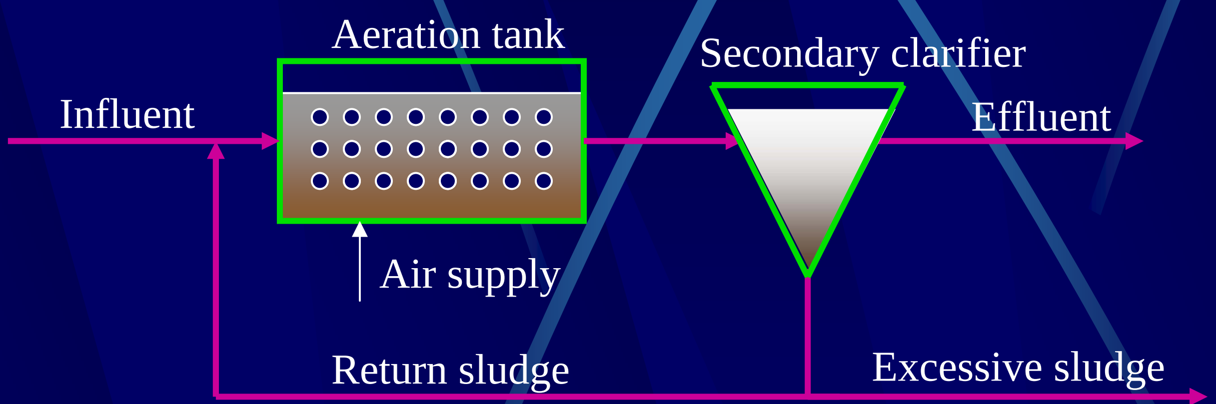
Advanced Treatment in Activated Sludge Process

Activated sludge process



Traditionally, activated sludge process is used to remove organic carbon (COD) from wastewaters (municipal and industries).

In the process, microorganism in the sludge obtain their energy for cell synthesis (growth) through breaking down organic compounds into inorganic compounds (carbon dioxide) with oxygen as an electron acceptor.

Since 1970s, eutrophication in inland waters results in the world-wide concern about nutrient (N, P) removal from wastewaters. Traditional activated sludge processes are expanded to be applied in successfully removing N and P from water and wastewaters.

Nitrogen Removal (Nitrification and Denitrification)

Nitrification

$NH_4^+ + 3/2O_2 \xrightarrow{\textit{Nitrisomenas}} NO_2^- + H_2O + 2H^+$

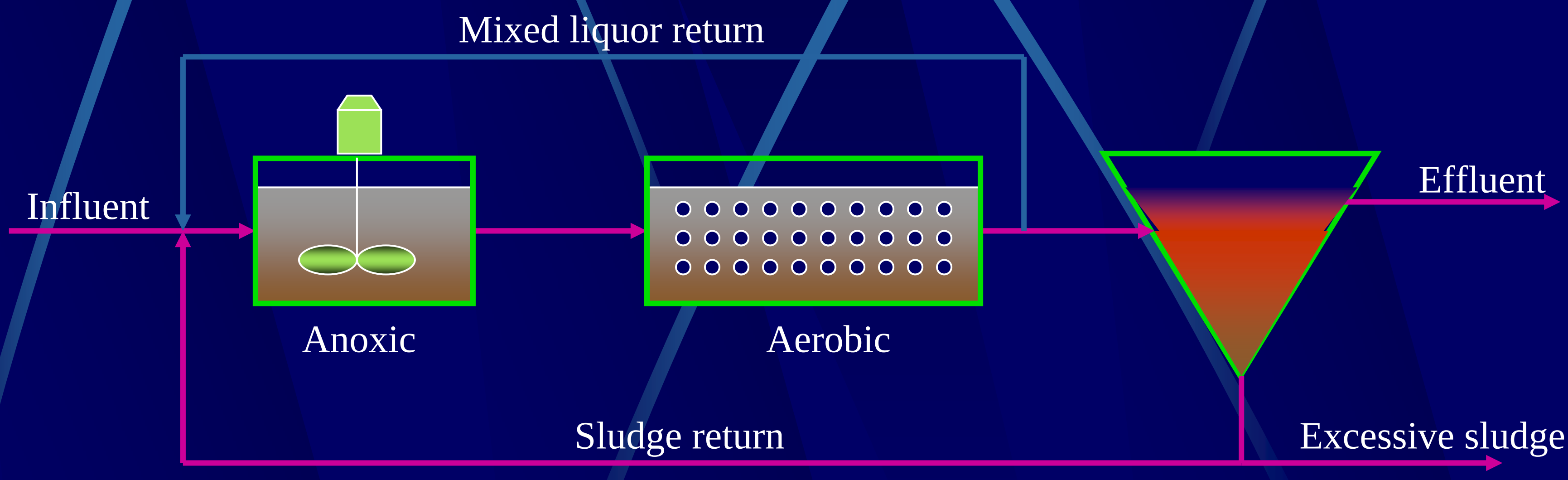
$NO_2^- + 1/2O_2 \xrightarrow{\textit{Nitrobacter}} NO_3^-$

Denitrification

$NO_3^- + Org \xrightarrow{\textit{Denitrifiers}} N_2 + CO_2 + H_2O + OH^-$

Nitrification and denitrification can be achieved in activated sludge process and biofilm process. However, activated sludge process is the most widely used process in municipal and industrial wastewater treatment.

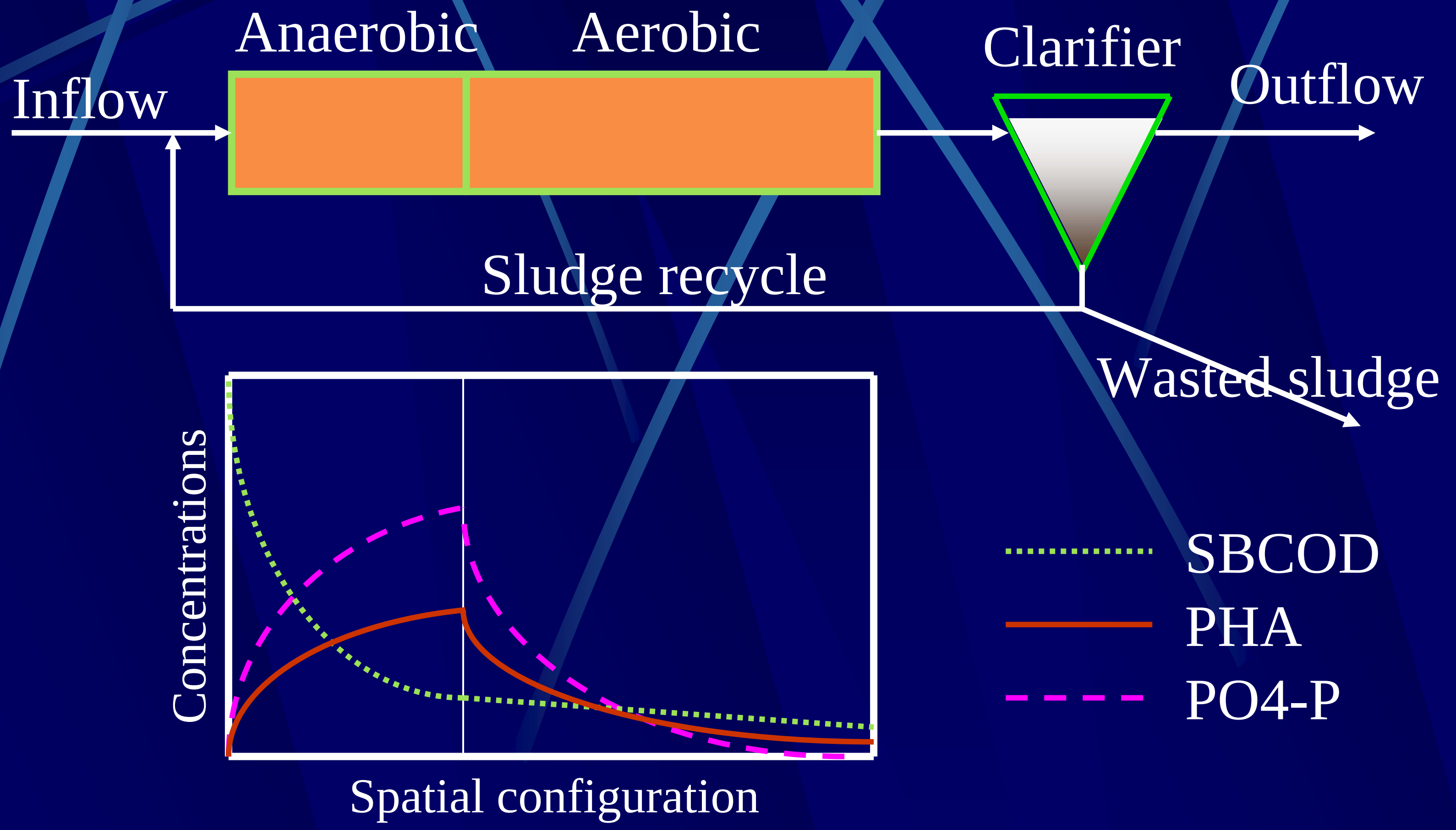
Single-stage Activated Sludge Nitrogen Removal Process



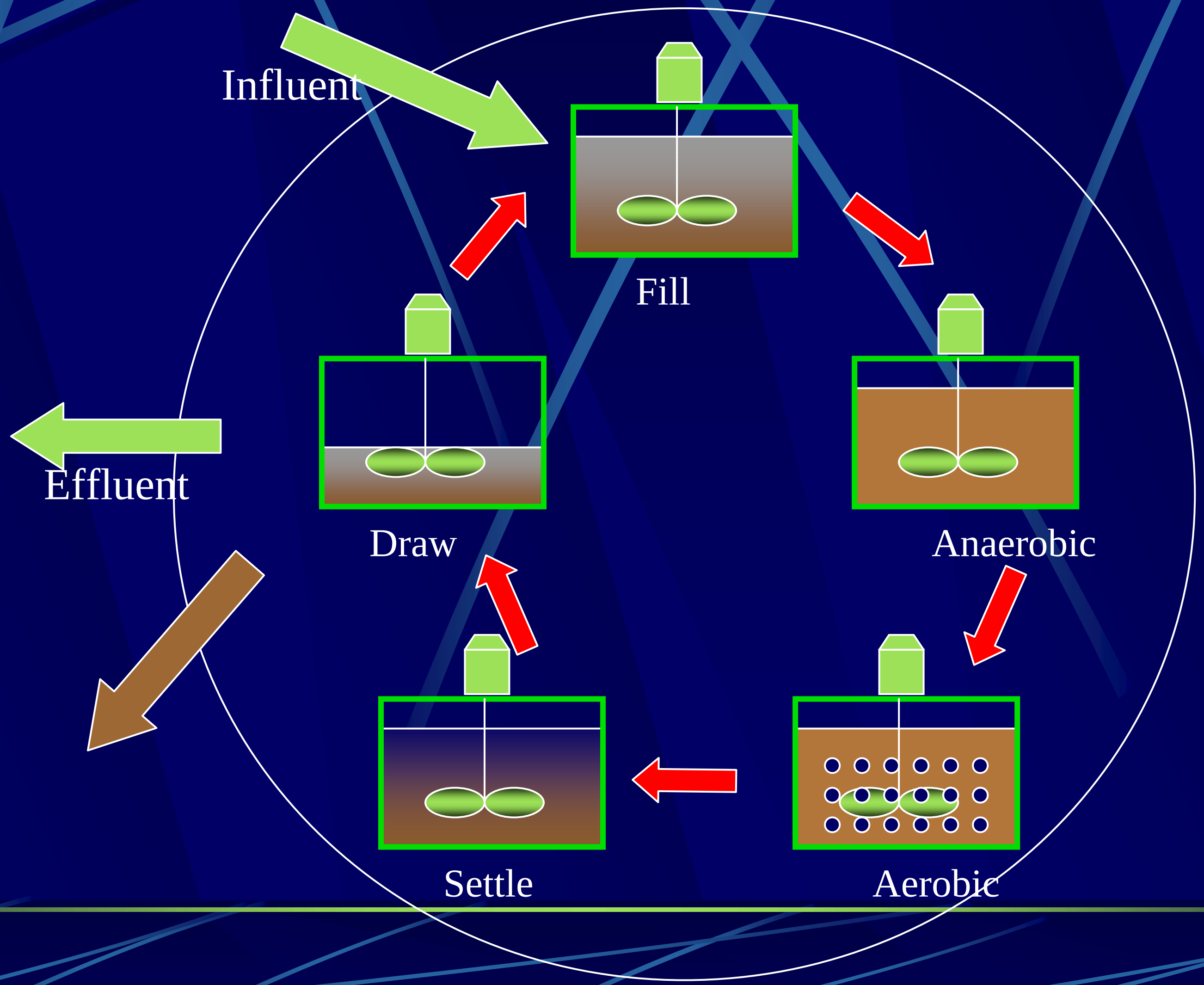
Phosphorous Removal (EBPR)

Activated sludge processes with alternating anaerobic and aerobic conditions have been successfully used for enhanced biological phosphorous removal (EBPR) from wastewater. This anaerobic-aerobic alternation can be achieved either by spatial configuration of anaerobic and aerobic zones in series in continuous flow systems with sludge recycle or by temporal arrangement of anaerobic and aerobic periods in sequence batch reactors.

Spatial Configuration of Anaerobic and Aerobic Zones in Series in Continuous Flow Systems

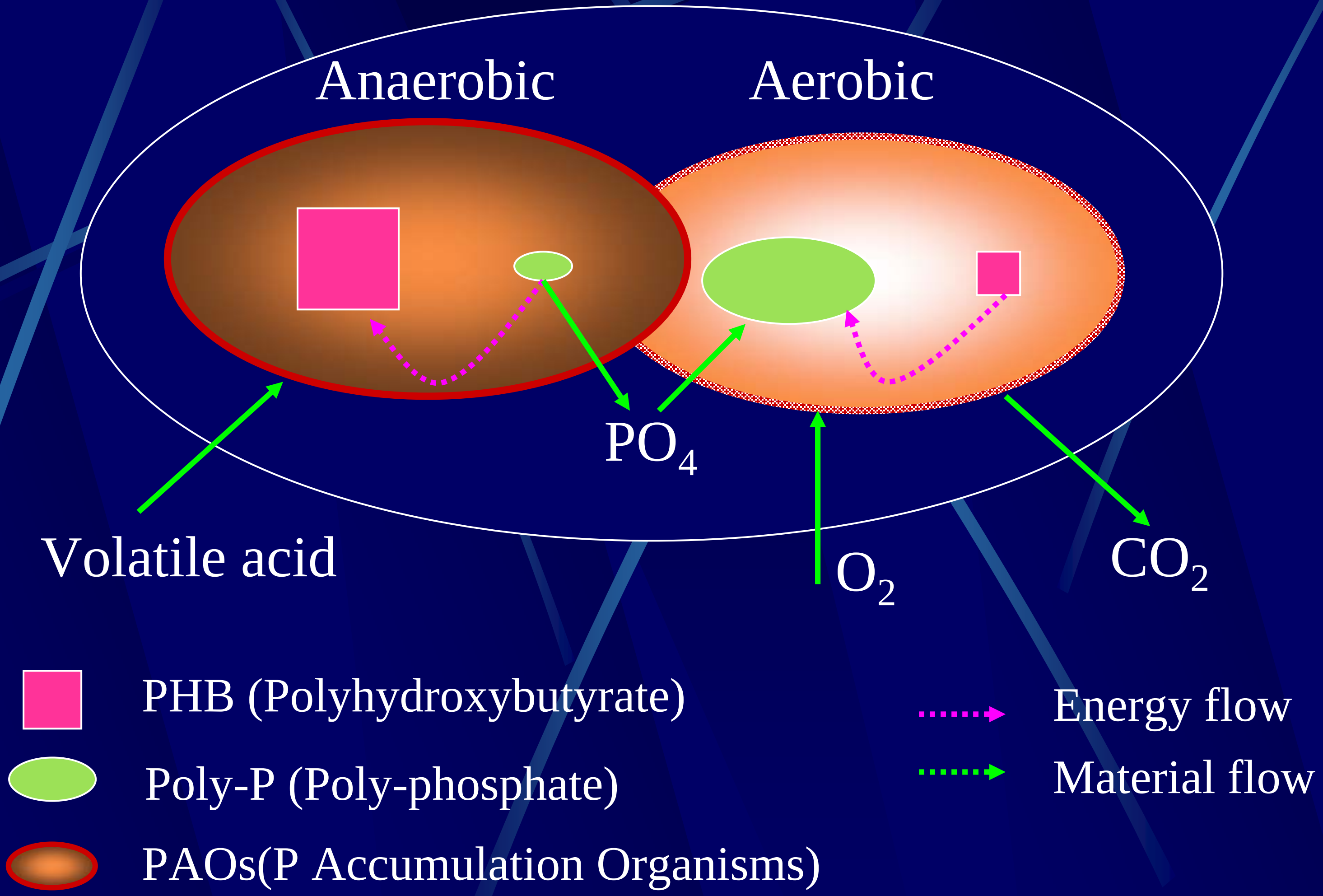


Temporal Arrangement of Anaerobic and Aerobic in Sequence Batch Reactor



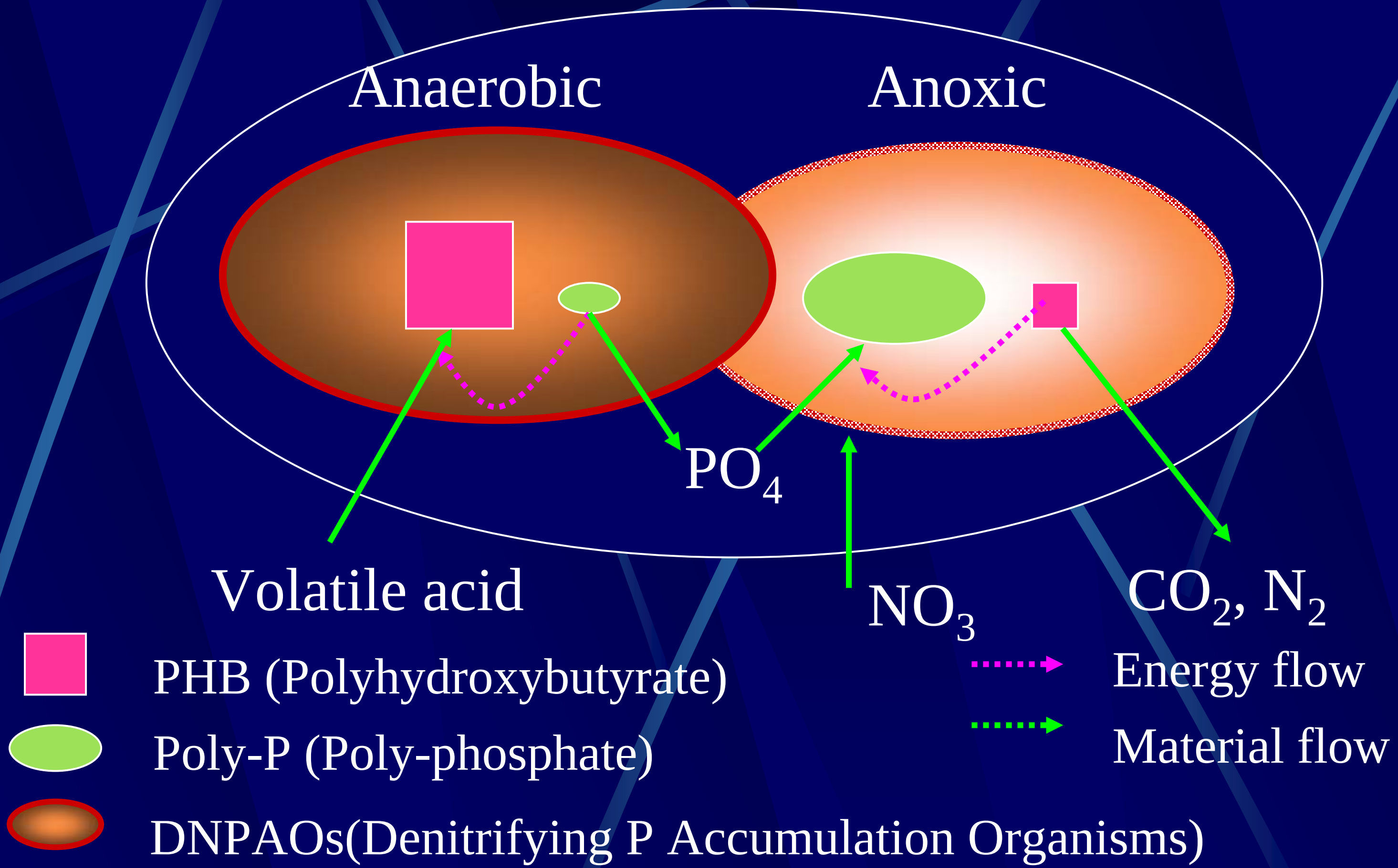
Polyphosphate-accumulating bacteria (PAB) play an essential role for EBPR in the anaerobic-aerobic process. To achieve high and stable phosphorous removal, it is essential to maintain a high percentage of PAB in the sludge of EBPR system.

- The mechanism of proliferation of PAB can be described as follows. It is typically observed in the anaerobic stage that the activated sludge releases P_i to the bulk solution with concomitant uptake of organic substrates. In the subsequent aerobic stage, it takes up more P_i than has been released in the previous anaerobic stage. The P_i removed from the wastewater is accumulated in the cell as polyP. Polyphosphate is a high-energy compound and its hydrolysis can supply energy to various biochemical reactions in the cell. In the anaerobic stage, the hydrolysis of intracellular polyP enables PAB to obtain the energy they need to take up organic substrates. Without electron acceptors (oxygen, NO_2^-/NO_3^-), aerobic bacteria and denitrifying bacteria are unable to obtain the energy required for the utilization of organic substrates, and they are thus unable to compete with PAB. Therefore, the introduction of the anaerobic stage leads to the precedence of PAB and to a rise in phosphorus content of the sludge. By withdrawing the phosphorus-rich sludge from the system as excess sludge, high phosphate removal efficiency can be achieved.



Reaction: Org + $O_2 \longrightarrow CO_2$ + Energy

Material balance (PAOs)

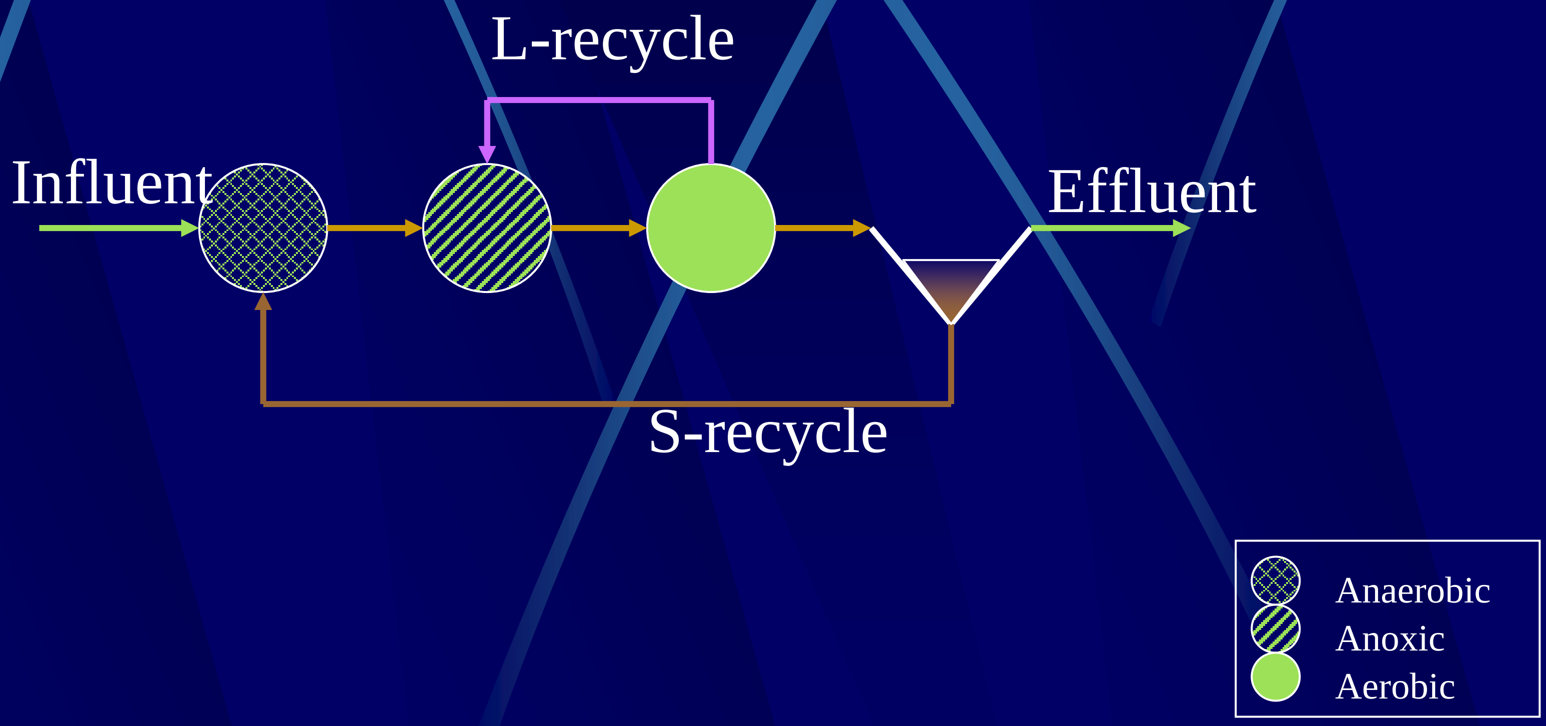


Reaction: Org + $NO_3 \longrightarrow CO_2 + N_2$ + Energy

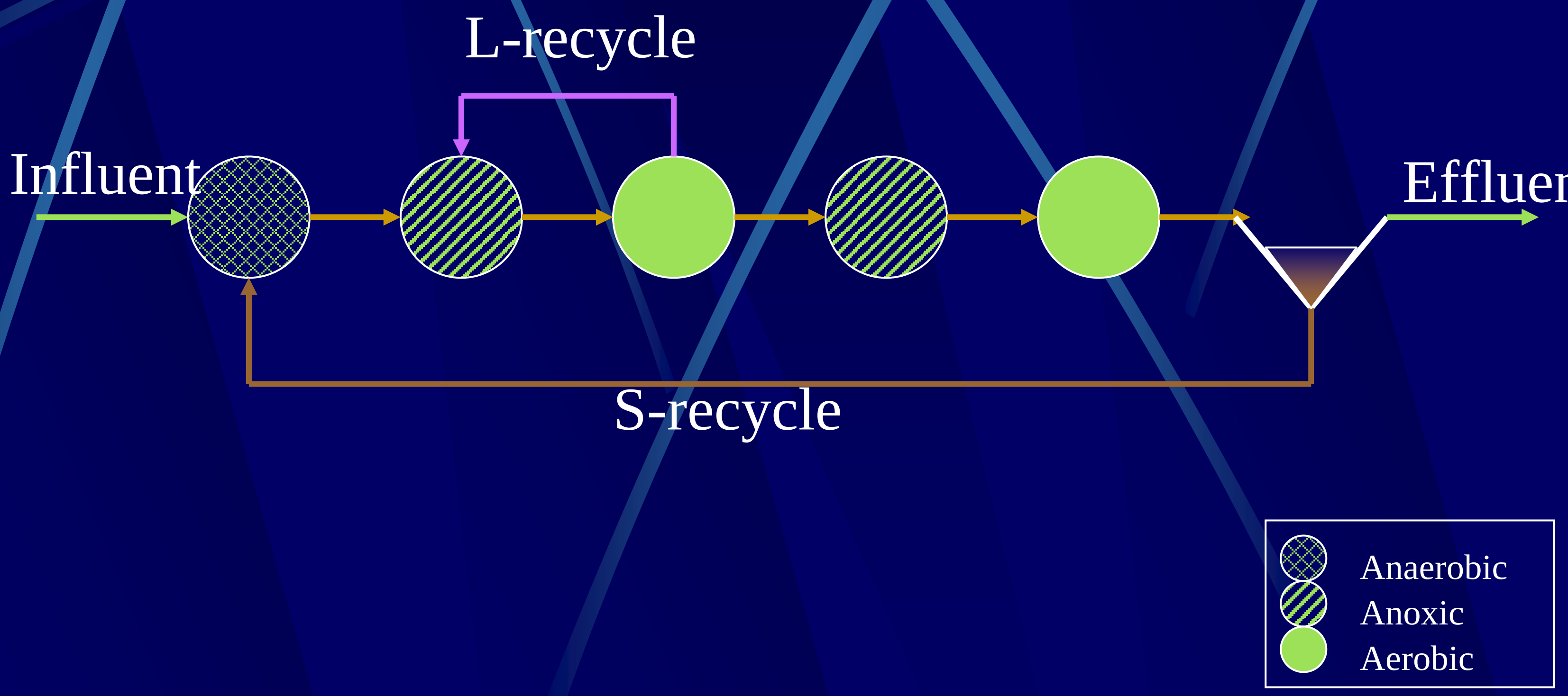
Material balance (DNPAOs)

Simultaneous nitrogen and phosphorus removal (DNEBPR)

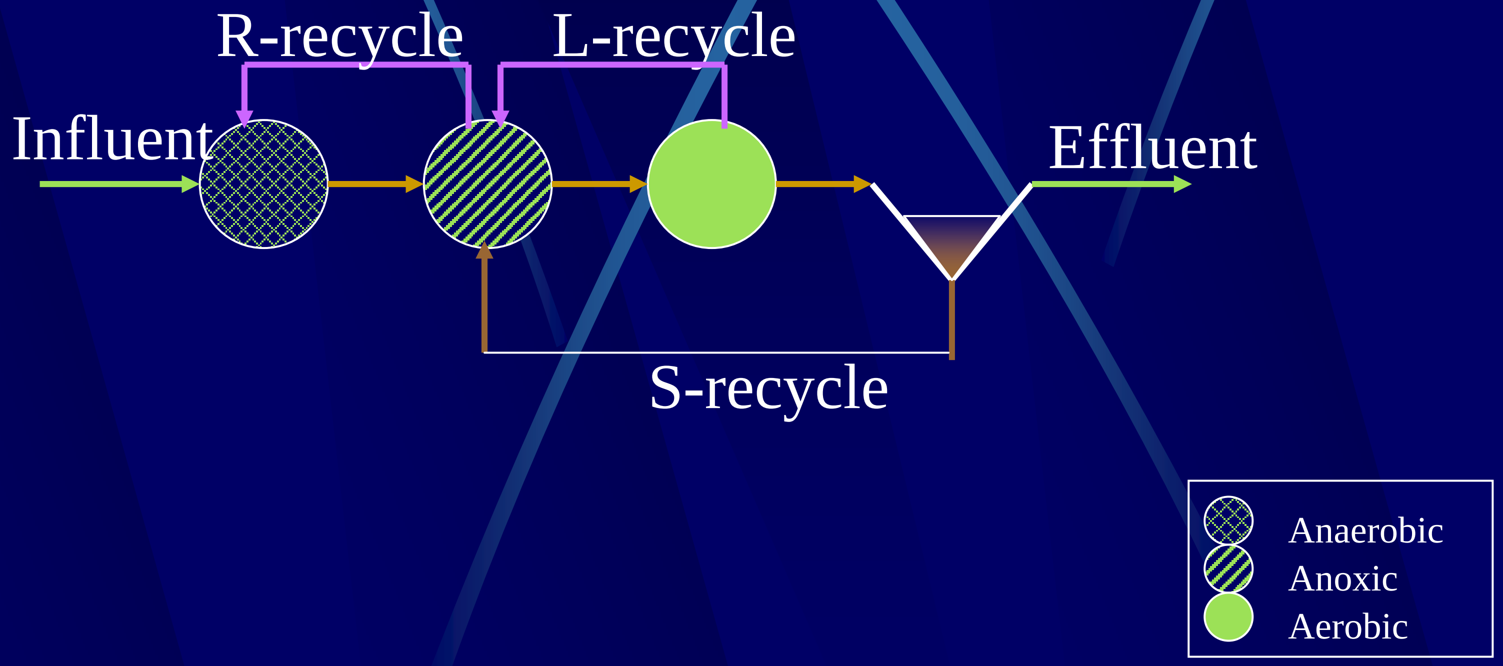
Bardenpho process



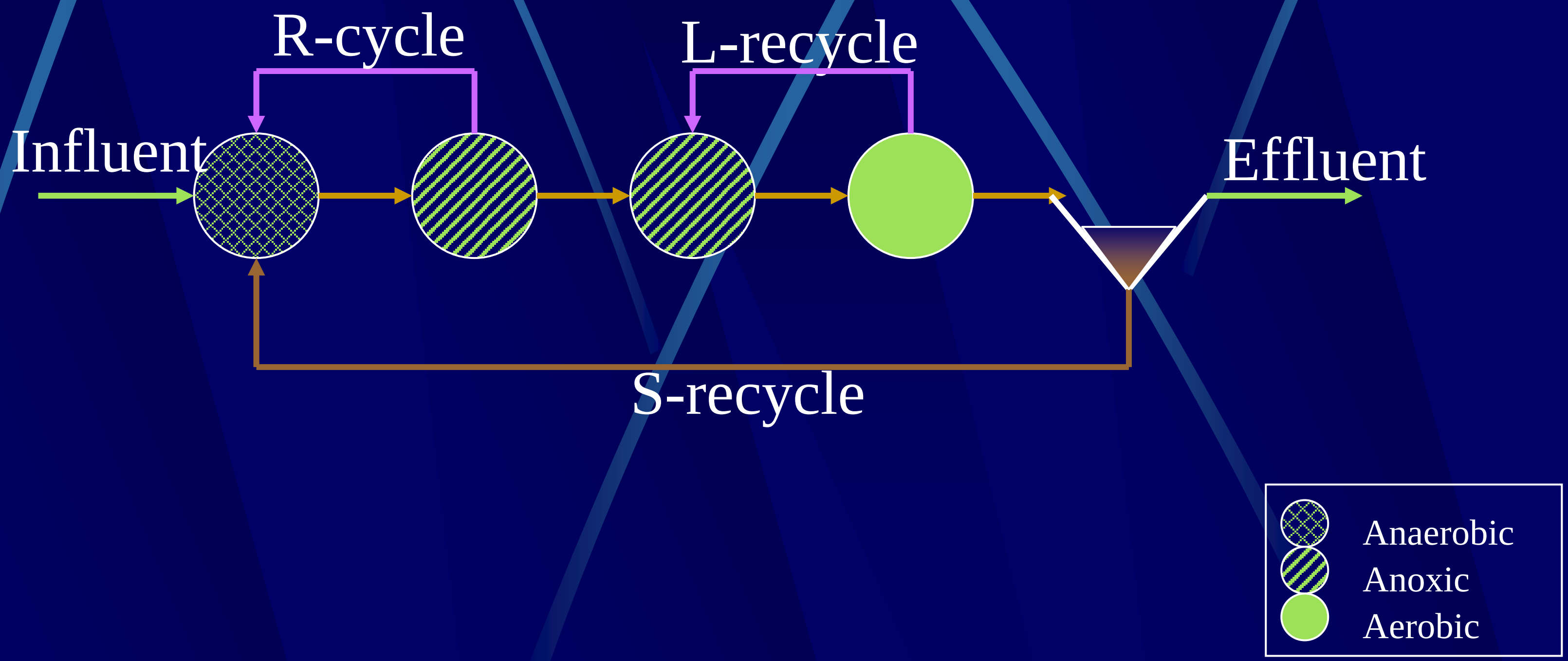
Modified Bardenpho process



UCT process


R-recycle
L-recycle
Influent
Effluent
S-recycle
Anaerobic
Anoxic
Aerobic

Modified UCT process



Johannesberg process (JHB)