How does warming affects the lindane dissipation and microbial activity in Soil?

Vishal Tripathi* & P.C. Abhilash

Institute of Environment & Sustainable Development, Banaras Hindu University, Varanasi 221005, India

E-mail: vishalbiotechbhu@gmail.com; pca.iesd@bhu.ac.in

1. Introduction:

▪Lindane belongs to the category of Persistent Organic Pollutants (POPs). There is a growing global priority for the remediation and management of persistent organic pollutants (POPs)-contaminated soil since POPs are one of the toxic groups of chemical pollutants and listed under the Stockholm Convention for global elimination. They are potentially hazardous to living organism because of their higher degree of halogenations, inclination to bioaccumulate in the lipid component, and their resistance to natural degradation [1].

▪ In times of global warming, the remediation and management of soils contaminated with persistent organic pollutant is a challenging task as the increasing atmospheric temperature will accelerate the volatility and long-range transport of pollutants [Fig. 1 & 2].

▪Although numerous studies and models are available on the effect of climate change and atmospheric temperature on soil system, soil moisture, soil organic matter, carbon dynamics [2], there is limited information available on the effect of climate change fate and behaviour of soil pollutants [Fig. 2]. and its consequences for the phytoremediation and bioremediation [3].

2. Materials and Methods:

The top layer garden soils were collected and dried in room temperature and passed through a sieve of mesh size 2-mm. The soil samples were spiked with four different concentrations of lindane such as 5,10,15 and 20 mg kg^{-1}.

▪The dissipation assays were conducted as batch experiments. Sixteen batches of pots were prepared in triplicate and filled with 600 g garden soil having four different concentrations of lindane, i.e., 5, 10, 15 and 20 mg kg^{-1}. Each batches of pots were incubated at four different temperatures such as 28 ºC (room temperature and hence taken as the control), 33 ºC and two elevated temperatures viz. 40 and 48 ºC , respectively.

▪ The residual lindane, soil microbial biomass carbon (MBC) and soil dehydrogenase activity from all the pots were analysed at a time interval of 15, 30 and 45 days.

3. Result and Discussion:

The effect of warming temperatures (28–48 ºC) on residual lindane concentration in soil is presented in Fig. 3&4. Irrespective of the initial lindane concentrations, the residual lindane in soil samples were significantly decreased with increasing temperature ($p < 0.001$) and incubation periods. The residual lindane in all the four different spiked concentrations were decreased with increasing temperature and found in the decreasing order of 28 ºC < 33 ºC < 40 ºC < 48 ºC. This temperature effect was more pronounced in soil samples incubated at 40 and 48 ºC.

▪Further we also analysed the microbial biomass carbon (Table 1) and soil dehydrogenase activity (Table 2) which were found to be lower with increase in temperature. Thus microbial activity has no role in lowering down the concentration of lindane in soil and increasing temperatures had a significant effect on the removal of lindane from soil.

▪So it is presumable that major process responsible for an enhanced dissipation of lindane at increased temperature was the volatilization rather than microbial degradation.

4. Conclusions and future perspectives:.

▪The experimental results clearly indicate that an increase in temperature can significantly enhance the dissipation of lindane from soil and also altered the microbial biomass and soil enzymes. Therefore, the remediation and management of such POPs contaminated soils are urgently required in order to prevent the long-range atmospheric transport of such volatile pollutants from soil. More studies are required to pinpoint the fate of pesticides under warming temperature and elucidate the role of other players such as precipitation, increased CO2, soil organic matter, microbial diversity, etc. on the fate and behaviour of the pesticides under warming temperature.

▪Moreover, the remediation and management of contaminated soils in a changing climate will require inventive measures to characterize the contaminated soil (Fig 5) and harness the plant–microbe–chemical communications as low input biotechnology for the enhanced remediation of contaminated soils in a changing climate (Fig 6).

5. Acknowledgement:

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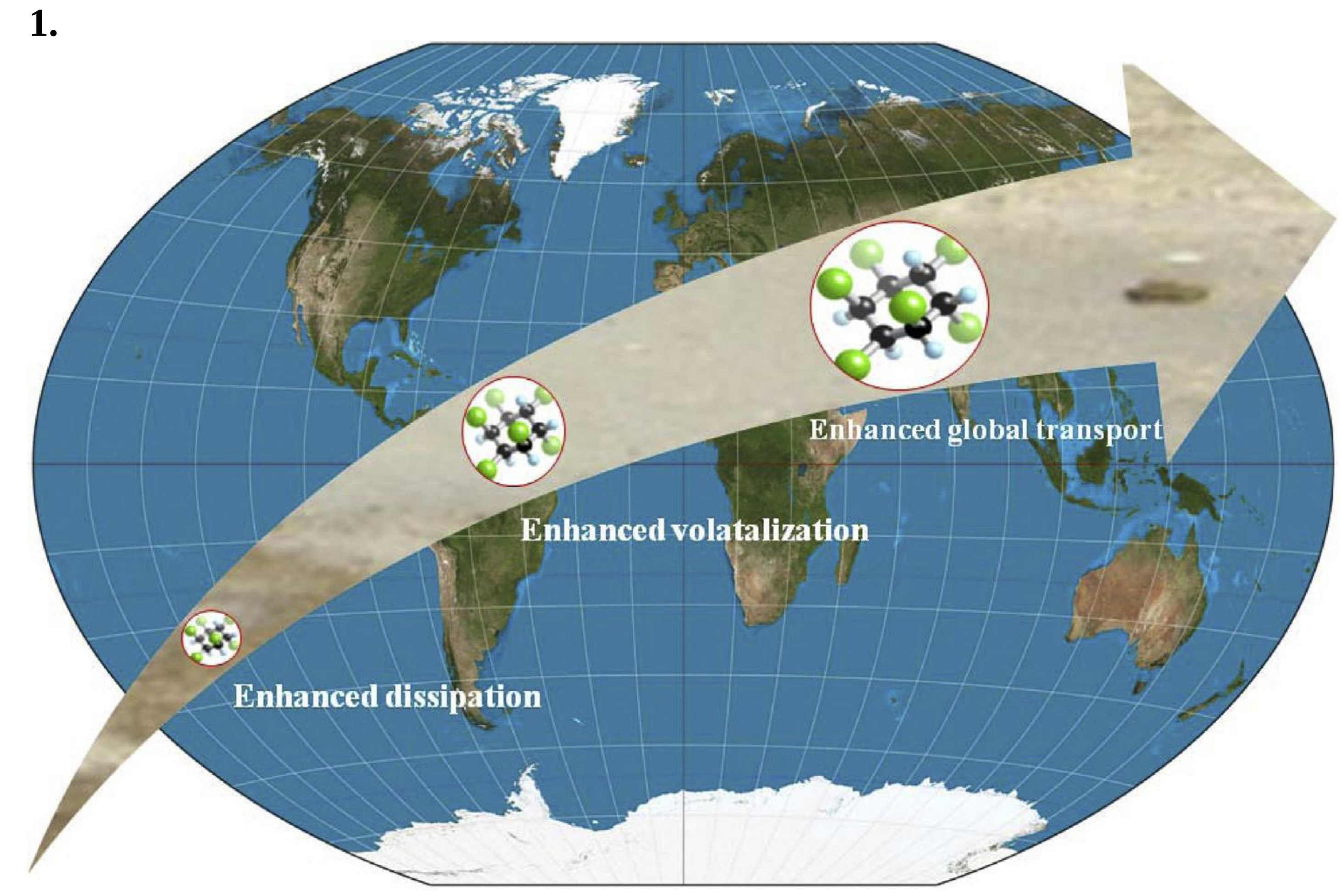
6. References:

[1] Abhilash, P.C., et al. (2014) *Environ. Sci Pollut. Res*. 20, 5879–5885; [2] Jacobson, C.S., et al. 2014. Agricultural soils, pesticides and microbial diversity. *Curr. Opin. Biotechnol*. 27, 15–20; [3] Tripathi, V. et al. (2014) *Ecological Engineering* 71, 318-325.

1.



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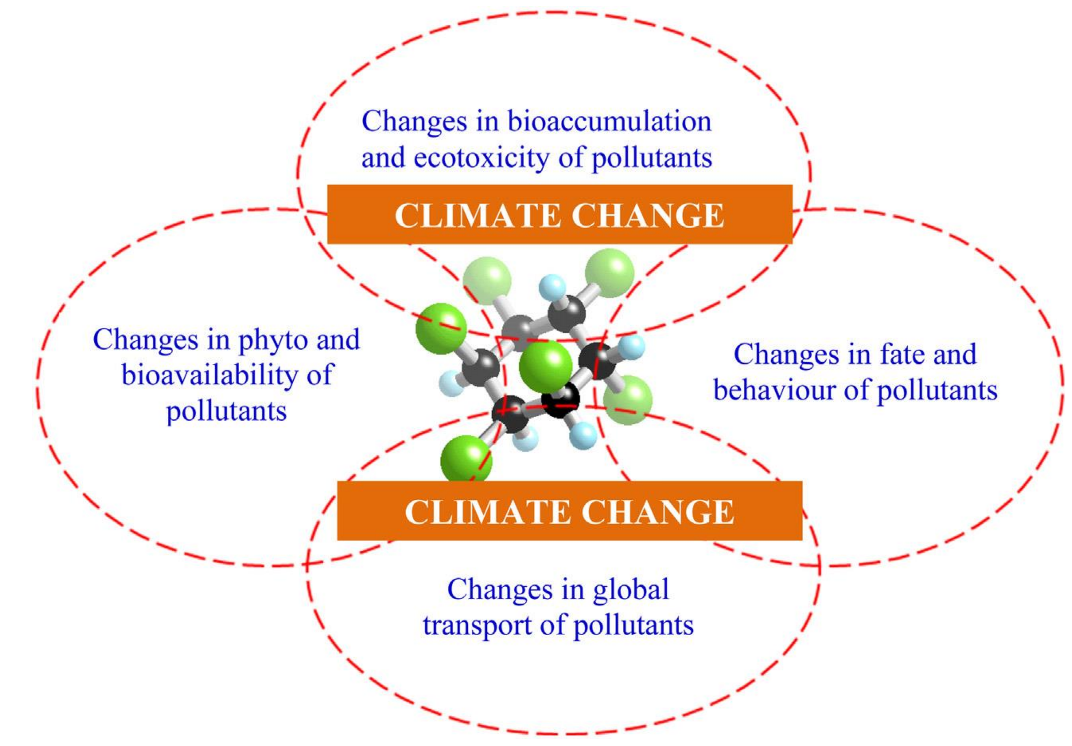

Fig. 1. The perceived impact of warming temperature on the dissipation and global transport of persistent organochlorine pesticides (OCPs).
Fig 2. Plausible effects of climate change on fate, behavior and bioremediation of pollutants.

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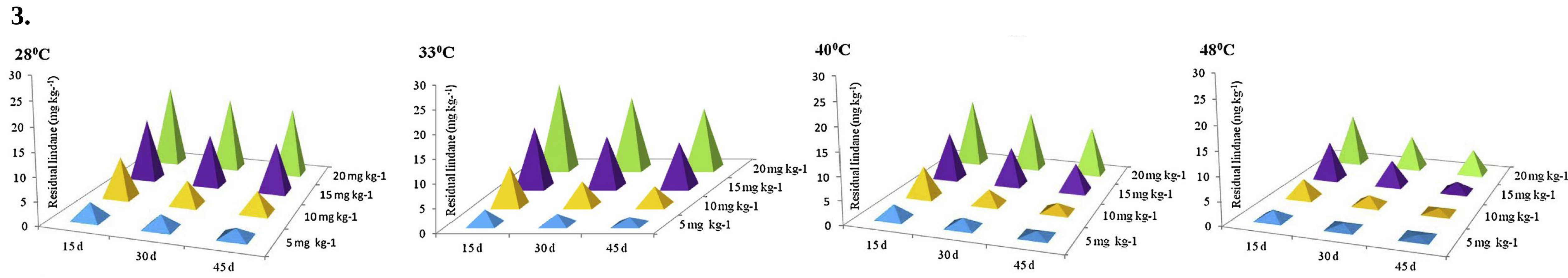

Fig. 3. Effect of warming temperatures (28 ºC < 33 ºC < 40 ºC < 48 ºC) on residual lindane concentration in soil after 0, 15, 30 and 45 days.

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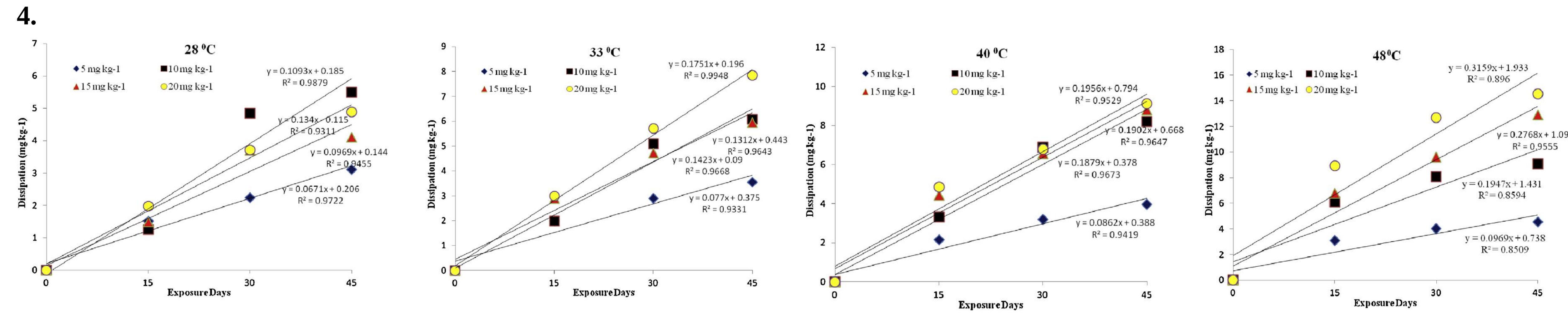

Fig. 4. The relationship of lindane dissipation from soil versus various incubation periods. Irrespective of the lindane concentration and incubation periods, the dissipation rate was linearly related with increasing incubation temperature

Tables. (1.) Effect of warming temperature on microbial biomass carbon in soil. Mean ± SD. **(2.)** Effect of temperature on soil dehydrogenase activity (µg TPF g^{-1} dwt of soil). Mean ± SD. The values with different letters in a particular spike level are significantly differ at $p < 0.05$ level (ANOVA-DMRT).

Table 1.

Treatments (mg Kg^{-1})	28ºC			33 ºC			40 ºC			48 ºC		
	15d	30d	45d	15d	30d	45d	15d	30d	45d	15d	30d	45d
5	68.1±1.3^{b}	74.2± 2.2^{c}	60.3± 3.0^{d}	66.2± 0.9^{c}	59.1± 3.3^{b}	53.0±1.9^{a}	62.0±1.6^{c}	56.2±2.0^{b}	49.0±2.0^{a}	56.0±1.2^{c}	47.0±3.1^{b}	41.3± 1.7^{a}
10	65.1±2.2^{b}	72.1± 3.0^{c}	58.1± 2.2^{d}	68.1± 2.3^{c}	53.1± 2.1^{ab}	49.1±1.1^{a}	60.5±2.0^{c}	51.1±2.1^{b}	43.1±2.7^{a}	55.2±1.0^{c}	42.2±1.1^{ab}	39.1± 2.3^{a}
15	70.2±2.2^{b}	74.61±2.9^{c}	52.6± 2.1^{a}	64.2 ± 2.1^{c}	50.6± 1.1^{b}	42.2±2.3^{a}	59.1±2.0^{c}	46.3±3.7^{b}	39.1±2.7^{a}	55.2±1.0^{c}	39.1±2.0^{b}	33.1±3.4^{a}
20	66.9±1.1^{c}	60.7±2.5^{b}	49.2± 1.1^{a}	70.0± 1.8^{c}	49.7±1.8^{b}	38.0±2.0^{a}	55.1±2.2^{c}	42.1±1.3^{b}	34.6± 1.9^{a}	48.3±2.2^{c}	31.3±1.2^{ab}	28.04±1.1^{a}

Table 2.

Treatments (mg Kg^{-1})	28ºC			33 ºC			40 ºC			48 ºC		
	15d	30d	45d	15d	30d	45d	15d	30d	45d	15d	30d	45d
5	44.1±1.6^{a}	50.2±0.9^{b}	48.0± 2.1^{ab}	46.2± 1.0^{b}	43.1± 1.8^{ab}	40.1±2.2^{a}	40.3±0.9^{c}	36.0±1.7^{b}	31.1±2.2^{a}	38.4±1.2^{c}	32.1±1.7^{b}	28.5±2.3^{a}
10	44.1±1.6^{a}	51.3±3.2^{b}	44.8± 1.0^{a}	45.2± 1.2^{b}	40.7± 3.0^{a}	39.1±2.8^{a}	38.7±2.2^{c}	32.9±1.3	29.5±2.7^{a}	35.1±2.3^{c}	30.3±2.2^{b}	26.3± 1.6^{a}
15	46.0±2.0^{b}	49.2±2.2^{bc}	40.1± 1.2^{a}	43.4 ±2.1^{b}	38.0± 1.6^{ab}	35.1±1.4^{a}	35.2±0.7^{c}	28.5±2.3^{ab}	25.5±1.8^{a}	32.1±2.0^{b}	28.3±1.0^{a}	25.3±2.1^{a}
20	43.4±2.0^{b}	45.1±1.3^{c}	39.2± 2.0^{a}	42.2± 1.9^{b}	35.0±1.2^{ab}	31.3±0.8^{a}	33.1±1.0^{c}	28.1±1.3^{b}	25.6± 2.3^{a}	29.1±1.4^{b}	25.3±1.1^{a}	22.1±2.1^{a}

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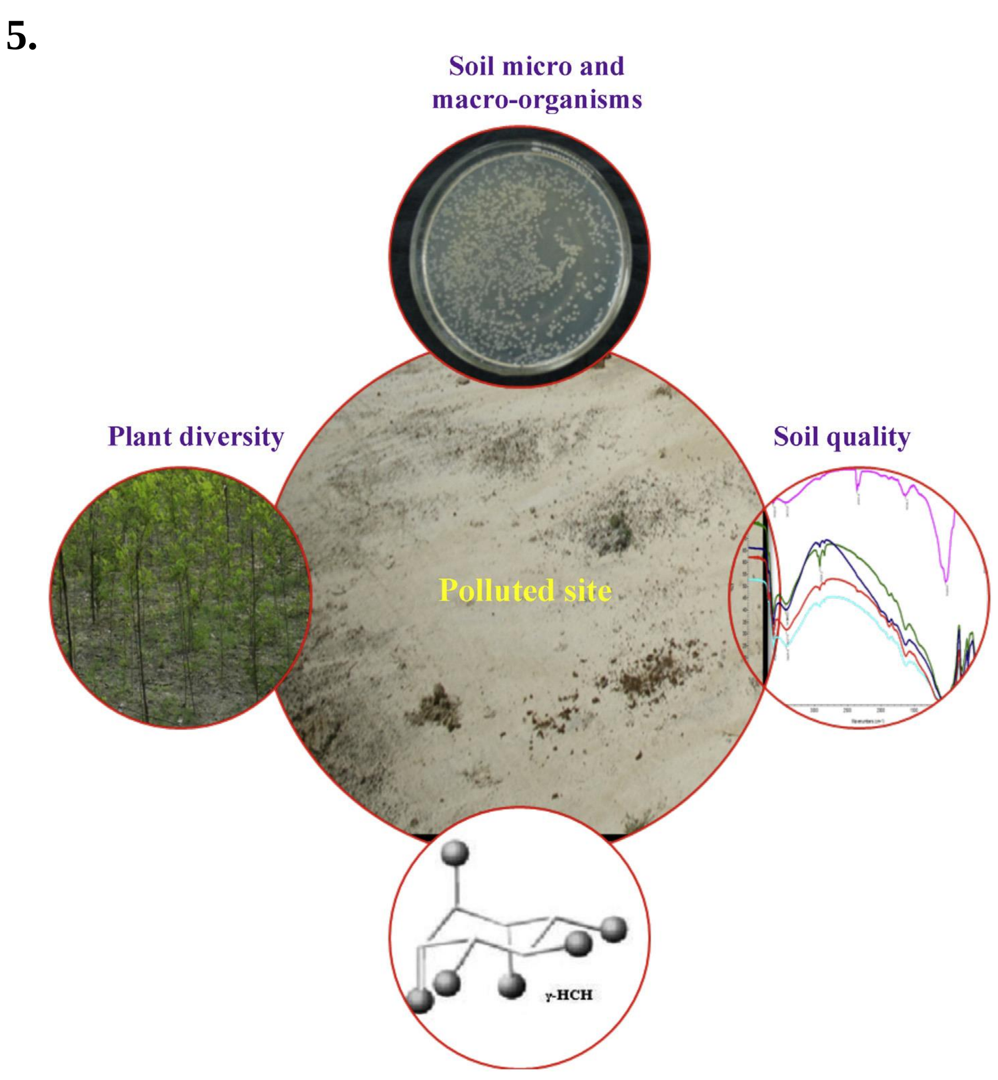

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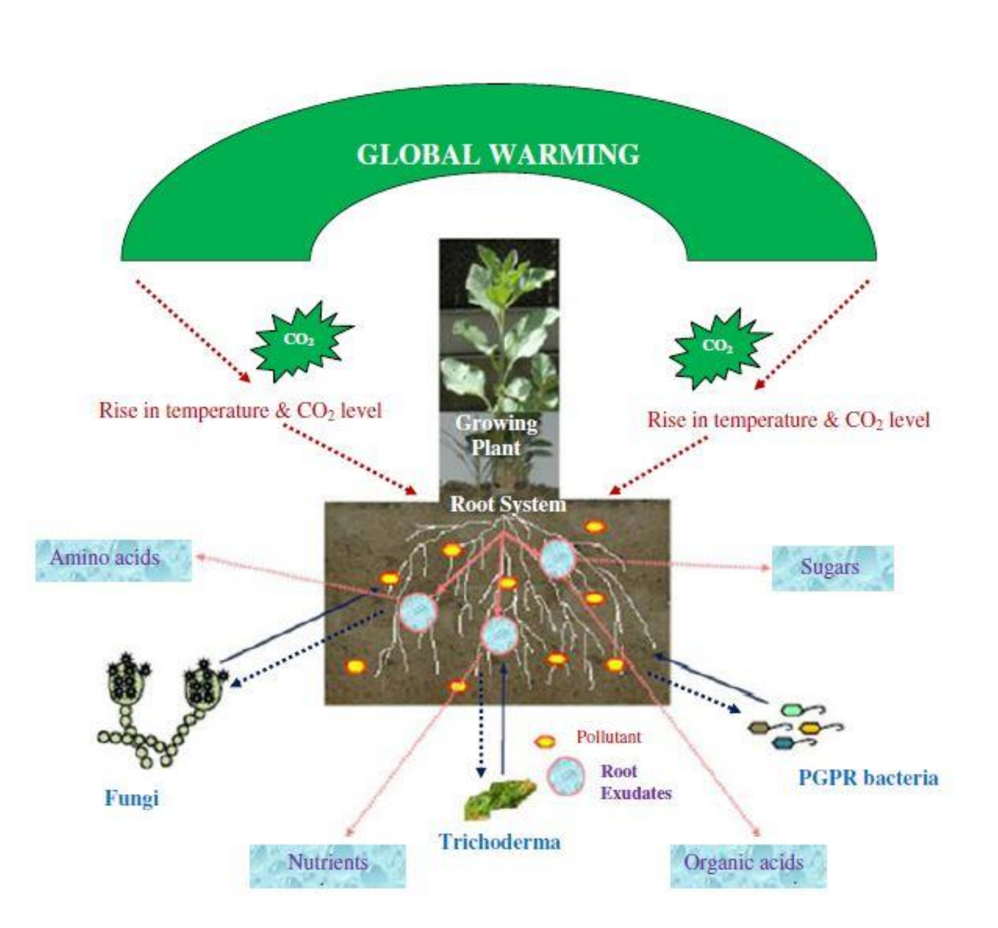

Fig. 4. Strategies for ecotoxicological profiling of a lindane contaminated soil based on pollutant level, soil quality, microbial and plant diversity for understanding the impact of warming climate on contaminated soil systems. **Fig. 5.** Possible impact of changing climate on plant–microbe–pollutant interactions. e.g. The increase in evapotranspiration may lead to increased pollutant uptake. Increase in atmospheric CO_2 concentration will increase photosynthesis and root exudation, may affect the microbial diversity microbial degradation phytoavailability of pollutants. The increase in atmospheric temperature may enhance the volatilization of organic pollutants which in turn affect the air–plant uptake of pollutants.