

**AP[®] ENVIRONMENTAL SCIENCE
2007 SCORING GUIDELINES**

Question 1

Read the Fremont Examiner article below and answer the questions that follow.

- (a) Identify ONE component of the sewage that is targeted for removal by primary treatment and ONE component of the sewage that is targeted for removal by secondary treatment. (2 points—1 point for each)**

| Primary treatment removal | Secondary treatment removal |
|---|--|
| Any relatively large (macroscopic) solid material (e.g. rocks, gravel, sand, solid human or animal waste, twigs, cans, etc) | Dissolved/suspended organic materials such as human waste products, soaps, detergents, food waste, pathogens (e.g., <i>E. coli</i>) |
| Fats, oil, or grease (FOG) | Phosphates, Nitrates |

- (b) For EACH of the pollutants that you identified in part (a), describe how the pollutant is removed in the treatment process. (2 points—1 point for each)**

PRIMARY TREATMENT

| Pollutant | Removal mechanism |
|---|---|
| All large objects such as rags, sticks, condoms, cans, tampons, fruit, etc. | Description of a physical process for removing solids from the liquid component (grid filtration, screening, sieving, nets, filters, etc.) |
| Sand, grit, fecal material | A settling tank; incoming wastewater is slowed so sand, grit, small rocks, fecal material can settle out (also called a detritor or sand catcher) |
| Fats, oil, or grease | Allowed to float to the top of the wastewater, where it can be mechanically skimmed off |

SECONDARY TREATMENT

| Pollutant | Removal mechanism |
|---|---|
| Any dissolved/suspended organic substance | 1) Effluent is brought in contact with oxygen and aerobic microorganisms that break down/consume the organic matter 2) Anaerobic microbial digester 3) Secondary sedimentation and floc removal |
| Pathogens (bacteria, <i>E. coli</i> , etc.) | Disinfection (chlorine, ozone, UV, etc.) |
| Phosphate | Lime, alum, aluminum sulfate, iron chloride, iron sulfate, biological removal |
| Nitrates/Ammonia | Denitrifying bacteria (anaerobic microbial digester) |

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Question 1 (continued)

- (c) Explain how sewage treatment plants create the solid waste problem that Dr. Goodwin mentioned in the article. (1 point)**

Particulates and other substances removed from wastewater during primary and secondary treatment create a significant amount of solid material which must then be disposed of elsewhere.

- (d) Two common methods of disposing of solid waste from sewage treatment plants are transporting it to a landfill or spreading it onto agricultural lands. Describe an environmental problem associated with EACH of these methods. (2 points)**

| Landfill Problems | Agricultural Problems |
|--|--|
| Takes up a considerable amount of landfill space (resulting in expansion or new development of landfills) | Human/animal health problems associated with bacterial wastes contaminating food/feed crops |
| Potential groundwater contamination (toxins, contaminants, heavy metals, leachates) | Potential groundwater/soil/plant contamination (toxins, contaminants, heavy metals, leachates) |
| Greenhouse gases, such as methane, produced during anaerobic decomposition can escape into the atmosphere and contribute to global warming | Incorporation of toxins/heavy metals into the food chain |
| Environmental effects associated with transportation of solid waste | Field runoff resulting in surface water contamination (eutrophication/oxygen depletion of surface waters due to wastes high in nitrogen or phosphorus) |

- (e) The final step in sewage treatment is disinfection. Identify ONE pollutant that is targeted during disinfection and identify ONE commonly used method of disinfection. (2 points—1 point for identifying a pollutant and 1 point for identifying a method of disinfection)**

Pollutants: Pathogenic contaminants:

- *E. coli* bacteria
- Coliform bacteria
- *Giardia*
- Pathogens
- Microorganisms/bacteria
- Cholera
- Viruses

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Question 1 (continued)

Method of disinfection (pollutant and disinfection method do NOT need to be linked):

- chlorine or ozone (or other oxidizing chemicals such as bromine, iodine or hydrogen peroxide, bleach/sodium hypochlorite, chloramines)
- ultraviolet radiation (UV)
- microfiltration (using ceramic filters)
- lime treatment
- electron beam radiation

(f) Identify ONE United States federal law that requires monitoring the quality of the treated sewage that is discharged into the Fremont River. (1 point for specifically identifying a U.S. federal law)

- (Federal) Water and Pollution Control Act (1956)
- National Environmental Policy Act (1969)
- (Federal) Water Pollution Control Act (1972), (1977), (1987)—“Clean Water Act” accepted
- (Federal) Safe Drinking Water Act (1974)—amended in 1996 to include protection of drinking water sources

(A) One component of sewage removed during primary treatment is solid waste and particles that are either blocked by a grate or settle out of the water in a settling pond. In secondary treatment of waste water, harmful pathogens that carry disease or viruses are removed.

(B) The solid waste particles are removed either when flowing water travels through a grate that blocks the larger solids from passing or when the particles settle out in a settling pond. Harmful pathogens can be taken out when cleansing additives, such as chlorine or ozone, are put in the waste water.

(C) Sewage treatment plants create solid waste problems because the fecal coliform (human waste) removed from the water has to be put somewhere. Although during biological oxidating aerobic bacteria eat much of the feces, there still is a large excess amount.

(D) The problem with merely transporting the solid waste to a landfill is that toxic substances in the waste can run out of the waste and leach far down into the soil. Sometimes, the chemicals and pathogens can even reach the groundwater, causing groundwater contamination which threatens the cleanliness of our water supply. Spreading the waste on agricultural lands does add nutrients, such as nitrates and phosphates, to the soil, making it more fertile. However, the waste can run off into streams and rivers, adding excessive amounts of nitrates and phosphates to the water. This can cause eutrophication, decrease dissolved oxygen, increase turbidity, and suffocate fish.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

Ⓔ one major pollutant targeted is fecal coliform or human waste. one common method of disinfection is the addition of chlorine or ozone to rid the water of potentially harmful pathogens and bacteria.

Ⓕ The clean water Act monitors the quality of treated sewage by controlling the output of wastes into bodies of water. Businesses or corporations must have a permit to dump anything into a body of water.

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One component removed from the sewage during primary treatment is human waste. During secondary treatment chemicals such as herbicides would be removed. The human waste is removed by filters that remove the waste from the water. The chemicals such as herbicides would be removed by treating the water with multiple filters that are designed to remove the chemicals. More solid waste could be produced from this because more machinery is required for the waste removal and more waste is being taken out of the water and has to be disposed of. ~~If~~ this waste is taken to a landfill this can produce more problems if the landfill leaks the waste into the groundwater. If the waste is dumped on agricultural land it can run off into nearby streams and rivers or pollute the soil if it is dumped on. Bacteria are removed from water during disinfection. One method is using chlorine on the water. The Sewer and Waste Water Treatment Act requires certain EPA standards to be met.

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In primary treatment, any large debris is taken out. This can be anything like plastic, large pieces of ^{any} material, glass bottles, etc. This particulate matter will be removed from the sewage. Secondary treatment removes grit and other small debris by using a "grit chamber". This is simply a filter that traps all of the grit and debris so that they are no longer in the sewage. The treatment process for primary treatment consists of a larger filter that pretty much does the same thing. The water is run through it and the bigger scale filter traps all of the unwanted materials. Although this does treat the water, it creates a lot of solid waste. As the water is run through the filters, all of the material that is trapped needs to go somewhere. It does not just disappear; it needs to be disposed of in some way. A lot of times, in order to dispose of this waste they take it to either landfills, or spread it out onto agricultural lands. Although these seem like reasonable ways to rid the

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plants of the solid waste, they are causing environmental problems as well. Transporting the waste to landfills takes up enormous amounts of space that should be being used ~~for~~ for another, more beneficial problem. Landfills are not a sustainable way of disposal. Also, spreading the waste over farmland can also be detrimental to the environment. When waste is spread over these lands as fertilizers, much of the time it is carried off ~~into~~ into the bodies of water around it by agricultural runoff. This waste that is being runoff now contains many nutrients from the cropland that cause eutrophication in the water. The final step in sewage treatment is disinfection. One pollutant that is likely to be removed is chlorine. Chlorine can be removed by a special process of disinfection. One law that requires monitoring the quality of the treated sewage dumped into the Fremont River is the Sewage Dumping Act.

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Question 1

Overview

The intent of this document-based question was to determine the level of students' understanding of municipal wastewater treatment and the environmental effects associated with the disposal of the wastes from wastewater treatment plants. This question also asked the students to identify one federal statute that relates to monitoring the quality of effluent discharge.

Sample: 1A

Score: 10

Part (a): Two points were earned: 1 point for correctly identifying removal of solid waste and particles in primary treatment, and 1 point for identifying removal of pathogens in secondary treatment.

Part (b): Two points were earned: 1 point for describing an appropriate physical method for removal (screening and settling) in primary treatment, and 1 point for giving an appropriate method (chlorine and ozone) for removing the biological component in secondary treatment. (The mention of screening and settling ponds in part (a) could also have earned the first point in part (b).)

Part (c): One point was earned for explaining the creation of solid waste at the treatment facility and the problem of disposing of this waste.

Part (d): Two points were earned: 1 point for describing groundwater contamination as a problem associated with landfill disposal (leaching into groundwater), and 1 point for describing the problem of runoff from agricultural disposal to nearby surface waters resulting in eutrophication.

Part (e): Two points were earned: 1 point for identifying fecal coliform as a pollutant targeted for disinfection, and 1 point for identifying treatment with chlorine/ozone as a disinfection method.

Part (f): One point was earned for correctly identifying the Clean Water Act.

Sample: 1B

Score: 7

Part (a): One point was earned for identifying human waste material for removal in primary treatment. No point was earned for identifying herbicides for removal in secondary treatment.

Part (b): One point was earned for describing filtering as a method of removing the solid material identified in part (a).

Part (c): One point was earned for explaining the creation of solid waste at the treatment facility and the problem of disposing of this waste.

Part (d): Two points were earned: 1 point for describing groundwater contamination as a problem associated with landfill disposal, and 1 point for describing the problem of surface water contamination due to runoff from agricultural disposal.

Part (e): Two points were earned: 1 point for identifying bacteria as a pollutant targeted for disinfection, and 1 point for identifying treatment with chlorine as a disinfection method.

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Question 1 (continued)

Part (f): No point was earned because no appropriate federal law is identified.

Sample: 1C

Score: 5

Part (a): One point was earned for correctly identifying removal of large debris in primary treatment. No point was earned for identifying components removed in secondary treatment.

Part (b): One point was earned for correctly describing filtering as a method of removing the solid material identified in part (a).

Part (c): One point was earned for explaining the creation of solid waste at the treatment facility and the problem of disposing of this waste.

Part (d): Two points were earned: 1 point for describing the impact on landfill space, and 1 point for describing the problem of runoff from agricultural disposal to nearby surface waters resulting in eutrophication.

Part (e): The student did not earn any points for identifying chlorine as a pollutant targeted for disinfection.

Part (f): The student does not identify an appropriate federal law, so no point was earned.