

Bardenpho® Process

Biological Nutrient Removal System



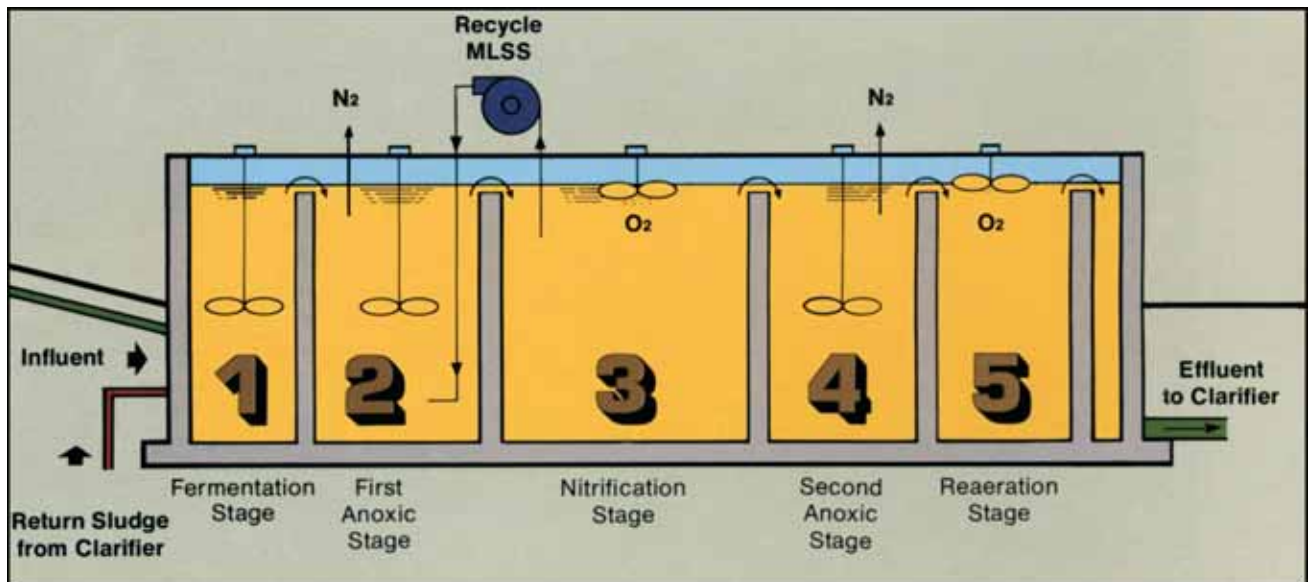
Biological Nutrient Removal System

Operating Principle

Bardenpho® Biological Systems represent an advance modification of the activated sludge process consisting of a multi-stage biological reactor. High levels of BOD, suspended solids, nitrogen, and phosphorus removal are consistently achieved without the use of chemicals.

Influent is mixed with activated sludge, returned from the final clarifier, in the fermentation stage. After contact, liquid is transported to an anoxic zone where it is mixed with nitrates from the nitrification zone. Oxygen, which is added in the nitrification zone, converts BOD to carbon dioxide, and ammonia to nitrate. In the second anoxic zone, nitrate is reduced to nitrogen gas.

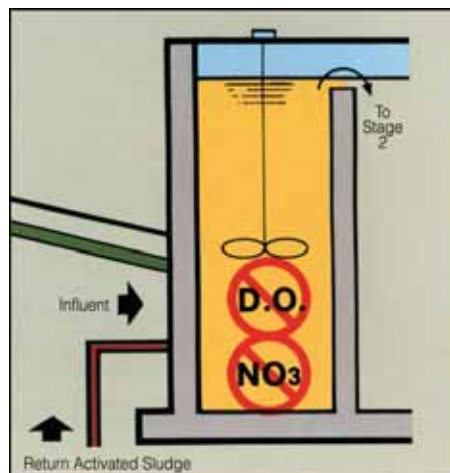
The final stage of the Bardenpho Process is a reaeration zone where the dissolved oxygen concentration is increased to prevent phosphorus from being released in the final clarifier.



Process Description

Fermentation Stage

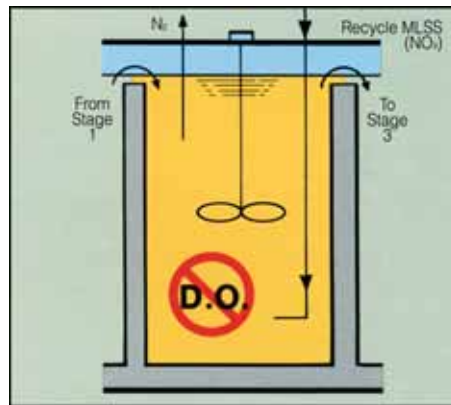
Activated sludge, consisting of a broad spectrum of organisms, is returned from the clarifier to the fermentation stage. This sludge is contacted with the plant influent to produce the appropriate stress condition that allows large quantities of phosphorus to be removed from the wastewater biologically in subsequent aerobic stages. Organism stress occurs in the absence of dissolved oxygen (DO) and nitrates (NO_3).



The Bardenpho Process

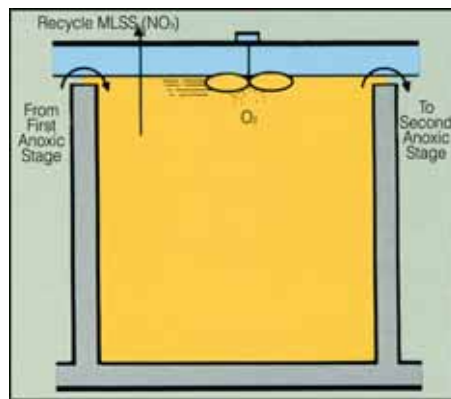
First Anoxic Stage

Mixed liquor containing nitrates from the third stage is recycled to the first anoxic stage. Here it is mixed with conditioned sludge from the fermentation stage in the absence of oxygen. Bacteria utilize BOD in the influent, reducing the nitrates to gaseous nitrogen. Approximately two-thirds of the influent nitrogen is removed in the first anoxic stage.



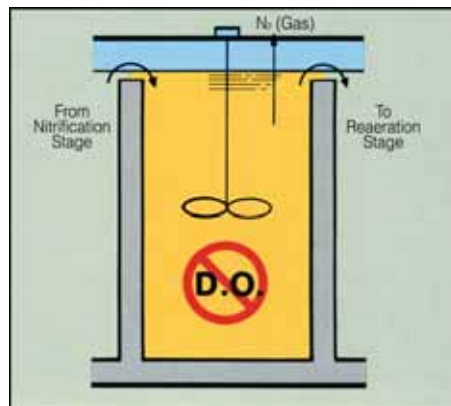
Nitrification Stage

Oxygen is introduced in the nitrification stage to oxidize BOD and ammonia. BOD is converted to new cell mass and carbon dioxide. Ammonia is converted to nitrate. Mixed liquor, containing the nitrates, is recycled back to the first anoxic stage. Luxury phosphorus uptake by the organisms occurs in this stage.



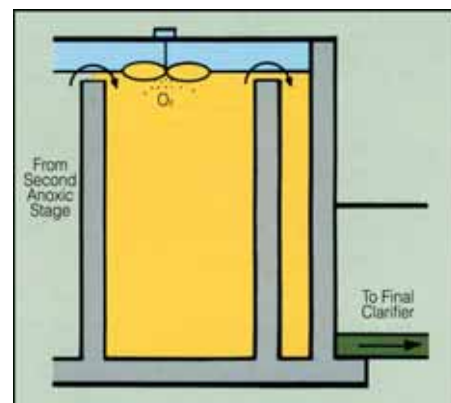
Second Anoxic Stage

Nitrate, recycled to the first anoxic stage, is introduced to the second anoxic stage where it is reduced (in the absence of oxygen) to nitrogen gas. This produces a low effluent nitrate concentration.



Reaeration Stage

When maintained in an aerobic environment, the Bardenpho system mixed liquor contains 5% to 6% phosphorus. If the sludge is permitted to become septic, phosphorus could be released in the final clarifier. Subjecting the sludge to reaeration introduces additional oxygen to the mixed liquor, insuring that it remains aerobic, thus retaining phosphorus.

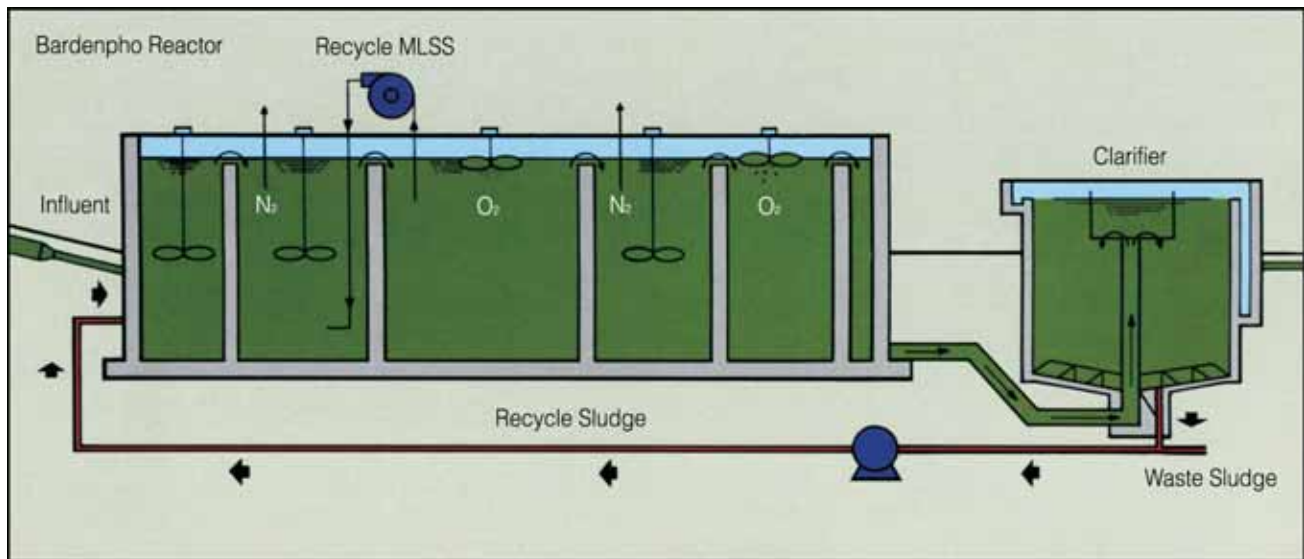


The Bardenpho Process

The overall Bardenpho Process is similar to a conventional activated sludge flowsheet. Raw or settled sewage (waste) enters the biological reactor and is mixed with return settled sludge. Mixed liquor from the reactor flows to

a clarifier where biological solids are removed from the treated wastewater and are recycled to a reactor basin. A portion of the sludge is wasted, removing excess

cell material generated during processing. Sludge wasting also removes phosphorus from the system.



Removal of Nutrients, Nitrogen and Phosphorus

No Expensive Chemical Required
Low effluent concentrations of BOD, nitrogen and phosphorus are achieved using the Bardenpho Process with little or no costly chemical additives. Reliability has been demonstrated at installations obtaining an AWT 5-5-3-1 effluent (BOD, SS, N, P).

Operating costs are lower than conventional nutrient removal processes. Also, the stable sludge can be disposed of directly, not like voluminous hard to handle chemical sludges.

Simple and Stable Operation
Bardenpho Systems are similar to conventional activated sludge plants, and personnel do not require retraining. The flowsheet is simple, with few control parameters to measure and adjust.

Compatible with the Carrousel® Biological Oxidation Systems
Typically, a Carrousel System is used as the nitrification stage in the Bardenpho Process. Many advantages associated with the Carrousel System therefore are inherently obtained. These advantages include lower construction and energy costs, while improving control and performance.

Existing Carrousel Systems can be upgraded to a Bardenpho Process when regulations change, requiring strict control of nitrogen and phosphorus.

Low Cost System
By eliminating chemicals from the process, Bardenpho Systems can reduce operating costs as much as \$400,000 per MGD over an estimated 20 year life. Other operating costs are similarly reduced.

Construction costs for a Bardenpho System are comparable to conventional activated sludge plants designed for secondary treatment, and only one-third to one-half that of other AWT plants.

Complete Process Design and Technical Support Services
Our company provides complete Bardenpho design and technical support services for Bardenpho Process treatment facilities. Our engineers have applied this proprietary technology* in designing over forty installations for the world's most sensitive and closely regulated watersheds. Perhaps the most telling tribute to the flexibility and effectiveness of the Bardenpho Process is the fact that every one of these facilities operates in full compliance with its discharge permit.



**Bardenpho systems include the wastewater treatment processes covered by Elmco Water Technologies U.S. patent number 3,964,998 and Bardenpho design, licensing, technical and start-up assistance services for treatment basins utilizing these processes.*

Typical Operating Installations - Bardenpho Process

Palmetto, Florida

Operation of the Palmetto, Florida advanced secondary treatment system began in October 1979. It is the first Bardenpho Process treatment facility in North America and is rated at 1.4 MGD. Performance results for six months of 1983, which are shown below, are typical of the outstanding performance achieved since start-up.

Note the wide variation of influent conditions - flow from .89 MGD to 1.6 MGD; BOD₅ from 156 to 76; SS from 136 to 62. This demonstrates the ability of the Bardenpho Process to adapt to variations in flow and wastewater concentration. Influent TKN was typically about 35 mg/l and phosphorous about 6 mg/l. Effluent quality for each constituent is below State and Federal requirements.



PALMETTO, FLORIDA WWTP PERFORMANCE RESULTS

Monthly Averages - 1983

Influent	June	July	August	September	October	November
Q, MGD	0.89	0.95	1.58	1.6	1.14	1.1
BOD, mg/l	156	127	76	81	92	132
SS, mg/l	136	122	62	65	128	133
Effluent						
BOD, mg/l	1.6	1.5	2.2	1.5	1.7	1.8
SS, mg/l	2	1	1.2	1.4	1.4	1.6
Total N, mg/l	2.4	2	2.5	2.5	2.4	2.8
NO, N, mg/l	1.3	1.3	1.6	1.7	1.7	1.8
NH, N, mg/l	0.4	0.2	0.4	0.4	0.3	0.3
Total N, mg/l	*1.7	*1.2	0.6	0.5	*1.0	0.4

* Alum was not being added for phosphorus removal during the indicated months. Alum was added during the months without asterisks for removal of P. A minimal dosage of alum is typical added immediately upstream of final clarification.

Typical Operating Installations - Bardenpho Process

Orange County Florida Easterly Sub-regional WWTP
 The Easterly Orange County Wastewater Treatment Plant began operation as a 6 MGD facility in early 1984. It consists of a full 5-stage Bardenpho Process with Carrousel aeration used in the nitrification stage.

The Easterly Orange County Bardenpho flowsheet is designed for Overland Flow / Wetlands effluent disposal. This requires a very high quality effluent which is consistently as good as the receiving water for protection of Wetland wildlife. Thus alum polishing is used to trim effluent phosphorus values to well below 1mg/l.

Other facilities worldwide currently have operating Bardenpho Systems and more are in design and construction phases. These

plants range in size from about 1 MGD to over 40 MGD with various climatic and influent conditions.



EASTERLY ORANGE COUNTY, FLORIDA PERFORMANCE RESULTS				
Monthly Average - 1985				
Effluent	Bod	TSS	TN	TP
January	2	2	1.9	0.2
February	2	1	1.5	0.2
March	2	1	1.3	0.2
April	2	2	1.6	0.4
May	2	2	2.3	2
June	2	1	1	1.7
July	2	2	2.9	1.9
August	2	2	2.9	1.9
September	2	2	2.5	0.4
October	1	2	1.7	0.2
November	2	2	2.1	0.3
December	2	1	2.5	0.7

Advantages and Benefits of the Bardenpho Process

Benefits

No Chemicals	<ul style="list-style-type: none">• Lower operating costs• No chemical sludge to dispose
Low Capital Cost	<ul style="list-style-type: none">• Comparable to conventional waste treatment plants• Biological nitrogen and phosphorus removal without costly chemical feed systems• Simple design minimizes construction
Simple and Stable to Operate	<ul style="list-style-type: none">• Few controls to monitor and adjust• Operation similar to conventional activated sludge plants, requiring no operator retraining• Long SRT provides process stability• Accommodates Carrousel Biological Oxidation System
Stable Sludge	<ul style="list-style-type: none">• Additional sludge digestion may not be required, allowing direct disposal
Energy Efficient	<ul style="list-style-type: none">• Low operating cost• Nitrate removal credit
You Deal with Us	<ul style="list-style-type: none">• More than half a century commitment to waste treatment• Experience• Recognize technological leadership• Reputable, long-term equipment supplier

