Key Topic 1: Landfills and Hazardous Materials

I. Describe different types of landfills and explain how they are regulated.
  a. Landfills are regulated under RCRA Subtitle D (solid waste) and Subtitle C (hazardous waste) or under the Toxic Substances Control Act (TSCA).
    i. Subtitle D focuses on state and local governments as the primary planning, regulating and implementing entities for the management of nonhazardous solid waste, such as household garbage and nonhazardous industrial solid waste. Subtitle D landfills include the following:
      1. **Municipal Solid Waste Landfills (SWLFs)** - Specifically designed to receive household waste, as well as other types of nonhazardous wastes.
        a. **Bioreactor Landfills** – A type of MSWLF that operates to rapidly transform and degrade organic waste.

      2. **Industrial Waste Landfills** – Designed to collect commercial and institutional waste (i.e. industrial waste), which is often a significant portion of solid waste, even in small cities and suburbs.
        a. **Construction and Demolition (C&D) Debris Landfill** – A type of industrial waste landfill designed exclusively for construction and demolition materials, which consists of the debris generated during the construction, renovation and demolition of buildings, roads and bridges. C&D materials often contain bulky, heavy materials, such as concrete, wood, metals, glass and salvaged building components.
        b. **Coal Combustion Residual (CCR) landfills** – An industrial waste landfill used to manage and dispose of coal combustion residuals (CCRs or coal ash). EPA established requirements for the disposal of CCR in landfills and published them in the Federal Register April 17, 2015.
    ii. Subtitle C establishes a federal program to manage hazardous wastes from cradle to grave. The objective of the Subtitle C program is to ensure that hazardous waste is handled in a manner that protects human health and the environment. To this end, there are Subtitle C regulations for the generation, transportation and treatment, storage or disposal of hazardous wastes. Subtitle C landfills including the following:
      1. **Hazardous Waste Landfills** - Facilities used specifically for the disposal of hazardous waste. These landfills are not used for the disposal of solid waste.
      2. **Polychlorinated Biphenyl (PCB) landfills** - PCBs are regulated by the Toxic Substances Control Act. While many PCB decontamination processes do not require EPA approval, some do require approval.

II. Identify examples of hazardous materials and toxic substances and describe their proper disposal and handling.

a. Hazardous waste is a waste with properties that make it a dangerous or capable of having a harmful effect on human health or the environment. Some examples include:
    i. Solvent-based paints
    ii. Batteries
    iii. Pesticides, herbicides, fertilizers
    iv. Motor Oils, antifreeze, brake fluid
    v. Chemicals or any corrosive materials (highly acidic or basic)
    vi. E-waste

Key Topic 2: Reuse, Recycling and Waste Diversion

I. Explain how the practices of reusing or recycling products conserves natural resources.
  a. Conserves natural resources such as timber, water and minerals
  b. Making a new product emits greenhouse gases that contribute to climate change and requires a lot of materials and energy - raw materials must be extracted from the earth, and the product must be fabricated then transported to wherever it will be sold.

II. Describe how recycled materials can be repurposed and further diverted from landfills.
  a. Another term referring to this type of use is "upcycle." Repurpose literally means give an item a new purpose whereas reusing something utilizes the product in its original intended form (container = container, etc.)
  b. When repurposing, a container could become a decorative wall hanging or a wall hanging could become a container—the possibilities are endless!
  c. Examples:
    i. Faux metal art from toilet paper tubes
    ii. Empty coffee can to plastic bag re-use dispenser
    iii. Planters

III. Explain how waste can be repurposed
  a. Here are other examples of products made using recycled materials:
    i. Glass: new glass bottles/jars, fiberglass, sand for road work/winter traction.
    ii. Plastic bottles: sleeping bags/ski jackets insulation, polar fleece fabric, Frisbees, new plastic bottles and containers.
    iii. Paper/cardboard: new cardboard, sheetrock, new paper, paper towels, egg cartons, phone books, building insulation, paper plates.
    iv. Metal/aluminum cans: new aluminum cans, bike/car parts, appliances.

Key Topic 3: Composting and Food Waste

I. Describe composting processes and identify how composting supports waste diversion efforts.

    a. Composting is the natural process of recycling organic matter, such as leaves and food scraps, into a valuable fertilizer that can enrich soil and plants. Anything that grows decomposes eventually; composting simply speeds up the process by providing an ideal environment for bacteria, fungi, and other decomposing organisms (such as worms, sowbugs, and nematodes) to do their work. The resulting decomposed matter, which often ends up looking like fertile garden soil, is called compost. Fondly referred to by farmers as "black gold," compost is rich in nutrients and can be used for gardening, horticulture, and agriculture.
    b. Food scraps and garden waste combined make up more than 28 percent of what we throw away. Not only is food waste a significant burden on the environment, but processing it is costly. The average cost to landfill municipal solid waste in the United States was around $55 per ton in 2019. With the United States generating more than 267 million tons of municipal waste in 2017 and sending two-thirds of that to landfills and incinerators, we spent billions of dollars on waste management. Composting at home allows us to divert some of that waste from landfills and turn it into something practical for our yards.

II. Explain how composting improves soil health and provide evidence for how composting supports water conservation efforts.
    a. Compost contains three primary nutrients needed by garden crops: nitrogen, phosphorus, and potassium. It also includes traces of other essential elements like calcium, magnesium, iron, and zinc. Instead of relying on synthetic fertilizers that contain harmful chemicals, composting offers an organic alternative. Research has shown the capability of compost to increase soil's water retention capacity, productivity, and resiliency.
    b. Agriculture is a major consumer of water in the United States, accounting for approximately 80 percent of the nation's water use. How can compost help? Research has shown the water-retaining capacities of soil increase with the addition of organic matter. In fact, each 1 percent increase in soil organic matter helps soil hold 20,000 gallons more water per acre. By using compost to foster healthy soil, farmers do not have to use as much water and can still have higher yields compared with farming with degraded soil.

III. Describe the problem of food waste and explain how it impacts the sustainability of the global food supply.
    a. Each day in the United States approximately one pound of food per person is wasted. This equates to 103 million tons (81.4 billion pounds) of food waste generated in America in 2017.
    b. Food wastage occurs at every step of the supply chain, with different types of foods being more or less likely to be lost at each step.
        i. According to data from the United States, Canada, Australia, and New Zealand that was collected by the Natural Resources Defense Council (NRDC), 20 percent of fruit and vegetables are lost during production, 12 percent are lost at the distribution and retail level, and a further 28 percent are lost at the consumer level. Seafood faces a similar fate, with 11 percent

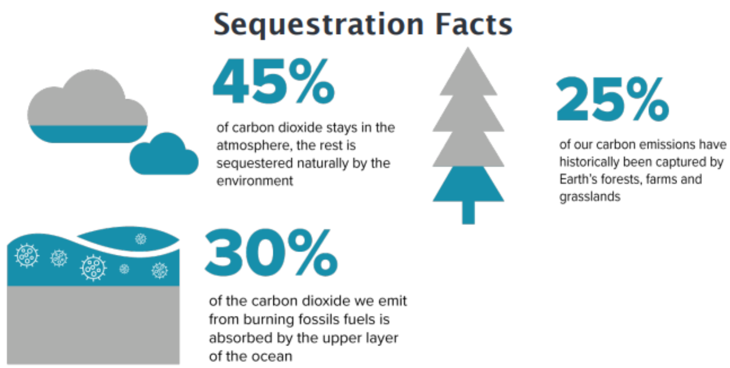
lost during production, 5 percent lost during processing and packaging, 9.5 percent lost at the distribution and retail level, and a further 33 percent lost at the consumer level.

Key Topic 4: Combustion with Energy Recovery (Waste-to-Energy)

I. Identify examples of closed loop energy systems and facilities.
   a. Coal mining waste repurposed as useful chemicals
   b. Hydraulic fracturing flowback and produced water reuse and treatment
   c. Anaerobic digestion as an opportunity for integrating waste management across food, energy, and agricultural systems
   d. Reduced water consumption through integrated management of renewable energy in arid regions

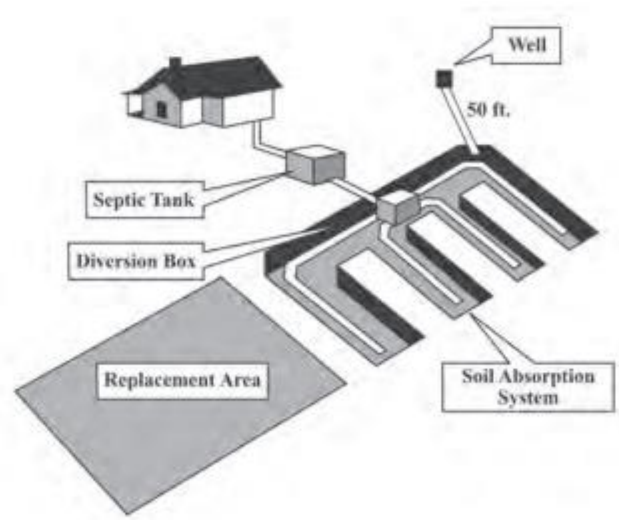
II. Compare methods of carbon sequestration and describe their potential as an energy source.
   a. Biological
      i. Biological Carbon Found in the Oceans
         1. Oceans absorb roughly 25 percent of carbon dioxide emitted from human activities annually.
      ii. Biological Carbon Found in Soil
         1. Carbon is sequestered in soil by plants through photosynthesis and can be stored as soil organic carbon (SOC).
      iii. Biological Carbon Found in Forests
         1. About 25 percent of global carbon emissions are captured by plant rich landscapes such as forests, grasslands and rangelands.
      iv. Biological Carbon Found in Grasslands
         1. While forests are commonly credited as important carbon sinks, California's majestic green giants are serving more as carbon sources due to rising temperatures and impact of drought and wildfires in recent years. Grasslands and rangelands are more reliable than forests in modern-day California mainly because they don't get hit as hard as forests by droughts and wildfires, according to research from the University of California, Davis. Unlike trees, grasslands sequester most of their carbon underground. When they burn, the carbon stays fixed in the roots and soil instead of in leaves and woody biomass. Forests have the ability to store more carbon, but in unstable conditions due to climate change, grasslands stand more resilient.
   b. Geological
      i. Geological carbon sequestration is the process of storing carbon dioxide in underground geologic formations, or rocks. Typically, carbon dioxide is captured from an industrial source, such as steel or cement production, or an energy-related source, such as a power plant or natural gas processing facility and injected into porous rocks for long-term storage.

c. Technological
    i. Graphene production
        1. The use of carbon dioxide as a raw material to produce graphene, a technological material. Graphene is used to create screens for smart phones and other tech devices. Graphene production is limited to specific industries but is an example of how carbon dioxide can be used as a resource and a solution in reducing emissions from the atmosphere
    ii. Direct air capture (DAC)
        1. A means by which to capture carbon directly from the air using advanced technology plants. However, this process is energy intensive and expensive, ranging from $500-$800 per ton of carbon removed. While the techniques such as direct air capture can be effective, they are still too costly to implement on a mass scale.
    iii. Engineered molecules
        1. Scientists are engineering molecules that can change shape by creating new kinds of compounds capable of singling out and capturing carbon dioxide from the air. The engineered molecules act as a filter, only attracting the element it was engineered to seek.



Key Topic 5: Human and Animal Waste Treatment

I. Evaluate the differences between municipal waste treatment and home sewage treatment systems.
    a. Home sewage treatment systems/On-site Wastewater Treatment
        i. Installing septic tank systems is common to provide on-site disposal systems, but it is a temporary solution at best. Because property size must be sufficient to allow space for septic system replacement, the cost to the municipality installing a centralized sewer system will be dramatically increased because of the large lot size.
        ii. Septic tank systems use both anaerobic (by bacteria that do not require oxygen) and aerobic (by bacteria that require oxygen) decomposition



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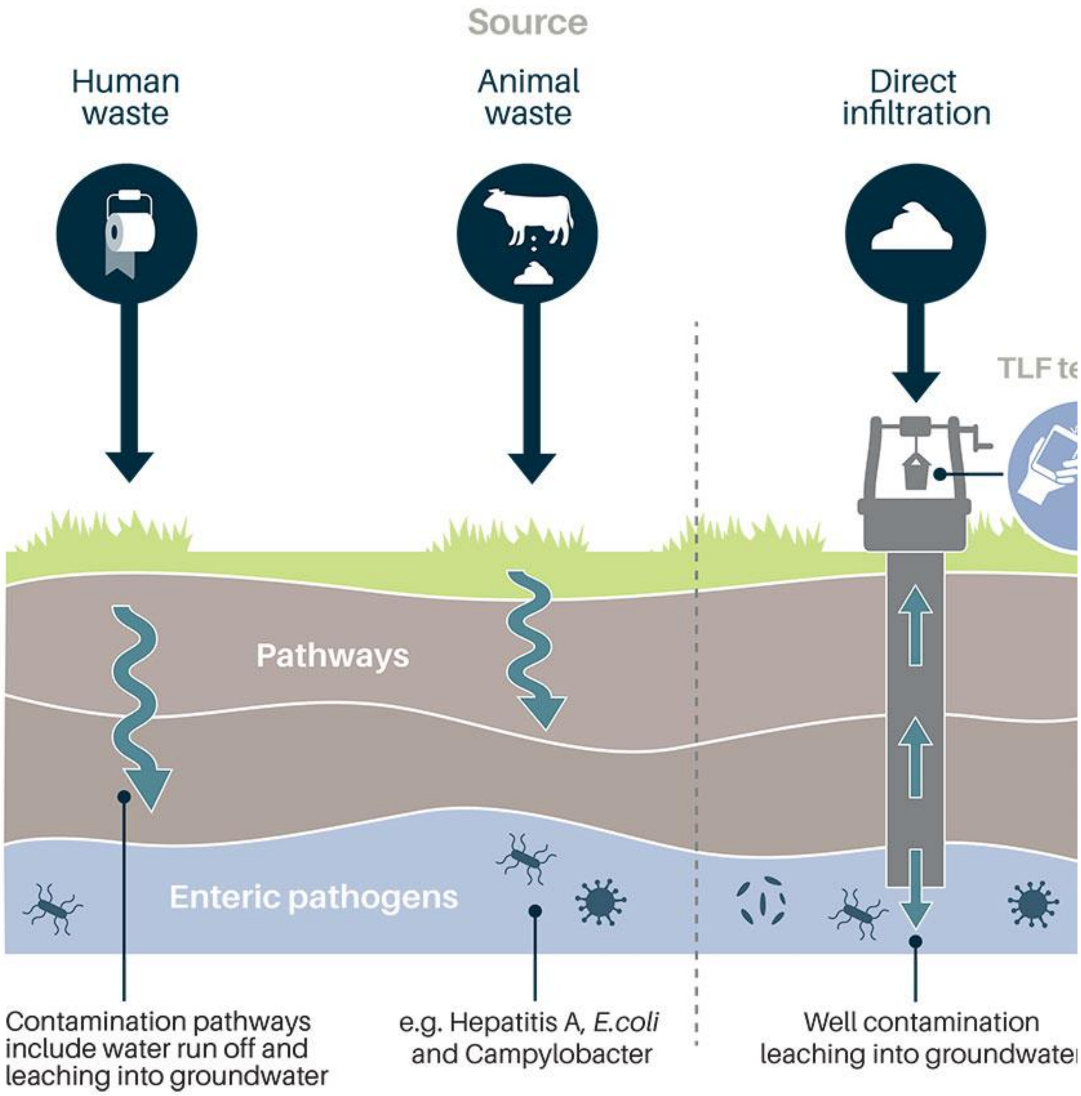
iii. The main difference between a septic system and a sewer system is a septic system treats your wastewater on site

b. Municipal waste treatment
   i. Centralized wastewater treatment facilities use aerobic processes, as do most types of lagoons.
   ii. Primary, secondary, advanced and final treatment steps

II. Compare and contrast the methods of waste treatment for human waste versus animal waste.
   a. While human waste is treated in municipal sewer systems and subject to strict regulation, animal waste is stored in open ponds (called lagoons) or pits and is applied untreated as fertilizer to farm fields.
   b. "The one big difference is WATER consumption…our animal manures are a lot more concentrated than human waste! This means it doesn't take as much to cause environmental issues and that conventional waste treatment systems used for human waste often won't perform well when used for animal waste"

III. Describe the impacts to ground and surface waters when fecal waste is not effectively managed.
   a. Swimming in waters with high levels of fecal coliform bacteria increases the chance of developing illness (fever, nausea, or stomach cramps) from pathogens entering the body through the mouth, nose, ears, or cuts in the skin.
   b. Diseases and illnesses that can be contracted in water with high fecal coliform counts include typhoid fever, hepatitis, gastroenteritis, dysentery, and ear infections.



c.

IV. Identify innovative methods for managing fecal waste to lessen the impact to natural resources.
   a. Biosolids land application (once properly treated to prevent heavy metals and pesticides leaching into water bodies).
      i. Agriculture
      ii. Reclamation sites
      iii. Forestry
      iv. Lawns and home gardens (not for use on fruits or vegetables that are eaten uncooked).
   b. Urban China turns sewage into power
      i. Converting sludge into clean energy starts by breaking down the slurry. Thermal hydrolysis combines the high-pressure boiling of waste or sludge with rapid decompression. Anaerobic digestion harnesses microorganisms to break down biodegradable material in the absence of oxygen. Much of

the end product can–with political will, tools and incentives–be recaptured as a gas, liquid or solid fuel.

Key Topic 6: Brownfields and the Restoration of Degraded Lands

I. Define a brownfield and identify the impacts of brownfield materials on soil and water quality.
   a. Brownfields are defined as abandoned or underutilized properties, including but not limited to industrial and commercial facilities, where redevelopment or expansion may be complicated by possible environmental contamination (real or perceived).
   b. Petroleum and pesticides contain dangerous hydrocarbons, while the waste from other types of manufacturing can contain a variety of metals, including lead, iron, mercury, arsenic, copper and cadmium. Heavy metals and hydrocarbons are of most concern to authorities because they are highly toxic and more pervasive in the environment, relative to other pollutants.
   c. Plants growing in contaminated soil directly take up metals and other pollutants. Metal-tolerant plants allow the accumulation of heavy metals in their tissues.
   d. Many brownfield contaminants are soluble in water and can rapidly drain into groundwater. This poses a risk to humans and animals that use aquifers as a source of drinking water

II. Explain methods for removing brownfield toxins and the role of federal and state entities in restoration.
   a. The EPA implemented a brownfield revitalization program in 1995. This program provides grants to communities and private businesses to help with the financial cost of cleaning up brownfield sites.
   b. Sites can be cleaned by washing or heat-treating contaminated soil.
      i. This can be done onsite, or soil can be removed and treated in a safer environment. It is cheaper to manage contaminated soils rather than try and remove contaminants at the outset
   c. Management techniques include growing plants that break down, rather than accumulate toxins, and chemical transformation of pollutants by increasing soil pH or adding phosphates

III. Compare "green" approaches to re-using degraded lands and identify the benefits these methods provide to local communities.

a. 
What will brownfields redevelopment look like in your community?
Green Space: Agriculture, community parks, trails, sports fields and facilities, open space and other recreational activities. These spaces also provide wildlife habitat and nature conservation opportunities.
Residential: Multi-family homes, like apartments and condos, single-family homes and other residential purposes, such as university and senior housing.
Industrial: Manufacturing buildings, warehouse, storage and distribution facilities, renewable energy production, research and development parks.
Mixed Use: Combination of two or more reuses (for example, an apartment building with retail and office spaces on the ground floor next to a public park).
Commercial: Offices, retail, restaurants, and other businesses; municipal buildings and non-profit centers.
Your voice and neighborhood knowledge can help create better brownfield reuse decisions. Get involved in the process!