ADDENDUM

Emerging Technologies

for Wastewater Treatment and In-Plant Wet Weather Management

Prepared by:

Office of Wastewater Management
U.S. Environmental Protection Agency
Washington, D.C.

EPA 832-R-12-011 Addendum

August 2013

United States Environmental Protection Agency

Preface

The U.S. Environmental Protection Agency (U.S. EPA) is charged by Congress with protecting the nation’s land, air, and water resources. Under a mandate of environmental laws, the Agency strives to formulate and implement actions leading to a balance between human activities and the ability of natural systems to support and sustain life. To meet this mandate, the Office of Wastewater Management (OWM) provides information and technical support to solve environmental problems today and to build a knowledge base necessary to protect public health and the environment in the future.

The original document was published in February 2008 under document number EPA 832-R-06-006, and the first update to this document with the new document number EPA 832-R-12-011, was released in March 2013. The March 2013 publication was produced, under contract to the U.S. EPA, by the Tetra Tech Corporation, and it provides current information and state of development as of the publication date. It is expected that this document will be revised periodically to reflect advances in this rapidly evolving area. This addendum, published in August 2013, was developed by the Office of Wastewater Management, US EPA to reflect new and more current information. The new information has been supplied by the manufactures or vendors and has not been verified by the EPA, Tetra-Tech, or the technical review expert panel.

For this addendum, information, interviews, and data development were conducted by the U.S. EPA. Some of the information, especially related to emerging technologies, was provided by the manufacturer or vendor of the equipment or technology, and could not be verified or supported by full scale case studies. In some cases, cost data were based on estimated savings without actual field data. When evaluating technologies, estimated costs, and stated performance, efforts should be made to collect up to date information.

The mention of trade names, specific vendors, or products does not constitute an actual or presumed endorsement, preference, or acceptance by the U.S. EPA or the Federal Government. Stated results, conclusions, usage, or practices do not necessarily represent the views or policies of the U.S. EPA.

Overview

This addendum has been developed to provide the latest updates to technologies included in the EPA's Emerging Technologies for Wastewater Treatment and In Plant Wet Weather Management (EPA 832-R-12-011) published in March of 2013. New information was received on the following technologies after the publication date. However, the EPA believes that the new information is important and/or better represents the actual performance of the technologies.

Compressible Media Filtration (FlexFilter™ and Bio-Flex Filter™ manufactured by WWETCO®). This addendum provides information that replaces and updated the information found in Chapter 2, pages 2-10 to 13 and Chapter 4, pages 4-4 to 4-7 of the March 2013 edition to the document.

Biological Double-efficiency Process (manufactured by BDP EnvirroTech®). This addendum provides new information that was not available at time of publication. This new information supplements the information found in Chapter 3 of the March 2013 edition to the document.

Alternative Disinfection (Solyay Chemicals NA/PERAGreen Solutions™). This addendum provides new contact information for Solvay Chemicals Chemical and replaces the information found in Chapter 2, page 2-27 and Chapter 4, page 4-17 of the March 2013 edition to the document.

Additional updates and/or addendums to this document will be considered as new technologies or more current information becomes available.

Contents

List of Figures

Treatment *prepared 2013* Technology Summary

Compressible Media Filtration (CMF)

Objective:

Multifunction, passive, high-rate filtration for wet- and dry-weather treatment applications.

State of Development:

Innovative.

Description:

The Compressible Media Filtration (CMF) technology was originally developed in the mid-1980's as a tertiary treatment process. In the mid 90's the technology was first implemented as a treatment method to process combined sewer overflows (CSOs) before UV disinfection in Columbus, GA, under an EPA funded grant and its performance was peer reviewed by the Water Environment Research Foundation (WERF, 2001).

This pioneering application by the Columbus Water Works, Columbus, GA, through the use of the CMF technology as part of the Columbus CSO Advanced Demonstration Facility, was recognized by EPA, WERF and other public, professional and technical groups as a scientific and engineering innovation for controlling, treating and disinfecting combined sewer system discharges. The CMF technology has since been applied to other CSO systems, storm water controls, and is being considered for control and treatment of separate sanitary sewer overflows (SSOs).

High rate media bed filtration technologies similar to CMF are currently being used for wet weather treatment in Japan in at least 20 installations with capacities ranging up to approximately 100 MGD (Fitzpatrick et al., 2012). Two CMF facilities treating CSO's have been operational in Atlanta, GA, (20 and 85 MGD) since mid-2000. The CMF was applied to storm water in 2007 (WWETCO, 2008). The largest CMF facility in the US (100 MGD) is under construction in Springfield, OH for CSO treatment with provisions for tertiary filtration and phosphorous control in the future (Fitzpatrick et al., 2011).

The two CMF technologies are the Fuzzy Filter™ manufactured by Schreiber and the FlexFilter™, manufactured by WesTech Engineering. The Fuzzy Filter™ was developed along the Japanese model in which the media is compressed in the direction of flow whereas the FlexFilter™ uses a lateral compression. The FlexFilter™ will be highlighted in this Technology Summary.

The WWETCO FlexFilter™ and Bio-FlexFilter™ use a synthetic fiber media bed that is passively compressed from the sides by the head of the incoming water. The lateral compression forms a cone-shaped porosity gradient that allows the stratification and removal of large and small particles from the top to the bottom of the media bed. The porosity gradient through the media bed, with its ability to handle heavy solids loading, gives the technology a wide range of uses. The filter can be used to:

1. Produce a reuse quality effluent as a tertiary filter including direct metal salt addition for phosphorous trimming;
2. Increase the organic removal capacity of a facility, and/or reduce its power consumption as an enhanced primary process; and
3. Treat excess wet-weather flow including biological treatment, when coupled with one of the two dry weather process operations as delineated in 1 and 2, above.

The first two functions are accomplished during dry weather, usually by a portion of the filter matrix. Dual-use filter concepts are shown in Figures 1 & 2. The entire matrix is sized for the worst case solids loading. Under one dual-use process train, during dry weather, part of the matrix acts as a tertiary filter (Figure 1 – left side) and the remaining portion is used for the common wet weather events (Figure 1 – right side). Generally, the entire filter matrix would be sized to handle the peak events. The tertiary filter cells can also be utilized to effectively remove or trim phosphate created by addition of metal salts directly to the filter influent, if and when needed. The filter cells are easily switched from one function to the other as the excess flow increases or decreases.

Another dual-use function is shown in Figure 2 where the filter is operated to enhance primary treatment and thus reduce loadings to the secondary portion of the plant. There are sufficient nutrients and oxygen cycling

Compressible Media Filtration (CMF) (continued)

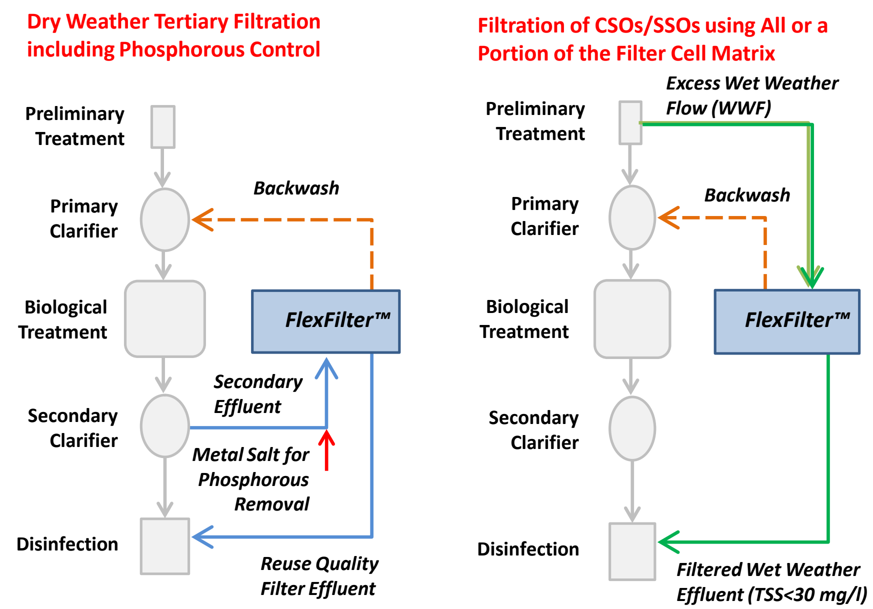

Figure 1. Multi-Function FlexFilter™ for Tertiary Filtration and Excessive CSO/SSO Flow Treatment.

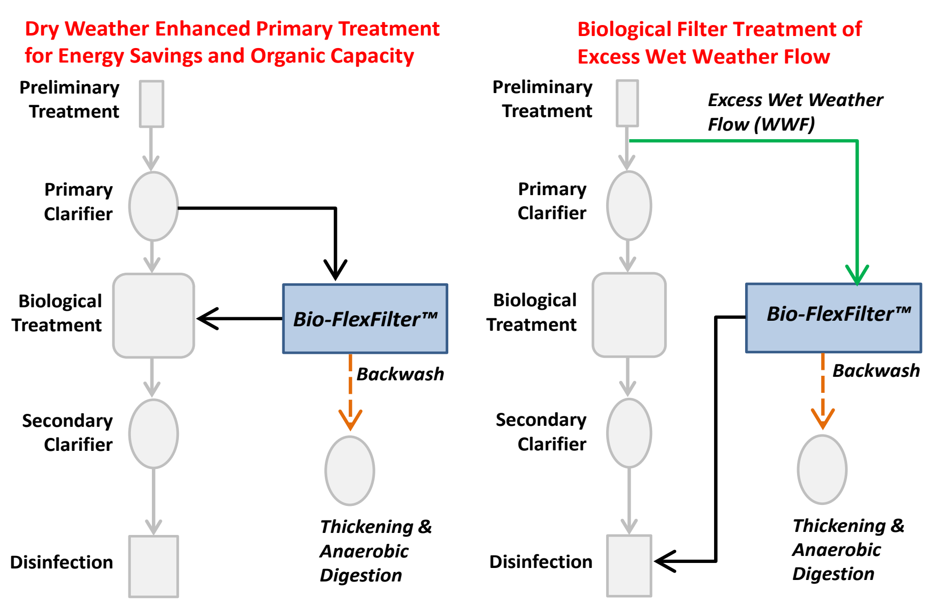

Figure 2. Multi-Function Bio-FlexFilter™ as Enhanced Primary and Excess Wet Weather Flow Treatment.

Compressible Media Filtration (CMF) (continued)

from the operation of the Bio-FlexFilter™ that it supports a healthy biofilm population in the media bed that reduces soluble organics as well as particulates from both dry and wet weather flows. The removals during wet weather conditions are generally sufficient to satisfy sanitary system secondary effluent limits.

One continuous treatment trial filtering primary influent for 6-months, impacted by CSOs, showed a consistent 38% soluble and a 70% total carbonaceous biochemical oxygen demand ($CBOD_{5)}$) removal (WWETCO, 2012). The filter performance in this comprehensive study compared favorably to that of other high-rate treatment technologies that have successfully demonstrated their long term ability to increase the peak flow treatment capacity of secondary treatment facilities (Fitzpatrick et al., 2008).

One of the advantages of the FlexFilter™ is that it does not require chemicals to treat the excess flow. It also operates as a safety net behind secondary clarifiers to push higher flows through the secondary without the risk of losing plant biomass, which is captured by the filter and returned (Fitzpatrick et al., 2012).

A filter cell treating wet weather or primary type solids uses the neighboring filter effluent for backwash supply. When treating a waste with low solids (primary or secondary effluent), the filter cell can use the influent water as backwash supply. Low head air scrubs the media and lifts the spent backwash into the backwash trough to waste. Backwash from the filter would normally be routed to the plant influent; backwash from the biofilter would normally be sent to solids processing. Excess biological growth is controlled with a dilute chlorine (3 mg/L) solution added to the backwash.

The passively operated matrix of the FlexFilter™ cells works with simple flow and level logic controls, open-close valves, and a low-head blower for cleaning and pumping the spent backwash water to waste. The multifunction filter makes this technology very attractive for satisfying current and future regulatory mandates for phosphorous control, excess wet-weather treatment and as an intermediate wastewater treatment step to reduce overall plant energy consumption and/or increase plant organic treatment capacity. A trial in Atlanta, GA, (McKern, 2004), showed that the FlexFilter™ is suitable for removal of TSS from raw CSO flow (75% to 94%) and sedimentation basin effluent (35%). The Bio-FlexFilter™ is suitable for meeting secondary treatment effluent criteria for $CBOD_5$ and TSS (effluent less than 30 mg/L each) for wet-weather flows (WWETCO 2012).

Sizing of the filter matrix is a function of hydraulic and solids loading and the available head. Peak hydraulic loading rates (HLRs) range from 10 to 20 gpm/sq ft, with the lower end for high-strength wastewaters like CSOs and primary influent sewage. The higher HLR would apply to the more dilute solids concentrations such as for tertiary filtration or for dilute wet weather filtration. Chemically assisted phosphorous removal HLR is 5 to 10 gpm/sq ft, depending on the concentration of metal salt/soluble phosphorous precipitate required. Biological treatment was demonstrated at 5 gpm/sq ft HLR.

For CSO or primary influent applications, the footprint of the concrete filter structure (10 MGD) including influent/effluent channels and operating and backwashing cell chambers would be less than 210 sq ft per MGD (WWETCO, 2012). A smaller footprint would be used for SSO or tertiary applications. For plants larger than 10 MGD, the filter system footprint decreases with increasing flows. Also according to the manufacturer, the filter matrix footprint can be reduced by about one-third by incorporating the influent and effluent channels above the filter cells. Further consolidation can be realized by placing the disinfection facilities above and backwash attenuation below the filter structure. The depth of the typical high solids filter is about 14 feet, but can be reduced by 30% with the consolidation described above. Steel tank tertiary filters are 6 feet tall. Existing filter basins at 6- and 7-foot depths can typically be retrofitted to accommodate multiple cells at one-half the area of a typical structure.

Comparison to Established Technologies:

According to Frank and Smith (2006) the WWETCO FlexFilter™ technology provided comparable effluent TSS (49 mg/L to 52 mg/L) with the ballasted flocculation systems in side-by-side testing. However, ballasted flocculation requires chemicals and ramp-up time (15 to 30 minutes) to achieve performance objectives.

Compressible Media Filtration (CMF) (continued)

In treating high strength CSOs (flush concentrations greater than 500 mg/l TSS) for 16 events, the maximum effluent Total Suspended Solids (TSS) was 36 mg/l; the 80th percentile was 22 mg/l and the 60th percentile was 50 mg/l. For the same testing the Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) had an average value of 26 mg/l with a standard deviation of 15 mg/l (Fitzpatrick et al, 2011). The WWETCO FlexFilter™ can meet similar or better TSS removals, requires no chemicals, and immediately achieves performance objectives.

The FlexFilter™ starts drained and ends drained without odor issues, without special startup protocols, and without special attention to mechanical equipment. Although the WWETCO filter footprint is generally somewhat larger than the footprint for ballasted sedimentation, it is roughly half as deep. Further consolidation is possible, as described above, and the wet weather treatment structure including disinfection can be located below ground in a smaller footprint than comparable technologies, and it is amenable to remote satellite applications. Remote unmanned wet weather treatment technologies that meet water quality criteria require far less infrastructure capital and operation resources than storage/transport/treatment solutions. The FlexFilter™ throughput for tertiary filtration is in the order of 98 percent (WWETCO, 2012). Average throughput for CSO is about 95 percent (< 5% backwash per McKern, 2004). The throughput for chemically assisted phosphorous filtration and biofiltration is in the order of 90 and 80 percent respectively (WWETCO, 2012).

Available Cost Information:

Approximate Capital Cost: Equipment includes the filter media bed (all internal structural metals, media, compression bladder, and air diffuser), complete controls, valves/gates and actuators and blower package with redundancy. Equipment costs vary with the scale of the facility. Smaller flows will result in greater redundancy because of the minimum size of the equipment. Unit costs decrease with increasing flows above 10 MGD. Equipment costs for the 10-MGD filter matrix can be generalized as follows:

Application	Estimated equipment cost ($ per gallon capacity)
Tertiary filter	Less than $0.06
SSO and primary effluent	Less than $0.07
CSO and influent	Less than $0.09

Approximate O&M Costs: Operation costs are summarized as follows (WWETCO, 2012):

1. Tertiary filtration – 10 kW per MGD treated (20 mg/L TSS influent)
2. SSO or primary effluent - 35 kW per MGD treated (100 mg/L TSS influent)
3. CSO or primary influent - 60 kW per MGD treated (200 mg/L TSS influent)

Vendor Name

WWETCO, LLC
3665 South West Temple
Salt Lake City, UT 84115
Telephone: (801) 265-1000
Attention: Mark Boner
Email: info@westech-inc.com
Web Site: http:/www.wwetco.com

Installations

FlexFilter™
Columbus, GA
Heard County Water Authority, Franklin, GA
Lamar, MO
Springfield, OH (2012)

Bioi-FlexFilter™
Manila, Philippines

Compressible Media Filtration (CMF) (continued)

Key Words for Internet Search:

Wet weather filtration, CSO, SSO, bio-filtration, enhanced primary filtration, intermediate wastewater treatment, roughing filter, HRT – High Rate Treatment, phosphorus removal, tertiary filtration, CMF - compressible media filter.

Data Sources:

Arnett, C.A., et al., “Bacteria TMDL Solution To Protect Public Health And Delisting Process in Columbus, GA,” WEFTEC, 2006.

Fitzpatrick, J.; Long, M.; Wagner, D.; Middlebrough, C. (2008) Meeting Secondary Effluent Standards at Peaking Factors of Five and Higher, *Proceedings of the 81st Annual Water Environment Federation Technical Exhibition and Conference*, Chicago, IL.

Fitzpatrick J.; Gilpin, D.; Kadava, A.; Kliewer, A.; Pekarek, S.; Schlaman, J.; Tarallo, S. (2010) Wet-Weather Pilot Studies Demonstrate Effectiveness of High-Rate Filtration Technologies. *Proceedings of the 2010 Water Environment Federation Technical Exhibition and Conference*; New Orleans, Louisiana.

Fitzpatrick J.; Weaver, T.; Boner, M.; Anderson, M.; O’Bryan, C.; Tarallo, S. (2011) Wet-Weather Piloting Toward the Largest Compressible Media Filter on the Planet. *Proceedings of the 2011 Water Environment Federation Technical Exhibition and Conference*; Los Angeles, California.

Fitzpatrick J.; Bradley, P.J.; Duchene, C.R.; Gellner II, J.; O’Bryan Jr., C.R.; Ott, D.; Sandino, J.; Tabor, C.W.; Tarallo, S. (2012) Preparing for a Rainy Day – Overview of Treatment Technology Options for Wet-Weather Flow Management. *Proceedings of the 2012 Water Environment Federation Technical Exhibition and Conference*; New Orleans, Louisiana.

Frank, D.A., and Smith III, T.F.; “Side by Side by Side, The Evaluation of Three High Rate Process Technologies for Wet Weather Treatment,” WEFTEC, 2006.

McKern, R. et al., “Atlanta CSO Pilot Plant Performance Results,” WEFTEC, 2004.

WERF, Peer Review: Wet Weather Demonstration Project in Columbus, Georgia, Co-published: Water Environment Research Foundation, Alexandria, VA, and IWA Publishing, London, U.K., 2003.

WWETCO, Boner, M., personal communication with Tetra-Tech, 2012.

WWETCO, Boner, M., personal communication with James Wheeler, EPA, 2013.

Biological Double-efficiency Process (BDP)®

Objectives:

The Biological Double-efficiency Process (BDP®) is a continuous biological wastewater treatment technology incorporating full Simultaneous Nitrification/Denitrification (SND).

- ✧ Increase the efficiency by at least 100% or more for biological organic matters removal, including nitrogen removal from nitrogenous streams (e.g., municipal sewage, industrial wastewater).
- ✧ Reduce energy consumption by 50% or more.
- ✧ Reduce carbon dioxide emissions by 50% or more.
- ✧ Reduce the amount of sewage sludge produced during treatment by 40% or more compared to other conventional processes.
- ✧ Reduce the footprint by about 50%.
- ✧ Reduce O&M cost by about 30%.

State of Development

Innovative.

State of Development:

Over 20 full-scale installations have been installed in China, including domestic sewage treatment plants (WWTPs) and industrial wastewater treatment facilities (e.g., petrochemical, oil refinery, textile and dyestuff, pharmaceuticals and personal care products, industrial wastewater with high concentrations of toxic chemicals, etc.).

Description:

The Biological Double-efficiency Process (BDP®) is the world's first full range Simultaneous Nitrification/Denitrification (SND) process. The BDP® technology involves both nitrification and denitrification occurring in a single bioreactor. The most common biological process completes the objective of nitrogen removal by both ammonia oxidation and nitrate/nitrite reduction to nitrogen gas. The autotrophic organisms use oxygen as the electron acceptor, to oxidize the ammonia in the aerobic environment. The heterotrophic organisms use nitrate/nitrite as the electron and carbon from organic compounds, prefer low to zero dissolved oxygen (DO), and are responsible for denitrification. The biological processes commonly used to remove the biological nitrogen consist of an aerobic process for nitrification and an anoxic process for denitrification. By controlling and keeping the DO concentration at a very low level (at an average of 0.3 mg/L), an oxygen concentration gradient across the floc-forming bacteria will be created. The activated-sludge floc will be only partially aerobic. Denitrification occurs in the anoxic zones established within the floc particles due to oxygen depletion. Therefore, both aerobic and anoxic conditions can be established inside a single bioreactor. Under these conditions, both the nitrification and denitrification microorganisms can prevail in performing their associated biological transformations. The SND process results in a reduction of the footprint, carbon, oxygen, energy, and alkalinity consumption compared to a conventional biological nitrogen removal process.

During long-term pilot project testing, the short-cut nitrification/denitrification also occurred in the SND process system (short-cut SND represents 40% of the total SND). Ammonia was just oxidized to nitrite. Without nitrate as the intermediate, nitrite will be reduced to nitrogen gas directly. These processes are termed short-cut nitrification/denitrification. According to the stoichiometry, the short-cut nitrification can reduce the oxygen consumption by 25% and the carbon consumption by 40% compared to a conventional nitrification/denitrification process.

Applications:

The BDP® process has been successfully implemented as a main stream biological treatment process for retrofitting and building new domestic sewage treatment plants and industrial wastewater treatment facilities (e.g., petrochemical, oil refinery, textile and dyestuff, pharmaceuticals and personal care products, industrial wastewater with high concentrations of toxic chemicals, etc.).

Process Control:

The main process controls include tracking: dissolved oxygen (DO at around 0.3 mg/L) and sludge concentration (MLSS at around 8 mg/L). A special aeration system is applied in the BDP® process as the oxygen distributer to create a low DO and micro-mixed condition. The monitored dissolved oxygen is also used for the automatic control of the blow volume of blowers and reflux ratio. A high sludge concentration with low food/microorganisms

Biological Double-efficiency Process (BDP) ® (continued)

ratio, results in smaller sludge flocs that can maintain a just sufficient aerobic condition in a low dissolved oxygen concentration. Ammonia oxidizing bacteria (AOB) are not inhibited by low DO conditions. In addition, for the denitrification process, insufficient carbon can inhibit the heterotrophic denitrifiers, which need carbon as electron donor under low oxygen concentration. According to full-scale application, the BDP process can work at a Carbon to Nitrogen (C/N) ratio as low as 0.17; however, a higher C/N ratio will lead to a higher nitrogen removal rate.

Configuration:

The BDP® process uses a bioreactor (basin) with a specific architecture enabling the simultaneous nitrification/denitrification. The BDP® process can be directly installed after the pre-treatment process, as a main stream biological wastewater treatment process, to substantially degrade chemical oxygen demand (COD) and nitrogen of organic pollutants. Some tertiary treatment is added after the BDP process for water saving purposes and/or reclamation.

Comparison to Established Technologies:

The BDP® process saves energy and carbon compared to conventional processes. Due to a highly efficient aeration system and hydraulic reflux system, the BDP® process can achieve up to an 80% reduction in power consumption. Based on the 7-8 years of full-scale applications and long-term data collection, the biomass production is reduced by an average of 40% compared to other conventional processes. Moreover, the high activated sludge concentration and improved simultaneous removal of nitrogen result in an average of a 50% smaller footprint. Also, O&M costs are reduced by an average of 30% over a 2-8 year period of operations monitoring.

Similar processes, such as DEMON®, SHARON®, ANAMMOX®, and others, have been successfully demonstrated for treating high strength side streams. Full-scale side stream systems have been operated in Europe for several years. There are nine full-scale DEMON side-stream installations in the Netherlands, Austria, Germany, Switzerland, Finland, and Hungary. The first U.S. side stream installation became operational in 2013 at the Hampton Roads Sanitation District (HRSD) in Virginia. Several other projects in the United States are in the design phase or are under construction including: the HRSD's York River WWTP in Seaford, VA; and the Alexandria Renew Enterprise WWTP in Alexandria, VA.

These processes have not yet been installed in the main liquid stream process at full scale deammonification, due to the difficulty in inhibiting nitrite oxidizing bacteria (NOB) growth in the full stream, the relatively lower temperature and ammonia concentration in the full stream influent, and the need for selective retention of the ANAMMOX bacteria. However, a full-scale full-plant deammonification demonstration has been installed at the Strass WWTP in Austria, where a side stream deammonification process provides seed for bioaugmentation in the full-plant testing. Full-plant deammonification has also been pilot tested at plants in Washington, DC and Virginia. Additional information can be found on innovative side stream nitrification and denitrification treatment technologies in the EPA's document on Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management (EPA-832-R-12-011, March 2013), Chapter 3, pages 3-16 to 3-21.

Key Words for Internet Search:

Ammonification, deammonification, Biological Double-efficiency Process (BDP), Simultaneous Nitrification/Denitrification (SND).

Vendor Name:

BDP®- BDP EnviroTech Limited
Eric JG Li
Ste.1506 Tower B-1, Golden Tower,
No. 82, East 4th Ring Middle Rd.,
Beijing 100124, China
Telephone: +86 10 5208 8022
Email: lijianguo@bdp-tech.com
Web site: http://www. Bdp-tech.com

Installations:

Over 20 full-scale application installations in China are in operation.
The largest installation currently is over 13 MGD.
5 domestic sewage treatment installations have been operated since 2005 in: Anhui, mainland China
Tianjin, mainland China
Jiangsu, mainland China
1 domestic sewage treatment plant is under construction
Tianjin, mainland China .

Biological Double-efficiency Process (BDP)® (continued)

There have been numerous full-scale industrial wastewater treatment installations since 2005, such as petrochemical, oil refinery, textile and dyestuff, pharmaceuticals and personal care products, industrial wastewater with high concentrations of toxic chemicals, etc. The largest installation currently is over 53 MGD (i.e. 1 million pounds COD_{Cr} per day). BDP EnviroTech is working on the first pilot project in the US. The technology is available commercially.

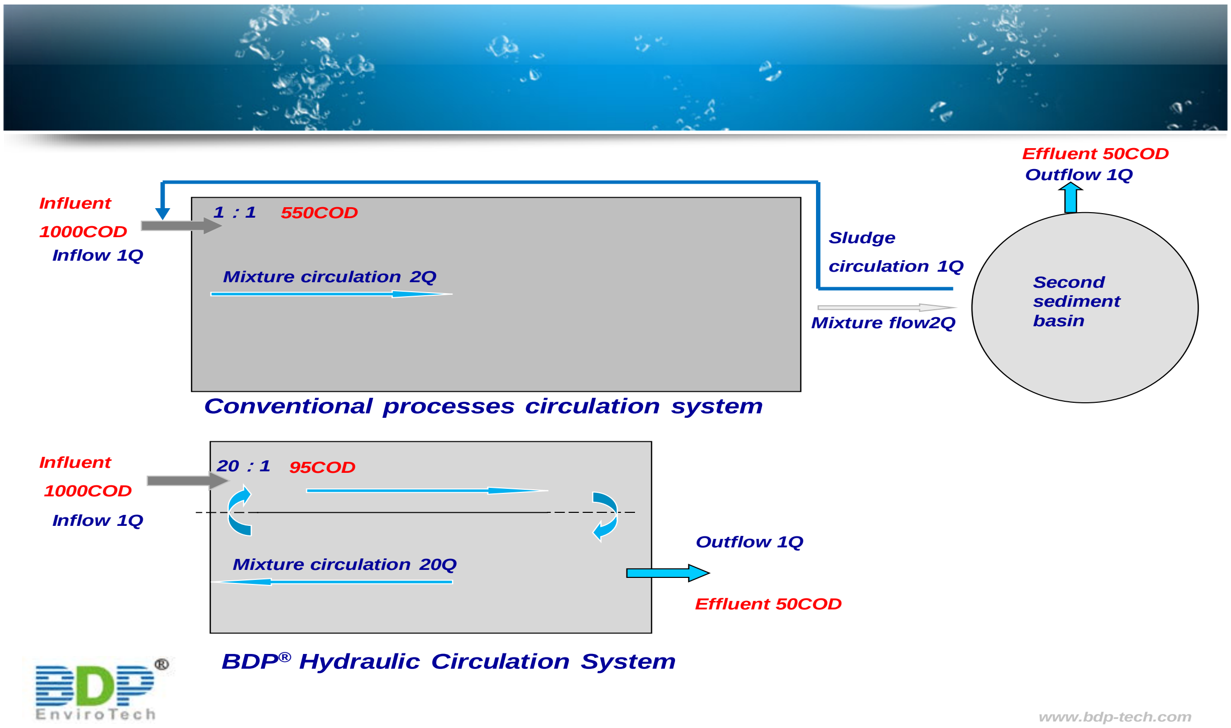

Figure 1: BDP® Hydraulic Circulation System Compared To Conventional Processes Circulation System

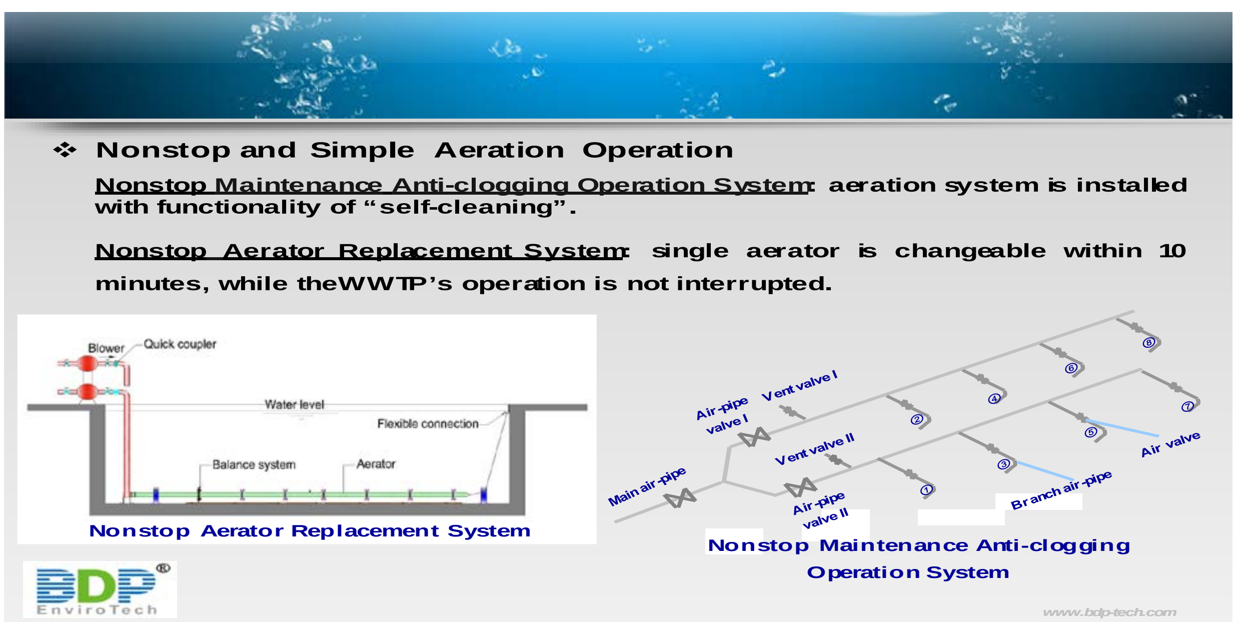

Figure 2: Nonstop and Simple Aeration Operation

Biological Double-efficiency Process (BDP)® (continued)

Treatment capacity: 10,000m³/d (2,640,000gpd)

Process flow before upgrading: coarse grid + pump station + fine grid + grit chamber + [A/O + BAF tank + Second sediment tank] + UV disinfection

Process flow after upgrading: coarse grid + pump station + fine grid + grit chamber + [BDP® basin] + UV disinfection

Technical Data :

	Index	Influent (mg/L)	Effluent before upgrading (mg/L)	Effluent after upgrading (mg/L)
Water Quality	COD_{Cr}	250 ~ 500	100	37
	BOD_5	100 ~ 200	20	< 2
	SS	100 ~ 200	30	< 10
	NH_3-N	80 ~ 150	45	< 1
	TP	5 ~ 9	2.5	< 1

BDP® EnviroTech

www.bdp-tech.com

Figure 3: Influent/Effluent Data After Upgrade To The Tianjin WWTP

BDP® EnviroTech

www.bdp-tech.com

Figure 4: *After Upgrading Original A/O Basin by BDP Technology, BAF Tank and Second Sediment Tank are Eliminated and Footprint is Cut in Half*

Biological Double-efficiency Process (BDP)® (continued)

Data Sources:

Housing and Urban-Rural Development Bureau of Jiangsu Province, Technical Guidebook of Upgrading Construction of Wastewater Treatment Plant in Taihu Lake Basin, Jiangsu Province, 2010.

Science and Technology Department, Ministry of Housing and Urban-Rural Development of the People's Republic of China, Technical Certification Report, 2010.

Hehai University, Research Report of Upgrading Construction of WWTP in the Taihu Lake Basin, Jiangsu Province, 2008.

Pan, J., et al,. "Study and Application of BDP Process for Cyanic Wastewater Treatment," China Water & Wastewater, Vol. 34(11), 2008.

Li, J., et al,. "Application of BDP Process in the Field of Petrochemical Wastewater Treatment," Water-Industry Market, Vol.5, 2012.

Zhang, P., et al., "Simultaneous Nitrification and De-nitrification in Activated Sludge System Under Low Oxygen Concentration," Frontiers of Environmental Science and Engineering in China, Vol. 1(1): 49-52, 2007.

Liu, Y., et al., "Study of Operational Conditions of Simultaneous Nitrification and De-nitrification in a Carrousel Oxidation Ditch for Domestic Wastewater Treatment," Bioresource Technology, Vol. 101: 901-906, 2010.

Alternative Disinfection [Peracetic Acid (PAA) and BCDMH]

Objective:
Alternatives to chlorine disinfection using disinfection products such as peracetic acid (PAA, also known as peroxyacetic acid [CH3CO3H]), or Bromo Chloro Dimethylhydantoin (1-Bromo-3-Chloro-5,5) [BCDMH]).

State of Development:
Emerging.

Description:

Alternative disinfectants are being applied to wet-weather flows because of their ability to act as high-rate disinfectants. PAA is a stronger oxidant than hypochlorite or chlorine dioxide, but not as strong as ozone. In parts of Europe and Canada, chlorine is not used because of the potential to form disinfection byproducts (DBPs). PAA is a strong oxidizing agent that can be used as a routine wastewater disinfectant. PAA does not affect effluent toxicity, so it does not need to be removed as with chlorine. Recently approved by EPA specifically as a wastewater disinfectant (Proxitane WW-12®), PAA is a clear, colorless liquid available at a concentration of 12 to 15 percent. With stabilizers to prevent degradation in storage it exhibits less than 1 percent decrease in activity per year. At the 12 percent concentration, its freezing point is approximately –40 °C. Although it is explosive at higher concentrations, at 15 percent or less, PAA does not explode. The solution is acidic (pH 2) and requires care in handling, transport, and storage. PAA has been used successfully in combination with UV disinfection, allowing reductions in lamp intensity and less frequent lamp cleaning. It is available in totes or in bulk, should be stored near the point of application, and should be well mixed where it is introduced. The dosage used for disinfecting secondary effluent depends on the target organisms, the water quality, and the level of inactivation required. For example, a dosage of 5 mg/L 15 percent PAA, with contact time of 20 minutes, can reduce fecal and total coliform by 4 to 5 logs in secondary effluent (Morris 1993). Dosage of 1–2 mg/L PAA is typical for secondary effluents. Note, however, that PAA is less effective for inactivation of spores, viruses, and protozoa including Giardia and Cryptosporidium (Koivunen et al. 2005; Liberti and Notarnicola 1999).

.

BCDMH is a chemical disinfectant used to treat drinking water. It is a crystalline substance, insoluble in water, but soluble in acetone. It reacts slowly with water, releasing hypochlorous acid and hypobromous acid. EBARA has devised a system to liquefy the BCDMH powder in a mixer with an injection device. The solution is injected directly into the wastewater, and it relies on the turbulence of the process to mix into the disinfection process.

Comparison to Established Technologies:

Compared to disinfection with chlorine compounds, PAA does not form harmful by-products after reacting with wastewater when using dosages typical for secondary effluent. For example, during the trial at St. Augustine, FL, (Keough and Tran 2011), an average PAA dose of 1.5 mg/L provided similar fecal coliform reduction as a 7 mg/L chlorine dose (both meeting the 200 cfu/00 mL limit), but the chlorine resulted in 170 µg/L total THM compared to 0.6 µg/L TTHM for PAA. With tertiary treatment, PAA can meet effluent limits of less than 10 cfu/mL but achieving very low (less than 2 cfu/100 mL) fecal coliform limits required high PAA doses (Leong et al. 2008). However, a residual of acetic acid could be present and might exert an oxygen demand or provide substrate for bacterial regrowth. Dosages and contact times are no more than required for disinfection with chlorine, so existing contact tanks should be adequate for conversion to PAA.

BCDMH has a small footprint and is easier to store than chlorine disinfection products. The feed stock is BCDMH powder, which is liquefied as needed by feeding through a dissolution mixer with clean water to form a solution that is injected into the wastewater. The BCDMH powder is reportedly highly stable, with a shelf life of longer than one year, making it potentially attractive for use in CSO applications that are characterized by intermittent operation. BCDMH is an effective disinfectant that can achieve bacterial reductions comparable to sodium hypochlorite, but it acts in a shorter amount of contact time (typically 3 minutes compared to 5 minutes for sodium hypochlorite), thereby reducing the size of the contact chamber, which can result in capital cost savings. Similar to sodium hypochlorite, BCDMH also produces disinfection byproducts (DBPs) and disinfection residuals, potentially requiring the use of a reducing agent.

Available Cost Information:

Approximate Capital Cost: Equipment required is similar to that used for hypochlorite systems.
Approximate O&M Costs: The cost of PAA is approximately $1.00/lb.

Alternative Disinfection [Peracetic Acid (PAA) and BCDMH] (Continued)

Vendor Name(s):

Peracetic Acid
FMC Corporation
Minh Tran
1735 Market St
Philadelphia, PA 19103
Telephone: 609-951-3180 or 267-357-1645
Email: Minh.Tran@fmc.com
Web site: http://www.microbialcontrol.fmc.com

Solvay Chemicals NA/PERAGreen Solutions
John Maziuk
Technical Development Manager
3333 Richmond Avenue
Houston, TX 77098
Telephone: 713-525-6815
Cell Phone: 832-527-3211
Email: John.maziuk@solvay.com
Web site: www.solvaychemicals.us

BCDMH
EBARA Engineering Service Corporation
Shinagawa, NSS-11 Building
2-13-34 Konan, Minato-Ku, Tokyo, Japan
Telephone: 81-3-5461-6111 (switchboard)
Web site: http://www.ebara.co.jp/en/

Installation(s):

Peracetic Acid
Many applications are in Europe, including:
- Milan/Taranto, Italy
- Kuopio, Finland

Canadian applications:
- Niagara Falls, Ontario
- Chateauguay, Quebec
- La Prairie, Quebec

U.S. Pilots:
- Hannibal, MO
- Steubenville, OH
- Jefferson City, MO
- St Augustine, FL
- Largo, FL

BCDMH
- Columbus, GA
- Akron, OH

Key Words for Internet Search:

Alternative disinfectant, CSO disinfection, Peracetic Acid, PAA, peroxyacetic acid, BCDMH, Bromo Chloro Dimethylhydantoin (1-Bromo-3-Chloro-5,5) [BCDMH]).

Data Sources:

Brian, K., and Tran, M., "Old City, New Ideas: Peracetic Acid in Wastewater Disinfection at St.Augustine," Florida Water Resources Journal, April, 2011.

Leong, et al., "Disinfection of Wastewater Effluent: Comparison of Alternative Technologies," Water Environment Research Foundation (WERF) Report 04-HHE-4, 2008.

Rossi, S., et al., "Peracetic Acid Disinfection: A Feasible Alternative to Wastewater Chlorination," Water Environment Research Foundation, Vol. 79, No. 4, pp. 341–350, 2007.

Moffa, P.E., et al., "Alternative Disinfection Technology Demonstrates Advantages for Wet Weather Applications," Water Environment and Technology, January 2007.

Combined Sewer Overflow Technology Fact Sheet Alternative Disinfection Methods web site: www.epa.gov/owmitnet/mtb/altdis.pdf.

Gehr, R., et al., "Disinfection Efficiency of Peracetic Acid, UV and Ozone after Enhanced Primary Treatment of Municipal Wastewater," Water Research, Vol. 37, No. 19, pp. 4573-4586, 2003.

Morris, R., "Reduction of Microbial Levels in Sewage Effluents Using Chlorine and Peracetic Acid Disinfectants," Water Science and Technology, Vol. 27, 1993.

Koivunen, J., and Heinonen-Tanski, H., "Inactivation of Enteric Microorganisms with Chemical Disinfectants, UV Irradiation and Combined Chemical/UV Treatments," Water Research, Vol. 39, No. 8, pp.1519-1526, 2005.

Alternative Disinfection [Peracetic Acid (PAA) and BCDMH] (continued)

WERF, Wet Weather Demonstration Project in Columbus, Georgia, 98-WWR1P.
Kitis, M., "Disinfection of Wastewater with Peracetic Acid: A Review," Environment International, Vol. 30, pp. 47–55, 2004.

Liberti, L., and Notarnicola, M., "Advanced Treatment and Disinfection for Municipal Wastewater Reuse in Agriculture," Water Science and Technology, Vol. 40, No. 4-5, pp. 235-245, 1999.

Meakim, J.T., et al., "Peroxyacetic Acid Restores Design Capacity for Fecal Coliform Compliance in an Underperforming UV Disinfection Wastewater System with No Capital Upgrade," Proceedings WEF Specialty Conference on Disinfection, 2009.