GIET University, Gunupur

Department of Biotechnology

B.Tech Biotechnology 6th semester

Frequently asked questions and answers

Environmental Biotechnology

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UNIT-1

Q1. Define environmental biotechnology.

Answer:
Environmental biotechnology is the application of biological organisms, processes, and systems to prevent, control, and remediate environmental pollution.

Q2. What is environmental monitoring?

Answer:
Environmental monitoring is the systematic observation and measurement of environmental parameters to assess pollution and ecosystem health.

Q3. What is a bioreporter?

Answer:
A bioreporter is a genetically engineered organism that produces a detectable signal in response to a specific pollutant.

Q4. What is a biomarker?

Answer:
A biomarker is a biological response indicating exposure to or effect of environmental contaminants.

Q5. Define biosensor.

Answer:
A biosensor is an analytical device that combines a biological recognition element with a transducer to detect pollutants.

Q6. Explain the role of environmental biotechnology in pollution control.

Answer:
It uses microorganisms, plants, and enzymes to degrade, detoxify, or remove pollutants in an eco-friendly and sustainable manner.

Q7. How does environmental monitoring help in pollution management?

Answer:
It provides early warning, helps assess pollution trends, and supports regulatory decision-making.

Q8. Explain how bioreporters detect pollutants.

Answer:
Bioreporters express reporter genes (lux, GFP, lacZ) when exposed to pollutants, producing measurable signals like light or fluorescence.

Q9. Why are biomarkers preferred for toxicity assessment?

Answer:
Because they reflect actual biological effects of pollutants rather than just their chemical presence.

Q10. Explain the principle of biosensors.

Answer:
A biosensor detects a pollutant through a biological interaction, which is converted into a measurable electrical or optical signal.

Q11. How can biosensors be applied in water quality monitoring?

Answer:
They detect BOD, heavy metals, pesticides, and pathogens rapidly and on-site.

Q12. Apply bioremediation techniques for soil pollution control.

Answer:
Microorganisms degrade organic pollutants, while plants immobilize or extract heavy metals from contaminated soil.

Q13. How can bioprospecting help identify pollutant-degrading microbes?

Answer:
By screening organisms from polluted habitats for novel metabolic pathways capable of degrading contaminants.

Q14. Suggest a biological method to control air pollution.

Answer:
Biofilters using microbes can degrade VOCs and sulfur compounds in industrial exhaust gases.

Q15. Apply microbial systems for heavy metal removal.

Answer:
Metal-resistant microbes accumulate or adsorb metals through biosorption and bioaccumulation mechanisms.

Q16. Differentiate between bioreporters and biosensors.

Answer:
Bioreporters are living organisms producing biological signals, while biosensors are devices integrating biological and electronic components.

Q17. Analyze the impact of heavy metal pollution on ecosystems.

Answer:
Heavy metals persist in the environment, bioaccumulate in food chains, and cause toxicity in plants, animals, and humans.

Q18. Compare biosorption and bioaccumulation.

Answer:
Biosorption is a passive surface binding process, whereas bioaccumulation is an active intracellular uptake.

Q19. Analyze why conventional methods fail in heavy metal removal.

Answer:
They are expensive, generate toxic sludge, and are ineffective at low metal concentrations.

Q20. Analyze microbial detoxification mechanisms.

Answer:
Microbes transform metals via redox reactions, chelation, efflux pumps, and enzymatic conversion to reduce toxicity.

Q21. Evaluate the advantages of environmental biotechnology over chemical methods.

Answer:
It is eco-friendly, cost-effective, sustainable, and produces minimal secondary pollution.

Q22. Assess the effectiveness of biomarkers in environmental monitoring.

Answer:
Biomarkers provide early and sensitive detection, but may be influenced by multiple stress factors.

Q23. Evaluate biosorption as a heavy metal removal technique.

Answer:
It is efficient and economical, but requires proper biomass regeneration and disposal strategies.

Q24. Justify the use of microbial systems in metal detoxification.

Answer:
Microbes adapt to extreme environments and possess metal-resistant genes that enable effective detoxification.

Q25. Evaluate bioprospecting in sustainable development.

Answer:
It supports innovation but must be regulated to ensure biodiversity conservation and ethical benefit sharing.

Q26. Design a biosensor for detecting heavy metals in water.

Answer:
Use a metal-responsive bacterial enzyme coupled with an electrochemical transducer for rapid detection.

Q27. Propose a biotechnological strategy for treating industrial wastewater.

Answer:
Combine activated sludge process, bioaugmentation, and biosensors for efficient treatment and monitoring.

Q28. Develop a microbial-based system for soil detoxification.

Answer:
Introduce genetically enhanced microbes capable of metal sequestration and organic pollutant degradation.

Q29. Design an integrated approach for monitoring air, water, and soil pollution.

Answer:
Use bioreporters, biosensors, and biomarkers for real-time and holistic environmental assessment.

Q30. Create a sustainable pollution control model using environmental biotechnology.

Answer:
Integrate bioremediation, biosorption, monitoring tools, and community participation to achieve long-term sustainability.

UNIT-2

1. What is biological wastewater treatment?

Answer:
Biological wastewater treatment is a process that uses microorganisms (bacteria, fungi, protozoa) to degrade organic pollutants into simpler, harmless substances like CO_2, water, methane, and biomass.

2. Define aerobic wastewater treatment.

Answer:
Aerobic treatment is a biological process where microorganisms degrade organic matter in the presence of oxygen, producing CO_2, water, and excess sludge.

3. What is anaerobic wastewater treatment?

Answer:
Anaerobic treatment is a biological process where organic matter is degraded in the absence of oxygen, producing biogas (methane + CO_2).

4. What is methanogenesis?

Answer:
Methanogenesis is the final step of anaerobic digestion where methanogenic archaea convert acetate, hydrogen, and CO_2 into methane.

5. Name the main groups of bacteria involved in anaerobic digestion.

Answer:

- Fermentative bacteria

- Acetogenic bacteria
- Methanogenic archaea

6. What is BOD?

Answer:
Biochemical Oxygen Demand (BOD) is the amount of oxygen required by microorganisms to decompose organic matter in wastewater.

7. Why are microorganisms essential in wastewater treatment?

Answer:
Microorganisms metabolize organic pollutants as a source of carbon and energy, thereby reducing pollution load and improving water quality.

8. Explain the role of fermentative bacteria.

Answer:
Fermentative bacteria break complex organic compounds (proteins, carbohydrates, lipids) into volatile fatty acids, alcohols, CO_2, and H_2.

9. What is the function of acetogenic bacteria?

Answer:
Acetogenic bacteria convert volatile fatty acids into acetate, hydrogen, and CO_2, which are substrates for methanogens.

10. Why are methanogens sensitive to oxygen?

Answer:
Methanogens are strict anaerobes; oxygen damages their enzymes and inhibits methane production.

11. Difference between aerobic and anaerobic treatment.

Answer:

Aspect	Aerobic	Anaerobic
Oxygen	Required	Not required
Sludge	High	Low
Energy	Consumes energy	Produces biogas

12. What is activated sludge process?

Answer:
It is an aerobic treatment process where microbial flocs oxidize organic matter under controlled aeration.

13. Which treatment is suitable for high-strength industrial wastewater?

Answer:
Anaerobic treatment, because it handles high organic loads and generates biogas.

14. How is pH controlled in anaerobic digesters?

Answer:
By buffering systems (bicarbonates) and controlling organic loading to maintain pH between 6.8–7.5.

15. Why is aeration important in aerobic treatment?

Answer:
Aeration supplies oxygen for microbial respiration and keeps biomass in suspension for effective degradation.

16. Application of UASB reactor.

Answer:
Used for treating municipal sewage and industrial effluents like distillery and sugar industry wastewater.

17. How is biogas utilized?

Answer:
Biogas is used for electricity generation, heating, and as a renewable energy source.

18. Analyze the stages of anaerobic digestion.

Answer:

1. Hydrolysis
2. Acidogenesis
3. Acetogenesis
4. Methanogenesis

Each stage is carried out by specific microbial groups.

19. Why does anaerobic digestion fail under shock loading?

Answer:
Sudden high organic load leads to acid accumulation, pH drop, and inhibition of methanogens.

20. Compare sludge production in aerobic vs anaerobic systems.

Answer:
Aerobic systems produce more biomass, while anaerobic systems produce minimal sludge.

21. Why temperature is critical in methanogenesis?

Answer:
Methanogens are temperature-sensitive; optimal ranges are mesophilic (35°C) and thermophilic (55°C).

22. Analyze the role of C:N ratio.

Answer:
An optimal C:N ratio (20–30:1) ensures balanced microbial growth and stable digestion.

23. Evaluate the advantages of anaerobic treatment.

Answer:
Energy recovery
Low sludge generation

Cost-effective for high BOD wastewater

24. Limitations of aerobic treatment.

Answer:

- High energy requirement
- Excess sludge generation
- Not suitable for very high organic loads

25. Is GMO-based treatment environmentally safe?

Answer:
Yes, if properly contained, but ecological risks and regulatory approvals must be addressed.

26. Evaluate the sustainability of biological treatment.

Answer:
Biological treatment is eco-friendly, cost-effective, and sustainable compared to chemical methods.

27. How can GMOs improve wastewater treatment efficiency?

Answer:
GMOs can be engineered for higher degradation rates, heavy metal resistance, and toxin breakdown.

28. Design an integrated wastewater treatment system.

Answer:
Primary treatment → Anaerobic reactor → Aerobic polishing → Tertiary treatment → Reuse.

29. Suggest future biotechnological innovations in wastewater treatment.

Answer:

- Genetically engineered microbes
- Biofilm reactors
- Microbial fuel cells
- AI-controlled bioreactors

30. Propose applications of treated wastewater.

Answer:

- Irrigation
- Industrial cooling
- Groundwater recharge
- Landscaping

UNIT-3

1. What is biodeterioration?

Answer:
Biodeterioration is the undesirable alteration of materials caused by microorganisms such as bacteria, fungi, algae, and insects, leading to loss of structural integrity or aesthetic value.

2. Define biodegradation.

Answer:
Biodegradation is the microbial breakdown of organic compounds into simpler substances like CO_2, water, and biomass.

3. What are xenobiotic compounds?

Answer:
Xenobiotics are synthetic or foreign chemicals not naturally found in ecosystems, such as pesticides, dyes, detergents, and hydrocarbons.

4. What is bioremediation?

Answer:
Bioremediation is the use of living organisms (microbes or plants) to detoxify or remove environmental pollutants.

5. Define phytoremediation.

Answer:
Phytoremediation is the use of plants to remove, immobilize, or degrade pollutants from soil and water.

6. Explain the principle of biodeterioration.

Answer:
Microorganisms utilize materials as nutrient sources, producing enzymes and metabolites that weaken or destroy the material.

7. Why are xenobiotics difficult to degrade?

Answer:
They possess complex structures, halogenation, and synthetic bonds that are not easily recognized by microbial enzymes.

8. How do microorganisms degrade hydrocarbons?

Answer:
Microbes use oxygenases and dehydrogenases to oxidize hydrocarbons into alcohols, acids, and finally CO_2.

9. Explain biodegradation of detergents.

Answer:
Linear alkyl benzene sulfonates are degraded by bacteria via desulfonation and β-oxidation pathways.

10. How are dyes biodegraded?

Answer:
Microbes reduce azo bonds using azoreductases, converting dyes into colorless or less toxic products.

11. How is biodeterioration prevented?

Answer:
By chemical preservatives, controlled humidity, antifungal coatings, and material modification.

12. Application of bioremediation in oil spills.

Answer:
Hydrocarbon-degrading bacteria are introduced to accelerate oil degradation in marine environments.

13. How are pesticides biodegraded?

Answer:
Microorganisms hydrolyze ester or amide bonds using specific enzymes like hydrolases.

14. Use of plants in heavy metal removal.

Answer:
Plants accumulate metals in tissues via phytoextraction.

15. Example of phytoremediation plant.

Answer:
Brassica juncea is used for lead and cadmium removal.

16. Differentiate biodegradation and biodeterioration.

Answer:
Biodegradation is beneficial pollutant removal, whereas biodeterioration is undesirable material damage.

17. Analyze types of bioremediation.

Answer:

- In situ: Treatment at the contamination site
- Ex situ: Excavation and treatment elsewhere

18. Mechanism of phytoremediation.

Answer:
Includes phytoextraction, phytostabilization, phytovolatilization, and rhizodegradation.

19. Analyze enzyme involvement in dye degradation.

Answer:
Enzymes like laccase and peroxidase break complex dye structures into simpler molecules.

20. Why is whole-cell system preferred over isolated enzymes in bioremediation?

Answer:
Whole cells provide enzyme regeneration, cofactor availability, and metabolic pathways.

21. Evaluate advantages of bioremediation.

Answer:
Eco-friendly
Cost-effective
Minimal environmental disturbance

22. Limitations of phytoremediation.

Answer:

- Slow process
- Limited to shallow contamination
- Metal toxicity to plants

23. Common prejudices against enzymes.

Answer:

- Enzymes are unstable
- Enzymes are expensive
- Limited industrial applicability

24. Advantages of biocatalysts.

Answer:
High specificity
Mild reaction conditions
Reduced by-products

25. Disadvantages of biocatalysts.

Answer:

- Sensitivity to pH and temperature
- Inhibition by contaminants

26. Design a bioremediation strategy for dye-polluted wastewater.

Answer:
Anaerobic bacterial treatment → Aerobic fungal treatment → Enzyme polishing step.

27. Propose an integrated phytoremediation model.

Answer:
Hyperaccumulator plants + rhizosphere microbes + periodic biomass harvesting.

28. Isolated enzyme vs whole-cell system (design concept).

Answer:

Aspect	Isolated Enzyme	Whole Cell
Stability	Low	High

Aspect	Isolated Enzyme	Whole Cell
Cofactor	External	In situ
Cost	High	Low

29. Future applications of biocatalysts.

Answer:

- Green chemistry
- Waste detoxification
- Biofuel production

30. Create a sustainable pollution control model using biocatalysts.

Answer:
Pollutant detection → Microbial/enzyme selection → Immobilization → Continuous bioreactor treatment → Safe discharge.

UNIT-4

1. What is biooxidation?

Answer:
Biooxidation is a biological process in which microorganisms oxidize inorganic or organic substances, often leading to solubilization of metals or transformation of fuels.

2. Define bioleaching.

Answer:
Bioleaching is the extraction of metals from ores using microorganisms, mainly acidophilic bacteria.

3. Name two microbes used in bioleaching.

Answer:
Acidithiobacillus ferrooxidans and *Leptospirillum ferrooxidans*.

4. What is indirect biooxidation?

Answer:
Indirect biooxidation involves microbial regeneration of ferric iron (Fe^{3+}), which chemically oxidizes metal sulfides.

5. What is biodesulfurization?

Answer:
Biodesulfurization is the microbial removal of sulfur compounds from fossil fuels like coal and petroleum.

6. Explain the direct mechanism of biooxidation.

Answer:
In direct biooxidation, microorganisms attach to mineral surfaces and enzymatically oxidize metal sulfides.

7. How does indirect biooxidation differ from direct?

Answer:
Indirect biooxidation is chemical oxidation by ferric iron, while microbes regenerate ferric iron from ferrous iron.

8. Why is bioleaching preferred over conventional metal extraction?

Answer:
It is cost-effective, eco-friendly, and suitable for low-grade ores.

9. Explain the role of microbes in petroleum extraction.

Answer:
Microbes reduce oil viscosity and produce gases, improving enhanced oil recovery (EOR).

10. What is biotechnology of fossil fuels?

Answer:
It involves applying biological processes to upgrade, clean, and recover fossil fuels.

11. Application of bioleaching in copper recovery.

Answer:
Copper is extracted from chalcopyrite ores using heap leaching with acidophilic bacteria.

12. How are microbes used in enhanced oil recovery?

Answer:
Microbes produce biosurfactants, acids, and gases that mobilize trapped oil.

13. Use of microbes in coal desulfurization.

Answer:
Bacteria oxidize pyritic sulfur, reducing sulfur emissions during combustion.

14. Application of biooxidation in gold mining.

Answer:
Biooxidation removes sulfide matrices, allowing cyanide leaching of gold.

15. Bioconversion of agricultural waste example.

Answer:
Rice straw is converted into biogas or bioethanol through microbial digestion.

16. Analyze the steps involved in bioleaching.

Answer:
Attachment → Oxidation → Metal solubilization → Recovery.

17. Compare chemical leaching and bioleaching.

Answer:

Aspect	Chemical	Bioleaching
Cost	High	Low
Environmental impact	High	Low
Ore grade	High	Low

18. Analyze microbial communities in oil reservoirs.

Answer:
Includes fermenters, methanogens, sulfate reducers, contributing to oil mobilization.

19. Why is indirect biooxidation more dominant?

Answer:
Ferric iron acts as a strong oxidant, enhancing mineral dissolution.

20. Analyze limitations of microbial desulfurization.

Answer:

- Slow kinetics
- Sensitivity to temperature and pH

21. Evaluate environmental benefits of bioleaching.

Answer:
Reduced toxic emissions
Lower energy demand
Minimal waste generation

22. Is microbial enhanced oil recovery sustainable?

Answer:
Yes, due to reduced chemical usage and improved recovery efficiency.

23. Evaluate biotechnology of fossil fuels.

Answer:
It improves fuel quality while reducing environmental pollution.

24. Advantages of bioconversion of organic waste.

Answer:

- Waste reduction
- Renewable energy production
- Value-added products

25. Limitations of biooxidation processes.

Answer:

- Long processing time

- Strict microbial growth conditions

26. Design a bioleaching-based metal recovery system.

Answer:
Low-grade ore → Heap bioleaching → Metal-rich leachate → Solvent extraction → Electrowinning.

27. Propose an integrated microbial EOR strategy.

Answer:
Reservoir characterization → Microbial injection → Nutrient supply → Oil mobilization → Recovery.

28. Develop a model for coal biodesulfurization.

Answer:
Crushing → Microbial oxidation → Sulfur removal → Clean coal production.

29. Suggest future innovations in fossil fuel biotechnology.

Answer:

- Engineered microbes
- Biosurfactant overproduction
- Genomic optimization

30. Create a sustainable bioconversion framework for organic wastes.

Answer:
Agricultural waste → Pretreatment → Anaerobic digestion → Biogas + digestate → Fertilizer & energy.

Unit-5

1. What are clean technologies?

Answer:
Clean technologies are environmentally friendly technologies that reduce pollution, minimize waste, and enhance resource efficiency.

2. Define composting.

Answer:
Composting is the aerobic microbial decomposition of organic waste into a stable, nutrient-rich product called compost.

3. What are biofertilizers?

Answer:
Biofertilizers are living microorganisms that enhance soil fertility by fixing nitrogen, solubilizing phosphorus, or stimulating plant growth.

4. Define biopesticides.

Answer:
Biopesticides are biological agents such as microbes or plant products used to control pests.

5. What is bioplastic?

Answer:
Bioplastics are biodegradable plastics produced from renewable biological sources like microbial polymers.

6. Explain the principle of clean technology.

Answer:
Clean technology focuses on pollution prevention at source rather than end-of-pipe treatment.

7. How does composting improve soil health?

Answer:
Compost improves soil structure, microbial activity, water retention, and nutrient availability.

8. Explain organic farming.

Answer:
Organic farming avoids synthetic chemicals and relies on biological inputs like compost, biofertilizers, and biopesticides.

9. How do biofertilizers differ from chemical fertilizers?

Answer:
Biofertilizers enhance nutrient availability biologically, while chemical fertilizers directly supply nutrients.

10. Explain microbial polymer production.

Answer:
Microorganisms synthesize polymers such as polyhydroxyalkanoates (PHAs) as intracellular carbon reserves.

11. Application of composting in waste management.

Answer:
Composting converts municipal and agricultural waste into valuable organic manure.

12. Use of biofertilizers in agriculture.

Answer:
Biofertilizers like *Rhizobium* reduce dependence on chemical nitrogen fertilizers.

13. Application of biopesticides.

Answer:
Bacillus thuringiensis is used to control lepidopteran insect pests.

14. Application of microbial enhanced oil recovery (MEOR).

Answer:
Microbes produce biosurfactants and gases that increase oil mobility.

15. Application of biogas technology.

Answer:
Biogas plants convert organic waste into methane-rich fuel and biofertilizer.

16. Analyze stages of composting.

Answer:
Mesophilic → Thermophilic → Cooling → Maturation stages, each dominated by different microbes.

17. Analyze the mechanism of bioplastic production.

Answer:
Excess carbon + nutrient limitation → PHA accumulation inside microbial cells.

18. Compare biofuels and fossil fuels.

Answer:

Aspect	Biofuels	Fossil Fuels
Renewability	Renewable	Non-renewable
Emissions	Low	High

19. Analyze bioethanol production steps.

Answer:
Pretreatment → Hydrolysis → Fermentation → Distillation.

20. Why is biohydrogen considered a clean fuel?

Answer:
It produces only water upon combustion and has high energy efficiency.

21. Evaluate advantages of organic farming.

Answer:
Soil sustainability
Reduced pollution
Safe food production

22. Limitations of biofertilizers.

Answer:

- Short shelf life
- Environmental sensitivity

23. Evaluate environmental benefits of bioplastics.

Answer:
They are biodegradable, reduce plastic pollution, and use renewable resources.

24. Limitations of biogas technology.

Answer:

- Initial installation cost
- Temperature sensitivity

25. Evaluate MEOR as a clean technology.

Answer:
MEOR reduces chemical usage and improves eco-friendly oil recovery.

26. Design an integrated clean technology model for rural areas.

Answer:
Organic farming + biogas plant + composting + biofertilizer use.

27. Propose a sustainable biofuel production system.

Answer:
Agricultural waste → Bioethanol/biogas → Energy + residue as fertilizer.

28. Develop a bioplastic-based waste reduction strategy.

Answer:
Microbial PHA production → Biodegradable packaging → Composting after use.

29. Ethical issues in environmental biotechnology.

Answer:

- GMO release risks
- Biodiversity loss
- Socioeconomic inequality

30. Regulatory frameworks governing environmental biotechnology.

Answer:
Includes biosafety guidelines, environmental protection acts, GMO regulations, and international conventions (e.g., Cartagena Protocol).