

Chapter 2) Understanding Aquaponics

Chapter Introduction:

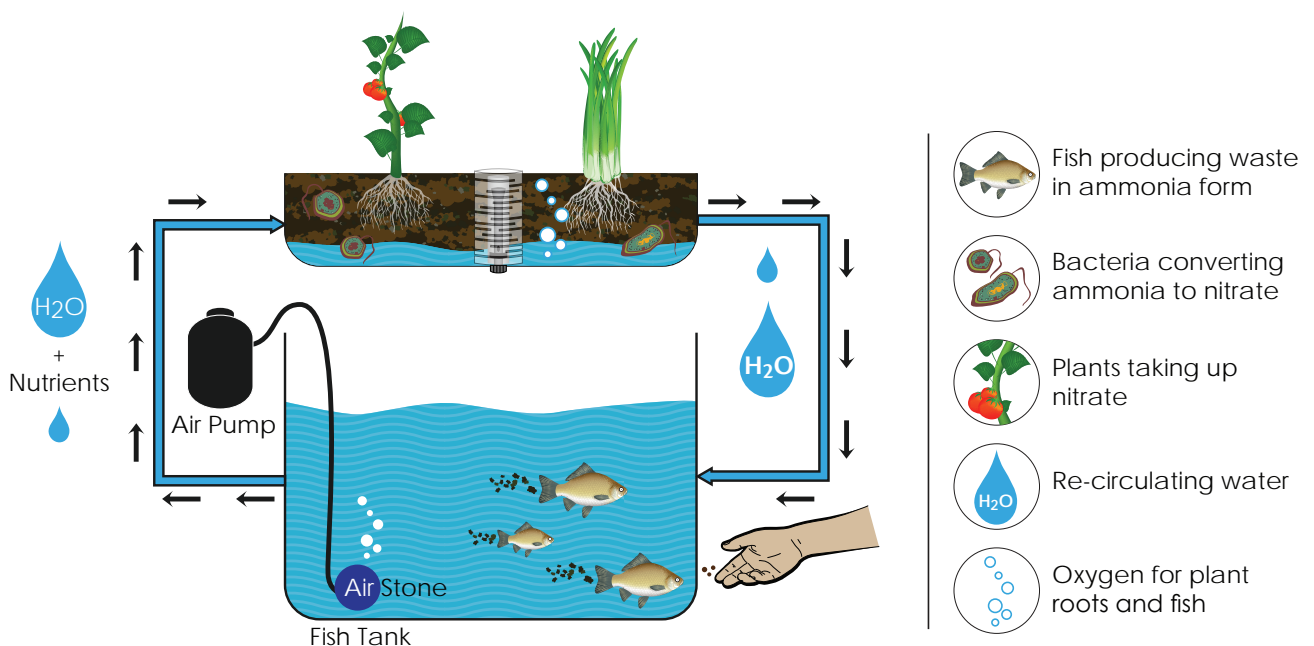
Building from the initial explanation of aquaponics in Chapter 1, this chapter goes into greater detail about the biological processes taking place in an aquaponics unit. First, the chapter will explain the major concepts and processes involved such as **the Nitrogen Cycle & the nitrification process**. Second, there will be an explanation of the vital role that bacteria play in key biological processes for aquaponics. Following this, there will be a discussion on the importance of balancing the aquaponics eco-system (fish, plants and bacteria) and the methods through which this can be achieved. The chapter will also cover the theoretical concepts for maintaining an aquaponics unit over time.

1) What is Aquaponics?

As described in Chapter 1, aquaponics is a form of organic soilless culture that combines two agricultural techniques, namely **aquaculture** and **hydroponics**. In one continuously recirculating unit, water containing fish waste passes from the fish tanks through a solids capture and a biofiltration process. It is here in the biofiltration process where bacteria convert the waste into accessible nutrients for plants. These nutrients, which are dissolved in the water, are then absorbed by the plants as the water passes through pipes, under rafts or media bed containers where the plants are rooted (see diagram below). This process of nutrient removal cleans the water, preventing the water from becoming toxic with harmful forms of nitrogen (ammonia and nitrite), and allows both fish and vegetables to thrive symbiotically. As such, both the fish and plants work together to create a healthy growing environment for each other.

This basic explanation of aquaponics introduces the major concepts at work in an aquaponics unit, but the main biological and chemical processes taking place need to be explained in greater depth in order to successfully manage the impacts on the fish, plants and bacteria.

Fig 2.1. The Biological Components in the Aquaponics Process



The Nitrogen Cycle:

The most important biological process in aquaponics is the **nitrification process**, which is an essential component of the overall **Nitrogen Cycle** seen in nature. But before we discuss these processes we'll briefly talk about nitrogen.

Nitrogen:

Nitrogen (N) is a chemical element and it is an essential building block for all life forms. Nitrogen is present in almost all amino acids which make up all proteins essential for many key biological processes for animals. It is also the most important inorganic nutrient for all plants.

Nitrogen, in gas form, is actually the most abundant element present in the Earth's atmosphere making up roughly 78% of it, with oxygen only making up 20%.

Yet, despite nitrogen being so abundant, it is actually only present in N_2 form (a very stable triple bond of nitrogen elements), which is inaccessible to plants. Therefore, nitrogen in its N_2 form must be 'fixed', or changed, so that plants can absorb it and use it for plant growth. **The nitrogen cycle**, seen all over in nature, facilitates this change or 'conversion' of nitrogen to other chemicals such as hydrogen or oxygen, making new chemical compounds like ammonia (NH_3) and nitrate (NO_3) that plants can easily use. This chemical change or 'fixation' is a completely natural process done by **bacteria** living in nature.

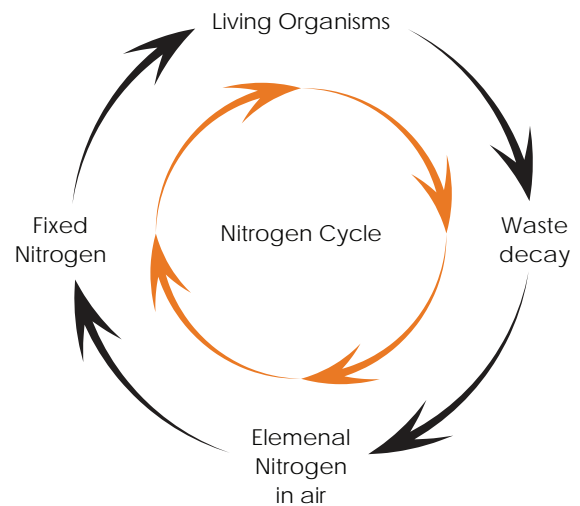
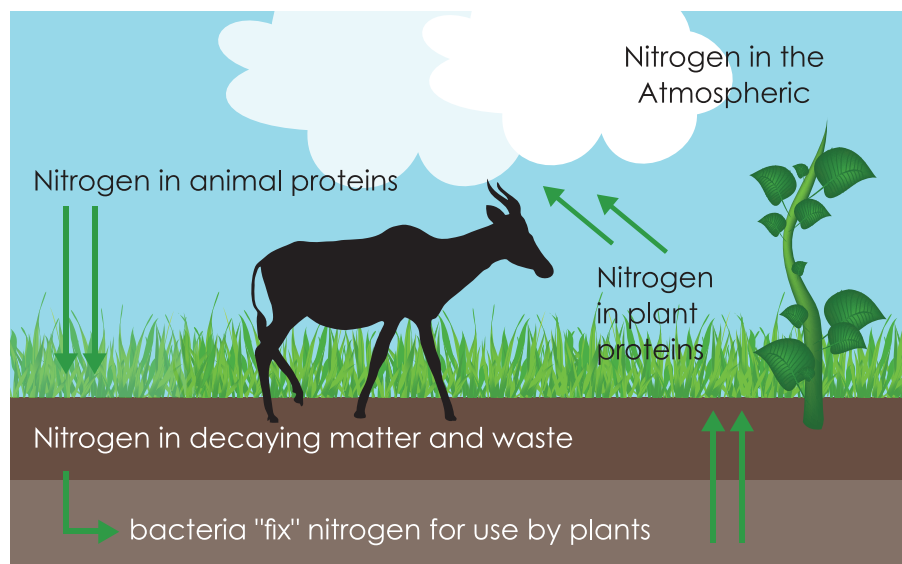


Fig 2.2 The Nitrogen Cycle

Fig 2.3 The Nitrogen Cycle in Nature



The small animal in the diagram above produces waste (faeces and urine) which is largely made up of ammonia (NH_3). Other decaying organic matter found in nature (like dead plants or dead animals) is also broken down by fungus and different bacteria groups into ammonia (NH_3).

This ammonia is then consumed or 'fixed' by a specific group of bacteria, which are very important for aquaponics, called '**nitrifying bacteria**'. These bacteria first convert the ammonia into nitrite compounds (NO_2^-) and then finally into nitrate compounds (NO_3^-). Plants then absorb the nitrate through their roots as a natural fertilizer which is then used for many growth processes.

So you can see from this simple explanation that **nitrifying bacteria**, which live in aerobic environments such as soil, sand, water and air, are the essential component of the nitrification process that converts plant and animal waste into accessible nutrients for plants.

The second diagram below (fig 2.4) shows the exact same process as the first one, but it includes a more complex flow chart showing you all the stages of the nitrogen cycle. At each section it highlights the type of bacteria and fungus working alongside the **nitrifying bacteria** which converts the ammonia from the plant and animal waste into nitrate – i.e. food for plants.

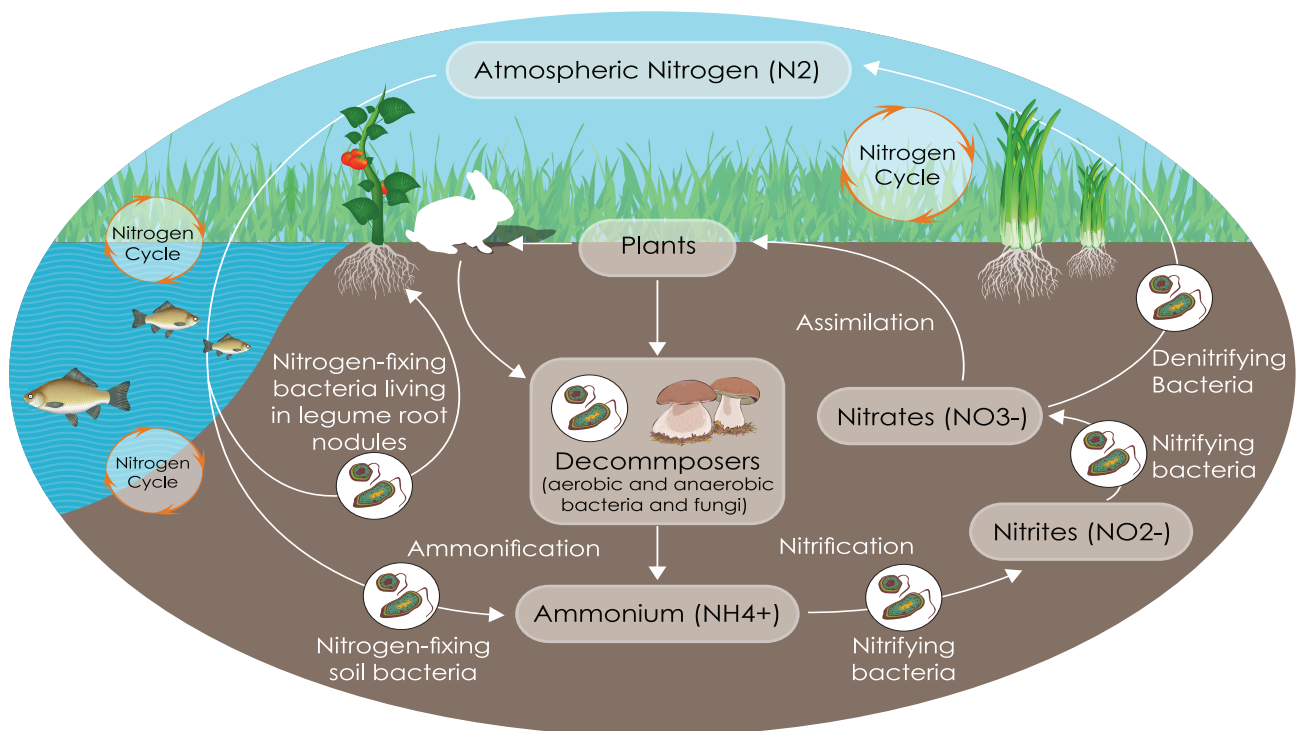


Fig 2.4 A More Detailed Description of the Nitrification Process Taking Place on the Soil Floor

Now, this natural process of nitrification by bacteria which happens in soil also takes place in water in the exact same way. So for **aquaponics**, the animal waste seen in the previous explanation is substituted with fish waste coming from the fish tanks. The same **nitrifying bacteria** that live on land will also naturally live in water and/or very moist conditions, converting ammonia from the fish waste into nitrate for plants to consume.