SILVERGLEN GROUP

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TECHNICAL NOTE · SUBJECT

# Technical Explanation of Biofilm Degradation, Biomass Mineralization, and Nutrient Fate in the Biopipe System

The Biopipe wastewater treatment system operates through a naturally established, self-regulating microbial biofilm. The biological processes occurring within this biofilm include organic matter oxidation, hydrolysis, endogenous respiration, nitrification, and denitrification.

Organic matter oxidation | Hydrolysis | Endogenous respiration | Nitrification | Denitrification

To understand the fate of dead bacteria, excess biofilm, and inorganic nutrients, it is important to distinguish between organic matter degradation and inorganic nutrient transformation.

## 1 What happens to dead bacteria and excess biofilm?

The microorganisms forming the biofilm have a natural life cycle involving growth, reproduction, death, and decomposition.

When bacterial cells die, their organic cellular components can be broken down by extracellular enzymes and other microorganisms within the microbial community. This process is known as microbial lysis and biodegradation.

The resulting organic compounds can subsequently be utilized by active microorganisms as carbon and energy sources.

Through endogenous respiration and mineralization, much of this biodegradable material is ultimately converted into:

| $CO_2$ | $H_2O$ | $NH_4^+$ |
|---|---|---|
| Carbon dioxide | Water | Ammonium and other inorganic nutrients |

The Biopipe system promotes these processes through continuous wastewater circulation, oxygen transfer, and the coexistence of different microbial populations within the biofilm.

Hydraulic shear also limits excessive biofilm accumulation by detaching aged or excess biomass. Detached material may undergo further biodegradation or be retained by the final filtration system.

> **Consequently,** Biopipe is designed to minimize excess biological sludge production and eliminate the need for conventional sludge recirculation, settling, and dewatering equipment.

## 2 What happens to nitrates?

Nitrate removal occurs primarily through biological denitrification.

The Biopipe biofilm contains oxygen-rich outer regions and oxygen-limited inner regions. These different microenvironments allow nitrification and denitrification to occur within the same biological reactor.

During nitrification, ammonium is converted into nitrate under aerobic conditions.

During denitrification, specialized microorganisms use nitrate as an electron acceptor under anoxic conditions, converting it into nitrogen gas ($N_2$).

This nitrogen gas can subsequently escape from the wastewater into the atmosphere.

> Therefore, nitrate is not removed through phagocytosis or physical filtration. It is biologically transformed into gaseous nitrogen through microbial metabolic reactions.

## 3 What happens to phosphorus (phosphates)?

During microbial growth, bacteria incorporate dissolved phosphorus into their cellular structures. As the biofilm naturally renews itself, portions of the biomass detach from the pipe surfaces and are transported toward the final cartridge filtration stage.

This detached biomass contains phosphorus that was previously assimilated during microbial growth. When the biomass is captured and subsequently removed through filter cleaning, the phosphorus associated with it is also removed from the treatment system.

Additionally, phosphorus associated with incoming suspended particles may be physically retained by the filtration stage.

Therefore, the observed reduction in Total Phosphorus is believed to result primarily from biomass assimilation and subsequent filtration rather than a dedicated biological phosphorus removal mechanism.

> **Important:** the extent of phosphorus reduction depends on wastewater characteristics, microbial growth, biomass detachment, and filtration performance. Biopipe does not guarantee a specific phosphorus removal efficiency.

## 4 What happens to potassium?

Potassium removal is not a claimed treatment function of the Biopipe system.

Although potassium is an essential nutrient for microbial metabolism and may be temporarily incorporated into bacterial cells, it is not biologically degraded or destroyed.

Potassium released during microbial decomposition generally returns to the dissolved phase.

> Consequently, Biopipe does not claim significant or guaranteed potassium removal, and potassium is expected to remain predominantly in the treated effluent.

## 5 Why does Biopipe not require conventional sludge handling?

The sludge-minimization mechanism of Biopipe is based on the combination of:

- Attached-growth microbial communities rather than conventional suspended-growth activated sludge.
- Continuous biodegradation and mineralization of organic matter.
- Endogenous respiration and recycling of biodegradable cellular material.
- Hydraulic shear that helps regulate biofilm thickness.
- Final filtration to capture detached biomass and residual suspended particles.

These mechanisms reduce the accumulation of excess biological solids and eliminate the need for the conventional sludge handling equipment normally associated with activated sludge treatment.

> It is important to distinguish between eliminating conventional sludge handling and claiming that all solid matter or inorganic nutrients disappear completely.

## Conclusion

The Biopipe system does not rely on bacteria physically consuming every substance present in wastewater. Instead, different pollutants undergo different biological and physical transformations:

| Component | Main transformation | Fate |
|---|---|---|
| **Organic matter and dead biomass** | Lysis, biodegradation, endogenous respiration, and mineralization | $CO_2$, $H_2O$, ammonium, and other inorganic nutrients |
| **Nitrogen (ammonium and nitrates)** | Nitrification and denitrification in the biofilm | Nitrogen gas ($N_2$), which escapes into the atmosphere |
| **Phosphorus** | Biomass assimilation and retention in filtration | Removed with filter cleaning; no guaranteed efficiency |
| **Potassium** | No claimed removal | Remains predominantly in the treated effluent |
| **Excess biomass** | Detachment by hydraulic shear and further biodegradation | Biodegraded or retained by the final filtration |

This distinction explains how Biopipe can achieve effective organic matter and nitrogen removal while minimizing biological sludge production through a self-regulating attached-growth ecosystem.