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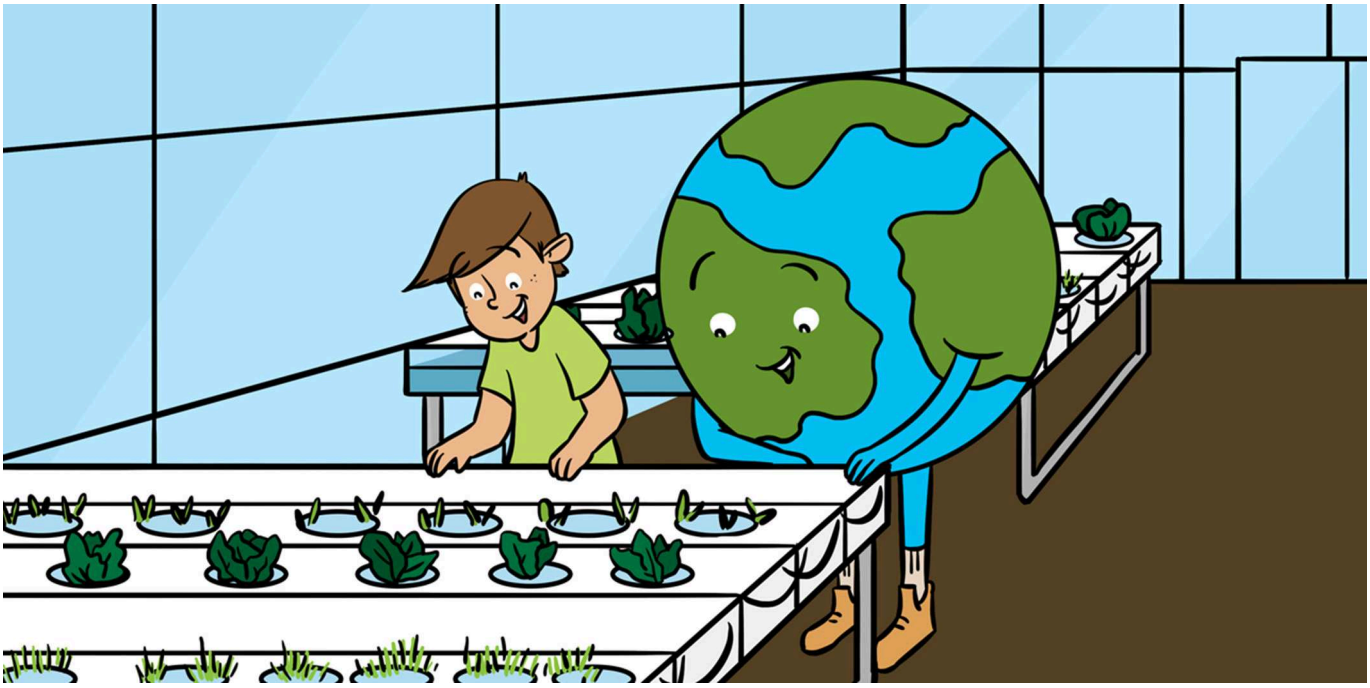

BIOPONICS: THE NEXT REVOLUTION IN SOILLESS AGRICULTURE

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Our food system is slowly becoming more environmentally friendly in response to global challenges such as climate change, the environmental damage caused by intensive agriculture, the increasing human population, and the growth of cities. Soilless agriculture, which involves growing plants without the use of soil, is a unique type of environmentally friendly food-production system. There are several soilless agriculture techniques, including bioponics. Bioponics is a new technique that aims to replace chemical fertilizers with organic or natural ones. These environmentally friendly fertilizers are recycled from plant- or animal-based waste materials, through the activity of microorganisms like bacteria. Therefore, bioponics is a sustainable method of producing fruits and vegetables, as it not only limits the use of chemical fertilizers but also conserves water and land resources and recycles important nutrients.

HOW CAN WE GROW ENOUGH FOOD WHILE PROTECTING THE ENVIRONMENT?

Our planet is facing great challenges, including climate change, an increasing global population, and the growth of cities. While the number of people who need to eat is constantly increasing, the traditional method of growing fruits and vegetables in soil can damage the planet. Traditional agriculture can remove necessary nutrients from the soil or may require the use of harmful chemicals, such as herbicides and pesticides, that can kill animals and insects. To reduce these negative consequences on the planet and to produce food that is more **sustainable**, it is important to limit the use of soil, water, and harmful chemicals, including **chemical fertilizers**. A new method of growing things, called **controlled environment agriculture** (CEA), may provide a possible solution. CEA is a form of soilless farming that is increasingly found in cities world-wide. In CEA, all types of fruits and vegetables can be cultivated within protected structures like greenhouses or tunnels, and under specific conditions of light, temperature, and humidity. CEA could allow us to use less water and fewer harmful chemicals, and to cultivate crops throughout the year instead of just during the warm seasons.

The major techniques of soilless agriculture are called **hydroponics** and **aquaponics**.

Hydroponics is a growing technique in which plants grow in a water-based solution, to which farmers add all the nutrients the plants require to grow. This form of agriculture uses materials like sand or clay balls to support the plants' roots while they grow in the water solution.

Aquaponics is a growing technique that combines hydroponic plant farming with **aquaculture**, which is fish farming. In this form of agriculture, plants grow in the water where the fish live, and all the nutrients necessary for plant growth are provided by fish instead of farmers. Indeed, thanks to the activity of microorganisms, these nutrients are created from fish poop and from the food the fish do not eat (Figure 1).

BIOPONICS: A SOILLESS AGRICULTURE SYSTEM THAT USES NATURAL COMPOUNDS AND MICROORGANISMS ACTIVITY

Bioponics is another type of CEA, in which plants derive nutrients from natural compounds. These compounds are plant-based (for example, corn steep liquor or sugar cane molasses), animal-based (for example chicken or cow manure) or mineral-based (for example granite dust or glauconite) natural substances released into the growing system

SUSTAINABLE

Something that people can use in the present without compromising the possibility for next generations to access it in the same way.

CHEMICAL FERTILIZERS

Fertilizers created by the chemical industry specifically to help crops grow better and produce more food.

CONTROLLED ENVIRONMENT AGRICULTURE

Innovative form of soilless agriculture in which fruit and vegetables can be cultivated within protected structures, such as greenhouses or tunnels, and under specific condition of light, temperature, and humidity.

HYDROPONICS

Technique of growing fruit and vegetable in the water instead of soil. All nutrients the crops needed to grow are put into water by farmers.

AQUAPONICS

Technique of growing fruit and vegetable that combines hydroponics with aquaculture. Plants grow in the water were fish live. All nutrients the crops needed to grow are provided by fish.

AQUACULTURE

Farming of aquatic organisms, such as fish, shrimps, and algae in the fresh water or sea water to produce seafood.

Figure 1

Controlled environment agriculture (CEA) involves the use of protected structures like greenhouses in which to grow plants without soil. Hydroponics is a type of CEA in which plants grow in the water to which farmers add all the nutrients they need to grow. Aquaponics is a type of CEA in which plants grow in combination with fish; all the nutrients they need to grow are provided by fish. Bioponics is a new type of CEA in which all the nutrients the plants need to grow come from natural compounds that are released into the water by microorganisms activity.

BIOPONICS

Technique of growing fruit and vegetables in the water instead of soil. All nutrients the crops needed to grow come from natural compounds that are released into water by microorganisms.

Figure 2

Picture of a bioponics system. Starting from left, color brown indicates the biofilter tank where the microorganisms transform the organic compounds like animal poop into simple molecules that are usable by plants; color light blu indicates the water recirculating tank that allows nutrients to be adequately diluted into water; color green indicates the growing tank where fruit and vegetable can grow.

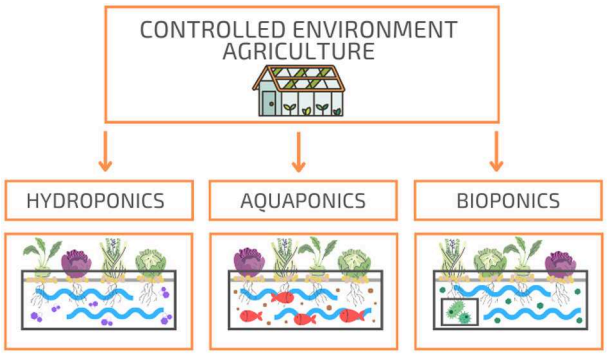

Figure 1

by the activity of microorganisms like bacteria, which transform these compounds into simple molecules that are usable by plants [1].

Bioponics also helps plants to grow due to the addition of beneficial microorganisms to the growing area. For example, a helpful type of fungi, called **mycorrhizal fungi**, can be added to plants, which then colonize plant roots. Mycorrhizal fungi create a formidable barrier against dangerous, disease-causing microorganisms called pathogens, so they protect plant roots while also aiding nutrient absorption and boosting plant growth. Therefore, in bioponics, microorganisms are very important, and their activity is essential throughout the food-production process.

Generally, a bioponics system consists of a tank called a biofilter tank, in which the bacterial activity takes place. In this tank, the animal- or plant-based organic compounds are transformed by the bacteria into plant-available forms of nutrients. A pump moves the nutrient-containing water into a water recirculating tank, which allows nutrients to be adequately diluted into water. The water recirculating tank is connected to the growing tank, where the fruits or vegetables are grown (Figure 2).

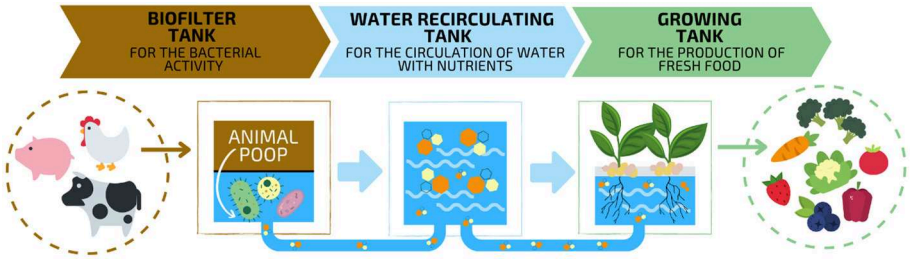

Figure 2

ADVANTAGES AND CHALLENGES OF BIOPONICS

Bioponics has environmental, economic, and social advantages. First of all, nitrogen and phosphorus are the major nutrients in the

MYCORRHIZAL FUNGI

Beneficial fungi that associate with plant roots. The fungi protect the roots from dangerous microorganisms and the fungi and plant provide each other with necessary nutrients.

chemical fertilizers used intensively in traditional agriculture, and the excess use of such fertilizers has negative consequences on nature, such as contamination of groundwater, waterways and soil that can negatively affect life cycles of beneficial microorganisms and animals [2]. Therefore, feeding plants with nitrogen and phosphorus generated from organic or natural compounds is a major environmental advantage of bioponics. Using organic or natural compounds to generate plant food also has economic advantages. For example, in developing countries, most chemical fertilizers must be purchased from other countries, which increases food production costs. Organic fertilizers, on the other hand, can be made anywhere in the world. This means that bioponics could reduce the cost of growing food in developing countries. In terms of social benefits, bioponics can strengthen bonds between people by promoting direct contact between farmers, local markets, and consumers. Local farmers can provide fresh and nutritious food while also creating opportunities for purchasers to socialize and cooperate.

Despite these advantages, bioponics has also several challenges. For example, because it contains living microorganisms, a bioponics system is fragile and can easily stop working properly. Therefore, managing these systems requires a great deal of knowledge and effort. Another challenge is that organic compounds, unlike chemical fertilizers, may be deficient in certain essential nutrients needed by plants [3]. For example, pig manure is low in potassium, which is important for plant health. Finally, because various types of animal manure are used as a natural source of nutrients for plants, it is important to be aware of potential risks to human health caused by the presence of heavy metals like lead, copper, or zinc. For example, chicken manure is often contaminated with high amounts of copper and zinc. These elements can accumulate in edible parts of plants and, when humans eat a lot of them, stomach aches can result [4]. Further food-safety research is needed to fully understand the possible health risks of bioponics.

In summary, bioponics could be a more sustainable soilless cultivation system than hydroponic one.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

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We are a group of 3rd Grade GT students at College Hills Elementary School in College Station, Texas. It is a Dual Language, Title I campus with a long history. We are a diverse group of friends who love to learn, tackle hard challenges, and have fun. We love to eat sweets, fruit, and anything with sugar. We learned about many scientific topics while reviewing this article and had fun sharing our thoughts. We would like to do it again!

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