Environmental Stewardship through Recovering Resources from Wastewater

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July 29, 2017

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Overview

- About Me
- Introduction
- Current Research
- Future Research
- Conclusion

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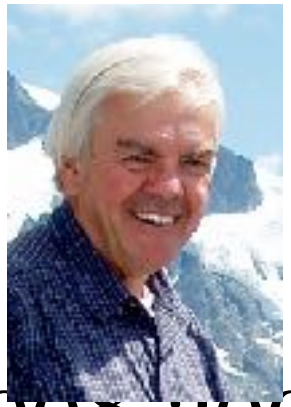
About Me

Madison, WI 2004-2008, 2011-2014



ENGINEERS WITHOUT BORDERS USA

Tampa, FL 2008-2009, 2014-present

About Me

Panama 2009-2011

Peace Corps

Costa Rica 2018

FULBRIGHT

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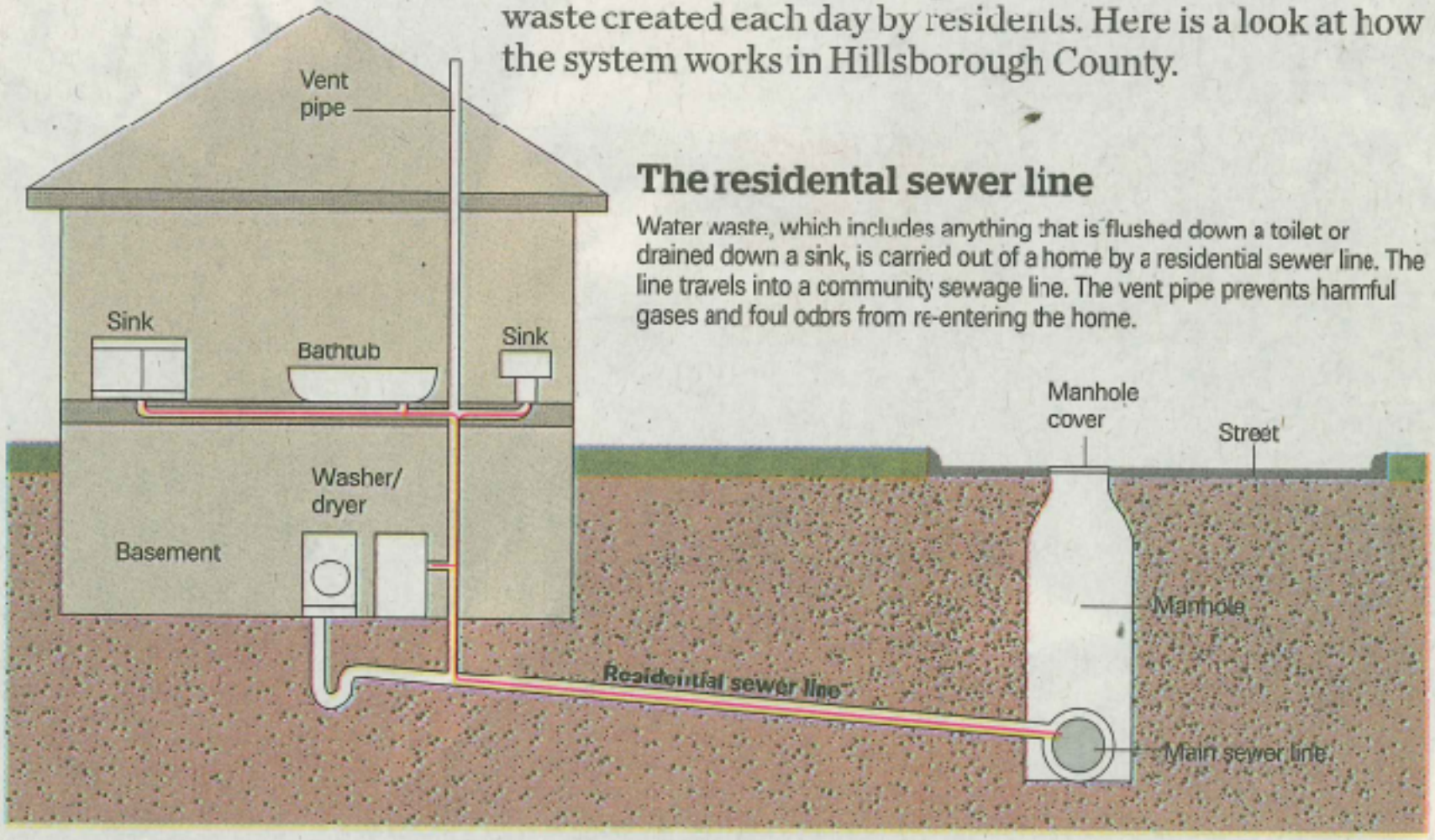
A dirty job

Sewage treatment centers process massive amounts of waste created each day by residents. Here is a look at how the system works in Hillsborough County.

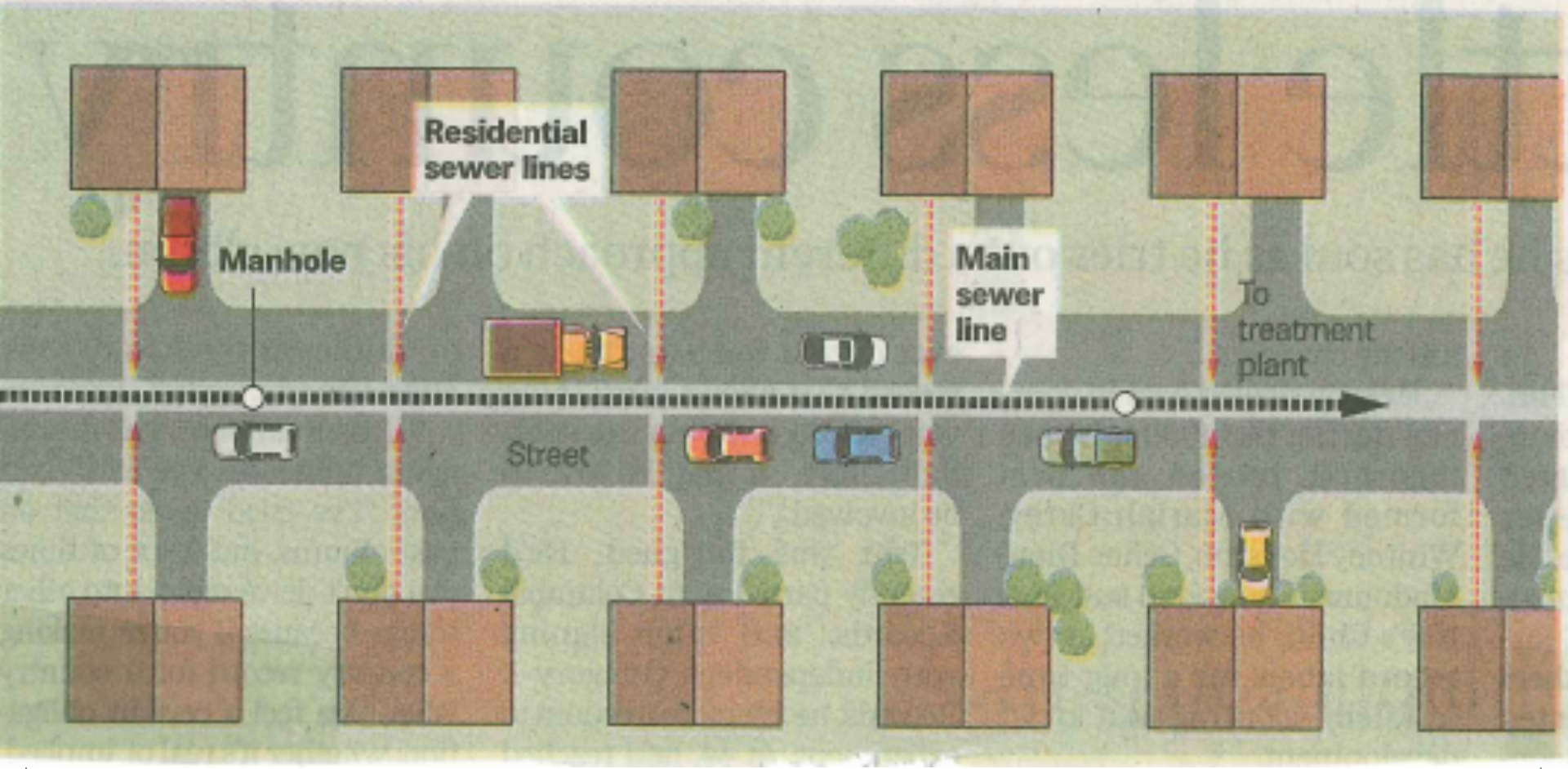


The residental sewer line

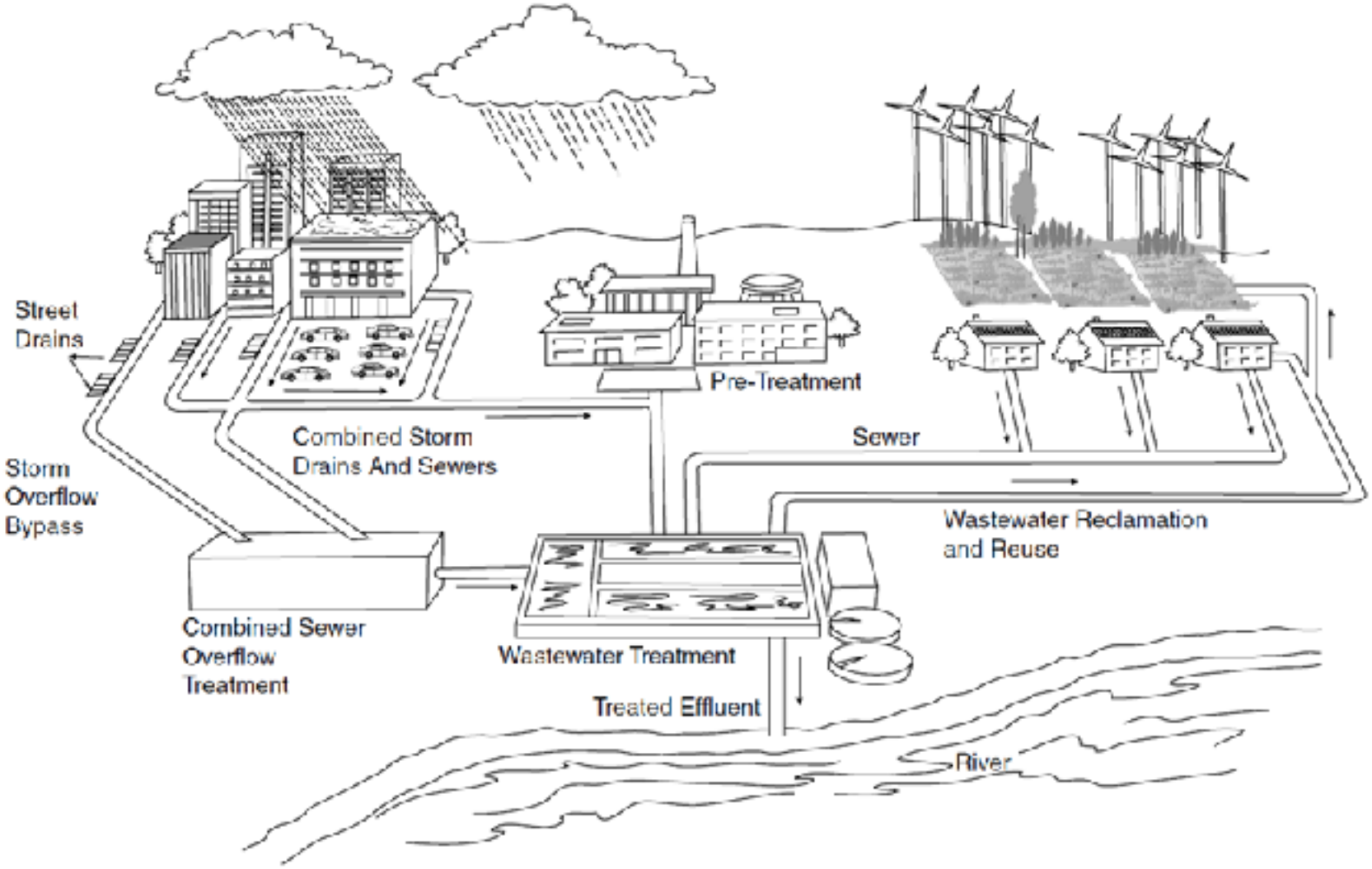
Water waste, which includes anything that is flushed down a toilet or drained down a sink, is carried out of a home by a residential sewer line. The line travels into a community sewage line. The vent pipe prevents harmful gases and foul odors from re-entering the home.

The community main sewer line

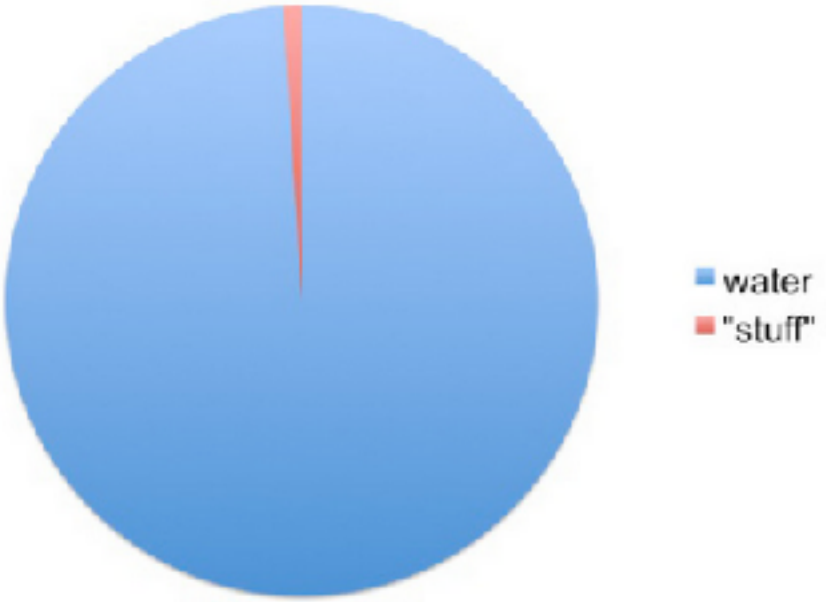
The residential sewer lines flow into a central sewer. A typical community sewer line is about 3-5 feet in diameter. Manholes appear periodically along the sewer line for maintenance purposes. The main line is completely gravity-powered and sends the sewage downhill to a pump station, then to the sewage treatment plant.



Where does it go?



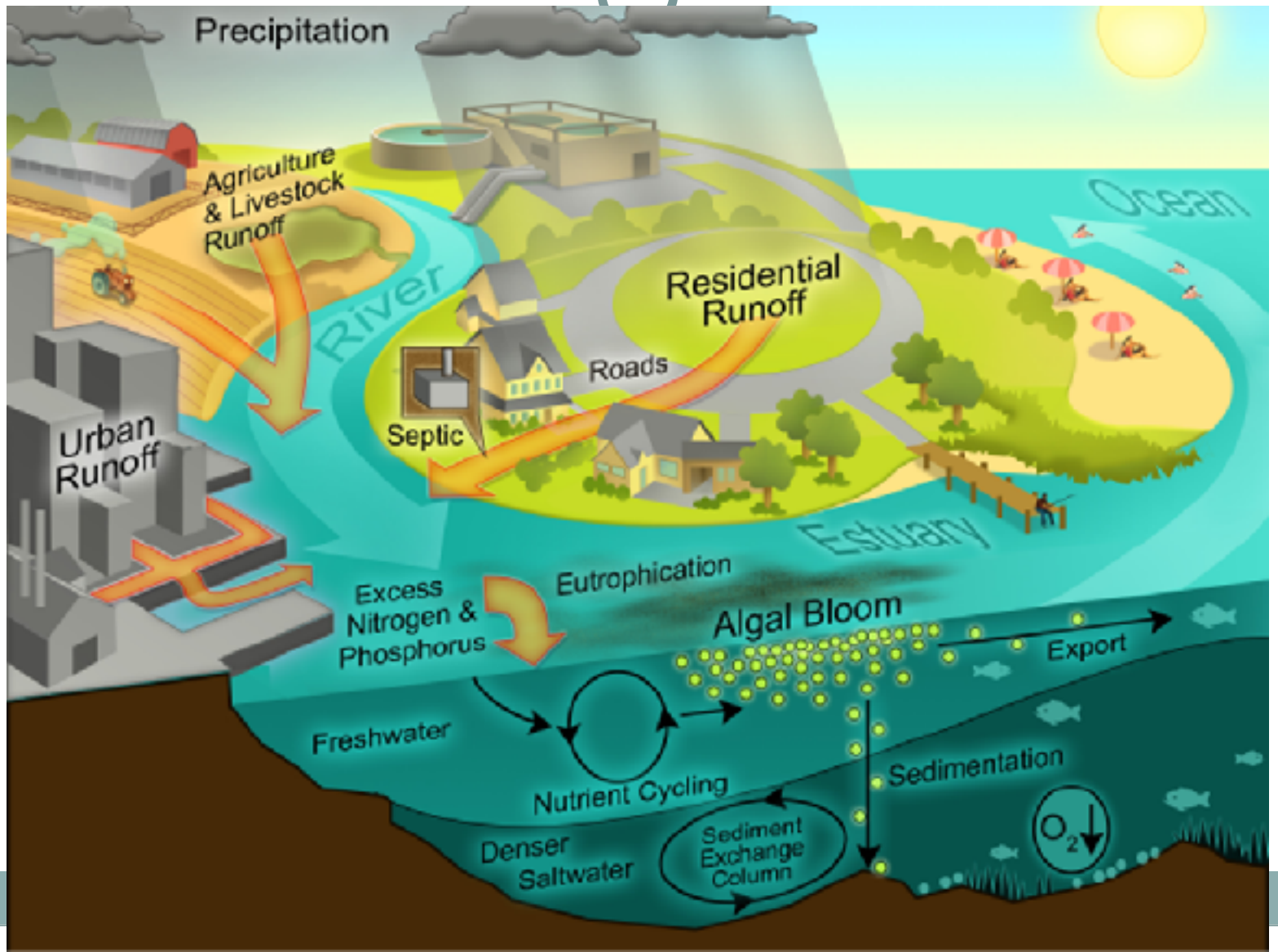
What's in wastewater?



Stuff includes…

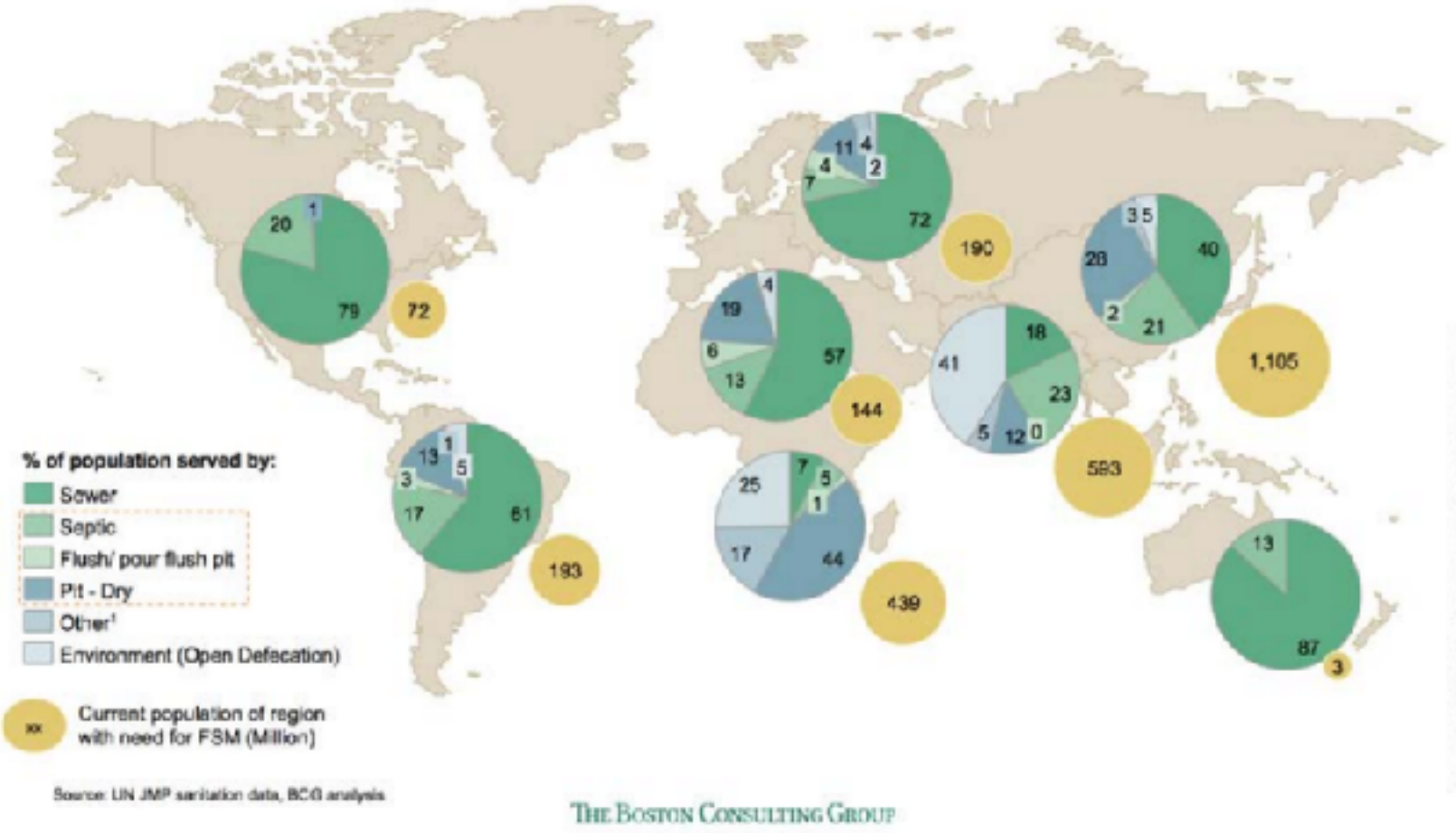
- Feces
- Pathogens
- Nutrients
- Cleaning products
- Medications
- Kitchen waste

Why is wastewater a problem?



Sanitation looks different in other places

Sanitation looks different in other places



Introduction

Sustainable Development Goals

Introduction

2.4 billion still lack access to sanitation

280,000 diarrheal deaths occur annually from inadequate sanitation

35% reduction in diarrheal deaths with improved sanitation

Introduction

Old paradigm: Removal

Wastewater as waste

NEW paradigm: Recovery

Wastewater as resource

N: Nutrients

E: Energy

W: Water

Introduction

Creation Care:

Genesis 2:15: To serve and to protect

Psalm 19:1: The sky above proclaims his handiwork

Take what was considered a waste, with no value, and see its purpose

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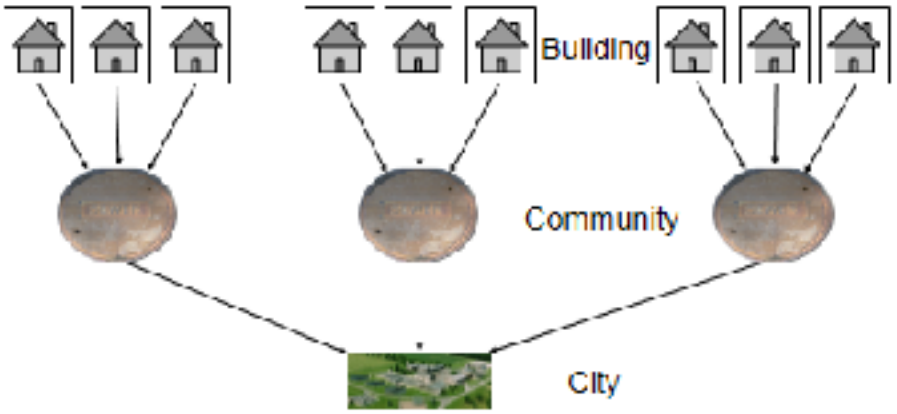
Current Research-Urban

Nutrient Management
In a Sewershed



Building = Urine

Community = Sewer Mining

City = Anaerobic Digestion, Struvite Precipitation

(Orner et al., *Environmental Engineering Science*, 2017)

Current Research-Urban

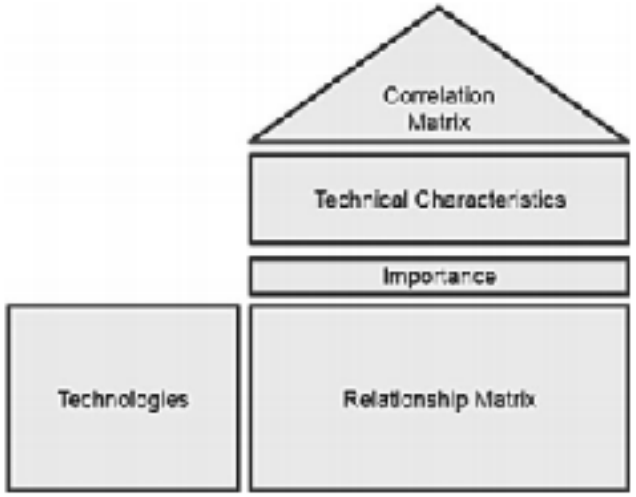


FIG. 1. Modified version of house of quality used to evaluate nutrient removal and recovery technologies at the building, community, and city scales. Adapted from Lowe (2000).

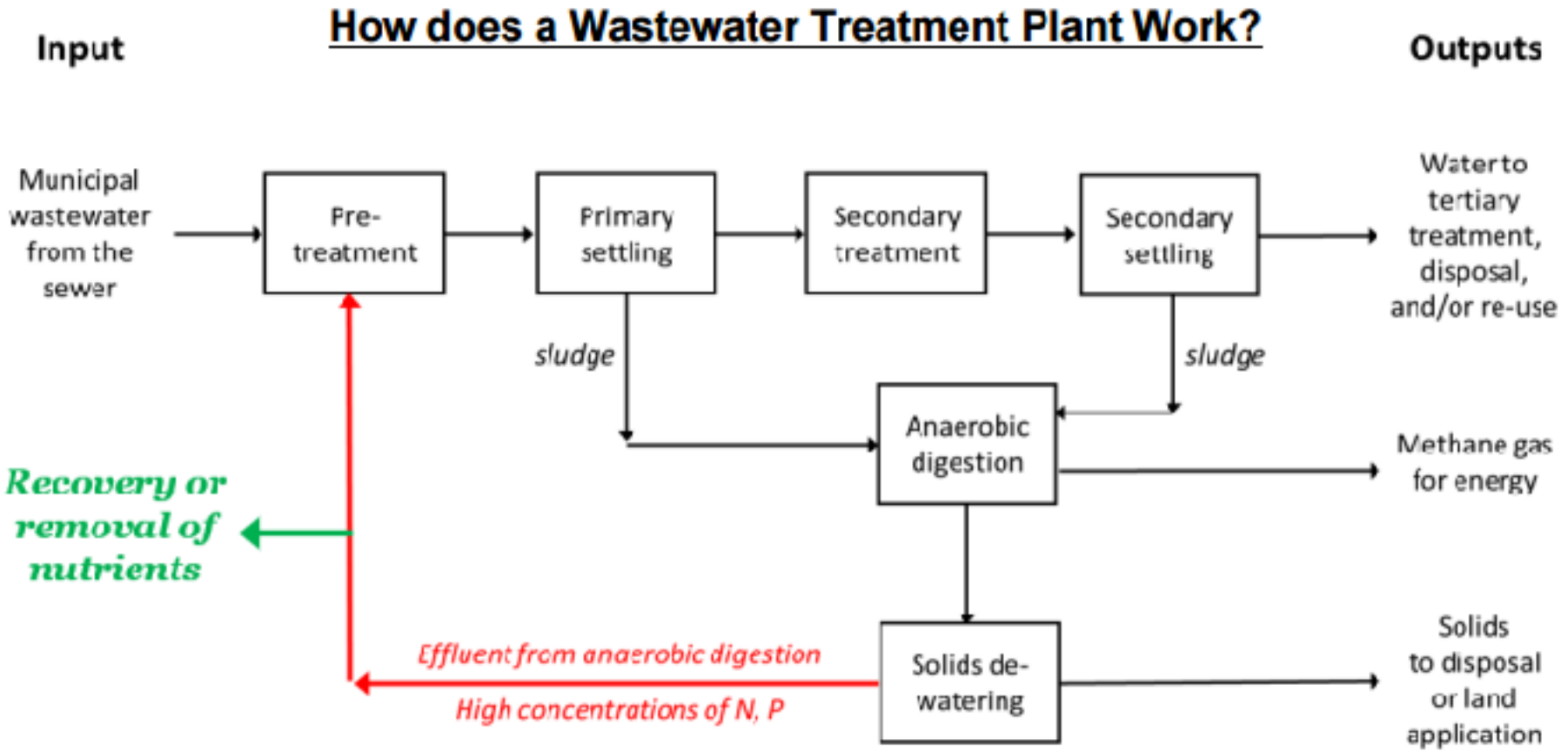
TABLE 4 HOUSE OF QUALITY FOR BUILDING-SCALE NUTRIENT MANAGEMENT TECHNOLOGIES

	Importance			O&M 1.5	SF 1.4	CC 1	OC 1	EP 0.5	TM 1.2	EI 0.7	PN 0.7	PP 0.7	A 1.3	
Technical characteristics	Ease of operation and maintenance	O&M	1											
	Size/density/footprint	SF	2											
	Capital cost	CC	3		✓									
	Operational cost	OC	4	✓										
	End products	EP	5											
	Technical maturity	TM	6	✓		X	X	✓						
	Environmental impact	EI	7		✓									
	Performance N	PN	8	✓				✓	✓	X				
	Performance P	PP	9	✓				✓	✓	X				
	Esthetics	A	10		✓	✓		✓						
Technologies	Conventional wastewater treatment			↓↓	↓	0	↓		↓↓				↓	33.9
	Composting toilet[a]			−	—	0	+	0	+	++	++	++	−	30.8
	Aerobic MBR			—	0	—	0	++	+	0	++	++	0	30.0
	Treatment wetlands			−	−	—	+	−	+	+	−	−	++	28.7
	Septic systems			−	−	−	0	—	++	—	—	—	+	27.6
	Direct urine application as fertilizer[a]			—	—	—	+	+	0	++	++	++	−	26.6
	Anaerobic MBR				0		0	↓	0	0			0	24.2
	Nitrification and distillation of urine[b]						0	0		↓	↓↓	↓↓		23.2
	Struvite–absorption with zeolites in urine[b]			—	—	—	−	+	−	0	+	+	—	19.3
	Urine ANAMMOX[b]			—	—	—	0	0	−	+	++	—	—	19.1
	Struvite precipitation from urine[b]			—	—	—	−	++	−	+	—	++	—	19.1
	NH_3 stripping to H_2SO_4 in urine[b]							↓		↓	↓↓			18.6
	Anaerobic digestion						0	0	↓					17.4
	Anion exchange in urine[b]			—	—	—	—	0	−	0	—	++	—	16.4

[a]Technology able to utilize urine diversion.
[b]Technology dependent on urine diversion.
✓, Positive correlation; MBR, membrane bioreactor; X, negative correlation.

(Orner et al., *Environmental Engineering Science*, 2017)

Current Research-Urban



Current Research-Urban

Struvite Precipitation

$MgNH_4PO_4$

Recovers ~90% P, ~20% N

What to do with remaining N?

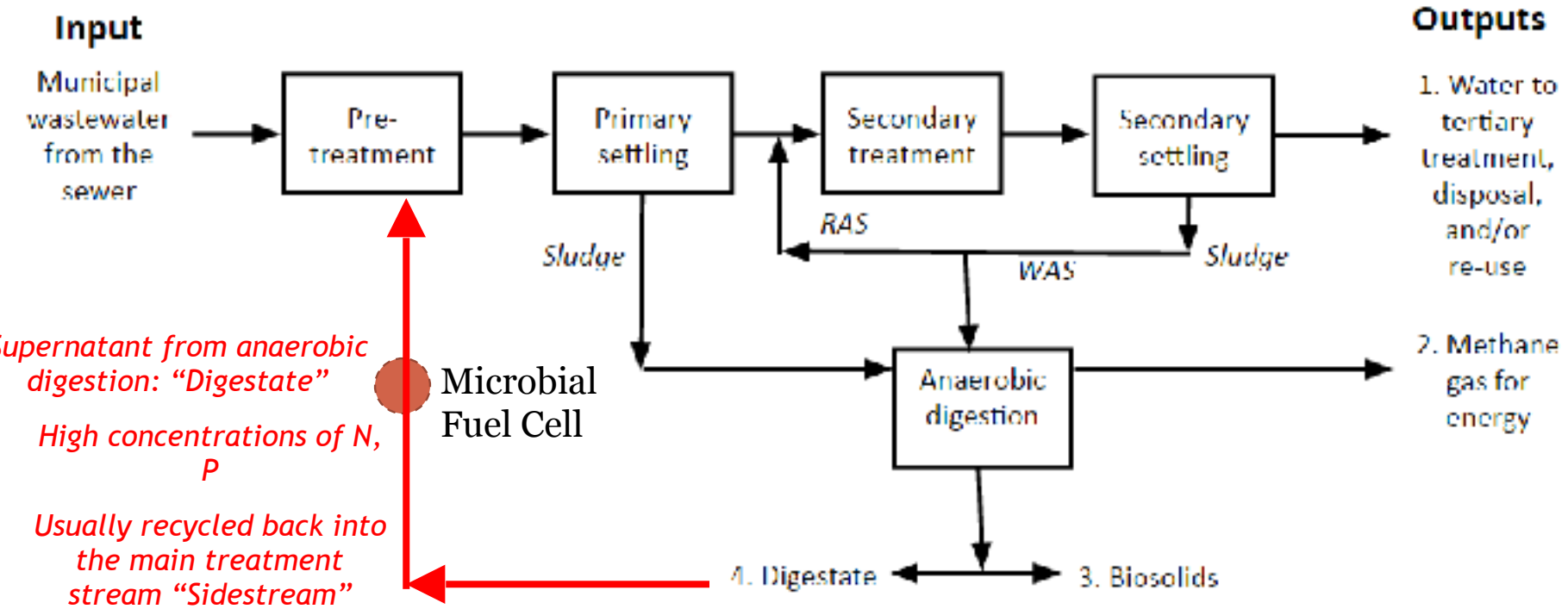
Current Research-Urban

Microbial Fuel Cells entered our field about 10-15 years ago

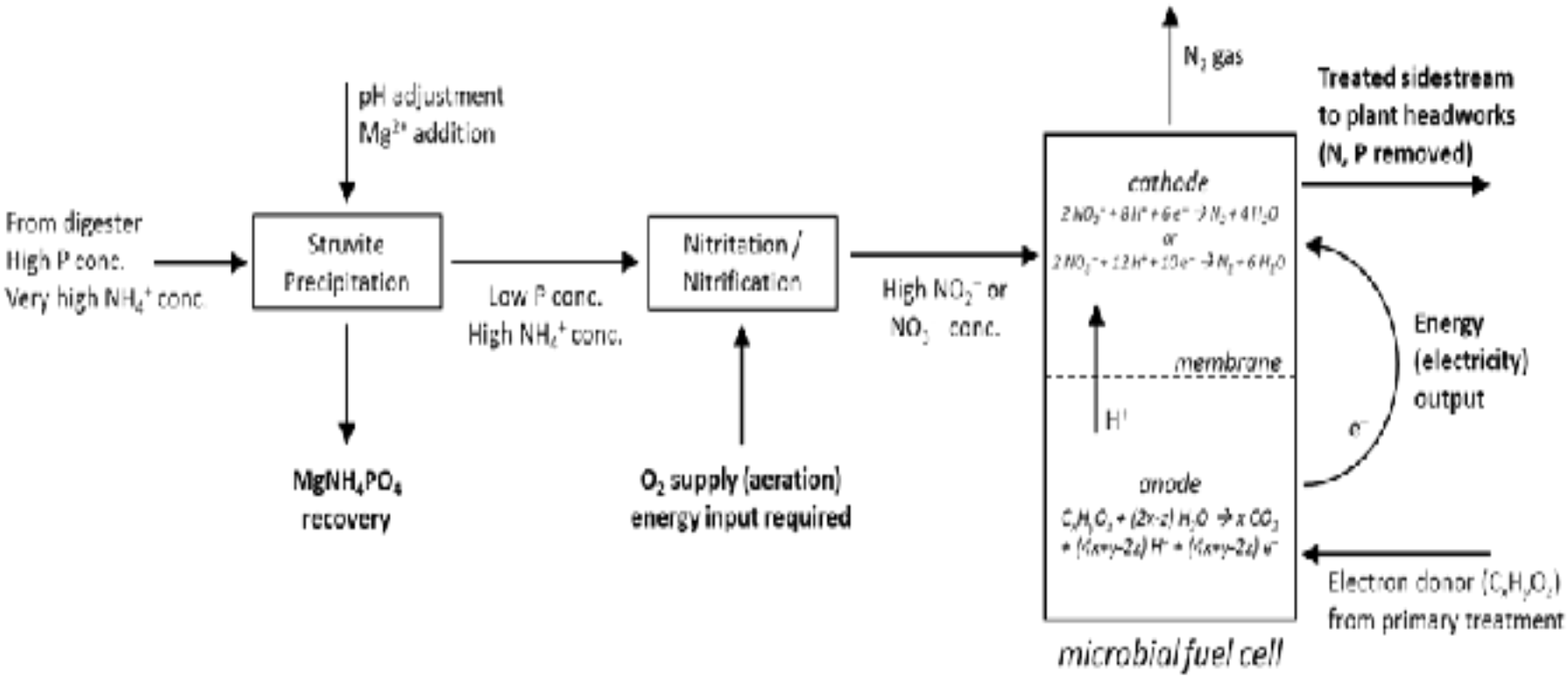
Bacteria mediate oxidation-reduction reactions, therefore electrons are being transferred

Overall Objective:

Build and assess the performance of a microbial fuel cell that both removes ammonium and provides energy.

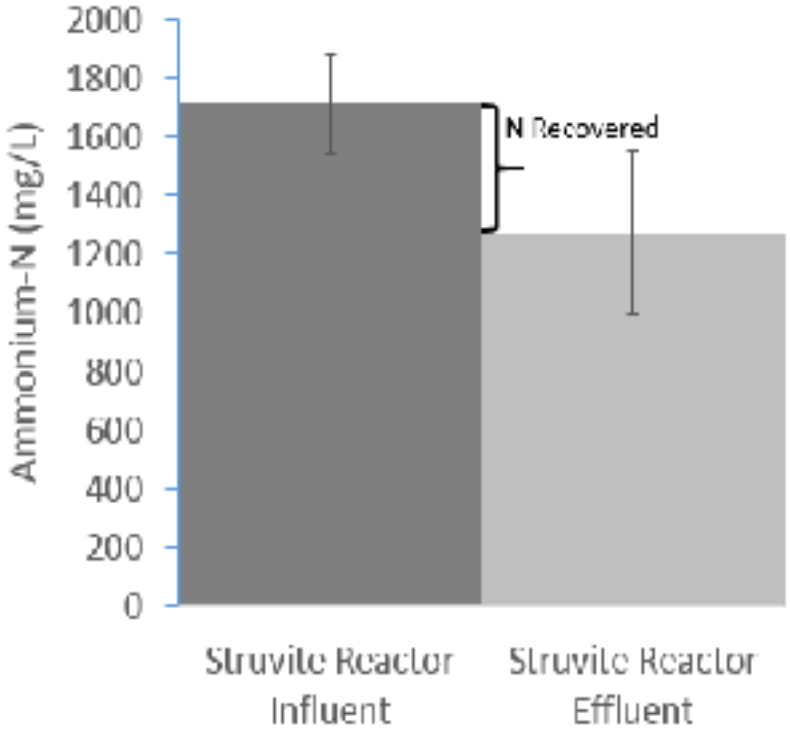


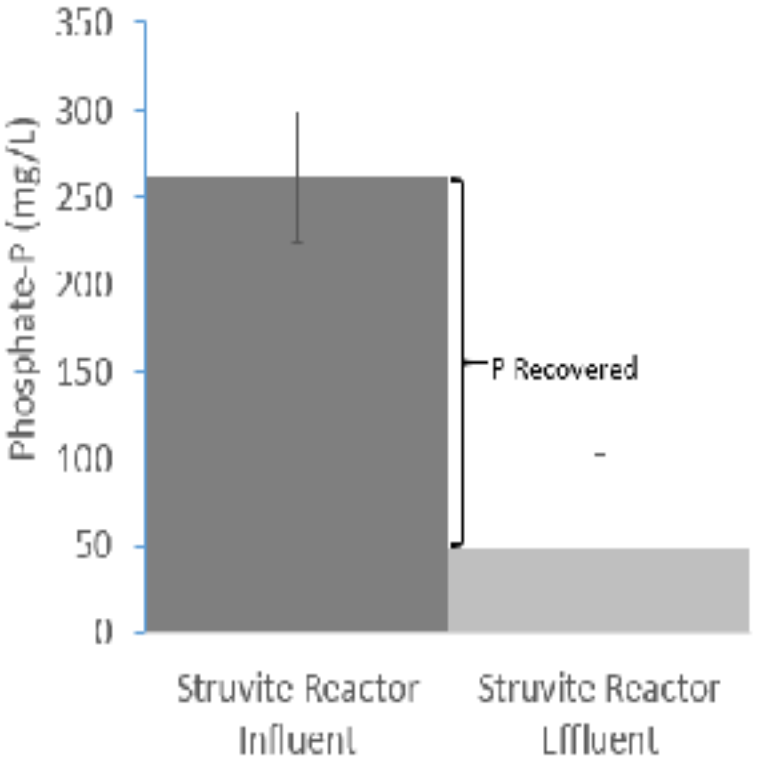
Microbial Fuel Cell Setup



Microbial Fuel Cell Setup

Data Collection





Ammonium and phosphate recovery during struvite precipitation.

Data Collection

Total Nitrogen Recovery and Removal (mg/L TN) in struvite reactor influent, struvite reactor effluent, nitrification effluent, and cathodic effluent.

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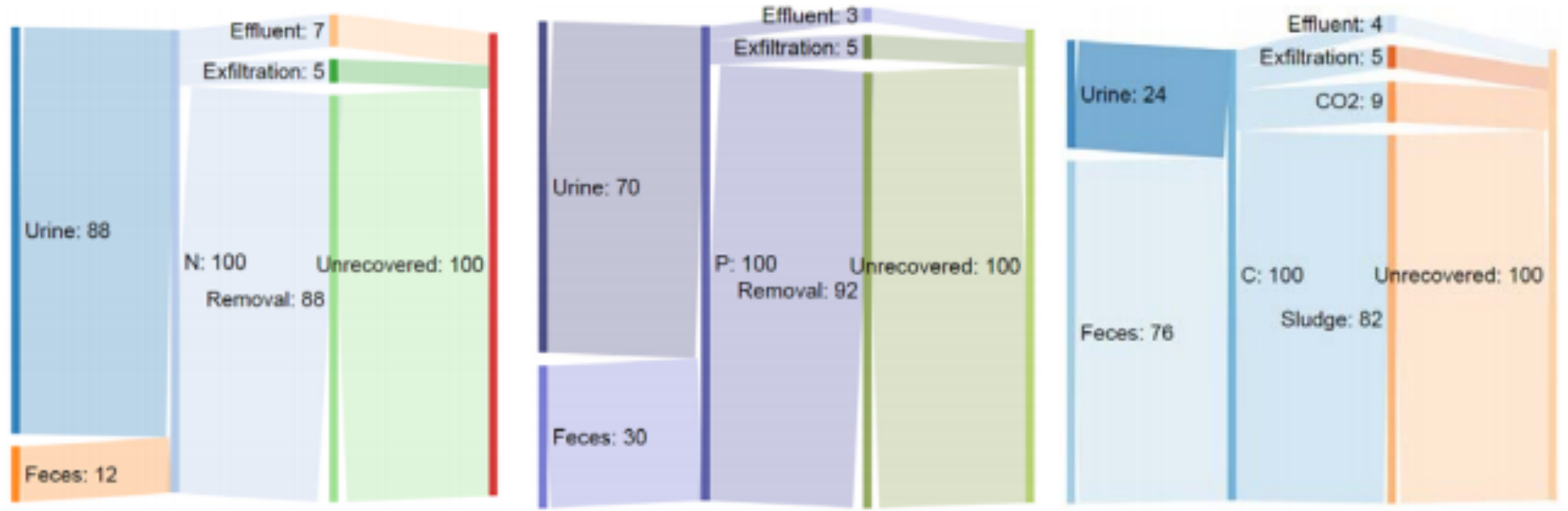
Current Research-Rural



3c) Sewered toilet (scenario of treatment from Gray and Becker, 2002)

Data Collection

Technology	Group		Nitrogen Recovery (%)		Phosphorus Recovery (%)	
	Before RRT	After RRT	Before RRT	After RRT	Before RRT	After RRT
Dig and Cover	1		0		0	
Bucket Latrine	1	1RRT	0	≤ 12	0	≤30
VIP Latrine	2	2RRT	0	≤ 17	0	≤18
Pour-flush w/ septic	2	2RRT	0	≤ 10	0	≤20
Sewered w/ tmt	2	2RRT	0	≤ 88	0	≤92
Double-vault composting latrine	3		≤ 30		≤100	
Urine-diverting composting latrine	3		≤ 92		≤100	

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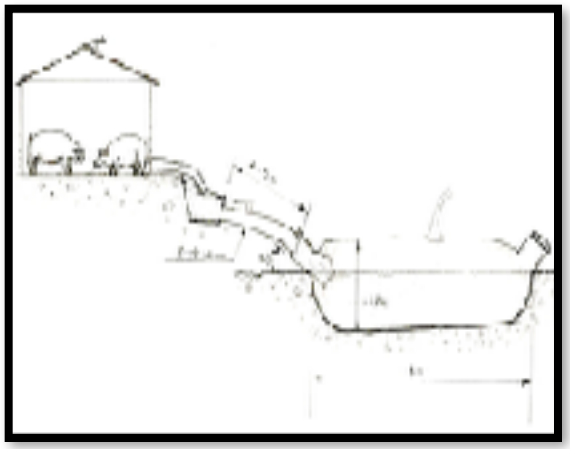
Future Research

Stage 1: Laboratory Setup
Analyze Microbial Community

Stage 2: Demonstration at Hillsborough County Northwest Facility

Future Research

Stage 3: Fulbright Research Grant to Costa Rica



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Conclusion

NEW paradigm: Recovery
Wastewater as resource
Nutrients, **E**nergy, **W**ater

Fulfills multiple Sustainable Development Goals

Fulfills our role as stewards of God's creation

Questions?