Bot-Sp-02 BIOREMEDIATION Credit Hours: 3 (2+1)

THEORY:

Introduction of the Course:

The course is about application of various living organisms viz. plants, microbes, etc. for remediation of contaminants and pollutants from different environmental spheres viz. lithosphere, hydrosphere, atmosphere. The living organisms individually or in combinations can degrade, detoxify, immobilize or minimize risk of contaminants to the environment of other living organisms, especially human. The course comprises an overview of the bioremediation process, its major types, strategies, factors and case studies as success stories at large scale.

Course Objectives:

The course is designed:

1. To understand basic importance and nature of bioremediation
2. To have concept of contaminants and pollutants in terms of its remediation through application of organisms
3. To have in depth idea of bioremediation technology, its level of advancement and existing challenges
4. To elucidate real world application of bioremediation for abatement of environmental pollution

Contents:

1. Basic concepts: environment, contaminant and pollutant

1.1 Definition and concept of environment

1.2 Concept of contaminant and pollutant

1.3 Types of pollutions and pollutants

1.3.1 Organic pollutants

1.3.2 Inorganic pollutants

1.3.3 Xenobiotics

2. Traditional approaches to pollution remediation

2.1 Traditional approaches for remediation of soil

2.1.1 *In situ* physico-chemical remediation approaches for soil, sediment, sludge, bedrock

2.1.1.1 Soil flushing and Vitrification

2.1.1.2 Encapsulation of contaminant areas with impermeable layers

2.1.1.3 Electrokinesis

2.1.2 *Ex situ* physico-chemical remediation approaches for soil, sediment, sludge bedrock

2.1.2.1 Landfarming

2.1.2.2 Soil washing

2.1.2.3 Chemical reduction / oxidation

2.1.2.4 Chemical extraction

2.3 Traditional approaches for remediation of water and air

3. Introduction to bioremediation

3.1 Bio treatment technologies for pollution control

3.2 Bioavailability: Sequestering and complexing

4. Bioremediation of soil, sediment, sludge, water and air

a. Bioremediation of polluted and contaminated soils, sediment and sludge, water and air

5. Microbial remediation

b. Molecular biological aspects of microbial remediation
   i. Biocatalyst selection and genetic modification
   ii. Enrichment and screening strategies.
   iii. Design of enrichment strategies relating to the environmental source

c. Microbial technologies for remediation of pollution
   i. Microbial acclimation, detoxification, Microbial activation and Microbial sorption
   ii. Cometabolism

d. Bacterial remediation

e. Mycoremediation

f. Phycoremediation

6. Phytoremediation

6.1. Non-assisted phytoremediation

6.1.1. Phytostabilization, Phytodegradation, Phytovolatilization, Phytoextraction

6.2. Assisted phytoremediation

6.2.1. Fungal-assisted phytoremediation

6.2.2. Bacterial assisted phytoremediation

6.2.3. Chemical assisted phytoremediation

6.2.4. Inorganic / organic chemical-assisted phytoremediation

6.2.5. Organic amendment-assisted phytoremediation

6.2.5.1. Compost-assisted phytoremediation

6.2.5.2. Biochar-assisted phytoremediation

7. Soil remediation through lower animals

6.1 Role of lower animals in pollutant detoxification

6.2 Role of earthworm in redistribution of heavy metals in soils

8. Case studies: Success stories of bioremediation at applied scale

6.1 Local case studies of Pakistan: Bioremediation success stories

6.2 International case studies: Bioremediation success stories at global scale

Practicals:

1. Sampling from contaminated sites and its characterization
2. Quantification of metals in the contaminated soil, water and biomass samples
3. Isolation of bacteria and fungi from indigenous non-polluted sources
4. Isolation of bacteria and fungi from polluted sources such as, oil wastes, polluted water from industries and sewage
5. Spray plate technique for testing the degradation ability of bacteria for different aromatic hydrocarbons
6. Bioremediation assays: Heavy metal resistant bacteria isolation through culturing method
7. Enrichment and isolation of pesticide degrading bacteria

Teaching-learning Strategies

1. Lectures
2. Field tours to contaminated sites and industrial areas
3. Group Discussion
4. Laboratory work
5. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the current and upcoming challenges of environmental pollution in Pakistan.
2. They will be able to learn basic and applied aspects of bioremediation as one of the possible indigenously adaptable technology for pollution abatement.
3. The students will be able think in an innovative way to apply bioremediation technologies in solution-oriented way.
4. They will be able to have acquaintance with the current developments in the field of bioremediation at national and international level.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Bhat, R.A., Hakeem, R., Qadri, H. (2020). Bioremediation and Biotechnology: Sustainable Approaches to Pollution Degradation. Springer Publishers. ISBN: 978-3-030-35691-0.
2. Hasanuzzaman, M., Prasad, M.N.V. (2020). Handbook of Bioremediation (1st Ed.). Academic Press. ISBN: 9780128193822.
3. Koul, B., Taak, P. (2018). Soil Remediation Through Algae, Plants and Animals. Springer Publishers. ISBN: 978-981-13-2420-8.
4. Kumar, V., Prasad, R., Kumar, M. (2021). Rhizobiont in Bioremediation of Hazardous Waste. Springer Publishers. ISBN: 978-981-16-0602-1.
5. Pandey, V.C., Singh, V. (2020). Bioremediation of Pollutants: From Genetic Engineering to Genome Engineering. Elsevier Publishers. ISBN: 978012819258.
6. Saxena, G., Kumar, V., Shah, M. (2020). Bioremediation for Environmental Sustainability (1st Ed.). Elsevier Publishers. ISBN: 9780128205242.

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