frontiers FOR YOUNG MINDS

EARTH AND ITS RESOURCES
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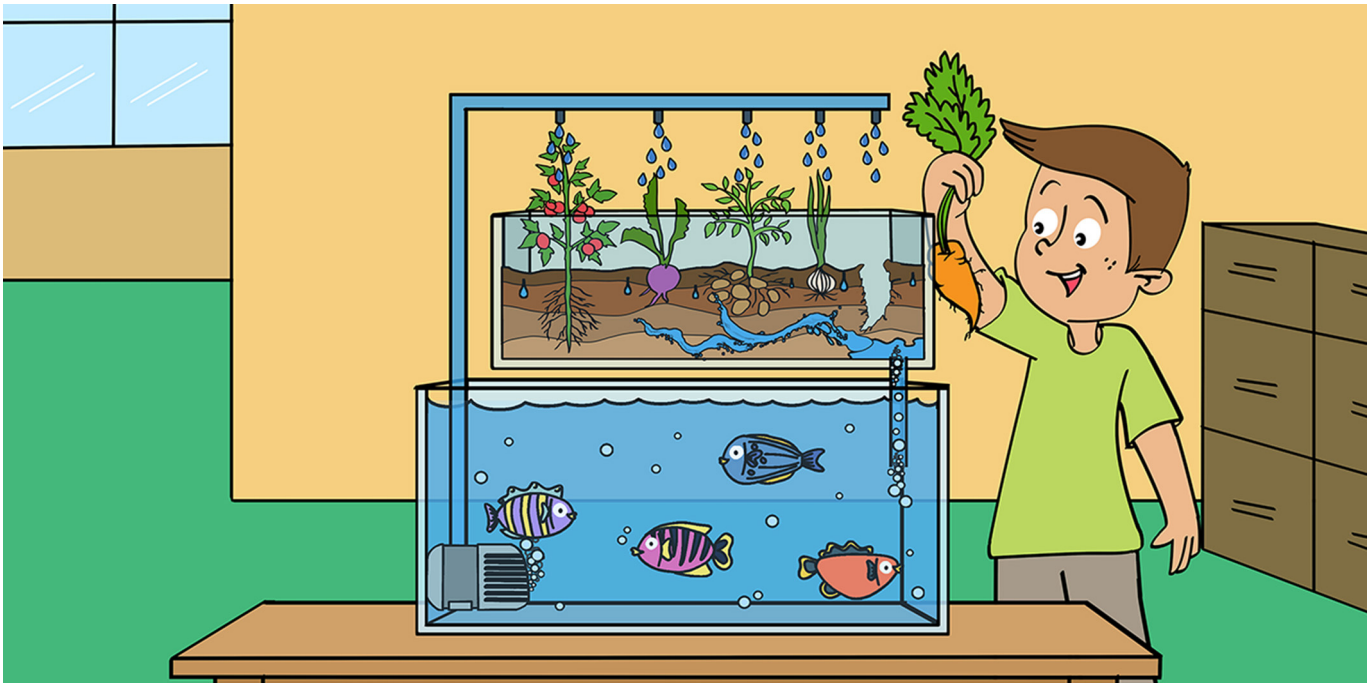

AQUAPONICS: A PROMISING TOOL FOR ENVIRONMENTALLY FRIENDLY FARMING

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YOUNG REVIEWERS:

CHERYL
AGE: 9

PRICE
AGE: 14

PROVIDENCE
AGE: 10

Nowadays, agriculture must face a new challenge: produce more food with fewer natural resources. To achieve this goal, scientists are testing a technique called aquaponics. Aquaponics was introduced many years ago by ancient Chinese and Mexican populations. In aquaponics, fish and plants are farmed together. How is this possible? Bacteria change the fish poop into nutrients useful for the plants. The plants take up these nutrients and clean the water, which can then be reused to farm the fish, and the cycle restarts! Aquaponics allows farmers to obtain two products at once, and to recycle the same water many times. Almost no wastewater is released into the environment! Aquaponics systems can have different sizes and do not need soil. They can be installed in both outdoor and indoor environments. Big aquaponic systems are used for commercial purposes, while small aquaponic systems can be used for urban farming—growing food within cities.

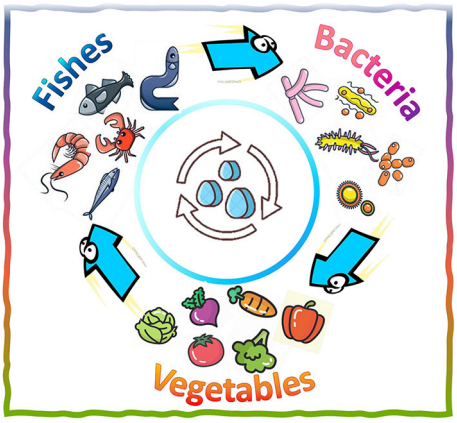

Figure 1

Figure 1

Water cycle within an aquaponics system. Bacteria convert the fish poop into nutrients that are good for the plants. The plants' roots take up these nutrients, and in doing so, they clean the water. The purified water is reused for fish farming. In this way, we obtain a closed water cycle, in which the same amount of water continuously flows. Water flows from the fish to the plants, and then back to the fish, and so on!

WHAT IS AQUAPONICS?

The population of the world is increasing rapidly, and there is not enough food to feed this growing population! Scientists have an important mission: they must find a method for producing more food without stressing the environment. Traditional farming techniques damage the environment in many ways. They harm natural resources and pose health risks to humans and wildlife. A technique called aquaponics could be a solution to this problem. The "aqua" part of this word comes from aquaculture, which is the practice of raising fish, shrimp, algae, and other seafood. The "ponics" part comes from hydroponics, which is the cultivation of plants in water, without soil. Aquaculture and hydroponics can exist separately, but when we combine them, we obtain aquaponics!

Aquaponics is a miniature version of a natural ecosystem. It works the way Mother Nature normally works in every aquatic environment! First, in aquaponics, we put the fish to work. By working, we mean eating and pooping. This results in water that is rich in nutrients—yes, the fish poop! Then, bacteria come into play. Bacteria convert the fish poop into a perfect fertilizer for plant growth. The plants take up this fertilizer with their roots and, in doing so, also clean the water. The clean water is reused for farming the fish (Figure 1). The cycle restarts!

In an aquaponics system, fish, plants, and bacteria work together as a team. This teamwork allows farmers to obtain two food products, fish and vegetables, using the same amount of water that would normally be used to obtain just one product. In this closed cycle, water is not wasted—the wastewater released into the environment is almost zero [1]!

Figure 2

Aquaponics has been used for about 1,500 years in China, where rice was grown in flooded paddy fields (top). In Mexico, the Aztecs produced vegetable on floating gardens called chinampas (bottom).

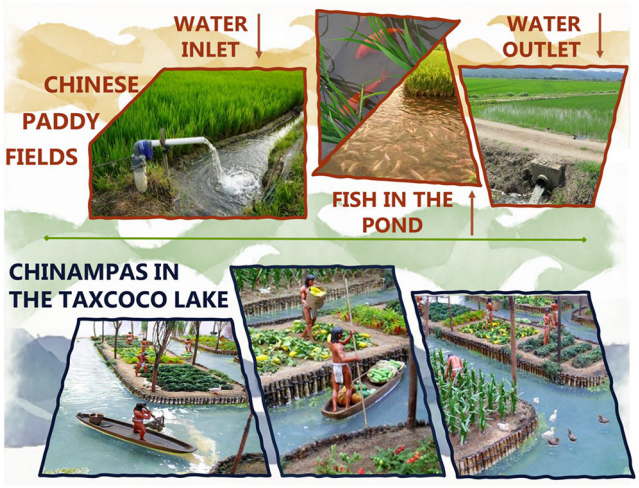

Figure 2

AQUAPONICS, PAST AND PRESENT

PADDY FIELDS

A flooded field used to grow rice.

The idea of aquaponics is quite old. The first forms of aquaponics were used about 1,500 years ago, in South China, Indonesia, and Thailand. The farmers there grew rice in **paddy fields** that also had fish in them. The fish poop served as fertilizer for the growth of the rice plants (Figure 2).

Five hundred years later, a population in central Mexico invented another form of aquaponics. This population, known as the Aztecs, created a big empire. The capital of the empire, called Tenochtitlán, was built on the shores of Lake Texcoco. In that wetland, the Aztecs did not have fertile lands to cultivate their food. For this reason, they built gardens floating in the lake, called chinampas. These floating islands were made of mud and dried plant residue. On the chinampas, farmers cultivated maize, squash, tomatoes, and other crops. The plants could take up nutrients from the lake water, which was rich in fish poop.

Although the concept of aquaponics is ancient, it was not until the 1970's that scientists rediscovered its potential. Nowadays, aquaponics is becoming quite advanced, and it provides a sustainable solution for agriculture, that will reduce the use of natural resources. Aquaponics uses up to 90% less water than traditional agriculture [2] and the plants grow much faster [3]! Aquaponics also reduces pollutants coming from the use of tractors and field chemicals [4].

Aquaponics systems can be installed both outdoors and in indoor, greenhouse-like environments. Indoors systems can allow food to be produced throughout the year! This is a great advantage in areas where the climate is not favorable for agriculture, for example, places with low temperatures, short daylight, and an absence of rain or freshwater for irrigation.

Figure 3

The three main aquaponic systems. Substrate aquaponics has a soil-like substrate to help plant growth. In channel aquaponics, the plants are placed within pipes that have nutrient-rich water running through them. In raft aquaponics, the plants are placed on floating rafts with their roots reaching down into the water for nutrients.

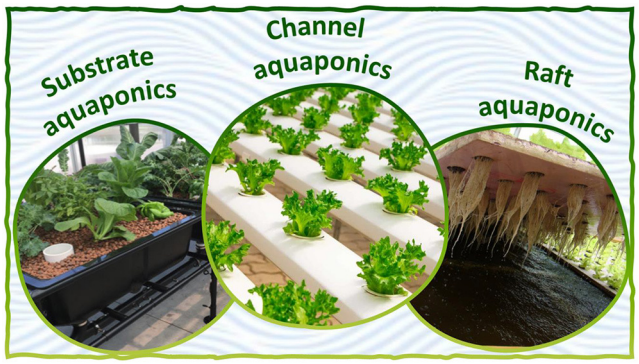

Figure 3

TYPES OF AQUAPONICS

There are three main aquaponics systems in use today (Figure 3). In **raft aquaponics**, the plants are grown on floating rafts. The rafts float in tanks filled with the wastewater from the fish culture. The plant roots dip into the water where they can absorb the nutrients from the fish poop. This method is most appropriate for small plants like salad greens, basil, spinach, chard, and others. In **substrate aquaponics**, the plants grow in a substrate that mimics the soil. This substrate sustains the plant roots and helps the bacteria to filter the water. This kind of system is suitable for all types of plants, but it is most often used for cabbage, broccoli, onions, fennel, carrots, tomatoes, peppers, cucumbers, beans, peas, squash, and melons. Last, in **channel aquaponics**, the wastewater from the fish flows through narrow pipes with holes, into which the plants are placed. The roots dip into the stream of water within the pipe, where they can uptake the nutrients from the fish poop. This growing method works well for plants that need little support, such as strawberries, leafy greens, and herbs. The pipes can also be placed vertically to save space.

There are many fish species that can be used in aquaponics systems. These systems can incorporate large, small, edible, or ornamental fish, it depends on the ultimate purpose of the system. The most common species of fish in aquaponics systems are tilapia, bluegill, catfish, carp koi, fancy goldfish, shrimp, and pacu.

RAFT AQUAPONICS

System in which plants are placed in holes drilled in rafts. The rafts float within tanks filled with fish wastewater. Plant roots dip in the water where they absorb nutrients.

SUBSTRATE AQUAPONICS

System in which plants are placed in holes drilled within pipes where continuously the fish effluent water flows. The roots dip into the water stream, where they can uptake the nutrients.

CHANNEL AQUAPONICS

System in which plants are placed within a substrate that mimics the soil. This substrate also contains bacteria that help the plant to uptake nutrients from the fish wastewater.

BENEFITS OF AQUAPONICS IN CITIES

Nowadays, there is a growing interest in small-scale aquaponics systems. These systems can be located within cities; for example, they can be located in parks, urban gardens, buildings, houses, courtyards, and on rooftops. Introducing small aquaponics systems into cities can bring many benefits. Aquaponics can provide a large variety of organic and seasonal fresh produce. These vegetables are environmentally friendly because they have a reduced

transport footprint—they do not need to be transported far before reaching our tables. Urban aquaponics systems can also encourage social initiatives. For example, they can promote **cohousing** and educational workshops, both of which provide people with a greater chance of meeting their neighbors. Aquaponics can also provide a shelter for birds and beneficial insects, which increases the city's **biodiversity** [5]. Last, urban aquaponics can help to create jobs for people in cities.

In summary, aquaponics is a circular soilless production system. It allows producing fish and vegetables together with the same amount of water, helping to save water. By participating in aquaponics, people can learn more about the lives of plants and fish. They can become more aware of how the foods they buy in grocery stores have been produced. This is especially important for younger people in cities and suburban areas, who are at risk of losing touch with the farming world. And one more important thing—participating in aquaponics is also a lot of fun!

TRANSPORT FOOTPRINT

Greenhouse gas emissions from transportation (trucks, airplanes, railways, etc.).

COHOUSING

Communities in which people have their own residences but share common spaces such as rooftops, courtyards, and balconies.

BIODIVERSITY

Set of all living forms that are on Earth—plants, animals, insects, fungi and micro-organisms, and their habitats.

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YOUNG REVIEWERS

CHERYL, AGE: 9
Hi, I am Cheryl. I have a cat named Delilah and two little sisters called Tanya and Alice. I live in a small city of Canberra. I am sometimes pretty shy and sometimes pretty cheeky. I absolutely love icecream especially "Cookies 'n' cream." Love you all.

PRICE, AGE: 14
Price loves making up stories and has also written a book (Ms. Wasteson and the waste empire). She enjoys gymnastics, athletics, volleyball, and basketball. She is brave and bouncy. Price also enjoys quality time with family and is very creative. At her school, she is part of a "green team" that works to protect the environment. She likes debating and has a passion to study and become an activist against social injustices.

PROVIDENCE, AGE: 10
Providence is the youngest amongst her three sisters. She is playful and bouncy. Providence is curious, talkative, and likes asking many funny questions, that leaves others laughing. She loves making new friends and traveling. Providence loves science experiments. During this process, she may destroy, repair or recycle some household items. As part of this adventure, Providence repaired a spoilt speaker. But after weeks of action, she modeled the speaker wires into skipping ropes. She is passionate about music and sports including volleyball.

AUTHORS

ROBERTA CALONE

I believe that we can take inspiration from nature to change the way we produce food. Most current farming techniques are strongly dependent on natural resources. Current agriculture needs a lot of land, water, and energy. This is seriously threatening the environment. Agriculture also produces a lot of pollutants that pose health risks for humans and animals. My research in aquaponics arises from the urgent need to improve food-production systems. Aquaponics is an ancient food-production system, forgotten for many centuries. Aquaponics allows us to increase agricultural productivity while reducing the use of natural resources. It is a circular system with almost zero waste. I started my research in Germany, as a university student and I am now continuing to study this topic for my Ph.D. at Bologna University. I am also in collaboration with some aquaponic farms in northern Italy. *roberta.calone3@unibo.it

FRANCESCO ORSINI

I was always intrigued by how a traditional sector like agriculture could accept and integrate innovation. We always think of farming as a rural activity, even though most of the world's population lives in cities, and innovative technologies for plant cultivation in highly urbanized environments are available. After taking part in community farming projects in African, South-East Asian and Latin American cities, I started to perform research on urban agriculture in Italy and Europe. Today I teach urban agriculture at Bologna University and coordinate research in an EU project called Food Systems in European Cities (FoodE).