Lesson Plan: Treatment Objectives **50 minutes**



**Lesson Description**



This lesson looks at what the term faecal sludge treatment means in the sanitation sector. It introduces four treatment objectives: (1) pathogen inactivation, (2) stabilization, (3) dewatering, and (4) nutrient management. The participants also discuss environmental, health, and logistical impacts of the treatment objectives.

**Learning Outcomes**





At the end of this session participants will be able to:

1. Identify four treatment objectives.
2. Relate the environmental, health, and logistical impacts to each treatment objective.
3. List seven ways pathogens can be inactivated.
4. Discuss the challenges in monitoring pathogen inactivation from faecal sludge.

**Materials**



* Paper
* Markers
* Activity: Pathogen Inactivation (1 for every 2 people)

Option A:

* Activity: Faecal Sludge Components (1 set)

Option B:

* Activity: Small Group Activity (1 per group of 3 or 4 people)

Optional:

* PowerPoint: Treatment Objectives
* Computer and projector

**Preparation**



* Review Chapter 2: Quantification, Characterization and Treatment Objectives in the book *Faecal Sludge Management: Systems Approach for Implementation and Operation*
* Write the heading “*Treatment Objectives*” on flip chart paper. Underneath write the following:

1. Pathogen inactivation
2. Stabilization
3. Dewatering
4. Nutrient management

* Print and cut out the Pathogen Inactivation Activity (1 for every 2 people)
* Option A: Print and cut out the Faecal Sludge Components Activity (1 set)
* Option B: Print and cut out the Small Group Discussions Activity (1 per group of 3 or 4 people)
* Optional: Use PowerPoint: Treatment Objectives
  + Review the PowerPoint presentation
  + Print the speaker’s notes
  + Check that the projector is working
  + Cue the PowerPoint on the computer

**Introduction 5 minutes**



1. In pairs, ask participants to write down their definition of faecal sludge treatment.
2. Ask some pairs to share their definition with the large group.
3. Explain that faecal sludge treatment is the fourth component of the sanitation service chain. It can be a confusing term because it has several meanings (especially if faecal sludge management is not your profession). Treatment can mean the inactivation of pathogens in faecal sludge. It can also mean transformations of faecal sludge (for example, dewatering and drying).
4. Present the lesson description or learning outcomes.

**Treatment Objectives 20 minutes**

**Option A: Large Group Activity**

1. Divide the participants into 4 groups (or use the case study groups). Hand out one faecal sludge component to each group: pathogens, organic material, nutrients, and water. Ask groups to briefly introduce their group and their component.
2. Explain that when faecal sludge is poorly managed, these components have negative impacts on the environment, public health and logistics of faecal sludge management. Tell participants that you will show them images of these impacts. Each group should stand up and give a brief explanation if they believe their faecal sludge component is responsible for this impact. Groups should also point at the other groups they believe are responsible for this negative impact.
3. Optional: Use PowerPoint: Treatment Objectives to show images of the potential impacts of poor faecal sludge management.

* *Sick person: Pathogens*

*Through the faecal-oral route, pathogens cause the spread of diseases. Pathogens can be spread via fingers, flies, fields, fluids, and food.*

* *Eutrophication: Nutrients and organic material*

*High concentrations of nutrients and organic material in surface water can disrupt the aquatic ecosystem. Algae in the water feed on the nutrients and reproduce rapidly, called an algal bloom. The algae blocks the sunlight from penetrating the water, and other aquatic plants are unable to grow. When the algae dies and is eaten by other organisms, the oxygen in the water is used up and aquatic organisms (like fish) suffocate. (When oxygen is depleted to low levels, this is called anoxic water.) In fresh water systems, phosphorous is the limiting nutrient whereas in salt water it is nitrogen.*

* *Smell: Organic material*

*Fresh excreta is smelly, in addition to putrefaction (decay of organic material).*

* *Heavy and voluminous: Water*

*Faecal sludge is difficult and expensive to transport because it contains so much water (water is heavy).*

* *Drinking water source contamination (groundwater and surface water): water, pathogens, nutrients*

*The more water in faecal sludge, the higher the risk of surface and groundwater contamination. Pathogens in wet faecal sludge will infiltrate into the ground faster and travel farther than pathogens in dry faecal sludge. Nutrients in faecal sludge can also contaminate drinking water sources, particularly nitrogen (nitrates can cause blue baby syndrome).*

* *Attracts vectors: Organic material*

*Vectors (for example, flies and rats) are a nuisance, and can also spread disease.*

1. Explain that other contaminants can be in faecal sludge, such as heavy metals from industrial pollution. This is not included as a treatment objective, because treatment does not remove them. The strategy should be to prevent them from entering the faecal sludge through the proper management of industrial waste. Other compounds, such as hormones and pharmaceuticals (trace organics) can also be in faecal sludge. This is something we are continuing to learn about, and the effectiveness of various treatment technologies for removing them.
2. Ask participants, “Are your faecal sludge components responsible for any positive impacts?”

* *Nutrients:*

*Plant growth:* *Plants need nutrients to grow. The three important nutrients, also known as macronutrients, are nitrogen, phosphorous and potassium.*

* *Organic material:*

*Soil conditioner: Farmers often focus on using fertilizers to increase crop growth. However, adding soil conditioners, particularly organic material, can be just as important. Soil conditioners improve the physical soil structure through microbial activity and by increasing the amount of pore space (making the soil less compact). This extra space increases air and water movement in the soil and allows better root growth, and reduces compaction. The organic material needs to be stabilized prior to application (broken down). This prevents negative impacts such as eutrophication, nitrate leaching, and harm to plants. The nutrients incorporated in the organic material will become gradually available to plants.*

* *Energy:*

*The breakdown of organic material produces energy. In an anaerobic setting it will produce biogas. In an aerobic setting the breakdown of organic material will generate heat. You therefore want less stabilized organic material if your goal is to produce energy. The less stabilized organic material has the potential to produce greater amounts of energy.*

*Note: Check if participants understood stabilization. Ask participants, “Would you want stabilized or fresh sludge for energy use? Ask participants, “Would you want stabilized or fresh sludge for agricultural use?”*

* *Water:*

*Irrigation: Plants require water to grow.*

1. Explain that this is why we have faecal sludge treatment objectives – to manage and reduce negative impacts, as well as increase the potential positive impacts. Show the “Treatment Objectives” flip chart to summarize the 4 different treatment objectives.

* *Pathogens: Pathogen inactivation*

*Depending on the use of the faecal sludge, pathogens need to be inactivated to the appropriate level. The degree of pathogen inactivation for different uses is still a new science and therefore existing recommendations are very strict. We look a bit more into how pathogens are inactivated after this section.*

* *Nutrients: Nutrient management*

*This generally means changing the form of the nutrients (for example, liquid or solid, inorganic or organic). Nutrients are not necessarily removed during treatment, but transformed. The form of the nutrient is important to manage, to protect the environment and for use. For example, nitrogen in an organic form (for example, composting) can be directly applied to crops. Whereas nitrogen in an inorganic (ionic) form (for example, leachate) could “burn” plants or leach into the groundwater.*

* *Organic material: Stabilization*

*Stabilized sludge means that easily degradable organic material is degraded by microorganisms. Stabilized sludge is important for agriculture. For energy purposes you do not want organic material to be as stabilized.*

* *Water: Dewatering*

*Dewatering means removing water from the faecal sludge, mainly through filtration or settling. The term drying is also sometimes used, and implies an increased level of dryness through evaporation or thermal energy (heat). To understand the two words, think of a wet towel. You first have to wring the towel (dewatering), then you have to hang your towel to dry (drying).*

1. Explain that stabilization and nutrient management are interconnected. When organic material is stabilized, nutrients are also stabilized. This means that nutrients are slowly released into the environment, allowing them to be better managed. In the treatment technologies lesson plan these two objectives will be merged together.
2. Explain that generally, faecal sludge is first dewatered and then stabilized or pathogens are inactivated. Before dewatering, there is also solid waste removal. This is considered pre-treatment. Although it is an important treatment objective, it is not covered further in this workshop.

**Option B: Small Group Activity**



1. Divide participants into groups of 3 or 4 people (or use the case study groups).
2. Explain that when faecal sludge is poorly managed, these components have negative impacts on the environment, public health and logistics of faecal sludge management. Each group will receive a paper with a table. In the left column are the potential negative impacts. In the right column is the component(s) responsible for these negative impacts. Participants need to go through the impacts and decide which faecal sludge components are responsible. They should place the faecal sludge component icons in this column. Several components could be responsible for an impact.
3. Hand out the faecal sludge component icons and the table of impacts. The groups have 5 minutes to complete the activity.
4. Ask the groups to share which impacts they associated to each component.

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* *Eutrophication: Nutrients and organic material*

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**Pathogen Inactivation 20 minutes**

1. Explain that we have covered the four faecal sludge treatment objectives. They are all equally important; however, pathogen inactivation is extremely important to protect human health. This is why we will focus on this objective in this section.
2. Explain to participants that they will be given images of a pathogen dying in various ways. In pairs, they should guess what the pathogen is dying of. They will have 5 minutes to complete the activity.
3. Hand out the Pathogen Inactivation Activity.
4. After 5 minutes, discuss each image as a large group.

|  |  |
| --- | --- |
|  | ***Age****: Just like any living organism, pathogens naturally die. Some live longer than others.* |
|  | ***Predation****: There are other microorganisms that feed on pathogens.* |
|  | ***Starvation****: Pathogens need to eat to survive. If there is no food, they will starve and eventually die.* |
|  | ***Temperature****: Pathogens have optimal growth temperatures. If it is too hot or too cold, they slow down their activity to survive for a longer time. However, over certain temperatures, molecules that are essential for life are denatured. Similar to the change in proteins you see when you fry an egg. References are available for the amount of time at different temperatures that are required for pathogen inactivation. Some pathogens, like Ascaris eggs, will survive for years even at 40°C.* |
|  | ***Moisture****: Just like humans, microorganisms need water. As moisture drops to a certain level, pathogens will start to die. Dehydration is the process of removing moisture.* |
|  | ***pH****: The pH is a measure of how acidic or basic (alkaline or caustic) something is. It ranges from 0 to 14, with 7 being neutral. A pH less than 7 is acidic and a pH greater than 7 is basic. Most pathogens can only survive within a range of 2-3 pH units. Furthermore, most pathogens cannot survive below pH 3 or above pH 10. By changing the pH of faecal sludge, pathogens can be inactivated.* |
|  | ***Solar radiation or ultraviolet light****: Sunlight can destroy pathogens with ultraviolet (UV) and infrared radiation. UV radiation damages DNA and kills living cells. The light rays must reach the pathogens to inactivate them, so this is only effective for pathogens on the surface of the sludge. Infrared radiation heats the sludge to reach temperatures that inactivate pathogens.* |

1. Ask participants, “How does storage kill pathogens?” Tell participants to circle the mechanisms.

* *Starvation, predation, and old age are natural deaths. When faecal sludge is stored, pathogens will naturally die these ways. It is difficult to know which mechanism is responsible for pathogen inactivation. They are therefore often regrouped as one mechanism called “time” or “storage”. Generally, storage takes the longest time to kill pathogens.*

1. Explain that there are a lot of different types of pathogens that have different tolerances to these mechanisms. There is still a lot of research that needs to be done to fully understand these mechanisms and how they impact pathogen inactivation. For example, the relationship between moisture level and pathogen inactivation is still unclear. The relationship between pH and other chemical reactions is also unclear (for example, ammonia)
2. Ask participants, “How do you know if a faecal sludge treatment technology has effectively inactivated pathogens?”

* *Ascaris eggs are very difficult to kill, so they are often used as an indicator for whether or not faecal sludge is safe after treatment. Ascaris is a type of roundworm (helminth). It is especially common in areas with warm climates and poor sanitation. Ask participants, “Why is it difficult to monitor pathogen inactivation in faecal sludge?” For now, Ascaris eggs can only be counted using a microscope or sending samples to a laboratory. It is time consuming, expensive, and requires technical skills.* [Optional: Use PowerPoint: Treatment Objectives to show images of Ascaris eggs.]
* *If testing is not possible, then you can monitor other operational parameters depending on the treatment, such as temperature, pH, and moisture. It is assumed that if the technology is operating properly, then the pathogens should be reduced as expected. All three parameters can be measured using long probes which are not too expensive.*
* *Put in place protective measures!*

**Review 5 minutes**



1. Divide participants into the same groups that were previously created.
2. Explain that it can be difficult to remember the four treatment objectives. Ask the groups to think of a fun and easy way to help people remember these objectives (for example, song, rhyme, acronym).
3. Optional depending on time: Share as a large group.

**Reflections on Lesson**

**Option A: Faecal Sludge Components**



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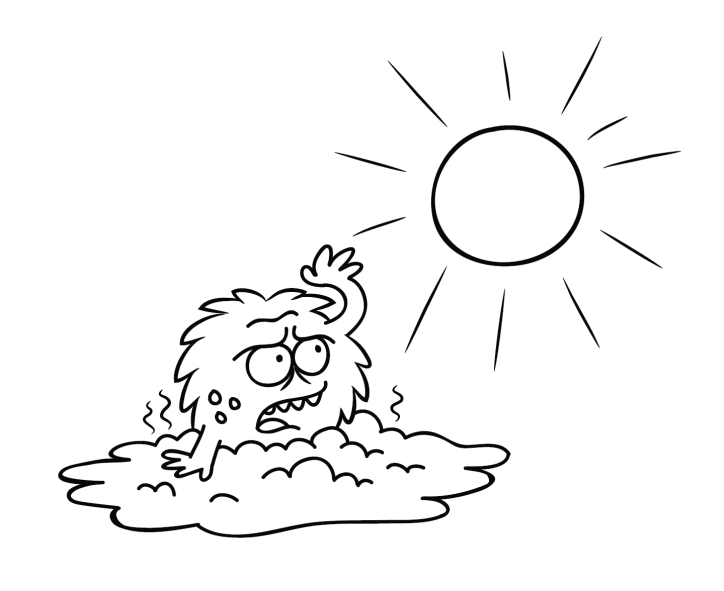
**Option B: Small Group Activity**



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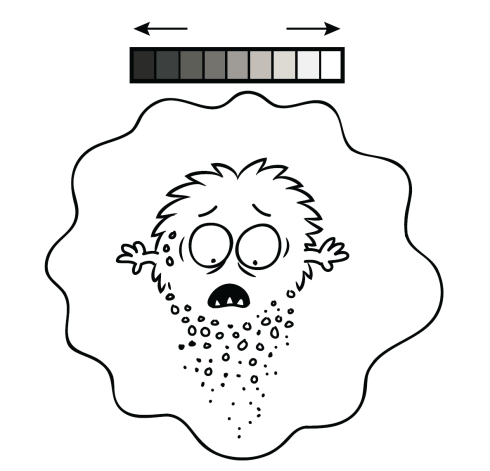
| Impact | Responsible Faecal Sludge Components |
| --- | --- |
| **Sick person:** What component will make people sick? |  |
| **Eutrophication:** What component would increase algae in surface water and lead to the death of aquatic organisms (like fish)? |  |
| **Smell:** What component would make faecal sludge smell badly? |  |
| **Heavy and voluminous:** What component makes faecal sludge heavy and voluminous to manage? |  |
| **Drinking water contamination (surface water or groundwater):** What component will increase the risk of water contamination? |  |
| **Vectors:** What component would attract vectors, such as flies and rats? |  |

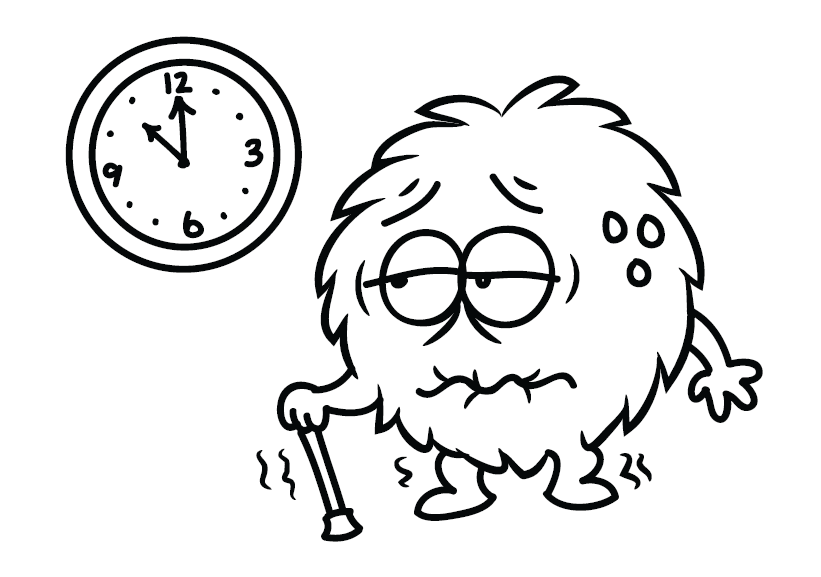
**Activity: Pathogen Inactivation**







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