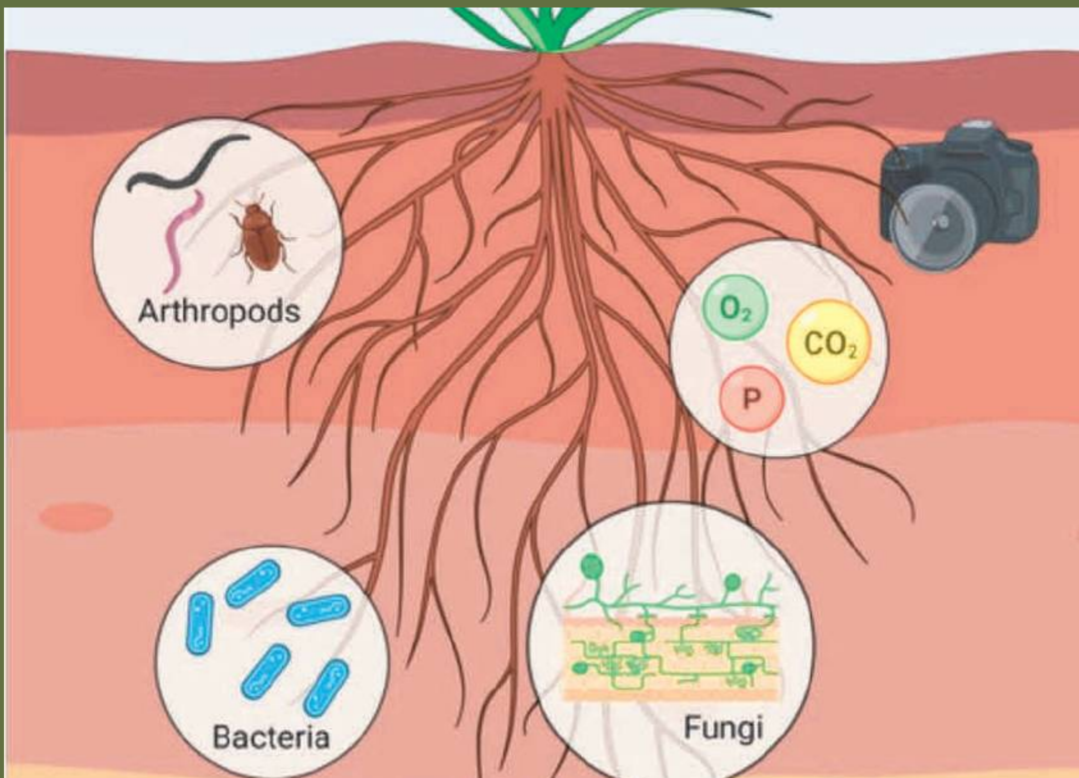
GREEN CHEMISTRY PRACTICES FOR A BETTER FUTURE

Project Number : 2023-1-BE02-KA210-VET-000154720

FROM WASTE TO COMPOST



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”Green Chemistry Practices for a Better Future”

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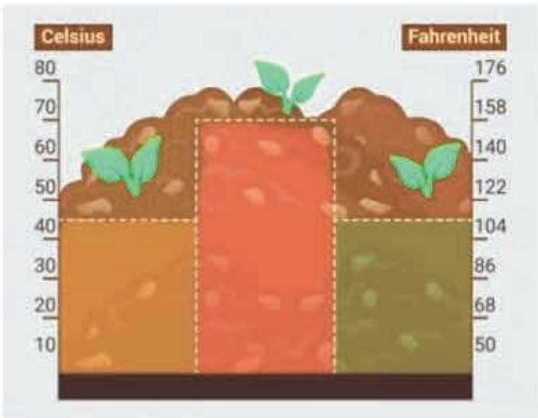

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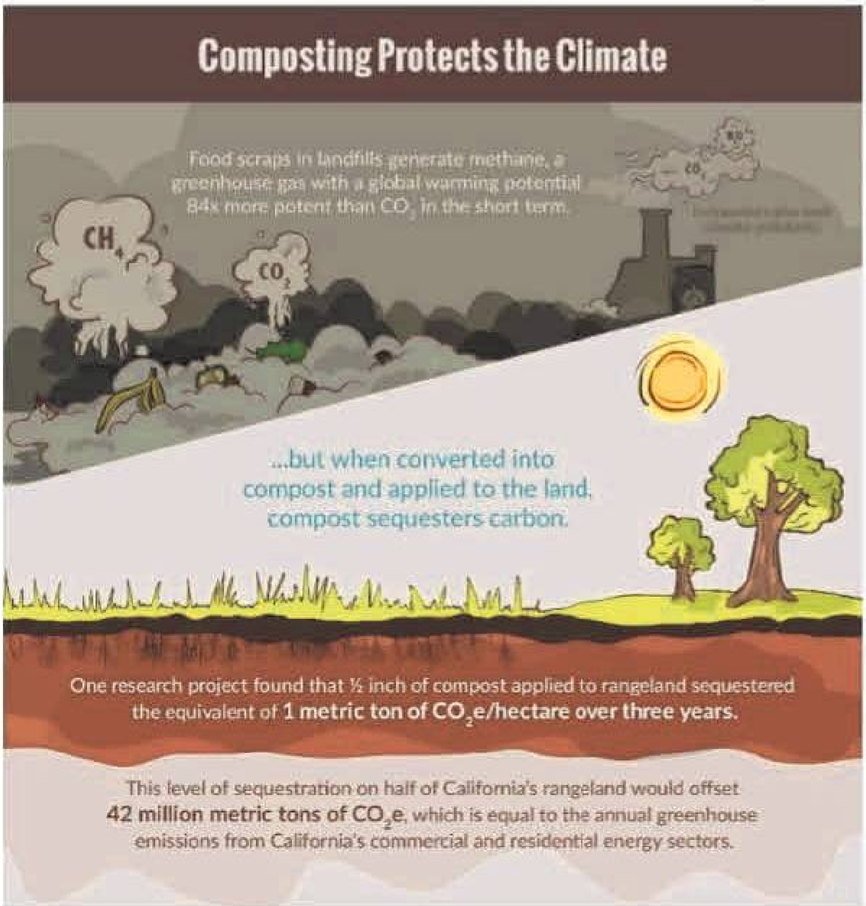


LESSON 1: **WHAT IS THE COMPOST?**

Duration: 1 hour

Lesson Objectives:

After completing this lesson the students will:

- Describe the compost and the composting process
- Become aware of the impact of composting on the environment

Activities:

1. Students will be asked if their family to make compost at their home. If the students say yes, they are asked to describe the process.
2. Ask the students who have the compost at home to bring a monster a sample to

   school for the next lesson.
3. Ask the students who answered no if they think they could also make compost at home. Ask them to think a plan for their own domestic compost.
4. Ask your students to search for more information about the compost and the composting process.
5. Each student will make a short presentation containing text and images (8-10 slides). 15 minutes.
6. Each student presents their information to the class. 15 minutes
7. The teacher draws the conclusions with the help of the students

Homework

He asks the students to find out about how compost is made at an industrial level in our country and in other countries and to make a short report

Theoretical course support

Composting is a fascinating but complex process that involves chemical reactions, bacteria, fungi and multiple organisms.

There's no common definition of compost or composting.

Composting is a waste management system that converts organic materials into a soil amendment through the process of degradation by microorganisms, ultimately resulting in the production of carbon dioxide, water, and humus.

It's sometimes defined as referring to hot composting, but you can achieve compost without heat. It's also defined as a process that produces humus. Yet humus itself is controversial, with some scientists arguing it does not even exist.

We've previously discussed the definition of compost and composting – and the disagreement around it – in depth.

A definition that does cover all bases is that composting is the act of collecting and storing organic material so it can decay and be added to soil to improve its quality.

The decaying process involves multiple organisms breaking down that material into a form that:

- Contains nutrients in a form that plants can access (with help from bacteria)
- Aids aggregation in the soil, which improves the structure of the soil

Do note that 'finished' compost has not finished decaying. While we can no longer see the organic matter, it continues to decay and release nutrients for some years.

Two chemical elements that are essential for composting are carbon and nitrogen. During the composting process, microorganisms, such as bacteria and fungi, use organic material (i.e. carbon containing compounds) as an energy source and as a basic building block for the production of cells. In order to further sustain these microorganisms, there also needs to be a sufficient supply of nitrogen, which is essential for the production of proteins, nucleic acids, amino acids, and enzymes present in cells.

Composting is a process in which microorganisms break organic material down into smaller parts. Composting is a subset of biodegradability; it refers to materials that biodegrade under certain conditions and within a specific time period. Many materials are biodegradable, though this process can sometimes take centuries. For a material to be compostable, it must break down under certain conditions (e.g. temperature, humidity, aeration) and do so in less than 12 weeks (though this can be slightly longer for certain types of industrial composting). The most common type of composting is done at home, in the garden. This involves placing organic matter into soil, where it then decomposes. Industrial composters are also widely used: these can process large quantities of materials under tightly controlled conditions.

WHY IS COMPOSTING IMPORTANT?

The world generates over 2 billion tonnes of waste every year, and more than 33% of this is not processed in an environmentally safe way. Developing a circular economy, in which materials are reused or safely reabsorbed into the Earth, is therefore a major priority for governments, organizations, and individuals all over the world. Composting food and other organic materials leads to significant reductions in methane emissions. The compost produced also has numerous benefits: it increases crop yields, improves water retention in the soil, and sequesters carbon.

WHAT IS THE FUTURE OF COMPOSTING?

The coming decades will see huge progress towards our goal of a circular economy. This will involve the production of new items that are fully compostable, such as shoes made from organic material. Items like this are already on the market, but we expect this trend to continue – and for consumer costs to decrease – in the coming years.

LESSON 2: **THE SCIENCE OF COMPOSTING: HOW COMPOST HAPPENS**

Duration: 2 hours

Lesson Objectives:

After completing this lesson the students will:

- Learn about the science of compost
- Describe what happens into the composting process
- Make connections between knowledge of Chemistry, Biology, Physics
- Explain the processes that take place during composting
- Explain the difference between aerobic and anaerobic composting

Activities:

1. Students will be asked about their homework - the report about the practice of composting in our country and in other countries.
2. Students will be asked about their domestic composting plan.
3. The teacher explains the science of composting using a structured summary of the main aspects of composting adapted to the grade level at which the lesson is taught. The teacher can use a blackboard or smart board.
4. After each learning sequence, the teacher asks the student to solve one task from the attached worksheet.
5. The students show your individual work
6. The teacher draws the conclusions with the help of the students

Theoretical course support

How compost is made

In the composting process, microorganisms eat organic waste and break it down into smaller parts. As the organic matter decomposes, nutrients like nitrogen are released back into the soil. Once everything has biodegraded, we are left with something known as "humus compost".
When it comes to industrial composting, there are three main types:

- Windrow composting: an open-air process in which compost is placed in long piles known as "windrows"
- In-vessel composting: where organic materials are placed into a large drum, silo, or similar container. These interior conditions allow for careful control of temperature, moisture, and aeration
- Aerated static pile composting: this process involves organic waste being placed in a large outdoor pile. Bulking agents are then added to the mix to improve airflow, and the piles are placed over a network of pipes that blow air in and out of the pile

Composting conditions

- Anaerobic - without air
    - anaerobic composting takes place when the conditions are not optimal for aerobic composting
- Aerobic - with air

Anaerobic v. aerobic composting

Aerobic composting has many benefits over anaerobic composting:

- It's faster.
- Due to high temperatures, it's more likely to kill diseases.

- It doesn't produce unpleasant smells (caused by the production of ammonia).
- As it produces CO_2 rather than methane, it is better for the environment.

However, anaerobic composting may retain more nitrogen than aerobic composting.

HOW DOES COMPOSTING WORK?

The three phases of composting

Composting is often divided into three phases.

Mesophilic stage (2-3 days): This stage is dominated by mesophilic bacteria. The compost heap starts to warm up as these bacteria give off heat. The temperature rises slightly; the number of microorganisms is high.

Thermophilic stage (1 week-a few months): As the heat increases, Thermophilic bacteria take over, creating an even hotter pile. Intense microbial activity.

Maturing stage (several months): As **thermophilic bacteria use up easily available proteins, fats, and complex carbohydrates**, the compost enters the maturing stage. Tougher material is broken down, with more work done by physical decomposers.

Compost Microorganisms

Data Source: Daniel L. Dindal: Ecology of Compost: A Public Involvement Project

Bacteria

Psychrophilic bacteria

These bacteria perform best at temperatures of around 13°C/ 55°F. But they'll also work at lower temperatures, including at -18°C/0°F! These bacteria give off a small amount of heat. If conditions are right, even when the weather is cold they can lead to the hotter conditions created by mesophilic bacteria.

Mesophilic bacteria

Mesophilic bacteria, which are also present in soil, thrive at temperatures between 21°C/ 70°F to 32°C/90°F. These bacteria give off more heat, and if conditions are right they will get hot enough for thermophilic bacteria to start work.

Thermophilic bacteria

Thermophiles are incredibly tough bacteria and may have been the first bacteria on earth. These bacteria prefer hotter temperatures and are most active at 46 – 60°C/ 115 to 140°F.

The reason many composters aim for hot compost is that thermophilic bacteria work faster than other bacteria. The high temperatures they produce also kill pathogens and weed seeds. However, if the compost exceeds 71°C/160°F these bacteria will start to die off, slowing down the composting process.

Nitrifying bacteria

Nitrifying bacteria play an important role in changing ammonium compounds to nitrates – which are then accessible to plants.

Actinomycetes

Actinomycetes, a higher form of bacteria that is similar to fungus, help to break down complex, woody materials which have been left behind by the thermophilic bacteria. These work best in moderate temperatures and produce long threadlike filaments which stretch throughout the compost.

Learn more: The Mind-Boggling Role Of Bacteria In Compost

Fungi

Fungi also help to break down tough materials. These can be more tolerant of heat and may start to appear in the thermophilic stages.

Chemistry of the compost

The composting process starts when compost materials are added to the compost pile.

Microorganisms use chemicals in their body to break down those materials. This involves a number of chemical processes including oxidation, or the process of adding oxygen. Specifically, bacteria oxidize carbon to carbon dioxide, creating heat as they do so.

Oxidation of carbon to CO_2 can release a great deal of heat.

Other chemical processes include reduction and hydrolysis.

Physical decomposers

The worms and snails are physical decomposers

Bacteria aren't the only things working away in your compost heap. Bacteria attracts larger organisms searching for food, while those larger organisms attract bigger organisms again.

Primary consumers, which include both bacteria and also larger decomposers such as worms, slugs and snails, eat the plant material.

Worms are particularly important in this process. They create tunnels in the compost which allows air and oxygen to circulate and nutrients to pass through the pile.

They also take in organic material and pass it through a digestive process rich in hormones, enzymes and fermenting processes.

Requirements for aerobic composting

Nutrients needed

Bacteria, actinomycetes and fungi need nutrients to live and reproduce.

Two of the frequently mentioned are **carbon** and **nitrogen**.

Carbon is used as an energy source and a building block.

Nitrogen is used to build proteins and other elements. Getting the right mix of carbon and nitrogen can help provide an optimum environment for composting.

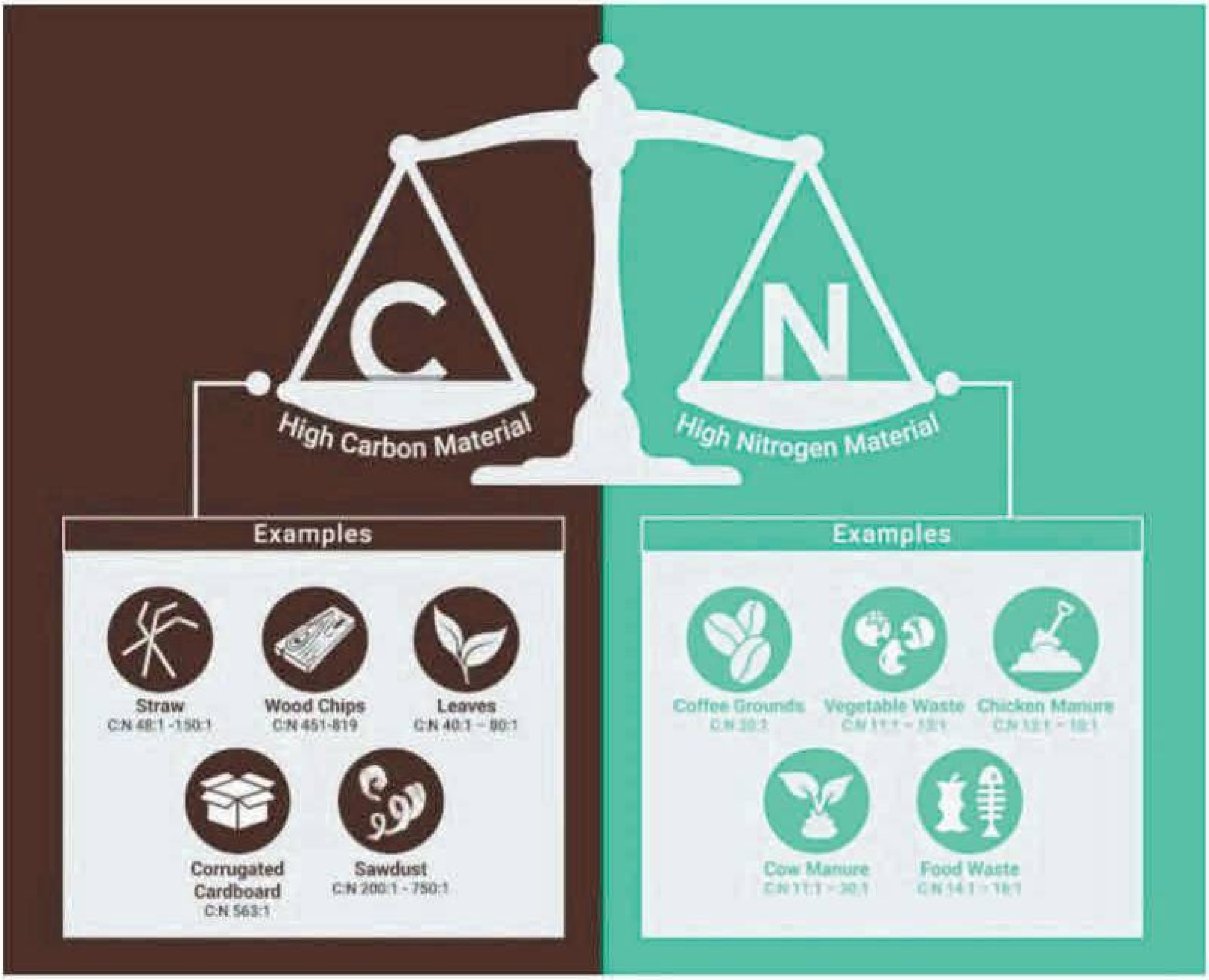
C/N Ratio

Of the many elements required for microbial decomposition, carbon and nitrogen are the most important. Carbon provides both an energy source and the basic building block making up about 50 percent of the mass of microbial cells. Nitrogen is a crucial component of the proteins, nucleic acids, amino acids, enzymes and co-enzymes necessary for cell growth and function.

To provide optimal amounts of these two crucial elements, you can use the carbon-to-nitrogen (C/N) ratio for each of your compost ingredients. The ideal C/N ratio for composting is generally considered to be around 30:1, or 30 parts carbon for each part nitrogen by weight. Why 30:1? At lower ratios, nitrogen will be supplied in excess and will be lost as ammonia gas, causing undesirable odors. Higher ratios mean that there is not sufficient nitrogen for optimal growth of the microbial populations, so the compost will remain relatively cool and degradation will proceed at a slow rate.

As composting proceeds, the C/N ratio gradually decreases from 30:1 to 10-15:1 for the finished product. This occurs because each time that organic compounds are consumed by microorganisms, two-thirds of the carbon is given off as carbon dioxide. The remaining third is incorporated along with nitrogen into microbial cells, then later released for further use once those cells die.

Although attaining a C/N ratio of roughly 30:1 is a useful goal in planning composting operations, this ratio may need to be adjusted according to the bioavailability of the materials in question. Most of the nitrogen in compostable materials is readily available. Some of the carbon, however, may be bound up in compounds that are highly resistant to biological degradation.



Do note that the terms **'Greens'** and **'Browns'** can be rather confusing. The names refer to their nitrogen and carbon content, not to their color.

Here are some examples of greens and browns with their C: N ratios.

Greens (N rich)

- Coffee Grounds: C: N 20:1
- Vegetable Waste: C: N 11:1 – 13:1
- Chicken Manure: C: N 13:1 – 10:1
- Cow Manure: C: N 11:1 – 30:1
- Horse Manure: C: N 22:1 – 50:1
- Sheep Manure: C: N 13:1 – 20:1
- Pig Manure: C: N 9:1 – 19:1
- Food Waste: C: N 14:1 – 16:1
- Grass clippings: C: N 9:1 -25:1

Browns (C rich)

- Straw: C: N 48:1 -150:1
- Bark (hardwood): C: N 116:1 – 436:1
- Bark (softwood): C: N 131:1 -1,285:1
- Corrugated cardboard: C: N 563:1
- Sawdust: C: N 200:1 – 750:1
- Wood chips (hardwood): C: N 451-819
- Leaves: C: N 40:1 – 80:1
- Seaweed: C: N 5:1 – 27:1

Bacteria also require phosphorus and potassium, as well as tiny quantities of minor elements.

Materials High in Carbon	C/N*
autumn leaves	30-80:1
straw	40-100:1
wood chips or sawdust	100-500:1
bark	100-130:1
mixed paper	150-200:1
newspaper or corrugated cardboard	560:1
Materials High in Nitrogen	**C:N***
vegetable scraps	15-20:1

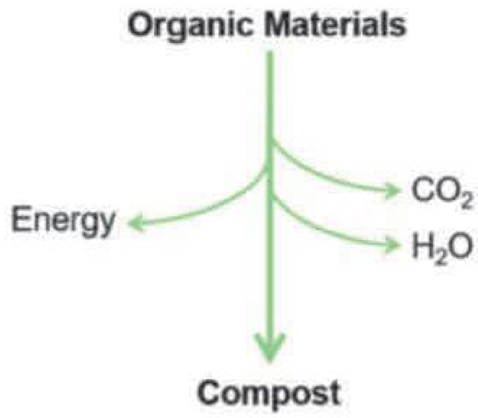
Materials High in Carbon	C/N*
coffee grounds	20:1
grass clippings	15-25:1
manure	5-25:1

Bacteria themselves consist of carbon and nitrogen, with a ratio of 8:1 (8 units of carbon to every 1 unit of nitrogen). To grow and multiply, they need carbon to maintain themselves and for energy, and nitrogen to grow proteins.

If the C: N ratio and other conditions are right, mesophilic microorganisms, which thrive in moderate temperatures, start breaking down the organic material in the compost, producing heat in the process.

These microorganisms do best in temperatures of around 20 to 45 degrees celsius.

Manure is a good compost material because it is rich in both nitrogen and phosphorus – it is even better when combined with carbon-rich straw. However, some manure may contain herbicides which can affect plant growth.



Oxygen

Another essential ingredient for successful composting is oxygen. As microorganisms oxidize carbon for energy, oxygen is used up and carbon dioxide is produced. Without sufficient oxygen, the process will become anaerobic and produce undesirable odors, including the rotten-egg smell of hydrogen sulfide gas.

Aerobic bacteria require oxygen to survive and for the chemical processes that digest compost material. While compost bacteria can survive on as little as 5% oxygen, when the pile starts to fall below levels of about 10%, parts of the pile may start to switch to anaerobic decomposition.

Oxygen levels will start to fall naturally as microbial activity increases and use oxygen. As this activity slows, the oxygen levels will rise again.

Moisture (water content)

Water is essential for microorganisms to survive. However, if there's too much water in the compost heap, it is difficult for microorganisms to access oxygen. The composting process will slow, and anaerobic composting may take place.

Water is the solvent for the nutrients necessary for the development of microorganisms.

Below 30% humidity - efficiency decreases

Over 60% humidity - prevents the diffusion of oxygen through the mass of substance subject to composting.

Nutrient Balance

Adequate phosphorus, potassium, and trace minerals (calcium, iron, boron, copper, etc.) are essential to microbial metabolism. Normally these nutrients are not limiting because they are present in ample concentration in the compost source materials.

pH levels

While the ideal range for microbial activity is 6.5 to 8.0, overall compost is fairly tolerant of pH levels. That's partly because different bacteria perform well with different pH levels.

pH levels will also vary during the composting process. During the first few days of composting, the pH levels could drop as low as 4 as organic acids are formed, and by the end of the process, pH levels end up between 7.5 and 8.0.

What are challenging concerning the compost?

Whether composting at home or in an industrial setting, people face the same essential challenge: keeping conditions at the right levels. The ratio of carbon and nitrogen must remain in balance: too much nitrogen starts to rot the compost, and too much carbon means that composting can't take place. Temperature, water levels, pH levels, and sufficient aeration are other important considerations.

LESSON 3: **Let's make compost!**

Duration: 1 hour

Lesson Objectives:

After completing this lesson the students will:

- Use theoretical knowledge in the practical realization of compost
- Explain the processes that take place during composting
- Become aware of the impact of composting on the environment

Pre-task:

The students received the task at home to make compost for educational purposes, according to a worksheet.

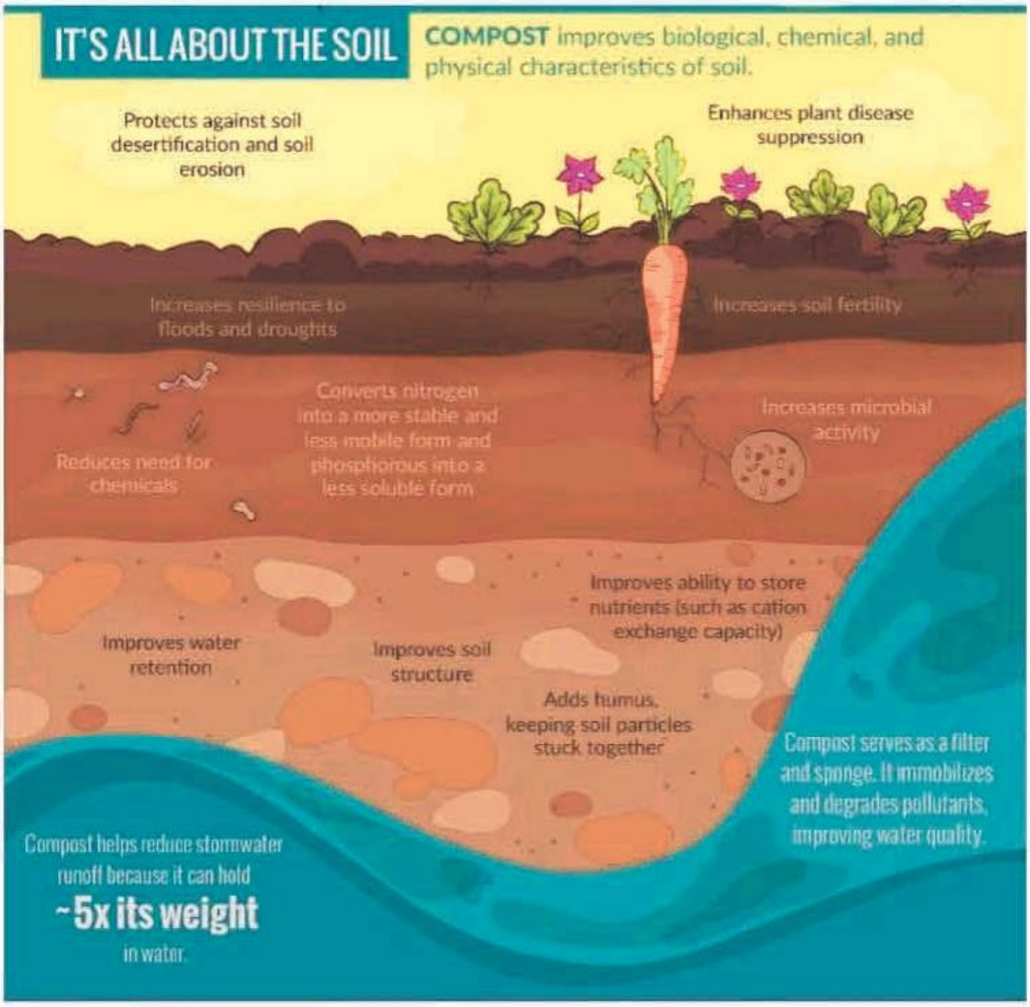
Activities:

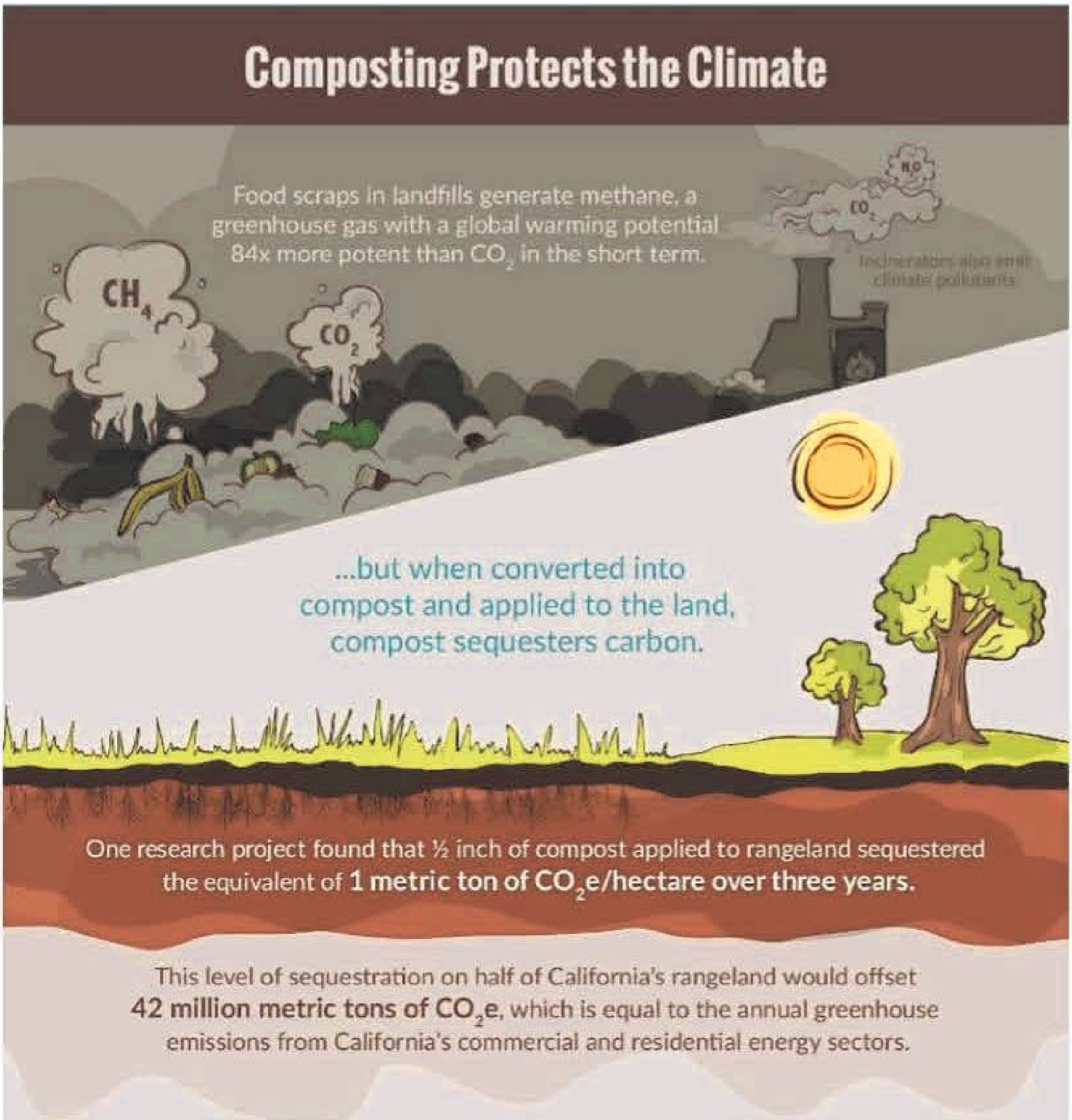
1. The students present their compost made at home and the observations made throughout the process collected in a presentation .ppt.
2. The teacher and the students ask questions
3. Students fill in a question sheet
4. The teacher says the conclusion: **"Everyone can compost at home. The benefits are multiple". The teacher invites students to** notice the two images below and to debate about the benefits of composting for the soil and for the climate.
5. The students are encouraged to involve their whole family in the habit of making their own compost.

Benefits for your soil & soil structure

a. Moisture retention
b. Improved drainage
c. Improved aeration
d. Increased nutrition

    e. Delivers nutrients at the right time
    f. Mycorrhizal Funghi
    g. Stabilises PH Levels
    h. Fewer plant pests and diseases
6. Benefits for the environment
    a. Prevents Erosion
    b. Reduce pollutants in stormwater
    c. Cleaning polluted soils
    d. Reduces emissions
        i. By replacing synthetic fertilisers
        ii. By reducing the amount of landfill
    e. Carbon sequestering
7. Benefits for economy
    a. Changing waste into product
    b. Lowers the cost of food
    c. Reduce landfill costs
    d. Cost of growing food
8. Benefits for your pocket
    a. Lower cost of gardening
9. Benefits for your health
    a. Healthy soil, healthy food
    b. Fewer pesticides, fewer diseases
    c. May help with mental health
    d. Cleaner Water, Fewer Diseases


IT'S ALL ABOUT THE SOIL
COMPOST improves biological, chemical, and physical characteristics of soil.
Protects against soil desertification and soil erosion
Enhances plant disease suppression
Increases resilience to floods and droughts
Increases soil fertility
Converts nitrogen into a more stable and less mobile form and phosphorous into a less soluble form
Increases microbial activity
Reduces need for chemicals
Improves ability to store nutrients (such as cation exchange capacity)
Improves water retention
Improves soil structure
Adds humus, keeping soil particles stuck together
Compost serves as a filter and sponge. It immobilizes and degrades pollutants, improving water quality.
Compost helps reduce stormwater runoff because it can hold
~5x its weight
in water.


Composting Protects the Climate
Food scraps in landfills generate methane, a greenhouse gas with a global warming potential 84x more potent than CO_2 in the short term.
CH_4
CO_2
...but when converted into compost and applied to the land, compost sequesters carbon.
One research project found that ½ inch of compost applied to rangeland sequestered the equivalent of **1 metric ton of CO_2e/hectare over three years.**
This level of sequestration on half of California's rangeland would offset **42 million metric tons of CO_2e,** which is equal to the annual greenhouse emissions from California's commercial and residential energy sectors.

Worksheet - INSTRUCTION FOR MAKE THE COMPOST AT HOME

How to make compost for school at home?

What is compost?

Compost is a natural, organic fertilizer that generally contains plant and animal waste. The remains are broken down with the help of bacteria, and the result is a dry, crumbly mixture that is rich in nutrients and dark in color. Compost is ecological, non-rainy and is successfully used in soil fertilization.

So, composting consists of breaking down organic material in the soil. Combining carbon-rich (brown) and nitrogen-rich (green) materials with water, air, and microorganisms causes them to break down into a soil-like material (called humus) within months. An ideal carbon to nitrogen (C:N) ratio (about 25-30:1) is required for an effective compost pile.

The presence of oxygen and water is necessary for the microorganisms that consume and digest the organic materials in a compost pile. While decomposition occurs aerobically and anaerobically, anaerobic decomposition is a slower process that produces unpleasant odors (think: landfills). As microorganisms oxidize carbon for energy, oxygen is consumed and carbon dioxide is produced. Without enough oxygen, the process will become anaerobic and produce undesirable odors, including the rotten egg smell of hydrogen sulfide. The pile needs moisture to promote microbial growth, but not so much that there is water flowing freely through the system. Excessive water content can inhibit oxygen transfer to microbes and promote anaerobic behavior. Compost piles should be turned regularly to aerate the system and reintroduce oxygen to the center of the pile, as well as to distribute moisture evenly throughout.

How to make compost for school at home?

1. We choose a transparent container: a P.E.T. with a capacity of 1.5 L or 2 L, preferably with a wider mouth; if not, we cut a lid, on which we then stick with adhesive tape.
2. We drill the container in the upper half.
3. We insert a layer of garden soil or flower soil, 1 cm high, into the container.
4. We add one **strat "kill"** (paper, cardboard, dry leaves, straw, sawdust, etc.), **rich in carbon (C)**, with the height of **6 cm**.
5. We add one **"green" layer** (coffee grounds, egg shells, fruit shells, vegetables, etc.), **rich in nitrogen (N)**, with the height of **2 cm**.

Note: the speed of composting is higher if the degree of comminution of the materials is higher.

6. We put a "cap", with a height of 1 cm, of garden soil/de flowers/compost.
7. **We moisten the substrate.** We ensure optimal humidity throughout the process composting.
8. We partially screw on the lid of the container. We shake and aerate the compost every day.
9. On a piece of paper, we add every day the observations about the state of your compost: color, (micro)organisms, smell, mass (if you have a kitchen scale), temperature (if you have a suitable thermometer), pH (we will measure it at school). At the end we can make a presentation in which we can show everything we have learned about composting, which can turn into a ***grade in chemistry.***
10. Tag the recipient (your name, class and date of incorporation composting) and bring it to school and store it in the specially arranged place, along with the other composting containers, informing the chemistry teacher.
11. Use the finished product to plant a flower in a pot for your classroom.
12. Attach pictures attach photos and videos from the composting process

OBSERVATION SHEET

Compost made by..................

Of the date............................

Initial weight.......................g

Intermediar weight.................g, on the date of.............

Final weight ....g

OBSERVATIONS (macroscopic level)	INTERPRETATION/conclusion

For more information:

https://www.compostmagazine.com/home-composting/

https://youtu.be/nxTzuasQLFo?si=1LzF8ZLp3VEUiE74

https://www.youtube.com/watch?v=_K25WjjCBuw

https://www.youtube.com/watch?v=OAVgBD1C3zU

Composting Education Resources for Kids + Free Video Tutorials

LESSON 4: **COMPOST CHEMISTRY**

Duration: 2 hours

Lesson Objectives:

After completing this lesson the students will:

- Explain what C and N are transformed into during the composting process
- Explain the pH variation during the composting process
- Describe the role of green and brown components in composting
- Recognizes functional groups in the composition of humic and fulvic acid
- Become aware of the impact composting on the environment

Activities:

1. The teacher moderates a frontal discussion with the students about compost
2. The teacher presents a scheme adapted for compost chemistry using white/black board
3. The teacher develops each sequence from the presented theme using a .ppt presentation.
4. The teacher invites the students to observe the 4 samples of compost and to express opinions regarding the humic/fulvic acid content, according to the color, according to the information in the images presented as theoretical support.
5. The students write the observation into the table.
6. The teacher asks the students to formulate conclusions and correlate them with the theoretical information about compost
7. The students are organized into groups and perform the pH determination experiment and humidity determination. (1 hour)
8. The students are encouraged to involve their whole family in the habit of making their own compost.

Theoretical course support

The Carbon/Nitrogen ratio

Of the many elements required for microbial decomposition, carbon and nitrogen are the most important. Carbon provides both an energy source and the basic building block making up about 50 percent of the mass of microbial cells. Nitrogen is a crucial component of the proteins, nucleic acids, amino acids, enzymes and co-enzymes necessary for cell growth and function.

To provide optimal amounts of these two crucial elements, you can use the carbon-to-nitrogen (C/N) ratio for each of your compost ingredients. The ideal C/N ratio for composting is generally considered to be around 30:1, or 30 parts carbon for each part nitrogen by weight. Why 30:1? At lower ratios, nitrogen will be supplied in excess and will be lost as ammonia gas, causing undesirable odors. Higher ratios mean that there is not sufficient nitrogen for optimal growth of the microbial populations, so the compost will remain relatively cool and degradation will proceed at a slow rate.

and moist tend to be high in nitrogen, and those that are brown and dry are high in carbon. High nitrogen materials include grass clippings, plant cuttings, and fruit and vegetable scraps. Brown or woody materials such as autumn leaves, wood chips, sawdust, and shredded paper are high in carbon. You can calculate the C/N ratio of your compost mixture, or you can estimate optimal conditions simply by using a combination of materials that are high in carbon and others that are high in nitrogen.

Materials High in Carbon	**C/N***
autumn leaves	30-80:1
straw	40-100:1
wood chips or sawdust	100-500:1
bark	100-130:1
mixed paper	150-200:1
newspaper or corrugated cardboard	560:1
Materials High in Nitrogen	**C:N***
vegetable scraps	15-20:1
coffee grounds	20:1
grass clippings	15-25:1
manure	5-25:1

As composting proceeds, the C/N ratio gradually decreases from 30:1 to 10-15:1 for the finished product. This occurs because each time that organic compounds are consumed by microorganisms, two-thirds of the carbon is given off as carbon dioxide. The remaining third is incorporated along with nitrogen into microbial cells, then later released for further use once those cells die.

Although attaining a C/N ratio of roughly 30:1 is a useful goal in planning composting operations, this ratio may need to be adjusted according to the bioavailability of the materials in question. Most of the nitrogen in compostable materials is readily available. Some of the carbon, however, may be bound up in compounds that are highly resistant to biological degradation. Newspaper, for example, is slower than other types of paper to break down because it is made up of cellulose fibers sheathed in lignin, a highly resistant compound found in wood. Corn stalks and straw are similarly slow to break down because they are made up of a resistant form of cellulose. Although all of these materials can still be composted, their relatively slow rates of decomposition mean that not all of their carbon will be readily available to microorganisms, so a higher initial C/N ratio can be planned. **Particle size also is a relevant consideration**; although the same amount of carbon is contained in comparable masses of wood chips and sawdust, the larger surface area in the sawdust makes its carbon more readily available for microbial use.

Carbon transformation

$$C + O_2 \Rightarrow CO_2 + Q$$

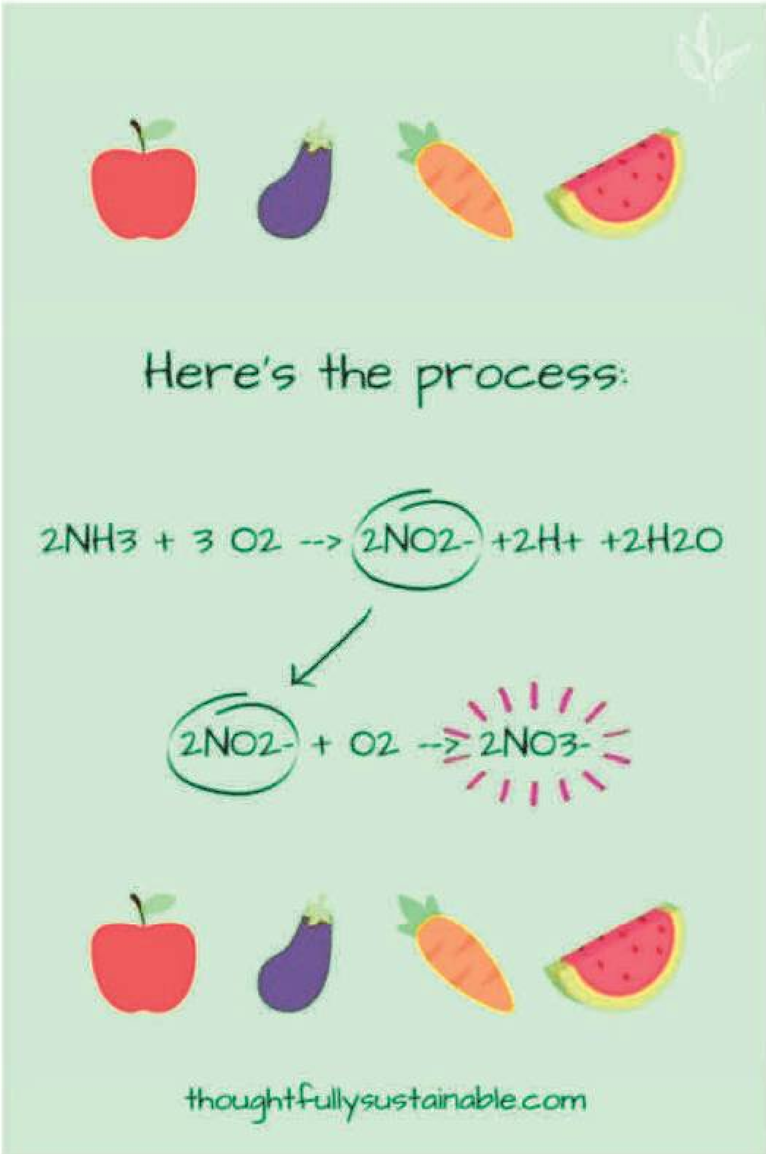
Nitrogen transformation

Into the chemistry on how the decomposition of plants works and why it's vital to soil health. The nitrogen, a vital element to plant growth, is made accessible to vegetation in 2 simple steps:

- When plants decompose, they create ammonia (NH_3).
- Ammonia is converted into nitrate ions (NO_3^+) by reacting with oxygen in a 2 step process.

NH_4^+: N_2 and NH_4^+:N_2 / NO_3^-: N_2 - the compost maturation index

Nitrate NO_3^- is the form of nitrogen that plants must have to survive and thrive! Here's what the chemical equations look like:

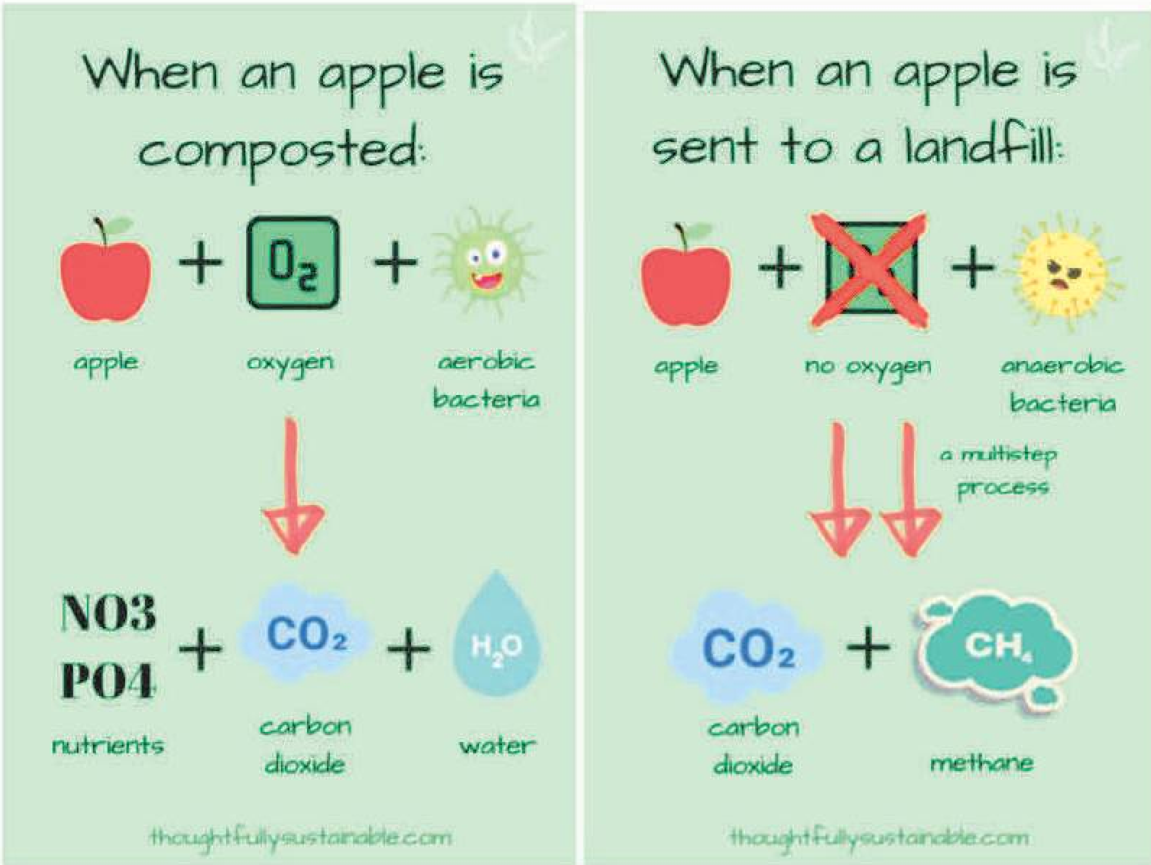


Composting is good for the soil and our food supply, and also an important way to **mitigate the production of the greenhouse gas, methane CH_4.**

Let's use an apple as an example.

When an apple is composted, it decomposes in the presence of oxygen and oxygen breathing (aerobic) bacteria and creates nutrients (nitrates and phosphates), carbon dioxide and water.

When an apple is thrown in the trash and sent to a landfill, it decomposes in the absence of oxygen by non-oxygen breathing (anaerobic) bacteria in a multi-step process that creates carbon dioxide and methane.



Methane is a gas that has a Global Warming Potential (GWP) that is ~25 times greater than carbon dioxide. That means that methane is ~25 times better at trapping heat in our atmosphere than carbon dioxide.

Oxygen

Another essential ingredient for successful composting is oxygen. **As microorganisms oxidize carbon for energy, oxygen is used up and carbon dioxide is produced.**

Without sufficient oxygen, the process will become anaerobic and produce undesirable odors, including the rotten-egg smell of hydrogen sulfide gas.

$$C + O_2 \Rightarrow CO_2 + Q$$

So, how much oxygen is sufficient to maintain aerobic conditions? Although the atmosphere is 21% oxygen, aerobic microbes can survive at concentrations as low as 5%. Oxygen concentrations greater than 10% are considered optimal for maintaining aerobic composting. Some compost systems are able to maintain adequate oxygen passively, through natural diffusion and convection. Other systems require active aeration, provided by blowers or through turning or mixing the compost ingredients.

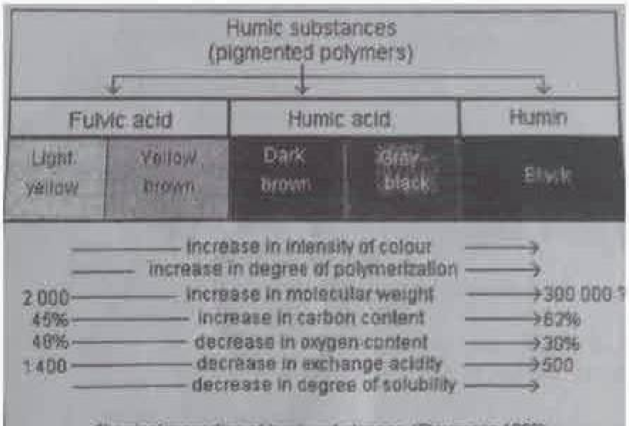
The organic composition of the compost

According to the origin, the organic matter in the soil/compost was classified into 2 main groups:

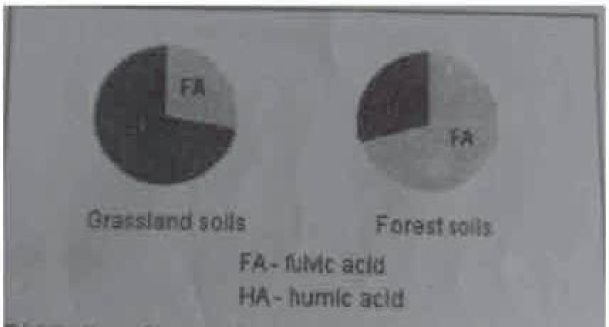
- The fresh and incompletely transformed **organic waste** (plants and animals), separable from the soil by mechanical means
- soil **humus**, which represents an integral part of the soil that cannot be separated from it by mechanical means

  The **humus** is the organic component of soil, formed by the decomposition of leaves and other plant material by soil microorganisms.

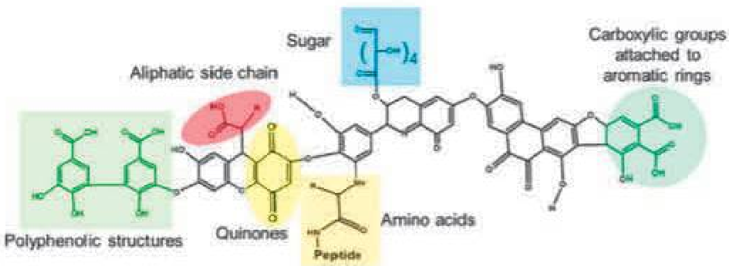
  The **humus** contains humic substances: **humic acids**, **fulvic acids**, **humina.**



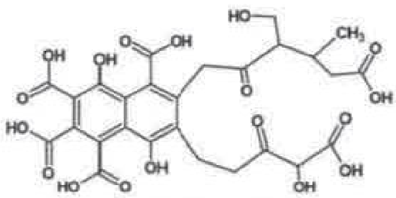
Chemical properties of humic substances. (Stevenson 1982)



Distribution of humus forms in grassland and forest soils. (Stevenson 1982)



Humic acid


Fulvic acid

Oxygen

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So, how much oxygen is sufficient to maintain aerobic conditions? Although the atmosphere is 21% oxygen, aerobic microbes can survive at concentrations as low as 5%. Oxygen concentrations greater than 10% are considered optimal for maintaining aerobic composting. Some compost systems are able to maintain adequate oxygen passively, through natural diffusion and convection. Other systems require active aeration, provided by blowers or through turning or mixing the compost ingredients.

Nutrient Balance

Adequate **phosphorus P**, **potassium K**, and trace minerals (calcium, iron, boron, copper, etc.) are essential to microbial metabolism. Normally these nutrients are not limiting because they are present in ample concentration in the compost source materials.

pH

A pH between 6.5 and 8.5 is optimal for compost microorganisms. As bacteria and fungi digest organic matter, they release organic acids. In the early stages of composting, these acids often accumulate. The resulting drop in pH encourages the growth of fungi and the breakdown of lignin and cellulose. Usually the organic acids become further broken down during the composting process. **If the system becomes anaerobic, however, acid accumulation can lower the pH to 4.5**, severely limiting microbial activity. In such cases, aeration usually is sufficient to return the compost pH to acceptable ranges.

While the ideal range for microbial activity is 6.5 to 8.0, overall compost is fairly tolerant of PH levels. That's partly because different bacteria perform well with different PH levels.

PH levels will also vary during the composting process. **During the first few days of composting, the PH levels could drop as low as 4 as organic acids are formed, and by the end of the process, PH levels end up between 7.5 and 8.0.**

EXPERIMENT: **DETERMINING THE pH OF THE COMPOST**

CHEMICAL REAGENTS
- different compost samples
- distilled water
- pH indicator paper

LABORATORY UTENSILS
- electronic balance
- Berzelius glasses
- watch glasses
- wash bottles
- graduated cylinder 50 mL
- rod glass
- filtration stand with ring
- funnel glass
- wadding

PROTECTIVE EQUIPMENT
- lab coat
- gloves

WORKING PROCEDURE
1. Weigh 5 g of compost onto a watch bottle.
2. Measure 50 mL of distilled water with a graduated cylinder.
3. Transfer the weighed compost into a Berzelius glass.
4. Pour the distilled water over the compost and stir with a stick for about 1 minute.
5. Let the glass rest for 5 minutes.
6. Prepare the filter funnel using cotton wool (it is more effective than filter paper).
7. Pour the obtained mixture over the filter material, first with the clear side like in the image below.
8. Extract a paper strip from the box and wet it in the obtained filtrate.
9. Measure the pH by comparison with the standard scale. Note the result.
10. Compare the results with those of the other workgroups and characterize the compost.

pH levels of compost

At any point during composting, you can measure the pH of the mixture.
Compost microorganisms operate best under neutral to acidic conditions, with pH's in the range of **5.5 to 8**.
During the initial stages of composting, the pH becomes acidic (5.5) due to the rapid production of organic acids. The acidic environment is harsh and kills some types of pathogens in the process, however these conditions also promote other microorganisms to break down tough organic material, including newspaper and other paper products with high cellulose content. If the composting pile becomes too acidic, the activity of helpful bacteria and fungi is limited. Eventually, the pH may rise to become neutral (7), but this level tends to drop to a pH of 6.5 to maintain slightly acidic conditions.

The pH of finished compost is usually between **6.5 and 7.5**.

OBSERVATION SHEET

	Belgian compost	Slovenian compost	Romanian compost	Turkish compost
pH				

Conclusion:

....

....

....

....

pH scale

$[H^+]$	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{-14}
pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Caracter	Foarte acid			Acid		Slab acid		Neutru	Slab alcalin		Alcalin		Foarte alcalin		
	Mediu acid							Normal	Mediu bazic						

Moisture compost determination

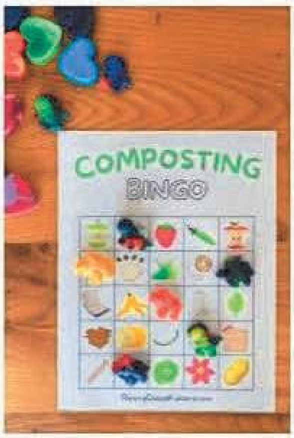
....

LESSON 5: HOW TO USE THE COMPOST?

https://readtheory.org/wp-content/uploads/2020/04/7th-Grade-Compost-All.pdf

The students have to play this quizz:
https://quizizz.com/admin/quiz/659820f99cf468266ecd88dd?source=quiz_share

The students have to play this funny game: Compost BINGO game.



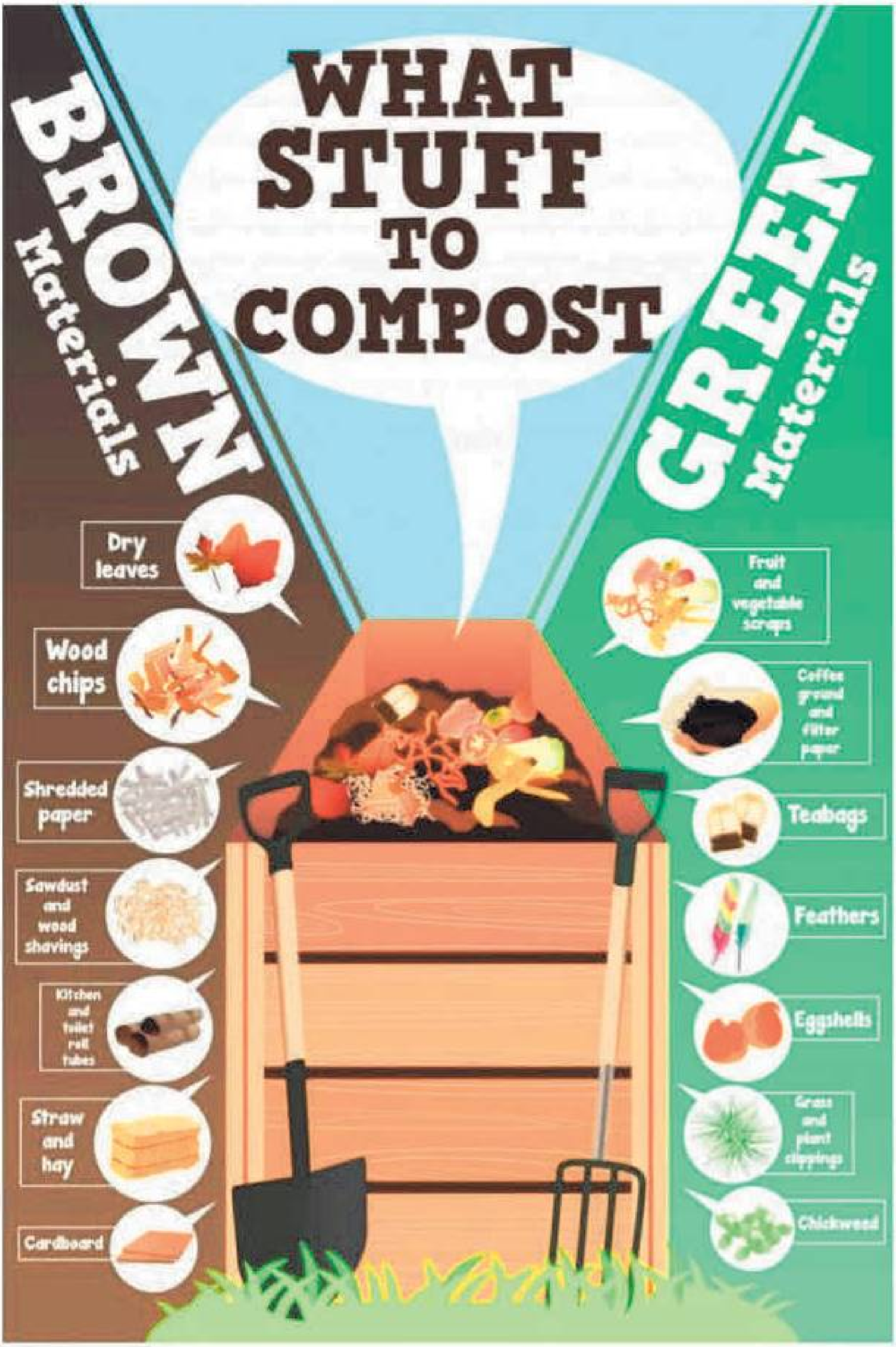
The students have to solve this rebus:
https://learningapps.org/watch?v=pf1zq5w0524

		1 B	A	C	T	E	R	I	A
2 N	I	T	R	O	G	E	N		
		3 H	U	M	U	S			
				4 P	I	L	E		
5 C	A	R	B	O	N				
	6 M	O	I	S	T	U	R	E	
	7 W	A	S	T	E				

You can use more resources:

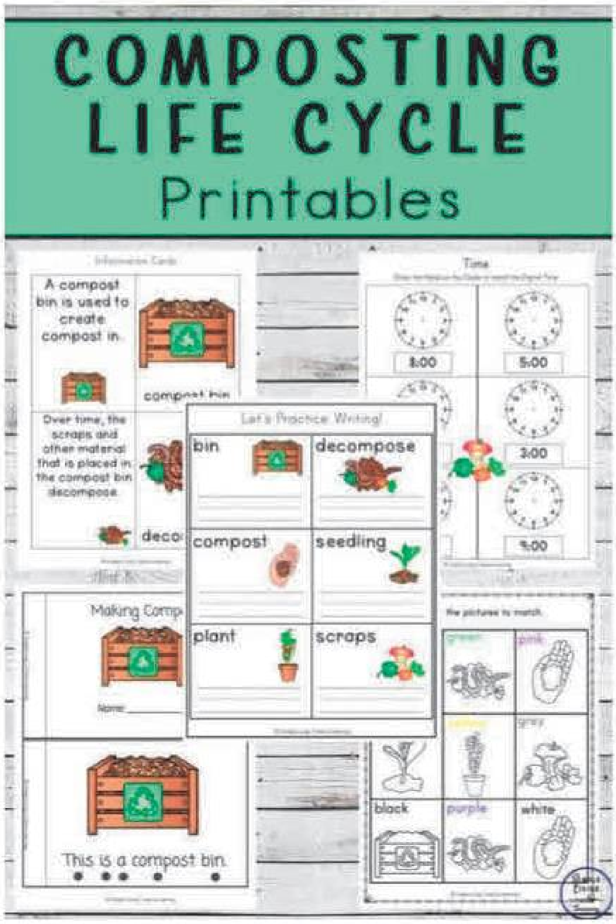
1. One ready lesson plan: Plan de lecție | Compostul: o investigație științifică (calacademy.org)
2. One short animated ready lesson for 7th grade (in Romanian language): Solul – amestec eterogen. Chimie clasa a 7-a (eduboom.ro)
3. One ready lesson plan 1st grade: Lesson-Plans-Compost-for-Kids.pdf (ncsu.edu)
4. One ready lesson plane for microbiology: Plan de lecție GRATUIT: Magia microbiană: explorarea proceselor biologice ale compostării (letsgocompost.org)
5. One ready lesson plan for 3-7 th grade: Compostarea este distractivă - Clasele 3-7 - Școli durabile (natureconnect.earth)
6. One ready lesson plane: PLAN DE LECȚIE DE COMPOSTARE (studylib.net)

Pictures gallery

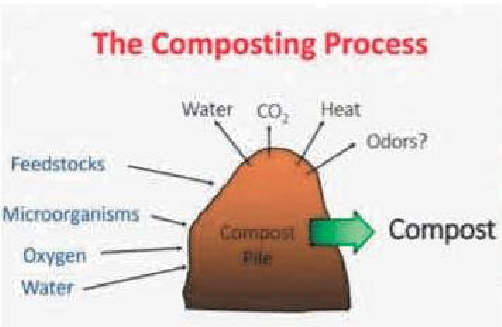

WHAT STUFF TO COMPOST
BROWN Materials
GREEN Materials
Dry leaves
Wood chips
Shredded paper
Sawdust and wood shavings
Kitchen and toilet roll tubes
Straw and hay
Cardboard
Fruit and vegetable scraps
Coffee ground and filter paper
Teabags
Feathers
Eggshells
Grass and plant clippings
Chickweed

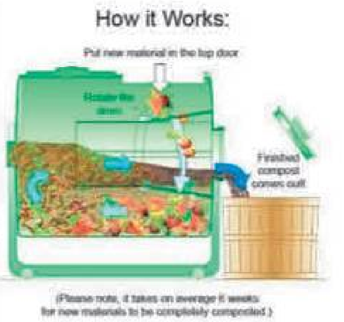

How to Compost: Browns & Greens
C
2/3
BROWN
N
1/3
GREEN
Grass clippings
Fruit scraps
Fall leaves
Corrugated cardboard
Twigs, chipped tree branches
Paper
Eggshells
Animal manure (no pet)
plants


COMPOSTING 101
What you can and can't place in your compost pile
COMPOST
Fruit Scraps
Vegetable Scraps
Dried Leaves
Eggshells
Jams
Napkins/Paper Towels
Cardboard
Grass/Plants
DON'T COMPOST
Meats/Grease
Dairy Products
Fish Waste
Citrus/Onion Peels
Animal Waste
Coated Paper
Diseased Plants
Sawdust



WHAT IS COMPOSTING ?





SWA

Name: ____________ Date: ____________

Compost Activity Sheet

Read the items below. Circle the ones that are organic and can be composted.

styrofoam cup	newspaper	grass clippings	peaches
plastic bag	orange peel	twigs	notebook
computer	crayon	banana peel	pine needles
glass bottle	celery stalks	avocado peel	television
adhesive tape	aluminum can	leaves	tree branch
lettuce	paper clip	tangerine peel	envelope

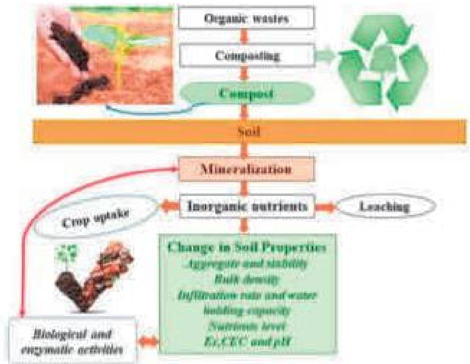
Write an item that can be compostable for each of the letters in the word "Compost".

C arrot stalk
O ____________
M ____________
P ____________
O ____________
S ____________
T ____________

Write the names of seven vegetables and seven fruits.

Vegetables	Fruits

Printed on recycled paper


Organic wastes
Composting
Compost
Soil
Mineralization
Inorganic nutrients
Crop uptake
Leaching
Change in Soil Properties
Aggregate and stability
Bulk density
Infiltration rate and water
holding capacity
Nutrients level
Ec,CEC and pH
Biological and
enzymatic activities


COMPOSTING for KIDS
The food scraps decompose and turn into super-healthy soil called COMPOST.


COMPOST
WHAT NOT TO COMPOST

The webografy

1.https://compost.css.cornell.edu/calc/cn_ratio.html

2.https://www.planetnatural.com/

3.https://www.eutron.ro

4.https://www.stahl.com/beyond-chemistry-from-a-to-z/what-is- composting

5.https://www.comsol.com/blogs/science-composting

6.https://www.compostmagazine.com/compost-science/

7.https://compost.css.cornell.edu/chemistry.html

8.https://www.thepipettepen.com/the-chemistry-behind-composting/

9.https://thoughtfullysustainable.com/the- chemistry-of-composting-saving-the-planet-one- food-scrap-at-a-time/

10.Radu Zlati | Cum testăm aciditatea solului în casă

11.https://educators.brainpop.com/lesson-plan/laboratory-practices/?bp-topic=bacteria

12.https://dubitumealaterre.wordpress.com/2020/03/14/co mposter-cest-pas-complique/

Lesson 6

Duration:6+6 hrs

Objectives: -At the end of these lessons , the students will have a better understanding of bacteria and mushrooms / fungi -aerobe/anaerobe fermentation of compost

Activities

Presentations:

Ask your students to prepare presentations about compost obtaining

Discussion:

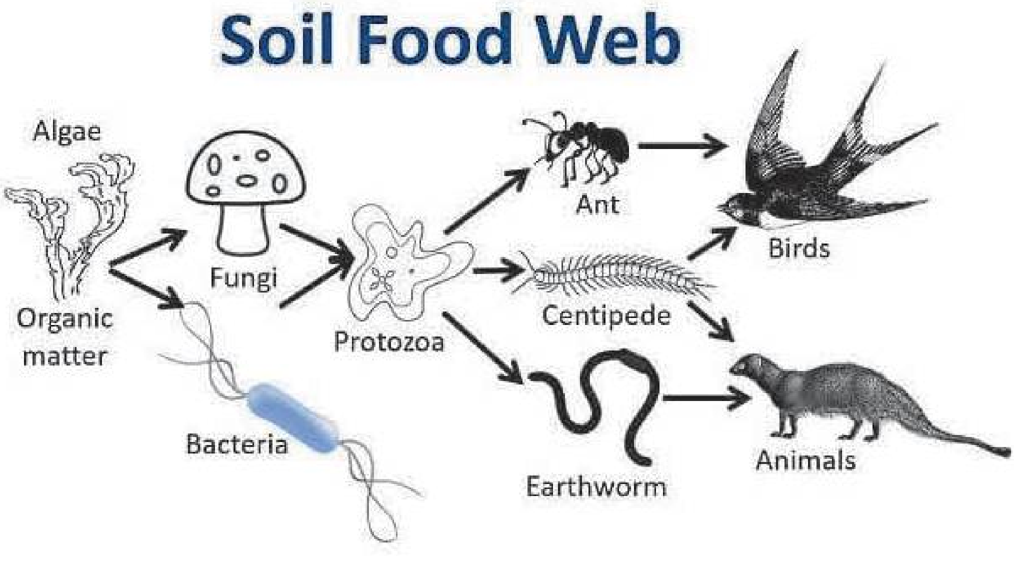
Students should present their presentations to the class and present their own solution suggestions regarding their compost samples

SOILS AND THEIR CHARACTERISTICS

Soils can be formed in a wide variety of environments in which organic material accumulates through the activity of primary producers. They range from the tundra soils of the Arctic zone, where about 11% of the Earth's carbonaceous soils are located, to the humid Antarctic valleys devoid of vascularized plants. In addition, even the deep areas where the roots of the plants do not penetrate and their products do not contain various microbial communities in such areas can lead to the formation of minerals such as dolomites. Microbial populations also exist in oil deposits or sandy soils. And soil microorganisms are dependent on energy sources and nutrients from the environment. Cyanobacteria contribute to the accumulation of organic material, especially in desert soils.

Soils are not static systems. They respond to a variety of environmental factors such as temperature and humidity, as well as to the effects of microorganisms.

The structure of the soils influences the availability of food, affecting the interactions between microorganisms .



Soils consist of sands, clays, silt and other particles. The organic material is provided by the decomposition of plants, animals, insects gradually transformed into humus. These various components form heterogeneous aggregates of different sizes that contain a complex network of pores. Bacteria and fungi are the main beneficiaries of these habitats.

Most soil bacteria are located on the surfaces of soil particles and need water and nutrients in their immediate vicinity. Bacteria are more frequently found on the inner surfaces of small pores (2-6 a diameter) where they are less exposed to become food for protozoa located on the outer surfaces of particles of sand or organic material.

Filamentous fungi, on the other hand, tend to be located on the outer parts of these aggregates. These filamentous organisms will form bridges between separate regions where the soil is available. Filamentous fungi can move nutrients and water in the soil over relatively long distances. Many other organisms, such as protozoa, nematode insects and other animals, are present in the soil, with bacteria and fungi as their main food.

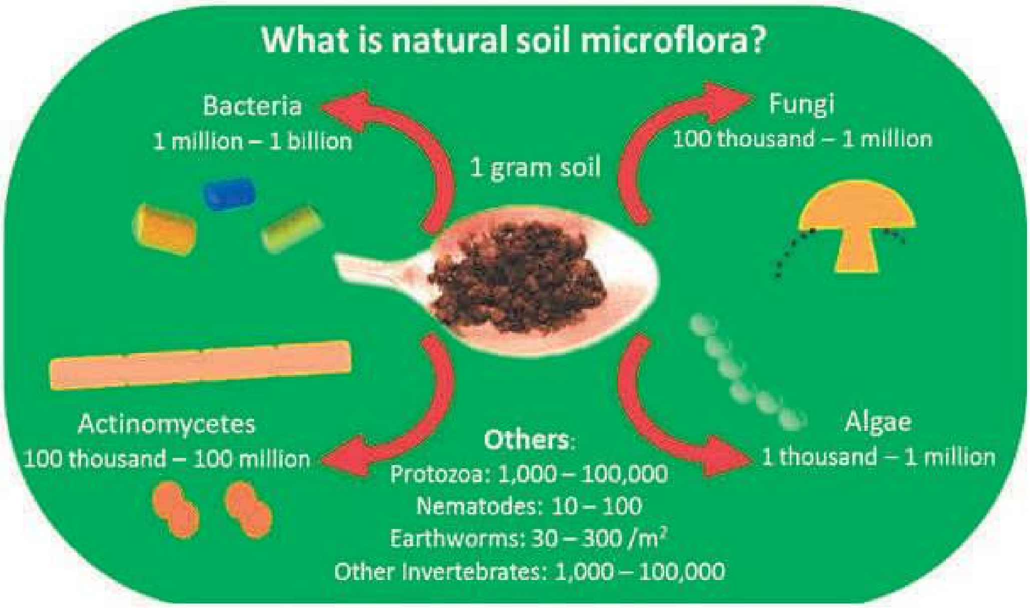
The limited diffusion of gases to and from these aggregates as well as the possibility of pore flooding can cause major changes in these microhabitats .

Soils represent relatively higher concentrations of CO2 and the possibility of pore flooding can cause major changes in these microhabitats.

When it rains, the soil can quickly transform from an aerobic environment with many anaerobic microsites into a pre-oderent anaerobic environment.

Other factors in turn influence soils. At a neutral PH, most of the solid components of the soil, including microorganisms, are negatively electrified. Positive ions, such as hydrogen and ammonium, will thus be attracted to these negative surfaces, a fact that will modify the microenvironment respectively. Sludge and humus, consisting of partially degraded and stabilized organic matter, attract and bind together a variety of organic and inorganic substances.

MICROORGANISMS AND SOIL FORMATION



Soils are formed in different environmental conditions. After the exposure of the geological material to environmental factors, after a volcanic eruption for example, it begins to be colonized by microorganisms. In the primary stage of soil formation, many cyanobacteria will be active that will fix atmospheric nitrogen and carbon. Once they were retained, originating from the decomposition of microorganisms, insects, plants and animals.

The microbial population in soils can be very high, reaching 108-109 cells per gram of dry soil. Fungi can be present up to several hundred hyphae meters per gram of soil

THE POPULATION OF MICROORGANISMS IN THE SOIL

Soil microorganisms can be classified both on the basis of the preference for hard-to-access or more easily available substrates, as well as the substrate concentrations they need. At the highest level of the required nutrients are microorganisms with a quick response such as sugars and amino acids. Among these microorganisms are the members of the genus: Pseudomonas, so-called zymogenic microorganisms.

Microorganisms that tend to use native organic matter to a greater degree are autochthonous microorganisms, bacteria of the genus Archaeobacteria.

Insects and other animals in the soil such as worms contribute in turn to the transformations of the organic material in its component. Such organisms serve as reducing decomposers, which means that they achieve not only the decomposition and mineralization of the soil, but also its fragmentation. This determines the growth of the soil for the use of bacteria and fungi.

It should also be noted the harmful role that some bacteria and fungi have on plants. For example, the Puccinia graminis fungus that produces wheat rust, Phytophthora infestans that is responsible for potato blight and the Erwinia bacterium that causes plant wilting.

Rhizospheres

The microbial populations in the soil respond to the release of organic material in the immediate vicinity of the plant roots, by increasing the number and changing the characteristics of the microbial colony. This region called the rhizosphere was first discovered by Lorenz Hiltner in 1904. This response is marked in poor, desert soils. Microorganisms in the rhizosphere serve as a source of non-digestive substances and at the same time play a critical role in the synthesis and degradation of organic material. complex set of interactions is carried out based on chemical signals. A member of the rhizosphere community is Rhizobium. This bacterium can also establish a symbolic relationship with the vegetables to which it supplies nitrogen. The bacterium presents a plasmid that contains in its coded formations that is not used in its free state. which exchanges chemical signals between the two.

The exchange of signals stimulates Rhizobium to stimulate specific factors that will activate the symbiotic process necessary for the infection of root rots and the development of nodules. The mature nodule is the site of nitrogen fixation

Actinorrhizae represent associations of actinomycetes with the roots of eight plant families

Some plants develop nodules of considerable size. For example, Alnus, Ceanohtus develop modules the size of a soccer ball.

Mycorrhizae are associations between fungi and roots and are found in about 95% of vascular plants. Five mycorrhizal associations have been discovered so far, which include separated and unseparated fungi.

Depending on the environment, microzoa cause an increase in available nutrients, especially phosphorus.

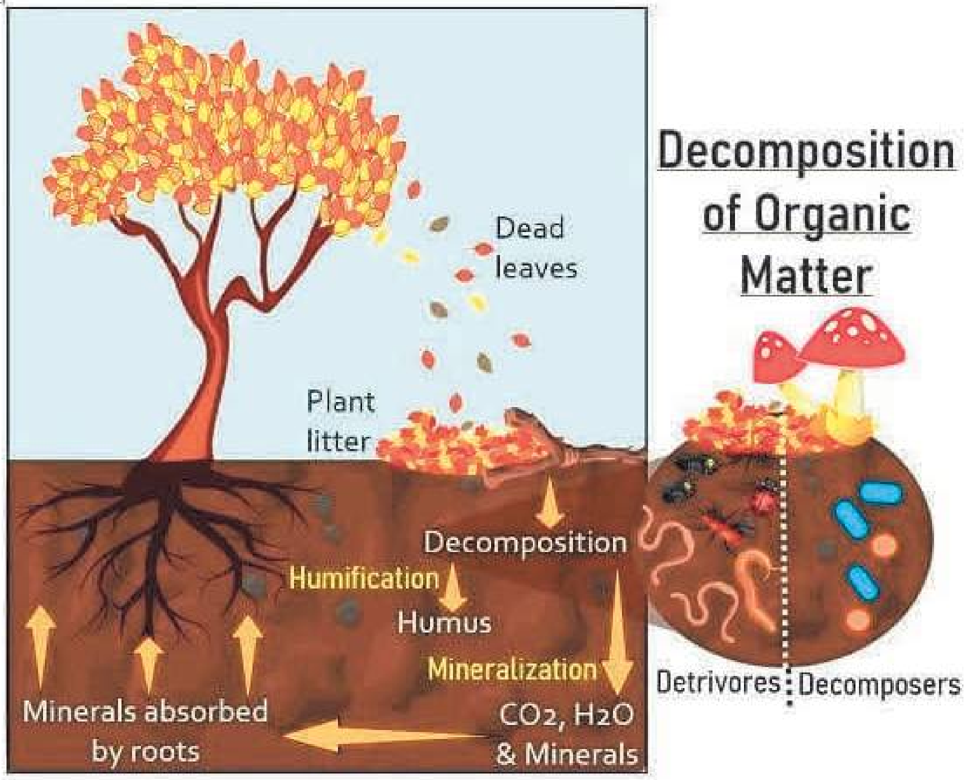
Tri- and tetra-partite associations. There are known cases in which the plant develops relationships with one or three different types of microorganism. These symbiotic associations involve the interaction of microorganisms associated with each other and with the plant. There are known associations between the plant and endomycosis, and Rhizobium, endomycorrhizae and actinorhiza, ectomycorrhiza, actinorhiza. A tetrapartite association includes endomycorrhizae, ectomycorrhizae, Frankia and the host plant.

Bacterial and fugitive endophytes of plants. Fungi and specialized bacteria can survive inside plants as endophytes. Microorganisms settle in the cortex of the roots between the parenchyma cells. This relationship can make the plant less susceptible to insect attacks, but on the other hand, it reduces the genetic variability of the plant by sterilizing it.

Endophytic bacteria have been discovered in potatoes, cotton or pears and generally do not have beneficial effects on plant growth.

Agrobacterium. The tumorigenic infections produced by Agrobacterium prevent the transfer of a portion of a tumorigenic plasmid from the bacterium to the plant. The tumor is produced by an imbalance of phytohormones controlled by the enzyme encoded by the bacterial plasmid.

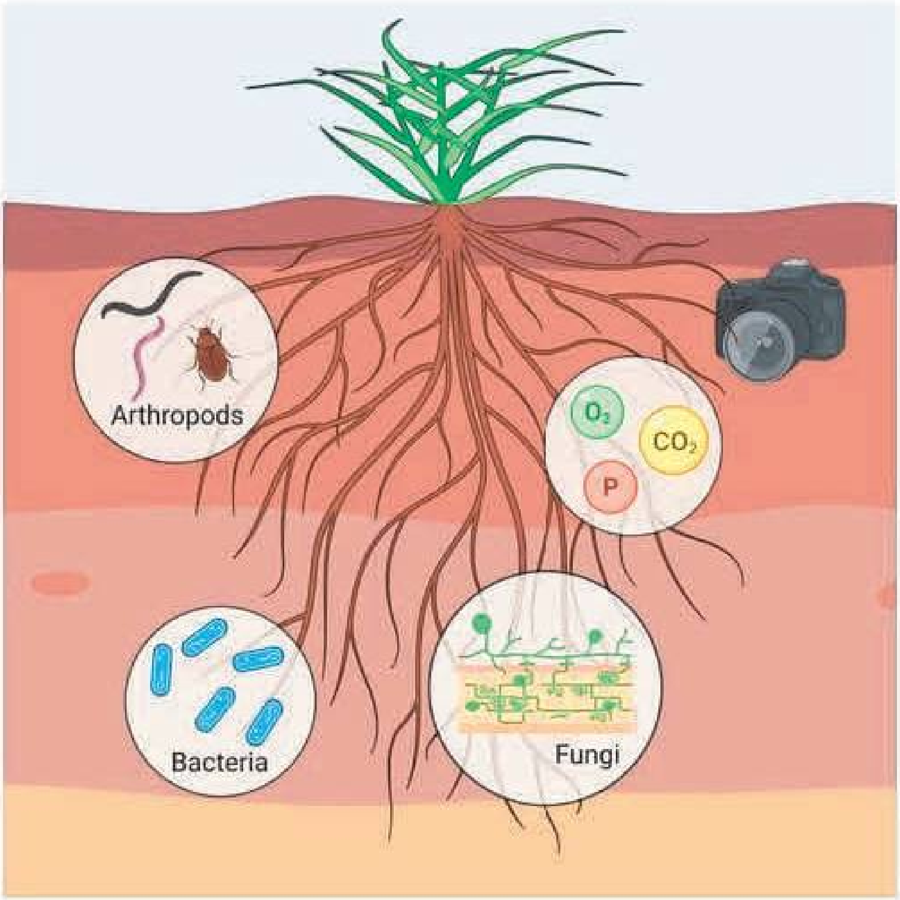
Free enzymes from insects, plants, animals and micro-organisms have a significant part of the biological activity in the soil. These free enzymes participate in a series of hydrolytic and potheolytic degradation reactions.



In cases where there is no balance between the production and decomposition of the organic material in the soil, it can either accumulate or dry out. In the latter case, soil fertility decreases. The production and decomposition of organic material depends on the temperature Above average annual temperatures of 25°C, in aerobic soils the organic material is degraded faster than it is produced. This is the case of the majority of humid tropical soils, where the decomposition of the organic material is very fast, and the fertility of the soil is lost quicklyTo limit the loss of nutrient material, many tropical plants have root systems that penetrate the decaying debris layer.

In contrast, in many temperate regions, the speed of decomposition is lower than the production of the nutrient substrate, which leads to its accumulation. The deep penetration of plant roots in these soils is explained by their low fertility. The soils in many regions coniferous trees suffer from an excessive accumulation of organic material. In winter, low temperatures limit the speed of decomposition. In summer, when the temperature is high, there is not enough water available for decomposition

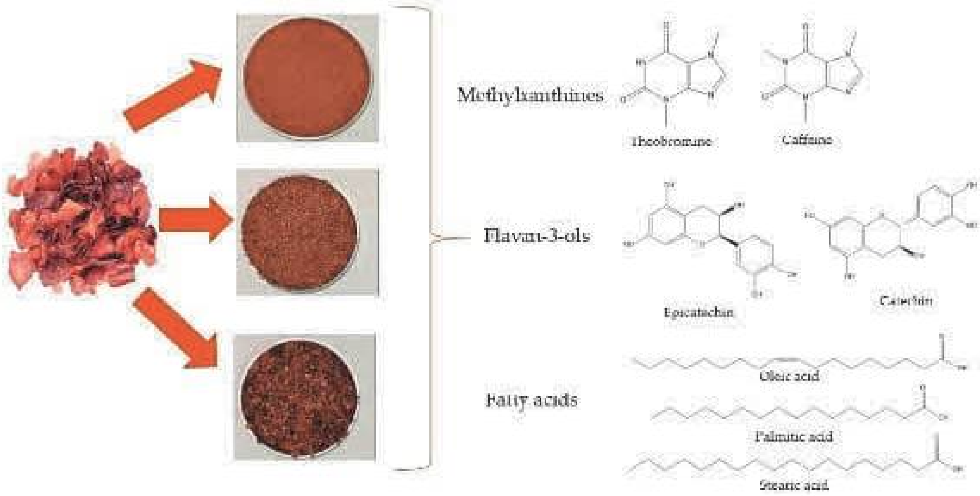
This short analysis of several types of soils opens the perspective of the various roles that microorganisms have in their formation .



Plants represent the major source of organic material on which microorganisms are dependent. Different types of microorganisms can be associated with the leaves, roots, stems or seeds of plants. Their presence directly influences the life cycle of the chains, by increasing the rate of release of organic material by roots. In the case of grass, the exudation of organic substances from the roots has a growth rate of 80% to 100%.

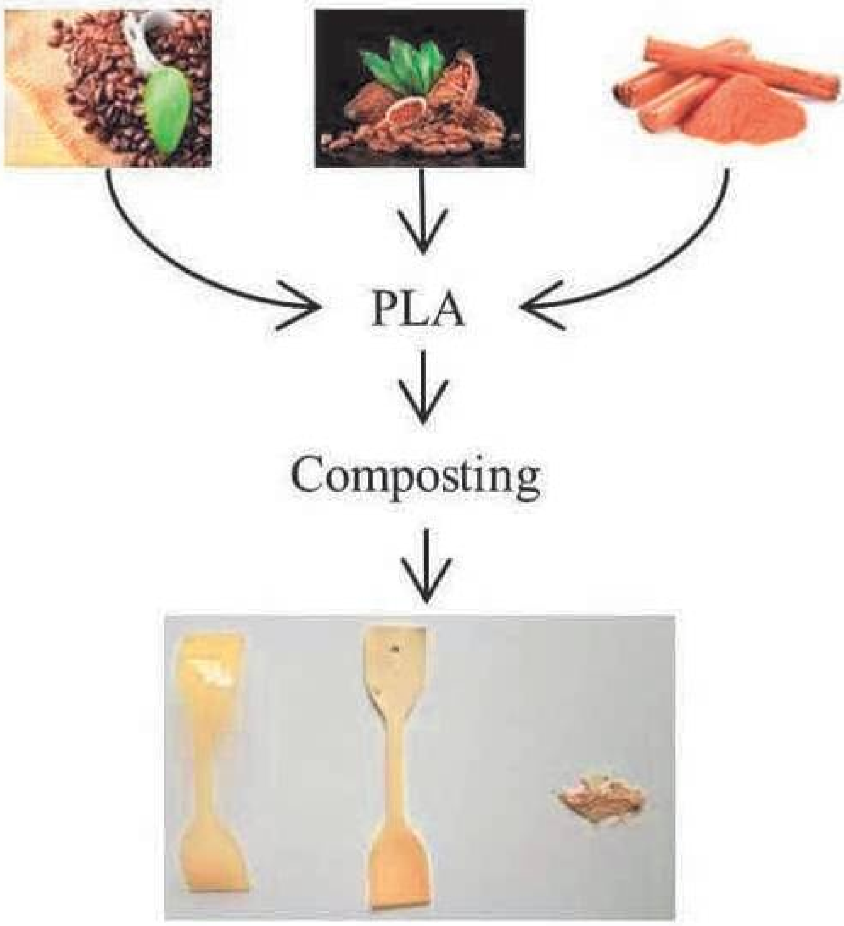
The materials from the roots represent a varied range of microbial substrates, inhibitors and stimulants


WASTEWELL
HOW COMPOSTING WORKS
PLANTS LIVE IN HEALTHY SOIL. FRUITS AND VEGGIES ABSORB THE NUTRIENTS FROM THE SOIL TO GROW.
WE EAT FRUITS AND VEGGIES FROM HEALTHY PLANTS. SOME NUTRIENTS REMAIN IN THE FOOD SCRAPS.
WORMS AND MICROORGANISMS BREAK DOWN THE FOOD SCRAPS INTO NUTRIENTS THE PLANTS CAN USE TO GROW.



Compounds removed by plant roots

Volatile compounds	Low molecular weight compounds	Compounds with high molecular mass
CO_2 ethanol, isobutanol, isoamyl alcohol, acetone, isobutyric acid, ethylene	Sugars, amino acids, vitamins, organic acids, nucleoids	Polysaccharides, enzymes


PLA
Composting

MICROBIOLOGY COMPOST LABORATORY

1. SAFETY INSTRUCTIONS

Wear a closed white coat with long sleeves.

It is strictly forbidden to drink, eat, smoke, chew gum, etc. during practical work or to leave the practical work room without a valid reason.

- Long hair tied up (flame, etc.) and short nails.

- Do not handle mobile phones during practical work.

- Do not wear any jewelry on your wrists and especially on your fingers.

- Be careful with alcohol + flame and other flammable products.

- Avoid contact of Gram reagents with the skin.

- Wash your hands thoroughly, brush your nails before and after handling, and before leaving the practical work room, even temporarily.

- Avoid opening windows and doors during handling.

- The student must avoid moving around during work, he/she must work seated, without sudden movements.

- Carefully open in the sterile zone of a Bunsen burner [a restricted space delimited by a radius of 10 cm around the flame of a Bunsen burner set to medium intensity (blue flame] the containers containing microbial cultures, in order to avoid any projection.

- The tubes or bottles are never held vertically but obliquely, their opening directed towards the flame.

- The pipettes, Pasteur pipettes or graduated pipettes must be held in an oblique position, their tips directed downwards.

- Generally speaking and for a right-handed manipulator, the right hand, which holds the platinum loop or the Pasteur pipette in the aseptic zone, must not move (elbow of the right hand on the bench). All necessary equipment: culture media tubes, dilution liquid tubes, sterile tubes or slides, must be carried from the left hand to the right hand .

- Flame, before and after handling, the platinum loop used for sampling, starting by heating the middle part of the instrument in order to dry out the culture remains before placing the end in the flame, this is to avoid any projection.

- Immediately notify the TP manager in the event of breakage of a container containing a culture, in the event of accidental contamination of a handler or any incident dispersing the microbial material.

- Sterilize all septic equipment at the end of the handling.

- Take all necessary measures to protect microbial strains and destroy them in order to avoid any contamination.

- Check with the teacher before leaving the room for water and gas taps.

2. STERILE HANDLING STATION ORGANIZATION

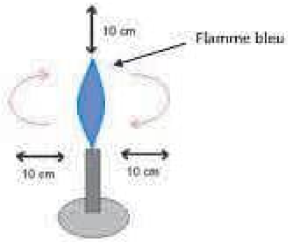
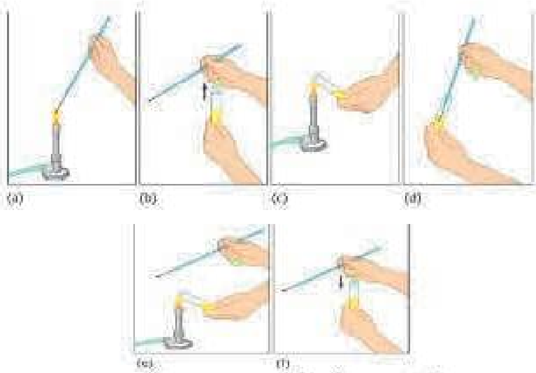


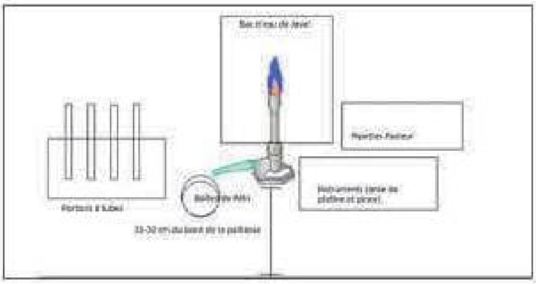
Fig. 1 : Rôles du bec bunsen.



How to grip the platinum loop and the bacterial suspension tube

The sterile handling station is organized as follows:

The Bunsen burner, which ensures the local sterility conditions essential for sterile handling, is placed in the center of the workstation 15 to 30 cm from the edge of the bench so that the manipulator is comfortable in handling it. To the right of the Bunsen burner are the instruments necessary for the work for a right-handed manipulator (Pasteur pipettes stored in a wide-mouth container, platinum handle and forceps arranged on a rack). The rest of the equipment is placed to the left of the Bunsen burner (the pathological product to be studied, the Petri dishes placed with the lid down, the sterile physiological water, etc.). Behind the Bunsen burner and slightly to the right, a plastic container filled with an antiseptic solution (bleach for example) in which the Pasteur pipettes used, the swabs and the single-use tubes will be placed. A left only has to reverse the positions (see Fig. 3).



Organization of the sterile handling station.

The work is done in a seated position, which requires that all the equipment be within reach. The student must have all the necessary equipment ready before starting the manipulation (all the equipment must be accessible without the student having to move or be helped by his colleagues). He must be able to manipulate without anything coming between him and the flame.

3. STUDY OF CULTURAL CHARACTERISTICS

The handout of bacterial systematics (see Dr. Boussena's course) gives for each bacterial species of veterinary interest studied, the characteristic aspects of its culture on culture media (liquid and especially solid). It is therefore imperative to know these details because they will serve as orientation indices for the choice of subsequent tests.

On liquid media, the presence of more or less significant turbidity, a deposit (bread crumb, slimy, etc.) or a veil will be noted.

On the other hand, on solid culture media, the following will be noted: the abundance of the culture and its appearance time, the characteristics of the isolated colonies and possibly, the presence of soluble pigments (Pseudomonas) or insoluble (Serratia).

The macroscopic examination of cultures is the first examination carried out from isolation after incubation. This study is based on naked eye and macroscopic observations to differentiate the characteristics of the strains studied (the appearance of colonies characteristic of each bacterial species is one of the first identification criteria).

It can only be described properly from well-isolated colonies: the colonies are all the smaller as they are close together.

- Macroscopic examination

Observing the macroscopic appearance of the colonies under the binocular microscope allows for an initial characterization, with possible orientation of the results during identification (facilitated examination under different lighting angles). The macroscopic identification elements are:

1- The shape of the colonies: round, irregular, etc.

Appearance of the outline: smooth, regular or irregular edges, serrated, jagged, sometimes even having extensions (jellyfish head).

Relief: rounded, semi-rounded, flat surface.

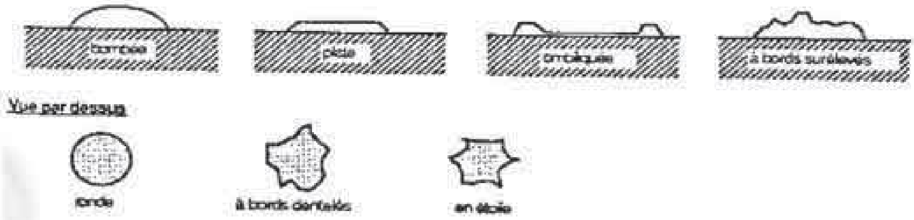
Center: sometimes raised, sometimes umbilicate (hollow).

2- The size of the colonies by measuring the diameter: punctiform or of measurable size. The size of a colony can only be assessed if it is sufficiently isolated (colonies packed tightly against each other do not reach their maximum size). However, it should not be forgotten that some bacteria produce colonies that spread as they age. Consequently, colonies are only comparable in size in areas of the culture medium with identical culture density.

3- The color of the colony and the opacity (opaque, translucent or transparent...). The transparency of the colonies must be assessed in natural and artificial light. Some colonies produce pigments which represent a valuable element of identification (e.g. golden yellow colonies for Staphylococcus aureus).

4- The appearance: smooth colony (S for smooth), rough (R for rough) or mucous (M).

5- The odor released by the entire culture.



6- The adhesion assessed by scraping using the platinum loop.

Colony shapes.

4. Study of morphological characteristics (microscopic appearance)

- Fresh state

This test determines the shape, arrangement and especially the mobility of bacteria. It consists of observing a drop of bacterial suspension, prepared with physiological water and placed between a slide and a coverslip. The observation is done under an optical microscope.

- Procedure

-Place a drop of a bacterial suspension (from 1 to 10 colonies placed in 5 ml of physiological water) on a glass slide

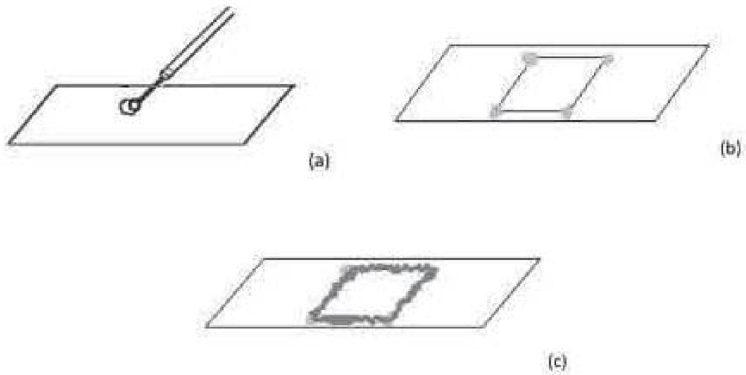
-Cover the drop with a coverslip (the suspension must not overflow the contours of the coverslip)

-Fix the coverslip with 4 beads of melted paraffin.

-Seal the slide with melted paraffin.

- Observe immediately under a microscope (x40 objective, condenser not raised to the maximum, diaphragm not completely open).

- After observation, immediately throw the slide into a jar containing bleach.



Stages of the fresh state

Observation under the microscope

It is done in white light, direct illumination of the preparation. Condenser lowered if the microscope allows it. Diaphragm closed (minimal light). Objective x 40 dry (without oil). For focusing, the objective is approximately 1 mm above the coverslip.

Observe the microbial communities in your compost over the course of several weeks or months as the compost heats up and then later returns to ambient temperature. Can you identify differences in microbial communities at various stages of the composting process?

Materials

- compound microscope

- 85% NaCl (physiological saline)
- methylene blue stain (Prepare stain by adding 1.6 g methylene blue chloride to 100 ml of 95% ethanol, then mixing 30 ml of this solution with 100 ml of 0.01% aqueous solution of KOH)

Procedure

1. Make a wet mount by putting a drop of water or physiological saline on a microscope slide and transfering a small amount of compost to the drop.

   Make sure not to add too much compost or you will not have enough light to observe the organisms.

2. Stir the compost into the water or saline (the preparation should be watery) and apply a cover slip.
3. Observe under low and high power. You should be able to find many nematodes (they should be very wiggly), flatworms, rotifers (notice the rotary motion of cilia at the anterior end of the rotifer and the contracting motion of the body), mites, springtails and fast-moving protozoans. Pieces of fungi mycelia can be seen, but might be difficult to recognize. Bacteria can be seen as very tiny, roundish particles, which seem to be vibrating in the background.
4. If you want to observe the bacteria directly, you can prepare a stained slide and observe the slide using a 100X oil immersion lens. To prepare a stained slide, mix a small amount of compost with a drop of physiological saline on a slide. Spread with a toothpick. Let the mixture air dry until you see a white dried film on the slide. Next fix the bacteria to the slide by passing the slide through a hot flame a few times. Stain the slide using methylene blue stain. Flood the slide with the methylene blue stain for one minute and then rinse with distilled water and gently blot dry using blotting or filter paper.
5. Fungi and actinomycetes may be difficult to recognize with the above technique because the entire organism (including the mycelium, reproductive bodies and cells) will probably not remain together. Fungi and actinomycetes will be observed best if you can find fungal growth on the surface of the compost heap. The growth looks fuzzy, powdery, or like a spiderweb. Lift some compost with the sample on top, and and prepare a slide with cover slip to view under the microscope. You should be able to see the fungi well under 100X and 400X. The actinomycetes can be heat-fixed and gram-stained to view under oil immersion at 1000X.
6. To separate nematodes, rotifers, and protozoans, a continuous column of water leading from the compost to the collection vial is necessary, and the following adaptation of the above method should be used: The compost is put into a beaker with the screen stretched across the top and taped in place. The beaker is then turned over into the funnel. Plastic tubing is placed at the end of the funnel stem and a screw clamp is placed a few inches below the end of the funnel stem on the pastic tubing.

   The plastic tubing should lead into a collection vial or small beaker. The clamp is closed and water is poured into the funnel until the beaker is about 1/2 filled. After a few days the clamp is slightly and slowly opened and organisms

Source:Natural Resources Microbiology Textbook, Elena Crocnan, Daniel Ovidiu Crocnan, 10th grade

https://biologyreader.com/soil

Immersive Reader (https_biologyreader.com)

soil microflora - Search Images (bing.com)

Diagram Composting Cycle (windows.net) .How Does Composting Work? – WasteWell

https://docs.google.com/document/d/1oa1sxRo354G26ioNbtojloCjo7 MFfjoIO9H60OIlUGg/edit?usp=drivesdk

Lesson 7

Duration : 2 Hours

Lesson Objectives :Upon completion of this course, students will be able to identify compost and its sources

Activities

Starter Activities

Ask students what compost

Define compost and its sources to students.

Compost :

We consume a lot of food every day in our house and we actually throw away a lot of garbage.İs it possibble to recycde these wastes in a way that is beneficial to nature ? Yes , we can make waste useful to nature by obtaining compost with our kitchen waste . So what is compost? The naturel fertilizer that emerges as a result of the accumulation of all kinds of organic wastes by providing suitable conditons is called compost .Wastes by providing suitable conditions is called compost .Wastes from our tea ,egghells,parts of our vegetables and fruits that we do not use,or vegetables and fruits that rot because they have been waiting in the fridge for a long time ,bread and even coffee residues can turn into a very functional and natural fertilizer when they are brought together under appropriate conditions

Compost types

1-Cold compost :in this application garden waste and kitchen waste are combined and collcted in a trash can .the mixture is left for a while ,taking care tol et it breathe .After the decay process is completed ,the fertilizer is ready.

2-Hot compost is very similar to cold compost in application.The only factor in between is the temperature.It is preferable to apply this variety in hot weather .,thanks to this, the decay process is accelerated.Hot compost uses fourmainelements;carbon,nitrogen ,air and water ,If the weather is warm enough, your compost will be ready in less than 1 month .İt is possible to create your own natural fertilizer in a trash can that you can position at home or outside

What to composted?

You can compost anything that comes from the soil at home .although animal products can be processed in municipal waste facilities ,you should avoid this products in home composting .Substances that you can comopst ;cardboard and paper in small pieces ,coffe pulp and filter ,egghells,wood ash ,vegetables and fruits ,mowed grass residues ,hair and feathers ,hay and straw ,houseplants ,shells of nuts ,sawdust,tea pulp,splinters

Substances such as walnut tree leaves,coal ash,milk and dairy product,diseased plants ,all kinds of ails ,meat or fish bones and residues ,cooked food ,plastic


Pre-Task :

Divide the students into 4 groups. Students will be asked to calculate the domestic vegetable and fruit waste to be produced across the country according to the amount of domestic vegetable and fruit waste they collect weekly and to research and compare real data.

Presentations:

Ask your groups to prepare a presentation on howdomestic vegetable and fruit waste is managed in your country.

Discussion :

Students should present their presentations to the class and state their own solution suggestions regarding domestic vegetable end fruit waste

WHY COMPOST?

Using animal manure insteadof chemical fertilizers and using plant wastes to increase the amount of organic matter are the most important measures to increase the fertility of te soil.

Compost is a humus -like product formed by the degradation of organic wastes by micro-organisms in an aerobic environment.The resulting product is in terms of organic matter and minerals according to the type of waste used differ.Environmental problems causedby chemical fertilizers can be prevented by composting domestic organic wastes,vegetable wastes and composting.

How do chemical fertilizers affect the environment and human life ?

Duration : 2 Hours

Lesson Objectives :

Upon completion of this course,students will have knowledge about the environmental damage caused by chemical fertilizers .They will be aware of the harms of chemical fertilizers to human health.

Activities

Starter Activities :

Ask them to find news about the harm that chemical fertilizers can cause to the environment and human health and bring them to the class.

Explain its effects on the environment and human health.

How Chemical Fertilizers Affects the Environment and Human Life :

Chemical fertilizers has continuously ranked among the top pollutants in the world, especially in bodies of soil .

İn Turkiye ,the total agricultural area decreased from 26,3 million hectares in 2001 to 23,9 million hectares in 2015.However ,while agricultural areas are decreasing ,the amount of chemical fertilizers consumed is increasing .Total fertilizer consumption increased from 5,1 million tons in 2007 to 5,9 million tons in 2016 with an increase of %16. In other words ,the fertilizer used per hectare has increased by %19 and as aresult, the soil has become inefficent .The use of chemical fertilizers in agricultural soils leads to the emission of significant pollutants into the environment.These pollutants cause an increase in salinity in the soil ,heavy metal accumulation ,and eutrophication in water .in addition ,according to the substance in the fertilizer structure,greenhouse gases are released into the atmosphere.The most importanat of these are nitrous oxides,which are 300 times more effective than carbon dioxide .

Group Work :

Divide the students into 4 groups. Ask them to prepare a poster on the harms of Chemical fertilizer to the environment and human health.

Discussion:

Students will show their posters in class and discuss the precautions that can be taken against the harms of chemical fertilizer.

Compost

Duration : 4 Hours

Lesson Objectives : Students can explain the types of compost and their differences

Actives: 1 Indentify the compost .Ask them to research the diffeence between hot and cold compost and how it is made and what are the materials that should not be put in the compost
Research :

Ask the students to researchwhat was done in ancient times to increase the fertility of the soil ,what methods were applied.

Actives 2 what are the alternative methods to chemical fertilizer?They are asked to investigate

WHAT İS COMPOSTİNG ?

Compost is an organic fertilizer and soil improver obtained as a result of decomposing or grinding animal and vegetable wastes.Composting is the process of converting biocheemically degradable organic matter into products that have been stabilized and mineralized by microorganisms,especially bacteria and fungi ,break down and decompose organic substances by biochemical means using the oxygen in the environment .

Certain conditions are required fort he composting process.It is important that the water content is between %45-60 for microorganisms to operate .This level of humidityprovides a favorabale environment for microorganisms to operate.This level of humidityprovidesa favorable environmentfor microorganisms to carry out their metabolic processes

The composting process usually takes place in two main stage is the breakdown of organic matter by microorganisms in aerobic conditions, that is in an environment where oxygen is present.At this stage ,the temperature increases,the internal temperature of the rotting materialcan reach up to 55-65°C.This temperatureof helps to kill harmful microorganisms and disinfect the compost.

WHAT ARE COMPOST WASTES

The general rule of thumb when defining usable waste when composting is that anything that was once alive is compostable .However,there are some exceptions.Basically,two types of materials are used when composting ,green and brown ,Green materials include fresh and wet waste and include waste such as green leafy vegetable ,herbs ,fruits,tea pulps ,eggshells and coffee grounds.Brown materials such as pieces of trees and branches ,dried leaves ,herbs ,pieces of paper,and nut shells.

The second stage continues for a longer period of time ,when the tempetature drops and more microorganisms come into play. This stage is when the compost matures and becomes stable.Eventually,the organic waste becomes compost and becomes a nutritious material for plants ,enriching the soil ,composting is an effective method for sustainable waste management and organic material recycling.

Howeverthere are alsosome materials that shouldnot be used when composting.Fruits in the citrus group are not preferred becaouse they can create every acidic environment .Too oily wastes and materials that are too large to dissolve in the soil are also not used in composting .Meat and dairy products are not suitable fort he cold compost method because this method cannot completely eliminate pathogens that may occur during the decomposition of meat and dairy products, which can put human health at risk .Therefore, it is important to maintain a proper balance with carefully selected materials when compsting.

COMPOST MAKING APPLİCATİON PROCESS

You will do it in a bucket ,ıt doesn'thappen in the house because it makes smells and bugs.It is imperative that you do this work in the garden or on the balcony .My recipe ripens in a short time .Not compost , which is an organic fertilizer,but a special mixtureof good quality peat is a substitute for ornamental plant soils.It has good nutritiousness.Once ready for use ,it is not necessary to add fertilizer.

1 

Pratical Compost

Stage 1,Preliminary preparation

At the bottom of the bucket, two fingers high soil is spread from the old soilin your pots.

What substances? There are 3 basic groups.

Which substances are put for what ?in summary ,it is as follws:

1- Wet substances ar efor Nitrogen ,potassium,phosphorus and various minerals .

-Green fresh leaves;Grass,grass,mowed grass that you will collect from the roadsides,

-Used tea pulp ,coffee grounds,filter coffee pulp,

-All kinds of vegetable scraps,apple peels,banana peels,peeled potatoes.

2- Dry materials ar efor the similarity to the soil ,fort he healthy content,fort he fibers to keep the soil airy,for carbon

-Various dry tree leaves, dried branches,and outer bark of died trees.İn autumn ,especially the fallen leaves of quince trees form a very high quality compost.Add plenty of this if you find it.

-Undyed cardboards, cardboards.

-The drying leaves of your plants ,every partof them that deteriorates and dries up.

-Hazelnut shells,peanut Shell ,shells,chestnut shells,damask nut shells if unsalted. (put crumbled)

-Small trimmings and powders of charcoal and lignite coal.

What substances should we avoid?

You should not put citrus peels such as lemons,oranges ,etc., in such samll-diameter compost.You should not put too much of fruits such as pears and peaches .Otherwise ,the acidity rises to a toxic level ,And don't add anything that others have recommended in this regard (various animal droppings,rancid fruits ,hair ,feathers,etc.)Because my recipe is a very special compost .Others are more organic fertilizer -style compost,

Their formation takes a very long time .You should shared the ingredients as much as possibble before adding them .Thin leaves ,fresh fruit peels,as well as thick leaves,cabbagestalks and dry branches should be cut into small pieces aand thrown into the bucket .So are their cartons.

Humidity/Wetness

The mixture should never be dry.It should not be so wet that it is soaking wet.Disrupt the accumulation once every ten days .İf it is too dry ,it should be soakedby sprinklig water .They rot from the inside ,begin to turn into soil .Excessive wetness is not good .Watering occurs ,it smells very ugly,it leads to a discharge of fragrant water from the bottom

It should be turned upside down every 10-15 days .Once the compost accumulation is complete ,it is no longer needed.İt isleft to wait.

What if the compost is insectivorous , wormed? Much better .İt indicates that things are going well.It accelerates the formation of compost.

Workshop:Compost will be made from household waste.

Pre-task :

As a first step ,students will provide a bcket with a large lid and drill holes in the bottom of this bucket to make it suitable for compost formation ,and a suitable room in our school will be allocated for composting.İn the second step ,students will collect and bring fruit and vegetable wastes that can be used in composting at home in their homes .These wastes should include organic materials such as fruit and vegetable peels ,eggshells, leaves

In the third step ,while applying this method,students will fillthe container with green and brown coloredmaterialsinaqual amounts.As the bucket used is full,they will continue to add the appropriate organic wastes (uncooked fruit and vegetable wastes,eggshells, etc) that they continue to accumulate at home .However,each time the added ingredients will be covered with dry sheets.Once a week ,the mixture in the bucket will be stirred and watered from time to time and moist .After each derssing ,it will be covered and it will be ensured that it is at the appropriate temperature.

Pre-task:

As a fist step ,students will provide a bucket with a large lid and drill holes i the bottom of this bucket to make it suitable for compost formation , and a suitable room in our school will be allocated for composting . In the second step ,students will collet and bring fruit and vagetable peels,eggshells, leaves.

İn the third step ,while applying this method,students will fill the container with green and brown colored materials in aqual amounts.As the bucket used is full, they will continue to add the appropriate organic wastes (uncooked fruit and vegetable wastes,eggshells,etc) that day continue to accumulate at home However ,each time the added ingredientswill be covered with dry sheets.Once a week ,the mixture in the bucket will be stirred and watered from time to time and moist.After each dressing,it will be ensured that it isi ar the appropriate temperature

Duration : 2 Hours

Lesson Objectives :

Upon completion of this lesson students will

- *Define Chemical fertilizers*
- *Know the most common harmful chemicals found in chemical fertilizers*
- *Explain the negative effects of chemical fertilizers on the environment and human health with examples.*

Activities

Research and Presentation :

Ask students to research the events about the harms of chemical fertilizers on human health and the environment and to prepare a presentation on the harms of chemical fertilizers by providing examples from these news.

Chemical Fertilizers :It is a fertilizer containing synthetic chemical usedto provide minerals that are missing in the structure of the soil .The main raw materials of a chemical fertiizer are natural gas ,phosphate rock and potash salt .The fertilizer formed as a result of the addition of compounds such as ammonia ,nitric acid,urea ,sulfuric acid,phosphoric acid and ammonium sulfate as additional inputs to these main substances caan be used in solid or liquid form.

Types of compost;

Nitrogen Fertilizers:Contains nitrogen ,which is importantfor the production of protein and chlorophyll by plants.Nitrogen fertilizers especially stimulate the development of foliage and leaves.

Phosphorus Fertilizer:Contains phosphorus, which is necessary for energy transfer ,cell division and root development of plants .

Potassium Fertilizers:Contain potasium to regulate the water balance of plants,increase their owerall groth.

Harms of chemical fertilizer use to the environment and human health

Chemical fertilizers are used as an indispensable part of modern agriculture.However,the potential effects of these fertilizers on human health should not be underestimated.The negative effects of chemical fertilizers on human health have been examined by researchers and various conclusions have been reached.

Some studies show that with the consumption of chemical fertilizers,the risk of some types of cancer increases.

Pesticides are chemical used to Project agricultural products.However ,these pesticides can cause serious harm to human health. In particular, the presence of pesticide residues in vegetable and fruits can adversely affect consumer health.

The harms of pesticides to human health include cancer ,reproducetive problems,hormonal disordes, nervous system disordes and immune system problems.Therefore ,it is important tos tay away from foods with high leves of pesticide residues and to prefer organic agricultural products

Comparison f compost fertilizer and chemical fertilizer.

Lesson Objectives :

What are the Differences Between chemical Fertilizer and Organic Fertilizer?

Features/ Fertilizer Type	Chemical Fertilizer	Organic Fertilizer
Example	Nitrogen,phosphorus and etc	Organic matter,microorganism so on.

Advantage	Chemical fertilizers are equally rich in the three esential nutrients (Nṣtrogen ,phosphate,potassium)necessary for crops anda re alwayss ready to provide immediate nutrients to plants if the situation demands it	It adds natural nutrients to the soil,increases the organic mattero the soil structure and slope,increases water holding capacity,reduces erosion from win and water ,Ensuresthe slow and consistent release of nutrients.
Disadvantages	Some chemical fertilizers have a high acid content.They have the ability to burn the skin .Its long term use reduces soil fertility..	Capable of slow release;Inorganic fertilizers ,the distribution of nutrients is uneven ,which in the long run enriches the structure of the soil.

COMPOST APPLİCATİON STUDY:

With the compost prepared by the students and the studentsa section of soil compost will be enriched in the garden of our school and plant palnting work and will have the opportunity to observe the growth stage of the seedlings and the benefit of the compost.Thus ,they will have the chance to learn and experience by making and experiencing the benefit of the product (compost)they have obtained.

MEASUREMENT AND EVALUATİON :

A- Fill in the blank spaces in the following sentences with appropriate words.

1- The naturel fertilizer that emerges as a result of the accumulation of all kinds of organic wastes by providing suitable conditons is called ……………..called.

2-Wastes that should not be put in compost;…………………,………………………,…………………,…………………..

3-Foods that can be put in compost in compost making;……,………,………,………………,………,………..,

B-Discuss the following discussion questions with your classmates.

1- What kind of effecet will the widespread use of compost have on the environment and the country's economy?

MEASUREMENT AND EVALUATİON ANSWER KEY:

A -1 compost

2- milk and dairy product,diseased plants ,all kinds of ails ,meat or fish bones and residues,cooked food,plastic.

3- Fruit and vegetable wastes,eggshells,tea and coffee wastes.