Chapter 11
Bioremediation

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EXERCISES

1. Which microorganisms are used in sewage water treatment and what is their role?

Ans: A diverse community of microorganisms plays a crucial role in sewage water treatment, breaking down pollutants and transforming the water into a safer state for release back into the environment. Here are some key players and their roles:

Bacteria:

***Aerobic bacteria:** These microbes thrive in oxygen-rich environments and are the workhorses of the initial stages. They use oxygen to break down organic matter, including carbohydrates, proteins, and fats, into simpler compounds. Some common examples include Acinetobacter, Pseudomonas, and Nitrosomonas.

***Anaerobic bacteria:** Taking over in oxygen-depleted zones, these bacteria handle complex organic molecules and produce methane gas as a byproduct. They are crucial for digesting sludge and reducing organic load. Some key players include Methanosaeta, Methanococcus, and Desulfovibrio.

***Facultative bacteria:** These versatile microbes can switch between aerobic and anaerobic respiration depending on oxygen availability. They play a vital role in adapting to changing conditions and maintaining treatment efficiency. Examples include Escherichia coli and Bacillus subtilis.

Protozoa:

*****These tiny single-celled organisms graze on bacteria, helping to control their populations and clarify the treated water. They also contribute to nutrient cycling and sludge reduction. Some common protozoa in sewage treatment include Paramecium, Vorticella, and Colpoda.

Fungi:

*****While less abundant than bacteria, fungi play a role in degrading complex organic matter, including cellulose and lignin. They also help to remove certain pollutants, such as heavy metals, from the wastewater. Examples include Trichoderma, Penicillium, and Aspergillus.

Algae:

*In some treatment systems, algae are used to remove nutrients, particularly phosphorus, from the wastewater. They take up the nutrients for growth, resulting in cleaner water. Green algae like Chlorella and Scenedesmus are commonly used.

The specific types and roles of microorganisms vary depending on the treatment plant technology and wastewater composition. However, their combined efforts are essential for effectively degrading pollutants and transforming sewage water into a safer form for environmental release or reuse.

2. Explain as to how biological oxygen demand represents the condition of sewage water?

Ans: Biological Oxygen Demand (BOD) as a Measure of Sewage Water Quality
BOD (Biochemical Oxygen Demand) is a crucial parameter used to assess the organic pollution level in sewage water. It indicates the amount of dissolved oxygen (DO) consumed by aerobic microorganisms while decomposing organic matter in a water sample over a specific period, typically 5 days.
Here's how BOD represents the condition of sewage water:

Higher BOD:

***Indicates high organic load:** Sewage with high organic matter content, like food waste, fecal matter, and industrial waste, will have a higher BOD. This means more oxygen is needed to break down the organic matter.

***Potential for oxygen depletion:** If the BOD of sewage is too high and discharged into receiving waters like rivers or lakes, it can deplete the available oxygen. This can harm aquatic life that relies on DO for respiration.

***Increased treatment needs:** Sewage with high BOD will require more intensive treatment in wastewater plants to remove the organic matter and reduce the BOD before discharge.

Lower BOD:

***Indicates lower organic load:** Sewage with low organic matter content has a lower BOD. This implies less oxygen is needed for decomposition, suggesting the water is less polluted.

***Reduced environmental impact:** Low BOD sewage poses a lower risk of oxygen depletion in receiving waters, protecting aquatic life.

***Potentially easier treatment:** Sewage with low BOD may require less intensive treatment in wastewater plants, making it more cost-effective and environmentally friendly.

Therefore, BOD serves as a valuable indicator of the organic pollution level and potential environmental impact of sewage water. It helps monitor the effectiveness of wastewater treatment processes and ensures the treated water meets discharge standards for protecting aquatic ecosystems.

Additional factors to consider:

***BOD alone is not a complete picture:** Other parameters like pH, temperature, and presence of toxic chemicals also influence the condition of sewage water.

***BOD levels can vary:** Depending on the source and composition of sewage, BOD values can range widely.

***Regulations and standards:** Different countries and regions have specific BOD limits for wastewater discharge, ensuring environmental protection.

3. How does any toxic substance get biomagnified among organisms? Explain in brief.

Ans: Biomagnification refers to the increasing concentration of a toxic substance as it moves up the food chain. Here's a simplified explanation of how it works:

1. Entry into the environment: Toxic substances can enter the environment from various sources like industrial waste, pesticides, and accidental spills. These substances can be:

***Persistent:** They resist degradation and remain in the environment for long periods.

***Bioavailable:** They can be absorbed by living organisms.

2. Uptake by primary producers: Microscopic organisms at the base of the food chain, like phytoplankton, absorb these toxins directly from water or soil.

3. Accumulation in their tissues: These organisms cannot effectively eliminate the toxins, leading to their build-up in their bodies.

4. Transfer through the food chain: When other organisms higher in the food chain, like zooplankton, feed on these contaminated primary producers, they ingest the toxins along with their food.

5. Lack of efficient excretion: The higher-level organisms also struggle to eliminate the toxins, leading to further accumulation in their tissues.

6. Concentration increases with each step: As each organism consumes one contaminated with higher concentrations, the toxin concentration becomes amplified, reaching alarming levels at the top predators.

This process results in:

***Higher toxicity at higher levels:** Top predators accumulate the highest concentrations, increasing their risk of harmful effects.

***Indirect exposure for humans:** Humans can get exposed to these toxins by consuming contaminated seafood or meat.

Understanding biomagnification is crucial for:

***Environmental protection:** Reducing pollution and managing environmental contamination to minimize toxic substance release.

***Food safety:** Monitoring food sources and setting limits on contaminant levels to protect human health.

***Conservation efforts:** Protecting top predators, particularly vulnerable species, from the detrimental effects of biomagnification.

4. What are xenobiotic compounds? How do these compounds affect the productivity of soil?

Ans: Xenobiotic Compounds and their Impact on Soil Productivity

Xenobiotic compounds are chemical substances that are foreign to a particular environment. They are not naturally produced by organisms in that ecosystem and are often synthetic in origin. Examples include pesticides, herbicides, industrial chemicals, pharmaceuticals, and personal care products. These compounds can enter the soil through various means, including:

***Agricultural practices:** Application of pesticides, herbicides, and fertilizers.

***Industrial activities:** Waste disposal, spills, and atmospheric deposition.

***Urban runoff:** Contamination from domestic wastewater and storm water.

While some xenobiotic compounds can be readily degraded by soil microorganisms, others are persistent and resistant to breakdown. These persistent xenobiotics can have significant negative impacts on soil productivity in several ways:

1. Disruption of soil microbial communities: Xenobiotic compounds can be toxic to soil microorganisms, including bacteria, fungi, and protozoa. These microbes play crucial roles in soil health by:

*****Decomposing organic matter and releasing nutrients for plants.
*****Suppressing plant pathogens and pests.
*****Stabilizing soil structure.
*****Cycling essential elements like nitrogen and phosphorus.

The disruption of these vital microbial communities can lead to reduced nutrient availability, increased pest and disease susceptibility, and impaired soil structure, ultimately impacting plant growth and crop yields.

2. Direct toxicity to plants: Some xenobiotic compounds can directly harm plants by disrupting their physiological processes. This can cause:
*****Inhibition of photosynthesis, leading to reduced energy production.
*****Disruption of nutrient uptake and metabolism.
*****Damage to plant roots and tissues.
*****Reduced seed germination and seedling growth.

These effects can significantly decrease crop yields and agricultural productivity.

3. Bioaccumulation and food chain transfer: Persistent xenobiotic compounds can be absorbed by plants and accumulate in their tissues. These contaminated plants can then be consumed by herbivores, leading to bioaccumulation, where the concentration of the compound increases within the food chain. This poses a risk to human and animal health, particularly for top predators.

4. Reduced biodiversity: The presence of xenobiotic compounds can also impact the diversity of soil organisms, including invertebrates like earthworms and insects. This loss of biodiversity can further compromise soil health and disrupt essential ecosystem functions.

Minimizing the negative impacts of xenobiotic compounds on soil productivity requires a multi-pronged approach, including:

***Reducing reliance on synthetic pesticides and fertilizers:** Promoting sustainable agricultural practices like organic farming and integrated pest management.

***Proper waste disposal and treatment:** Preventing harmful chemicals from entering the environment.

***Developing soil remediation strategies:** Encouraging the natural degradation of persistent xenobiotic compounds through bioremediation techniques.

By understanding the detrimental effects of these foreign compounds and implementing responsible practices, we can protect the valuable resource of fertile soil and maintain productive agricultural systems for future generations.

5. Discuss the process of aerobic and anaerobic decomposition of sewage waste water treatment.

Ans: Sewage wastewater treatment relies on both aerobic and anaerobic decomposition processes to break down organic matter and harmful pollutants, achieving a cleaner and safer release of water back into the environment. Here's a breakdown of these processes:

1. Aerobic Decomposition:

***Oxygen-powered breakdown: Aerobic bacteria, which require oxygen to survive, play the starring role in this process.**

***Stages of decomposition: The process typically involves two stages:**

.Primary stage: Organic matter like carbohydrates, proteins, and fats are broken down into simpler molecules like amino acids and sugars.

.Secondary stage: Ammonia and other nitrogenous compounds are converted into nitrates and nitrites by nitrifying bacteria, allowing plant life to utilize them.

***Benefits:**

.Efficiently removes BOD (biochemical oxygen demand), a key indicator of organic pollution.

.Reduces pathogens and harmful bacteria present in sewage.

.Produces sludge as a byproduct, which can be used as fertilizer or further treated for energy generation.

***Drawbacks:**

.Requires high energy input for aeration, increasing operational costs.

.Sensitive to fluctuations in oxygen levels and temperature.

2. Anaerobic Decomposition:

***Oxygen-free breakdown: In the absence of oxygen, different types of bacteria take over, utilizing fermentation and methanogenesis pathways.**

***Stages of decomposition:**

.Hydrolysis: Large organic molecules are broken down into smaller soluble compounds.

.Acidogenesis: These smaller molecules are further fermented into volatile fatty acids.
.Acetogenesis: Volatile fatty acids are converted into acetate.
.Methanogenesis: Acetate is converted into methane and carbon dioxide by methanogenic bacteria.
***Benefits:**
.Lower energy requirement compared to aerobic processes.
.Produces methane gas, a potential renewable energy source.
.Reduces sludge production.
***Drawbacks:**
.Slower and less efficient in overall pollutant removal compared to aerobic processes.
.Methane gas production can contribute to greenhouse gas emissions if not properly managed.
.Requires a controlled environment to maintain optimal conditions for methanogenic bacteria.
Integration of processes:
.Often, wastewater treatment plants employ a combination of both aerobic and anaerobic processes for optimal efficiency and pollutant removal.
.Anaerobic treatment may be used as a pre-treatment step to break down complex organic matter before the water enters the aerobic stage.
.The digestate or sludge produced from anaerobic digestion can be further processed for biogas production or fertilizer use.

6. What are the different types of solid wastes produced?

Ans: Solid wastes encompass a wide variety of materials we discard. Understanding their different types is crucial for effective waste management and environmental protection. Here's a breakdown of some key categories:

1. Municipal Solid Waste (MSW):
***Generated in households, offices, institutions, and commercial establishments.
***Includes food scraps, paper and cardboard, plastics, glass, textiles, yard waste, and miscellaneous items.
***Often the most familiar type of waste requiring regular collection and disposal.

2. Industrial Waste:

*Generated by manufacturing, processing, and construction activities.
*Can be diverse, including hazardous materials like chemicals, solvents, and heavy metals; non-hazardous wastes like scrap metal, construction debris, and packaging materials; and some specific types like biomedical waste from healthcare facilities.
*Requires specialized handling and disposal due to potential environmental and health risks.

3. Agricultural Waste:

*Generated from farming and agricultural practices.
*Includes crop residues, animal manure, packaging materials, pesticides, and fertilizers.
*Can pollute water resources if not properly managed.
*Can be potentially reutilized as compost or biogas feedstock.

4. E-waste:

*Discarded electronic and electrical equipment.
*Contains hazardous materials like lead, mercury, and cadmium, posing environmental and health risks.
*Requires proper recycling and treatment due to its complexity and resource potential.

5. Construction and Demolition Waste:

*Generated from construction, renovation, and demolition activities.
*Includes concrete, wood, bricks, drywall, pipes, and roofing materials.
*Can be recycled or reused depending on the type of material.

6. Hazardous Waste:

*Any waste that poses a threat to human health and the environment due to its toxicity, flammability, corrosivity, or reactivity.
*Requires special handling, transportation, and disposal under strict regulations.
*Examples include batteries, medical waste, paints, and pesticides.

Additional types:

*Biomedical waste from healthcare facilities.
*Radioactive waste from nuclear power generation.
*Mining waste generated from extraction and processing activities.

7. Discuss the role of different microorganisms in the process of composting of solid waste.

Ans: The humble compost pile is a bustling metropolis of microscopic life, teeming with diverse microorganisms that play crucial roles in transforming organic waste into rich, nutrient-rich compost. Each microbial group contributes a unique skill set, working together in a well-orchestrated choreography of decomposition:

Phase 1: The Mesophiles Take the Stage:

*****As you add fresh organic materials like food scraps, leaves, and yard waste to the pile, mesophilic bacteria take center stage. These heat-loving microbes thrive in temperatures between 30°C and 55°C (86°F and 131°F).

*****Using oxygen readily available in the open pile, they rapidly break down easily degradable carbohydrates, sugars, and proteins.

*****This initial decomposition generates heat, creating a warm and cozy environment for the next act.

Phase 2: The Thermophiles Turn Up the Heat:

*****As the temperature rises above 55°C (131°F), the mesophiles step aside for the thermophiles, who love the sizzling temperatures. These robust bacteria can withstand up to 65°C (149°F) and are highly efficient at degrading cellulose, the main component of plant cell walls.

*****Their activity further increases the temperature, killing harmful pathogens and weed seeds, making the compost safer and more suitable for plant growth.

Phase 3: The Fungi Join the Party:

*****While the temperatures remain high, fungi enter the scene, their long filamentous hyphae penetrating deeper into the pile, reaching areas inaccessible to bacteria.

*****Fungi are experts at decomposing lignin, a complex compound found in woody materials, making them crucial for complete waste breakdown.

*****Their presence also helps retain moisture and structure in the compost pile.

Phase 4: The Curtain Falls, Decomposition Slows:

*****As the readily available organic matter diminishes and temperatures cool, the microbial activity naturally slows down.

*****Mesophilic bacteria return, along with actinomycetes, filamentous bacteria that further decompose complex organic matter and contribute to the earthy smell of mature compost.

The Unsung Heroes:

***Beyond the bacteria and fungi, other tiny actors contribute to the composting magic.**

*****Protozoa graze on bacteria, regulating their populations and preventing bad odors.

*****Nematodes feed on fungi and bacteria, contributing to decomposition and nutrient cycling.

Through their synchronized performance, these diverse microorganisms transform waste into a valuable resource rich in humus, nutrients, and beneficial microbes. By understanding their roles, we can create and maintain optimal composting conditions, maximizing the efficiency and quality of our homemade soil enricher.

8. How are pesticides harmful for non-target organisms?

Ans: Pesticides, designed to target and eliminate specific pests, often inflict unintended harm on non-target organisms, creating ecological imbalances and posing potential threats to wildlife and human health. Here are some ways pesticides can harm non-target organisms:

Direct toxicity:

***Exposure through ingestion:** Non-target organisms like insects, birds, and mammals can be accidentally poisoned by consuming contaminated food, water, or soil. This can lead to immediate death, organ damage, reproductive problems, and other health issues.

***Exposure through contact:** Pesticide residues on leaves, skin, or fur can be absorbed by non-target organisms, causing a range of toxic effects, depending on the pesticide type and dose.

***Spray drift:** During application, pesticides can drift beyond the target area, reaching non-target organisms in surrounding habitats. This can be particularly harmful to pollinators like bees and butterflies, vital for healthy ecosystems.

Indirect effects:

***Disruption of food webs:** By eliminating key species like spiders or insects that prey on pests, pesticides can indirectly harm other animals that rely on them for food, impacting predator-prey dynamics and food availability.

***Habitat alteration:** Certain pesticides can damage vegetation or alter plant communities, affecting the habitat and resources available for non-target organisms.

***Bioaccumulation:** Some pesticides can persist in the environment and accumulate in the tissues of organisms throughout the food chain, reaching potentially harmful levels in top predators. This phenomenon, known as biomagnification, can pose risks to wildlife and human health.

Specific concerns:

***Neonicotinoids:** These systemic insecticides, affecting the nervous system of insects, are linked to bee population declines and potential impacts on other pollinators.

***Glyphosate:** The herbicide glyphosate, used widely in agriculture, has been associated with harmful effects on amphibians, butterflies, and soil microbial communities.

***Organochlorides:** Persistent and bioaccumulative, these older pesticides, while banned in many countries, still pose threats to wildlife and human health through long-term environmental contamination.

Minimizing harm:

***Integrated pest management (IPM):** Utilizing non-chemical control methods like habitat manipulation, natural predators, and biological control agents to reduce reliance on pesticides and minimize risk to non-target organisms.

***Targeted application:** Utilizing application methods and technologies that minimize drift and exposure to non-target areas.

***Choosing safer alternatives:** Opting for less harmful pesticides with shorter persistence and lower toxicity to non-target organisms.

9. Briefly explain as to how microorganisms can bioremediate toxic pesticides into harmless and non-toxic compounds.

Ans: Microorganisms possess remarkable abilities to degrade and detoxify a wide range of pollutants, including harmful pesticides. This process, known as bioremediation, offers a natural and often sustainable solution to environmental contamination. Here's how they achieve this feat:

1. Diverse Arsenal of Enzymes:

Microorganisms, particularly bacteria and fungi, produce a diverse array of enzymes that can target specific chemical bonds within pesticide molecules. These specialized enzymes are like molecular scissors, breaking down the complex pesticide structures into smaller, less harmful compounds.

2. Degradation Pathways:

Different types of microorganisms employ different degradation pathways to dismantle specific pesticides. Some common pathways include:

***Hydrolysis:** Breaking down pesticide molecules by adding water molecules, often making them more water-soluble and readily eliminated.

***Oxidation:** Adding oxygen atoms to the pesticide, potentially splitting it into smaller fragments or transforming it into less toxic forms.

***Conjugation:** Attaching non-toxic molecules to the pesticide, altering its properties and rendering it less harmful.

3. Microbial Cooperation:

Bioremediation is often a collaborative effort. Different microbes with distinct enzymatic capabilities can work together in a consortium, each tackling a specific part of the pesticide molecule. This teamwork allows for the complete degradation of complex pesticides that a single microbe might struggle with.

4. In situ vs. Ex situ Approach:

Bioremediation can be carried out in two main ways:

***In situ:** Microorganisms are directly applied to the contaminated site, either naturally occurring or specifically chosen for their degrading abilities. This method is cost-effective but might be slower.

***Ex situ:** Contaminated soil or water is removed and treated in bioreactors with specific microbial cultures under controlled conditions. This method is often faster and more targeted but requires additional infrastructure.

Benefits of Bioremediation:

***Natural and sustainable:** Utilizes naturally occurring microorganisms, minimizing reliance on chemical or physical remediation methods.

***Cost-effective:** Often cheaper than traditional remediation methods in the long run.

***Efficient:** Can effectively degrade a wide range of pesticides, even persistent ones.

***Environmentally friendly:** Does not introduce harmful chemicals or create additional pollution.

While bioremediation is a promising technology, it's important to acknowledge that it may not be a one-size-fits-all solution. Factors like the type of pesticide, environmental conditions, and microbial community diversity can influence the effectiveness of the process.

10. Which of the following compounds can be removed from waste water during treatment using lime?
(a) Organic compound
(b) Phosphorous salts
(c) Ammonia
(d) Urea
Ans: (b) Phosphorous salts.

11. Maximum decomposition of water takes place during:
(a) Primary treatment only
(b) Primary and Secondary treatment both
(c) Secondary treatment only
(d) Secondary and tertiary treatment both
Ans: (c) Secondary treatment only.

12. Which enzyme is mainly responsible for hydrolytic breakdown of pesticides?
(a) Peroxidare
(b) Oxidare
(c) Cytochrous P 450
(d) Esterare
Ans: (d) Esterare.

13. Which of the following is not a strategy of bioremediation?
(a) Sludge digestion
(b) Composting
(c) Slury bioreactor

(d) Biopiles
Ans: (a) Sludge digestion

14. Assertion: Bioremediation is a process through which toxic pesticides can be completely removed.
Reason: Microorganisms can be used for bioremediation of toxic chemicals.
(a) Both assertion and reason are true and the reason is correct explanation of assertion.
(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.
(c) Assertion is true but reason is false.
(d) Both assertion and reason are false.
Ans: (b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.

15. Based on the colour coding and type of container for disposal of health care waste, choose the correct match:
(a) Yellow — recyclable plastic waste
(b) Red — metallic body
(c) White — sharp metals, needle, syringes
(d) Blue — general health care waste
Ans: (c) White — sharp metals, needle, syringes.

16. What is the basis of classifying organisms into four risk groups?
Ans: There are several different classification systems for infectious microorganisms, each with its own criteria and level of detail. However, the widely used "four risk group" system, often followed by the World Health Organization (WHO) and other agencies, focuses primarily on these key factors:
1. Pathogenicity:
***Group 1:** Agents unlikely to cause human or animal disease.
***Group 2:** Agents that can cause human or animal disease but pose a low risk to laboratory workers and the community.
***Group 3:** Agents that cause serious human or animal disease and pose a moderate risk to laboratory workers and the community.

***Group 4:** Agents that cause serious human or animal disease and pose a high risk to laboratory workers and the community.

2. Mode of transmission:

***The risk group also considers how easily the agent can be transmitted between humans, animals, or the environment. For example, an airborne virus with high infectivity would be placed in a higher risk group than a bacteria transmitted only through direct contact with infected wounds.

3. Availability of effective prophylaxis and treatment:

***The availability of vaccines, antiviral drugs, or antibiotics for the agent plays a role in determining its risk. Agents with readily available and effective treatments may be classified in a lower risk group compared to those lacking specific interventions.

4. Stability in the environment:

***Some agents remain infectious for extended periods in the environment, increasing the risk of exposure and contamination. This factor also contributes to the overall risk assessment.

Additional considerations:

***Some systems also consider host factors like individual susceptibility or the potential for zoonotic transmission (transmission from animals to humans).

***The risk group classification is dynamic and can be revised based on new scientific information about the agent or changes in its epidemiology.

SUMMARY

• Large population and various human activities lead to the drastic shortage of fresh water in India.

• A large part of the population is unaware of the treatment of sewage waste before discharge.

• Sewage water consists 1percent inorganic and organic matter suspended in soluble form, which can be detected by Biological Oxygen Demand (BOD) value.

• Sewage water contains the microflora of human intestinal tract as well as many soil and water species, some fungus and viruses.

• Sewage disposal plants are operated for treatment of waste water before its release into streams. The waste water treatment plants are designed based on their capability to provide primary, secondary (biological), and tertiary (advanced) treatment.

• Primary treatment removes large floating objects, secondary treatment removes suspended organic material through microbiological degradation, whereas tertiary treatment removes phosphorus and nitrogenous nutrients and all suspended organic matter from waste water.

• All non-liquid waste materials generated from households, streets, industrial, commercial and agricultural activities are called solid wastes.

• Solid wastes can be categorised into two groups:

(i) biodegradable waste and (ii) non-biodegradable waste.

• Decomposition of solid wastes are associated with various diseases, like malaria, dengue, SARS, plague; attract animals, flies, vermins and can play a major role in the transmission of diseases.

• Solid waste management refers to the process of collecting, treating, and disposing of solid material that is discarded or is no longer useful.

• The handling and managing of solid waste involves two approaches—dumping and recycling the waste.

• Organic waste can be recycled through the process of composting. Fruits and vegetables waste, animal dung and fallen leaves from plants form an excellent soil conditioner and fertiliser (compost).

• Health care solid waste contains many infectious pathogens which needs incineration or safe burial immediately. The handler of the waste needs to take all precautions (wearing mask and gloves) while handling waste.

• Industrial solid waste can be of different kinds and the main concern associated with industrial waste is the proper disposal of chemical, biological and toxic metals, which is handled by the respective industries.

• Composting is the most powerful biological, chemical and physical activity, available in natural environment, where organisms under suitable conditions carry out biological degradation of material.

• Biomedical Waste Management Rules 2016 (BMWM) categorises the biomedical waste into four major categories based on the segregation pathway and standard colour code assigned for containers.

• Yellow colour code is for anatomical waste, soiled waste, discarded or expired medicines, chemical waste, bedding, microbiology and biotechnology and other clinical laboratory waste.

• Red colour code is for contaminated plastic waste: waste generated from disposable items like intravenous tubes, bottles, catheters, syringes without needles, fixed needle syringes with their needles cut, urine bags, vaccutainers and gloves.

• White colour code for sharps including metals; used, discarded and contaminated metal sharps, needles, syringes with fixed needles, needles from needle tip cutter, blades, scalpel or any other contaminated sharp object that may cause puncture and cuts.

• Blue colour code is for metallic body implants, broken or discarded and contaminated vials, ampoules .

• As per WHO guidelines, the biomedical waste is also classified on the basis of risk factors involved into four major groups.

• It is important to segregate waste at the point of its generation from handling point of view.

• Common Biomedical waste Treatment Facility (CBWTF) is available within 75 km of travelling distance of a health care facility.

• A symbol indicating ‘Biohazard’ should be placed in all colour coding and labels.

• The radioactive waste should be disposed of according to the guidelines issued and as per the provisions of the said rule.