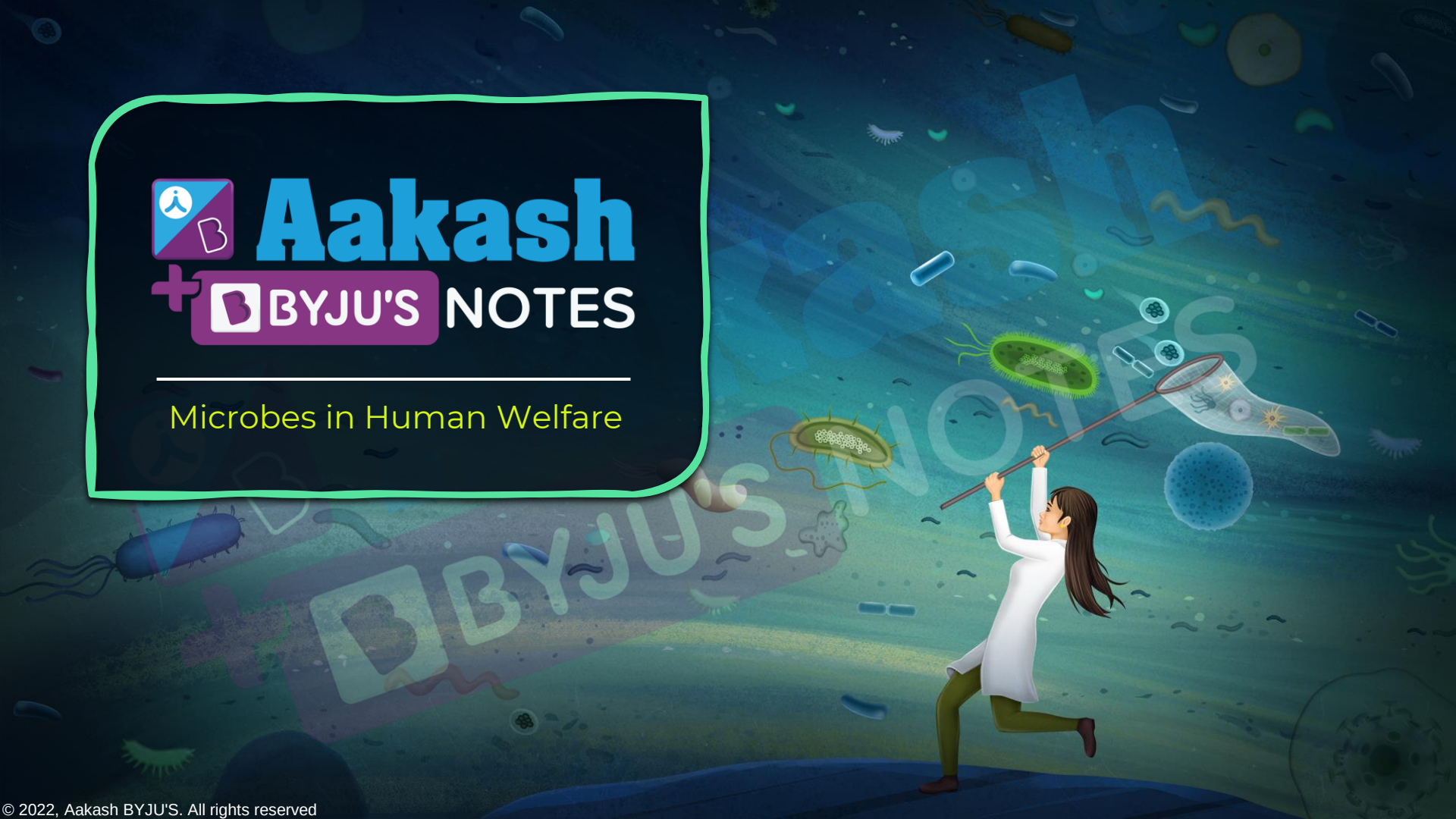
Aakash + BYJU'S NOTES

Microbes in Human Welfare



Key Takeaways

1. **Microbes in household products**
   - Curd
   - Cheese
   - Bread
   - Idli & dosa
   - Toddy
2. **Microbes in industrial products**
   - Fermented beverages
   - Antibiotics
   - Chemicals
   - Enzymes
   - Bioactive molecules

Microbes in sewage treatment

3

Primary treatment

Secondary treatment

4

Microbes in production of biogas

Microbes in farming

5

Biocontrol agents

Biofertilisers

Summary

Microbes

- **Microbes** are **tiny living organisms** that cannot be seen with the naked eye.
- These microbes are **present not only in the human body,** but all around like **in soil, water and air.**
- Some are found in the **most extreme habitats like soil buried below many layers of snow.**
- Some are also found near the **deep-sea hydrothermal vents with temperatures reaching up to 100°C.**
- One can observe them with the help of a microscope. Hence, they are named microorganisms/microbes as they need to be **magnified** over many folds/times **to become visible**.

Microbes

Magnified 1000 X

Bacteria

Magnified 1000 X

Fungi

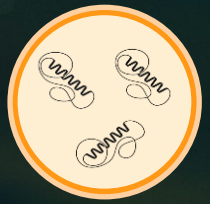
Magnified 1000 X

Protozoa

Magnified 100,000 X

Virus

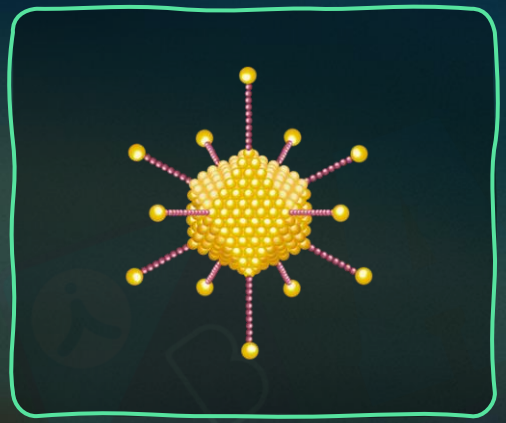
Magnified 100,000 X



Prions

Microbes

Adenovirus



TMV

Bacteriophage

Magnified by 1,00,000-1,50,000X

- Examples of viruses include adenovirus, Tobacco Mosaic Virus (TMV) and bacteriophage.

Microbes in Household Products

Curd

- Curd is a fermented product obtained with the help of *Lactobacillus* bacteria which converts milk to curd.
- **Lactic acid bacteria (LAB)** – include
  - *Lactobacillus lactis*
  - *Lactococcus lactis*
  - *Lactobacillus bulgaricus* etc.
- LAB produce acids that coagulate and partially digest the milk proteins
- Starter culture consists of millions of LAB which multiply to produce curd at suitable temperatures.
- In **anaerobic condition,** LAB carry out **lactic acid fermentation for energy production.**

Lactobacillus bacteria

Microbes in Household Products

Advantages of curd

- Enhanced nutritional value - Vitamin B12
- Easy to digest
- Probiotic – Gut health improves
- Safe to consume for lactose intolerant people
- Enhances texture and flavor

Microbes in Household Products

Cheese

- Cheese, is one of the **oldest** food items in which microbes are used.
- It is a partially degraded concentrate of milk, fat & protein.
- Different varieties of cheese are known by their characteristic **texture, flavour and taste** and the specificity coming from the microbes used.

Some types of cheese

Swiss cheese	Roquefort cheese	Camembert cheese
Large-holed cheese ripened by Propionibacterium shermanii	Ripened by *Penicillium roqueforti*	Ripened by *Penicillium camemberti*

Microbes in Household Products

Bread

- Prepared from dough fermented using **Baker's yeast**
- Dough appears puffed up due to **production of CO_2**
- CO2 and ethyl alcohol evaporate on baking, leaving the bread **porous and soft**

Idli & dosa

- Fermented preparation of **rice** and **black gram**
- Prepared using *Leuconostoc* and *Streptococcus*

Toddy

- Traditional drink of some parts of South India
- Made from fermented sap of palm known as *Caryota urens*
- Fermented by naturally occurring yeast

Microbes in Industrial Products

- In industry, **microbes** are used to **synthesise** many **products** valuable to **human beings.**
- For production on an **industrial scale,** fermentors are required.
- A large number of **microbes** can be **grown in a fermentor.**
- Many fermentors **combine** to form a **fermentation plant.**

Fermentors

Fermentation plant

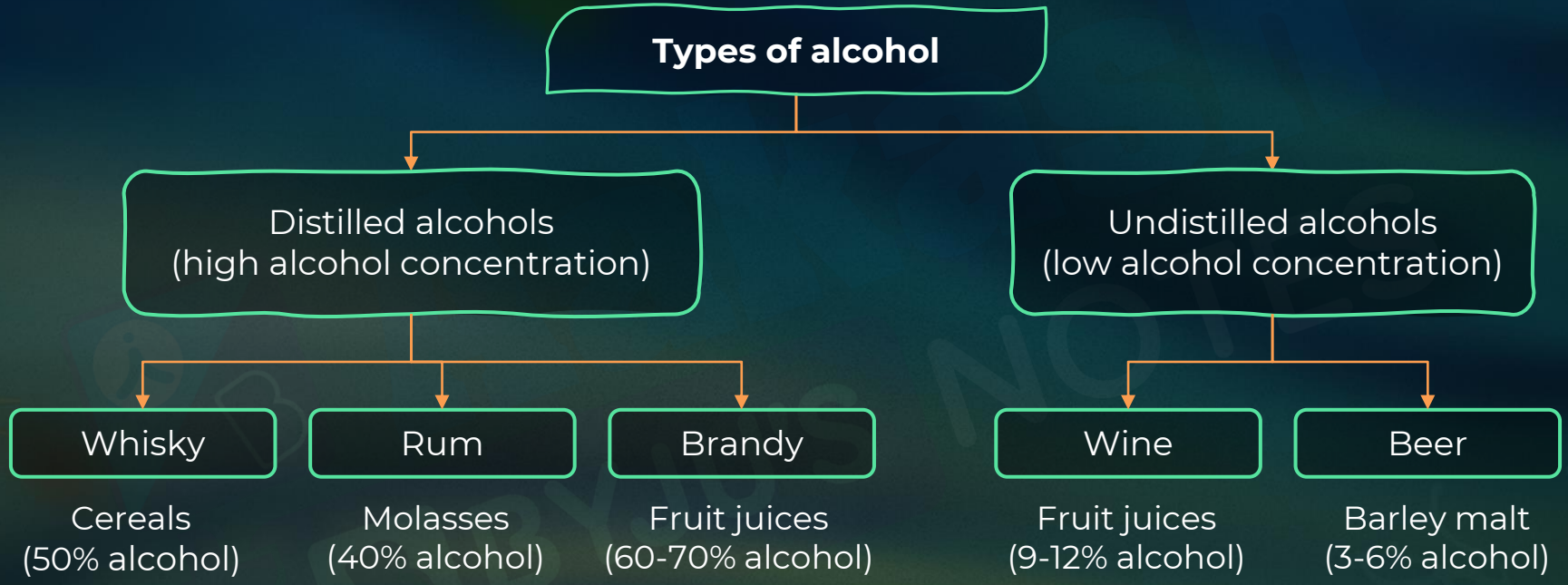
Microbes in Industrial Products

Microbes are used in manufacturing of several industrial products

- Fermented beverages
- Antibiotics
- Chemicals
- Enzymes
- Bioactive molecules

- Produced by alcoholic fermentation of organic substrates
- Mostly yeast species are used
- Most commonly used yeast is *Saccharomyces cerevisiae*
  - Also called Brewer's yeast
- Other yeast used include
  - *S. ellipsoideus* - wine yeast
  - *S. pireformis* - ginger beer/Ale yeast

Microbes in Industrial Products



Microbes in Industrial Products

Antibiotics

Chemical substances, which are produced by some **microbes** and can kill or inhibit the growth of other (disease-causing) microbes.

Anti **against**

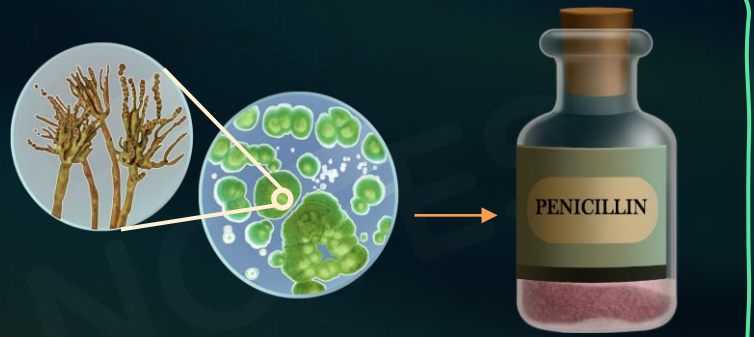
Bio **life**

- Anti is a Greek word that means **'against'.**
- Bio means **'life',** together they mean 'against life' (in the context of disease causing **organisms**).
- Whereas, with reference to **human beings,** they are **'pro-life'** and **not against.**

Microbes in Industrial Products

Antibiotics

- **Antibiotics** are the **medications** that can kill bacteria.
- Antibiotics were discovered by **Alexander Fleming.**
- **Alexander Fleming** observed a mould growing on one of his **unwashed** culture plates around which *Staphylococci* could not grow.
- He found out that it was due to a chemical produced by the mould.
- He named it **penicillin** after the mould *Penicillium notatum***.**



Microbes in Industrial Products

Antibiotics

- **Ernst Chain and Howard Florey** found the full potential of **penicillin** as an **effective antibiotic.**
- This **antibiotic** was extensively used to treat **American soldiers** wounded in World War II.
- **Fleming, Chain and Florey** were **awarded** the **Nobel Prize** in **1945**, for this **discovery.**

Some other antibiotics and their source

Cephalosporium acremonium

↓

Cephalosporin

Bacillus subtilis

↓

Bacitracin

Streptomyces griseus

↓

Streptomycin

Micromonospora purpurea

↓

Gentamicin

Microbes in Industrial Products

Antibiotics

Antibiotics have greatly **improved** our **capacity** to treat **deadly diseases.**

- Plague
- Whooping cough (kali khansi)
- Diphtheria (gal ghotu)
- Leprosy (kusht rog)

Microbes in Industrial Products

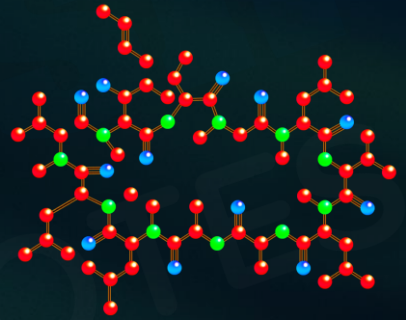
Chemicals, Enzymes and Bioactive molecules

Chemicals

- Any **material** with a **definite chemical composition**

Enzymes

- **Substances** which act as **biological catalysts**



Bioactive molecules

- **Molecules** which are functional in living systems or can interact with their components

Microbes in Industrial Products

Organic acids

Microbes	Product	Usage
(a) *Aspergillus niger (fungus)*	Citric acid	Employed in dyeing, inks, medicines, flavouring and preservation of food
(b) *Acetobacter aceti (bacterium)*	Acetic acid	Used in preparation of vinegar
(c) *Clostridium butylicum (bacterium)*	Butyric acid	Used for making rancid butter
(d) *Lactobacillus (bacterium)*	Lactic acid	Curd
(e) *Aspergillus niger, Penicillium (fungi)*	Gluconic acid	Used to produce calcium gluconate which is used in treating calcium deficiency

Microbes in Industrial Products

Enzymes

Lipases

- Used in **detergent** formulations
- Helpful in **removing oily stains** from laundry
- Obtained from: *Candida lipolytica, Geotrichum candidum*

Pectinases & proteases

- Help in clarifying fruit juice
- Pectinases obtained from:
  - *Aspergillus niger,*
  - *Byssochlamys fulva*
- Proteases obtained from - *Aspergillus* and *Bacillus* sp. and *Mortierella renispora*

Streptokinase

- Used in **clot buster**
- Helps in removing clot from blood vessels of patients who have undergone myocardial infarction
- Obtained from: *Streptococcus*

Amylase

- Degrades starch
- Obtained from:
  - *Rhizopus, Aspergillus* and *Bacillus* sp.

Microbes in Industrial Products

Bioactive molecules

Cyclosporin A

- Used as an **immunosuppressive agent** in organ transplant patients
- Produced by - *Trichoderma polysperma*

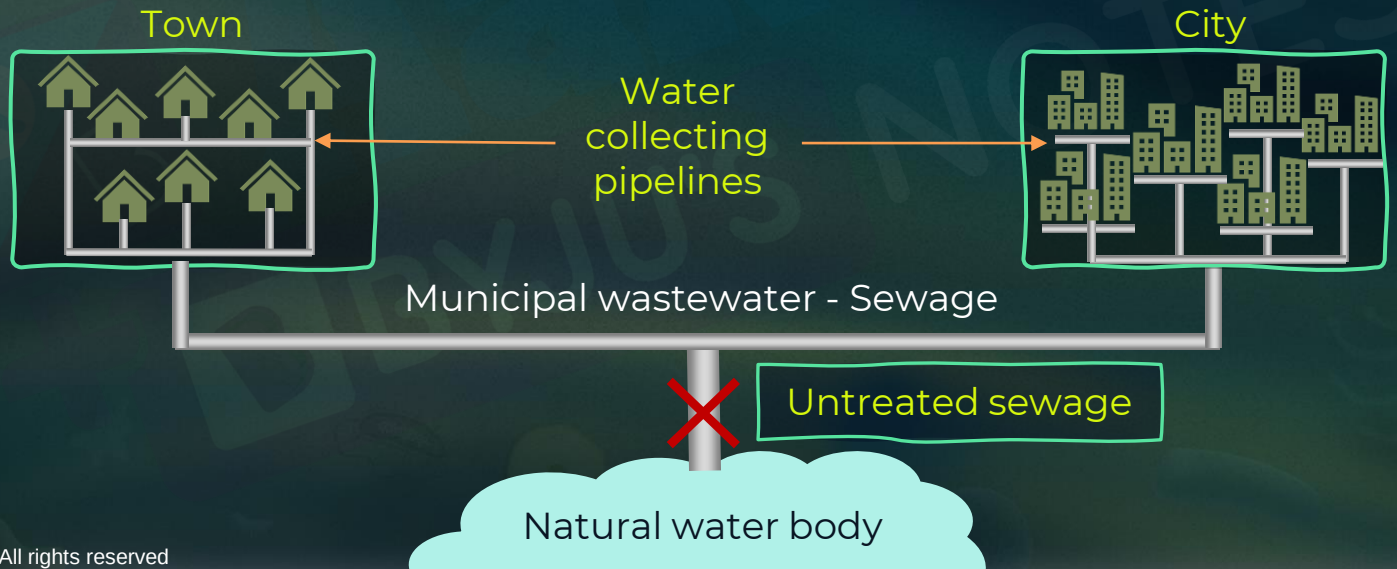
Statins

- Used as **blood-cholesterol lowering agents**
- Acts by competitively inhibiting enzyme responsible for synthesis of cholesterol
- Statins resemble mevalonate
  - Competitive inhibitor of β-hydroxy β-methylglutaryl CoA reductase or HMG CoA reductase
- Produced by - *Monascus purpureus*

Microbes in Sewage Treatment

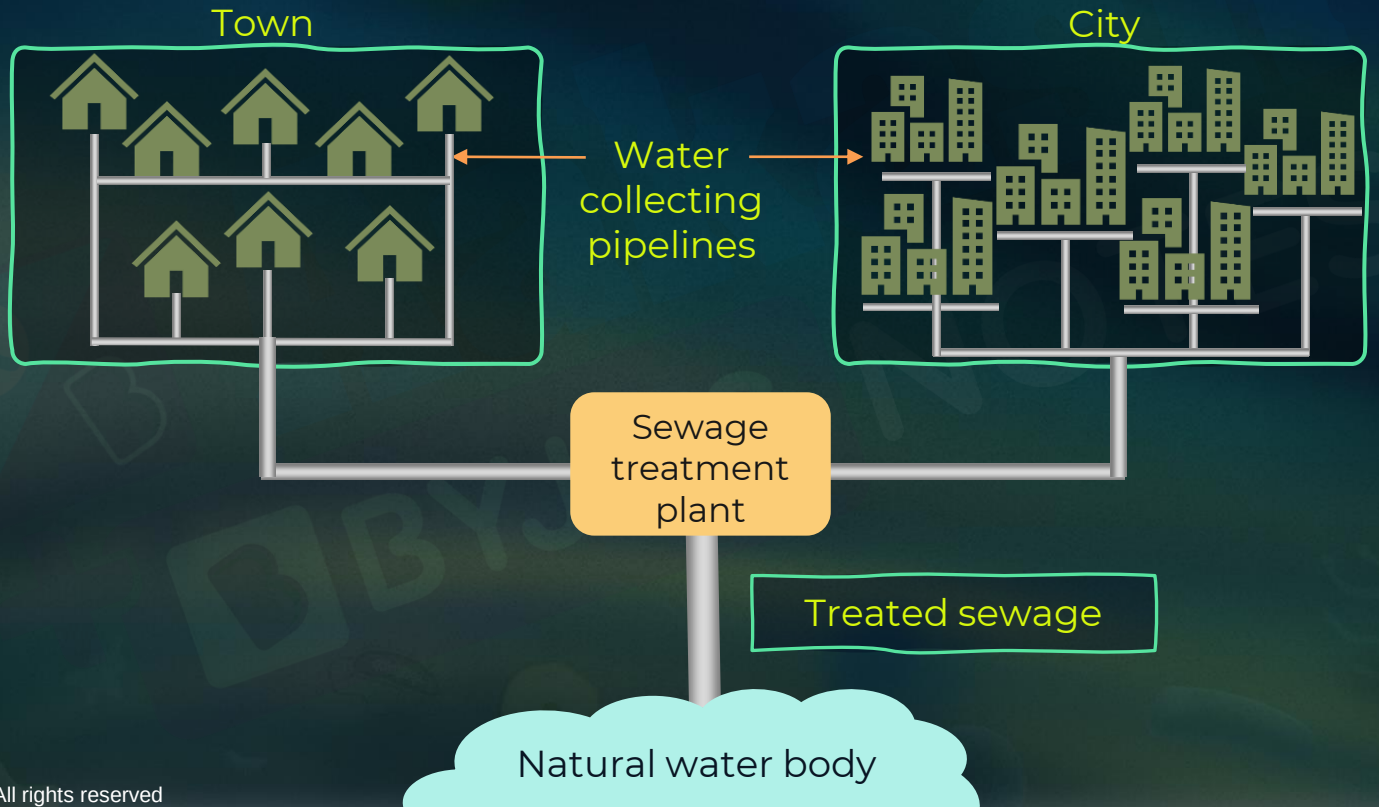
- **Untreated sewage** if discharged in water body pollutes the water body.
- As a result:
  - Aquatic animals start **dying**
  - **Water** becomes **unfit** for use
  - **Water-borne diseases spread**

Thus, sewage must not be discarded into the natural water bodies directly.



Microbes in Sewage Treatment

Sewage needs to be treated in a **sewage treatment plant** before releasing into water body.



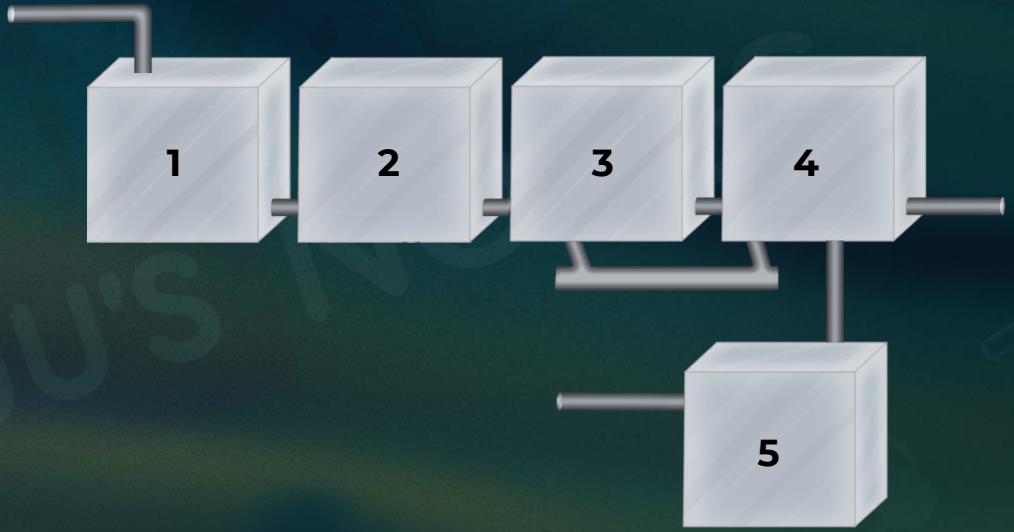
Microbes in Sewage Treatment

Sewage treatment plant

Sewage treatment plant can be defined as a **plant having multiple chambers dedicated to treat sewage, using heterotrophic microbes.**

The process of sewage treatment is divided into:

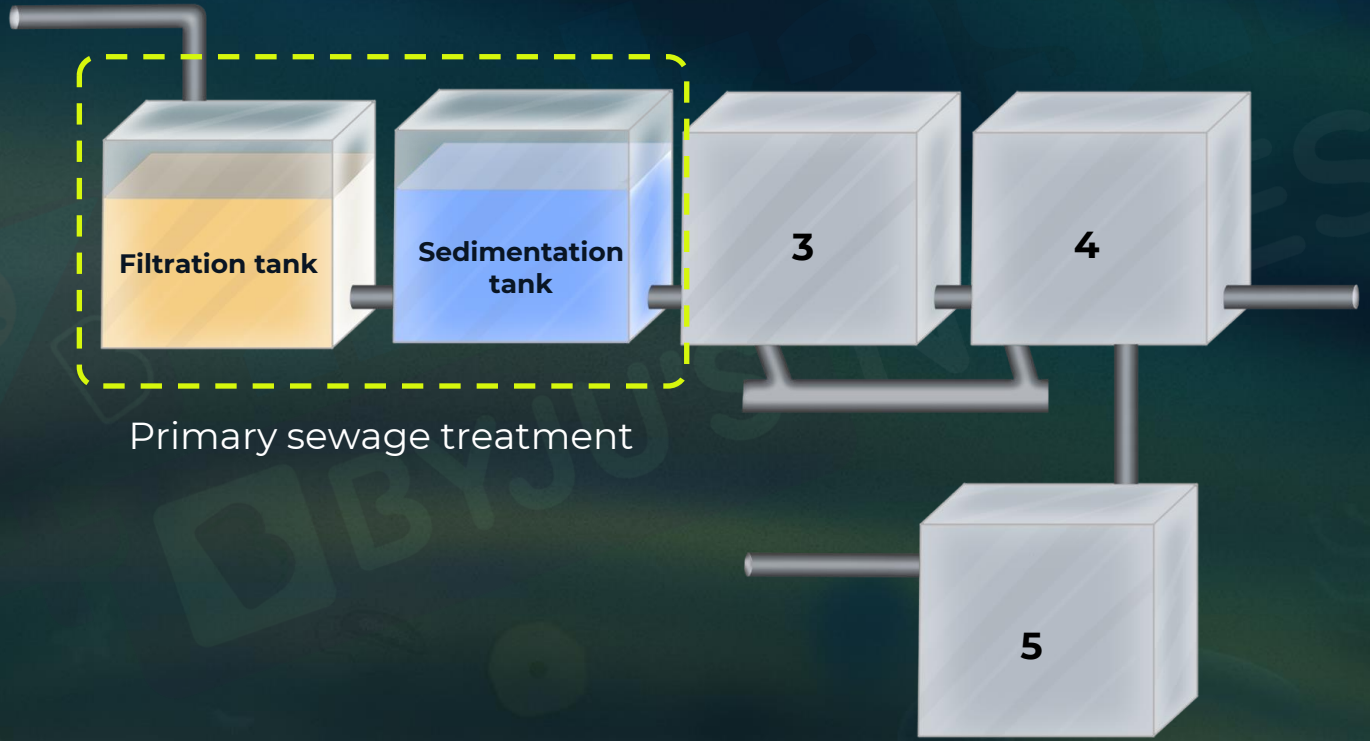
- **Primary sewage treatment**
- **Secondary sewage treatment**



Sewage Treatment Plant

Primary sewage treatment

This treatment involves removal of large and small suspended floating particles **through simple physical processes like filtration and sedimentation.**



Primary sewage treatment

Primary Sewage Treatment

Sewage enters the first tank for primary treatment

Tank 1 - Filtration tank

- It has **multiple filters** arranged one after the other.
- Each filter has a **different pore size.**
- **1st filter** has the largest pore size, and the **pore size decreases gradually** over the subsequent filters.
- Sewage enters the tank with a variety of waste materials inside it.
- It includes **diapers, sticks, clothes, bottle, shoes** etc.
- All these floating solid debris get filtered out according to their size and separate out.
- Therefore, tank 1 removes majority of floating solid debris (small and large) by **sequential filtration method.**

Primary Sewage Treatment

Then the sewage enters the next tank of the primary treatment

Tank 2 - Sedimentation tank

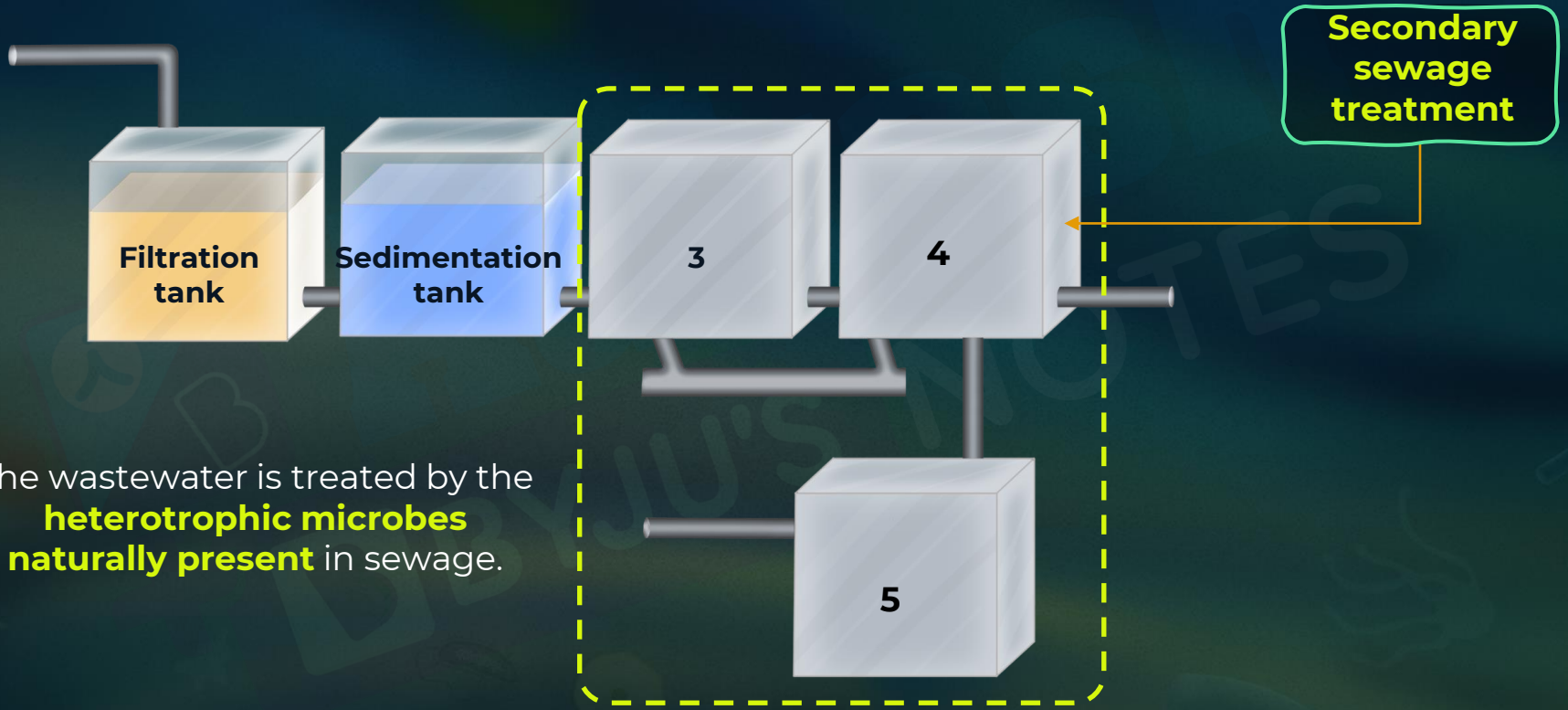
- The smaller solid particles which cannot be removed by sequential filtration are transferred to other tank called **sedimentation tank.**
- The **grits** (soil and small pebbles) are heavier than water.
- Thus, when the sewage is left undisturbed in this tank, the heavier particles start settling down – **sedimentation.**
- Small solid debris, which are heavy, settle down and form the **sediment.**
- This sediment is called **the primary sludge** as it is obtained by primary treatment.
- The lighter floating portion of the sewage which includes water, dissolved elements and microbes forms the supernatant which is called the **effluent.**

Supernatant = Effluent

Sediment = Primary Sludge

Secondary Sewage Treatment

Removal of **organic matter** from the sewage through **microbial action**



The wastewater is treated by the **heterotrophic microbes naturally present** in sewage.

Secondary Sewage Treatment

Effluent from the sedimentation tank is **sent to next tank** for secondary treatment.

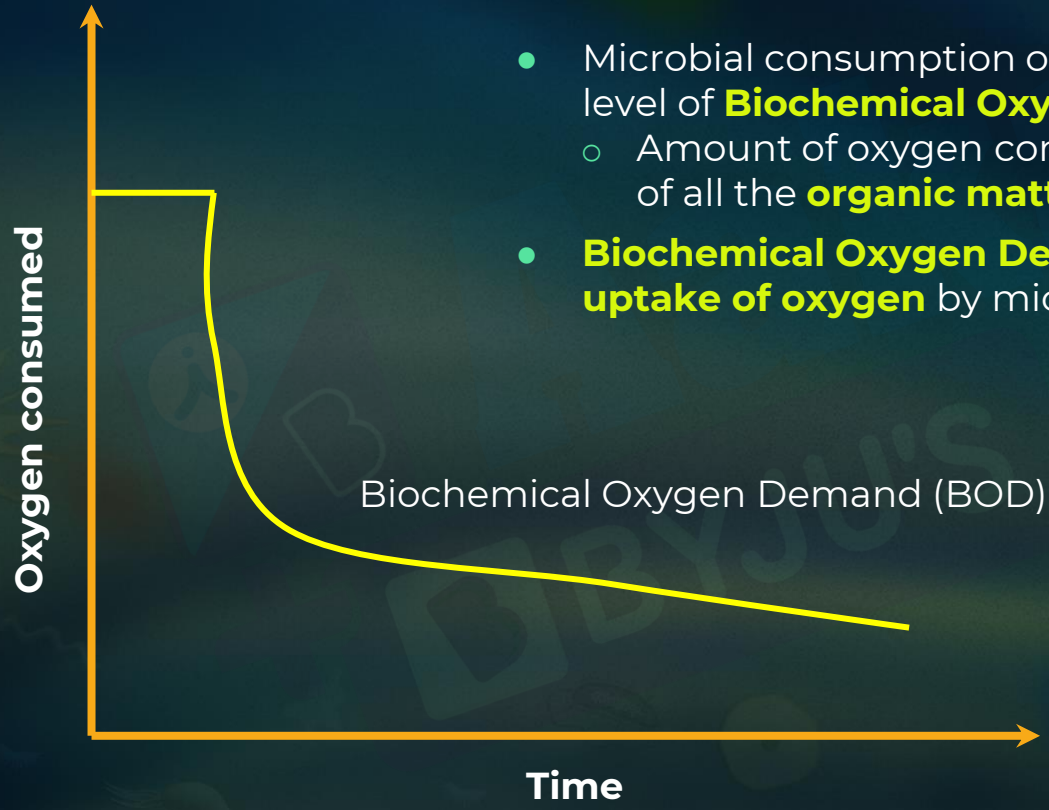
Tank 3 - Aeration tank

- The **effluent** consists of large amount of **organic matter.**
- The **heterotrophic microbes naturally** present in the sewage are **bacteria and algae**.
- This large tank is **mechanically agitated,** and **air is constantly pumped into it.**
- Manual, mechanical agitation and pumping of air causes **increase in the number of aerobic microbes.**
- Large number of aerobic microbes join to form **flocs.**
- If we observe microscopically, **microbial floc is a mesh like structure formed by masses of bacterial and fungal filaments.**
- This microbial floc **consumes and digests the organic matter present in the sewage.**

Secondary Sewage Treatment

Biological Oxygen Demand

- Microbial consumption of the organic matter **decreases** the level of **Biochemical Oxygen Demand (BOD)**
  - Amount of oxygen consumed by the **bacteria** for oxidation of all the **organic matter** in **one liter of water**
- **Biochemical Oxygen Demand (BOD)** test measures **rate of uptake of oxygen** by microorganisms in a sample of water

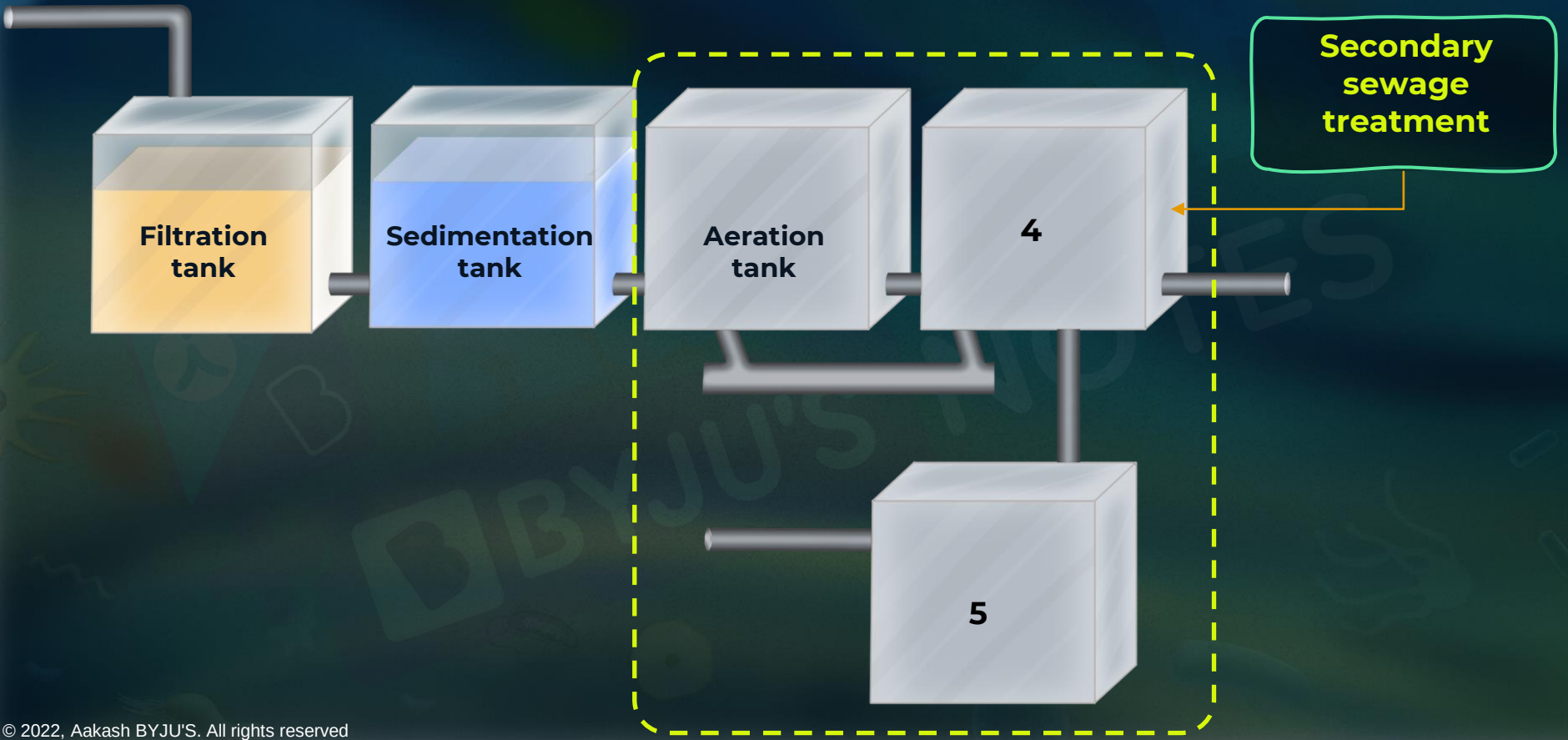


Secondary Sewage Treatment

Biological Oxygen Demand

- Biochemical Oxygen Demand (BOD) is **indirectly** the measure of the **organic matter present** in the water
- **Greater the BOD** of waste water = **higher the amount** of organic matter = greater the **polluting potential** of water
- Sewage water is treated till the BOD is **reduced**

Secondary Sewage Treatment



Secondary Sewage Treatment

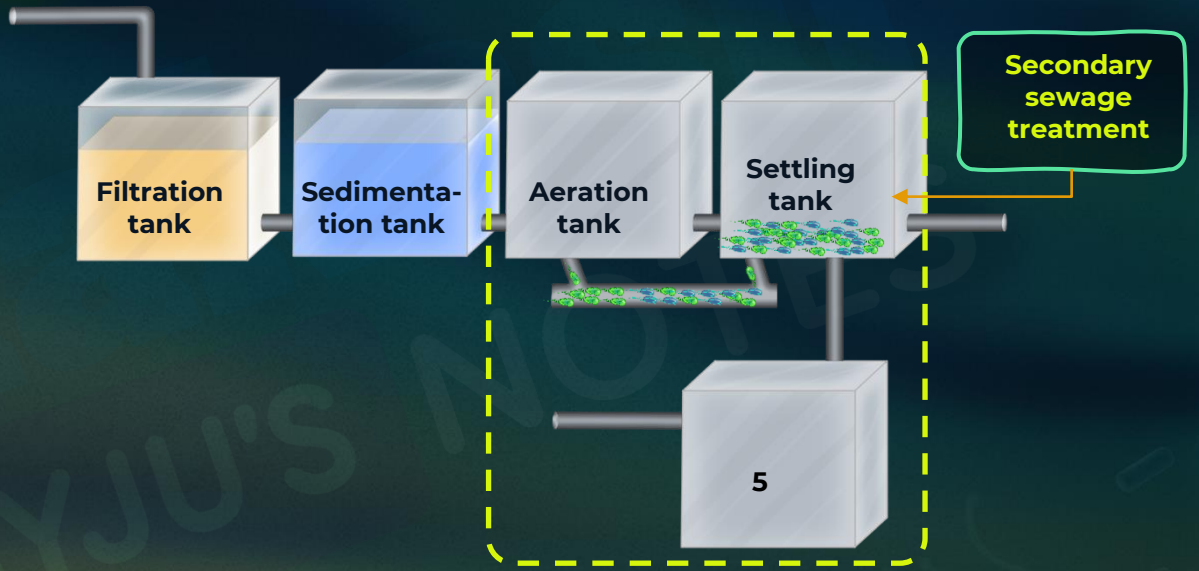
Effluent from the aeration tank is sent to next tank of secondary treatment

Tank 4 - Settling tank

- Once the BOD of sewage (waste water) is reduced significantly, the **effluent is then passed into a settling tank** where the bacterial **'flocs' sediment.**
- This sediment is called **activated sludge.**
- The clean supernatant is the **treated effluent.**
- Flocs contain **heterotrophic aerobic microbes and fungal filaments.**

Secondary Sewage Treatment

- A small portion of activated sludge is **pumped back to aeration tank.**
- This small portion acts as **inoculum** for the next batch of sewage.
- This inoculum **helps in the formation of floc in the aeration tank next time.**
- Remaining major portion of the activated sludge is transferred to another tank.



Secondary Sewage Treatment

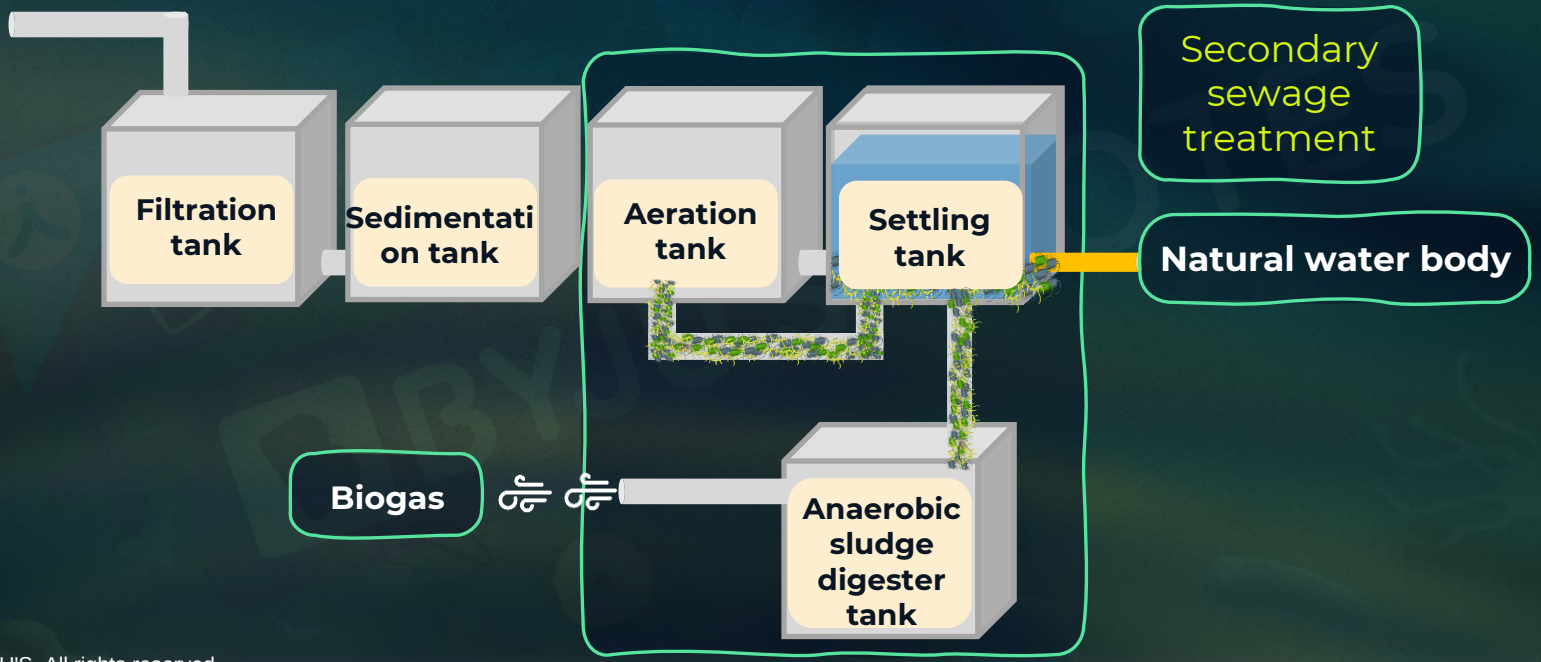
Tank 5 - Anaerobic sludge digester tank

- The sludge digester tank **does not have oxygen,** so **aerobic bacteria die** in the absence of oxygen.
- Different kinds of **anaerobic bacteria** present in this chamber **digest the aerobic bacteria and the fungal filaments** in the activated sludge.
- This digestion releases **mixture of gases like methane, carbon dioxide** and **hydrogen sulphide.**
- These gases form **biogas** which is used as **source of energy and is inflammable.**
- Thus, from the anaerobic sludge digester tank, we obtain two useful byproducts
  - **biogas**
  - **manure**

Microbes in Sewage Treatment

At the end of the sewage treatment there are two major outputs:

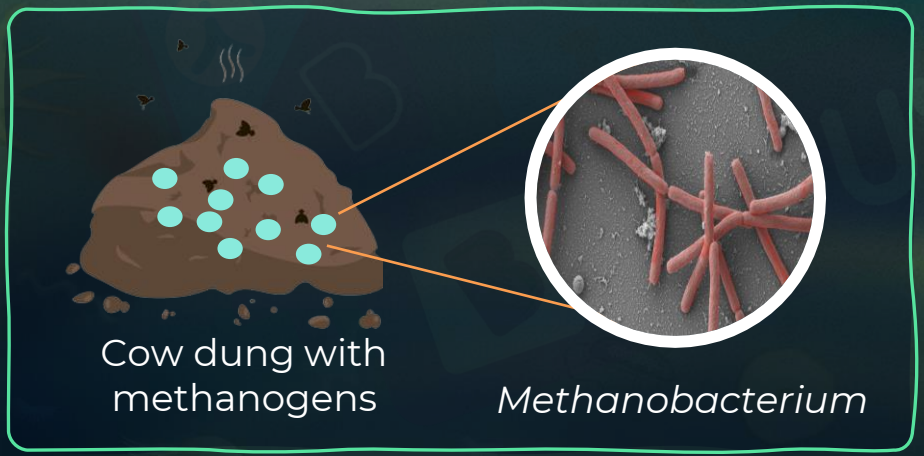
- **1st – Treated sewage water which can be released into natural water body and is non-polluting.**
- **2nd – Really useful byproduct which is biogas**

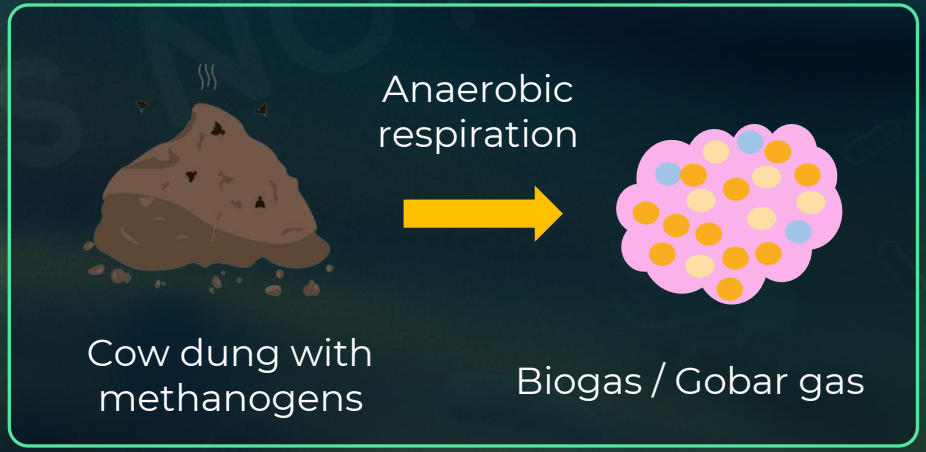


Microbes in Production of Biogas

- Methanogens are bacteria present in the **rumen** of cattle and their dung.
- They help in the **digestion of cellulose.**
- The most common **methanogen** is ***Methanobacterium.***

- **Cow dung** contains **cellulose.**
- **Methanogens** present in the **cow dung** acts on the cellulosic material **anaerobically.**
- They result in the production of biogas, also known as **gobar gas.**





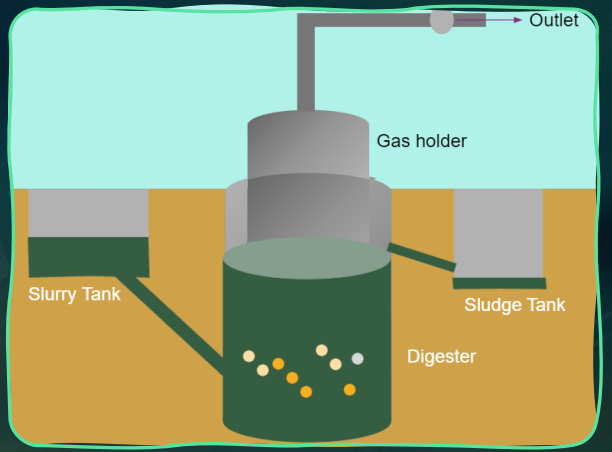
Microbes in Production of Biogas

- **Biogas** is a **mixture of different gases** that are produced due to **microbial activity of methanogens.**
- It **predominantly** consists of
  - **Methane** (approx. 50-70%)
  - **Carbon dioxide** (30-40%)
  - **H_2 and H_2S** (10%)
- **Calorific value** of biogas is **4429 Kcal/m^3** at 50% methane content.
- Technology for biogas in **India was developed by Indian Agricultural Research Institute** and **Khadi and Village Industries Commission.**

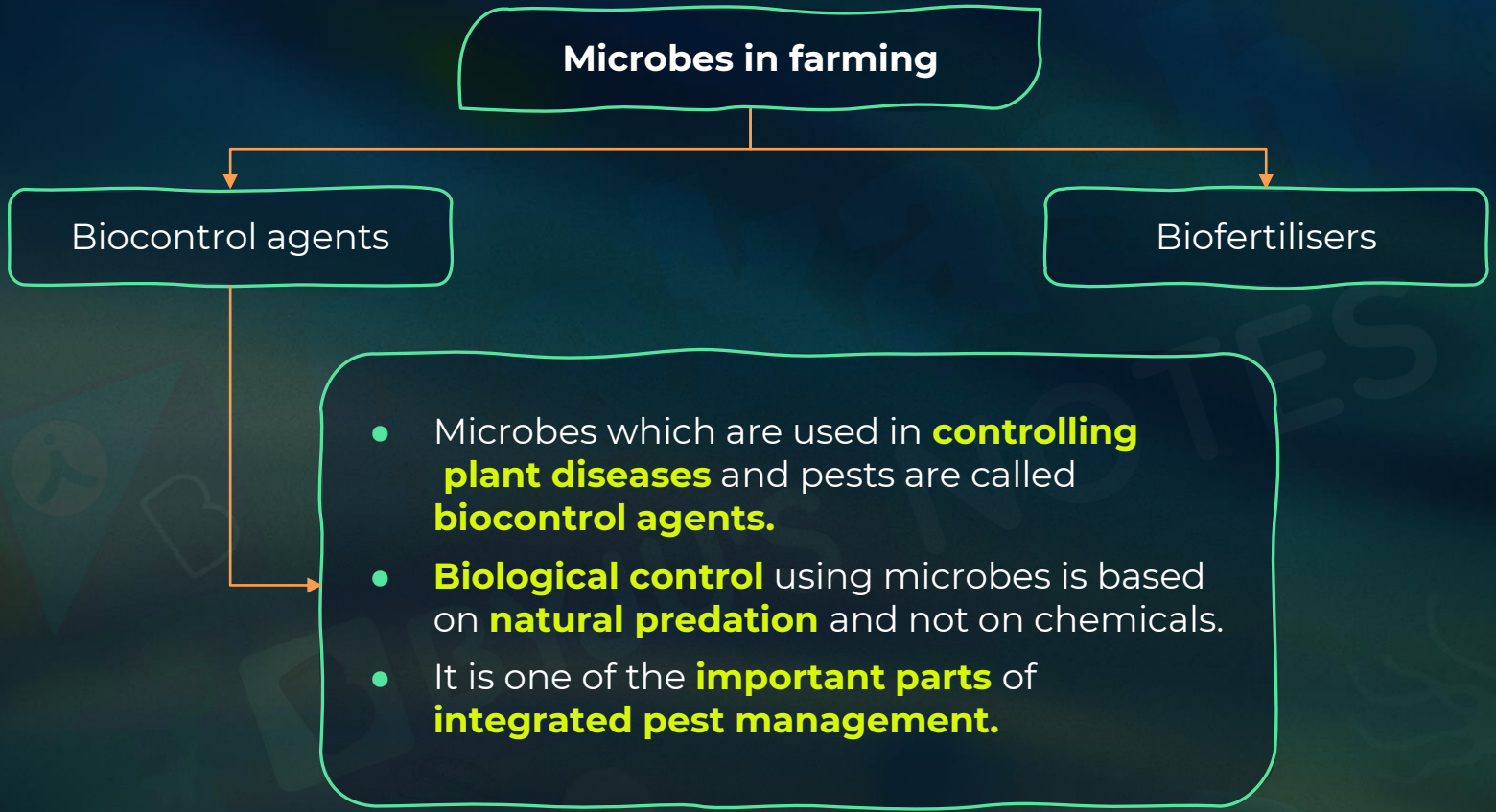
Microbes in Production of Biogas

Parts of biogas plant

- **Digester**
  - 10-15 m deep tank in which biowastes and cow dung slurry is collected
- **Gas holder**
  - It is a floating cover which collects the gas and has an outlet
- **Slurry tank**
  - Slurry is added into digester through this tank
- **Sludge tank**
  - Spent slurry is collected and removed through this tank



Microbes in Farming



Microbes as Biocontrol Agents

Advantages of using microbes as biocontrol agents

Do not pollute the environment

- The **consumption of chemicals sprayed** on **vegetables** or **fruits** for a long period can result in certain **health issues.**
- This can be avoided by using **microbes as biocontrol agents.**

In biocontrol, beneficial insects are retained but harmful pests are eliminated.

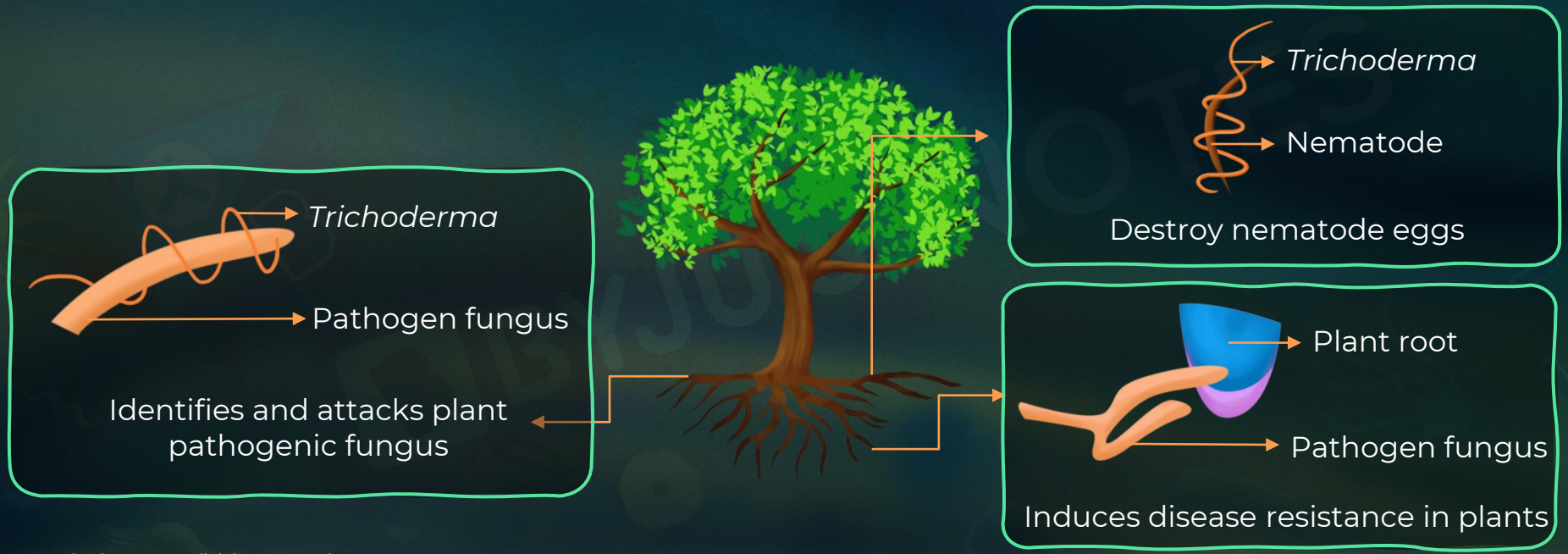
Does not eradicate pests but keeps them under **manageable** levels

- Hence, the **ecosystem is not disturbed.**

Microbes as Biocontrol Agents

Fungi as a biocontrol agent

- *Trichoderma* is a species of **fungi** found in the **root ecosystem.**
- It **controls several pathogens** affecting **plants** and acts as a **biocontrol** agent.



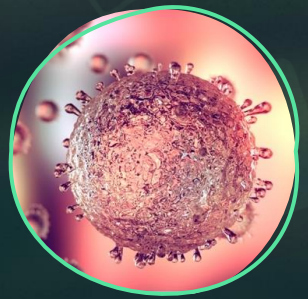
Microbes as Biocontrol Agents

Virus as a biocontrol agent

- **Baculoviruses** are pathogens that attack **arthropods.**
- These **viruses** belong to the genus **Nucleopolyhedrovirus (NPV).**
- They have **species specific** narrow spectrum insecticidal applications.

Nucleopolyhedrovirus (Baculoviruses)

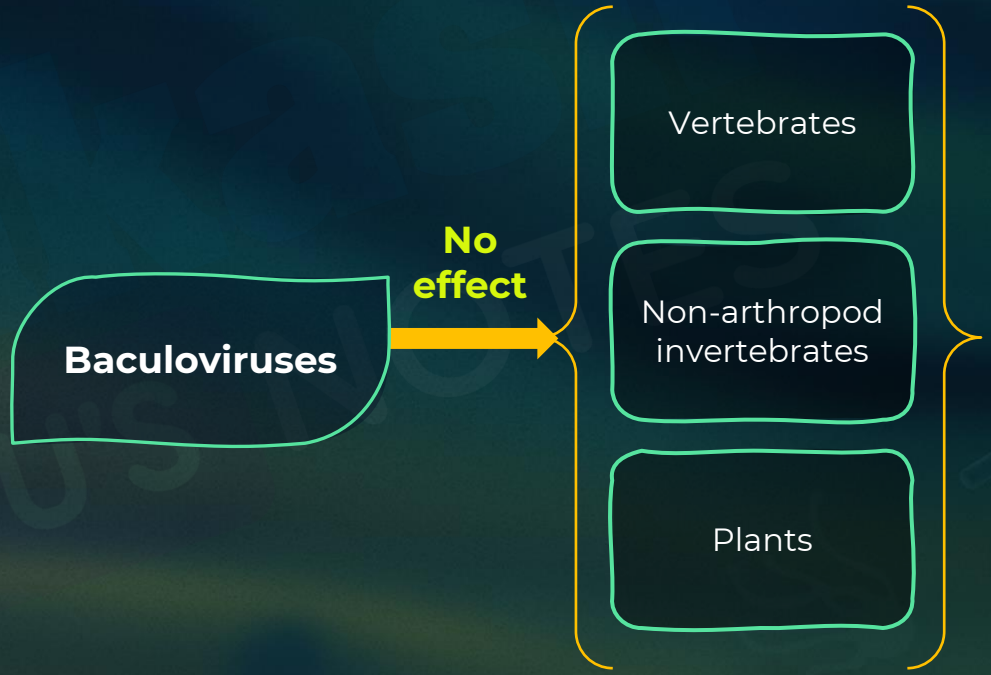
Insects and other arthropods



Microbes as Biocontrol Agents

Virus as a biocontrol agent

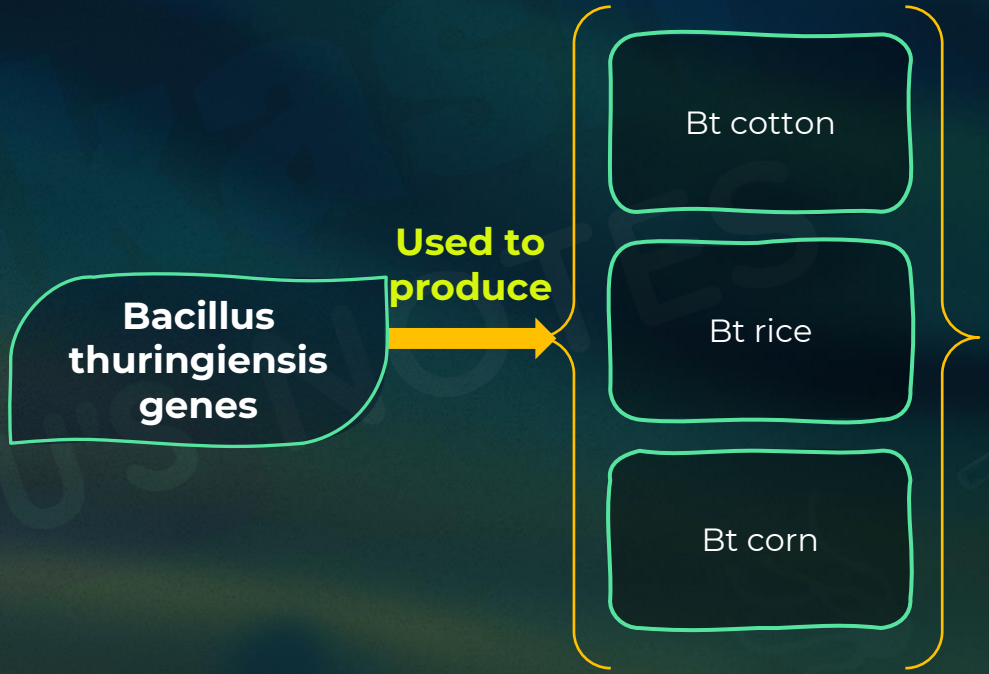
- The specialty of this virus is that it is **restricted** to its host range and **does not** kill other **organisms.**
- These viruses are **excellent candidates** for **species-specific,** narrow spectrum insecticidal **applications.**
- They have been shown to have **no negative impacts on plants, mammals, birds, fish** or even on **non-target insects.**



Microbes as Biocontrol Agents

Bacteria as a biocontrol agent

- *Bacillus thuringiensis* is the most widely used option.
- It produces an endotoxin encoded by gene *Cry IAc.*
- This gene is incorporated into plants so that they produce the same endotoxin which kills the insects feeding on the plants.



Microbes as Biocontrol Agents

Integrated Pest Management

Knowledge of the pests, their life cycles, their interaction with the environment helps in developing a holistic approach in managing the pest

- The **IPM** approaches are very economical.
- Baculoviruses are considered as a desirable factor for **integrated pest management (IPM),** as it helps in controlling pests without affecting other **species (species specific).**

Integrated Pest Management

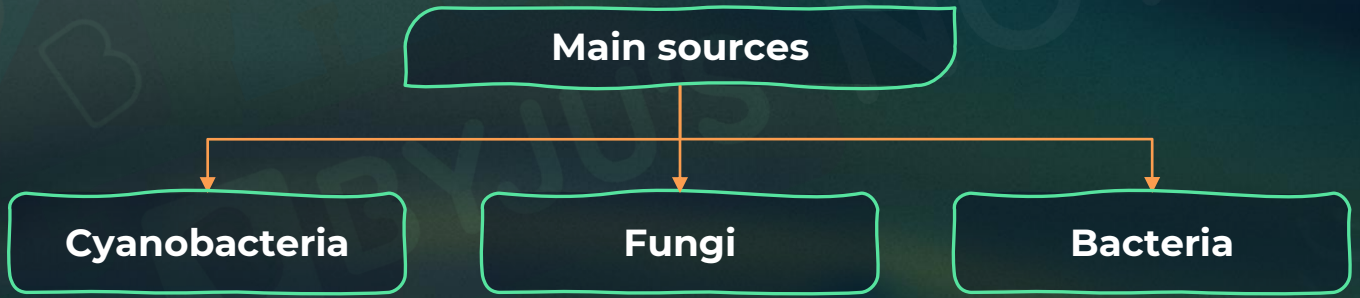
Animals as biocontrol agent

- Not only microbes but **certain animals** are also used as **biocontrol agents.**
- For example
  - **Ladybird** is used to kill aphids.
  - **Dragonflies** are useful to get rid of **mosquitoes.**

Ladybird | Aphids | Dragonfly | Mosquito

Microbes as Biofertilisers

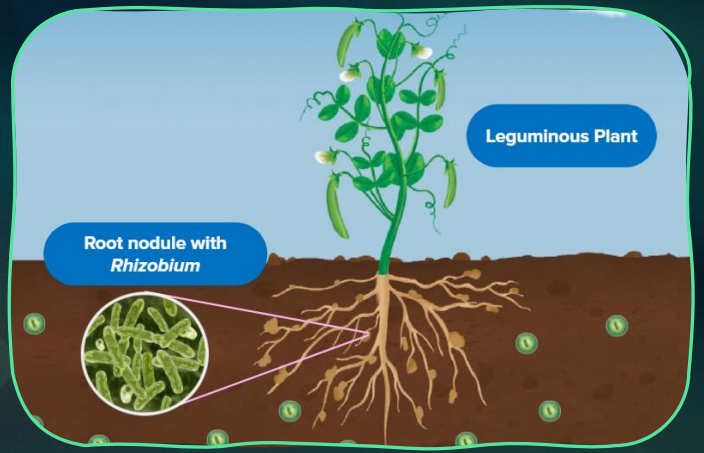
- One way to **provide nourishment to crops** is through the use of **fertilisers.**
- However, usage of **chemical fertilisers** has resulted in increase in **pollution.**
  - They also have a damaging impact on health of organisms.
- Hence, utilisation of biofertilisers for farming is gaining prominence.



Microbes as Biofertilisers

Bacteria as biofertiliser

- The **nodules** on the roots of **leguminous** plants formed in symbiotic association with *Rhizobium* helps in nitrogen fixation.
- *Azotobacter* and *Azospirillum* bacteria are other examples of **biofertiliser.**
  - These are free living bacteria
- In rice fields, *Aulosira,* helps fix nitrogen non-symbiotically.



Microbes as Biofertiliser

Fungi as biofertilizer

- **Mycorrhiza –** symbiotic relationship between fungi and roots of the plant.
- Here, the **fungi absorb phosphorus** from the **soil** and pass it on to the plant.
- Most of the **fungi** that belong to genus *Glomus* form the **mycorrhiza.**

They absorb and store nitrogen, phosphorus, potassium and calcium

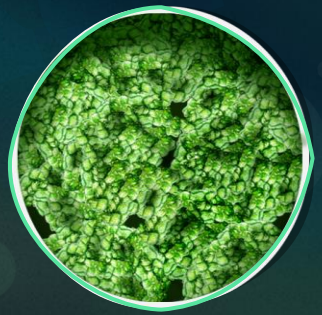
They are also called **vesicular arbuscular mycorrhizae (VAM).** It plays a significant role in phosphorus nutrition in plants.

Microbes as Biofertiliser

Cyanobacteria as a biofertiliser

- **Cyanobacteria** are **autotrophic** microbes widely distributed in aquatic and terrestrial environments.
- Many of them can **fix atmospheric nitrogen,** e.g. *Anabaena, Nostoc, Oscillatoria.*
- *Anabaena azollae* lives in **symbiotic association** with the **free floating water** fern Azolla and fixes **atmospheric nitrogen.**
- *Anabaena cycadae* lives in coralloid root of *Cycas.*

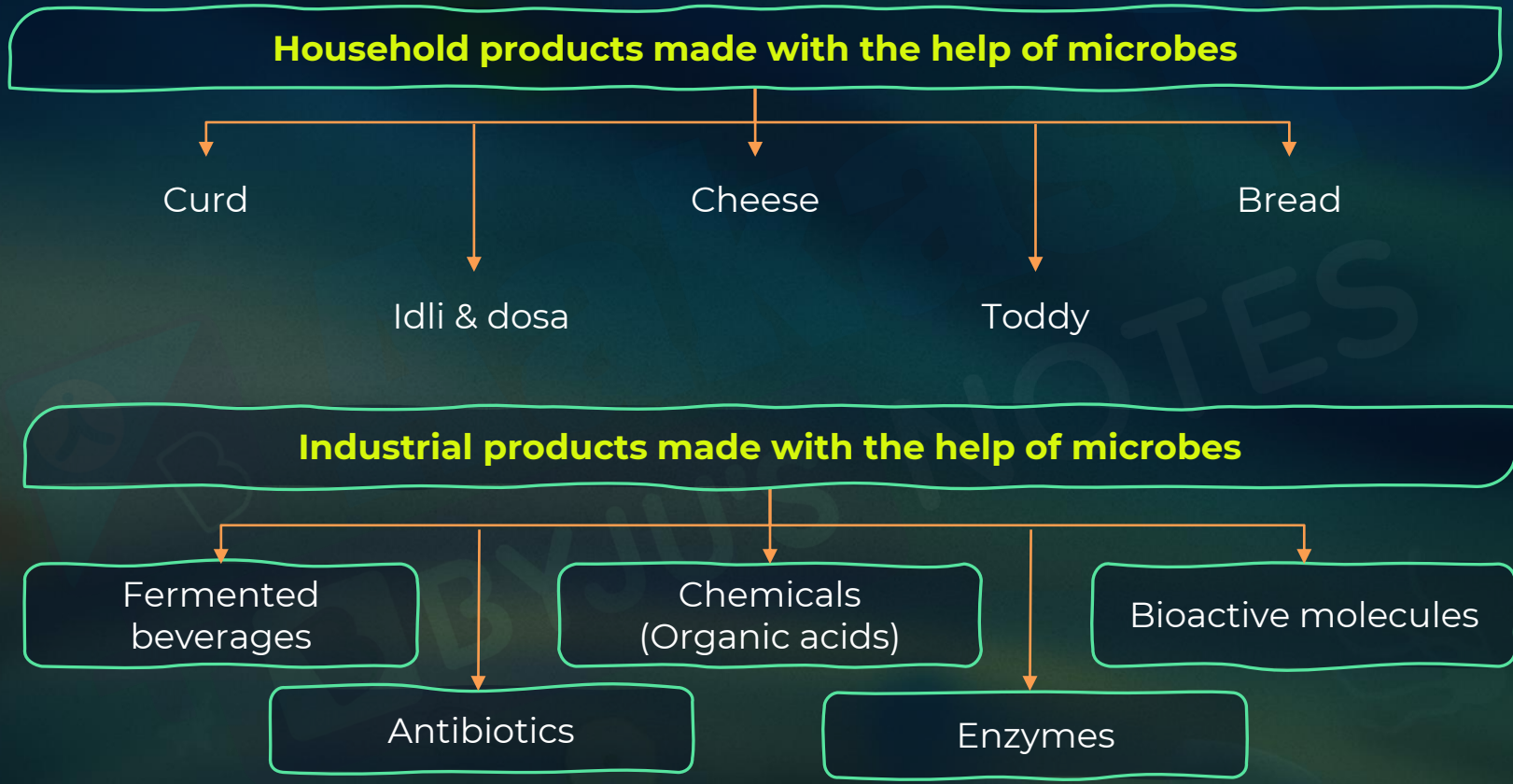
Fix atmospheric nitrogen



Anabaena azollae

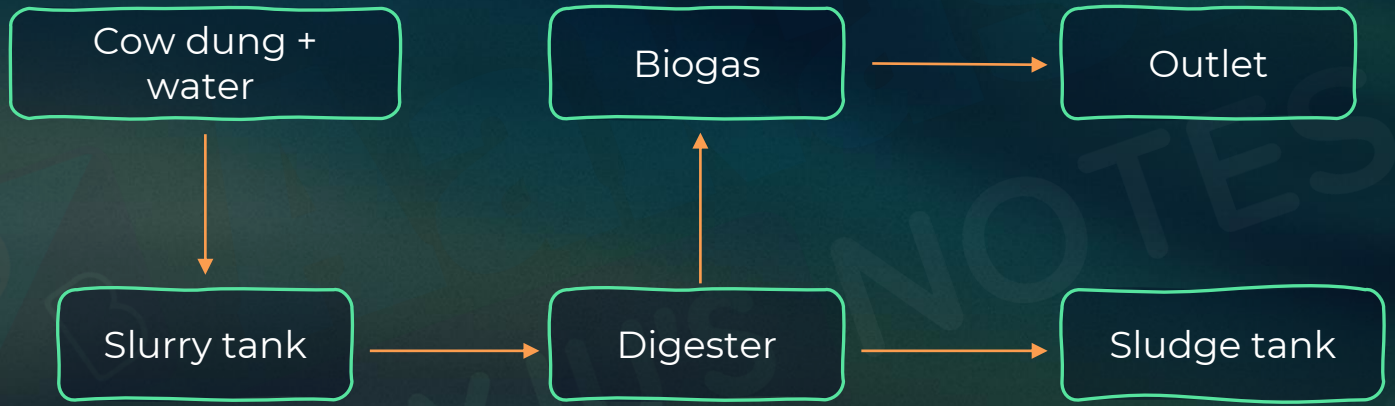
Nostoc

Summary



Summary

Schematic representation of a biogas plant



Summary

Biocontrol agents

Virus	*Baculovirus*
Fungi	*Trichoderma*
Bacteria	*Bacillus thuringiensis*
Animals	Ladybird & dragonfly