Removing nutrients in wastewater

Find out why and how we remove nutrients from wastewater.

Nutrients are essential

Nutrients are substances that provide nourishment or energy. Two of the essential elements to all life is nitrogen and phosphorous. These are essential nutrients that are used in living things for energy, building cell membranes, proteins and DNA.

Nutrients are necessary to sustain life in our waterways. But nutrients become pollutants when there is too much and can have harmful effects.

Nutrients in wastewater

Nutrients like nitrogen and phosphorous is commonly found and stored in natural materials. Nutrients are found in wastewater. They come from a wide range of household products like fertilisers, foods, soaps and detergents. Human waste is also a key source of these nutrients in wastewater.

Too much nitrogen and phosphorous, particularly when they are easily accessible in water can causes excessive plant growth. This can lead to eutrophication, where the overgrowth of weeds, algae and cyanobacteria (blue-green algae), cause algal blooms, depleting oxygen and killing animal life.

Did you know?

Wastewater that comes into our treatment plants are about 99% water! What's in the other one per cent?

High quality recycled water keeping creeks and rivers healthy.

Did you know?

You can help us reduce nutrient loads in wastewater by choosing eco-friendly products. Find out other ways you can help on our Wastewater treatment webpage.

To protect freshwater ecosystems, we need to treat wastewater to be safely discharged and recycled.

Removing nutrients in wastewater

To remove nutrients in wastewater we use secondary or biological treatment stages. We add billions of microorganisms (including good bacteria) suspended in the wastewater. We create environments that speed up natural biochemical processes. These microbes help us remove nitrogen that cause eutrophication, particularly nitrogen in forms easily used by plants (nitrates, nitrites and ammonia). We turn this nitrogen into nitrogen gas. Phosphorous is removed at the same time by phosphate accumulating organisms (POAs).

Sampling mixed liquor in aeration phase.

Most of the nutrients (nitrogen and phosphorus) are removed through a combination of aerobic (plenty of oxygen), anoxic (low oxygen) and anaerobic (no oxygen) processes.

Removing nitrogen and phosphorous

Nitrogen

Nitrogen removal is done through aerobic and anoxic processes.

Aerobic zone

Nitrification is an aerobic process, which involves converting ammonium (NH_4) in wastewater into nitrates. Two types of bacteria are responsible for nitrification, Nitrosomonas and Nitrobacter. The Nitrosomonas oxidise ammonia, largely from urine, to the intermediate product nitrate (NO_2). The Nitrobacter convert nitrate to nitrite (NO_3). The conversion of ammonia to nitrite involves a complex series of reactions. Significant oxygen is required for the conversions. Aeration supplies the oxygen needed by the bacteria to drive the reaction.

Approximate equations for the reactions can be written as:

For Nitrosomonas:

$$2NH_4 + 3O_2 \rightarrow 2NO_2^- + 2H_2O + 4H + \text{new cells}$$

For Nitrobacter:

$$2NO_2 + O_2 \rightarrow 2NO_3^- + \text{new cells}$$

Anoxic zone

The next step in the process is removing nitrate and forming nitrogen gas (or denitrification). An anoxic environment is critical to enable denitrification. Under anoxic conditions, there is no 'free' oxygen in the water. Facultative bacteria use either 'free' oxygen, or the oxygen in nitrate for their metabolic processes. When there is no 'free' oxygen, they can only use the oxygen from nitrate for their metabolic processes, resulting in the release of nitrogen gas. Several types of bacteria are responsible for converting nitrate to nitrogen gas (N_2). The basic path for reducing nitrate to nitrogen gas is:

$$\underset{\text{nitrite}}{NO_3^-} \rightarrow \underset{\text{nitrate}}{NO_2^-} \rightarrow \underset{\text{nitric oxide}}{NO} \rightarrow \underset{\text{nitrous oxide}}{N_2O} \rightarrow \underset{\text{nitrogen gas}}{N_2}$$

Phosphorous

Removal of phosphate by phosphate accumulating organisms (POAs) is a two-step process. POAs initially release phosphorus to the mixed liquor (wastewater and activated sludge containing microorganisms) under anaerobic conditions. Later in an aerobic phase, POAs take up much larger quantities of phosphorus. We can then remove this phosphorus as part of excess sludge.

Did you know?

We turn recycle organic solids into a safe and reusable fertiliser called biosolids. See our Wastewater treatment and Solids recycling webpage for more information.

Anerobic zone

In the anaerobic zone, volatile fatty acids (VFAs) are introduced as additional food for the POAs. When there is no oxygen available, the POAs take up the VFAs and release phosphate to the mixed liquor.

The POAs now have a large supply of energy in the form of stored volatile fatty acids for metabolism and growth.

Aerobic zone

In the aerobic zone, there is a large increase in the mass of POAs, which are now capable of absorbing much more phosphorus from the mixed liquor than they released during the anaerobic stage. The phosphate is now part of the bacterial cell mass and is removed as sludge in the clarifier.

Removing nutrients is important to protect the environment but is also important to improving efficiency at water recycling plants. High nutrient levels can affect equipment such as reverse osmosis membranes.

Find out more

See our St Marys Advanced Water Recycling Plant page to learn about reverse osmosis and The Replacement Flows Project.