Pharmaceutical Active Compounds Removal by Constructed Wetlands Under Different Redox Conditions

AHMED F. HAMADEH[1]

PIET LENS[2] AND GARY AMY[1]

[1]KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KAUST), SAUDI ARABIA.

[2] UNESCO-IHE INSTITUTE FOR WATER

Outlines

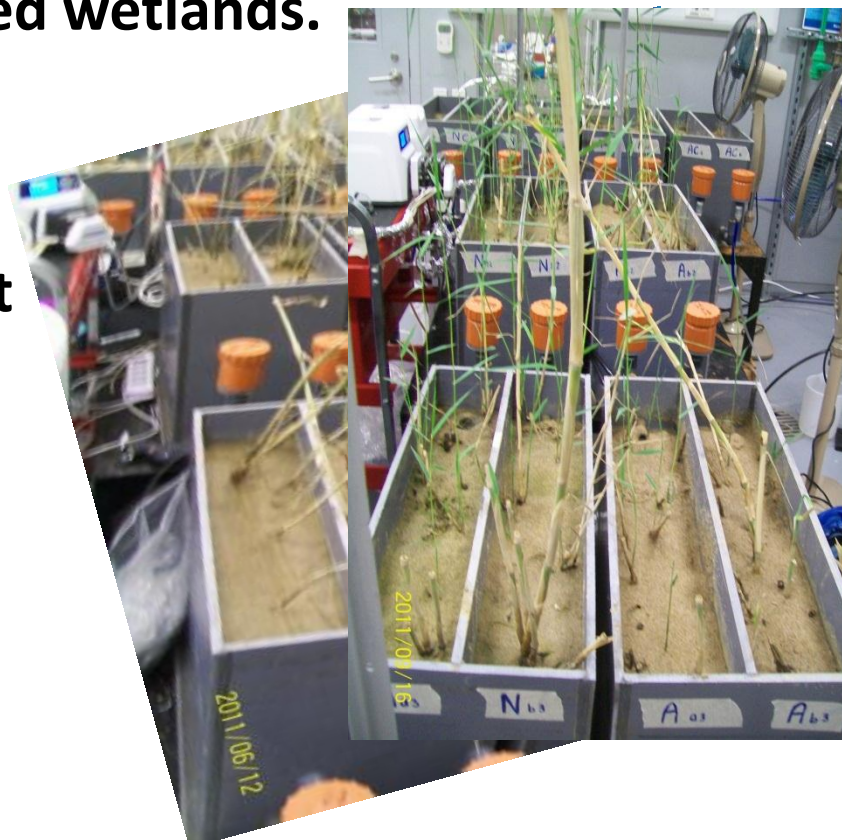
- Objectives and Methodologies
- Set-up preparation
- WW Composition
- Feeding water quality
- Organic matters and nutrients removal
- Organic matters characterization
- OMPs properties and removals
- Plant role in the treatment
- Conclusions

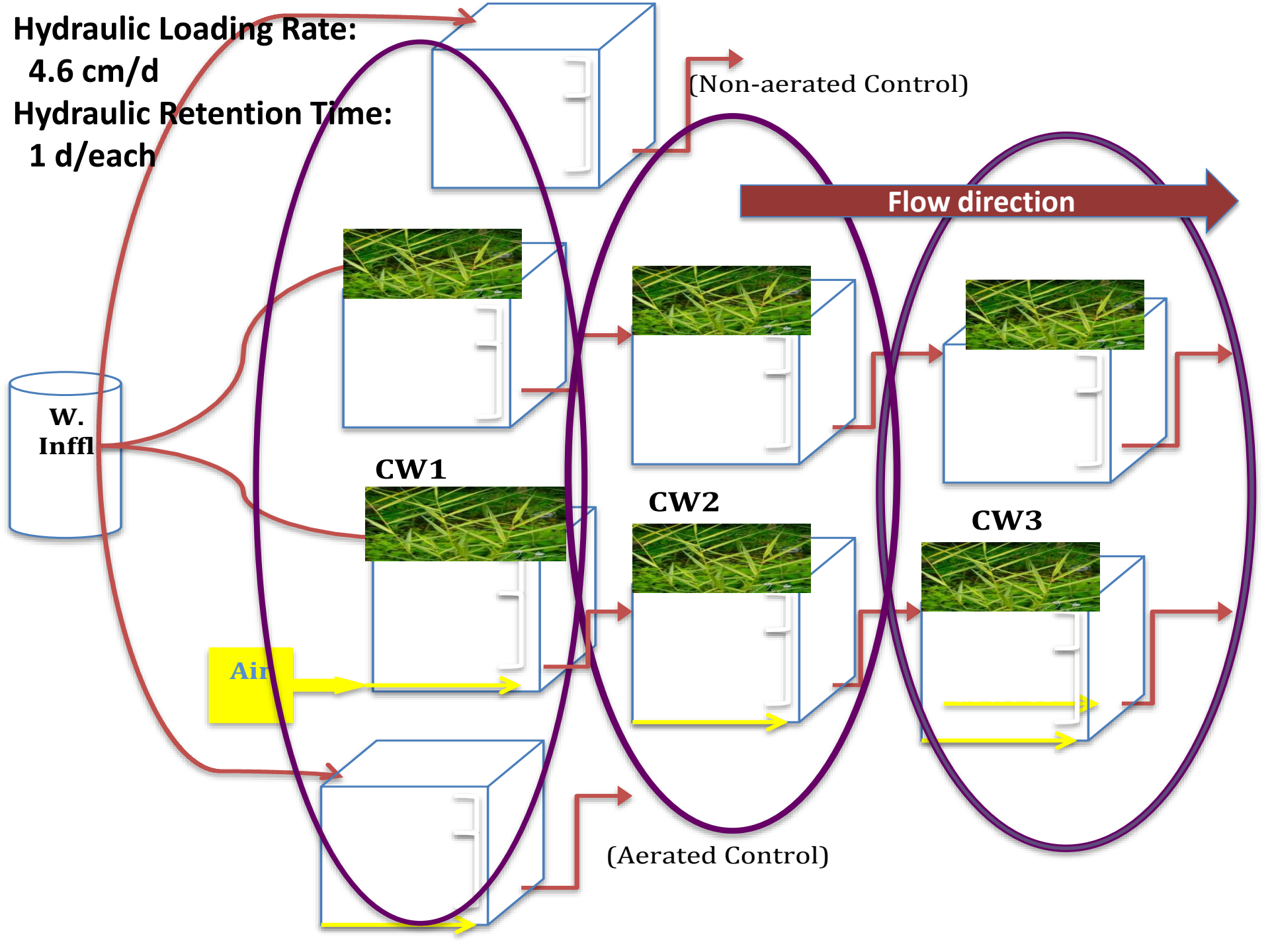
Study Objectives

- Study removal processes of nutrients (C, N & P) through CWs under different Redox conditions.
- Assess the removal efficiency of nutrients and selected group of Organic Micropollutants (OMPs) through CWs.
- Specify the plants role in the wastewater treatment during horizontal Subsurface flow constructed wetlands.

Methodology

- Build lab scale subsurface flow CWs and study the performance for different nutrients and OMPs present in wastewaters, planted with Phragmites *australis* plant and feed with 2° Eff. synthetic ww.



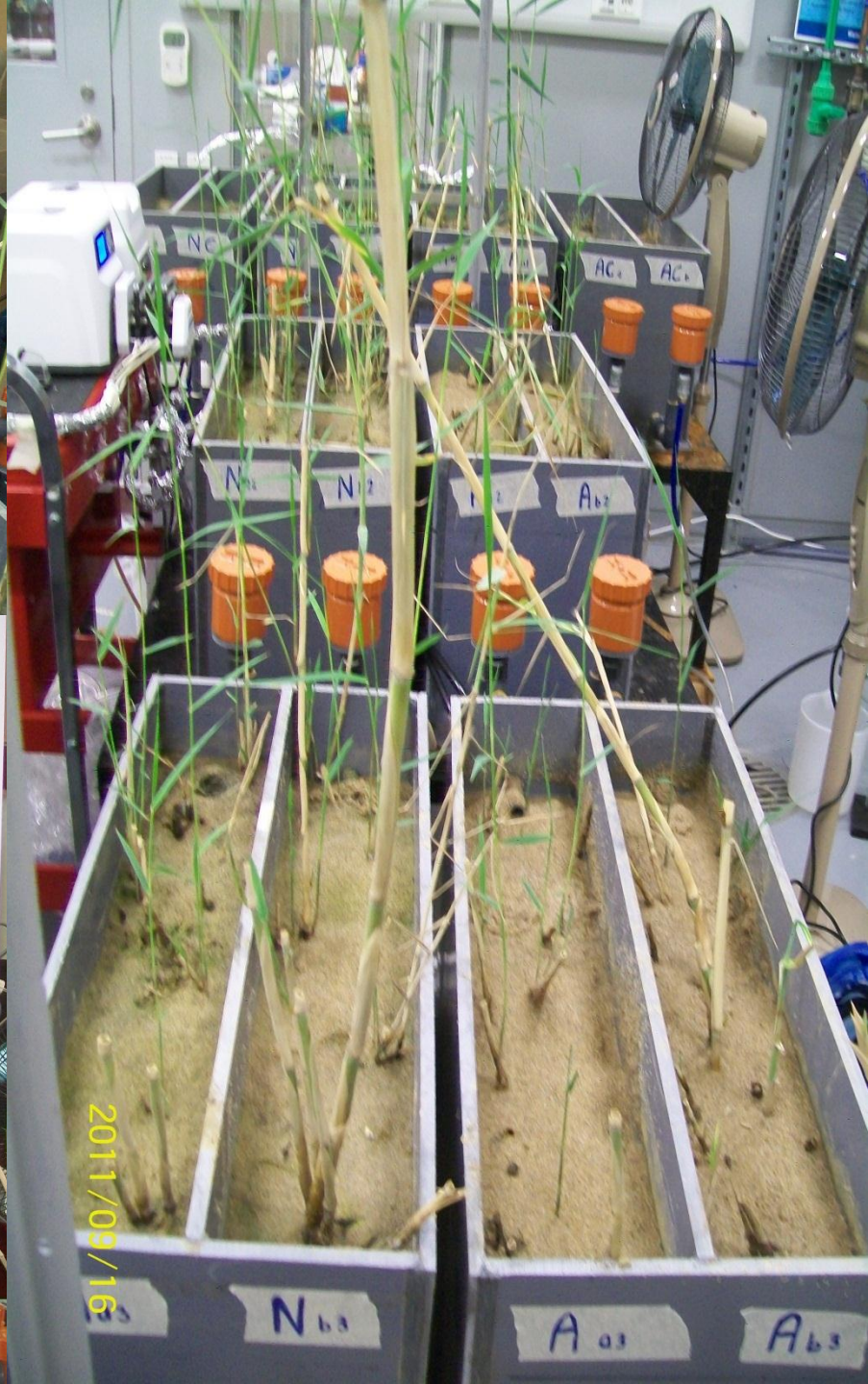

Hydraulic Loading Rate:
4.6 cm/d
Hydraulic Retention Time:
1 d/each
(Non-aerated Control)
Flow direction
W.
Inffl
CW1
CW2
CW3
Air
(Aerated Control)

Setup Preparation

Phragmites australis plant harvesting


2011/09/11


2011/09/11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Synthetic WW composition

No.	Material	Inff. Conc (ppm)	SE Conc. (ppm), 80% Red.
1	NaAc-3H2O	131.64	26.33
2	Urea	91.74	18.35
3	NH4Cl	12.75	2.55
4	KH2PO4	23.40	4.68
5	CaCl2	168.43	33.69
6	FeSO4-7H2O	7.73	1.55
7	MgHPO4-3H2O	29.02	5.80
8	MgCl2-6H2O	79.97	15.99
9	Peptone	17.41	3.48
10	Starch	122.00	24.40
11	Milk Powder	116.19	23.24
12	Yeast	52.24	10.45
13	Soy Oil	55.69	11.14
14	ZnCl2	0.21	0.04
15	PbCl2	0.10	0.02
16	MnSO4-H20	0.11	0.02
17	NiSO4-6H2O	0.33	0.07
18	CuCl2-2H2O	0.53	0.11
19	Cr(NO3)3-9H2O	0.77	0.15

(Source: Jiang, T. (2007) Characterization and modelling of soluble microbial products in membrane bioreactors. PhD thesis, Ghent Un., Belgium.

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19	Cr(NO3)3-9H2O	0.77	0.15

This composition was modified by:
✓ adding Inorganic Nitrogen source NO3 (about 3mg/l as N).
✓ adding Sulfate SO4 around 10mg/l.

(Source: Jiang, T. (2007) Characterization and modelling of soluble microbial products in membrane bioreactors. PhD thesis, Ghent Un., Belgium.

Feeding water quality

Parameter	Unit	Concentration
DOC	mg/l	9.61 ± 1.5
TN	mg/l	8.35 ± 0.87
NO_3^- as N	mg/l	3.63 ± 0.25
NH_4^+ as N	mg/l	1.98 ± 0.67
Organic N.	mg/l	2.83 ± 0.87
SO_4^{-2}	mg/l	12.33 ± 2
Specific UV Abs.	l/mg.m	0.23± 0.04
COD	mg/l	41

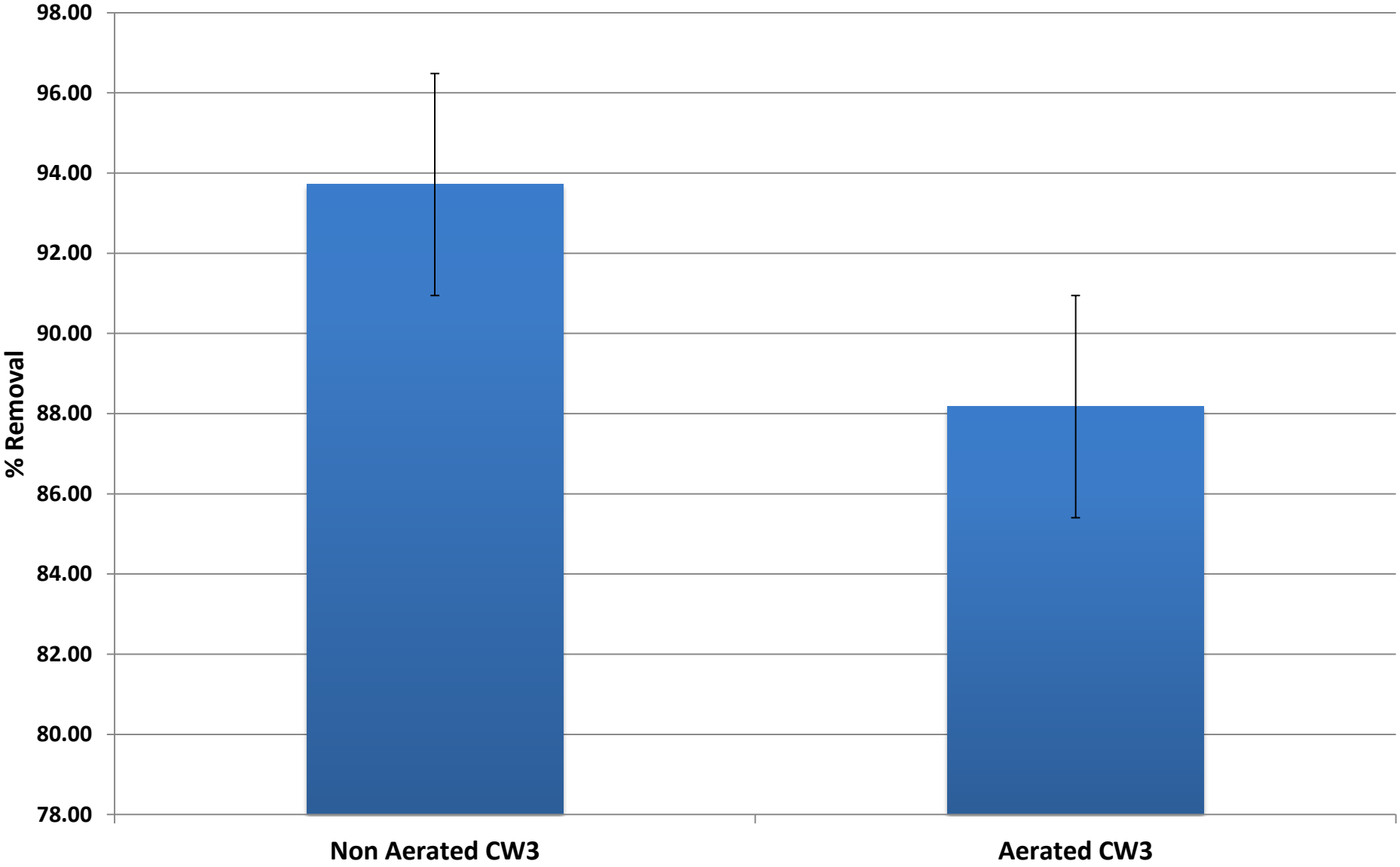
DOC and TN changes in the influents

Aerated influents		
Influent	DOC (mg/L)	TN (mg/L)
CW1	9.61	8.35
CW2	0.81	1.48
CW3	0.82	0.9

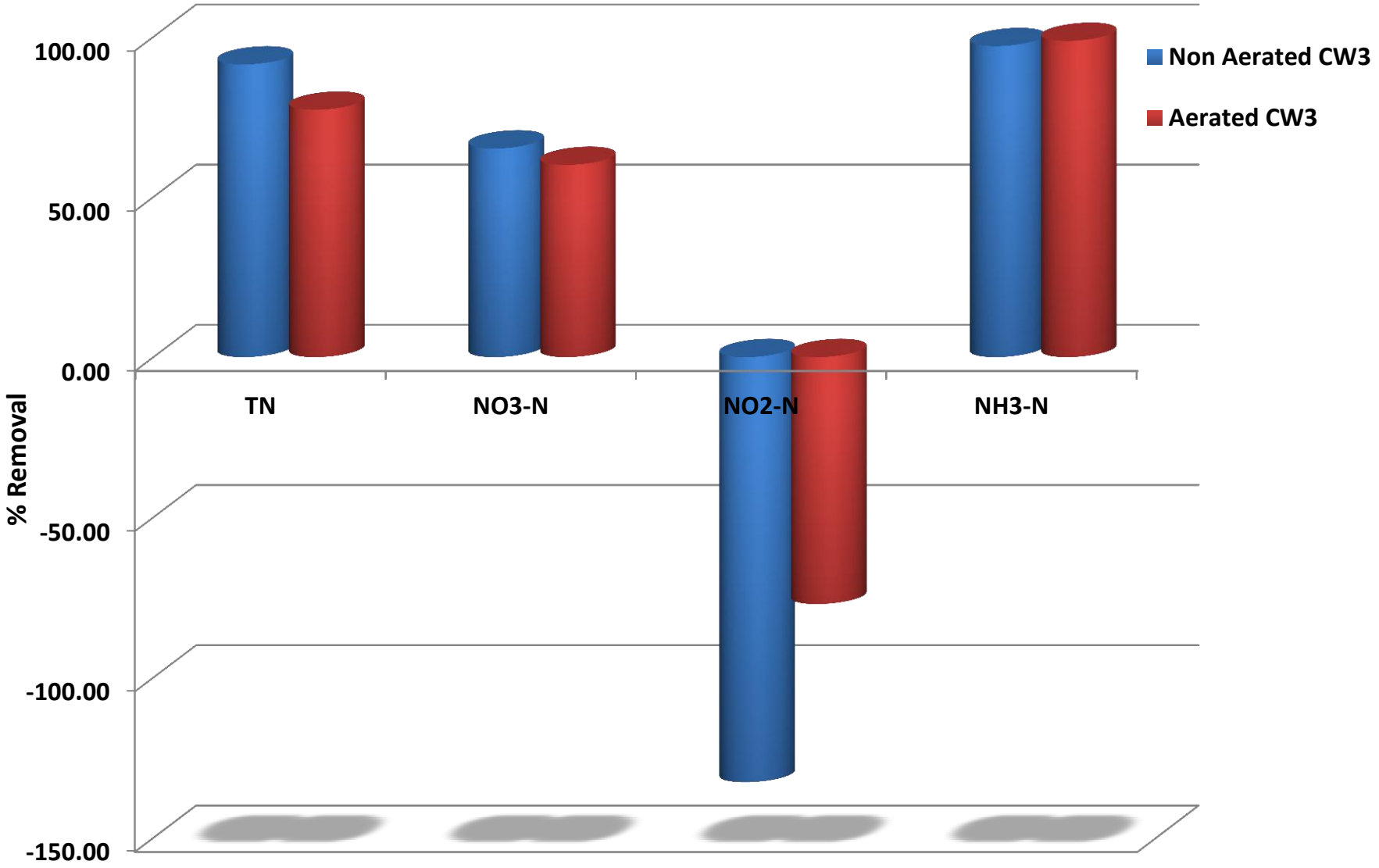
FLOW

Non-aerated influents		
Influent	DOC (mg/L)	TN (mg/L)
Cw1	9.61	8.35
CW2	0.59	2.17
CW3	0.74	1.34

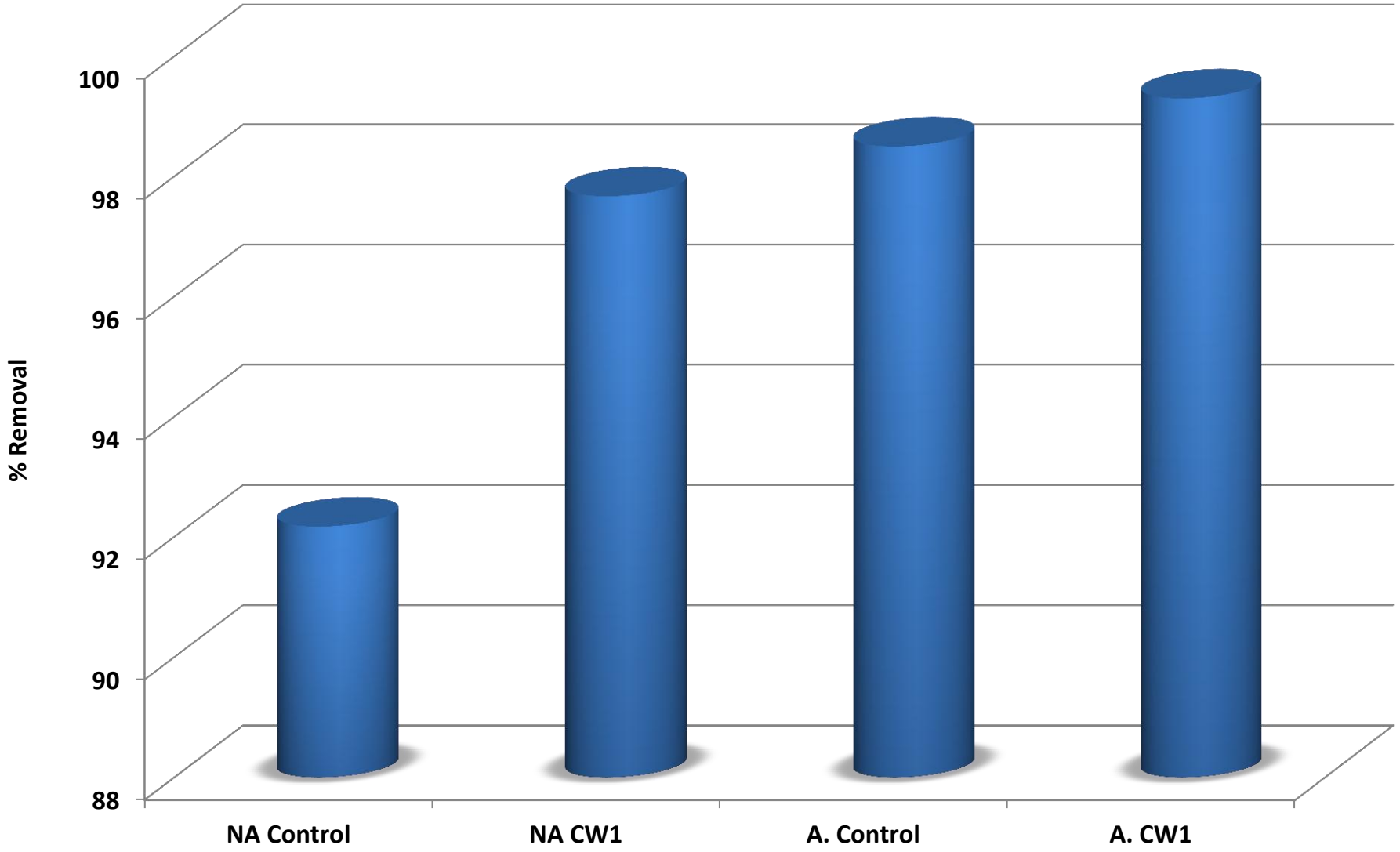
Total % Removal for DOC



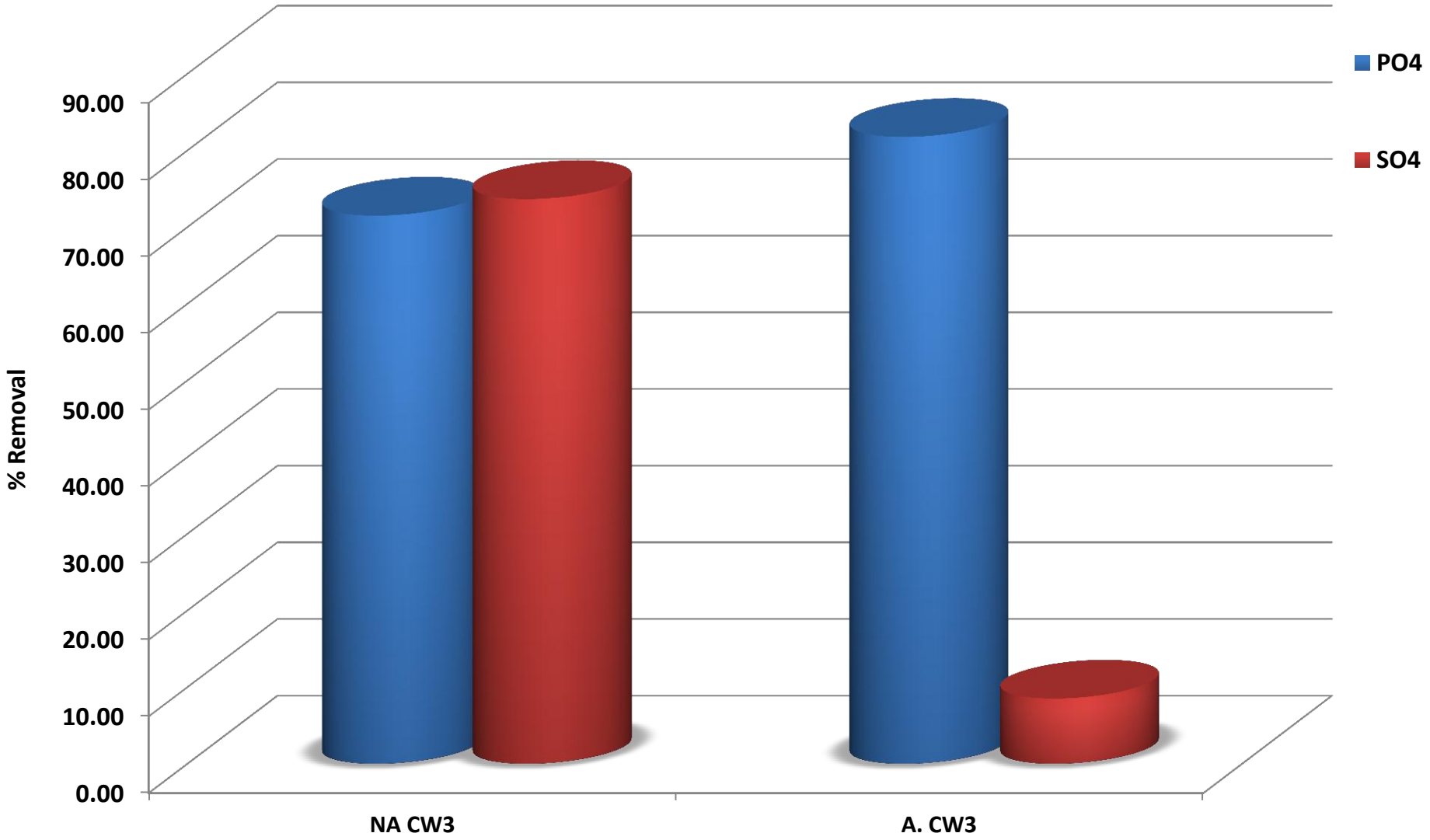
Total % Removal for TN, NO_3^-, NO_2^- and NH_3^+



Organic Nitrogen % Removal



Total % removal of Phosphate & Sulfate

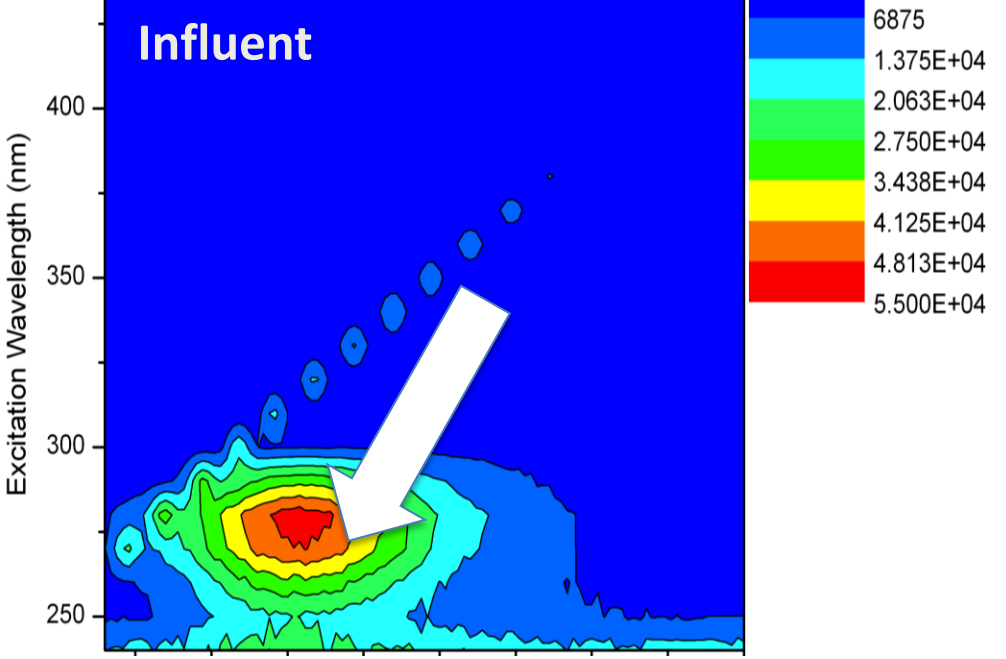


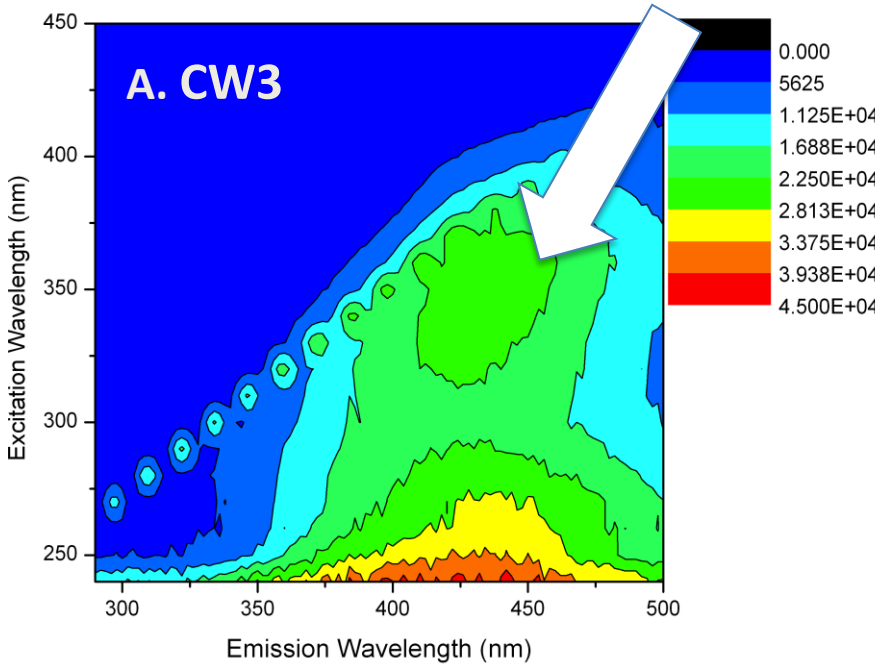
Fluorescence excitation and emission matrix (FEEM)

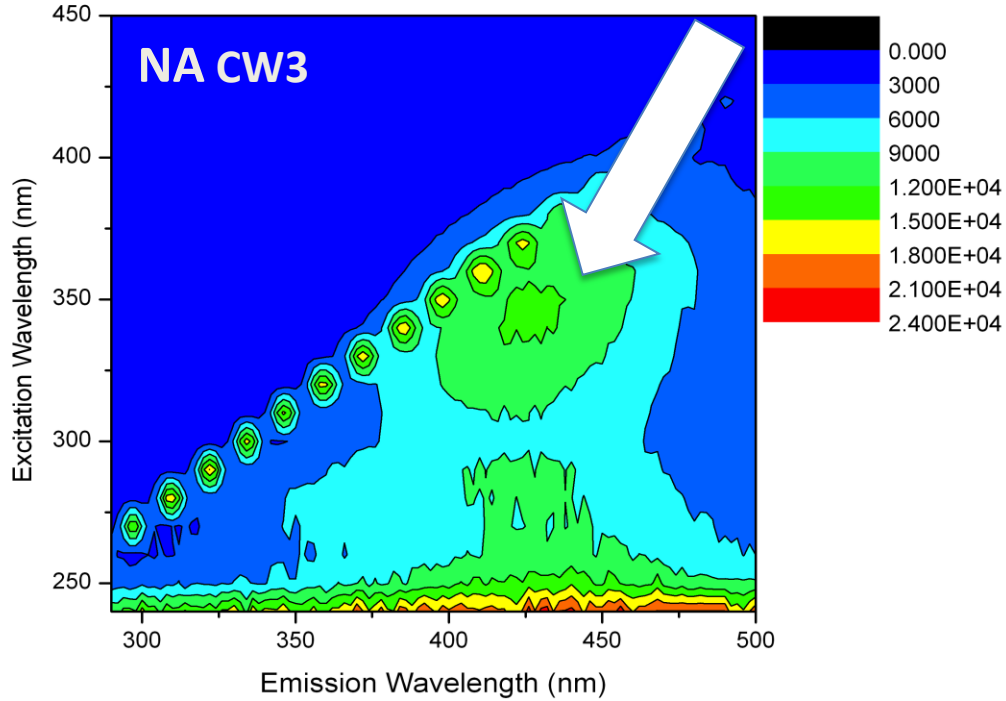
FEEM spectra analysis is a tool that helps to investigate which fractions of DOC are available in the water samples

Region	Excitation (nm)	Emission (nm)	Description
1	320-350	400-480	Humic/Fulvic-like organic matter fraction
2	240-280	430-480	Humic-like organic matter fractions
3	250-270	320-360	Protein-like organic matter fractions

The organic matters fraction in the influent are proteins like only but the effluents are containing Humic/ Fulvic like organic matter fractions



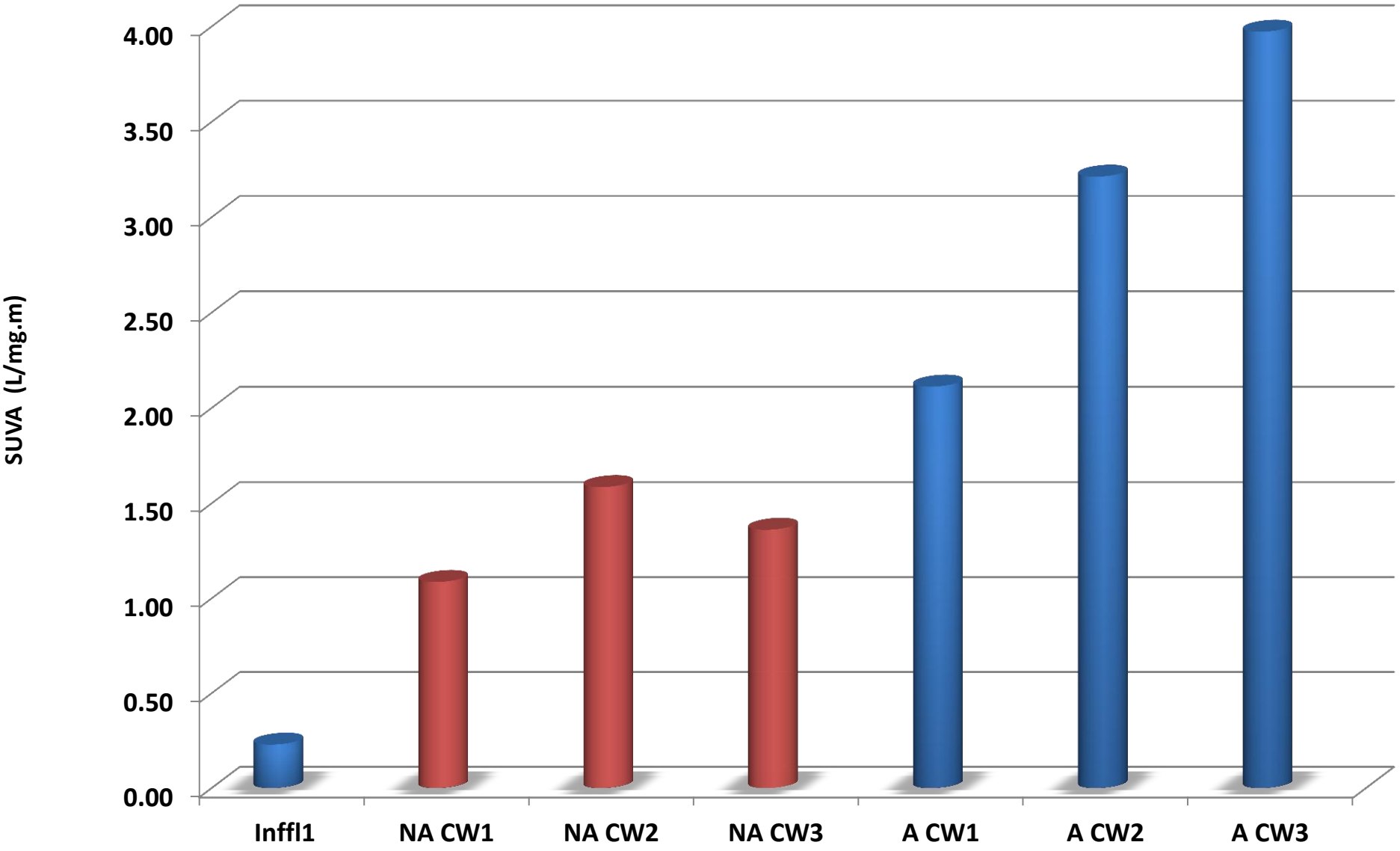




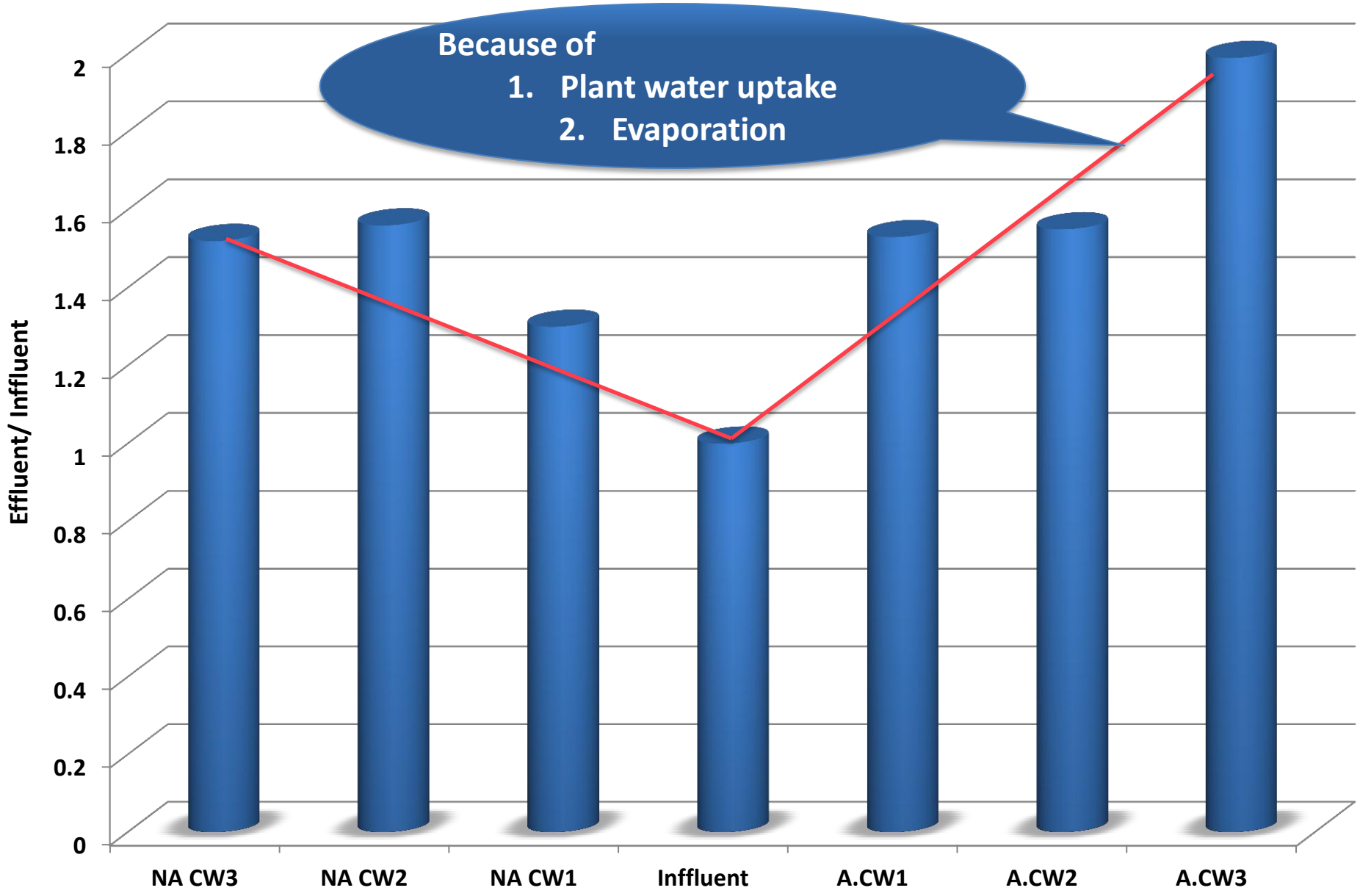
Fluorescence EEM analysis of influent and effluent

	Source	Excitation (nm)	Emission (nm)	Intensity	Reduction in intensity (%)
Peak 3 Protein-like organic matter fractions	A CW1	275	355	8250	85
	NA CW1	275	355	8250	85
	A Control	275	355	6250	89
	NA Control	275	355	17250	69
	A CW3	275	355	11250	80
	NA CW3	275	355	7500	86

Specific UV Abs. Changes



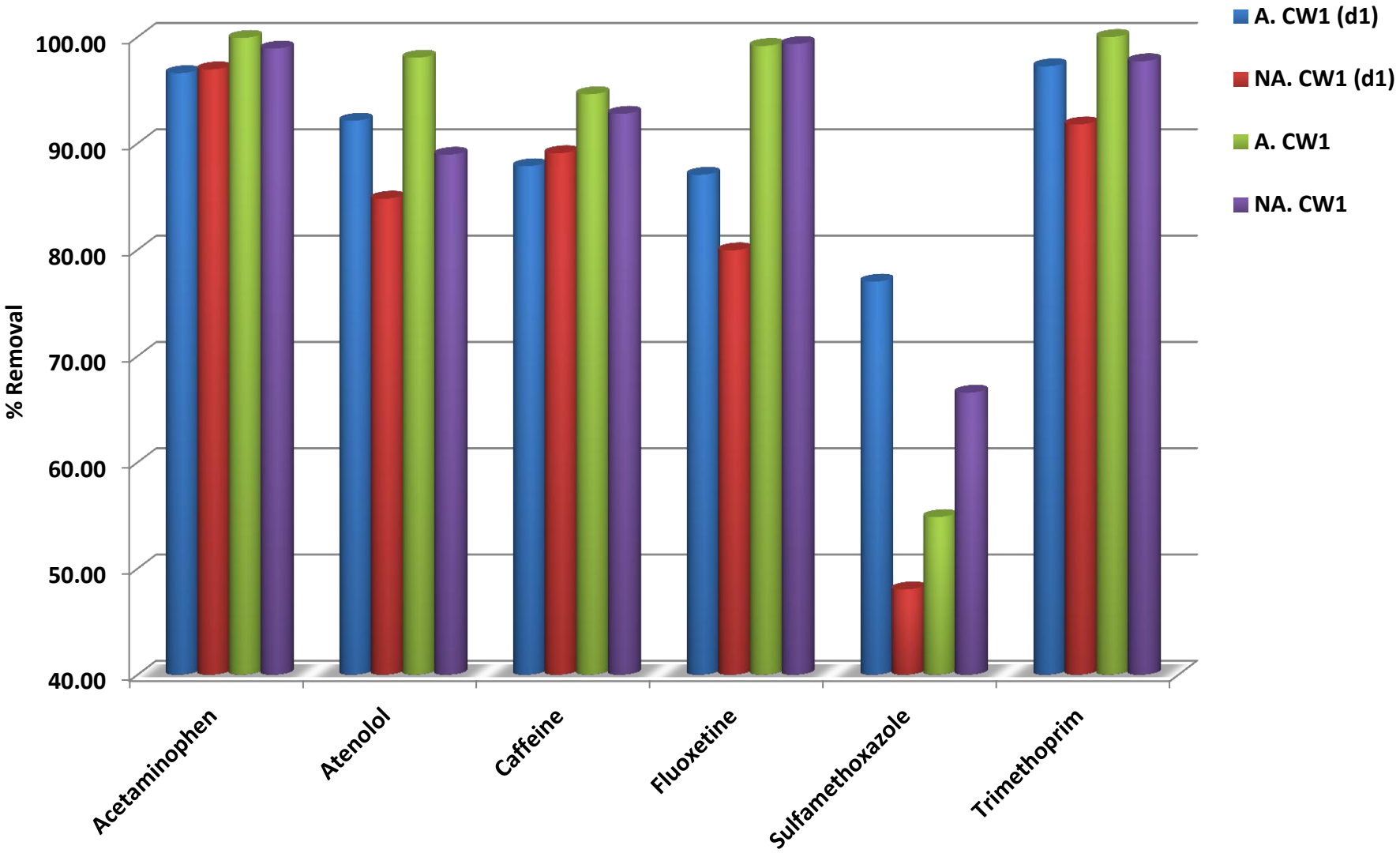
Chloride concentrations changes through CWs



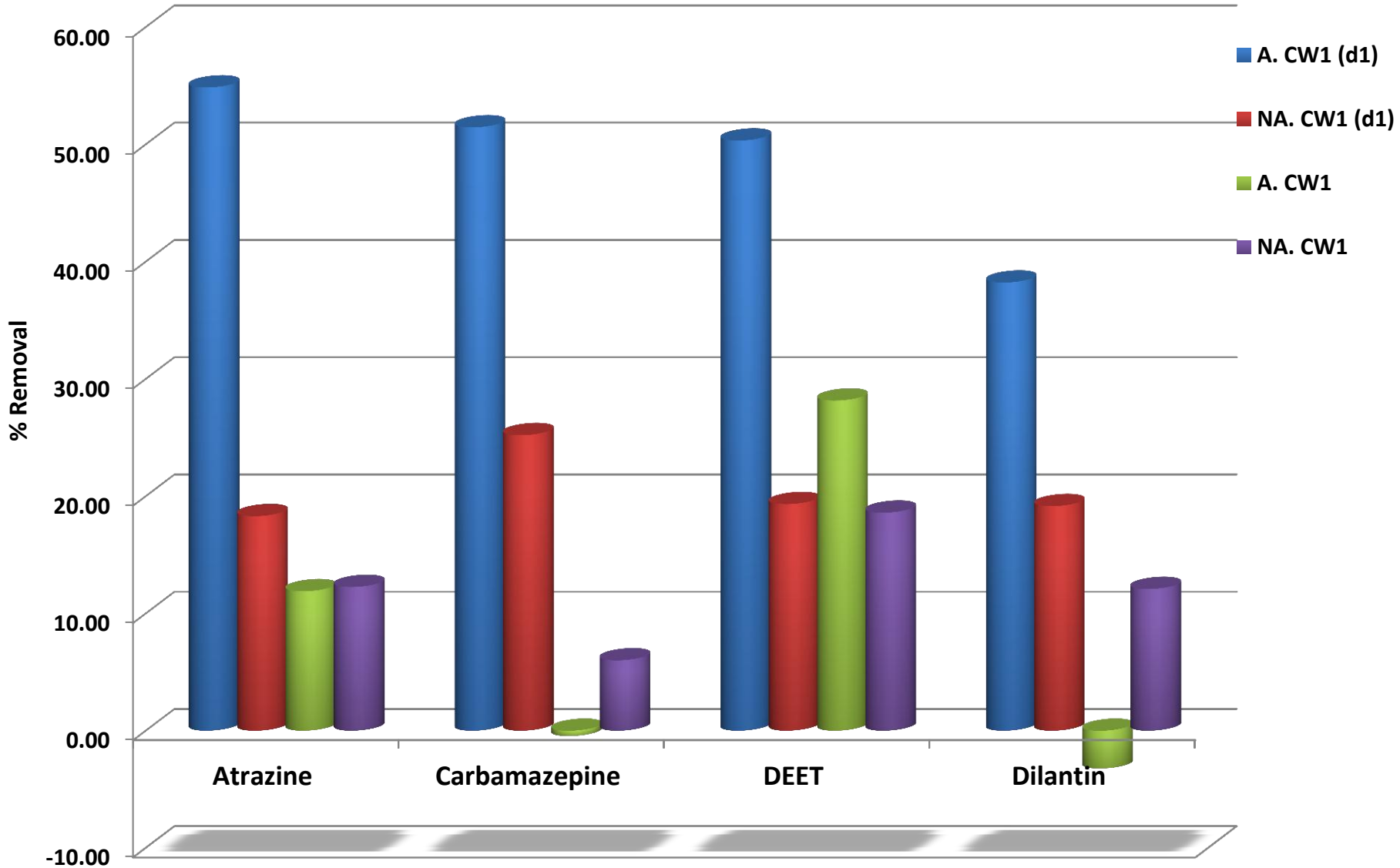
Physical-chemical properties of OMPs

No	OMPs Name	Conc (ng/l)	M. Wt (g/mol)	K_{ow}	pka
1	Acetaminophen	268	151.2	0.46	9.38
2	Atenolol	1927	266.34	0.16	9.6
3	Caffeine	831	194.1	-0.07	10.4
4	Fluoxetine	225	309.1	4.05	10.3
5	Sulfamethoxazole	322	253.3	0.89	5.5
6	Trimethoprim	651	290.1	0.91	7.12
7	Atrazine	546	215.7	2.61	1.7
8	Carbamazepine	649	236.1	2.45	13.9
9	DEET	387	191.1	2.18	0.67
10	Dilantin	248	252.3	2.47	8.33

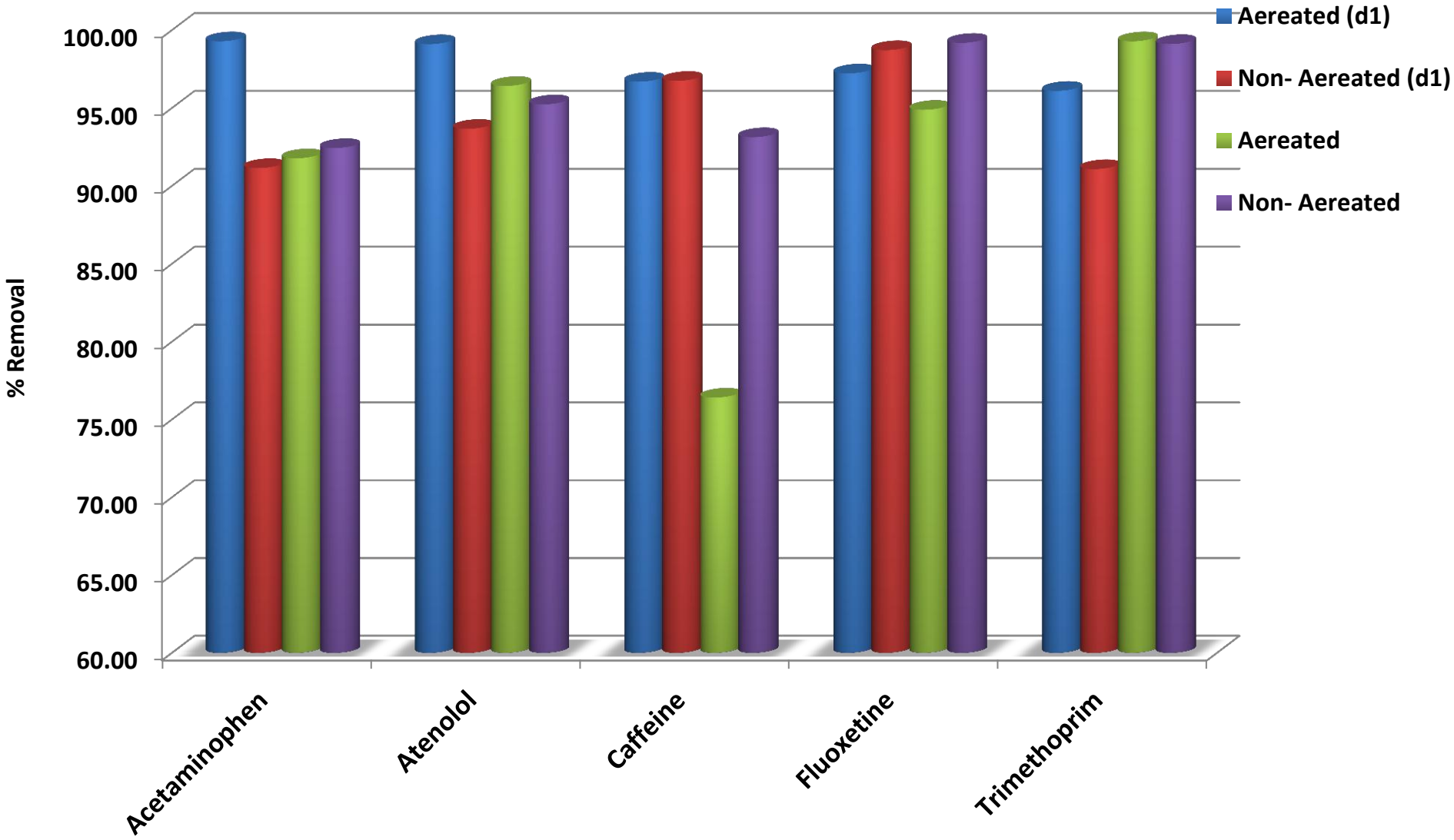
% Removal of OMPs through CW1 (1)



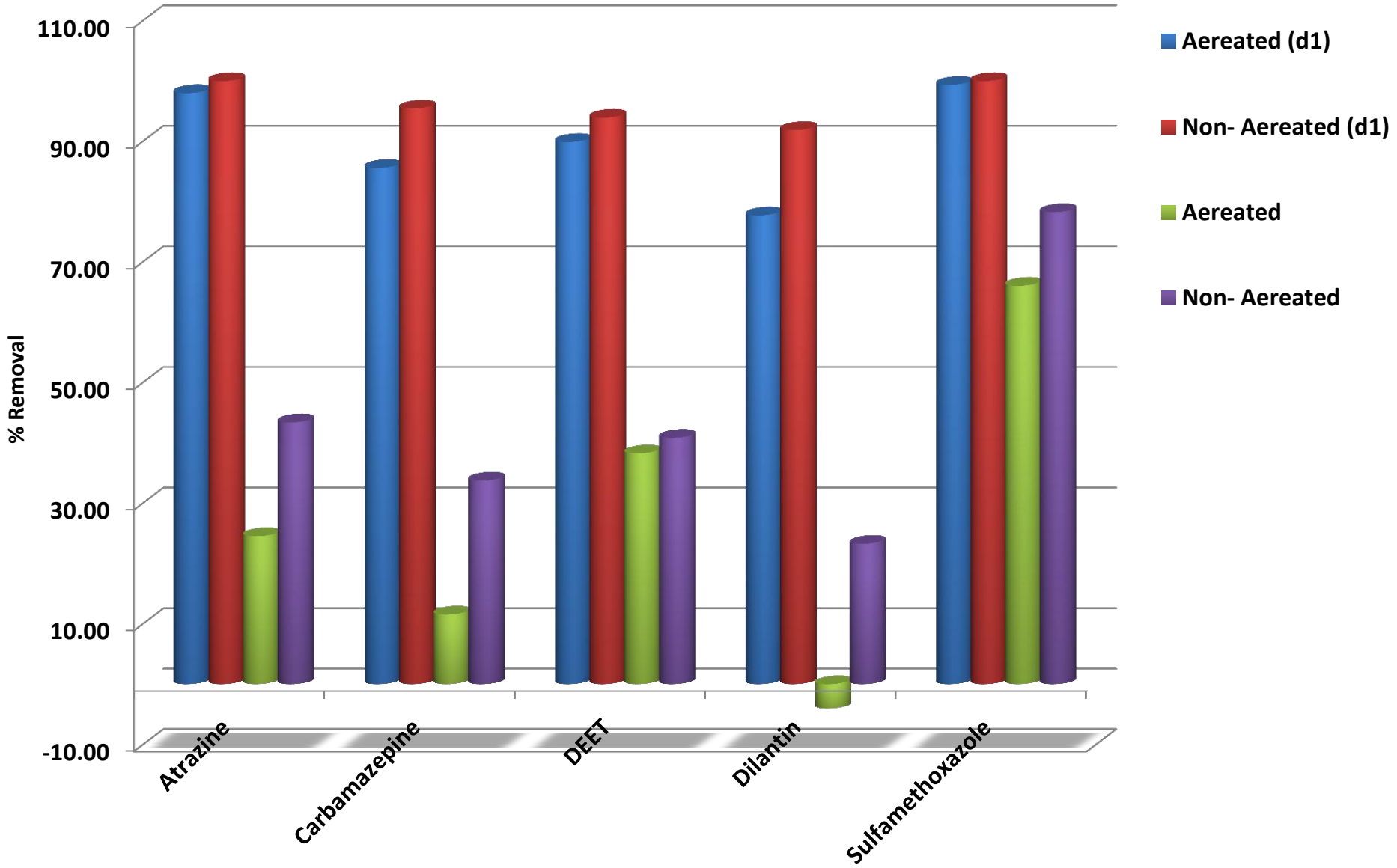
% Removal of OMPs through CW1 (2)



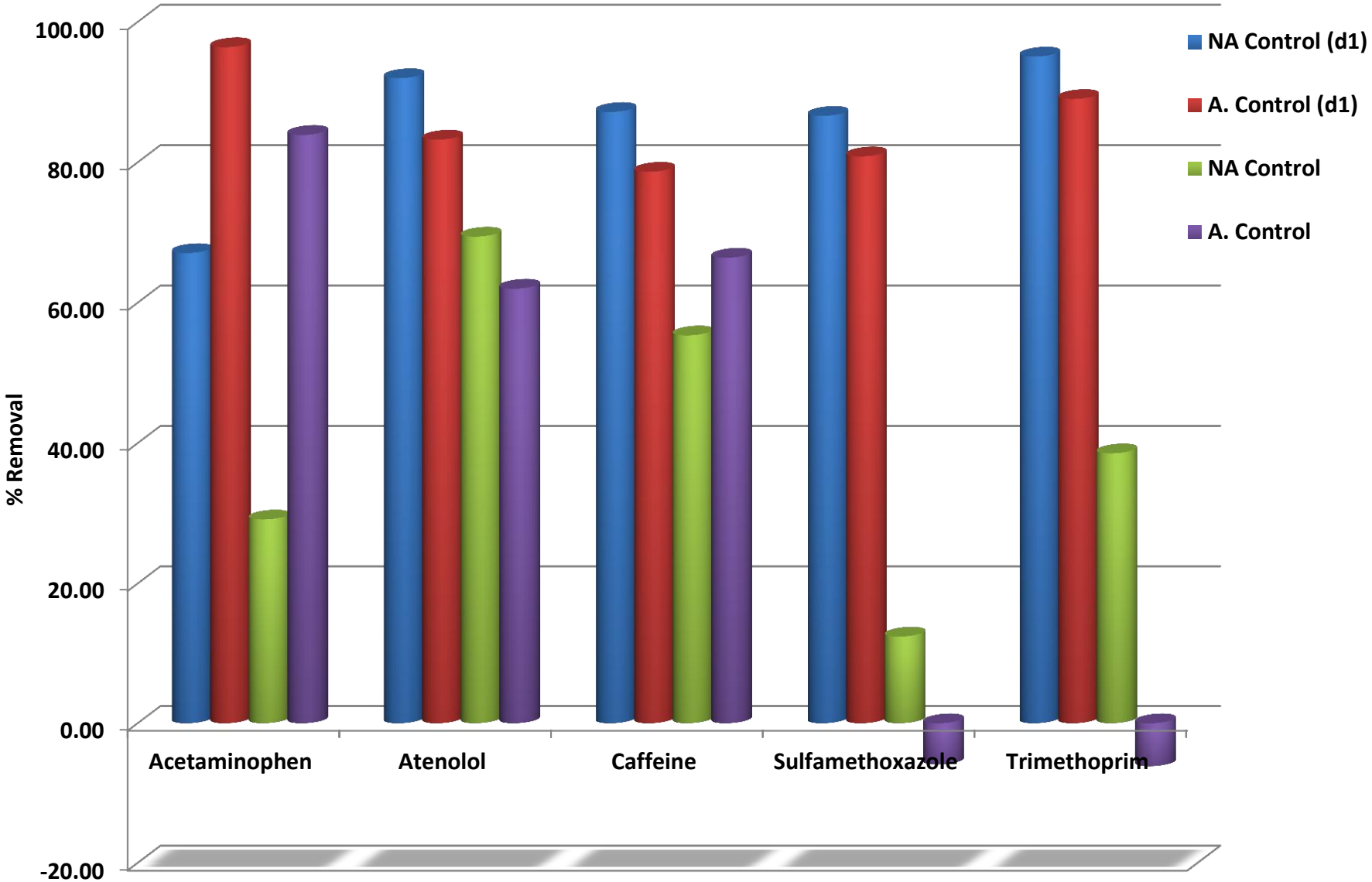
Total % Removal of OMPs (1)



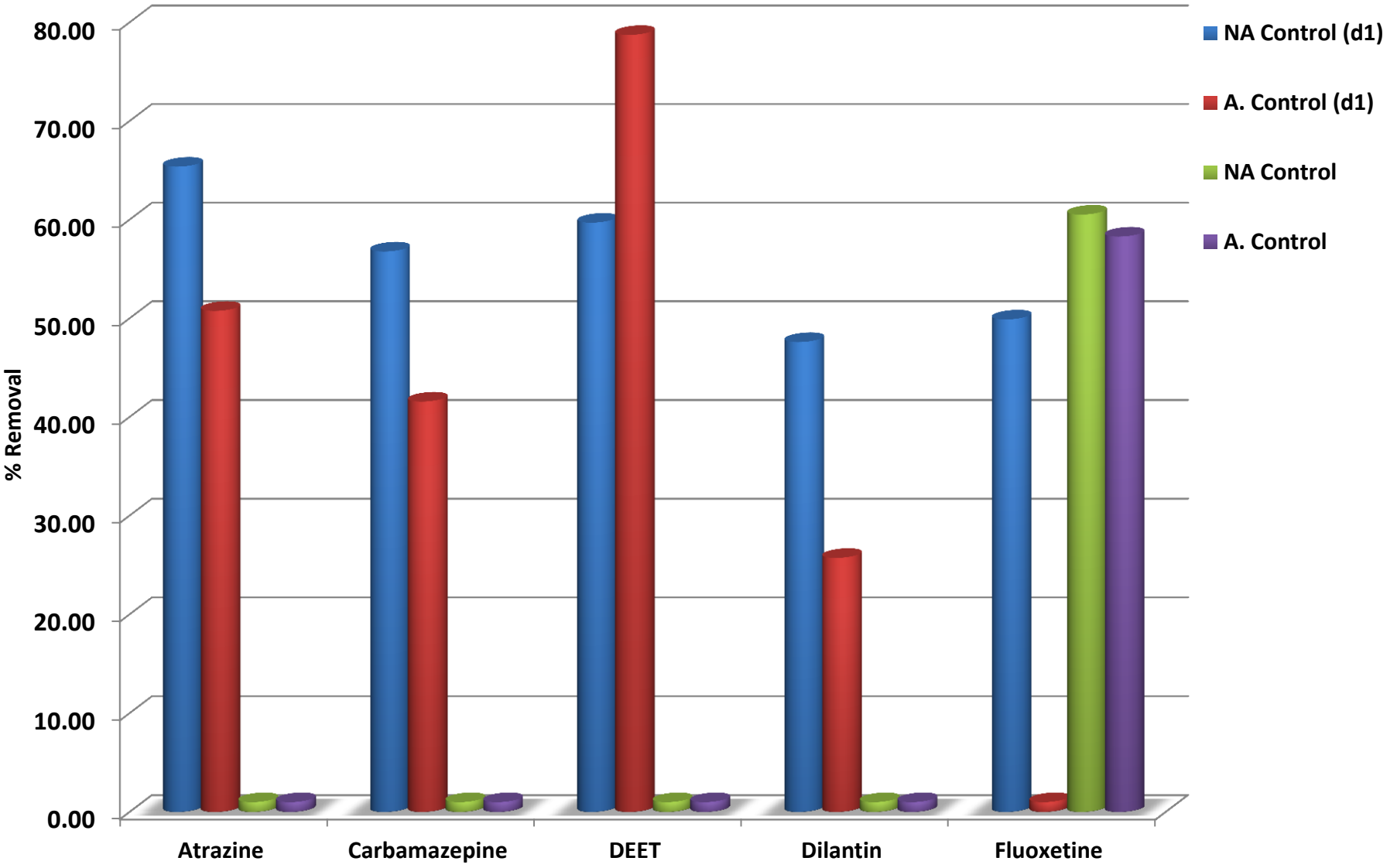
Total % Removal of OMPs (2)



% Removal of OMPs in Un-Planted CWs (1)

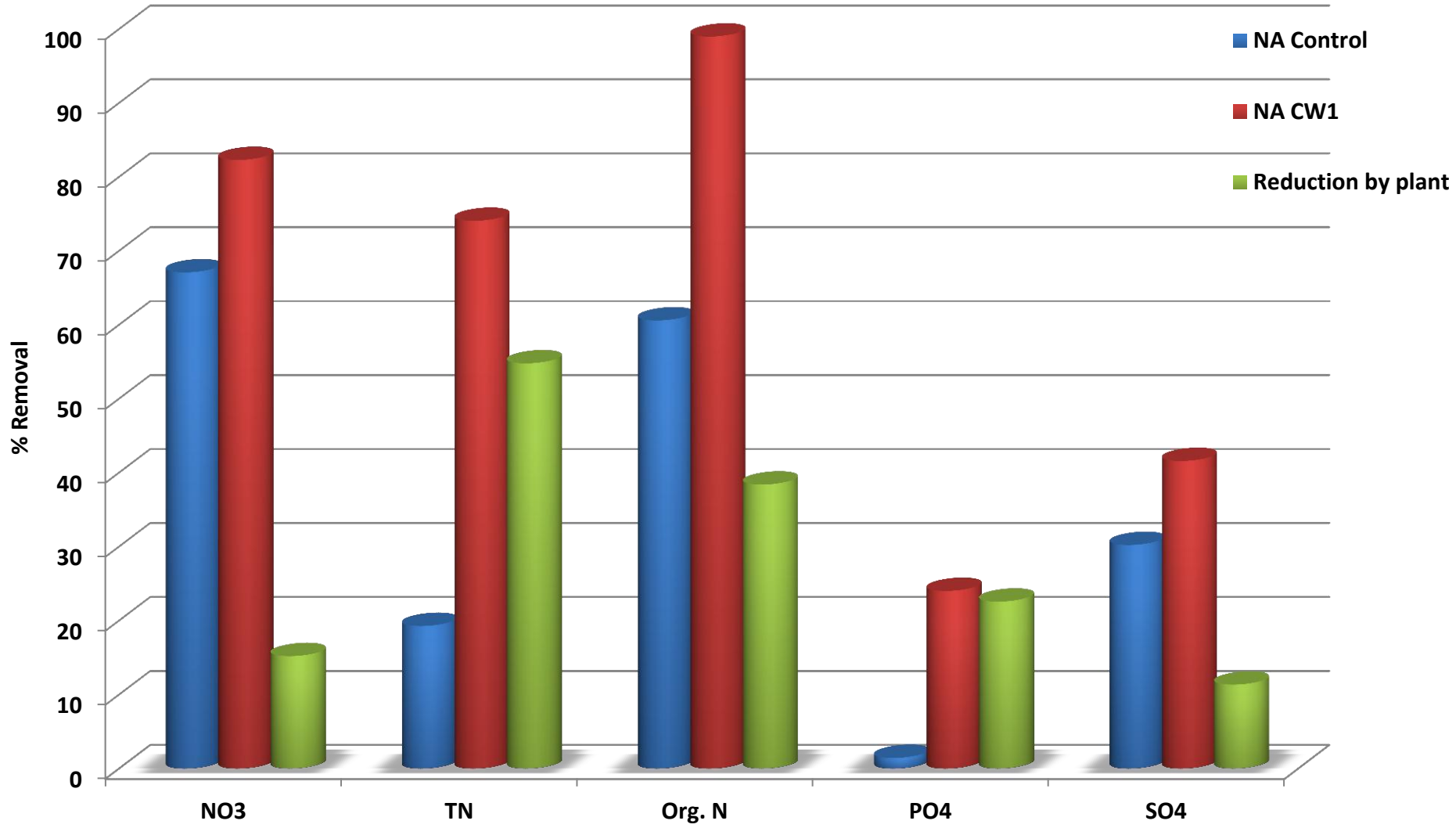


% Removal of OMPs in Un-Planted CWs (2)

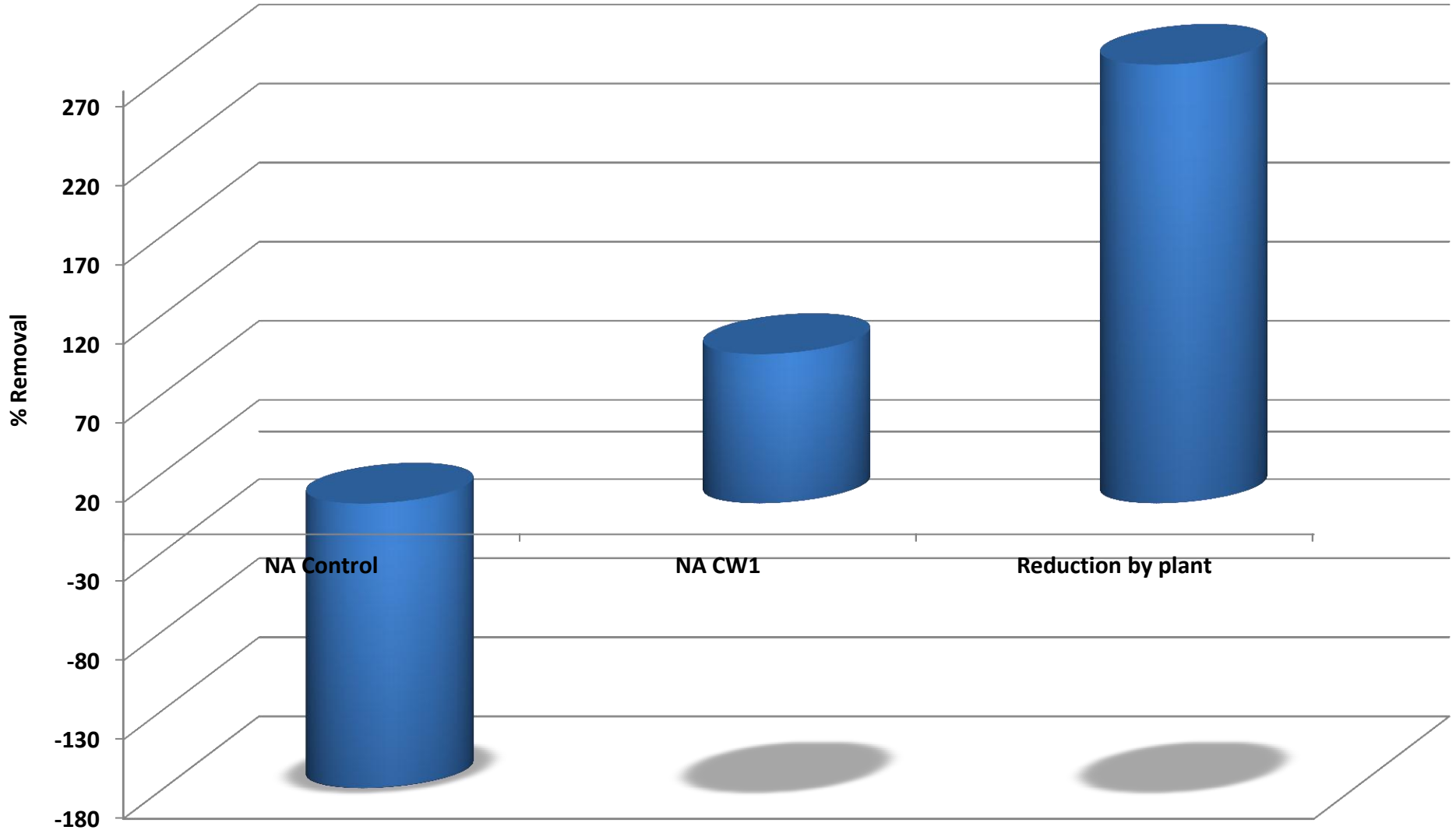


What is the plant role *Phragmites australis* in CWs???

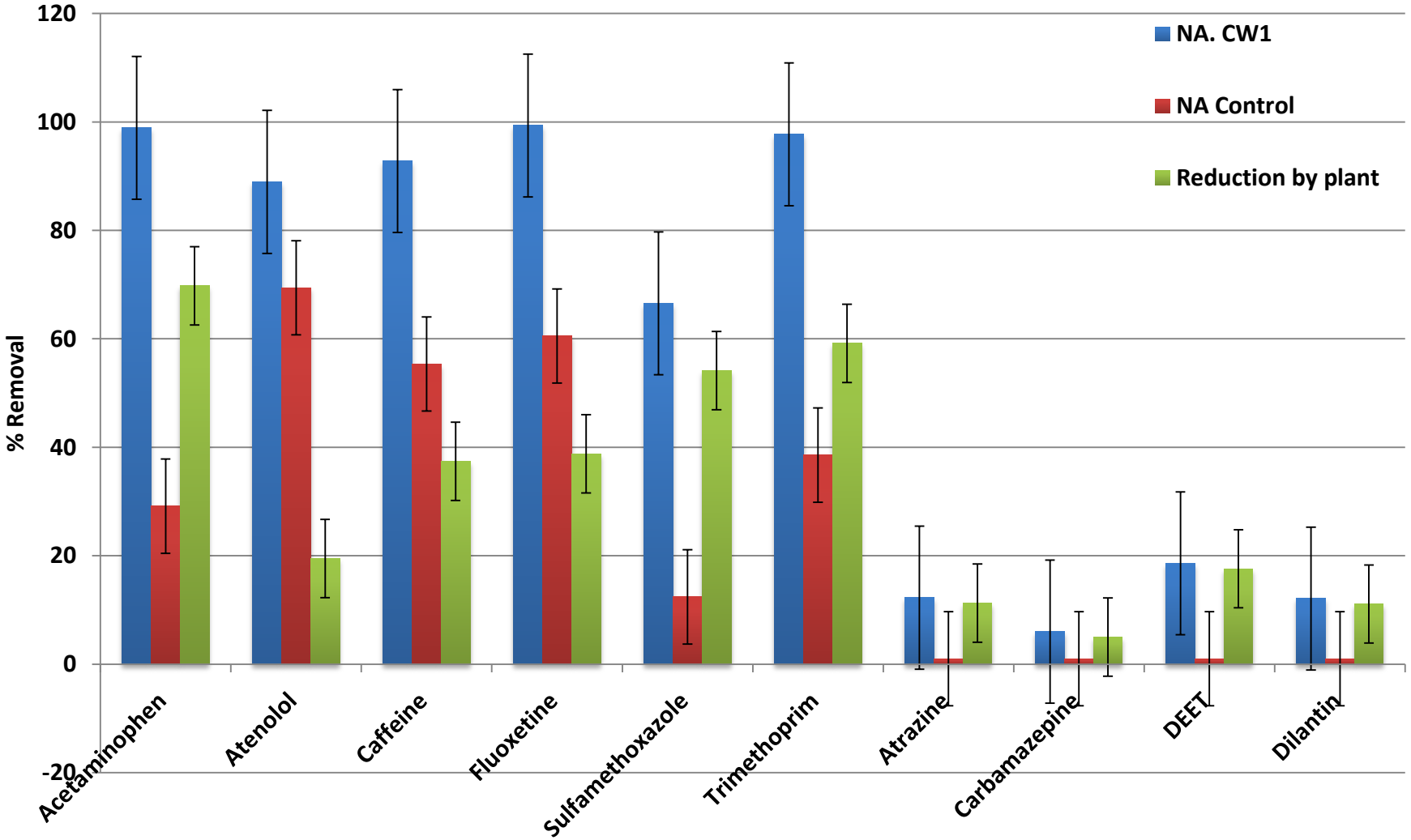
Nutrients reduction by the plant



Ammonia reduction by the plant



OMPs reduction by the plant



Conclusions (1)

- Achievable Removals are: DOC (95%), TN (75%), NH_3^+(99%), org N.(98%), and PO_4^{-3} (73%).
- Plants "e.g. *phragmites australis"* in CWs play an essential role in the treatment especially for nitrogen and phosphates removals during secondary wastewater treatment. It removes; 15% (TN), 55% (Org. N.), 38% (NO_3^-), and phosphate (22%).
- The Plant also contributes effectively in removals of some OMPs such as: Acetaminophen, Caffeine, Fluoxetine, Sulfamethoxazole, and Trimethoprim.

Conclusions (2)

- Caffeine, Atrazine, Carbamazepine and Dilantin showed better removals under Non Aerated conditions.
- Humics and fulvic like organic matter where found in the effluents (especially in aerated row because of plant degradation.
- Providing air gas to CWs systems enhances phosphate removal.

Thank You
and
Any
Question?