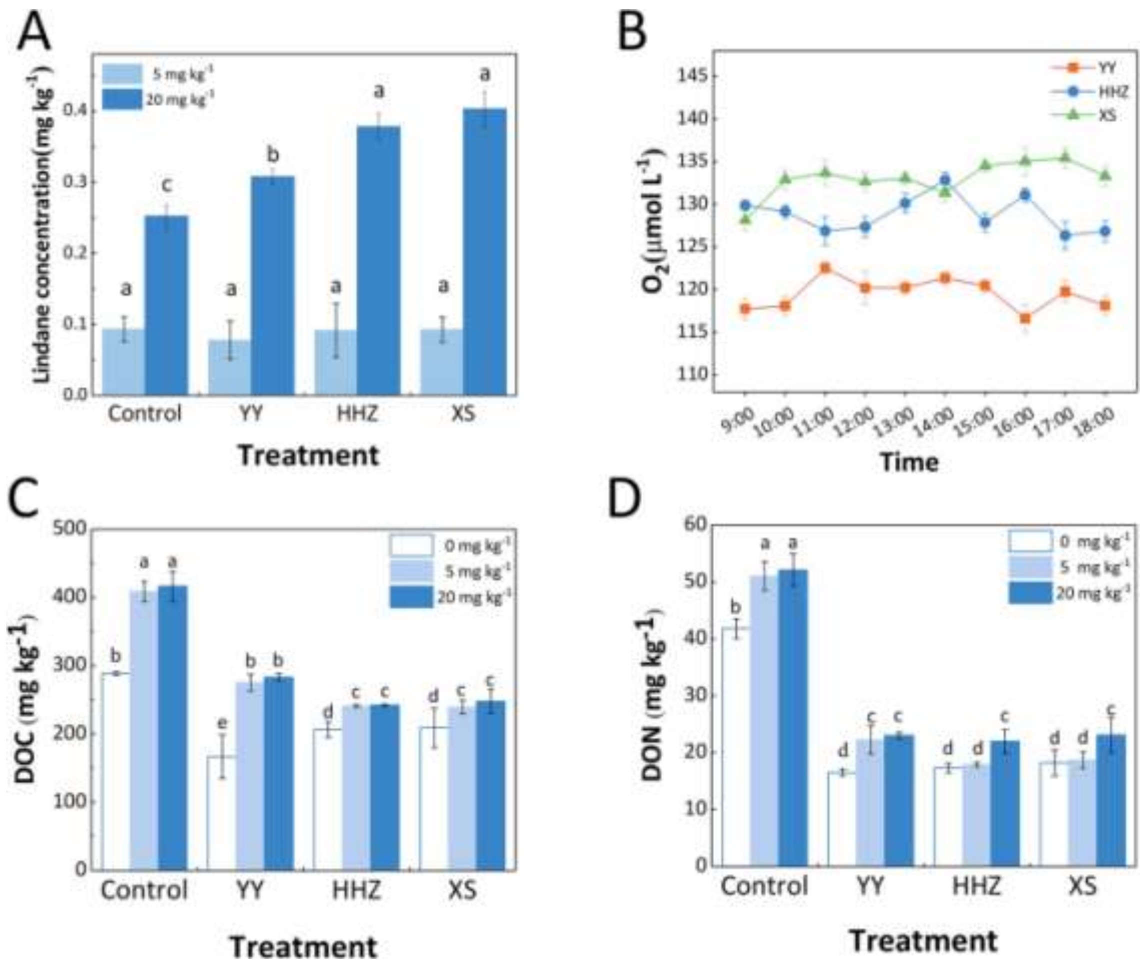
d nd: not detected.

After 60 days of growth, no visible symptoms of lindane toxicity were observed for all cultivars of rice. The root length, shoot height and biomass of roots and shoots presented no consistent difference between polluted and unpolluted treatments. The hybrid YY showed the maximum biomass in both roots and shoots (6.75 g and 41.95 g respectively), and indica HHZ had the highest while japonica XS the lowest shoot height and root length.

Source: http://sci-hub.tw/https://doi.org/10.1016/j.envint.2019.104975

Assembly of root-associated microbiomes of typical rice cultivars in response to lindane pollution (2019)

Table 1: The concentration of residual lindane in rhizosphere soils after 60-day growth of rice (A), the average radial oxygen loss (ROL) among different rice cultivars (B), and concentrations of dissolved organic carbon (DOC) (C) and dissolved total nitrogen (DTN) (D) among three rice cultivars at lindane doses of 0, 5 and 20 mg kg^{-1}.



Bars are the standard error of means of three replicates. Different letters indicate significant differences among treatments at the P < 0.05 level. Abbreviations for treatments: Control: the control without rice; XS, japonica cultivar XS519; HHZ, indica cultivar HHZ; YY, hybrid cultivar YY12.

The unplanted control resulted in the lowest concentration of residual lindane in soils, with 0.09 and 0.25 mg kg^{-1} at 5 and 20 mg kg^{-1} of lindane, respectively; while rice growth significantly inhibited lindane dissipation in soils in highly polluted soil, with a residual concentration ranging from 0.30 to 0.40 mg kg^{-1} ($P < 0.05$). Among the three cultivars, lindane concentration in rhizosphere soils of hybrid YY was significantly lower than those of conventional indica HHZ and japonica XS at highly polluted treatments ($P < 0.05$).

Source: http://sci-hub.tw/https://doi.org/10.1016/j.envint.2019.104975

Evaluation of the effectiveness of a bioremediation process in experimental soils polluted with chromium and lindane (2019)

Table 1: Inhibition of germination [IG (%)] *in L. esculentum, R. sativus, L. sativa* and *Z. mays*. Treatments: I) Non-contaminated soil; II) Soil contaminated with lindane 25 μg kg^{-1}; III) Soil contaminated with Cr (VI) 50 mg kg^{-1} ; IV) Soil contaminated with Cr(VI) 50 mg kg^{-1} and lindane 25 μg kg^{-1} ; V) Soil contaminated with Cr(VI) 50 mg kg^{-1} and lindane 25 μg kg^{-1} and after 14 days of stabilization, inoculated with the quadruple actinobacteria consortium. Values that sharing the same letter were not significantly different ($p < 0.05$).

Treatment	**Residual concentrations**	**(Inhibition of germination) IG (%)**			
	Lindane (μg kg^{-1})	***L. esculentum***	***L. sativa***	***R. sativus***	***Z. mays***
I	0	5 ± 2%^{a}	5 ± 2%$^{a'}$	4 ± 3%$^{a''}$	3 ± 3%$^{a'''}$
II	25	17 ± 3%^{b}	2 ± 1%$^{a'}$	2 ± 1%$^{a''}$	6 ± 2%$^{a'''}$
III	0	57 ± 1%^{c}	72 ± 4%$^{b'}$	65 ± 5%$^{b''}$	3 ± 1%$^{a'''}$
IV	25	± 4%^{d}	75 ± 3%$^{b'}$	63 ± 3%$^{b''}$	8 ± 4%$^{a'''}$
V	5	26 ± 2%^{e}	48 ± 4%$^{c'}$	31 ± 4%$^{c''}$	0 ± 0%$^{a'''}$

a Media ± standard deviation.

b The values indicated in treatments II, III and IV corresponds to the concentration achieved after the stabilization period (14 days) and maintained after the incubation period (14 days); in V corresponds to the concentration determined after stabilization and bioremediation periods (28 days).

The IG, evaluated in L. sativa and R. sativus, did not show significant differences between the control (treatment I) and the soil contaminated with lindane (treatment II), indicating that the concentration of lindane used did not cause an appreciable toxic effect for these species. The IG of L. esculentum presented significant differences among the five treatments tested, demonstrating differential sensitivity to individual toxicants.

Source: http://sci-hub.tw/https://doi.org/10.1016/j.ecoenv.2019.06.019

Lindane degradation by root epiphytic bacterium Achromobacter sp. strain A3 from Acorus calamus and characterization of associated proteins. (2019)

Table 1: Average rate and kinetic parameters for lindane degradation at different concentrations by isolated bacterial strain Achromobacter sp. A3.

Lindane concentration (mg l^{-1})	**Average rate of degradation (mg l^{-1} day^{-1})**	**K (d^{-1})**	**$T_{1/2}$ (d)**	**R^2**
10	0.61	0.169	4.1	0.993
50	2.96	0.146	4.75	0.971
100	4.55	0.077	9	0.977

Average rate of lindane degradation increased with increase in lindane concentration as the rate of reaction at any time depends on the concentrations of the reactants at that particular time.

Source: https://sci-hub.tw/10.1080/15226514.2018.1524835

Lindane dissipation in a biomixture: Effect of soil properties and bioaugmentation (2018)

Table 1: First-order kinetic parameters for lindane removal in biomixtures formulated with different soil types bioaugmented and non-bioaugmented, with two successive pesticide additions (100mgkg^{-1}, each one). Different letters indicate significant differences between bioaugmented and non-bioaugmented systems ($p < 0.05$, Tukey test)

Biomixtures	**Parameters**					
	k (d^{-1})	**$t_{1/2}$ (d)**	**k (d^{-1})**		**$t_{1/2}$ (d)**	
	Fist lindane contamination		**Second lindane contamination**			
CS-bioaugmented	0.028 ± 0.002[b]	25.0 ± 2.0[a]	0.022	± 0.002[a]	32.2	± 3.0[b]
CS-non-bioaugmented	0.013 ± 0.001[a]	51.7 ± 1.4[b]	0.043	± 0.001[b]	16.0	± 0.4[a]
SS-bioaugmented	0.034 ± 0.002[b]	20.2 ± 1.0[a]	0.011	± 0.003	63.1	± 16.1
SS-non bioaugmented	0.021 ± 0.001[a]	32.9 ± 2.0[b]	ND		ND	
SLS-bioaugmented	0.029 ± 0.002[a]	23.8 ± 1.9[a]	0.037	± 0.003[b]	18.8	± 1.7[a]
SLS-non bioaugmented	0.026 ± 0.001[a]	27.2 ± 1.3[a]	0.007	± 0.001[a]	99.8	± 1.6[b]

CS: clayey soil; SS: Sandy soil; SLS: silty loam soil; k: degradation constant; t1/2: half life time; ND: not determined.

Source: https://doi.org/10.1016/j.ecoenv.2018.03.011

Microbial-enhanced lindane removal by sugarcane (Saccharum officinarum) in doped soil-applications in phytoremediation and bioaugmentation.(2017)

Table 1: Comparison of reported works on the phytoremediation of lindane.

Plant species/Microorganism	Concentration of lindane	Lindane dissipation	References
Spinacia oleracea L.	20 mg/kg	61% after 45 days	Dubey et al., 2014
Withania somnifera Dunal	20 mg/g	73% after 145ays	Abhilash and Singh, 2010a
Sesamum indicum L	20 mg/g	58.7% after 124 days	Abhilash and Singh, 2010b
Lolium multiflorum Rye grass		120 h	Li et al., 2002
Transgenic Nicotiana tabacum		25% more removal	Singh et al., 2011
Jatropha curcas L	20 mg/kg	72% after 300 days	Abhilash et al., 2013
Transgenic Arabidopsis thaliana			Dick, 2014
Maize plants/Streptomyces strains	2 mg/kg	94.4% after 21 days	Alvarez et al., 2015
Maize plants/Streptomyces A5		55%	Alvarez et al., 2013
Cytisus striatus/Rhodococcus erythropolis ET54b & Sphingomonas sp. D4	35 mg/kg		Becerra-Castro et al., 2013a
Cytisus striatus/Rhodococcus erythropolis ET54b & Sphingomonas sp. D4	65 mg/kg	43-53% enhanced removal in 2 weeks	Becerra-Castro et al. 2013b
Saccharum sp/Candida VITJzN04	100 mg/kg	95% in 30 days	Present study

The Table briefs the previously reported works on phytoremediation of lindane using various plants. The lindane degradation efficiency exhibited by others reports were less compared to the results presented in this study. Therefore, treatment of lindane contaminated soil using phyto- myco treatment along with bio-stimulation is superior due to the great efficiency of Candida VITJzN04 both as a lindane degrader as well as plant growth promoter. The Saccharum-Candida inoculation could be useful as cheap and effective alternative for the bio-treatment of lindane impacted soil.

To survey the BCF for the radish in farm level, two sites contaminated with endosulfan (2.274 and 51.00 mg kg^{-1}) were selected at Gochang in South Korea. In this study, the BCF of endosulfans in the root was 0.015 and 0.071, respectively. The BCF of endosulfan sulfate was of the range 0.069–0.097. These BCFs for the radish were similar to the previous reports (Hwang et al. 2016).

Source: J Environ Manage. 2017 May 15;193:394-399. doi: 10.1016/j.jenvman.2017.02.006. Epub 2017 Mar 1.

Organochlorine phytotoxicity to alkaline soil/International journal of agricultural biology (2016)

Table 1: Shoot length; shoot dry weight, root length, root dry weight and seed germination of four plants grown in varying concentration of lindane-contaminated alkaline soil for 10 days. Values are the mean ±SD.

Plant	[Lindane] (mg/kg dry soil)	% seed germination	Shoot length (cm)	Shoot dry weight (mg)	Root length (cm)	Root dry weight (mg)
	0	100±0a	20.6± 1.5a	54.0±13.5a	14.6± 1.4a	**54.0± 13.5a**
Corn	0.2	85±5.8a	14.5± 1.5b	55.8±20.5a	10.4± 1.7b	**55.8± 20.5a**
	2	80±10a	14.0± 1.7b	53.0±15.1a	9.2±1.8bc	**48.4± 14.0a**
	20	75±5a	13.0± 1.2b	43.5±10.6a	7.0± 1.1c	**41.0± 18.3a**
Sunflower	0	100±0a	8.4± 1.0a	28.5±7.33a	7.9± 1.8a	**16± 3.6a**
	0.2	95± 5.8a	6.8±1.4ab	26.4±6.07a	4.3± 1.9b	**20.6± 8.8a**
	2	95± 5.8a	4.2± 0.9c	23.2±4.33a	3.9± 1.7b	**17.7± 4.2a**
	20	85± 5.8a	5.6±1.4bc	25.8±7.28a	4.0± 1.3b	**10.1± 5.5b**
Water morning glory	0	85± 5.8a	7.7± 0.9a	18.4± 2.8a	7.3± 0.6a	**7.0± 3.0a**
	0.2	75±5a	6.8±0.7ab	16.8± 6.0a	4.9± 0.9b	**6.9± 1.2a**
	2	45**±15b**	6.4**±0.9b**	16.7**±8.4a**	4.0**±0.7b**	**5.8±2.1a**
	20	65±15a	5.6±0.7b	14.3± 2.8a	3.6± 0.9b	**5.2± 1.3a**
Pumpkin	0	90±10a	2.3± 1.2a	63± 2.6a	6.5± 1.7a	**15± 1.0a**
	0.2	60±10b	8.0± 1.3b	61.0±1.7ab	1.8± 0.2b	**10.±4.5a**
	2	50±10b	3.8± 1.8c	57.0± 3.0b	1.8± 0.2b	**9.0±2.6b**
	20	**55±5b**	**4.4± 1.7c**	**54.7± 5.8b**	**1.8± 0.4b**	**9.0±.6b**

Source: Organochlorine phytotoxicity to alkaline soil/International journal of agricultural biology, vol. 14, no. 5, 2016