

AP[®] ENVIRONMENTAL SCIENCE

2016 SCORING GUIDELINES

Question 3

Municipal solid waste (MSW) is the trash collected from households and businesses.

- (a) Use the data provided in the graph to respond to the following.
- (i) **Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
(1 point for a correct explanation for the change in per capita generation from 2000 - 2012)
- People or businesses practicing one of the following: refuse, reduce, reuse, recycle, or repurpose.
 - Lighter materials contribute to less MSW creation (e.g. plastic bottles not glass bottles)
 - Less material used in products (newspapers smaller, aluminum cans less massive)
 - Technology reduces waste generation (e.g., reading magazines online → less paper)
 - Economic recession → less consumption → less MSW produced
- (ii) **Calculate** the percent increase in total MSW generation from 1980 to 2012.
(1 point for the correct answer with work shown)

$$\frac{(250 \text{ million tons} - 150 \text{ million tons})}{150 \text{ million tons}} \times 100 = 66\% \text{ to } 67\%$$

- (b) Two ways of managing MSW are incineration and disposal in landfills.
- (i) **Identify** one disadvantage of waste incineration.
(1 point for a correct identification of a disadvantage of waste incineration)
- | | |
|---|---|
| <ul style="list-style-type: none">• Specific air pollutant (e.g., CO, CO₂, dioxin, halogens, particulates, SO_x, NO_x)• Ash disposal necessary• Incinerator is expensive to construct and/or operate | <ul style="list-style-type: none">• MSW supply and quality may be limited requiring additional fuel• Reduced quality of life and property value due to incinerator and supply trucks |
|---|---|
- (ii) **Identify** one disadvantage of waste disposal in landfills.
(1 point for a correct identification of a disadvantage of waste disposal in landfills)
- | | |
|--|---|
| <ul style="list-style-type: none">• Ground water, surface water, or soil contamination through some transport mechanism• Reduced quality of life and property value due to landfill and supply trucks | <ul style="list-style-type: none">• Release of methane or CO₂• Odor source• Attracts vermin• Habitat destruction• Preclusion of other land uses• Explosion/seepage hazard from methane produced |
|--|---|

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Question 3 (continued)

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

- (c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
(3 points – 1 point for each step in the process of generating electricity from landfill gas)

Step	Description of Step
Acquire fuel (chemical energy)	Methane collected or gathered
Use fuel (chemical → mechanical)	Fuel is combusted to produce steam or hot air
Generate electricity (mechanical → electricity)	Steam or hot air spins/turns/rotates a turbine/generator to generate/produce electricity

- (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
(1 point for a correct description of a human health problem associated with piles of discarded tires)

- Discarded tires provide habitat for mosquitoes/pests that can be disease vectors.
- Tires may catch fire and release air pollutants that cause respiratory issues in humans.

- (e) Composting is one way to reduce the amount of waste that enters a landfill.

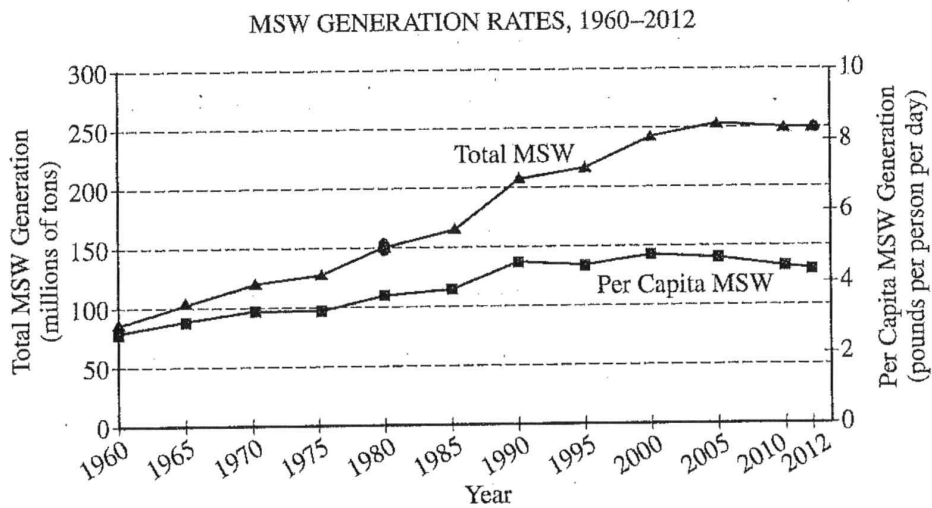
- (i) Other than reducing the volume of waste, **identify** one advantage of composting.
(1 point for a correct identification of an advantage of composting)

- The resulting compost can be used or sold as fertilizer or soil amendments.
- Municipal composting facilities may provide jobs.
- MSW may emit less foul odor if organic material is composted.
- Tipping fees and trash removal costs may be reduced due to removal of dense compostable material.

- (ii) **Identify** one disadvantage of composting.
(1 point for a correct identification of a disadvantage of composting)

- Compost may attract undesirable animals (vermin).
- Compost may emit foul odors or spontaneously combust.
- Nutrients released from decomposing organic matter may run off into surface waters and cause water quality problems.
- Compost may release methane.
- Composting organic material requires a great investment of time and labor by humans.

3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.



- (a) Use the data provided in the graph above to respond to the following.
- Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
 - Calculate** the percent increase in total MSW generation from 1980 to 2012.
- (b) Two ways of managing MSW are incineration and disposal in landfills.
- Identify** one disadvantage of waste incineration.
 - Identify** one disadvantage of waste disposal in landfills.

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

- Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
 - Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
- (e) Composting is one way to reduce the amount of waste that enters a landfill.
- Other than reducing the volume of waste, **identify** one advantage of composting.
 - Identify** one disadvantage of composting.

a.) i.) A reduction in per capita MSW can be attributed to recycling. Recycling takes many items formally only able to be placed in a landfill, ~~and~~ processes these items, and turns them into new products. New recycling plants and programs have been

initiated throughout the U.S., reducing per capita waste.

ii.) % increase = $\frac{|y_2 - y_1|}{y_1} = \frac{|250 - 150|}{150} = \frac{100}{150} = \frac{2}{3} = 66\%$ increase

b.) i.) One disadvantage of waste incineration is that it is costly. Building efficient waste incinerators that do not pollute high levels of toxins is very expensive. Some countries like Sweden ^{and Japan} have been able to build these plants, but it is less feasible in the United States when landfills that address the same MSW needs are available and land is cheap.

ii.) One disadvantage of waste disposal in landfills is the release of methane. When organic matter decomposes in landfills, it releases methane, a ~~toxic~~ ^{potent} greenhouse gas. Landfills are the number one producer of methane in the United States.

c.) To produce electricity from waste buried in landfills, a landfill must be designed to capture ~~and~~ methane (which is produced from rotting organic waste). Once captured, methane must be refined and then it can be burned to produce steam and power a turbine, which spins a magnet in a coil of wire to produce electricity. The landfill must be capped well for methane to become

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concentrated enough to harvest. A cap of clay and plastic can be used between layers of refuse to contain the methane. Then methane release valves and pipes must be engineered to collect the rising methane. Then it can be burned and go through the previously mentioned process.

d.) One human health problem from the unregulated piles of tires is the spread of disease carrying mosquitos. Diseases like Zika, malaria, and yellow fever, are caused by mosquitos. When tires are piled in an unregulated way, they hold water, which is perfect for mosquitos to lay their eggs in.

e.) i.) One advantage for composting waste is that it ~~releases the~~ produces rich soil that can be used for gardens or as natural fertilizer. Spreading compost ~~that~~ made fertilizer is better than spread petrofertilizer because the compost runs off less and therefore causes less eutrophication.

Also if a person has a self composting system, their carbon footprint is reduced because no transportation was required to make the compost-made fertilizer.

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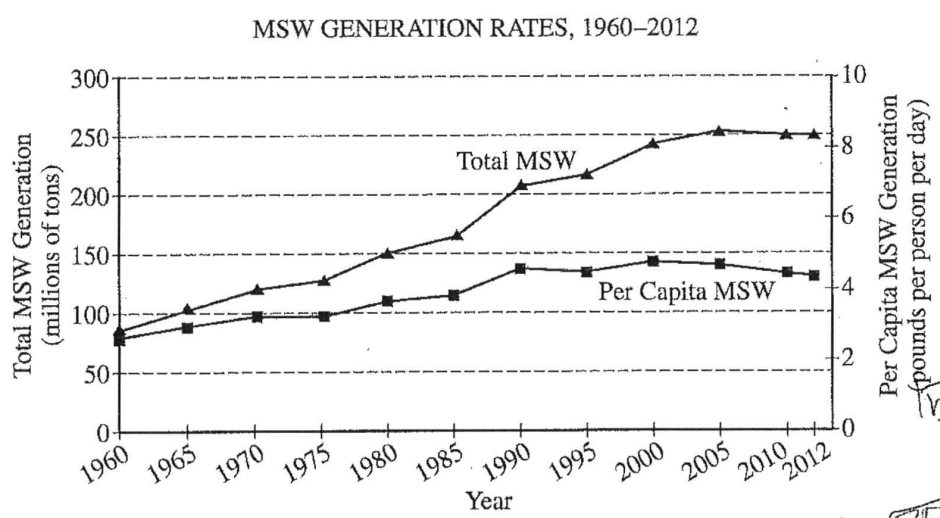
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ii.) One disadvantage of composting is that it can create an unsightly, smelly pile of refuse that neighbors or neighborhood associations don't like. Some Home owners associations forbid composting because of the smell and view.

Composting can lead to disease

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3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.



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$$\begin{array}{r} 150 \\ 15 \overline{) 225} \\ \underline{150} \\ 75 \end{array}$$

$$\begin{array}{r} 15 \\ 15 \overline{) 225} \\ \underline{150} \\ 75 \end{array}$$

$$\begin{array}{r} 3 \\ 3 \overline{) 90} \\ \underline{60} \\ 30 \end{array}$$

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$$\begin{array}{r} 15 \\ 15 \overline{) 225} \\ \underline{150} \\ 75 \end{array}$$

- (a) Use the data provided in the graph above to respond to the following.
- (i) **Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
 - (ii) **Calculate** the percent increase in total MSW generation from 1980 to 2012.
- (b) Two ways of managing MSW are incineration and disposal in landfills.
- (i) **Identify** one disadvantage of waste incineration.
 - (ii) **Identify** one disadvantage of waste disposal in landfills.
- Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.
- (c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
- (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
- (e) Composting is one way to reduce the amount of waste that enters a landfill.
- (i) Other than reducing the volume of waste, **identify** one advantage of composting.
 - (ii) **Identify** one disadvantage of composting.

~~a) i) Population density has the population of the US has increased meaning more waste will be produced in general. Per capita waste may have decreased due to an increase in the recycling of paper and plastic.~~ ii) $250 \div 150 \approx 1.6$ % increase

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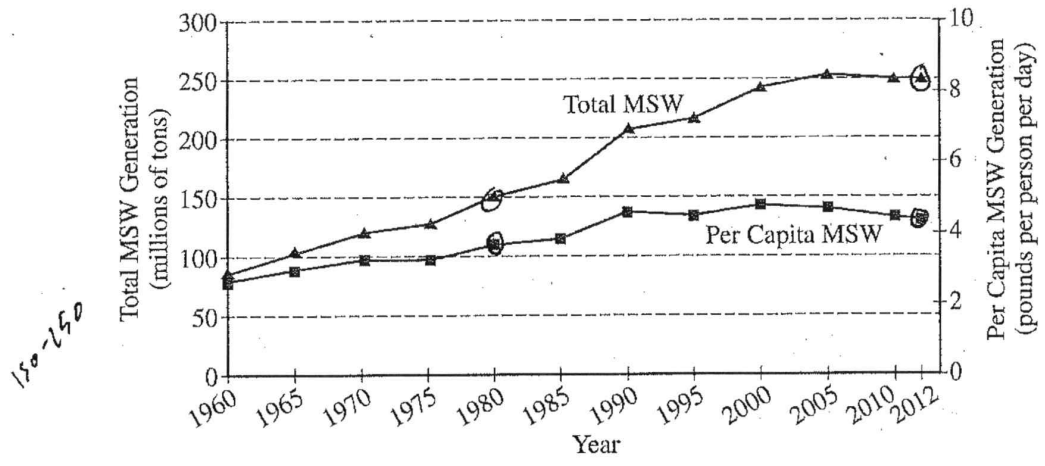
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- b) Waste incineration pollutes the air with greenhouse gases such as CO_2
- ii) Waste disposal in landfills allows pollutants to leach into the groundwater
- c) Waste in landfills will decompose and the methane produced can be collected and burned to turn a turbine to generate electricity
- d) A human health problem from tire piles can happen when the pile catches fire and cannot be put out. Respiratory issues can happen as a result of the pollutants released in smoke.
- e) Composting allows humans to put back the nutrients taken from the earth as an organic fertilizer.
- ii) A disadvantage to composting is that it produces an unfavorable odor.

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3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.

MSW GENERATION RATES, 1960-2012



- (a) Use the data provided in the graph above to respond to the following.
 - (i) **Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
 - (ii) **Calculate** the percent increase in total MSW generation from 1980 to 2012.
 - (b) Two ways of managing MSW are incineration and disposal in landfills.
 - (i) **Identify** one disadvantage of waste incineration.
 - (ii) **Identify** one disadvantage of waste disposal in landfills.
- Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.
- (c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
 - (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
 - (e) Composting is one way to reduce the amount of waste that enters a landfill.
 - (i) Other than reducing the volume of waste, **identify** one advantage of composting.
 - (ii) **Identify** one disadvantage of composting.

a) i.) One probable cause for the change in per capita waste generation from 2000 to 2012 is the increase in recycling programs especially in major cities in the U.S. where recycling bins are becoming more prevalent and homeowners even have their own like in Chicago.

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ii) Total MSW Generation increased from 150 million tons in 1980 to 250 million tons in 2012. This is an increase of 66%. There is a 100 million ton difference and 100 is 66% of the starting MSW generation in 1980.

b.) i.) One major disadvantage of waste incineration is the harmful greenhouse gases that are released into the atmosphere when waste is incinerated. These gases can lead to pollution, furthering of the greenhouse effect, and global warming.

ii) One disadvantage of waste ~~disposal~~ disposal in landfills is that landfills are lined with a material that may breakdown over time. This could lead to liquid waste from these landfills (including noxious chemicals) seeping into the ground and into groundwater, contaminating the water supply. The liquid could also runoff from landfills into streams or lakes, contaminating them and destroying ecosystems.

c.) ~~Waste liquid~~ Waste liquid collected from these landfills can be used as fuel to power turbines and create energy.

d.) Poorly regulated piles of tires can be set fire to and rubber burns slowly and releases fumes that are very dangerous to humans and can cause respiratory illness.

e.) i) One other advantage of composting is that it creates very nutrient rich soil which can be used as a fertilizer for growing plants in.

ii) One disadvantage of composting is that if you are composting

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Around your house it will smell and it will attract animals
such as raccoons and they will try to get into the composting
bins.

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2016 SCORING COMMENTARY

Question 3

Overview

The intent of this question was for students to evaluate uses and alternate disposal methods for solid waste in the United States. Information on municipal solid waste (MSW) produced in the United States from 1960 to 2012 was presented in graphical form: two lines on the same graph, one describing Total MSW created and the other describing the Per Capita MSW created. In part (a) students were asked to explain the change (decline) in per capita MSW as depicted in the graph and calculate the percent increase in total MSW from 2000 to 2012.

In part (b) students were asked to identify a disadvantage of waste incineration and waste disposal in landfills. In part (c) students were asked to describe how electricity can be generated from waste buried in a landfill. The correct description included a methane capture step, a heat to steam or hot air step and then a turbine/generator spin step. The steps were not linked and therefore a student could earn one, two, or all three points in this part. Part (d) required students to identify human health problems that may result from piles of discarded tires. Finally in part (e) students were asked to identify an advantage and a disadvantage of composting.

Sample: 3A

Score: 10

Two points were earned in part (a): 1 point was earned for explaining that the probable cause for the change in per capita waste generation from 2000 to 2012 “can be attributed to recycling,” and 1 point was earned for successfully calculating the percent increase in MSW from 1980 to 2012. One point was earned in part (b)(i) for identifying an incineration disadvantage as cost because “building efficient waste incinerators is ... expensive.” One point was earned in part (b)(ii) for identifying that “release of methane” from landfills is a disadvantage. Three points were earned in part (c) for describing the following specific steps in the production of electricity from waste buried in a landfill: Landfills can be designed to “capture methane,” then the methane is “burned to produce steam” that finally “spins a magnet in a coil of wire.” One point was earned in part (d) for describing discarded tire piles as a source for “disease carrying mosquitoes.” Two points were earned in part (e) for identifying an advantage of composting as a source of “rich soil that can be used for gardens” and a disadvantage of composting as “it can create an unsightly, smelly pile.”

Sample: 3B

Score: 8

One point was earned in part (a) for explaining that “an increase in the recycling of paper and plastic” is the probable cause in the amount of MSW produced per capita between 2000 and 2012. Two points were earned in part (b): 1 point for identifying a disadvantage of waste incineration as “pollutes the air with greenhouse gasses such as CO₂” and 1 point for identifying a disadvantage of landfills as “allows pollutants to leach into the groundwater.” Two points were earned in part (c) for describing the specific steps in the production of electricity from waste buried in a landfill as “methane produced can be collected and burned” to “turn a turbine.” One point was earned in part (d) for describing a human health issue associated with tire piles that catch on fire as “respiratory issues” due to “pollutants released.” Two points were earned in part (e) for identifying an advantage of composting as a source of “organic fertilizer” and a disadvantage of composting as producing “an unfavorable odor.”

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Question 3 (continued)

Sample: 3C

Score: 6

Two points were earned in part (a): 1 point for explaining “the increase in recycling programs” as the probable cause for the change in per capita waste generation from 2000 to 2012 and 1 point for correctly calculating the percent increase in total MSW generation from 1980 to 2012 using a prose description. One point was earned in part (b) for identifying a disadvantage of waste disposal in landfills as “liquid waste ... seeping into the ground and into the groundwater, contaminating the water supply.” One point was earned in part (d) for describing a human health problem associated with discarded tires as “tires can be set fire to ... and releases fumes ... and can cause respiratory illness.” Two points were earned in part (e) for identifying an advantage of composting as a source of “nutrient rich soil which can be used as a fertilizer” and a disadvantage of composting as “it will smell.”