Performance of moving bed biofilm reactor on the removal of wastewater derived dissolved organic nitrogen

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Outline

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- ✓ Methodology
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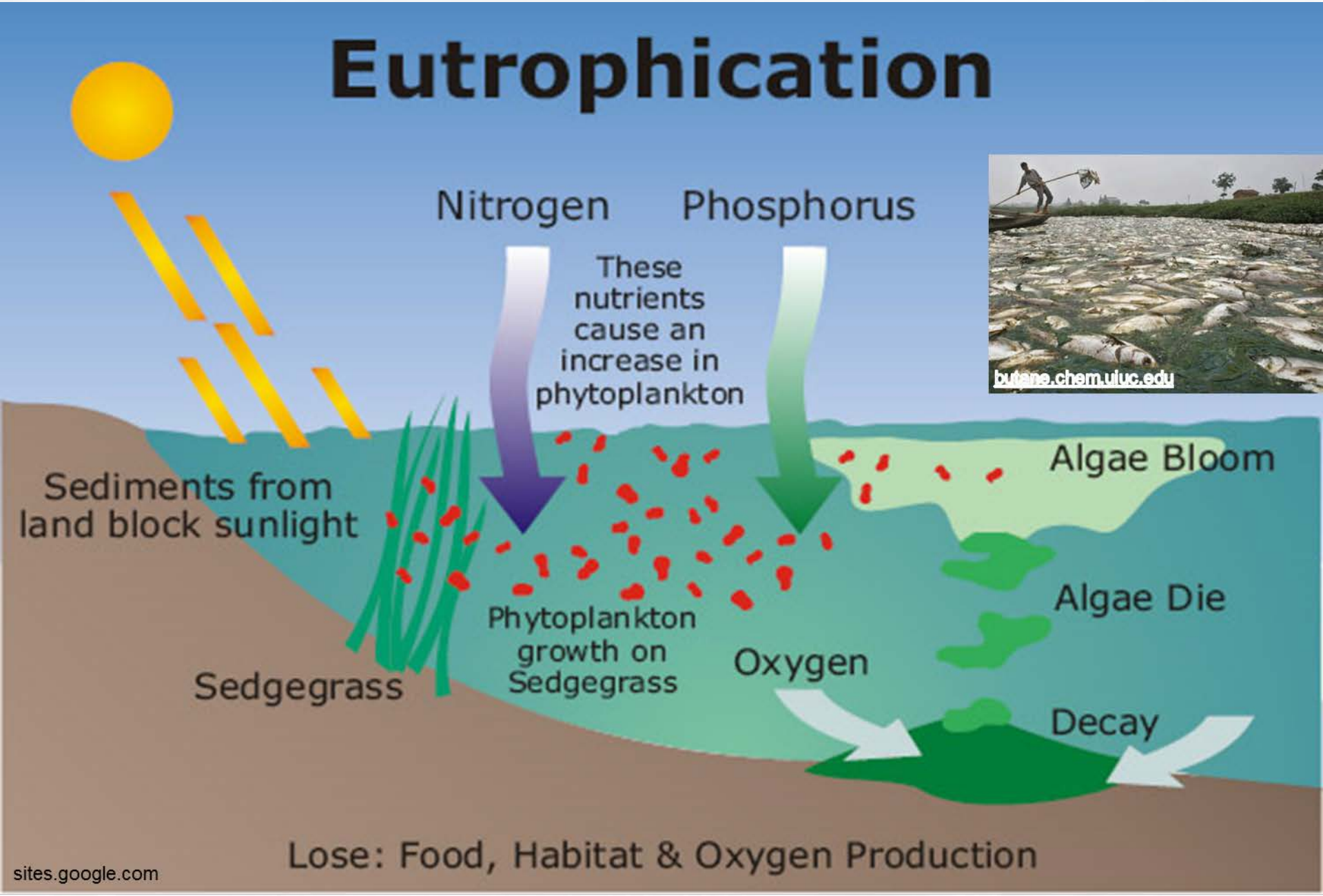
Introduction



Introduction

- Excess dissolved organic nitrogen (DON) compounds present in wastewater discharge leads to eutrophication in downstream receiving waters
- Eutrophication threatens the safety of drinking water resources potentially
- Current treatment technologies are not adequate for the removal of organic nitrogen

Introduction

- An integrated Moving Bed Biofilm Reactor (MBBR) system using bacteria and algae is proposed
- MBBR has been used in the treatment of
  - industrial
  - rural domestic
  - municipal wastewater

Introduction

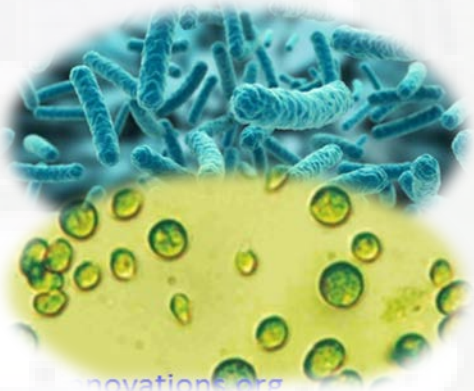
- MBBR media increases the removal capacity through protected surface area for the growth of bacteria and algae
- Utilize whole tank volume for productivity
- Easy expansion
- Ease of operation and reliable
- Cost effective

Introduction

- DON in surface waters may originate from:
  - Effluent from wastewater treatment plants (WWTPs)
  - Industrial sewage
  - Rural domestic sewage
  - Agricultural runoff
- Effluent DON may consist of
  - High molecular weight compounds such as amino acids, proteins, nucleic acids
  - Humic substances such as lake sediments, peats, brown coals

Composition of DON

- Bioavailable DON (ABDON)
  Fraction of DON that is directly or indirectly available as an N source for aquatic plant species



- Biodegradable DON (BDON)
  portion of DON that is biodegradable to bacteria

BDON and ABDON

- The BDON and ABDON in water environment depends on the environmental conditions such as
  - Residence time
  - Temperature
  - Type of living organisms present
  - DO level
  - pH

- BDON and ABDON discharged to water bodies
  - Contains high biological oxygen demand compounds
  - Consumes dissolved oxygen and causes eutrophication

Research Justification

- Removal of effluent DON is essential for the safety of receiving waters
- A portion of DON cannot be removed (refractory) using current wastewater treatment technologies and is discharged to receiving waters
- Once entering the receiving waters, biodegradation of DON (to ammonia and eventually nitrate) could start if optimum conditions are met

Research Justification

- The produced ammonia and nitrate are used by algae and other phytoplankton and consequently excessive growth of algae and phytoplankton cause eutrophication in receiving waters
- Nitrate in drinking water can cause Blue Baby syndrome
- Increased levels of nitrate in water can make toxic metals more soluble

Objective

- To investigate the impact of MBBR process on removal of DON, BDON, and ABDON
- To study whether DON, BDON, and ABDON can be minimized by Hydraulic retention times (HRT) in MBBR system
- To determine the effect of bacterial and algae consortia in the bioavailability of DON

Methodology

- **Experimental Setup and Operation**
  - Reactor;
    - was made of polyvinyl chloride (PVC)
    - working volume was 8.0 liters
    - length x height x width was 40 x 25 x 25 cm

Methodology

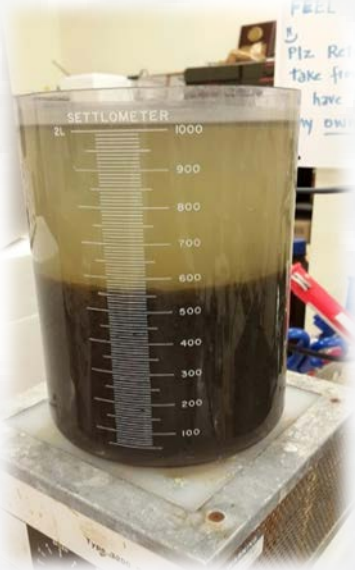
- Moving Bed Bioreactor ;
  - operated at a constant temperature of about 25^{o}C (room temperature)
  - continuous aeration was provided through diffusers
  - airflow rate was regulated to maintain minimum dissolved oxygen (DO) level of 6.0 mg/L
  - polyethylene MBBR media
- HRT of 1 and 3 days were studied for the operation

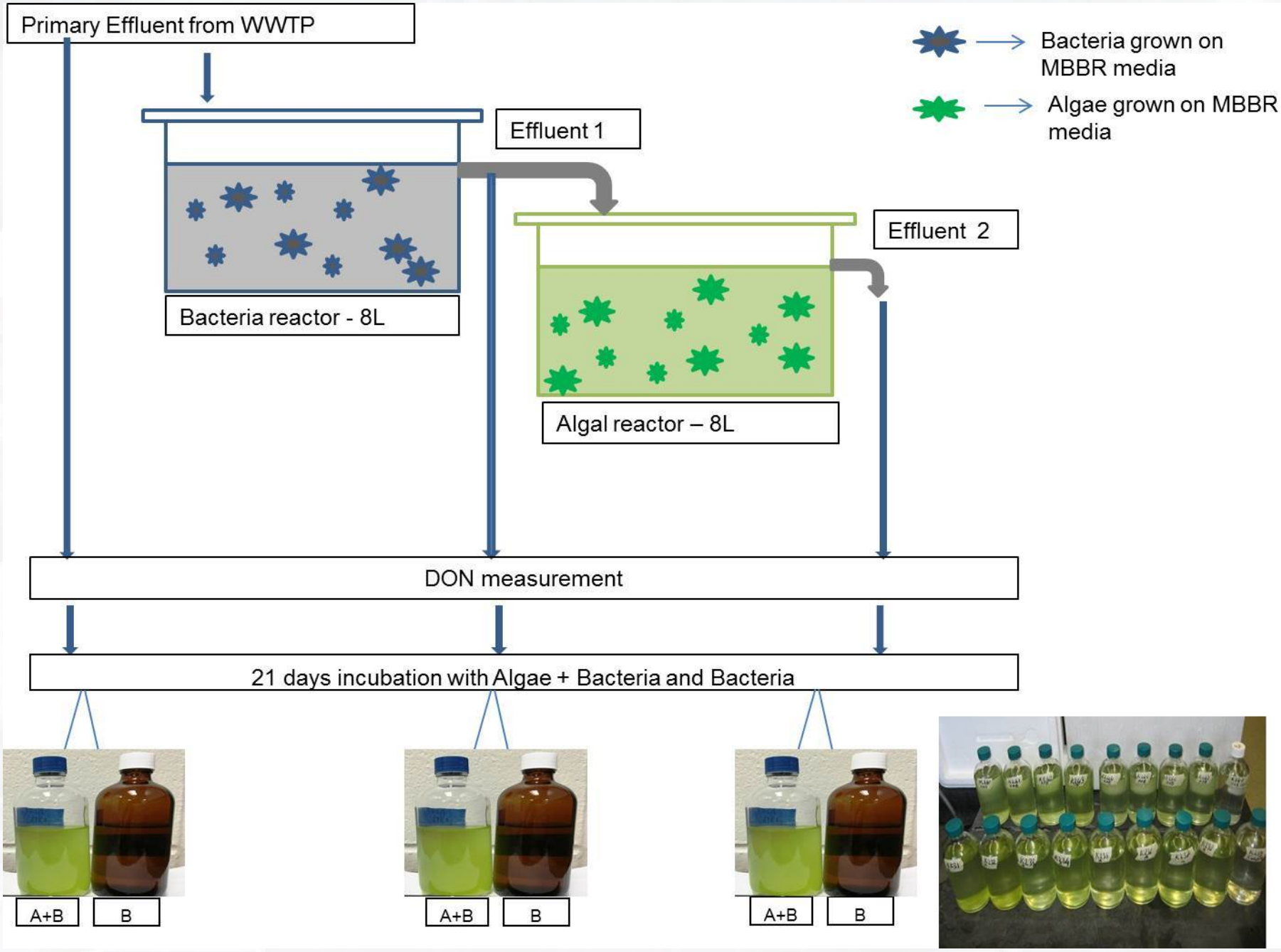
Methodology

- Grab samples were collected from after primary locations in the City of Fargo (ND, USA) WWTP and used as influent to the integrated system reactors
- Sampling from the reactor was started daily after the steady state conditions were attained

Methodology

- For BDON and ABDON determination;
  - Mixed culture bacteria containing ammonium oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) is used
  - Pure-culture algae, *Chlamydomonas reinhardtii* was used




Primary Effluent from WWTP
Bacteria grown on MBBR media
Algae grown on MBBR media
Effluent 1
Effluent 2
Bacteria reactor - 8L
Algal reactor – 8L
DON measurement
21 days incubation with Algae + Bacteria and Bacteria
A+B
B
A+B
B
A+B
B

Methodology

- **Parameters Studied**
  - Dissolved ammonia
  - Dissolved nitrite
  - Dissolved nitrate
  - TDN
  - SCOD

DON determination

- Subtractive method used to measure DON

$$DON = TDN - (DNH_3^-N) - (DNO_2^-N) - (DNO_3^-N)$$

- BDON or ABDON = Initial DON –Final DON

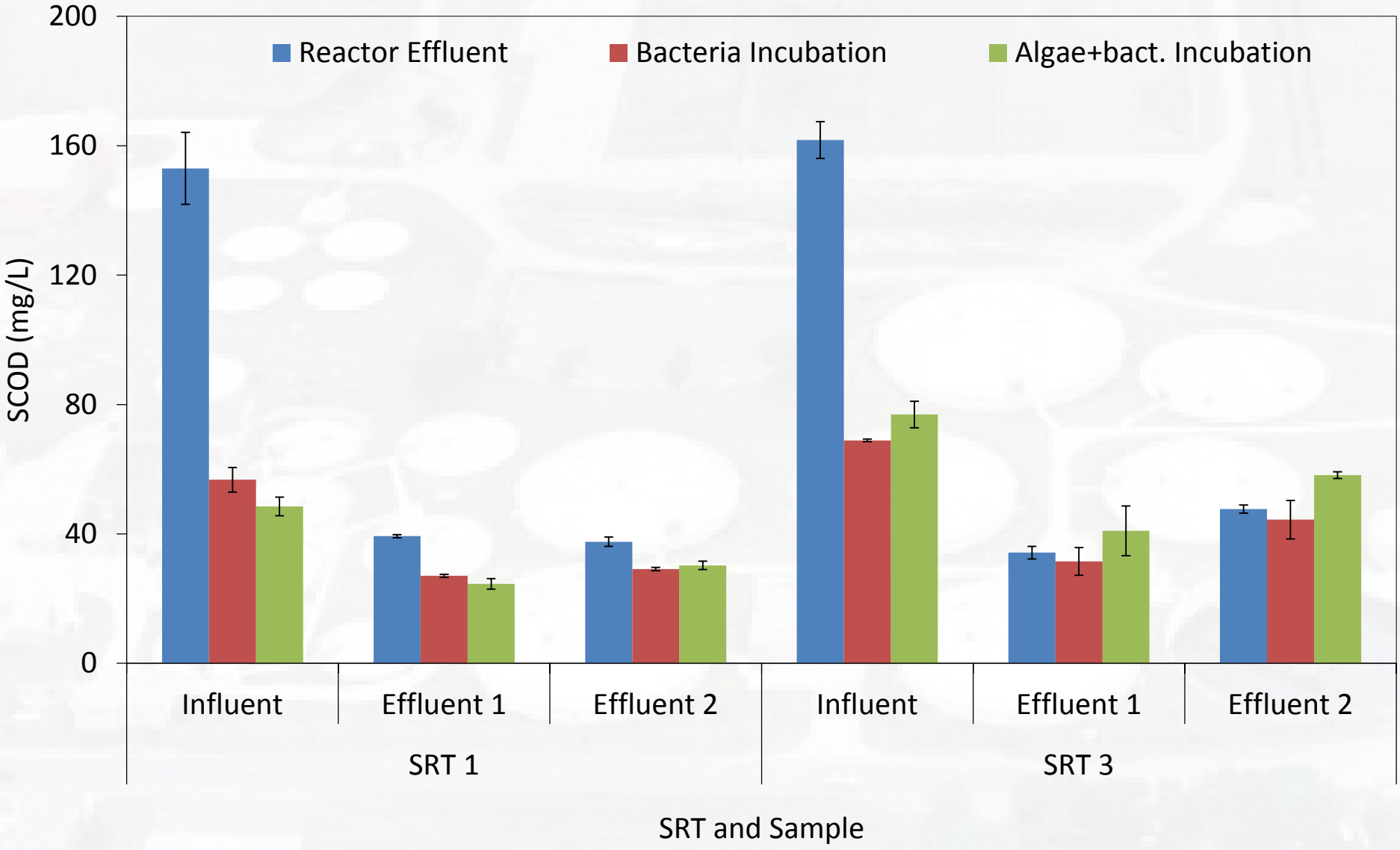
$$= [(DON_i - DON_f) - (DON_{bi} - DON_{bf})]$$

Typical values of nitrogen species in Fargo WWTP

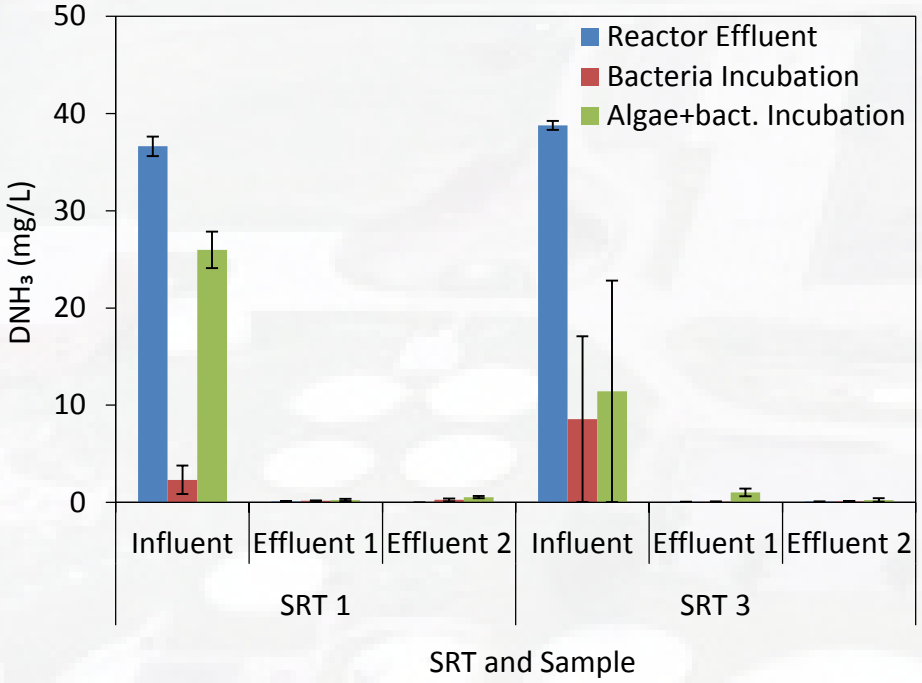
A trickling filter (TF) treatment plant

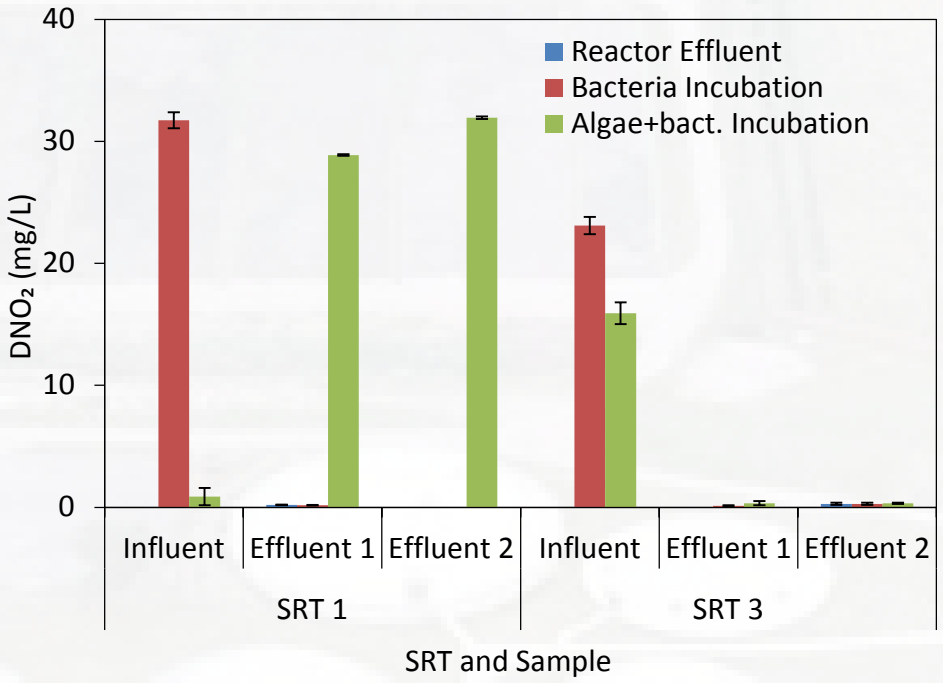
Sampling location	NH_3-N	NO_2-N	NO_3-N	TDN	DON
Primary clarifier	33.74	0.26	0.27	43.13	9.65
BOD trickling filter	20.50	0.16	8.65	36.27	6.59
Nitrification trickling filter	1.19	0.21	31.90	36.59	3.76

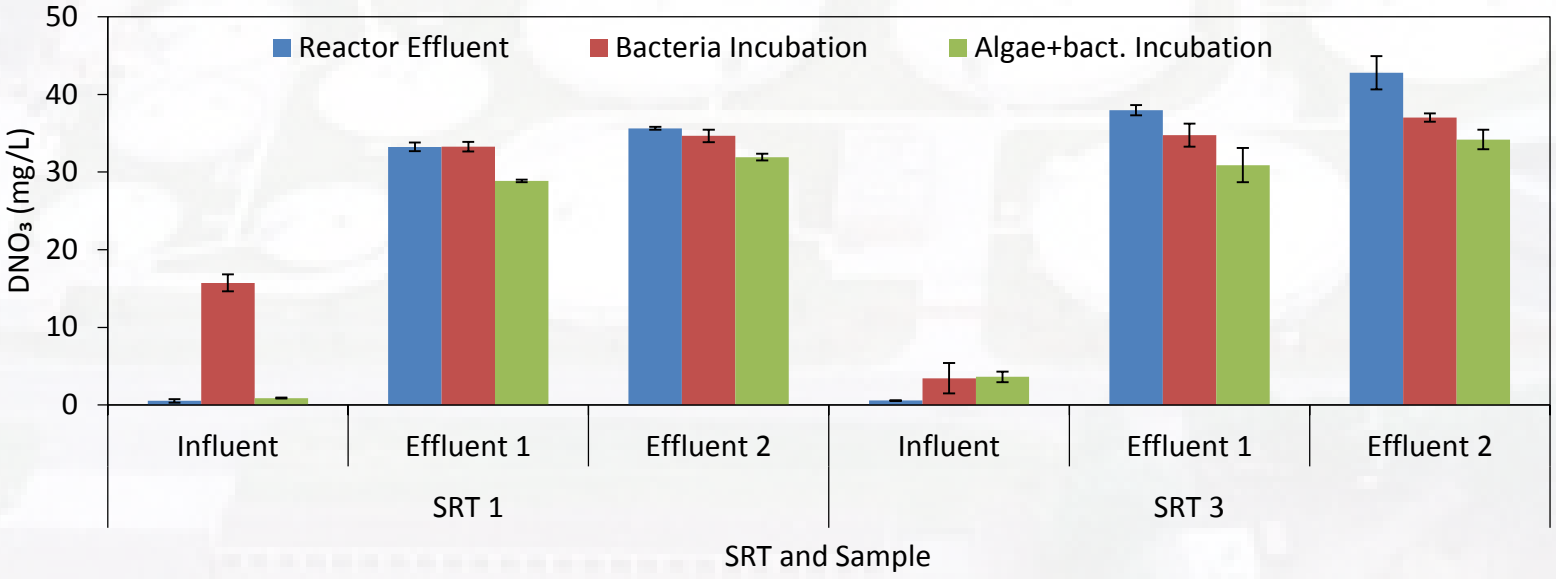
SCOD


200
160
120
80
40
0
SCOD (mg/L)
Reactor Effluent
Bacteria Incubation
Algae+bact. Incubation
Influent
Effluent 1
Effluent 2
Influent
Effluent 1
Effluent 2
SRT 1
SRT 3
SRT and Sample

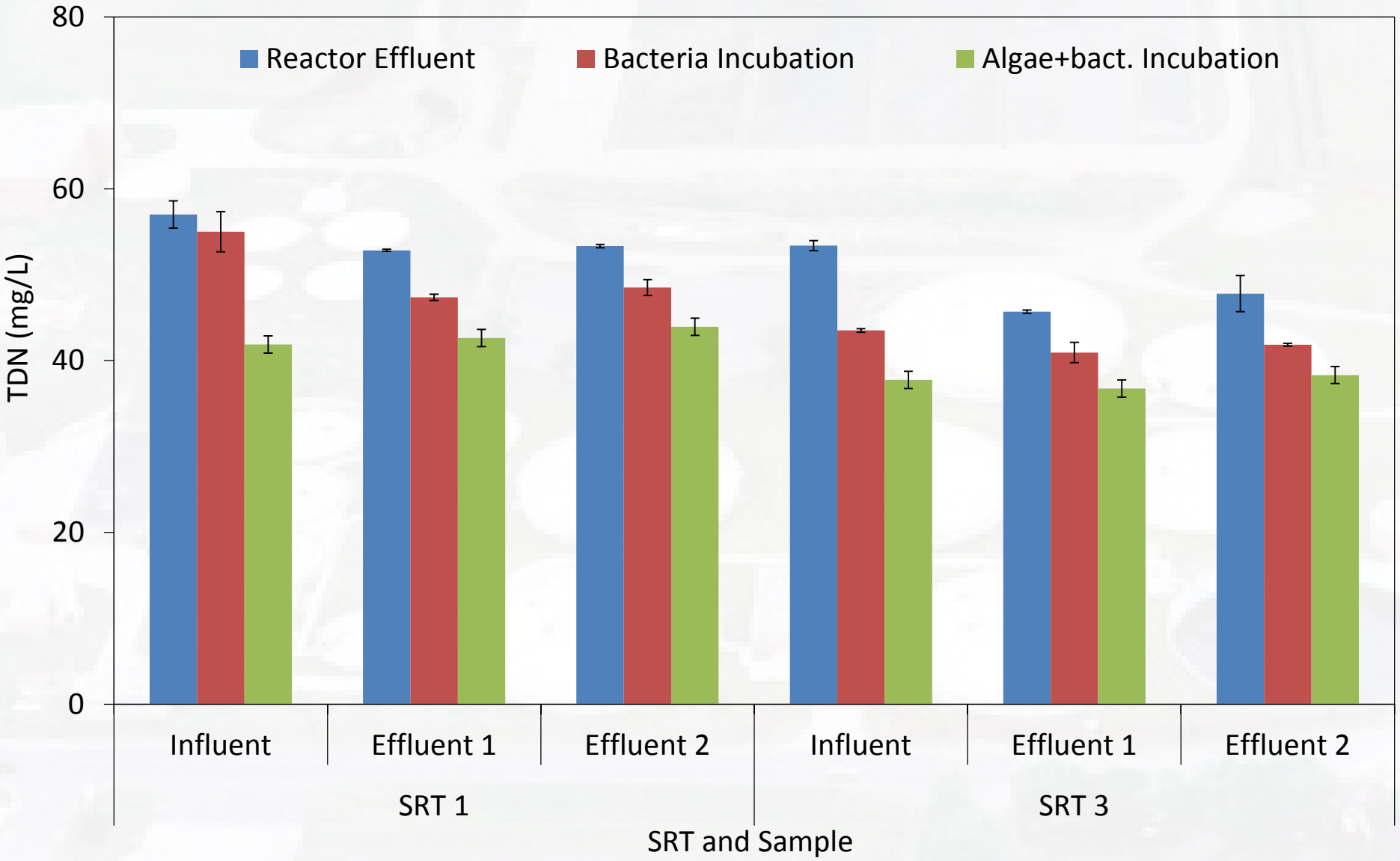
Dissolved Inorganic Nitrogen



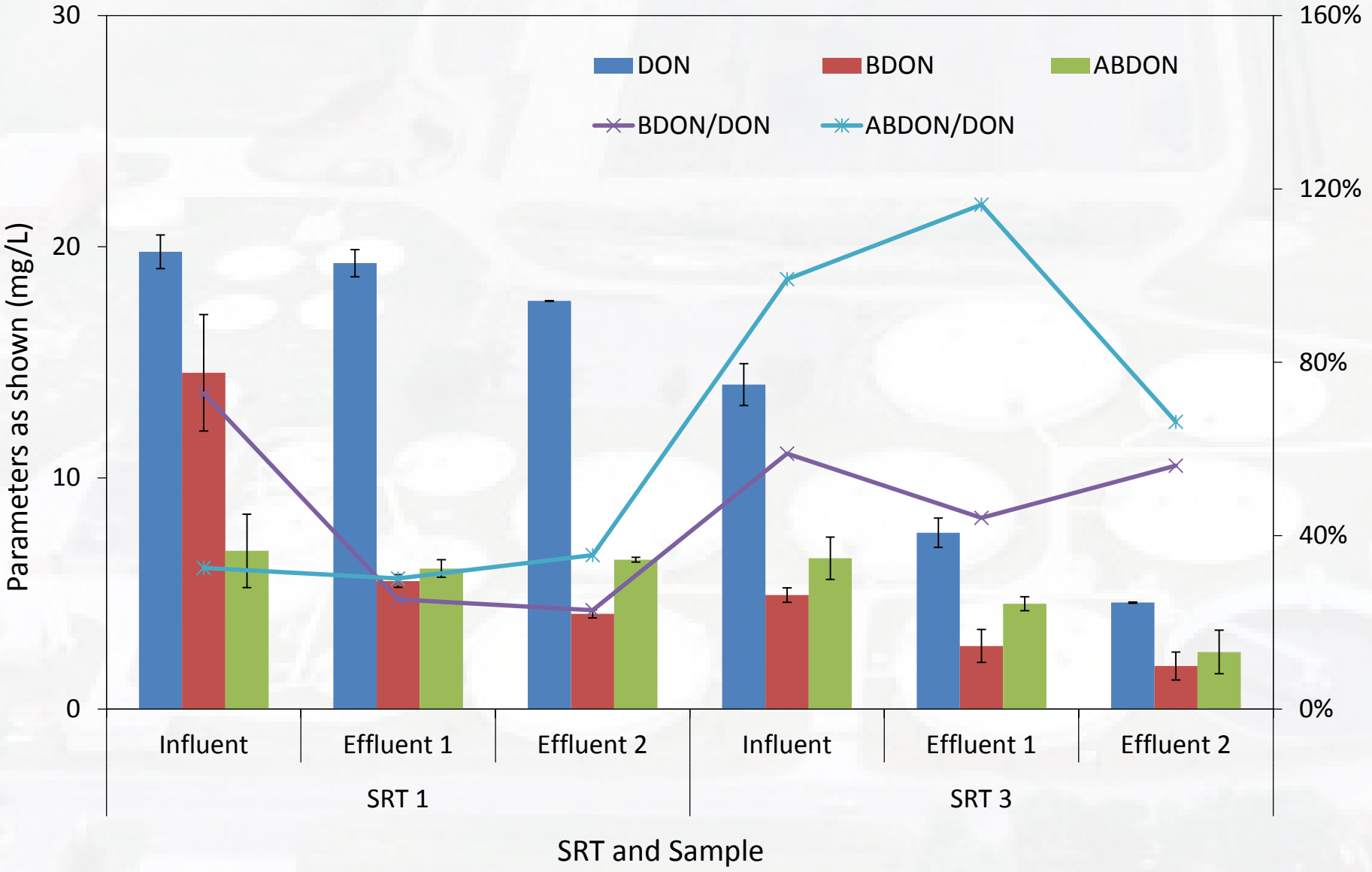




Total Dissolved Nitrogen



DON, BDON, ABDON



Conclusions

- Only 2 SRTs within a limit range were tested in this study
- Effluent SCOD decreases significantly from that of influent.
- There is no significant difference in SCOD concentration between the reactor effluent and post incubation with bacteria and algae + bacteria.
- The SCOD concentration is slightly higher in algae + bacteria seeded samples compared to that of bacteria only seeded samples.

Conclusions

- Reactor effluent TDN concentration remained the same throughout the treatment phases.
- BDON/DON and ABDON/DON ratio ranges from 44 – 75%
- No significant difference between BDON and ABDON after incubation of the reactor effluents

Future work

- The algal reactor effluent to be exposed to UV light to investigate the fate of DON.
- Running the reactor with cell recycling which is more relevant to the common wastewater treatment process is recommended for future work
- Chemical structure of DON, BDON and ABDON should be investigated

THANK YOU

Q & A