Application of a holistic approach for the selection of wastewater treatment technologies

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Wastewater Treatment
From this….

EcoNomics™

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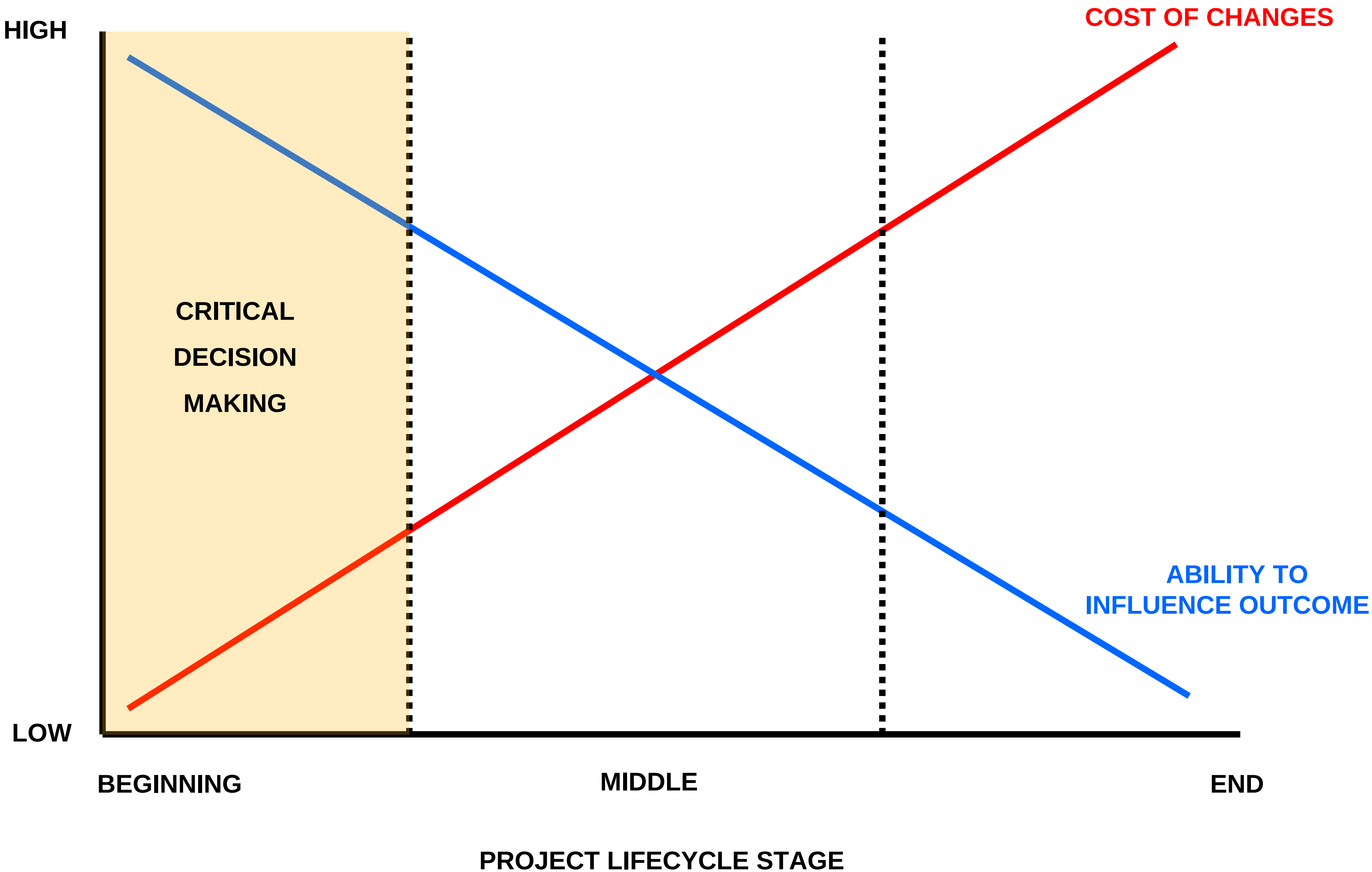
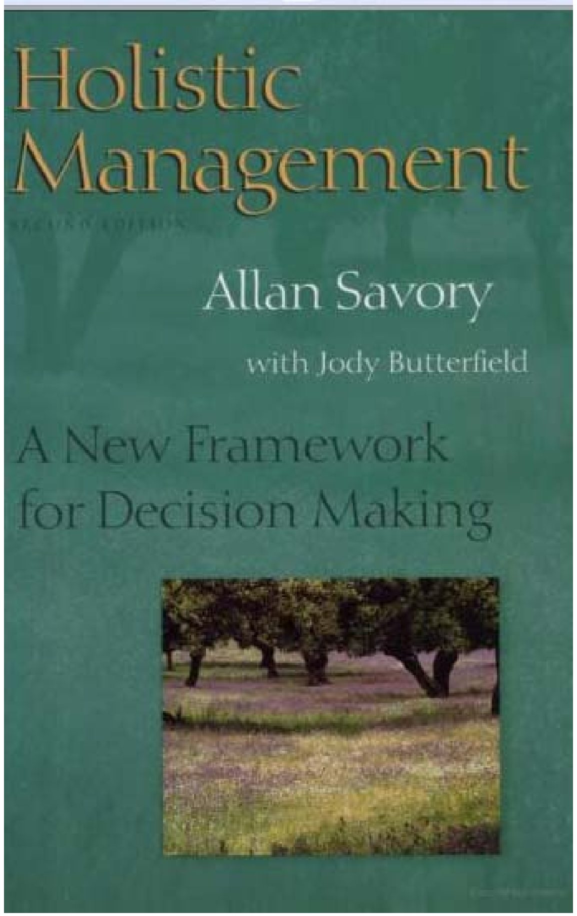
To this

How do we get there?

Identify Risks and Opportunities

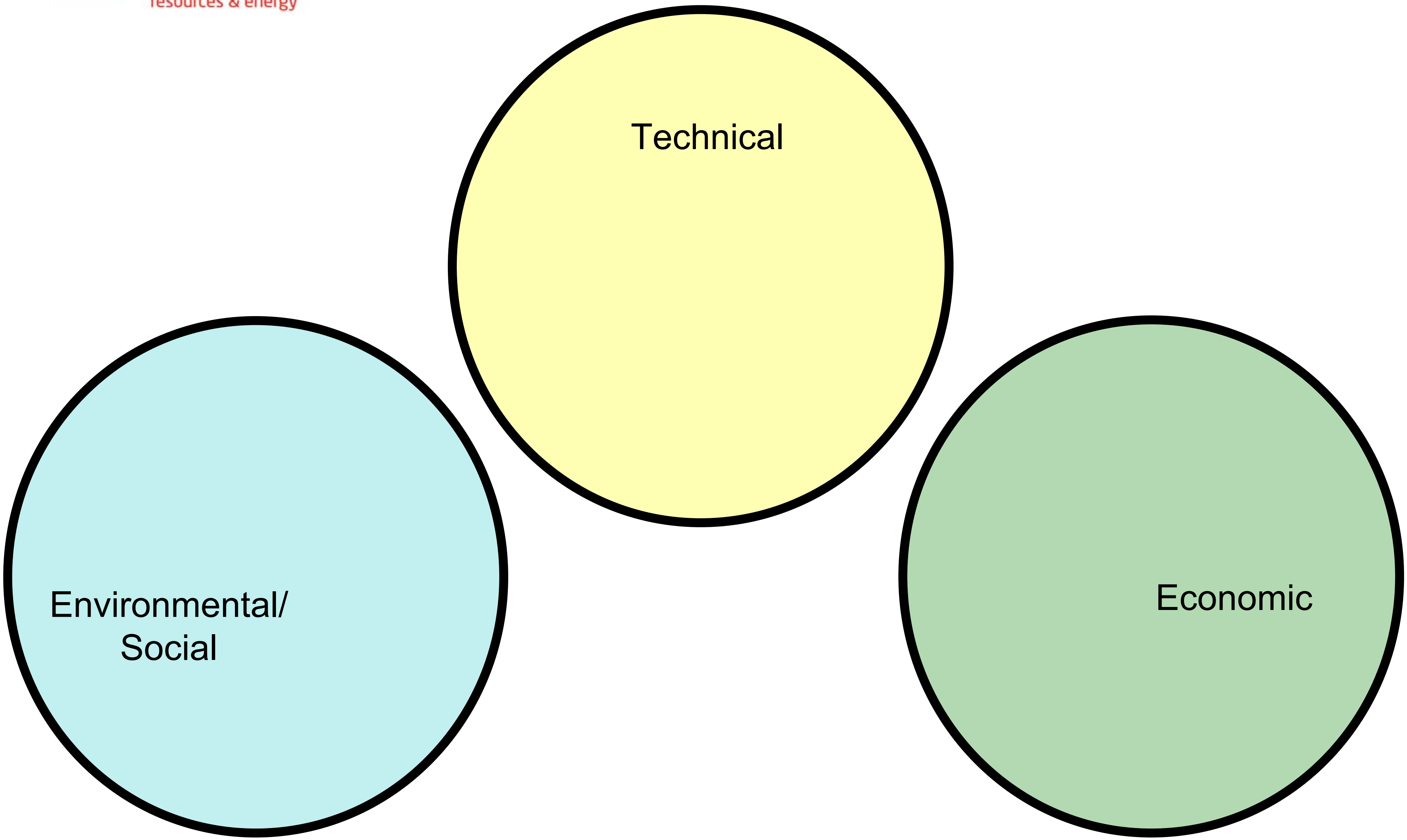


The holistic approach for decision making



Holistic Management:
A New Framework for Decision Making
by Allan Savory (Author),
Jody Butterfield (Author)
1998

What is Holistic?



Why is a Holistic Approach Important?

Are we meeting the challenge of delivering water treatment solutions in the changing marketplace?

The Holistic Approach

Decision making tools

- Pareto Analysis
- Paired Comparison Analysis
- Grid Analysis – Decision Matrix Analysis
- Decision Trees
- Plus-Minus-Interesting (PMI)
- Force Field Analysis
- Six Thinking Hats
- Cost-Benefit Analysis


The Decision Matrix

Building a Decision Matrix

- Parameters

STEP 1:
Decide on Parameters

↓

STEP 2:
Assign Weights

↓

STEP 3:
Evaluate and Score

↓

STEP 4:
Calculate and Compare

Objective

The objective of this work is to apply a holistic approach, which employs a decision matrix as a tool, to integrate technical, economic and environmental objectives for the selection of wastewater treatment solutions

2 Case Studies:

1. Selection of a wastewater treatment process for landfill leachate
2. Selection of polymers for waste activated sludge (WAS) thickening

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Part 1
Selection of a landfill leachate treatment process

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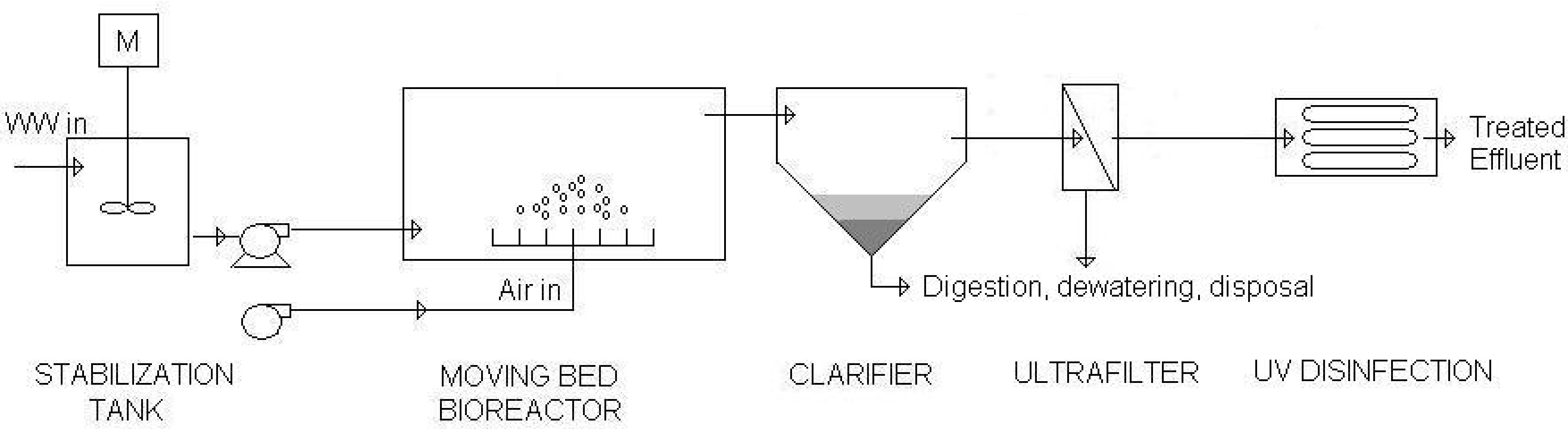
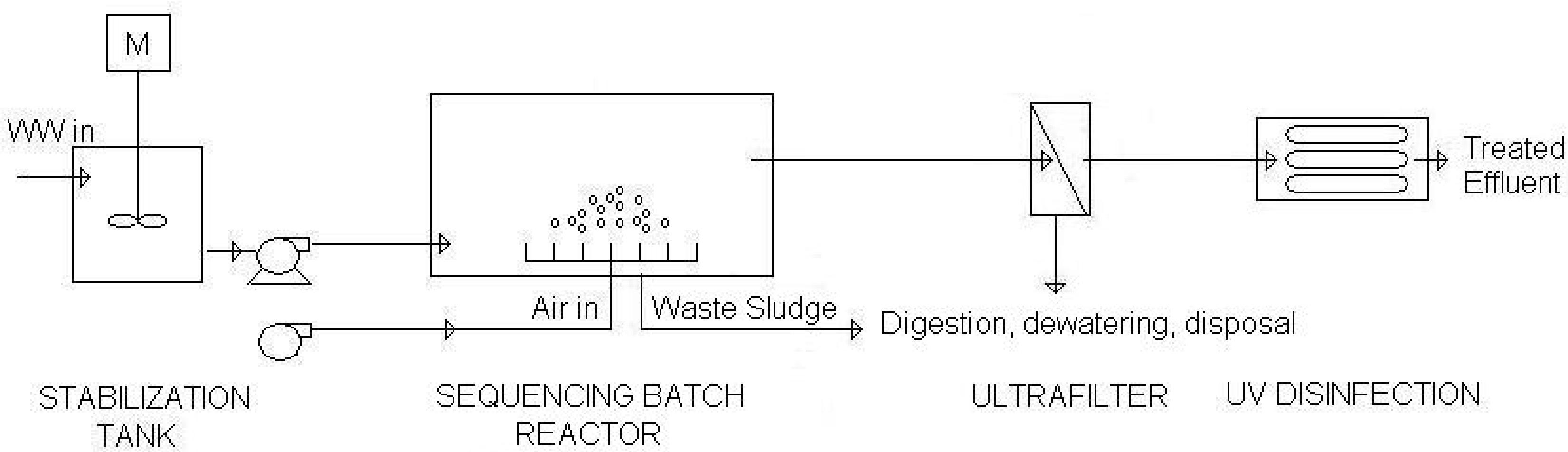
Part 1 - Selection of a landfill leachate treatment process



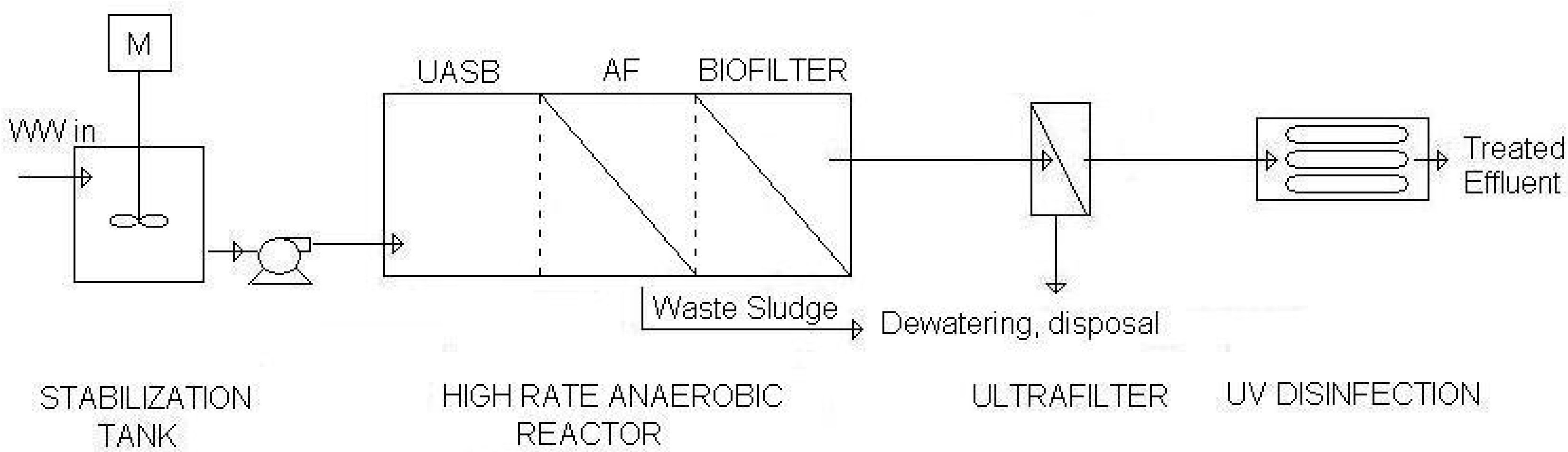
Option A. Moving Bed Biofilm Reactor (MBBR). Including stabilization tank, MBBR, secondary clarifier, tertiary treatment with ultra filtration and UV disinfection and aerobic sludge digestion, sludge dewatering with landfill disposal.

Part 1 - Selection of a landfill leachate treatment process



Option B. Sequencing Batch Reactor (SBR). Including stabilization tank, SBR, tertiary treatment with ultra filtration and UV disinfection, aerobic sludge digestion, sludge dewatering with landfill disposal.

Part 1 - Selection of a landfill leachate treatment process

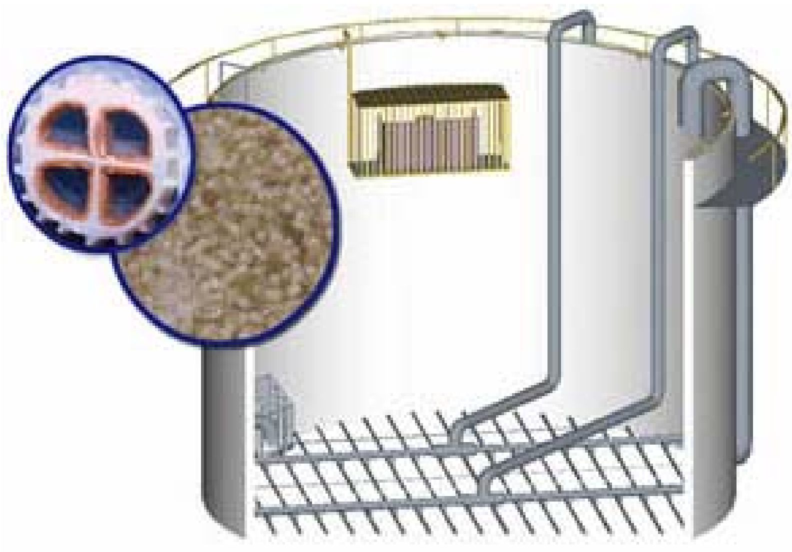


Option C. High Rate Anaerobic Reactor (HRAR).
Including stabilization tank, HRAR combining UASB and AF reactors in a hybrid process, aerobic-anoxic biofilter, secondary clarifier, tertiary treatment with ultra filtration and UV disinfection, sludge dewatering with landfill disposal.

Part 1 - Selection of a landfill leachate treatment process

Option A. Moving Bed Biofilm Reactor (MBBR)

- Compact design
- Expandable
- Load responsive
- Minimal maintenance



www.cleantech.com/mbbr

Part 1 - Selection of a landfill leachate treatment process

Option B. Sequencing Batch Reactor (SBR)

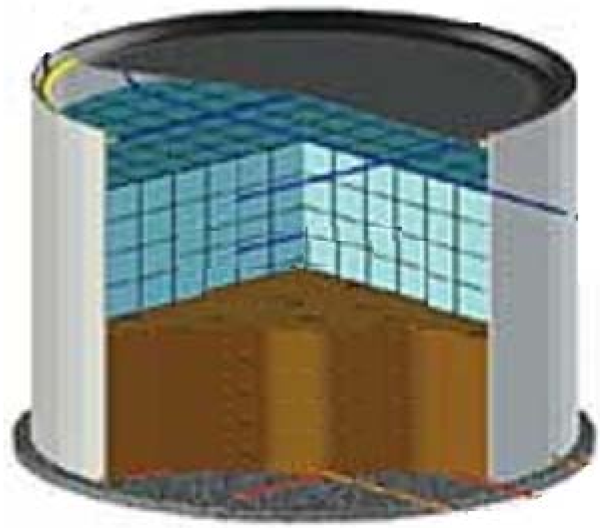
- Compact design
- Expandable
- Capacity to buffer fluctuating wastewater chemistry and strength
- Intelligent control system

www.ircnet.lu/src/request/pictures/sbr_plant.jpg

Part 1 - Selection of a landfill leachate treatment process

Option C. High Rate Anaerobic Reactor (HRAR)

- Resistant to shock loads
- Capable of handling variable hydraulic loads
- Low operation and maintenance costs
- Production of biogas for energy



www.engetec.info/wastewater/anaerobic.htm

Selection of a landfill leachate treatment process – Decision Matrix

General Indicator	Specific Indicator	Weight (%)
Technical	Applicability	30
	Durability	
	Area required	
	Design/build complexity	
	Process complexity	
	Process reliability	
	Operational flexibility	
	Energy requirements	
	Consumables required	
	Personnel requirements	
Economic	Investment costs	35
	O&M costs	
	Generation of valuable products	
	Applications to leachate treatment	
Environmental	Community acceptance	35
	Generation of residuals	
	Noise generation	
	Odour generation	
	Reproduction of vectors	
	Visual impact	

Part 1 - Selection of a landfill leachate treatment process

Decision Matrix – Technical

Weight (%)	General Indicator	Specific Indicator	Option A (MBBR)	Option B (SBR)	Option C (HRAR)
			Score	Score	Score
30	Technical	Applicability	5	5	3
		Durability	3	3	3
		Area required	5	5	3
		Design/build complexity	3	1	3
		Process complexity	3	1	3
		Process reliability	5	5	3
		Operational flexibility	3	1	3
		Energy requirements	3	1	5
		Consumables required	5	3	5
		Personnel requirements	5	3	3
		Subtotal (out of 50)	**40**	**28**	**34**
		Subtotal (out of 30)	**24**	**16.8**	**20.4**

Part 1 - Selection of a landfill leachate treatment process

Decision Matrix - Economic

Weight (%)	General Indicator	Specific Indicator	Option A (MBBR) Score	Option B (SBR) Score	Option C (HRAR) Score
35	Economic	Investment costs	5	1	3
		O&M costs	3	3	5
		Generation of valuable products	3	3	5
		Previous applications	3	5	3
		Subtotal (out of 20)	**14**	**12**	**16**
		Subtotal (out of 35)	**24.5**	**21**	**28**

Part 1 - Selection of a landfill leachate treatment process

Decision Matrix - Environmental

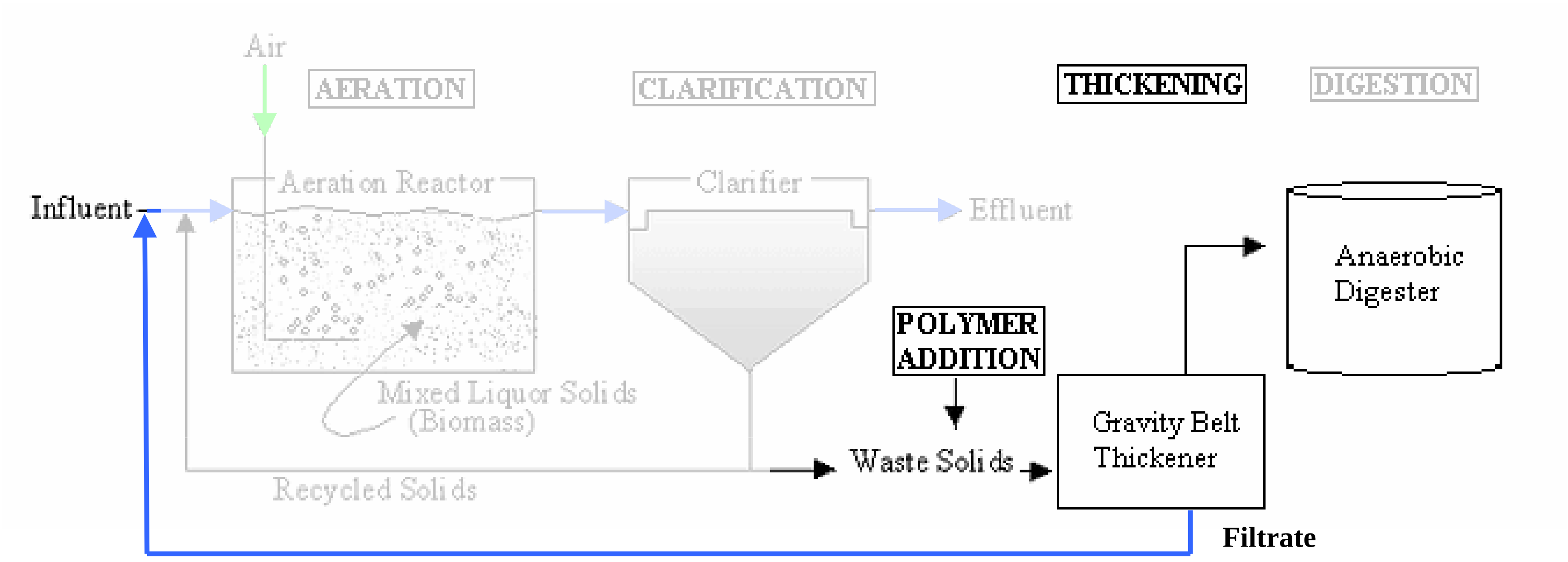
Weight (%)	General Indicator	Specific Indicator	Option A (MBBR) Score	Option B (SBR) Score	Option C (HRAR) Score
35	**Environmental**	Community acceptance	5	3	1
		Generation of residuals	3	3	5
		Noise generation	3	1	5
		Odour generation	3	1	1
		Reproduction of vectors	5	5	5
		Visual impact	5	5	3
		Subtotal (out of 30)	**24**	**18**	**20**
		Subtotal (out of 35)	**28**	**21**	**23.3**

Part 1 - Selection of a landfill leachate treatment process

Weight	General Indicator	Option A (MBBR)	Option B (SBR)	Option C (HRAR)
30%	Technical	24.0	16.8	20.4
35%	Economic	24.5	21.0	28.0
35%	Environmental	28.0	21.0	23.3
100%	**Total (%)**	**76.5**	**58.8**	**71.3**

Part 2
Selection of a polymer for WAS thickening

Part 2 - Selection of a polymer for waste activated sludge thickening



Part 2 - Selection of a polymer for waste activated sludge thickening

PART 1:
BENCH TESTING
8 POLYMERS

PART 2:
FULL SCALE TESTING
3 POLYMERS

1

2

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Selection of a polymer for sludge thickening – Decision Matrix

Phase	Parameter	Parameter Weight	Phase Weight
Thickened Sludge	Total Solids	4	
	Total Volatile Solids	1	
	TKN	2	
	Total Phosphorus	2	
	Total BOD	1	
	TOTAL	**10**	**80%**
Filtrate	Total Solids	1	
	Turbidity	1	
	TKN	2	
	Ammonia	3	
	Total Phosphorous	3	
	TOTAL	**10**	**20%**

Selection of a polymer for waste activated sludge thickening

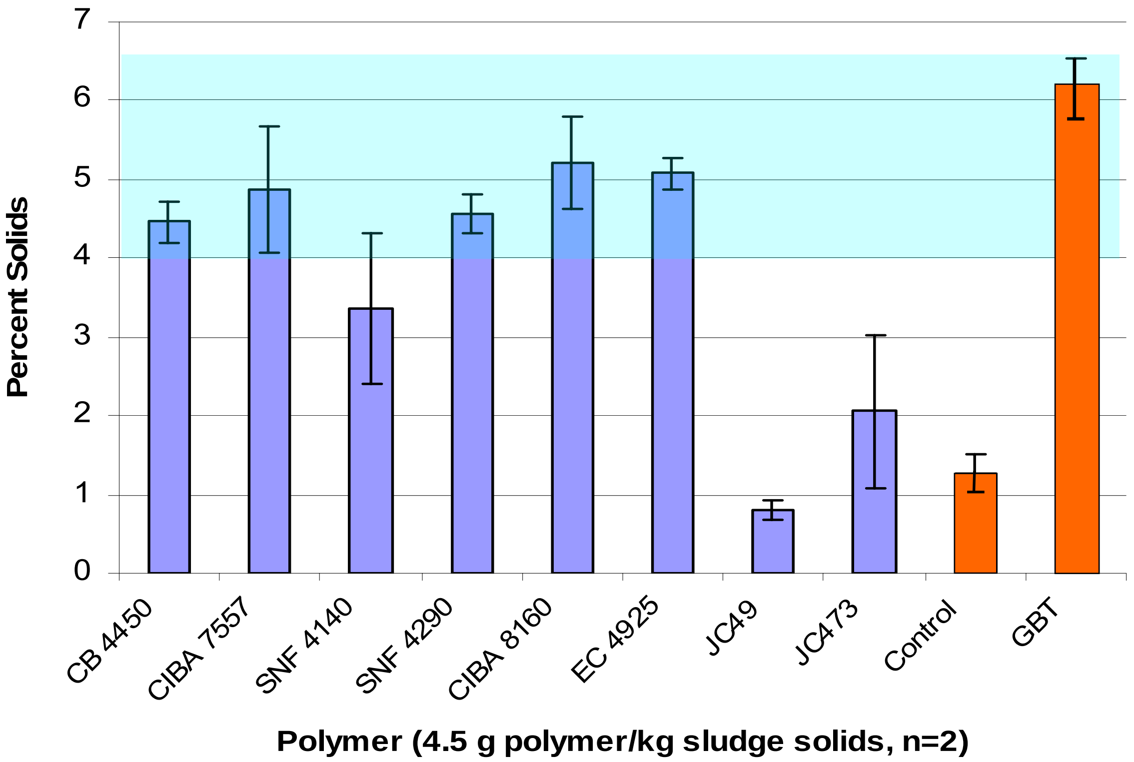
Converting Values to Z Scores

$$z = \frac{x - \mu}{\sigma}$$

Where:

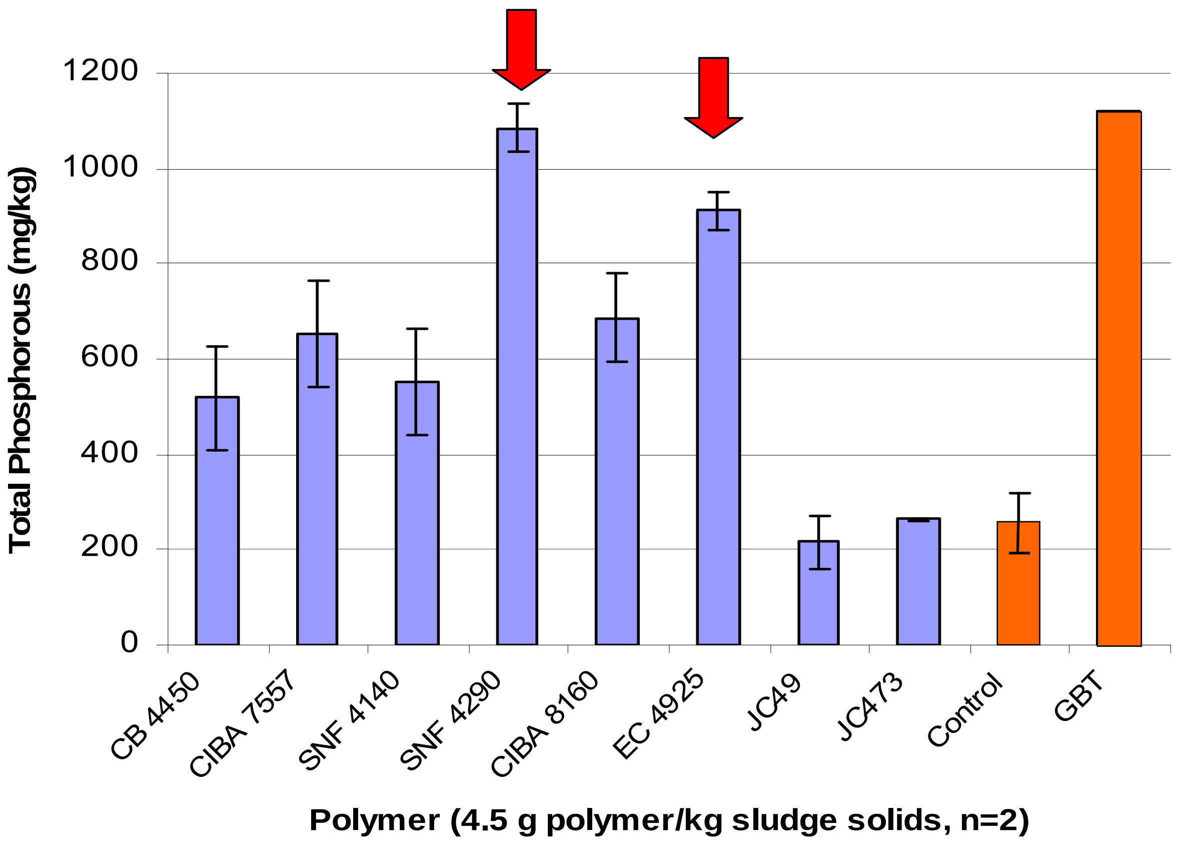
- z is the value of the standardized z-score, in units of standard deviation
- x is the value of the raw data point
- μ is the sample mean of the raw data
- σ is the sample standard deviation of the raw data

Part 2 - Selection of a polymer for waste activated sludge thickening.



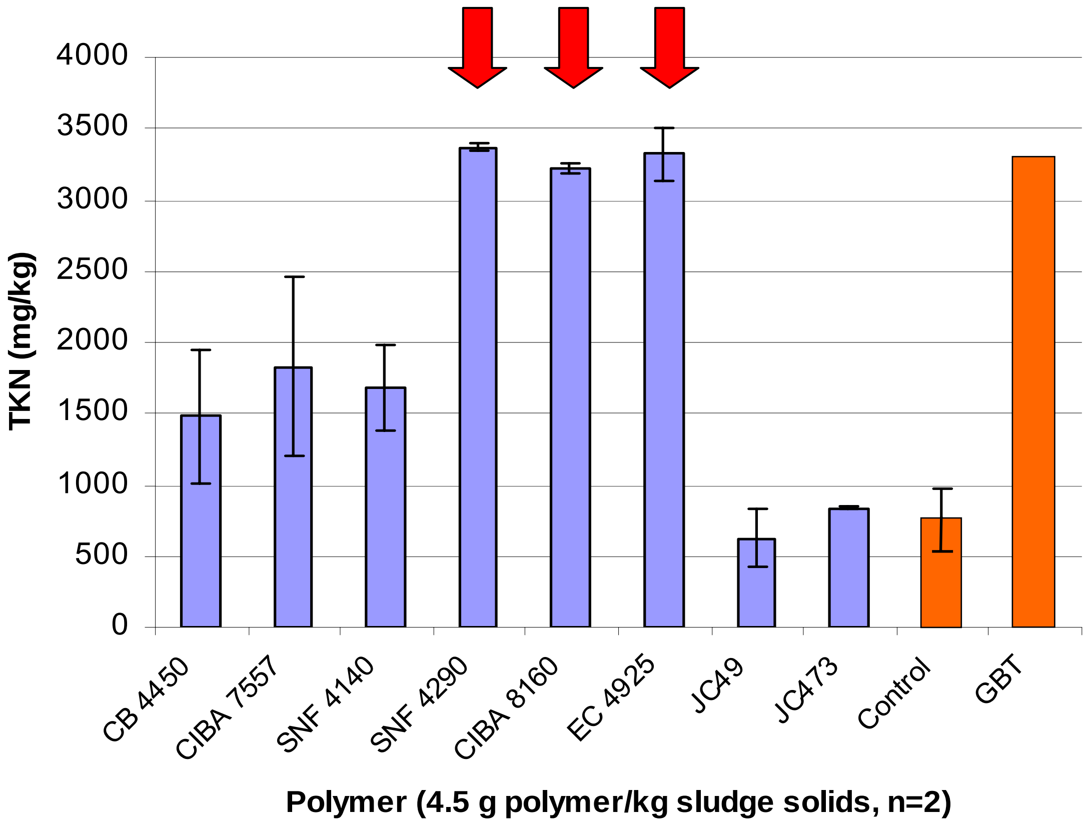
Results & Discussions

Part 2 - Selection of a polymer for waste activated sludge thickening.



Results & Discussions

Part 2 - Selection of a polymer for waste activated sludge thickening.



Results & Discussions

Part 2 - Selection of a polymer for waste activated sludge thickening.

Polymer	Thickened Sludge (80%)	Filtrate (20%)	Total
CB 4450	0.8	0.9	1.7
CIBA 7557	3.7	0.1	3.8
SNF 4140	-1.5	-1.1	-2.6
SNF 4290	**7.0**	**-1.0**	**6.0**
CIBA 8160	**5.0**	**0.0**	**5.0**
EC 4925	**5.5**	**-0.4**	**5.1**
JC 49	-10.6	2.0	-8.6
JC 473	-9.3	-1.1	-10.4

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Balanced Decision Making

Consciously Weighing our Objectives

What Does This Cost?

The Holistic Approach

Solution for BALANCED decision making

SUPPORT for all types of DECISIONS

Save TIME and MONEY

IM

Appendix – Sample Calculation

- Sample Calculation

	Total Solids	Z Score
Polymer 1	4.58	-1.13
Polymer 2	5.22	0.77
Polymer 3	5.08	0.37
average	4.96	
st. dev	0.34	

$$\frac{4.58 - 4.96}{0.34}$$

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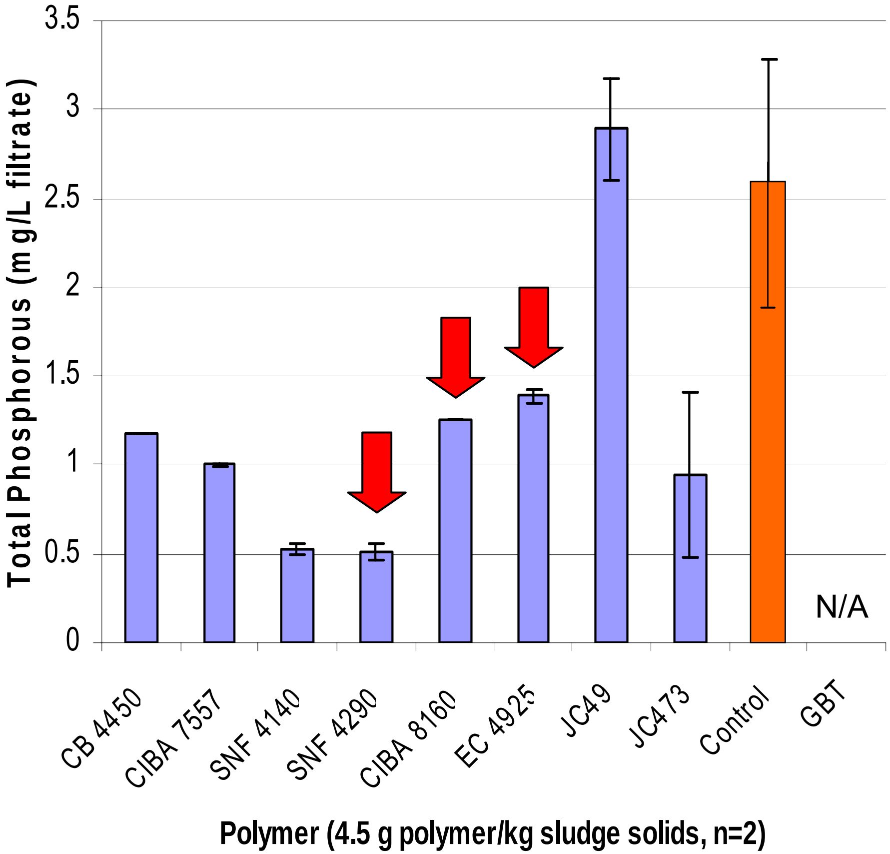
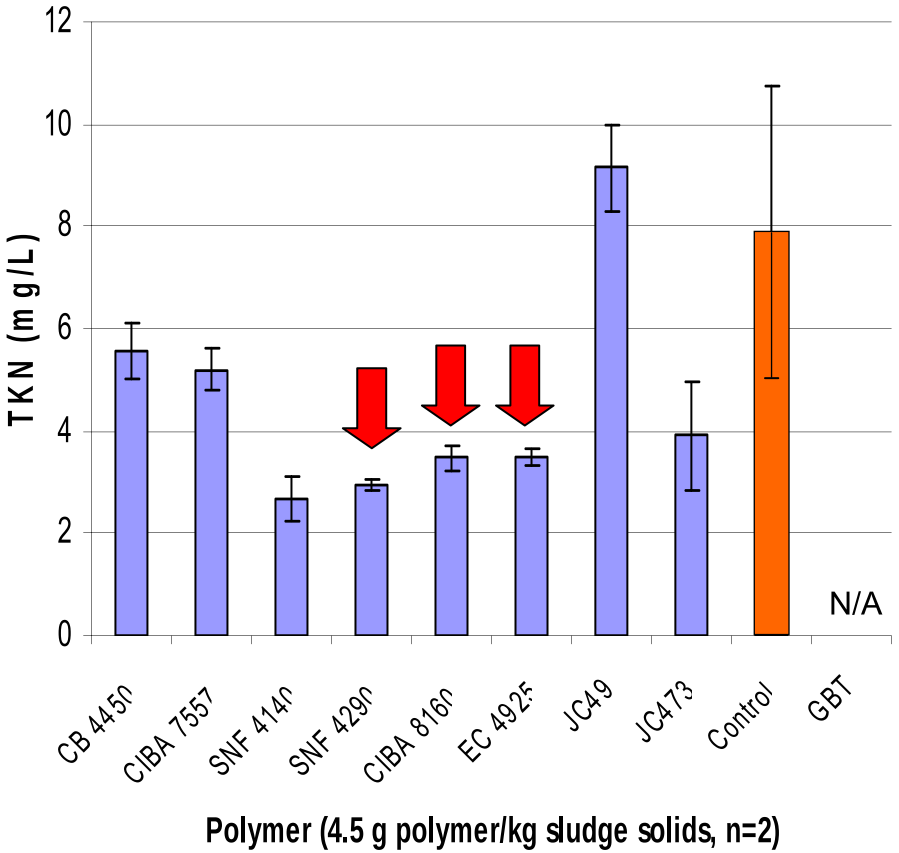
Appendix – Part 2 – Filtrate TP and TKN



Total Phosphorous



TKN

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Appendix – Part 2 – Materials and Methods

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Appendix – Part 2 – Materials and Methods

- Solid and liquid phases were examined with respect to the following parameters:
  - Solids tests: Total solids, volatile solids, suspended solids, turbidity
  - Chemical/nutrient tests: Ammonia nitrogen, total Kjeldahl nitrogen, total phosphorous, BOD

- Samples prepared in triplicate using 4.5 g of polymer per kg sludge solids
  - 300 mL samples thickened at bench scale for 10 minutes