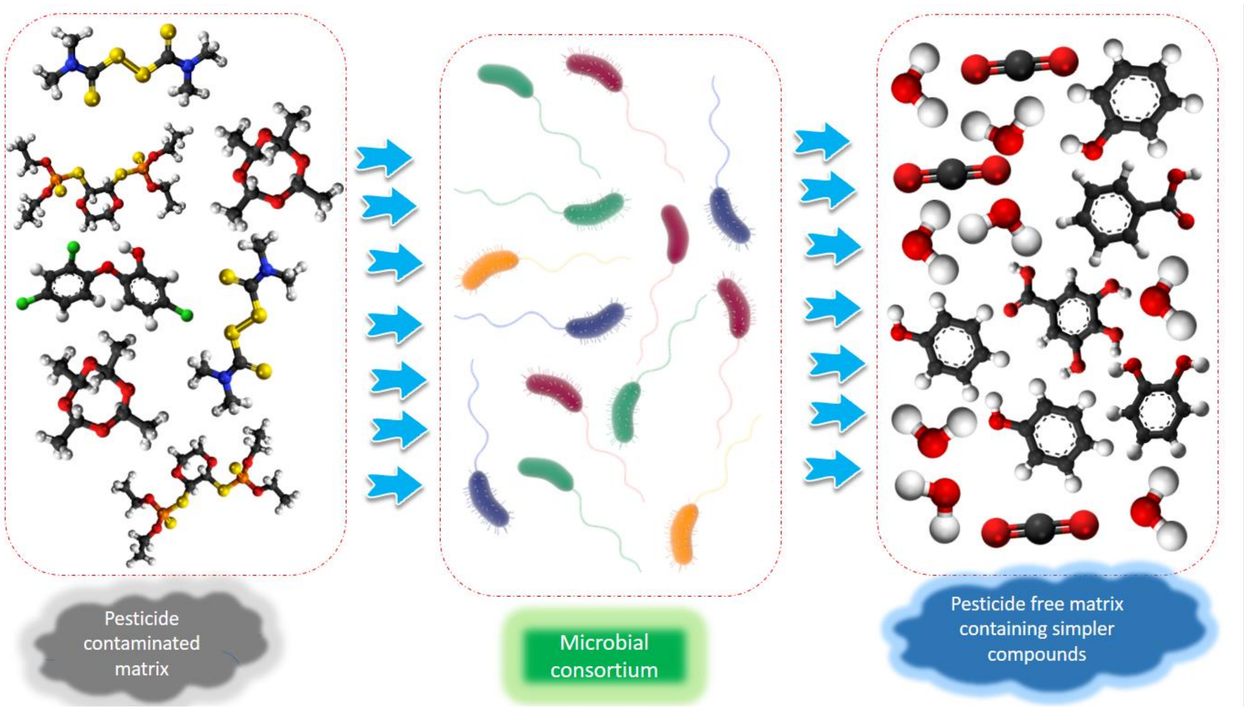
Supplementary Materials

Highlights

- Various bioremediation approaches used for the degradation/removal of pesticides
- *Bacillus* sp. and *Pseudomonas* sp. plays very important role in the biodegradation
- Pesticides are of mainly two types including chemical and bio pesticides
- Several bioreactors are applied for the treatment of pesticides
- It is encouraged to use of bio-pesticide which are less toxic and easily degradable

Graphical Abstract



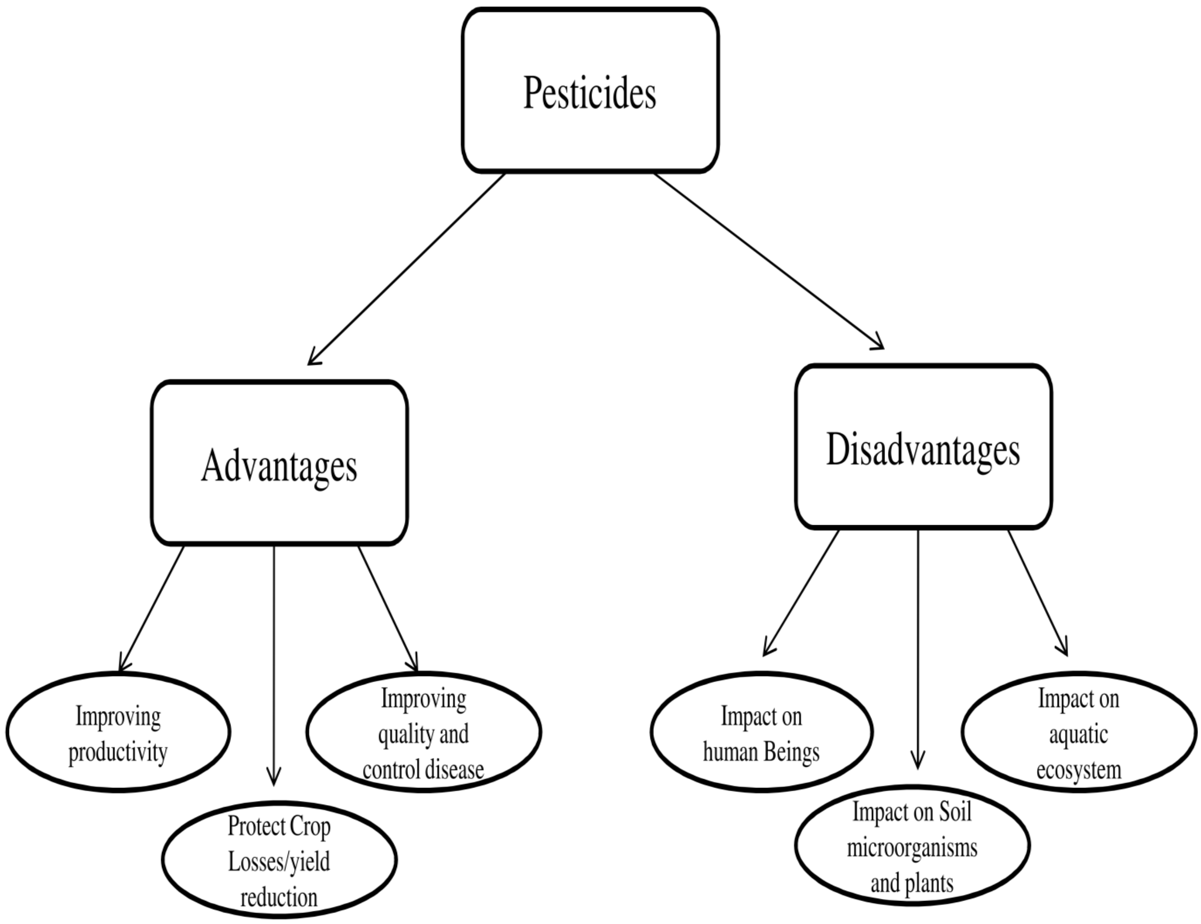


Fig. S1. Advantages and disadvantages of various types of pesticides.

Table S1. Advantages and Disadvantages of Different Types of Bioreactors

Order	Bioreactors	Advantages	Disadvantages	References
1	Airlift loop reactor (ALR)	i Less energy ii Easy design scale up	i Hydrodynamic mass transfer and bioreaction is complex and they strongly couple together ii Poor mixing	[150]
2	Internal loop airlift bioreactor (ILAB)	iPreferredat large scale ii High and readily controllable liquid circulation velocity iii High efficiency of homogenization iv Intense mixing, better mass transfer performance	iSparging can damage mammalian cells and insect cells ii Agitation may have detrimental effect on animal cell bioreactors iii Damage to cells on macrocarriers is found to result from the power dissipation in the form of turbulent eddies	[151]
3	External loop airlift bioreactor (ELAB)	i Versatility ii Simple construction iii Ease of operation iv Fewer chances of media contamination v Lower energy consumption vi Absence of regions of high shear exist near the impeller	i Oxygen mass transfer rate is smaller than that in well-mixed bioreactors ii Limit the growth rate of cells	[65]
4	Bioactive foam emulsion reactor	i No packing in the reactor ii Not subject to clogging iii Surpasses the performance of existing gas phase bioreactors iv Reuse of emulsion cells v Rapid mass transfer	i Stability problems at high air velocity ii Oxygen limitations	[70]
3	Bio scrubbers	i Excellent stability of process parameters (pH, temperature, nutrients) ii Relatively small pressure drop iii Relatively small equipment size	i Elevated production of wastes ii Contaminants in the liquid state iii Low efficiency in the case of substances poorly soluble in water iv Necessity to control the growth of biomass to restrict the amounts of solid waste being produced	[152, 97]
4	Hollow membrane reactors	i Compact with a high interfacial area between air and bio-film phase ii High cell densities	i High construction costs ii Long-term operational stability iii High cost of membrane fabrication	[152, 153]

		iii Independent control of air and nutrient flow rates with no flooding	iv Membrane fouling	
5	Two-phase partitioning bioreactors (TPPBs)	i Robust and reliable ii Enhancing the productivity in fermentation technology	i Scale up of mechanical agitation may not be feasible ii Requires large quantities of organic solvent iii Excessive energy inputs	[154]
6	Fluidized bed bioreactors	i Immobilization of microorganisms on small, porous fluidized media as bio-films results in higher biomass concentration ii Reducing hydraulic retention time (HRT) with high treatment efficiency iii No bed clogging, high pressure drop, poor mixing and oxygen transfer iii Provides larger surface area for nutrient transfer	i Relatively high energy consumption	[155]
7	Spouted bed bioreactor (SBBR)	i Systematic intense mixing ii Better contact between substrate and cells iii Faster oxygen transfer rate	i May be difficult to maintain the bed fluid dynamics in large beds	[156]
8	Packed bed reactor	i Efficiency and stability ii Easy scale-up	iLarge dead zones ii Channeling iii High pressure drop across the column	[43]
9	Monolith bioreactor	i Low pressure drop ii Large pore sizes iii Large specific surface area and thin walls iv Better liquid distribution at low liquid flow rates v High mechanical strength vi Scaling up relatively easy	i Clogging of the channels for long term stable operation	[156]
10	Flat plate vapor phase bioreactor	i Low cost ii Good performance	i Accumulation of dead cells on the top of the bio-film ii Lack of activity in the surface film	[157]

11	Novel rotating rope bioreactor	i High volatility along with high watersolubility ii Higher interfacial area iii High oxygen mass transfer rate iv Greater microbial culture stability v Higher substrate loadings and removal rates	i Technology is not well established	[158]
12	Bio-trickling filters	i Effective treatment of acid ii Produces pollutants iii Lower pressure drop during long-term operation	i Accumulation of excess biomass in the filter bed ii Complex construction and operation iii Production of secondary waste streams	[159]
13	Bio-filters	i Lack of mobile aqueous phase ii Suitable for low water solubility gases iii High efficiency in BOD removal iv Large area for mass transfer between the phases v Low operating and capital costs	i Clogging of the medium ii Medium deterioration iii Less treatment efficiency at high concentrations of pollutants iv Limited flexibility and control	[160, 161]