EVALUATION AND COMPARISON OF BIOFLOCS DERIVED FROM DIFFERENT CARBON SOURCES AS FEED INGREDIENTS FOR SHRIMP

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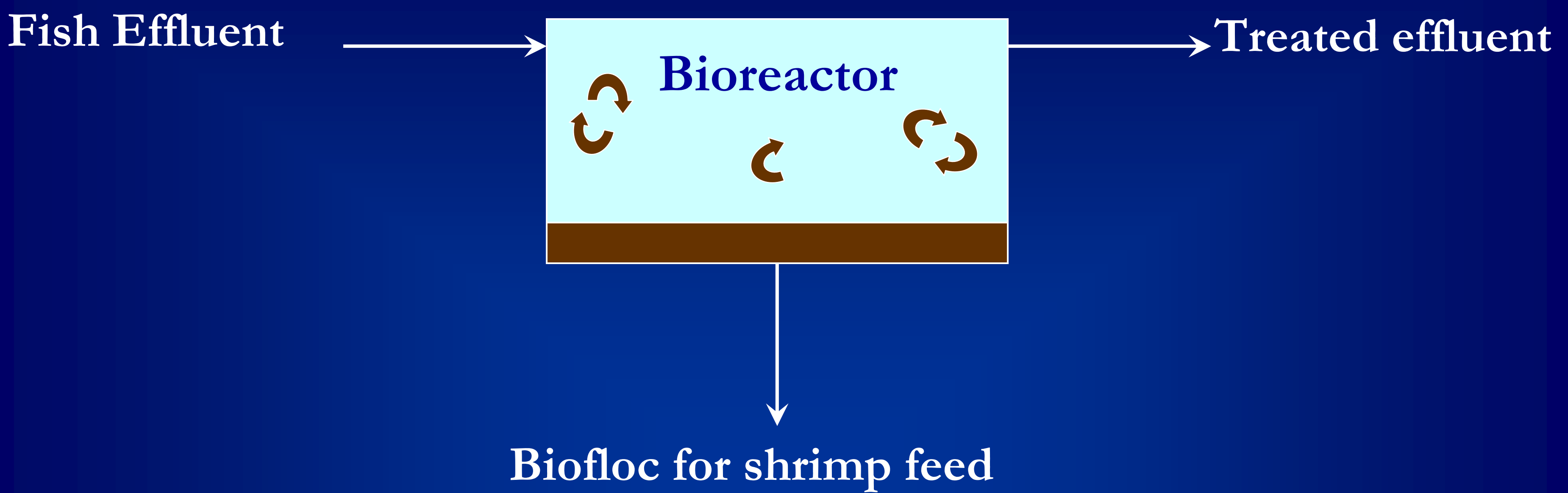
Introduction

Biofloc technology – using bioreactors

- Bioreactors
  - Remove nutrients/pollutants from aquacultural effluent waters
  - Convert nutrients/pollutants into bacteria protein
  - Bioflocs are harvested from bioreactors
- Biofloc can be used as an ingredient in shrimp feed replacing fishmeal and other proteins
- Overall, bioflocs technology is sustainable

NOTE: Bioflocs = Bacterial protein = Biomass = Microbial flocs = Activated sludge



- Fish effluent (high nutrients, organics, solids)
- Treated effluent (low nutrients, organics, solids)
- Biofloc for shrimp feed (protein generation)

Sequencing batch reactors (SBRs)

a suspended growth biological process

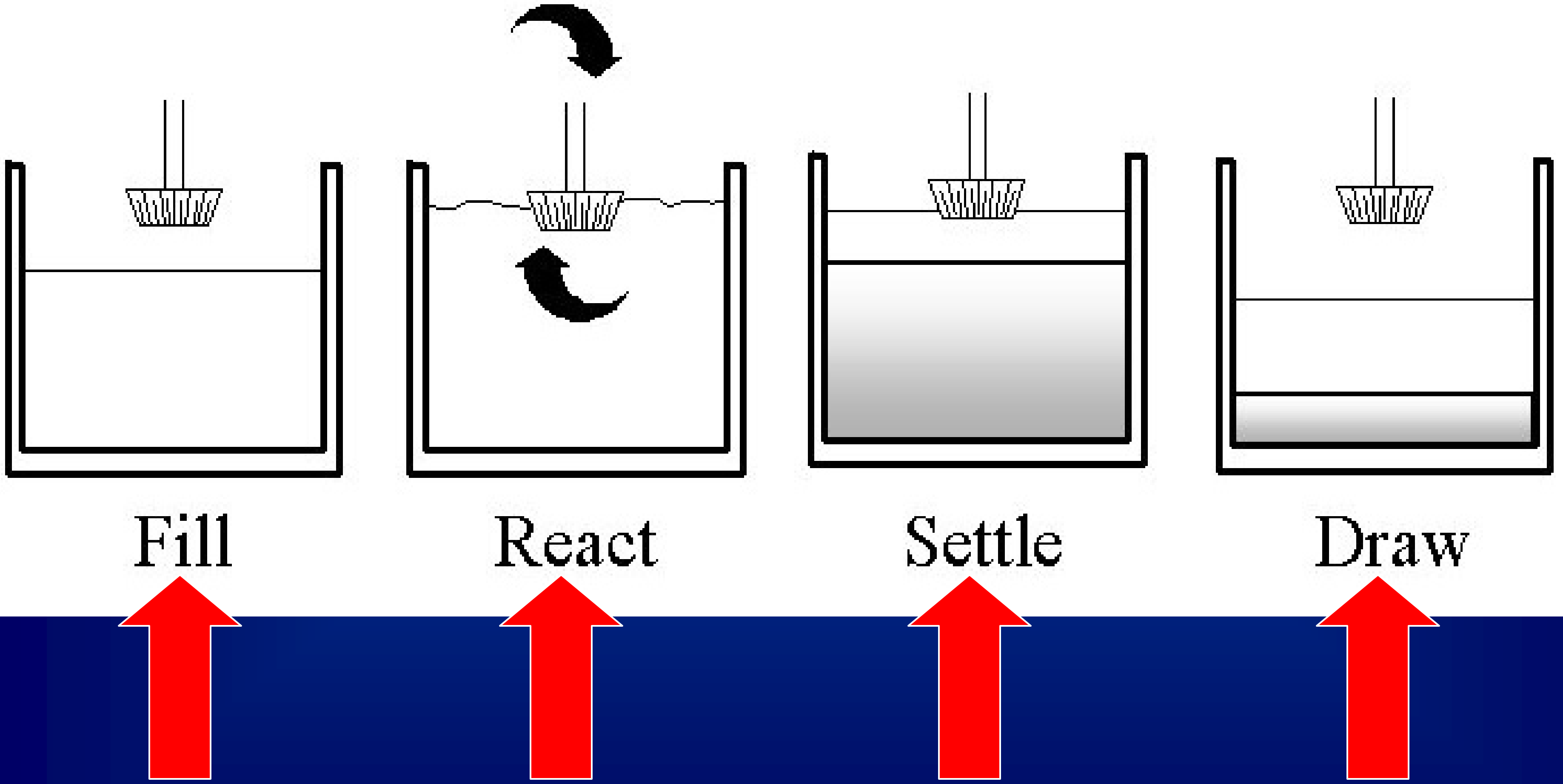


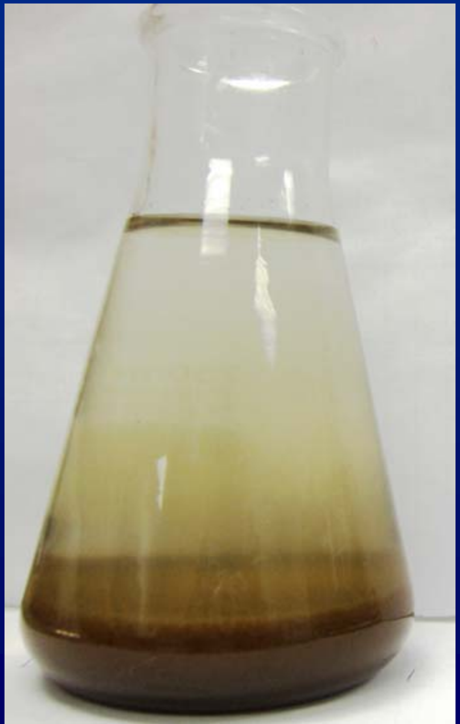
Photo source: http://www.lifesciences.napier.ac.uk/

Bioreactor

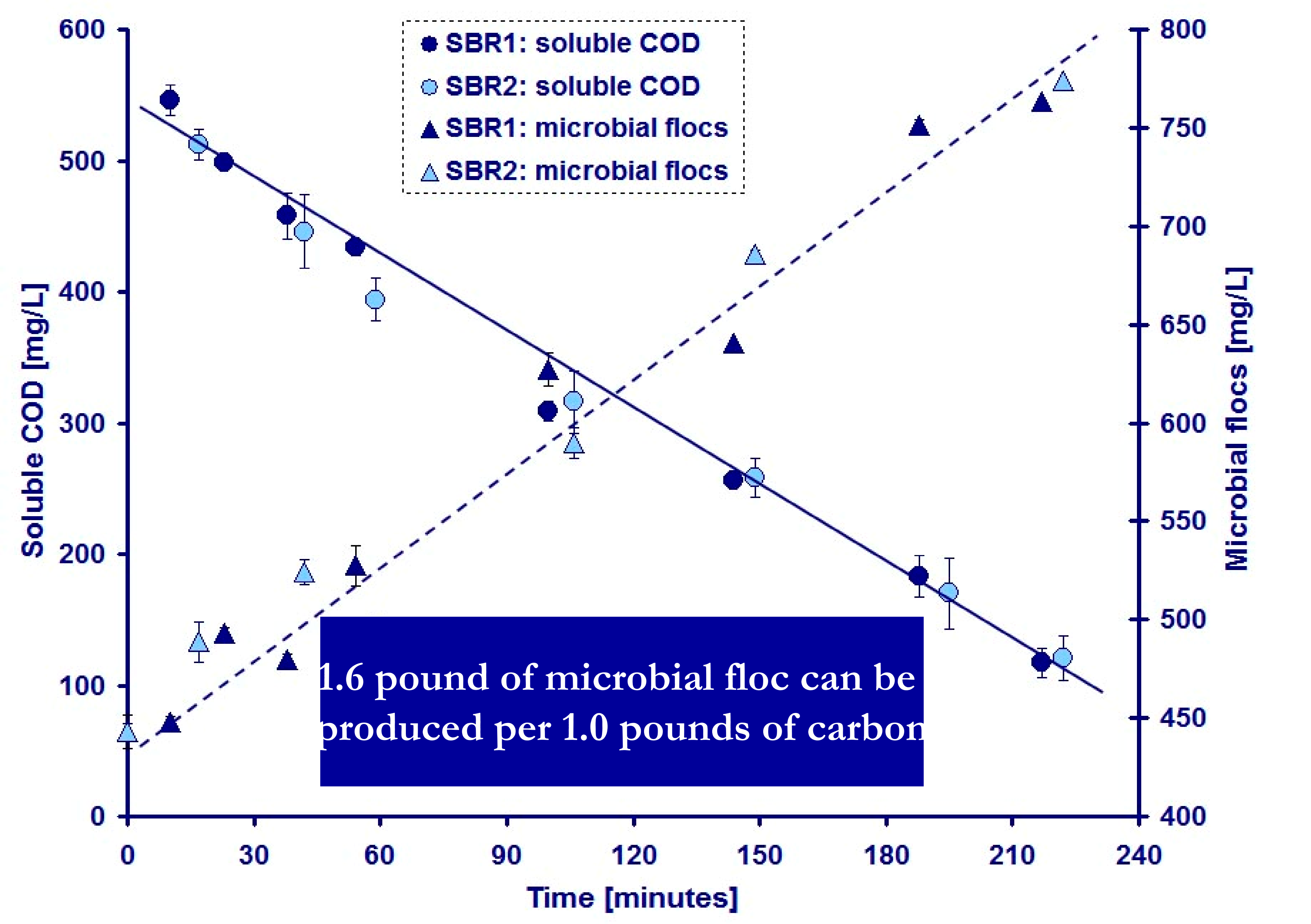
Controlled system that supports a biologically active environment

Typical removal rates for SBR vs MBR

Reactor Type	Removal rates			
	Ammonia	Nitrite	Nitrate	Suspended solids
SBR	> 90%	> 90%	0 - 90%	> 95%
MBR	> 90%	> 90%	> 90%	> 99%



Microbial floc generation as soluble COD is removed



1.6 pound of microbial floc can be produced per 1.0 pounds of carbon

Nutrition Studies

Evaluate if bioflocs can be used as an ingredient in shrimp feed

What are bioflocs?

- Bioflocs are a conglomerates of
  - Bacteria
  - Protozoa
  - Filamentous organisms
  - Algae
  - Multivalent cations
  - Exocellular polymers (ECP)
    - Biopolymers (polysaccharides & proteins)
  - etc...

Typical nutritional properties for biofloc **SBR vs MBR**

	Dry matter basis				
	Crude protein	Carbo-hydrates	Total ash	Crude fiber	Crude fat
SBR	41-49%	31-36%	12-13%	13-15%	0-1%
MBR	35-43%	22-28%	22-28%	14-18%	< 0.1%

Shrimp Feeding Trial

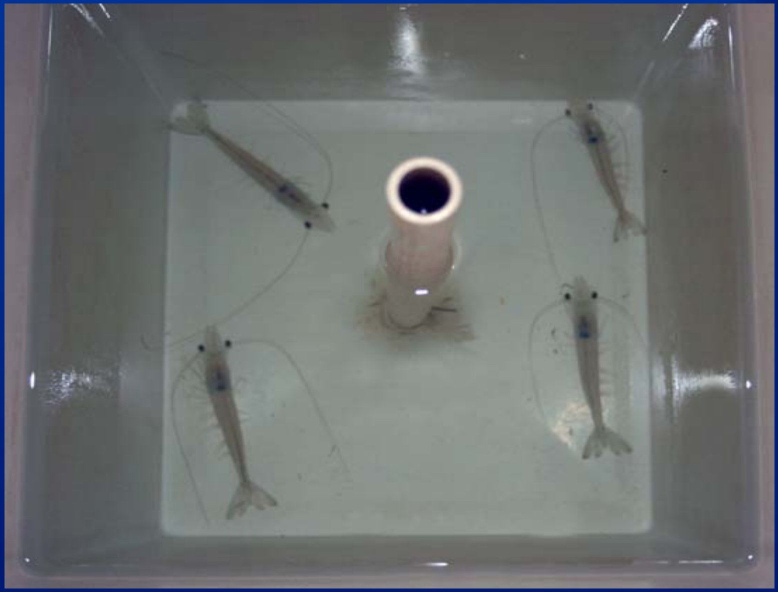
- Biofloc were harvested from SBR and MBR
- Biofloc dried & incorporated into shrimp feed replacing fishmeal and soy protein
- 35 day feeding trials
  - Min. 4 shrimp per tank
  - Min. 8 replicates per diet

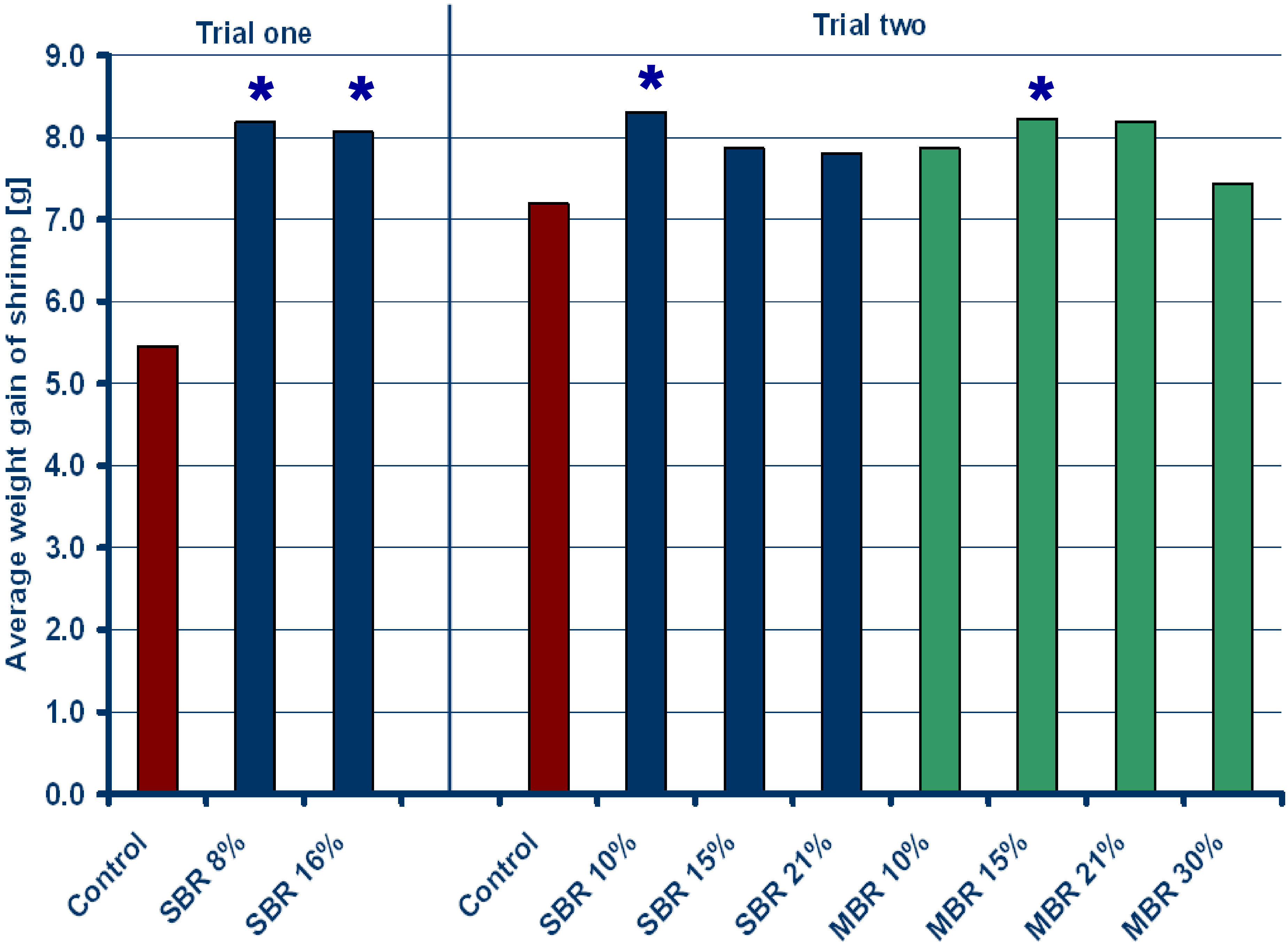
Diets

- Diets equivalent for:

  Crude protein (35%), total fats (8%), crude fiber (2%), etc...

- Biofloc inclusion replaced:
  - Soybean from 0 to 100%
  - Fishmeal from 0 to 67%




Trial one
Trial two
Average weight gain of shrimp [g]
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
*
*
*
*
Control
SBR 8%
SBR 16%
Control
SBR 10%
SBR 15%
SBR 21%
MBR 10%
MBR 15%
MBR 21%
MBR 30%

What in bioflocs contributed to enhanced growth?

- Crude protein?

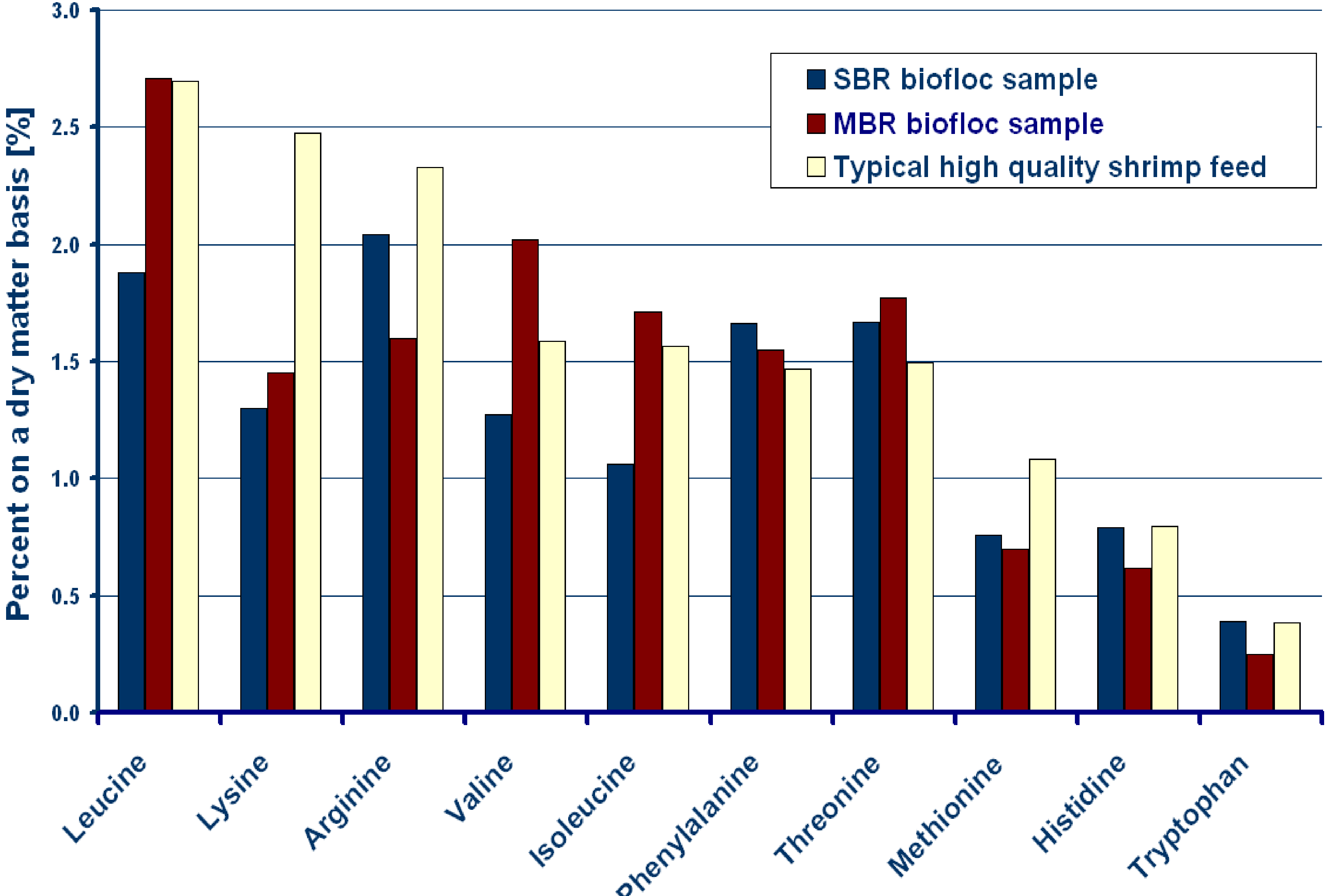
  No
- Crude fats?

  No
- Energy?

  No
- Fiber?

  No
- A fatty acid?

  No, no fats in bioflocs
- An amino acid?



3.0
2.5
2.0
1.5
1.0
0.5
0.0
Percent on a dry matter basis [%]
SBR biofloc sample
MBR biofloc sample
Typical high quality shrimp feed
Leucine
Lysine
Arginine
Valine
Isoleucine
Threonine
Methionine
Histidine
Tryptophan

Bioreactor Operations

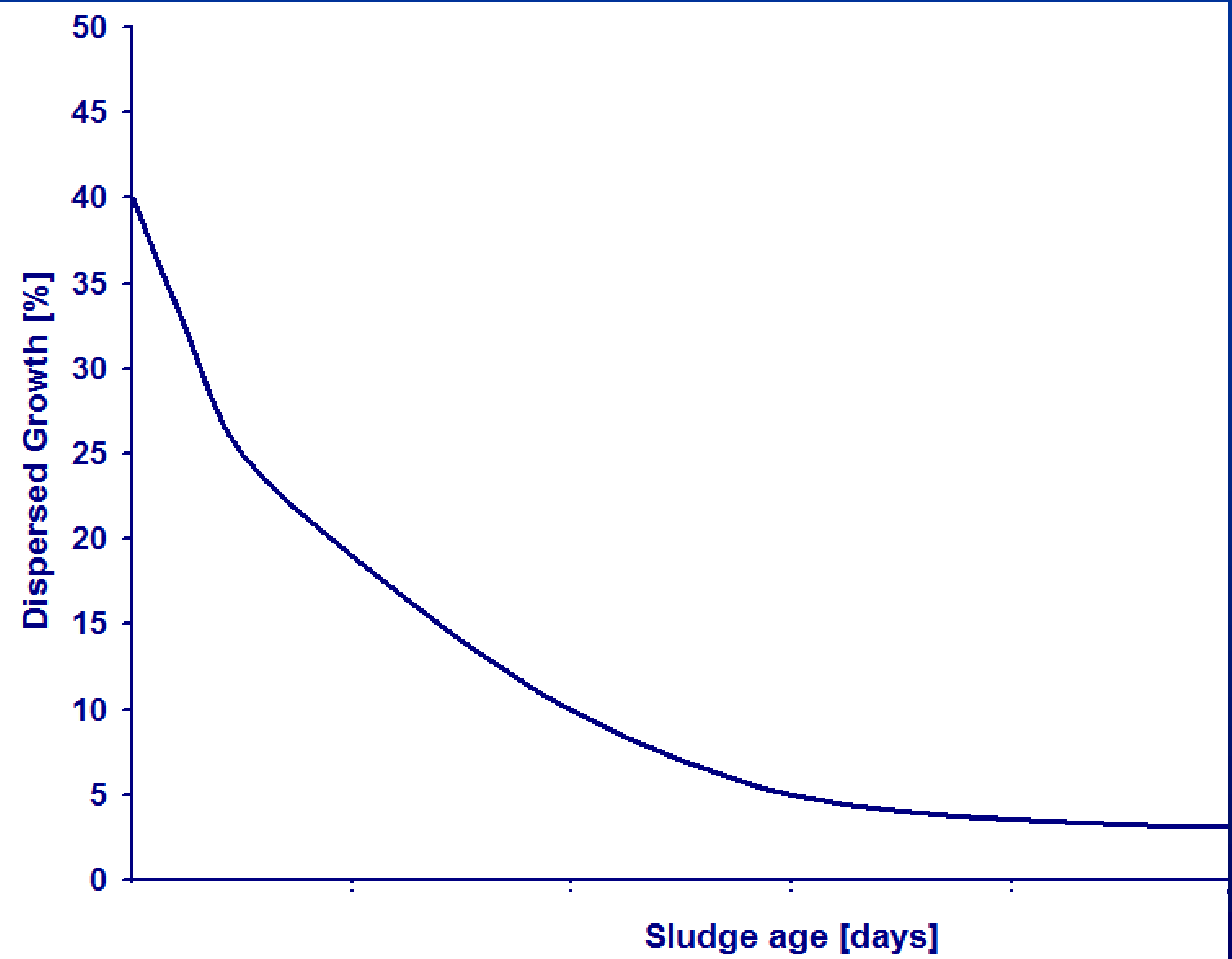
Manipulation of treatability and nutritional properties of bioflocs

- Reactor types
  - SBR
  - MBR
  - CSTR
  - Plug flow
  - etc...
- Supplementation
  - Carbon
  - Acid or bases
  - Flocculants
  - Ions
  - etc...

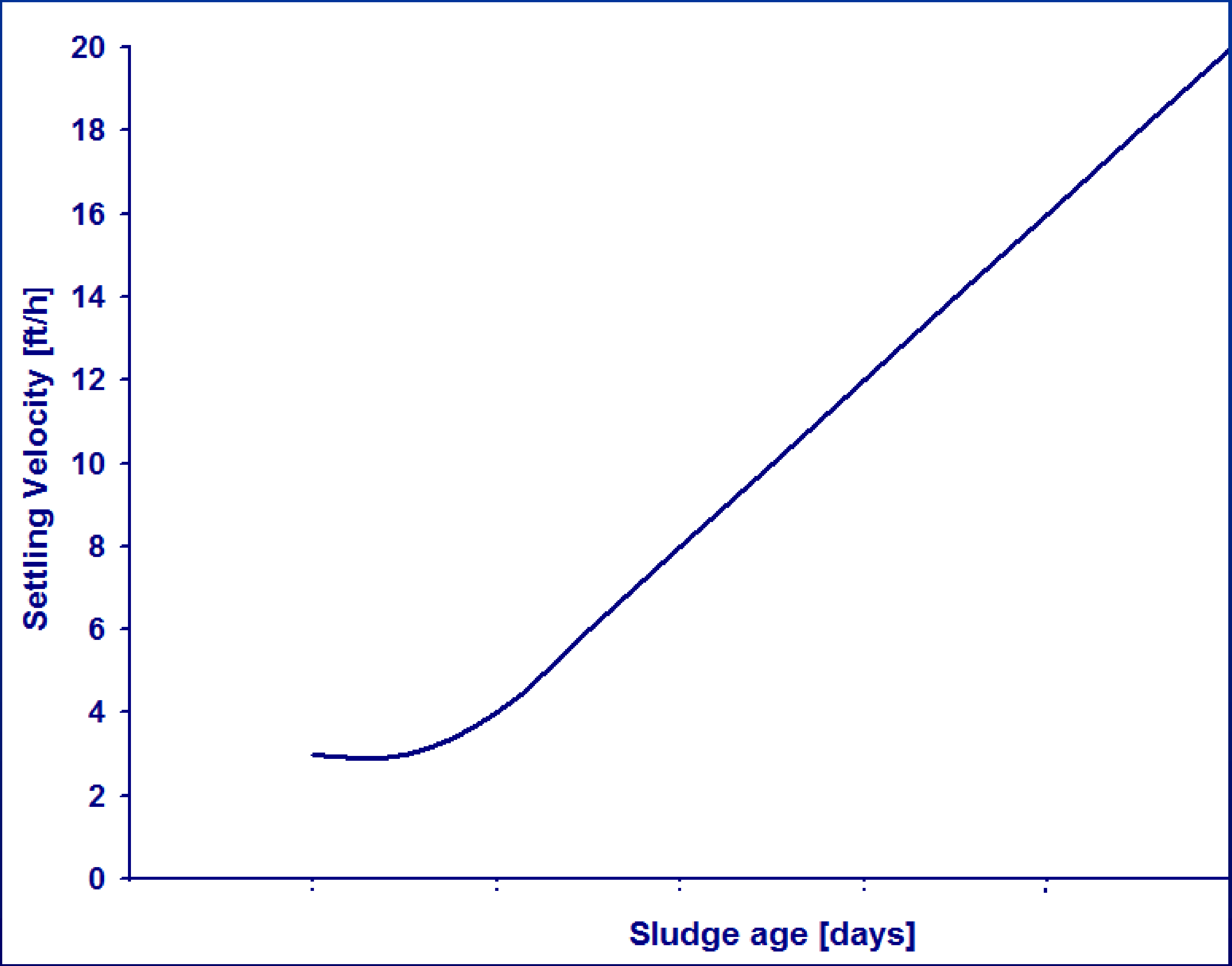
Others

- Mixing rates
- Loading rates
- Food: Microorganism
- Temperature
- Oxygen levels
- pH
- Nutrients
- Micronutrients
- Recycle ratios
- Hydraulic residence time
- Sludge residence time
- etc...

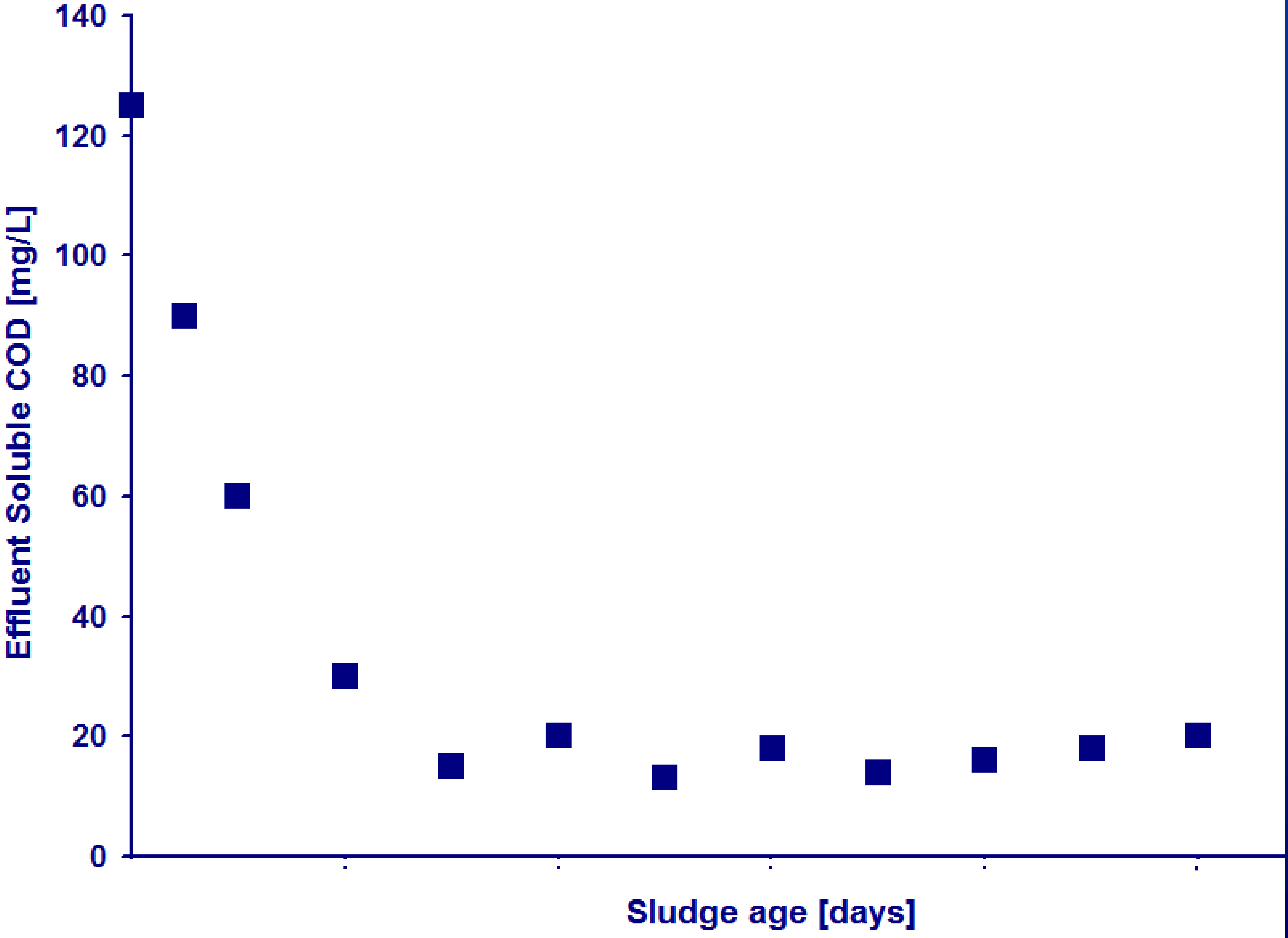
Percent pin flocs



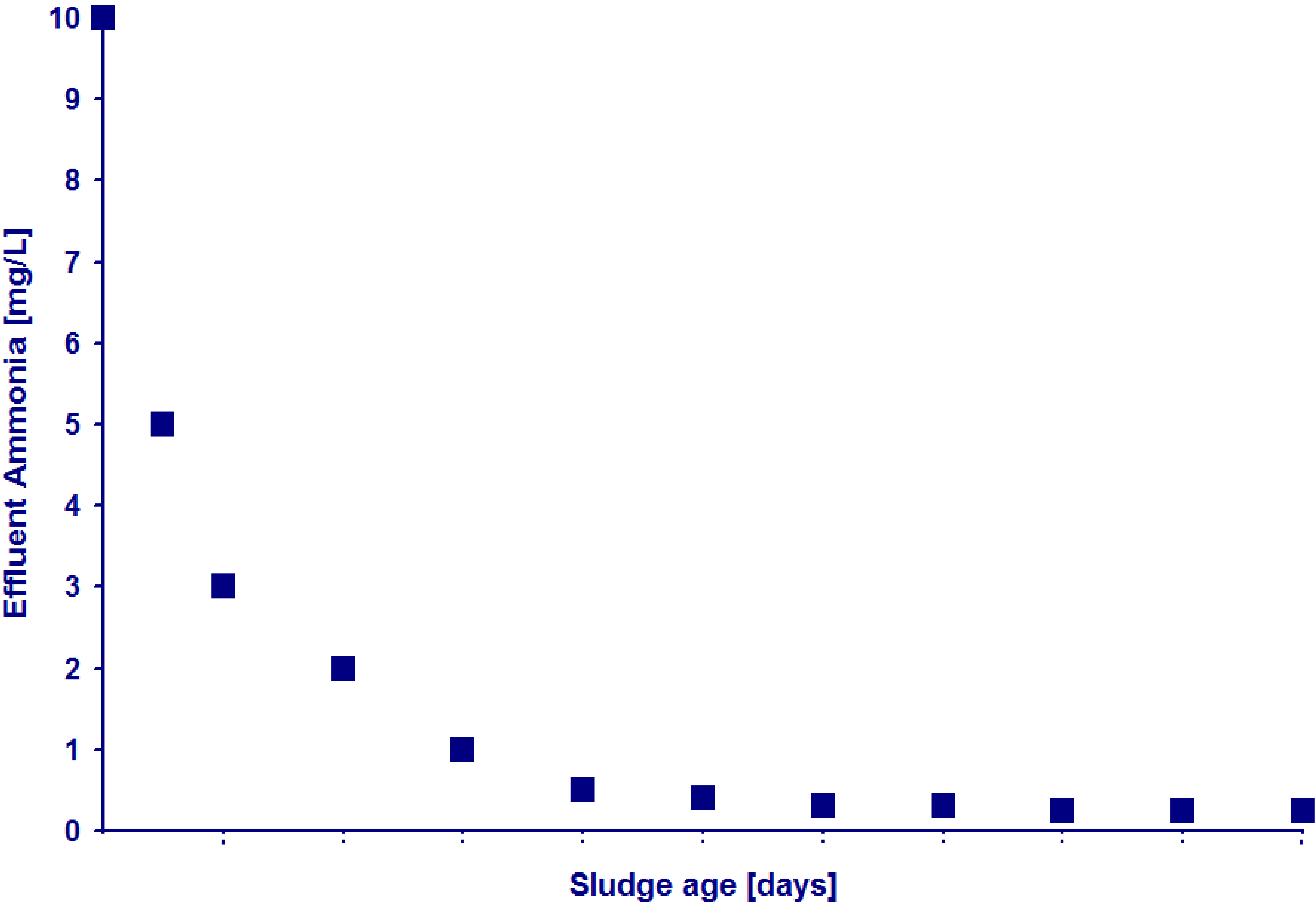
Biofloc settling velocity



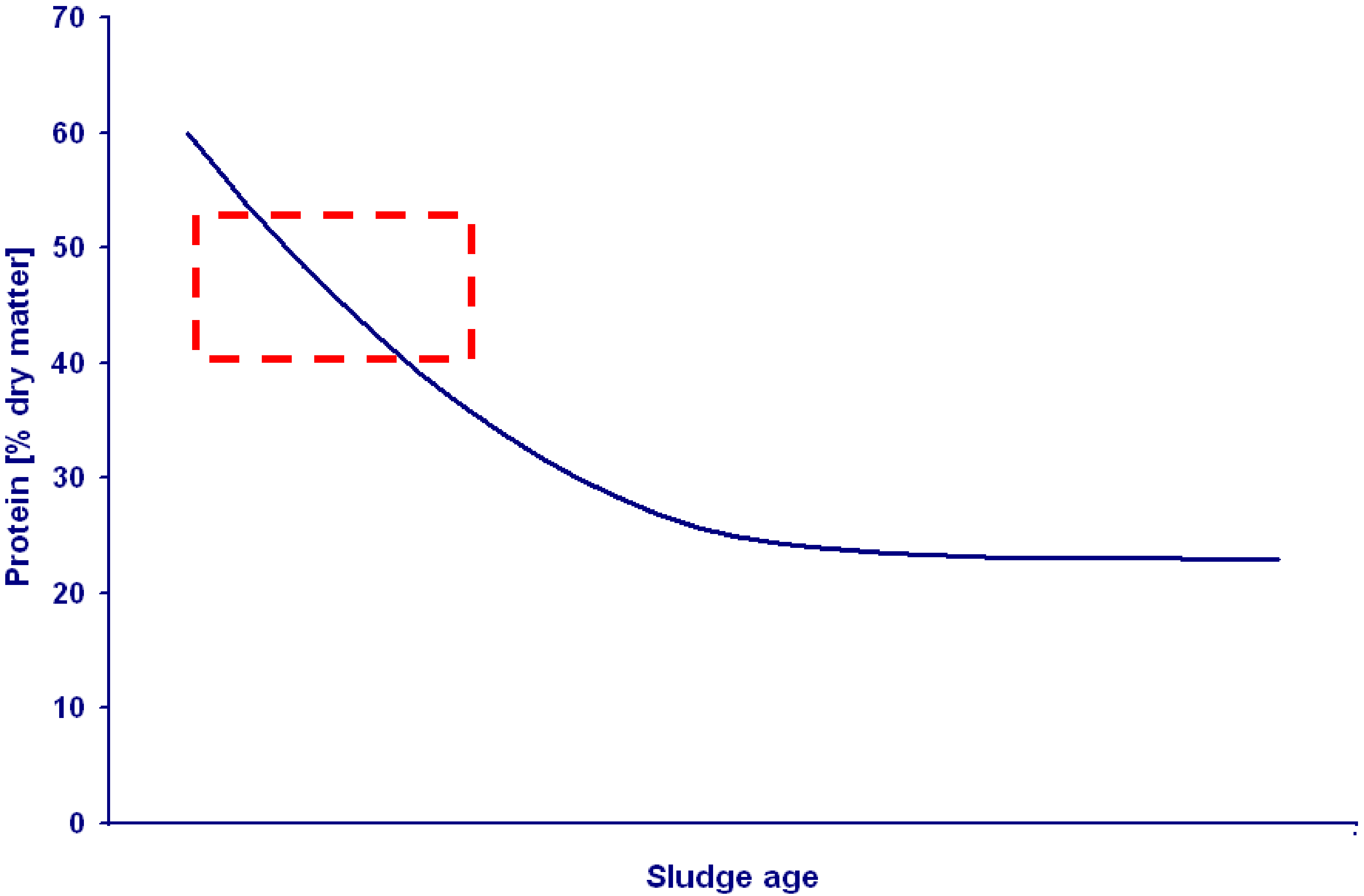
Effluent soluble COD



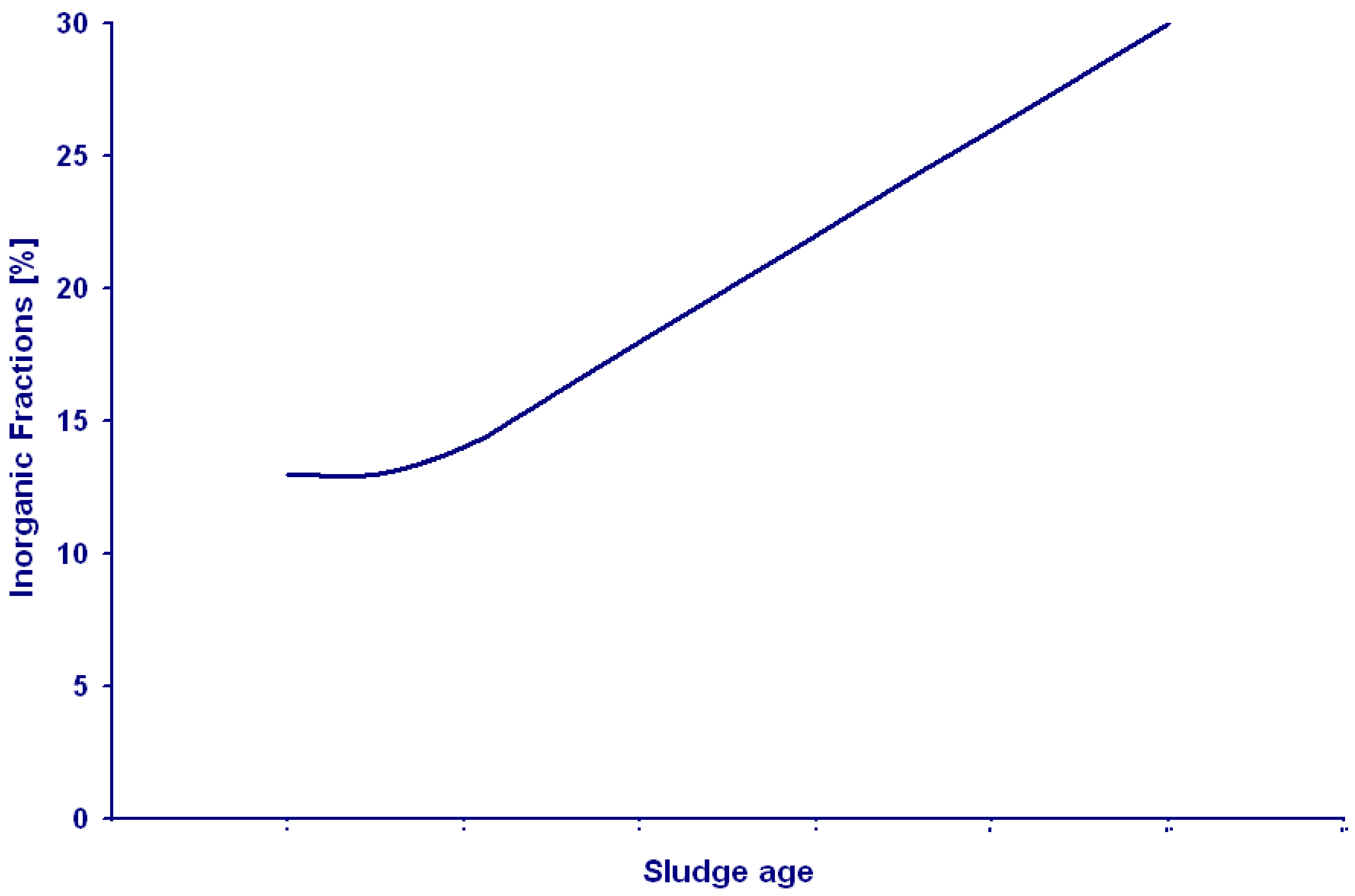
Effluent ammonia



Biofloc protein manipulation



Inorganic fraction of bioflocs



Current research

New biofloc types

- Hershey Chocolate effluent (cocoa, sugars, etc.)

- Tilapia RAS effluent (freshwater)
  - Sucrose [$C_{12}H_{22}O_{11}$]

  New

  - Calcium acetate [$Ca(C_2H_3O_2)_2$]
  - Glycerol [$C_3H_5(OH)_3$]

Results as of today

- Bioreactor/treatability studies
  - **No carbon** (in SBR) ok for removing nutrients but produces low biofloc levels
  - **Sucrose** good for removing nutrients but generates bioflocs with excessive fungus (high SVI)
  - **Calcium acetate** and **glycerol** good for removing nutrients and generates excellent bioflocs (low SVI)
- Nutrition studies
  - Already analyzed nutritional properties
  - Two weeks away from completing nutrition studies

Results as of today

- Nutrition studies
  - Already analyzed nutritional properties

    Notes:
    - Proteins similar in all bioflocs
    - Mn high in several biofloc types
    - Ca is high in calcium acetate bioflocs
  - Two weeks away from completing nutrition studies

Conclusion

- Biofloc technology could potentially:
  - Reduce water demand needed for aquaculture production
  - Increase effluent handling and its reuse
  - Serve as a model for the treatment of fish farm effluent which could be applied by other operations worldwide
  - Reduce soybean and fishmeal requirements in shrimp feed
  - Ultimately, offer a sustainable option for the culture of shrimp

Acknowledgements

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Questions?