Sustainable Water Treatment and Reuse

ROTHWELL
WATER

Company Origin & History

Origin of Rothwell

Rothwell Water was cofounded in December 2012 by Peter L. Timpany, CSBR inventor, and Mr. Keonho Lee, with the goal of conducting a global water business based on CSBR process engineering experience applied to more than 30 wastewater /sewage treatment plants worldwide.

The Anyang Bakdal Underground Sewage Treatment Plant, implemented by Rothwell and which won the International Water Association's (IWA) No.1 Award for Resource Recovery has become a cornerstone event to successfully achieve Rothwell's goal of entering the global Water Market.

The Package CSBR Sewage Treatment System developed for Wastewater Treatment projects in Bolivia is an innovative eco-friendly technology that overcomes the Not In My Backyard (NIMBY) phenomenon, highlighting Rothwell's importance in the water business.

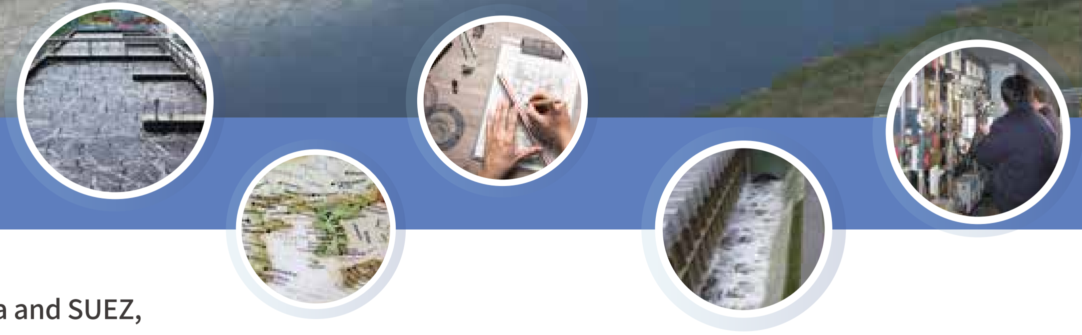
Our technology portfolio is applied to domestic and international markets, fulfilling our vision of being a global water company.

Chairman of Rothwell Associates
CTO of Rothwell Water
Peter L.Timpany

CEO of Rothwell Water
Keonho Lee

History

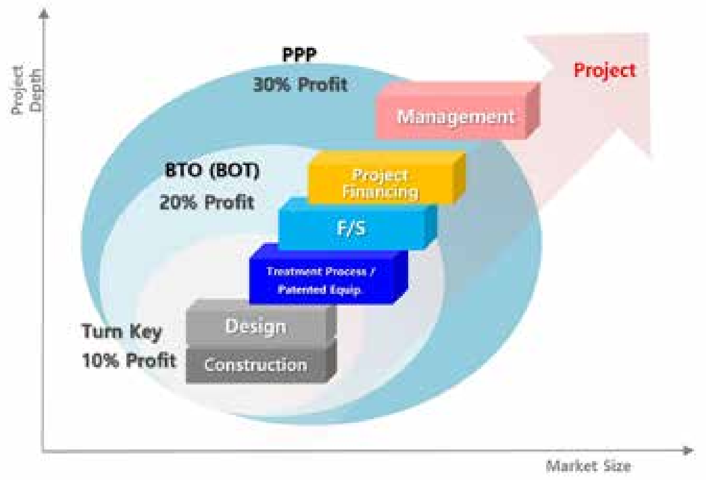
- 2012.12 Established Rothwell Watertech Glocal, Inc.
- 2014.03 Certification of Venture Company / R&D Institute
- 2014.12 Awarded 'Excellent Environment Venture Company' (Korea Environmental Industry & Technology Institute; KEITI)
  Registered patent for CMBR Processing System (Patent No. 10-1472421)
- 2015.04 Registered patent for Small Package CSBR Process System (Patent No. 10-1510405)
- 2015.11 Received 'The Citation of Excellent Small and Medium Business' (Minister of Industry and Commerce)
- 2016.08 Changed company name to Rothwell Water Co., Ltd.
- 2017.05 Registered patent for Advanced Treatment Process with Activated Sludge Purification System (Patent No. 10-1744451)
- 2017.12 Registered license for Engineering and Construction of Domestic Water Facilities



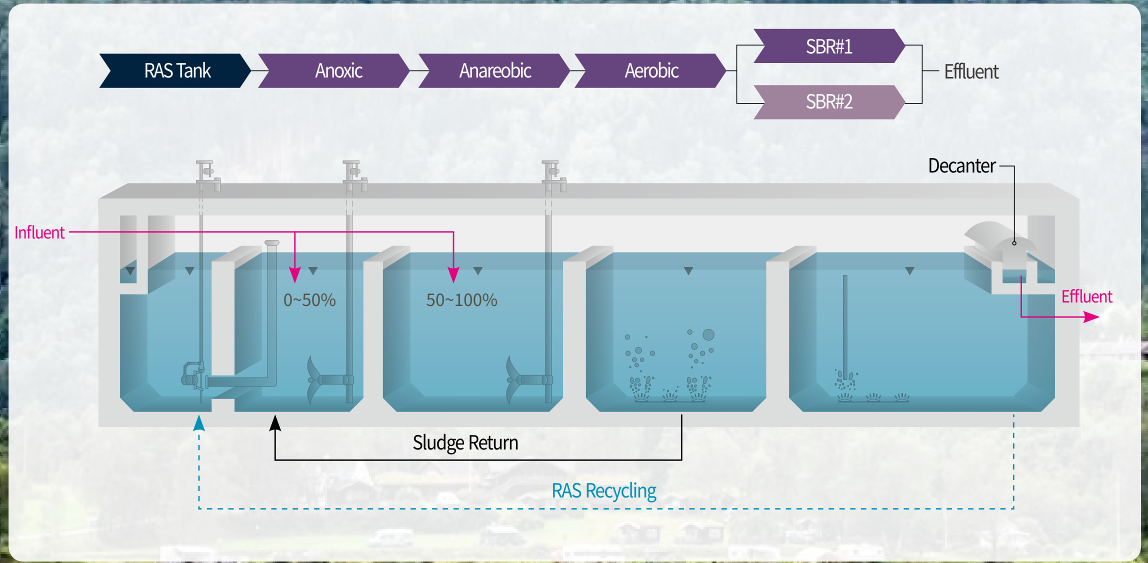
Business Model

- Rothwell sets its business benchmark to global water companies like Veolia and SUEZ, and performs PPP (Public Private Partnership) business model based on water treatment process technology.
- Rothwell has global executives with broad experience in the water business. Our CEO has 35 years of experience managing water projects; our CTO has 50 years of experience designing water treatment processes; and our COO has 28 years of experience in field work.
- Based on the design of water treatment process, we accomplish competent engineering services as business development, feasibility study, financing modeling, designing, manufacturing, construction, and commissioning/operation management.

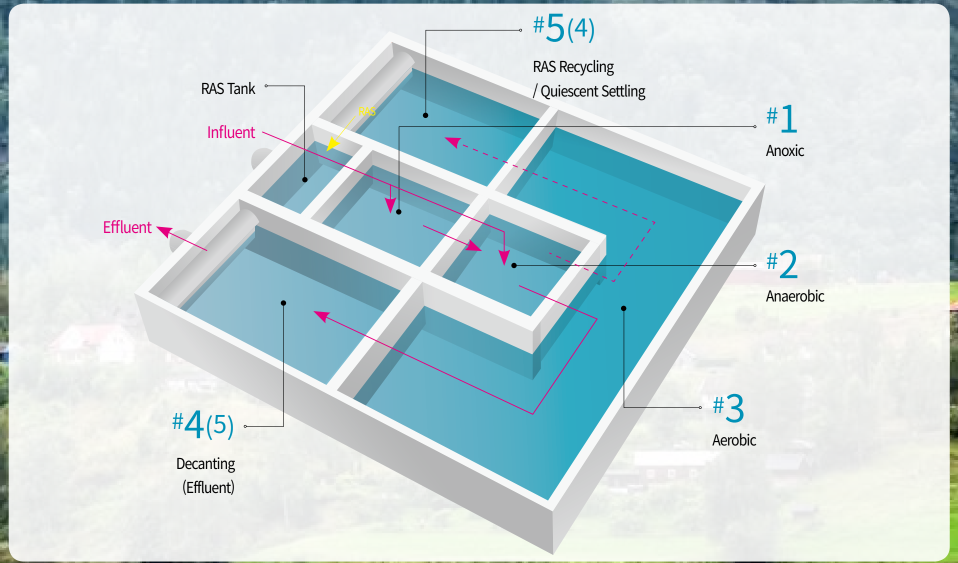
Development/FS → Process Design → Patent equipment manufacturing → Site Installation → Commissioning → Performance Guarantee → Post Management



Process Flow



Bioreactor Composition



Major Features of CSBR

Split Sewage Inflow (anoxic/anaerobic) | Stationary Disk Diffuser | Retrievable Type Diffuser | TRAS (sludge concentration) | RAS (sludge cycle) | Two SBR Series (constant water level and continuous flow) | Hydraulic Decanter (air pressure from blower)

Technology Introduction - CSBR

Constant Level and Continuous Flow Sequencing Batch Reactor

Competencies

CSBR™ is a water treatment process that achieves continuous flow by improving batch operation flow of conventional SBR (Sequencing Batch Reactor) process.

- A_2O activated sludge process with continuous process flow is arranged in the first stage.
- Two series of SBR system, maintaining a fixed water level, are arranged at the end of A_2O process.

Process Flow

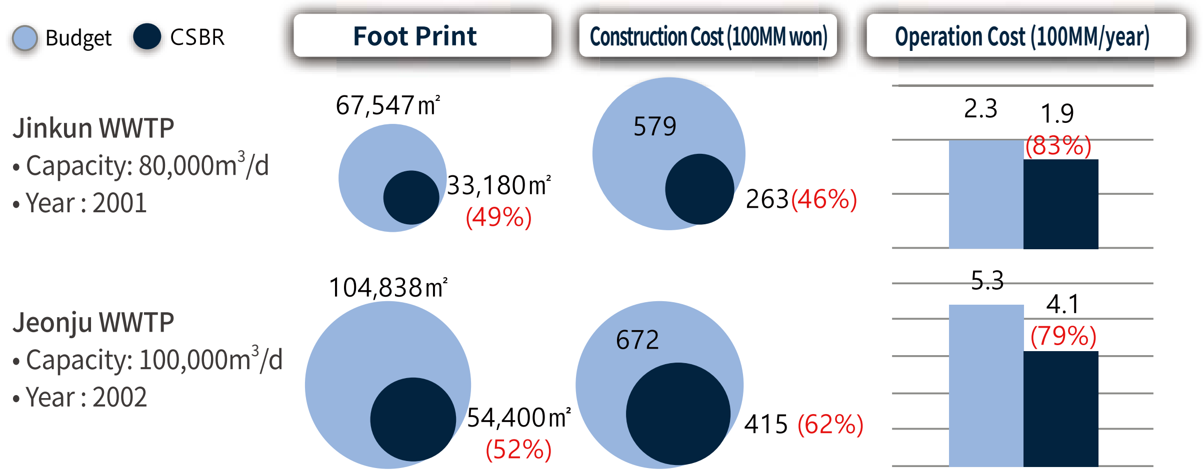
- CFR (Continuos Flow Reactor) Cell is part of A_2O process that maintains continuous flow with anoxic, anaerobic and aerobic zone in the first stage, and two SBR reactors in a row alternatively in the second stage.
- The influent undergoes anaerobic/aerobic reaction from organic decomposition process and flows into the lower water level SBR tanks - in which sedimentation and supernatant discharge occurs.
- The influent is mixed with sludge and undergoes SBR reaction with aerobic, anaerobic and sedimentation processes - therefore biodegradation is once again performed.
- The microbial sludge is discharged to the outside through the thickened return activated sludge (TRAS) system on the bottom of SBR tank, where sedimentation occurs. The remaining sludge is mixed with the influent of the previous stage and the process is repeated in bioreactors.

Economic Value

	BNR	CSBR
Construction Cost	100%	70%
Operation Cost	100%	85%
Foot Print	100%	70%

* BNR : Biological Nutrient Removal

Practical Case



Decanting Device

CSBR™ adapts a hydraulic decanter system using pressure of air blower achieving maintenance-free guarantee in whole life cycle of the plant.
The patent of continuous SBR system was granted to Aqua Aerobic in the United States in 1993 by Peter Timpany and co-inventor Mark Lansdell, as registered trademark MSBR™. (MSBR: Modified Sequencing Batch Reactor).

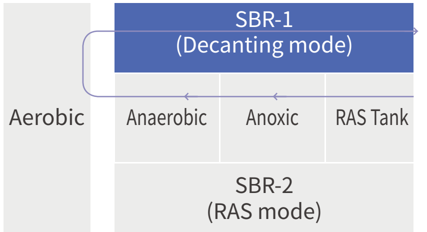
CSBR and MSBR

	Reactors	Patents	Removals	Technology Improvements	Reactor/Equipment Characteristics
CSBR	A_2O SBR Continuous Flow	Peter L. Timpany (Rothwell Water)	Removal of Organics/ Nitrogen/ Phosphorus	Sludge circulation and scum removal> 5 Stage A_2O> MBR application	1. Deep(8m) front aeration system> High oxygen delivery efficiency 2. Performance guarantee for decanting device/aeration device only
MSBR		Mark Lansdell (Aqua Aerobic)	Removal of Organics / Phosphorus	Improved organic and phosphorus removal > 6 Stage A_2O> MBR application	1. Partial aeration & surface mixing 2. Performance guarantee with collective delivery condition for pump /mixer/aerator/decanter etc.

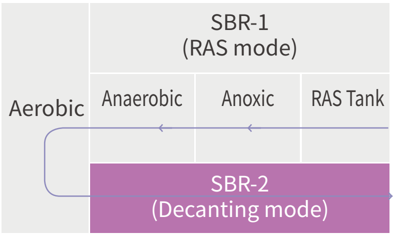
Technology Introduction - CSBR

Reactor Operation Stage

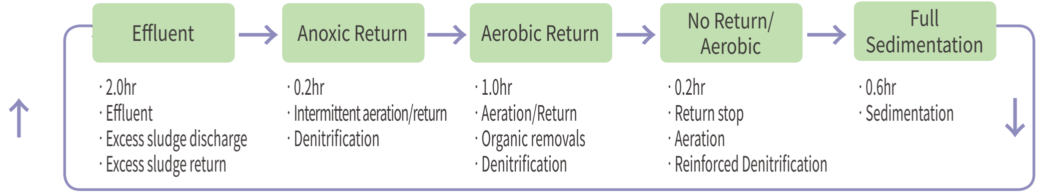
Step.1



Step.2



Aerobic/Settling Tank Operation Mode



Water Quality

Parameter	Influent (max/min)	Treated Water Quality	
		BNR	CSBR
BOD_5	270/100	15	≤10
COD_{cr}	685/200	≤ 55	≤ 40
TSS	287/100	≤ 15	≤ 15
NH_4-N	20/15	≤ 2	≤ 2
TKN	30/20	≤ 8	≤ 5
PO_4-P	6.0/3.0	≤ 1.0	≤ 1.0

PKG CSBR

Rothwell's Package CSBR Processing System (PKG CSBR) has been developed as a part of the Bolivian Government's Wastewater Treatment project to solve the eutrophication problem of Lake Titicaca, the largest lake in South America, by applying CSBR's proven design techniques using Corrugated Steel Pipes. The success of PKG CSBR technology has been proven by an outstanding operation performance in Guri City's Pilot Plant in South Korea.

Corrugated steel pipe production> Purchasing

Types of corrugated steel pipes (One-piece/ half-moon type)

Reactor equip. installation (Diffuser/pump/pump/discharge device)

Package modularization ($50m^3/d$, HxWxL = 4x4x8m)

($50m^3/d$, 100KWh/d) PKG CSBR Interior (BOD_5<10, TN<20, TP<1.0 mg/l)

PKG CSBR

Production to Construction

Performance Characteristics

Performance Indicators		Unit	Influent	Effluent
Water Quality	BOD_5	mg/l	60~300	10
	COD_{cr}	mg/l	150~700	40
	TSS	mg/l	80~300	10
	T-N	mg/l	30~80	15
	T-P	mg/l	5~20	1
Daily Capacity		m^3/d	50~3,000	
Construction Cost		won	50% of existing concrete structures	
Operation Cost		%	50%, compared to CAS	
Construction Period		month	6	
Scalability		%	200%	

*CAS : Conventional Activated Sludge

Underdeveloped Countries	Developing countries	Developed countries
South Korea 1980~90's	2000~2010	Present

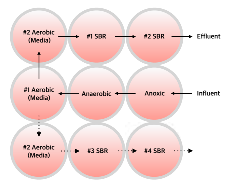
Organic Substance Removal		Eutrophication	Reinforcement		Increased Flow		Reuse	
BOD_5 mg/l	TSS mg/l	BOD_5 /TSS	T-N	T-P	BOD_5	COD_{Cr}	T-N	T-P
30 →20	70 → 20	20 → 10	60 → 40	8 → 2	10 → 5	40 → 20	40 →20/5	2 →0.2/0.1

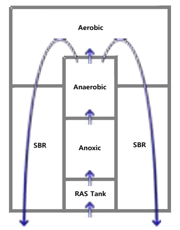
Secondary Treatment (CAS) | Biological Nutrient Removal | Increased Phosphorous Removal | MBR | U/F | R/O

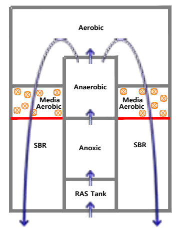
CSBR™ → MCSBR™ → CMBR™

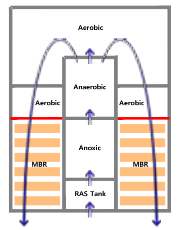
Technology Trends and Portfolio

PKG CSBR®	CSBR®	MCSBR®	CMBR®
Small Scale WWTP	Medium, Large Scale WWTP	Increased Capacity of CSBR WWTP	Reclamation of CSBR WWTP
Guri, Titicaca Lake	36 Plants in Operation	BJ in Korea	Anyang Bakdal
- Cap.; 50~3,000m^3/day - BOD_5 10mg/l - COD_{Cr} 40mg/l - TSS 10mg/l - T-N 20mg/l - T-P 1mg/l	- Cap.; 5,000~1mil. m^3/day - BOD_5 10mg/l - COD_{Cr} 40mg/l - TSS 10mg/l - T-N 20mg/l - T-P 2mg/l	- Upgrade 130~150% - BOD_5 5mg/l - COD_{Cr} 40mg/l - TSS 10mg/l - T-N 15mg/l - T-P 1mg/l	- CSBR® Upgrade 200% - BOD_5 3mg/l - COD_{Cr} 20mg/l - TSS 0mg/l - T-N 10mg/l - T-P 0.5mg/l









Vacuum Degassing

The Vacuum Degassing process was developed in 1990 and its treatment efficiency has been proven through on-site operations in Europe and Asia. Regardless of season, Vacuum Degassing enables effective advanced treatment for existing and new activated sludge treatment plants, with low construction cost, maximum processing capacity, and effluent quality stabilization.

Process Features

Efficiency

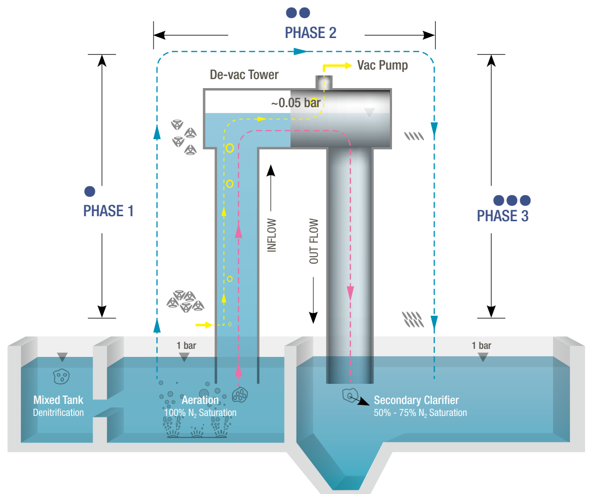
- Ensure continuous sludge settling efficiency throughout the year
- Consistent high return sludge concentration of up to 2%
- Maintain a high MLSS concentration of 6,000 to 8,000 mg/ L

Economic Value

- Scum collection and treatment facilities are unnecessary in the second settling tank
- Concentrated excess sludge discharge reduces dewatering energy and chemical consumption
- Reduced surface area of secondary settler by 30%
- Reduced reactor size by about 50% compared to existing BNR wastewater treatment plants

Stability

- No sludge floatation in the secondary clarifier
- Prevent overload and processing degradation during rain
- Stable processing performance and easy operation management
- Elimination of sludge bulking problems due to filamentous microorganism and prevention of potential Nocardia growth



Vacuum Degassing

Bio Media(MBBR)

Bio Media(MBBR), which improves the water quality and treatment efficiency of existing wastewater treatment plants using Media, was developed in Norway in 1990 and has been applied to more than 200 sewage treatment plants around the world. Bio Media(MBBR) is semi-permanent, operates stably and can be applied wherever it is needed. Especially, it is very useful in improving treatment capacity of existing sewage treatment plants.

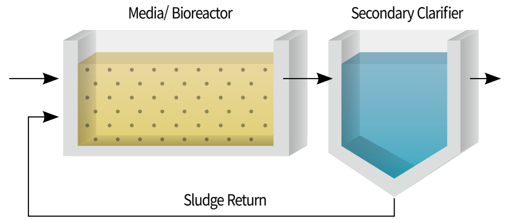
Process Features

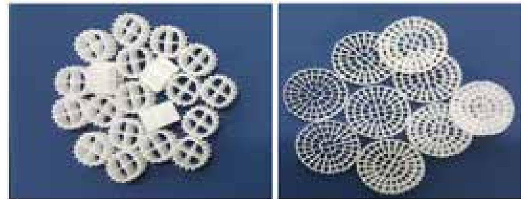
Compactness

- Minimization of required site area since new construction/expansion is not necessary
- Improvement of treatment capacity of plant by adding media
- Low initial investment
- Possibility to utilize existing civil structures
- Easy to increase processing capacity

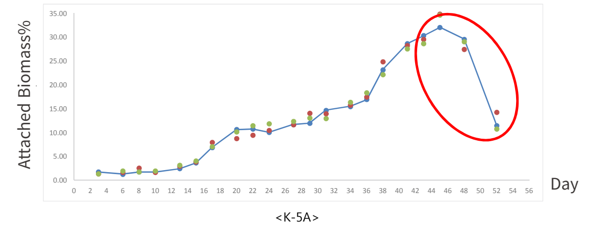
Stability

- Stable operation at high loads
- High MLSS concentration ensures stability to external fluctuations
- Quick recovery after major upsets
- No sludge bulking in the secondary clarifier

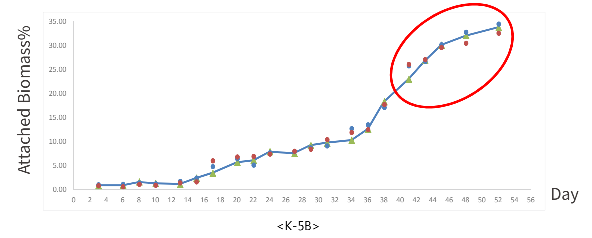




K1 K5(A/B)



Type	Size (mm)	Density	Weight (g/ea)	Porosity (%)	Specific surface area (m²/m³)	Surface area (cm²/ea)	Number of Media (ea/m³)	Material	Patents	Patent no.	Patent holder
K-1	7×10	0.944	0.1690	69.3	668	6.68	1,000,000	PE	Kaldnes	expired	Veolia (for MBBR™)
K-5A	25×3.5	0.951	0.3455	71.0	1,340	40.21	335,000	PE	Waterful	Korea 30-0617651 (~2026) USA: 8934 China; 1481786	Veolia
K-5B	25×3.5	0.953	0.3684	71.0	1,340	40.21	335,000	PE+Enzyme			Rothwell Water



1. Suwon Phase-1 WWTP (220,000m^3/d)
2. Kumi WWTP (330,000m^3/d)
3. Kunjang Industrial WWTP (30,000 m^3/d)
4. Wonnung WWTP (80,000 m^3/d)
5. Gaeun WWTP (2,000 m^3/d)
6. Uijeongbu WWTP (200,000 m^3/d)
7. Jeonju WWTP (100,000 m^3/d)
8. Byukje WWTP (30,000 m^3/d)
9. Bakdal WWTP (250,000 m^3/d)
10. Daegu Technopolice Industrial WWTP (4,500 m^3/d)
11. Pyeongchang WWTP (18,000 m^3/d)
12. Byeolrae WWTP (27,000 m^3/d)
13. Minrak WWTP (16,000 m^3/d)
14. Samsong WWTP (16,000 m^3/d)
15. Sanming WWTP (80,000 m^3/d)
16. Beijing Qinghe WWTP (120,000 m^3/d)
17. Huai'an Municipal WWTP (20,000 m^3/d)
18. Okotoks WWTP (3,000 m^3/d)
19. Juangriego WWTP (10,000 m^3/d)

Rothwell Main Technology References

CSBR™

Name of Project	Flow [m^3/day]	Country	Status	Process
Bakdal WWTP (Underground)	250,000	South Korea	Commissioned 2017	CSBR
Nongso WWTP (Underground)	100,000	South Korea	Commissioned 2016	MSBR
Sosabeol WWTP (Underground)	22,000	South Korea	Commissioned 2015	MSBR
Daegu Techno Police Industrial WWTP (Underground)	4,500	South Korea	Commissioned 2014	CSBR
Samsong WWTP (Underground)	16,000	South Korea	Commissioned 2013	CSBR
Jumunjin WWTP	4,800	South Korea	Commissioning 2013	CSBR
Byeolrae WWTP (Underground)	27,000	South Korea	Commissioned 2013	CSBR
Minrak WWTP (Underground)	16,000	South Korea	Commissioned 2013	CSBR
Gulhwa WWTP (Underground)	47,000	South Korea	Commissioned 2012	MSBR
JinKun-II WWTP (Underground)	20,000	South Korea	Commissioned 2010	CSBR
Wonnung WWTP	80,000	South Korea	Commissioned 2008	CSBR
Byukje WWTP	30,000	South Korea	Commissioned 2007	CSBR
Kunjang Industrial Park WWTP	30,000	South Korea	Commissioned 2006	CSBR
Jeonju WWTP	100,000	South Korea	Commissioned 2005	CSBR
Yeosu WWTP	110,000	South Korea	Commissioned 2004	CSBR
Jinkun WWTP	80,000	South Korea	Commissioned 2004	CSBR
Gwangyang WWTP	24,000	South Korea	Commissioned 2002	MSBR
Incheon International Airport High Strength WWRP	20,000	South Korea	Commissioned 2000	MSBR
CAP CANA	110,000	Dominican Republic	In operation	MSBR
D'Clase Industrial/Zona Franca Gurabo WWTP	1,700	Dominican Republic	In operation	MSBR
Charoen Pokhand Poultry Processing WWTP	6,600	U.S.A	Commissioned 1998	MSBR
Marys Ville WWTP	40,000	U.S.A	In operation	MSBR
Cumana East WWTP	25,000	Venezuela	Commissioned 1999	MSBR
Juangriego WWTP	10,000	Venezuela	Commissioned 1990	MSBR
Mariposa WWTP	207,360	Venezuela	Commissioned 1999	MSBR
Punta Gorda WWTP	80,000	Venezuela	Commissioned 1996	MSBR
Huai'an Municipal WWTP	20,000	China	Commissioned 2007	CSBR
Jiaozhou Textile Industrial Park 100% WWTP	20,000	China	Commissioned 2006	CSBR
Sanming Municipal WWTP	80,000	China	Commissioned 2004	CSBR
Shenzhen Municipal WWTP	120,000	China	Commissioned 2001	MSBR
Songjiang East Municipal WWTP	30,000	China	Commissioned 2004	MSBR
Wuxi Municipal WWTP	30,000	China	Commissioned 2003	MSBR
Taiyuan Iron and Steel Industry. WWTP	50,000	China	In operation	MSBR
Kunming Puz haoWWTP	100,000	China	Commissioned 2015	MSBR
Estevan WWTP	6,000	Canada	Commissioned 1995	MSBR
Okotoks WWTP	3,000	Canada	Commissioned 1998	MSBR

Consulting / Feasibility Study References

Name of Project	Capacity [m^3/day]	Country	Year	Process	Remark
Pohang WWTP	25,000	South Korea	2003	Bio-SAC Media	
Gaeun WWTP	2,000	South Korea	2003	Queensland	
Kumi WWTP	330,000	South Korea	2005	DNR	BNR Upgrade
MNB Very High Strength Chemical Industrial WWTP	340	South Korea	2008	MBBR Media	
Uijeonbgu WWTP	200,000	South Korea	2009	MLE	BNR Upgrade
Suwon Phase-1 WWTP	220,000	South Korea	2009	TEC	BNR Upgrade

Feasibility Study / R&D

	Name of Project	Detail	Supporting Organization	Period
Feasibliity Study	Pioneering Support Project for Overseas Construction Market	8 waterworks projects in Central Java, Indonesia	ICAK	14.1.1~14.12.31
	Business Support Project for SMEs	Expansion of environmental market project using CSBR	KEITI	14.6.1 ~ 15.4.30
	Feasibility Study Support for Overseas Environmental Projects	Juliaca, Peru WWTP Project	KEITI	14.6.23 ~ 15.2.28
	Support Project for Industry Cooperation Development	Colombia Water Treatment Industry Development Cooperation	KIAT	14.7.1 ~ 14.12.31
	Support Project for Overseas Plant Feasibility Study	Puno, Peru WWTP Project	KOPIA	14.10.23 ~ 15.2.28
	Feasibility Study Support for Overseas Environmental Projects	Abancay, Peru WWTP Project	KEITI	15.4.15 ~ 15.12.31
	Pioneering Support Project for Overseas Construction Market	Small cities' WWTP near Titicaca Lake in Peru	ICAK	15.7.1 ~ 15.12.31
R&D	New Product Project for Overseas Demand	PKG CSBR Sewage Treatment System with Ultrasonic waves (MOU with Ministry of Environment and Water, Bolivia)	TIPA	16.12.16 ~ 18.12.15
	Development Project for Start-up Growth Technology	Development of biological advanced treatment CMSBR process with increased water quality and capacity	TIPA	17.10.30 ~ 18.10.29

Vacuum Degassing(Biogradex™)

500m^3/d or above

Name of Plant	Flow [m^3/day]	Country	Year	Remark
Babiak	600	Poland	2007	BNR upgrade
Biskupiec Pomorski	980	Poland	2006	BNR upgrade
Cedry Wielkie	600	Poland	2006	BNR upgrade
Czestochowa	70,000	Poland	2010	Upgrade
Dzierzgon	2,300	Poland	1999	New facility
Gdansk	6,000	Poland	2009	New facility
Gdansk	6,000	Poland	2006	BNR upgrade
Gorzow	27,000	Poland	2007	BNR upgrade
Jawor	6,000	Poland	2005	BNR upgrade
Kaliska	500	Poland	2002	BNR upgrade
Lubochnia Dworska	1,000	Poland	2000	New facility
Luzino	850	Poland	2010	New facility
Luzino	650	Poland	1997	New facility
Milakowo	650	Poland	2006	BNR upgrade

Name of Plant	Flow [m^3/day]	Country	Year	Remark
Moszczenica	850	Poland	2010	New facility
Moszczenica	650	Poland	1997	New facility
Pieniezno	1,300	Poland	1997	New facility
Przodkowo	600	Poland	2001	BNR upgrade
Qinghe WWTP	120,000	China	2008	BNR Upgrade
Redzikowo	1,050	Poland	1997	BNR upgrade
Swarozyn	550	Poland	1995	New facility
Sztum	5,500	Poland	1995	New facility
Tartu	20,500	Estonia	2004	BNR upgrade
Turawa	4,000	Poland	1998	New facility
Witnica	1,400	Poland	2010	New facility
Witnica	1,400	Poland	2006	New facility
Witnica	1,000	Poland	1999	New facility
Zerkow	750	Poland	2007	BNR upgrade

Bio Media(Kaldnes media™)

Industrial			5,000m^3 or above
Name of Plant	Flow [m^3/day]	Country	Year
AO Kondopoga	14,000	Russia	2000/2004
Arkhangelsk Pulp and Paper	17,400	Russia	2007
Bahia Sul	15,000	Brazil	2007
Bhadrachalam	6,400	India	2007
Billerud Gruvön Mill	6,000	Sweden	2006
CMPC Inforsa	6,000	Chile	2006
CMPC Laja	7,700	Chile	2005
CMPC Pacifico	5,500	Chile	2009
CMPC Puente Alto	5,500	Chile	2006
CMPC Santa Fe	9,000	Chile	2006
Fraser Papers, Maine	6,000	U.S.A	2002
Norske Skog Follum	8,000	Japan	2007
Papelera Sniace	10,690	Spain	2010
Quesnel River Pulp	6,000	Canada	2005
Rottneros Utansjö	7,350	Sweden	2005
SCA Graphic Ortviken	10,000	Sweden	2004
SCA Packaging Munksund	11,200	Sweden	2009
Stendal Mill	6,100	Germany	2004
Stora Enso Anjalankoski	8,000	Finland	2005

Municipal			2,000m^3 or above
Name of Plant	Flow [m^3/day]	Country	Year
Broomfield, Colorado	4,697	U.S.A	2002
Corby STW	4,000	England	1998
EDAR Gavà-Viladecans	12,000	Spain	2010
EDAR Vilareal	4,908	Portugal	2010
Fields Point , RI	34,200	U.S.A	2010
Gardermoen	5,790	Norway	1998
Lille Marquette	14,630	France	2012
Lillehammer	3,840	Norway	1994
Nyköping	3,660	Sweden	1998
Pyewipe	3,960	England	1998
RA-2	19,000	Norway	2002
Röti	8,349	Switzerland	2004
Sjölunda	6,230	Sweden	1998
TEDA West (Phase 1)	4,200	China	2006
Trois Frontières CC3F	8,000	France	2008
Uddebo	2,700	Sweden	2008
Visby	5,800	Sweden	2007
Wildcat Hill, Flagstaff, AZ	6,600	U.S.A	2008
Yucaipa	4,037	U.S.A	2007

ROTHWELL
WATER

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