

Student Clues Handout

The “Great Escape” Box Challenge

Scenario:

Listening to the news on the radio, you discover that your local Water Resource Recovery Facility (Sewage Treatment Plant) has reported that something has gone wrong in the treatment process, and the waterways in your community may have sewage contamination. Normally the plant is highly efficient, and the treated water released from the plant in the river is amazingly clean. Today the plant officials report somewhere there is a problem in the treatment process and the effluent (treated water) is not free of contaminants like nitrogen and phosphorus. Your job is to uncover the clues and solve the mystery as to why the treatment process is failing.

To solve the mystery, you will be given clues that can reveal the numbers needed to unlock three boxes of additional clues and information. **Box 1** will describe the *primary treatment of wastewater* and the processes involved in separating the solids and liquids. **Box 2** includes clues to the *digestion and biological and chemical removal of pollutants in wastewater*. **Box 3** has information about the *treatment of solid materials (sludge)* that results from wastewater treatment.

You will need the information from all three boxes to open the final box that includes the final clues that will allow you to determine what went wrong in the wastewater treatment plant. If you are the first group to successfully solve the mystery your group will receive a prize.

Clues and Hints

There are a variety of different types of clues, including visual and physical clues, analogies, puzzles, and logic problems. If you get stuck and cannot determine how to solve a clue needed to open the box, you can ask the escape artist (instructor) for help. But only ask for help once everyone in your group has tried to solve the clue. Our escape artists will give you time warnings to help you monitor your time.

(see next page)

Box 1: Primary Treatment of Wastewater: Sedimentation (6 numbers to unlock)

Clue 1 and 2- (NOTE: Each clue represents one digit- when 2 clues are listed it counts as 2 digits)

Solids settle down to the bottom of the tank,
This process is simple, just let gravity thank.
How many letters are in the word that describes this phase?
Use this count to help in your escape.

Clue 3

To unlock this mystery, find the number that works. The answer is found in the way the bear looks. Your friends will be envious.



Clue 4

You might want to sit on this clue for a while.

Clue 5

I need to crack the code, but time has run out. Take time to look about.

Clue 6



Roses are red and violets are:

Box 2: Digestion and Biological and Chemical Removal of Pollutants (6 numbers to unlock)

Clue 1

I make up 78% of the atmosphere and can be found in wastewater treatment plants. Who am I?

Clue 2 and 3

Above me is my fellow pollutant.

Below me is a poison.

Be careful if you mix all our symbols,
you might need some naps to recover!

Clue 4

Phosphorus and nitrogen please go!

Preventing blooms in our pristine waters that flow

In this key phase, pollutants are trapped.

Perhaps this is where the problem can be mapped.

Clue 5 and 6

A duck was given \$9, a spider was given \$36, a bee was given \$27.

Based on this information, how much money would be given to a cat?

Box 3: Disinfection and Treatment of Solid Materials (Sludge) (6 numbers to unlock)

Clue 1

Somewhere on this penny is a little man. Find him if you think you can. His first name starts with a letter in this location of the alphabet.

Clue 2

Microbes work best with oxygen's aid,
Breaking down waste before it can invade.
These tiny helpers must have air,
Count the letters in their name for your next fare.

Clue 3

Phosphorus hides in the thickest of sludge,
But we treat the solids, we never budge.
Through digestion or drying, we handle with care,
The next number you need is hidden in there.

Clue 4

I'm a type of bacteria, don't you know?
I thrive in the absence of oxygen's glow.
I break down organics with skill and might,
Producing biogas, day and night.
(Answer choices: gram positive =1; gram negative =2; anaerobic = 3; aerobic = 4)

Clue 5

How many bones are in me?
Probably more than in a flea.
It is so sweet there are 26 in my feet.
Word has it that my hand has 27.
My chest has 12, one more than 11.
Don't be mum, how many are in my thumb?

Clue 6

An apple is 4 cents, a banana is 6 cents, and a grapefruit is 8 cents. How much is a pear?

Solution Box 4 (3 numbers to unlock)

Clue 1 and 2

I help fight germs often in pools. However, I can disinfect wastewater, too. Who am I?

Clue 3

I am often used in aerobic respiration and all living things need me. Who am I?

Instructor Answer Key

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There are a variety of different types of clues, including visual and physical clues, analogies, puzzles, and logic problems. If you get stuck and cannot determine how to solve a clue needed to open the box, you can ask the escape artist (instructor) for help. But only ask for help once everyone in your group has tried to solve the clue. Our escape artists will give you time warnings to help you monitor your time.

(see next page)

CLUES

Box 1: Primary Treatment of Wastewater: Sedimentation (6 numbers to unlock)

Clue 1 and 2- (Each clue represents one digit- when 2 clues are listed it counts as 2 digits)

Solids settle down to the bottom of the tank,

This process is simple, just let gravity thank.

How many letters are in the word that describes this phase?

Use this count to help in your escape.

Hint. The word “SEDIMENTATION” has 13 letters. Answer: 13

Clue 3

To unlock this mystery, find the number that works. The answer is found in the way your bear looks. Your friends will be envious.



Hint. Number of green bears. Answer: 5

Clue 4

You might want to sit on this clue for a while.

Hint. Placed under chair Answer: 6

Clue 5

I need to crack the code, but time has run out. Take time to look about.

Hint. A stopped clock in room Answer: 6

Clue 6



Roses are red and violets are: **Hint. Number of blue dots. Answer: 5**

Box 1 opens to 135665

Box 2: Digestion and Biological and Chemical Removal of Pollutants (6 numbers to unlock)

Clue 1

I make up 78% of the atmosphere and can be found in wastewater treatment plants. Who am I?

Answer: 7 (Atomic Number of Nitrogen)

Clue 2 and 3

Above me is my fellow pollutant.

Below me is a poison.

Be careful if you mix all our symbols,
you might need some naps to recover!

Answer: 15 (Atomic Number of Phosphorus)

Clue 4

Phosphorus and Nitrogen please go!

Preventing blooms in our pristine waters that flow

In this key phase, pollutants are trapped.

Perhaps this is where the problem can be mapped.

Hint. Number of words that start with letter “P”. Answer: 8

Clues 5 and 6

A duck was given \$9, a spider was given \$36, a bee was given \$27.

Based on this information, how much money would be given to a cat?

Hint. Count the number of legs. Answer: 18 dollars (\$4.50 per leg).

Box 2 opens to 715818

Box 3: Disinfection and Treatment of Solid Materials (Sludge)

Clue 1

Somewhere on this penny is a little man. Find him if you think you can. His first name starts with a letter in this location of the alphabet.

Answer 1 (Need a penny, a pocket microscope, and to see Abraham)

Clue 2

Microbes work best with oxygen's aid,

Breaking down waste before it can invade.

These tiny helpers must have air,

Count the letters in their name for your next fare.

Hint. Number of letters in "MICROBES". Answer: 8

Clue 3

Phosphorus hides in the thickest of sludge,
But we treat the solids, we never budge.
Through digestion or drying, we handle with care,
The next number you need is hidden in there.

Answer: 6 ("SLUDGE" has 6 letters.)

Clue 4

I'm a type of bacteria, don't you know?
I thrive in the absence of oxygen's glow.
I break down organics with skill and might,
Producing biogas, day and night.
(Answer choices: gram positive =1; gram negative =2; anaerobic = 3; aerobic = 4)

Answer: 3

Clue 5

How many bones are in me?
Probably more than in a flea.
It is so sweet there are 26 in my feet.
Word has it that my hand has 27.
My chest has 12, one more than 11.
Don't be mum, how many are in my thumb?

Answer: 2

Clue 6

An apple is 4 cents, a banana is 6 cents, and a grapefruit is 8 cents. How much is a pear?

Hint. The price of each fruit is calculated by multiplying the number of vowels by 2 cents.

Answer: 4 cents

Box 3 opens to 186324

Solution Box 4 (3 numbers to unlock)

Clue 1 and 2: *I help fight germs often in pools. However, I can disinfect wastewater, too. Who am I?*

Answer: 17 (Atomic Number of Chlorine)

Clue 3: *I am often used in aerobic respiration and all living things need me. Who am I?*

Answer: 8 (Atomic Number of Oxygen)

Box 4 opens to 178

Final Clue (printed out and placed into Box #4):

Once you determine *Who am I?*, Put the jigsaw puzzle together. Note the location of pink dots that represents where phosphorus is in the wastewater treatment plant. **Now consider this:** When phosphorus is present, water isn't clean. Use your diagram as well as the information found in each box to determine why the water treatment process is failing.

If you need a little extra help, consider this clue

I'm tiny and unseen, a life form so small,
In soil and in water, I'm found one and all.
I help in the fight against sickness and rot,
What am I, a friend, though you might think I'm not?

Answer: The phosphorus removing microbes are failing, the phosphate is not being removed during the biological stage.

Box 1: Primary Treatment of Wastewater

Information about the Primary Treatment of Wastewater

Part 1. Primary Treatment

1. *Screening and sedimentation*

The waste enters and flows through a screen to remove large materials such as cans, bottles, and other inorganic materials. These materials are removed and moved to a landfill.

2. **Grit removal in the grit chamber**

Sand and other inorganic particles settle to the bottom, and oils and fats remain at the top.

3. **Settling Tanks**

The water is moved into settling tanks (primary clarifiers) where it moves very slowly, allowing the solids to settle to the bottom and scum rises to the top. The solids are removed for treatment and scum is removed. Primary treatment removes about 60% of the suspended solids that enter the facility and about 35% of the biodegradable organic matter.

4. **Removal of Water**

Water then flows to the secondary treatment process.

Box 2: Digestion and Biological and Chemical Removal of Pollutants

Information about the Digestion and Biological and Chemical Removal of Pollutants

Secondary Treatment- Bacteria Digest Pollutants

1. Aerobic treatment

An aeration tank (aeration) introduces oxygen to the water for the microorganisms (bacteria, algae, and fungi) that consume around 90% of organic material. They “eat” the organic matter and “breathe” the oxygen.
This process is called “activated sludge”

2. Nitrogen and phosphorus removal

Nitrogen is usually present in wastewater as ammonium.

When basins are aerated, microorganisms oxidize (eat) the ammonium and convert it into nitrate. That process is called nitrification.

When that water is then sent to an anaerobic basin (no oxygen) a different group of microbes “breathe” (respire) on the nitrate and convert it into nitrogen gas. That process is called denitrification. The nitrogen gas bubbles out of the water and into the air, that is how nitrogen is removed from the wastewater

Phosphorus can be removed biologically or chemically.

Biological: Microbes release internal storage of phosphorus (called polyphosphate) during an anaerobic phase to store carbon. Next, they go to an aerobic phase. There they “eat” internal stocks of organic carbon and “breathe” oxygen gas. That produces energy which they use to take up phosphorus from the wastewater and links together to make polyphosphate inside themselves. When their biomass is settled in a clarifier and collected, phosphorus from the wastewater is removed.

Chemical: chemicals, such as iron and aluminum can be added to the wastewater after secondary treatment. Iron and aluminum bind to phosphate. It forms particles that can then settle and be removed in clarifiers.

3. Secondary Settling in Secondary Clarifiers

Treated water from the activated sludge basin flows into secondary clarifiers.

The solids (mostly bacteria biomass that grew in the activated sludge process) now settle to the bottom of the clarifiers.

The solids are collected and further treated in later processes

Box 3: Disinfection and Treatment of Solid Materials (Sludge)

Information about the disinfection and treatment of solid materials (sludge)

Part 1: Disinfection

1. Inactivate Microorganisms. To reduce the discharge of harmful bacteria and viruses, the clarified effluent from the secondary clarifier is treated with chlorine or ultraviolet light to inactivate microorganisms.
2. Discharge into Waterway. The treated effluent is then discharged to a receiving waterway, such as a lake or river.

Part 2: Treatment of Solid Materials (Sludge)

- A. The solids from the primary and secondary clarifiers are sent to solids treatment. The goals are to reduce the volume of the solids and stabilize organic material (reduce odor and health impacts).
- B. **Thickening**: Gravity thickener used to concentrate the solids and reduce the volume.
- C. **Anaerobic Digestion**: Reduces the mass of the solids, eliminates pathogens, aids in the sludge drying process anaerobically.
- D. **Methane production**: Anaerobic bacteria synthesize organic acids to form acetate, hydrogen gas, and carbon dioxide.
Anaerobic microbes consume acetate, hydrogen, and carbon to form methane gas and carbon dioxide.
- E. **Dewatering**
Sludge from the anaerobic digester is then dewatered to reduce the weight of the solids before hauling off site to be buried or used in soil as soil conditioner/fertilizer.

Steps of Primary Treatment of Wastewater

Box 1: Primary Treatment of Wastewater

Information about the Primary Treatment of Wastewater

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4. Removal of Water

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Steps of Digestion and Biological and Chemical Removal of Pollutants

Box 2: Digestion and Biological and Chemical Removal of Pollutants

Information about the Digestion and Biological and Chemical Removal of Pollutants

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