Review on Bioremediation of Pesticides

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minimizing human exposure to pesticides and to maintain the fertility of the soils for proper productivity. ere is a dearth of studies related to these issues in India Uttar Pradesh is the largest consumer followed by Punjab, Haryana and Maharashtra. Regarding the pesticide share across agricultural crops, cotton account for 45% followed by rice (25%), chillies/vegetables/fruits (13-24%), plantations (7-8%), cereals/millets/oil seeds (6-7%), sugarcane (2-3%) and other (1-2%) [12,14].

Pesticide classi cation

Pesticides encompass a variety of di erent types of chemicals including herbicides, insecticides, fungicides and rodenticides. Pesticides are usually classi ed on the basis of structure (Table 2). e structural classi cation include organochlorine, organophosphorus, carbamates, nitrogen based pesticides [14].

Bioremediation history and use

Bioremediation from it root meaning means to use microorganisms to remediate/ destroy or to immobilize pollutant from environment [15]. Natural Bioremediation has been used by civilizations for the treatment of waste water but intentional use for reduction of hazardous waste is more recent development. Modern bioremediation and use of microbes to consume pollutants are credited in part to George Robinson He used microbes to consume an oil spill along the coast of Santa Barbara, Calfornia in the Tale 1960.

Pesticide concerns

Pesticides are not only toxic to humans but they pose a threat to safety of soil water and air quality [16]. e pesticide contamination of surface and ground water pose a serious threat to surrounding ecosystems. e organochlorine and organophosphates cause tumors, irritability and convulsions [14]. Besides this organochlorine pesticides cause serious environmental issues due to Biomagni cations (Figure 1; Table 3).

Pesticide bioremediation methods

e level of toxicity caused by the pesticides leads to the great need for bioremediation. No doubt in some cases intrinsic bioremediation occurs because of microbes that are already present in polluted ecosystems, but it is also true that in some cases intrinsic bioremediation is not adequate. e requirements for the process of bioremediation of pesticides given by Ref. [14] are summarized in Table 4.

Strategies for pesticide remediation

Pesticide pollution is a serious environmental problem and their remediation is necessary. Ideally treatment should result in destruction of the compounds without generation of intermediates (Table 5).

Bacterial degradation of pesticides

Bacteria species that degrade the pesticides belongs to genera [illegible], [illegible], [illegible], [illegible], and [illegible] [17]. Recently [illegible] sp is also found to degrade pesticides.

e complete biodegradation of the pesticide involves the oxidation of the parent compound resulting in to carbon dioxide and water, this provides energy to microbes. e soil where innate microbial population cannot be able to manage pesticides, the external addition of pesticide degrading micro ora is recommended. Degradation of pesticides by microbes not only depends on the enzyme system but also the conditions like temperature, pH and nutrients. Some of the pesticides are easily degraded however some are recalcitrant because of presence of anionic species in the compound. Besides organophosphorus compounds, the Neonicotionoids are degraded by the Pseudomonas species (Figure 2).

Role of fungi

e minor structural changes that fungi does to degrade pesticides and render them into nontoxic substances and release them into soil where it is susceptible to further degradation. e various fungi which have shown ability to degrade pesticides are given in Table 6.

Role of enzymes

Enzymes take part in key role in Biodegradation of any xenobiotics and are able to renovate pollutants to a noticeable rate and have prospective to restore polluted environment [18]. Enzymes are also involved in the degradation of pesticide compounds, both in the target organism, through intrinsic detoxi cation mechanisms and evolved metabolic resistance, and in the wider environment, via biodegradation by soil and water microorganisms. [illegible] theoretical oxygen demand (TOD) enzyme is a representative of a much larger family of enzymes with application in the biocatalysis of environmentally relevant reactions. Fungal enzymes especially, oxidoreductases, laccase and peroxidases have prominent application in removal of polyaromatic hydrocarbons (PAHs) contaminants either in fresh, marine water or

Pesticide	Examples
Insecticide	
Organophosphorus	Diazinon, dichlorvos, dimethoate, malathion, parathion
Carbamate	&DUEDU\O SURSR[XU $OGLFDUE PHWKL
Organochlorine	''7 PHWKR[\FKORU WR[DSKHQH PLUH[
Cyclodienes	Aldrin, chlordane, dieldrin, endrin, endosulfan, heptachlor
Herbicides	&KORURSKHQR[\ DFLGV KH[DFKORUREH
Nitrogen-based	Picloram, Atrazine, diquat, paraquat
Organophosphates	Glyphosate (Roundup)
Fungicide	
Nitrogen-containing	7ULD]LQHV GLFDUER[LPLGHV SKWKDOL
Wood preservatives	&UHRVRWH KH[DFKORUREHQ]HQH
Botanicals	Perethrin, permethrin
Antimicrobial	Chlorine, quaternary alcohols

Table 2: 7\SHV RI 3HVWLFLGHV DQG ([DPSOHV IUR

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Pesticide	Persistence (Half-life)	Health Effects
Aldrin	20 days to 1 year	Nervous system effects. Probable carcinogen. Large doses : convulsions, death. Moderate doses : dizziness, headaches, vomiting, uncontrolled muscle movement
Dichlorodiphe nyltrichloroethane (DDT)	2 to15 years	Nervous system effects (tremors, seizures); probable carcinogen
Chlordane	4 years	Nervous system, digestive system, liver effects. Headaches, irritability, confusion, weakness, vision problems, vomiting, stomach cramps, diarrhea, and jaundice for lower doses. Higher doses : convulsions and death.
Dieldrin	Up to 7 years	Nervous system effects. Probable carcinogen. Large doses: Convulsions, death. Moderate doses: Dizziness, headaches, vomiting, uncontrolled muscle movement.
Heptachlor	0.4 to 2 years	Nervous system damage, liver and adrenal gland damage, tremors

Table 3: +HDOWK HIIHFWV RI FRPPRQ SHVWLFLGHV IURP 5HI > @

Factor	Conditions required
Micro organisms	Aerobic or Anaerobic
Natural biological processes of micro organisms	Catabolism and Anabolism
Environmental factors	2[\JHQ FRQWHQW 7HPSHUDWXUH S+ (OHFWURQ DFFHS
Nutrients	&DUERQ 1LWURJHQ R[\JHQ HWF
Soil moisture	25-28 % of water holding capacity
Type of soil	Low clay or slit content

Table 4: Requirements for the process of bioremediation of pesticides, from Ref. [ ]

Technology	Treatment time in months	Treatment media	**Removal efýciency**	References
Bioremediation	3 (ex-situ)	Soil, sludge, ground water, sediments	Up to 99.8%	[ ]
Phyto remediation	3 (ex-situ)	Soil, sludge, ground water, sediments	Up to 80%	[ ]

Table 5: Technologies available for treatment of pesticide-contaminated sites.

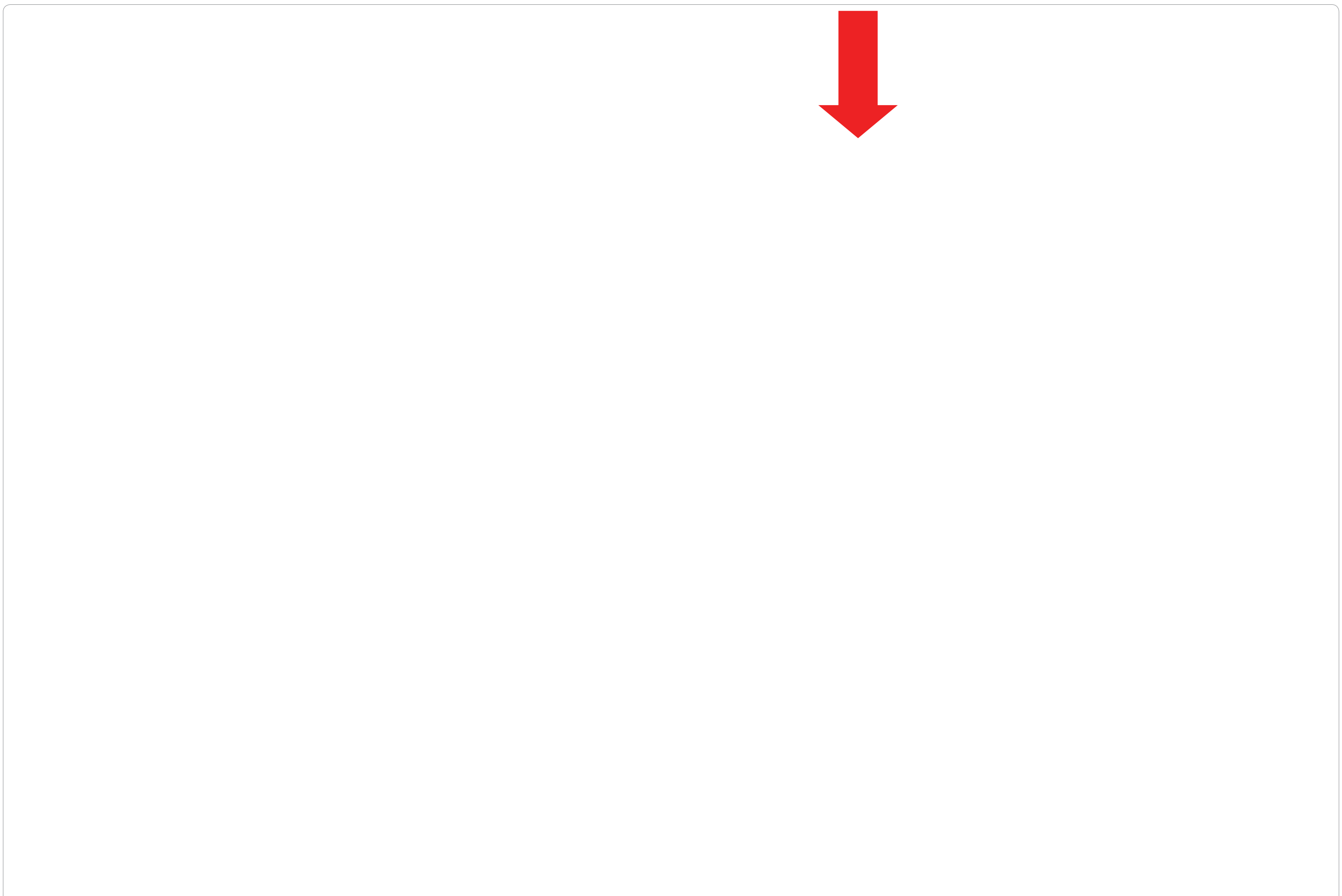

Figure 2: %LRDYDLODELOLW\ DQG GHJUDGDWLRQ RI SKHQDQWKUHQH LQ FRPSRVW DPHQ

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Species of fungi	Potential for degrading pesticide	Reference
Flammulina velupites, Stereum hirsutum,Coriolus versicolor,Dichomitus squalens, Hypholoma fasciculare, Auricularia auricula, Pleurotus ostreatus, Avatha discolor and Agrocybe semiorbicularis	WULD]LQH SKHQ\OXUHD GLFDUER[LPLG FKORULQDWHG RUJ	> @
White-rot fungi	+HSWDFKORU DWUD]LQH WHUEXWK\OD]LQH OLQGDQH PHWD JDPPDKH[DFKORURF\FORKH[DQH (g-HCH), dieldrin, diuron, aldrin, DDT, etc.,	> @

Table 6:

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