Supporting Information (SI) for:

Coupling a Rotating Biological Contactor with an Anaerobic Baffled Reactor for Sustainable Energy Recovery from Domestic Wastewater

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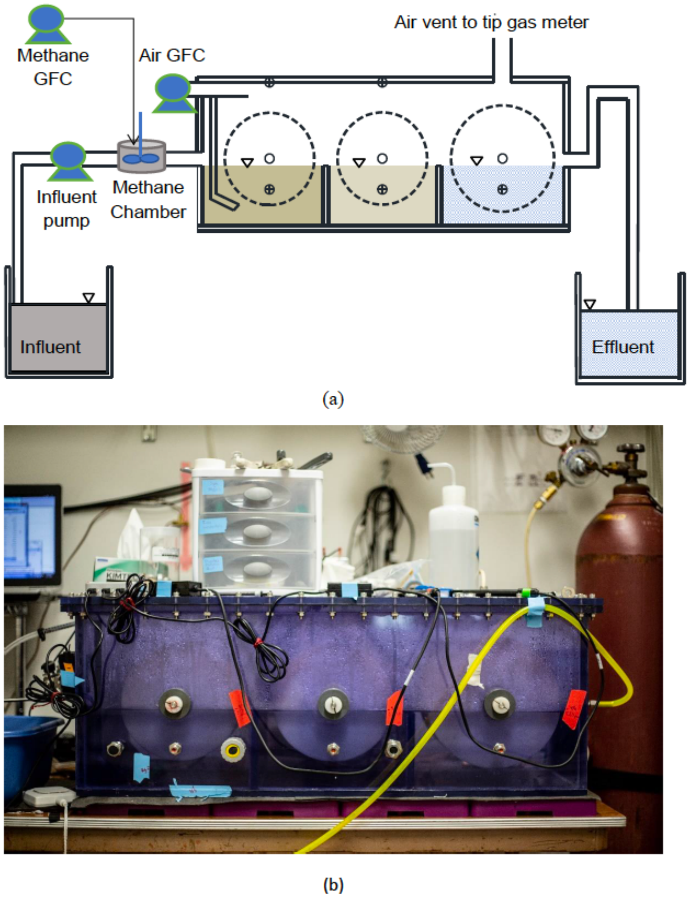
A. Summary of Rotating Biological Contactor Design process

Design parameters for the RBC were based on criteria outlined in Grady et al. (2011).[1] The reactor was designed to accommodate a flowrate of ~30 L/day, hydraulic loading rate of 0.08 to 0.16 m^3/m^2 day with influent BOD_5 concentration of 200 mg/L. To ensure sufficient oxygen transfer, the RBC was designed with a surface organic loading of 12 to 20 g of SBOD/m^2 day (20-35 g SCOD) for each chamber. The first two stages were designed to remove carbonaceous biological oxygen demand (BOD). The third stage was designed to remove nitrogenous BOD, as carbonaceous BOD concentrations were estimated to be below 20 mg /L in the third stage. A more detailed descripton of the lab-scale RBC is presented in Table A.1.

Table A.1 Lab-scale rotating biological contacter parameters

Parameter	**Baffle region**	**First and Second Stage**	**Third Stage**
Disk Diameter (m)	N/A	0.2	0.23
Number of Disks	0	8	8
Area of disks (m^2)	0	0.065	0.085
Length of Stage (m)	0.018	0.24	0.277
Width of Stage (m)	0.256	0.256	0.256
Depth of Stage (m)	0.297	0.297	0.297
Over baffle height (m)	0.128	0.128	0.129
Volume (L)	1.37	18.25	21.06
Liquid Volume (L)	0.59	7.86	9.15
HRT (day)	0.02	0.24	0.28



Supplementary Figure A.1 (a) Laboratory-scale rotating biological contactor (RBC) (V = 17.6 L). Synthetic feed was sparged with methane gas using a gas flow controller (GFC) in the methanation chamber. Air was supplied to the closed reactor using a GFC, and air flow out of the reactor was measured with a precision wet tip gas meter. (b) Image of reactor

B. Labortory study

B1. Synthetic Wastewater

The synthetic wastewater used in this study (Table B.1) simulated anaerobic effluent from anaerobic treatment of domestic sewage.[2,3] A half strength wastewater (recipe in Table B.1 diluted by 2) was used during the start-up period.

Table B.1 Composition of influent synthetic wastewater in mg/L.

Chemical Formula (Manufacturer, Location)	**Concentration in Feed (mg/L)**
KH_2PO_4 (Acros Organics, NJ, USA)	11
$CaCl_2 \cdot 2H_2O$ (Fisher Chemicals, Fair Lawn, NJ)	5
$MgCl_2 \cdot 6H_2O$ (VWR, West Chester, PA)	33
KCl (End Chemicals, Gibbstown, NJ)	16
NH_4Cl (Beantown Chemicals, Hudson, NH)	150
$Na_2S \cdot 2H_2O$ (Alfa Aesar, Ward Hill, MA)	59.5
$C_3H_5NaO_2$ (Spectrum Chemical MFG CORP, New Brunswick, NJ)	116.643
$CH_3COONa.H_2O$ (Amersco, Solon, OH)	44.336
Ensure (Abbott, Chicago, IL)	8.036
$FeSO_4 \cdot 7H_2O$ (Fisher Chemicals, Fair Lawn, NJ)	5.49
$CoCl_2 \cdot 6H_2O$ (Fisher Chemicals, Fair Lawn, NJ)	1.70×10^{-1}
$ZnSO_4 \cdot 7H_2O$ (Amersco, Solon, OH)	2.50×10^{-2}
H_3BO_3 (Fisher Chemicals, Fair Lawn, NJ)	6.00×10^{-2}
$MnCl_2 \cdot 4H_2O$ (Fisher Chemicals, Fair Lawn, NJ)	4.00×10^{-2}
$CuCl_2 \cdot 2H_2O$ (Ward's Science Rochester, NY)	2.70×10^{-2}
$Na_2MoO_4 \cdot 2H_2O$ (Fisher Chemicals, Fair Lawn, NJ)	2.50×10^{-2}
$Al_2(SO_4)_3$ (Fisher Chemicals, Fair Lawn, NJ)	1.67×10^{-2}
$NiCl_2 \cdot 6H_2O$ (Fisher Chemicals, Fair Lawn, NJ)	2.40×10^{-2}
Na_2SeO_4 (VWR, West Chester, PA)	1.70×10^{-3}

B2. Henry's Constant

A dimensionsless Henry's Law constant was calculated using Equations (B1) and (B2) for a temperature of 20°C :

$$LogK_H(atm) = -\frac{675.74}{T\ (K)} + 6.88 \tag{B1}$$

Where $K_H$is Henry's constant [atm] at temperature T [K], 675.74 and 6.88 are constants (provided by Tchobanoglous, 2003)

$$K_{H,T}\left(\frac{mole/L(aq)}{mole/L(gas)}\right) = \frac{R * T\left(\frac{l * atm * K}{mole * K}\right) * 55.6\left(\frac{moleH_2O}{L_{H_2O}}\right)}{K_H\ (atm)} \tag{B2}$$

where, $K_{H,T}$ is the dimensionless Henry's constant, R is the gas constant (0.08205 L-atm/mole-K), T is the temperature in degrees Kelvin, 55.6 is the molar concentration of water, and K_H is Henry's constant [atm] at temperature T [K].[4]

B3. Tracer Test: Model

The mass balance on the barrier region is

$$V_1\frac{dC_1}{dt} = QC_{H2O} - QC_1 \tag{B3}$$

where, V_1 is the volume of the barrier area of the RBC,

C_1 is the concentration of the tracer in the barrier region and its effluent over time,

t is time, since the injection,

Q is the flowrate, and

C_{H2O} is the concentration of the tracer in the influent water, which is zero.

The mass balance on the first chamber of the RBC is

$$V_2 \frac{dC_2}{dt} = QC_1 - QC_2 \tag{B4}$$

where, V_2 is the volume of the first chamber of the RBC, and

C_2 is the concentration of the tracer in the first chamber and its effluent over time.

The mass balance on the second chamber (which has the same volume as the first chamber, V_2 is

$$V_2 \frac{dC_3}{dt} = QC_2 - QC_3 \tag{B5}$$

where, V_2 is the volume of the second chamber, and

C_3 is the concentration of the tracer in the second chamber and its effluent over time

The mass balance on the third chamber is

$$V_3 \frac{dC_4}{dt} = QC_3 - QC_4 \tag{B6}$$

where, V_3 is the volume of the third chamber, and

C_4 is the concentration of the tracer in the third chamber over time

The differential equations (Eq (1)–Eq (4)) were integrated, and rearranged to solve for the concentration of conservative tracer in each of the reactors and their effluents (assuming completely mixed conditions). Unlike the familiar model for CMFRs in series with equal volumes, the mathematics do not simplify to a simple expression.

The concentration of tracer in the barrier chamber and its effluent can be modeled as:

$$C_1 = C_0 \, e^{\frac{-t}{\theta_1}} \tag{B7}$$

where, C_0 is the concentration in the barrier area immediately after of the injection of the tracer, assuming completely mixed conditions, and

Θ_1 is the hydraulic retention time of barrier area.

The concentration of tracer over time in the first chamber of the RBC, C_2, can be modeled as:

$$C_2 = \frac{C_0}{1 - \frac{\Theta_2}{\Theta_1}}\left(e^{\frac{-t}{\Theta_1}} - e^{\frac{-t}{\Theta_2}}\right) \tag{B8}$$

where, Θ_2 is the hydraulic retention time in the first chamber.

The concentration of tracer over time in the second chamber, C_3, can be modeled as:

$$C_3 = \frac{C_0}{\left(1 - \frac{\Theta_2}{\Theta_1}\right)^2}\left(e^{\frac{-t}{\Theta_1}} - e^{\frac{-t}{\Theta_2}}\right) - \frac{C_0}{\Theta_2\left(1 - \frac{\Theta_2}{\Theta_1}\right)}\left(t\, e^{\frac{-t}{\Theta_2}}\right) \tag{B9}$$

where, Θ_2 is the hydraulic retention time in the second chamber.

The concentration of tracer over time in the third chamber, C_4, can be modeled as:

$$C_4 = C_0 * \left(\frac{1}{\left(1 - \frac{\Theta_2}{\Theta_1}\right)^2\left(1 - \frac{\Theta_3}{\Theta_1}\right)} e^{\frac{-t}{\Theta_1}} - \frac{1}{\left(1 - \frac{\Theta_2}{\Theta_1}\right)^2\left(1 - \frac{\Theta_3}{\Theta_2}\right)} e^{\frac{-t}{\Theta_2}} - \frac{1}{\Theta_2\left(1 - \frac{\Theta_2}{\Theta_1}\right)\left(1 - \frac{\Theta_3}{\Theta_2}\right)}\left(t\, e^{\frac{-t}{\Theta_2}}\right) + \frac{1}{\left(\frac{\Theta_2}{\Theta_3}\right)\left(1 - \frac{\Theta_2}{\Theta_1} \cdots\right.}\right.$$

$$e^{\frac{-t}{\Theta_4}}\left(\frac{1}{\left(1 - \frac{\Theta_2}{\Theta_1}\right)^2\left(1 - \frac{\Theta_3}{\Theta_2}\right)} - \frac{1}{\left(1 - \frac{\Theta_2}{\Theta_1}\right)^2\left(1 - \frac{\Theta_3}{\Theta_1}\right)} - \frac{1}{\frac{\Theta_2}{\Theta_3} * \left(1 - \frac{\Theta_2}{\Theta_1}\right)\left(1 - \frac{\Theta_3}{\Theta_2}\right)^2}\right)$$

(B10)

where, Θ_3 is the hydraulic retention time in the third chamber.

C. Engineering Process Model

C1. Process flow of Model Scenarios

The following process flow diagrams were created in CapdetWorks.

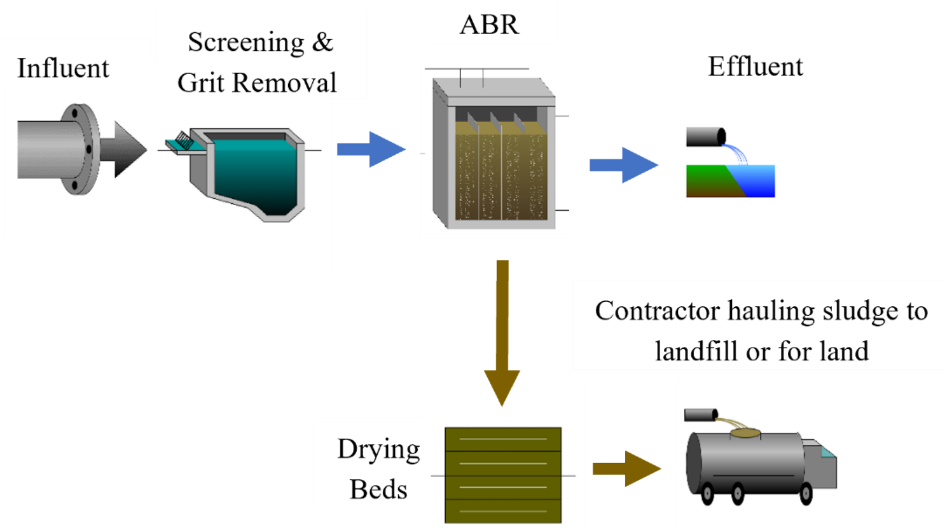


Figure C.1 Process flow for the anaerobic treatment scenario, using an ABR.

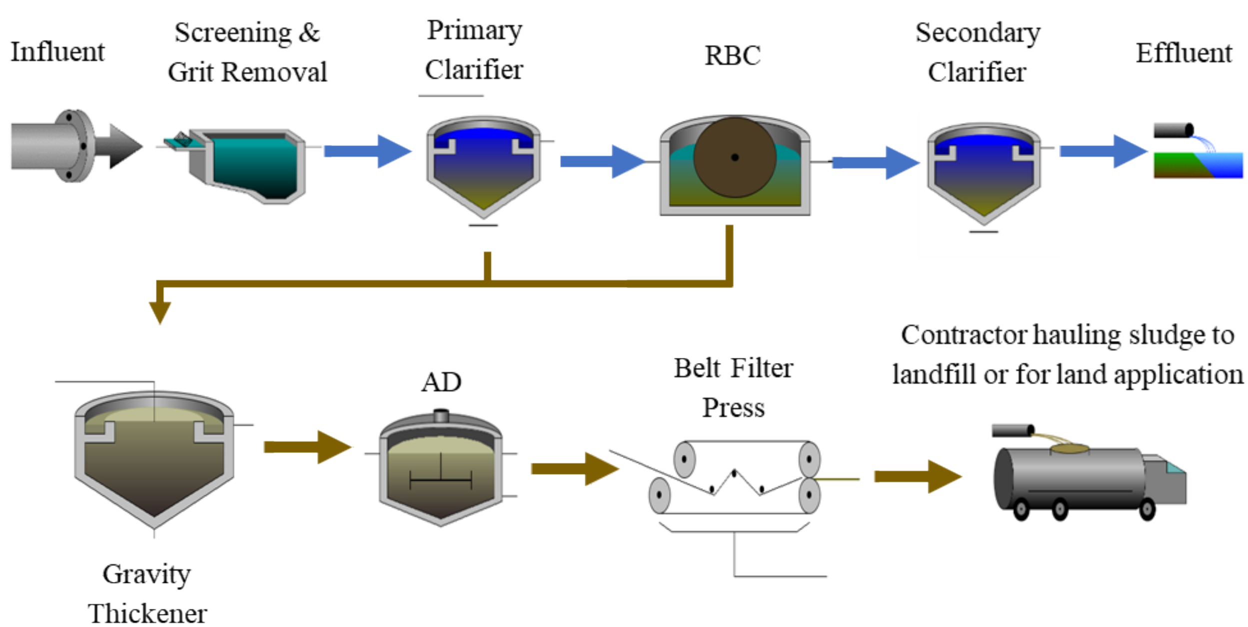


Figure C.2 Process flow for the aerobic treatment scenario, using an RBC+AD.

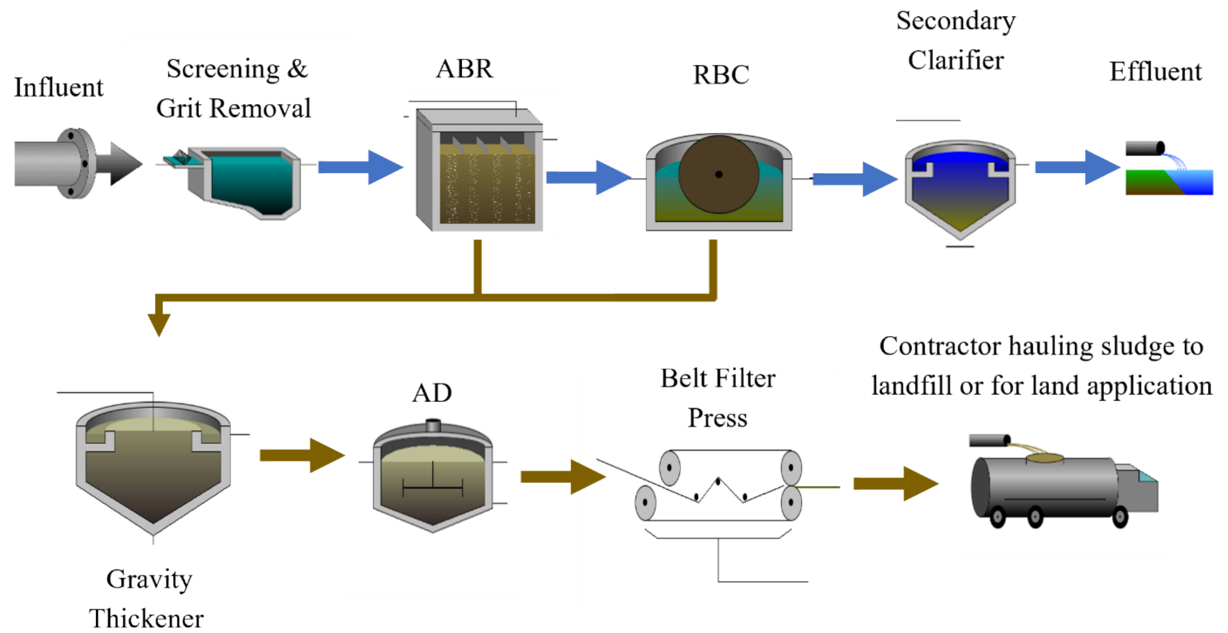


Figure C.3 Process flow for the anaerobic followed by aerobic treatment scenario, using an ABR+RBC+AD.

C2. Building the Process Engineering Models

Table C.1 Influent wastewater characteristics (value ± standard deviation) used for the modeling framework, from the Milton Regional Sewer Authority (MRSA) Milton, PA.[5]

Design Criteria	**Units**	**Value ± SD**
Average flow	MGD	2
TSS	mg/L	171 ± 132
VSS	mg/L	147 ± 103
BOD_5	mg/L	241 ± 99
$SBOD_5$	mg/L	92 ± 30
COD	mg/L	531 ± 217
SCOD	mg/L	203 ± 66

Table C.2 Life cycle inventory for 15–20°C treatment for 2 MGD of domestic wastewater (base case values).

Process	Parameter	Unit	ABR	RBC	ABR+RBC
ABR	Effluent COD	mg/L	90 [5]	-	90 [5]
	Effluent dissolved CH_4	mg/L	27 [5]	-	27 [5]
	Effluent dissolved CH_4 as COD	mg/L	108[5]	-	108[5]
	Gaseous CH_4 production	m^3/d	547	-	547; [5]
RBC	Influent COD	mg/L	-	255†	90[5]
	Influent Dissolved CH_4 as COD	mg/L	-	-	108[5]
	Electricity	kWh/d	-	396	337
	Effluent BOD5	mg/L	-	30	30
Anaerobic digestion	Mixing, electricity	kWh/d	-	48	24
	Heat losses	MJ/d	-	3.57 E+02	2.57 E+02
	Heat consumed	MJ/d	-	1.78 E+03	8.92 E+02
	Gaseous CH_4 production	m^3/d	-	350	176
	Construction, AD plant for sewage sludge	piece	-	5.61 E-02	1.74 E-02
Cogeneration	Electricity generated	kWh/d	1.33 E+03	8.67 E+02	1.75 E+03
	Heat generated	MJ/d	7.04 E+03	4.81 E+03	9.39 E+03
	Construction, heat and power cogeneration unit, 160 kW_e	piece/d	3.12 E-05	2.06 E-05	3.12 E-05
Dewatering, sludge drying bed	Land occupation	m^2	741[5]	-	-
	Sand	kg	1.82 E+04 [5]	-	-
	Gravel	kg	3.81 E+05 [5]	-	-
Dewatering, belt filter	Electricity	kWh/d	-	71	43
	Acrylonitrile (polymer)	kg/d	-	8.0	4.9
Sludge disposal (landfill)	Solid waste treated, sanitary landfill (TS)	kg/d	111	390	266
	Sludge transport, freight, lorry	kg*km/d	1.13 E+04	3.92 E+04	2.66 E+04
Sludge disposal (land application)	Nitrogen fertilizer avoided	kg/d	2.5	8.5	5.8
	Phosphorus fertilizer avoided	kg/d	2	6.8	4.7
	Quicklime	kg/d	28	96	65
	Electricity, consumed	kWh/d	8.1	47	29
	Diesel, from crude oil, consumption mix	kg/d	0.1	0.58	0.36
	Solids for land application	kg/d	136	477	325
	Sludge transport, freight, lorry	kg*km/d	6.88 E+03	2.37 E+04	1.61 E+04

† Estimated from Primary effluent at MRSA.

C3. Normalization Factors

Table C.3 Factors used for normalization of damage category impacts (adapted from Lautier et al., 2010).[6]

	United States	Europe	Units
Resource Depletion	203,000	152,000	MJ Primary/Point
Human Health	0.0388	0.0071	DALY/Point
Ecosystem Quality	4,380	13,700	PDF-m2-yr/Point
Climate Change	20,600	9,950	kg CO2-eq/Point

C4. Uncertainty Analysis

Table C.4 Base Case (Most Likely), Minimum (or Standard Deviation for Normal and Lognormal Distributions), and Maximum Values and Distribution Types Used for Uncertainty Analysis

Component	Input Parameter	Value	Units	Distribution	SD	min	max
ABR	Specific CH_4 Production (gas)	0.17	L/g CODr	Lognormal	2‡		
	Total Solids	252	mg/L	Triangular		90	336
	Volatile Solids Destroyed	1060	mg/L	Triangular		318	3498
	Effluent BOD5	60	mg/L	Normal	36		
	Effluent COD	90	mg/L	Normal	50		
	Influent COD	531	mg/L	Normal	378		
	Dissolved CH_4	27	mg/L	Normal	6		
RBC	Electricity Consumption	140000	kWh/year	Triangular		112,000	168,000
ABR+RBC	Electricity Consumption	123000	kWh/year	Triangular		98,400	147,600
	Dissolved CH_4 Removal	0.8	%	Triangular		0.64	0.96
Gravity Thickening	Polymer Thickening	0.005	kg /kg of dry solids	Triangular		0.003	0.007
Anaerobic Digestion	VS destroyed	56	%	Triangular		50	62
	Biogas Yield	0.94	m^3biogas/ kg VS_r	Triangular		0.75	1.12
	CH_4 Content, biogas	65	%	Triangular		60	70
	Power, mixing	0.0065	kW/m^3 digester	Triangular		0.005	0.008
Combined Heat and Power System	Fugitive CH_4 emissions	3.1	%	Triangular		1.7	5.2
	Electrical efficiency	25	%	Uniform		24	31
Sludge Disposal	Disposed Solids ABR	252	kg/d	Uniform		90	336
Landfill	Transport Distance	50	km	Triangular		10	160
Land Application	Transport distance	50	km	Triangular		10	160

‡ Geometric Standard deviation

C5. Technoeconomic analysis

General Assumptions

- Default values from the CapdetWorks [7] software package were used for building the engineering process models except for the parameters listed in Table C.4. The parameters listed in Table C.4 were adjusted based on experimental results from previous anaerobic experiments [5,8] and experimental results for methane oxidation in a rotating biological contactor (RBC) reported in this paper.
- Assumed life time to be 15 years for RBC units, 20 years for mechanical components, 25 years for pumps and 40 years for structural components.[9]
- Default assumptions in CapdetWorks:
  - Nutrient removal was not modeled in any of the physical, biological or chemical processes. The only reduction in nutrients is due to anaerobic growth.
  - Clarifiers were designed based on average flow rate.
- For screening and grit removal, the screening equipment was assumed to be cleaned manually (Wade, 2015).
- All systems were modeled to operate at 20^0 C, except for anaerobic digestion, which was operated at 35ºC, and with a pH of 7.4 (Sills, 2016).
- Measured influent COD to SCOD ratio (Wade, 2015) was used for influent BOD to SBOD conversions.
- Anaerobic Baffled Reactor (ABR):
  - ABR modeled as one UASB with an HRT of 0.55 days.[8]
- Percentage of TSS removal in Primary Clarifier was assumed to be 60%.[10]
- Fraction of VSS in TSS was assumed to be 0.725 for RBC and secondary clarifier effluents.[11]
- Anaerobic Digestion:
  - One primary digester tank, and an additional digester tank to be operated during the cleaning of the primary tank.
  - Sized the digester based on total volatile solids entering the digester from the gravity thickener.
- A check was conducted to ensure that a 1 m belt will be sufficient for Belt Filter Press following method from Tchobanoglous et al. (2003)
- Solids disposal:
  - Sludge was stabilized by adding 200 kg of lime per ton of solids.[8]
  - Two 12-ton dumpsters were purchased for the model. The dumpsters are to be filled in an alternating manner, so that when one is full and is trucked off site for disposal, the second can be filled.
  - One dumpster was accounted for in the construction phase for landfill, and the second in the construction phase for land application.
  - Dumpsters were changed every 30 years (CAPDETWorks Default for the truck).
  - Transportation of sludge was contracted out to a trucking company based on information from MRSA.
- Combined heat and power (CHP)
  - CHP was sized at 54.8, 36.6 and 73.8 kW for ABR, RBC and ABR+RBC respectively, based on methane production from ABR and AD.
- The combined treatment system (ABR+RBC) was modeled with experimental results for the ABR,[8] and included the dissolved methane in the ABR effluent as an influent for the RBC.

Table C.5 Input and design parameters used to model unit processes for the three treatment scenarios: ABR, RBC, ABR + RBC, with their respective distributions were applicable, or minimum and maximum values used (in parenthesis). Design parameters not listed used the CapdetWorks defaults. Grey shading was used when the assembly did not have the treatment unit (such as an ABR unit for the RBC+AD assembly).

Unit Process	Design Criteria	Units	ABR	RBC+ AD	ABR+RBC
ABR	HRT	day	0.53[5]		0.53[5]
	Volume	m^3	4013[8]		4013[8]
	Construction Multiplier	$\$/m^3$	219¶		219§
	Sludge Loading Rate	kg COD/ (kg VSS d)	1[8]		1[8]
	COD Removal	%	0.95[8]		0.95[8]
	Specific CH_4 Production (gas)	L/g COD_r	0.17[5]		0.17[5]
	Influent Sulfate	mg/L	30[5]		30[5]
	Influent Solids Retention	%	0.955[8]		0.955[8]
	Yield of Acidogens		0.16[5]		0.16[5]
	Yield of Methanogens		0.035[5]		0.035[5]
	Yield of Sulphidogens		0.057[5]		0.057[5]
	Sludge Flow	MGD	0.0104		0.0362
Primary Clarifier	Side water depth	ft		14[5]	
	Weir overflow rate	gal/(ft d)		12700[5]	
	Diameter	ft		50[5]	
RBC	Number of stages	piece		4	4
	Media surface area	m^2		49880[7]	59180 [7]
	Media surface area in first stage	m^2		27220 [7]	35580 [7]
	Hydraulic Loading Rate	m^3 /(m^2.day)		0.13 [7]	0.15 [7]
	Contactor underflow Solids	mg/L		100.4 [7]	105 [7]
	Electricity consumption	kWh/year		140000 [7]	123000 [7]
	Dissolved CH_4 Removal	%			0.8
Gravity Thickening	Depth	m		3.5[5]	
	Mass loading	kg/(m^2.hr)		2.0[5]	
Anaerobic Digester	Specific Gravity			1.02[8]	
	VS destroyed	%		56.0[10]	
	Biogas Yield	m^3biogas/ kg VS_r		0.94[10]	
	CH_4 Content, biogas	%		65[10]	
	Power, mixing	kW/m^3 digester		0.0065[10]	
CHP	Fugitive CH_4 Emissions	%	3.1[13]		
	Electrical efficiency	%	25 [14]		
Belt Filter Press	Cake solids content	%		22[5]	
	Hydraulic loading	L/s		2.3[5]	
	Polymer dose	% dry weight		0.55[5]	
Drying Beds	Depth applied	in	10[5]		
	Time to drain	day	10[5]		
	Final Solids	%	60[5]		
	Lime added	kg/ Ton of solids	200[8,15]		
Landfill	Percent sludge disposed	%	45[16]		
	Transport distance	km	50[12]		
Land Application	Percent sludge disposed	%	55[16]		
	Transport distance	km	50[12]		

¶Construction multiplier calculated as: 1783 x $Volume^{-0.2528}$

Cost Assumptions used in in CapdetWorks:

- This is a Class 4 estimate using parametric models and factoring in the pricing of equipment. The margins on this estimation are 15-30% on the lower end, and 20-50% on the higher end.[17]
- Used default values for unit costs, labor rates, chemical costs, cost indices and equipment costs.
- Used RS Means location factor adjustment of 0.97 for Harrisburg, PA.[18]
- Calculated land costs to be 6400 dollars per acre [19] using a year conversion index of 191.2 for 2011 and 222.9 for 2018.[17]
- Converted capital and operation costs from 2018 USD to 2022 USD by using inflation factor of 1.1343.[20]

Table C.6 Additional cost assumptions used for capital costs calculated in CapdetWorks as well as for combined heat and power system (Source: CapdetWorks).[7]

Additional Cost Assumptions	**Value (%)**
Engineering Design Fee	15
Miscellaneous	5
Administration/Legal	2
Inspection	2
Contingency	10
Technical	2
Profit and Overhead	15

D. Supplementary Results

D1. Recipe H Midpoints

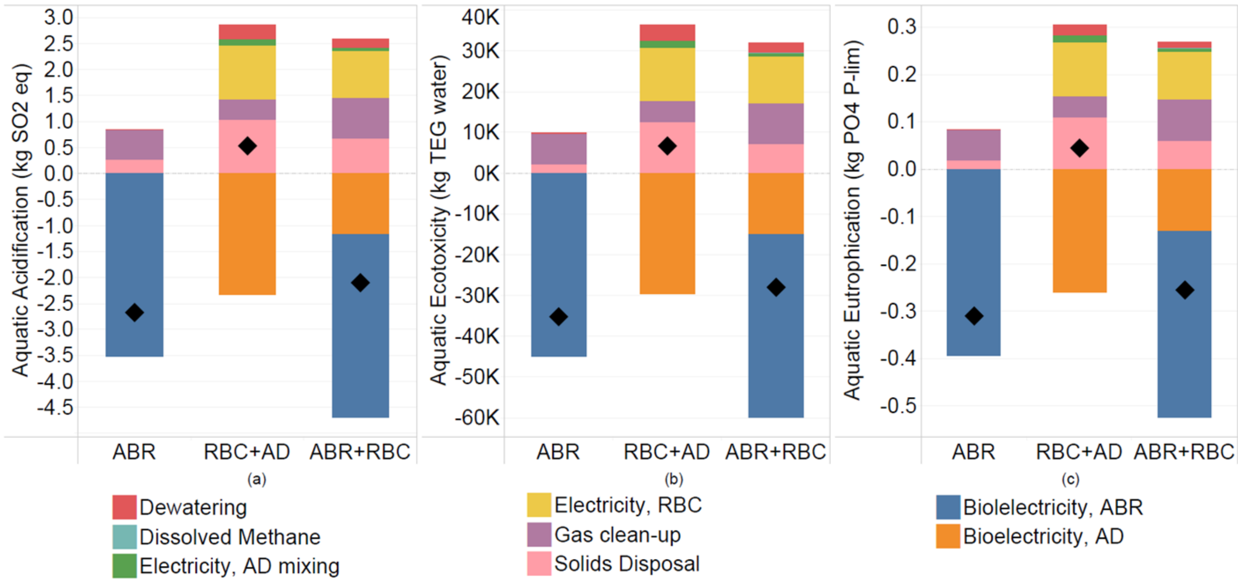


Figure D.1 Base case environmental impact for ReCiPe midpoint (H) categories (a) Aquatic acidification (kg SO_2 eq.), (b) Aquatic ecotoxicity (kg TEG water), and (c) Aquatic Eutrophication (kg PO_4 P-lim) for three treatment scenarios: ABR, RBC+AD and ABR+RBC. Harmful impacts are represented by values with positive magnitudes, and beneficial impacts are represented by values with negative magnitudes. Net impacts are shown as black diamonds.

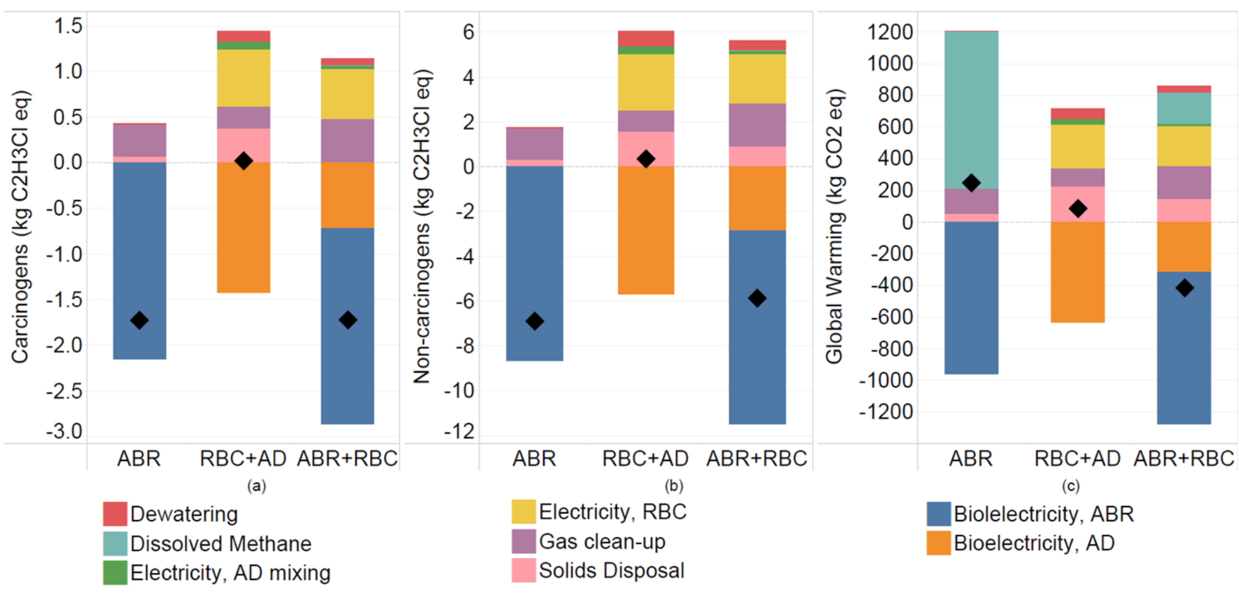


Figure D.2 Base case environmental impact for ReCiPe midpoint (H) categories (a) Carcinogens (kg C_2H_3Cl eq.), (b) Non-carcinogens (kg C_2H_3Cl eq.), and (c) Global Warming (kg CO_2 eq.) for three treatment scenarios: ABR, RBC+AD and ABR+RBC. Harmful impacts are represented by values with positive magnitudes, and beneficial impacts are represented by values with negative magnitudes. Net impacts are shown as black diamonds.

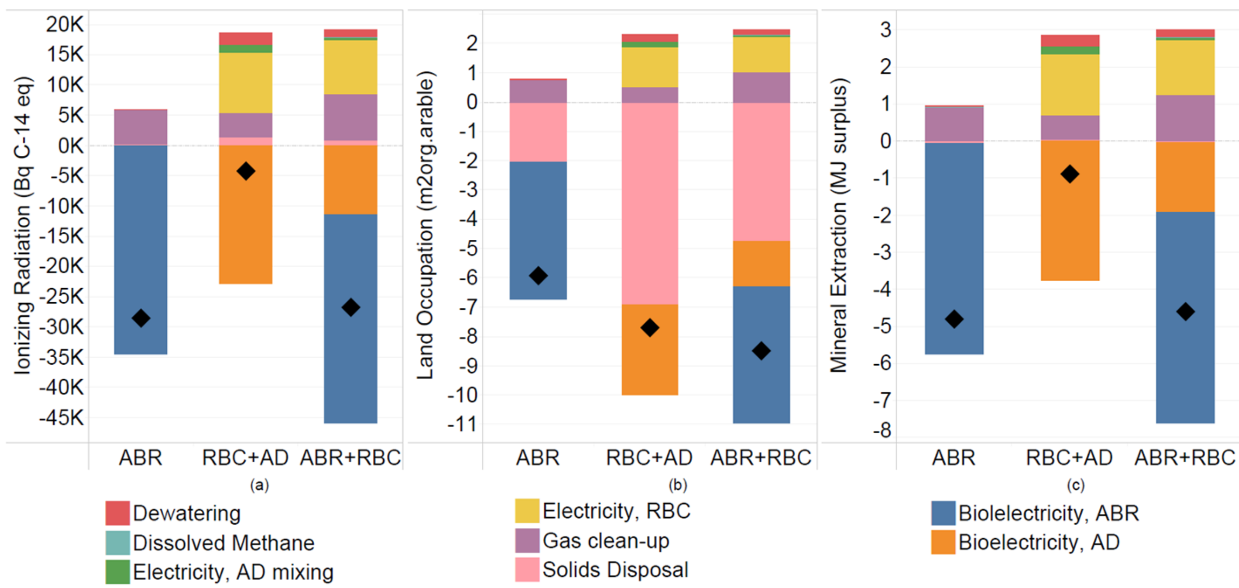


Figure D.3 Base case environmental impact for ReCiPe midpoint (H) categories (a) Ionizing radiation (Bq C-14 eq.), (b) Land occupation (m^2org.arable), and (c) Mineral extraction (MJ surplus) for three treatment scenarios: ABR, RBC+AD and ABR+RBC. Harmful impacts are represented by values with positive magnitudes, and beneficial impacts are represented by values with negative magnitudes. Net impacts are shown as black diamonds.

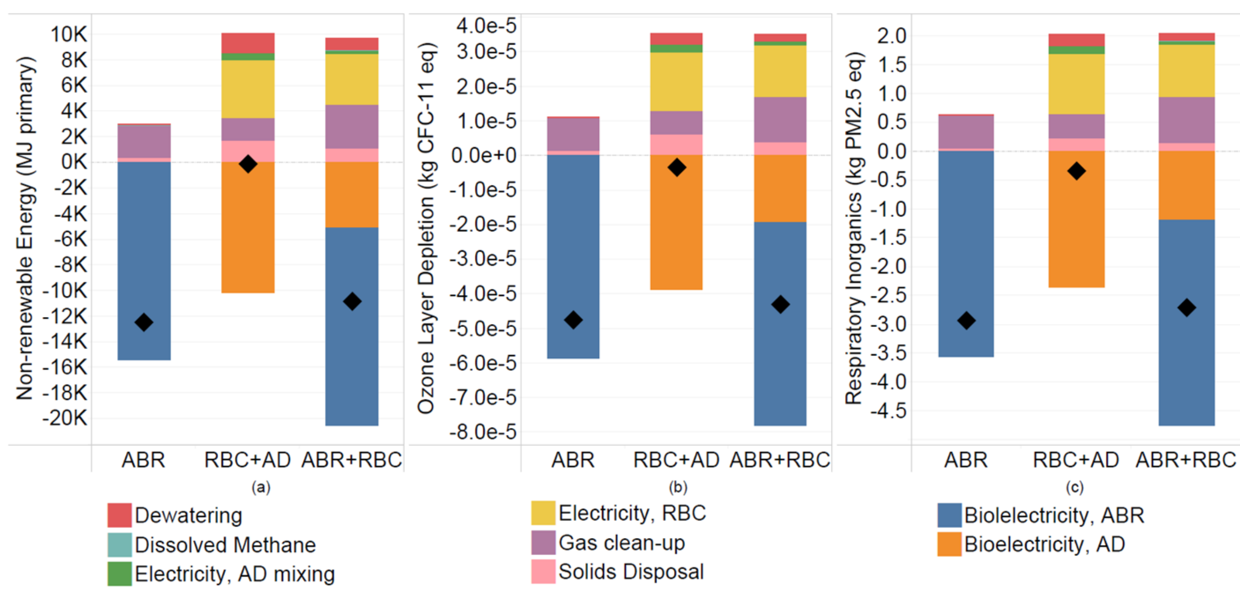


Figure D.4 Base case environmental impact for ReCiPe midpoint (H) categories (a) Non-renewable energy (MJ primary), (b) Ozone layer deletion (kg CFC-11 eq.), and (c) Respiratory inorganics (kg $PM_{2.5}$ eq.) for three treatment scenarios: ABR, RBC+AD and ABR+RBC. Harmful impacts are represented by values with positive magnitudes, and beneficial impacts are represented by values with negative magnitudes. Net impacts are shown as black diamonds.

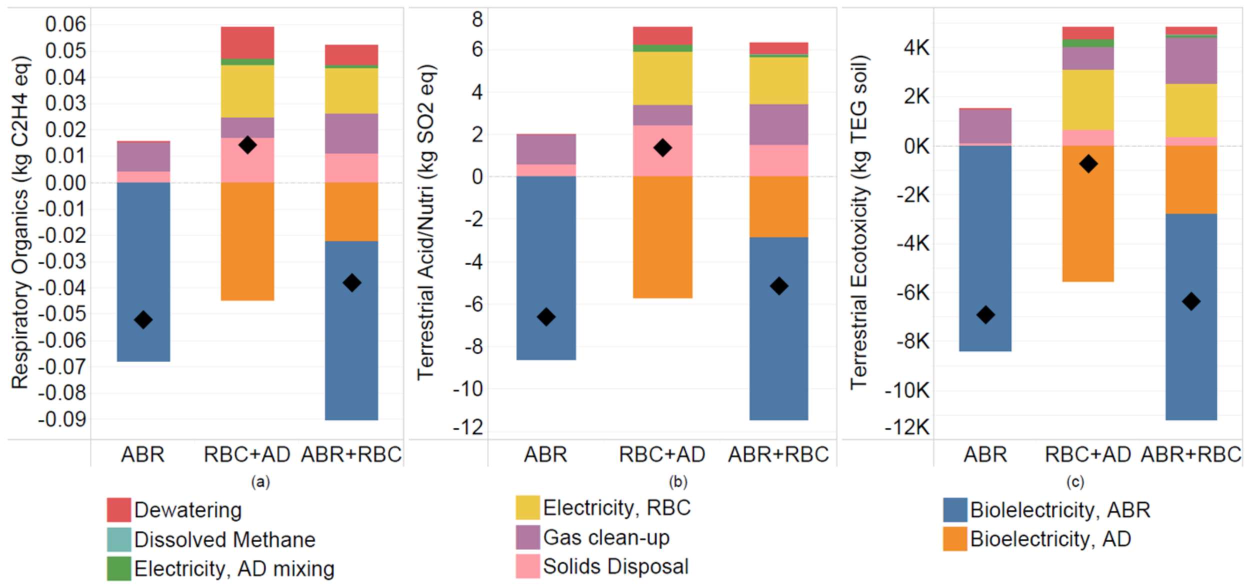


Figure D.5 Base case environmental impact for ReCiPe midpoint (H) categories (a) Respiratory Organics (kg C_2H_4 eq.), (b) Terrestrial Acidification/Nutri (kg SO_2 eq.) and (c) Terrestrial ecotoxicity (kg TEG soil) for three treatment scenarios: ABR, RBC+AD and ABR+RBC. Harmful impacts are represented by values with positive magnitudes, and beneficial impacts are represented by values with negative magnitudes. Net impacts are shown as black diamonds.

D2. Capital and Operating Costs

Table D.1 Capital costs in 2022 USD for three process assemblies designed to treat 2 MGD: anaerobic baffled reactor (ABR), rotating biological contactor (RBC) + anaerobic digestion (AD) and ABR+RBC.

Process	ABR	RBC+AD	ABR+RBC
Preliminary Treatment	279,038	279,038	279,038
ABR	1,361,160	0	1,361,160
Primary Clarification	0	291,515	0
RBC	0	973,229	851,859
Secondary Clarifier	0	468,466	467,332
Drying Beds	360,707	0	0
Gravity Thickening	0	112,182	112,182
Anaerobic Digestion	0	1,985,025	1,985,025
Belt-Filter Press	0	921,052	921,052
Aggregate Disposal	12,341	20,928	10,368
Cogeneration	167,209	168,632	225,184
Other Costs	7,685,087	9,528,120	10,221,456
Total	9,865,542	14,748,187	16,434,655

Table D.2 Yearly operating costs in 2022 USD for three process assemblies designed to treat 2 MGD: anaerobic baffled reactor (ABR), rotating biological contactor (RBC) + anaerobic digestion (AD) and ABR+RBC.

Process	ABR	RBC+AD	ABR+RBC
Preliminary Treatment	71,744	71,971	72,312
ABR	189,893	0	191,027
Primary Clarification	0	60,643	0
RBC	0	50,646	44,408
Secondary Clarifier	0	77,287	76,033
Drying Beds	47,584	0	0
Gravity Thickening	0	12,958	12,754
Anaerobic Digestion	0	82,123	81,329
Belt-Filter Press	0	6,395	6,383
Aggregate Disposal	13,817	50,301	17,561
Cogeneration	-38,428	-25,429	-51,633
Other Costs	193,965	193,965	19,397
Total	478,576	580,863	644,139

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