Bench-scale Arsenic Treatability Study of Municipal Wastewater to Support the New Jersey Department of Environmental Protection's Water Quality Standards Variance Development

March 1, 2018— May 31, 2019

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Project Overview

Main Objective

Determine the feasibility of using ferric chloride and alum coagulation to reduce arsenic in municipal wastewater to less than 2 µg/L.

Tasks

Phase 1: Chemical Characterization of Wastewater and Sludge

Phase 2: Coagulation Treatment of Wastewater - Jar Tests

Phase 3. Filtration Removal of As in Plant A Effluent

a) Adsorptive Filtration

b) Direct Co-precipitation Filtration

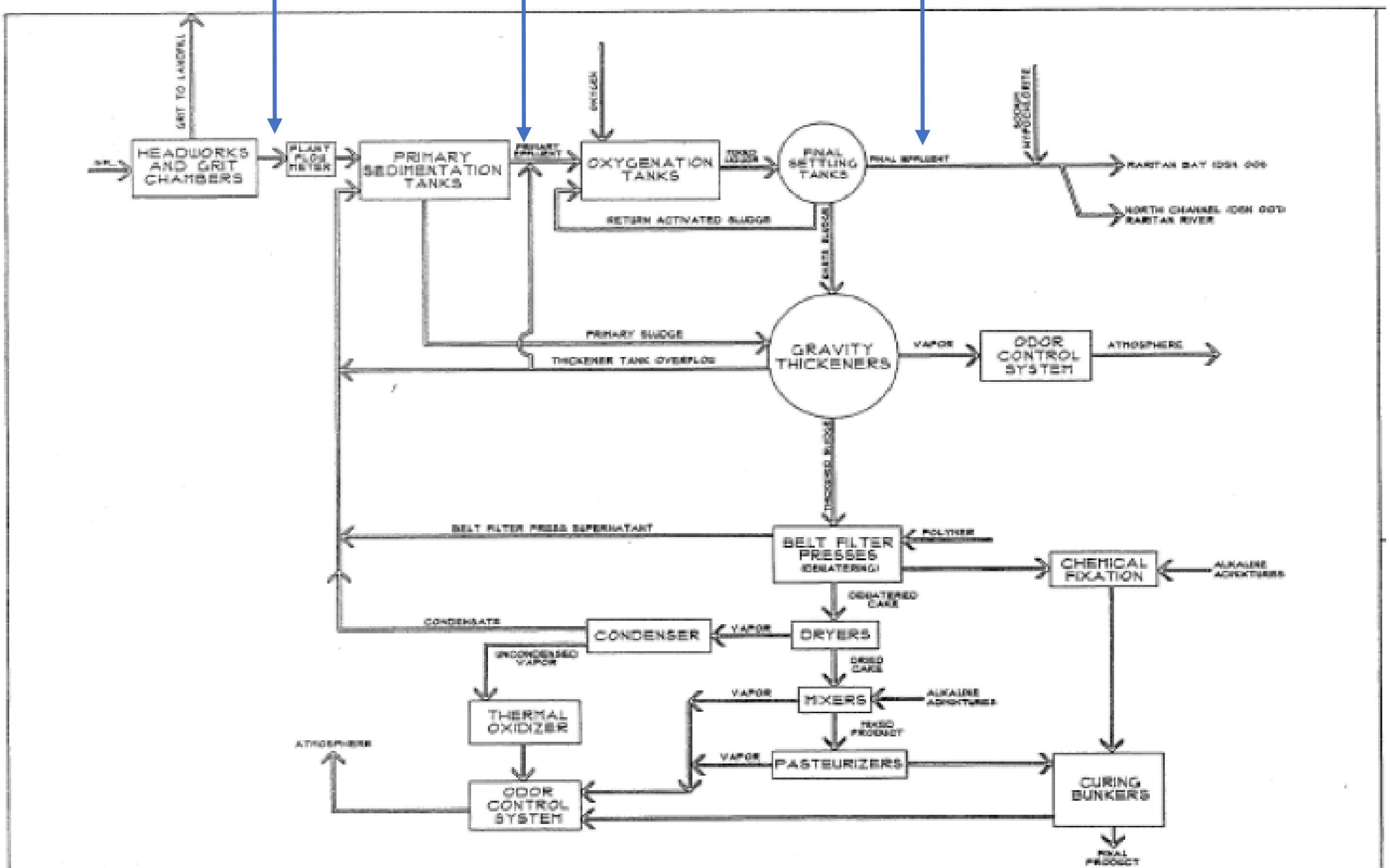
Phase 1: Chemical Characterization of Wastewater

Wastewater Treatment Plant A

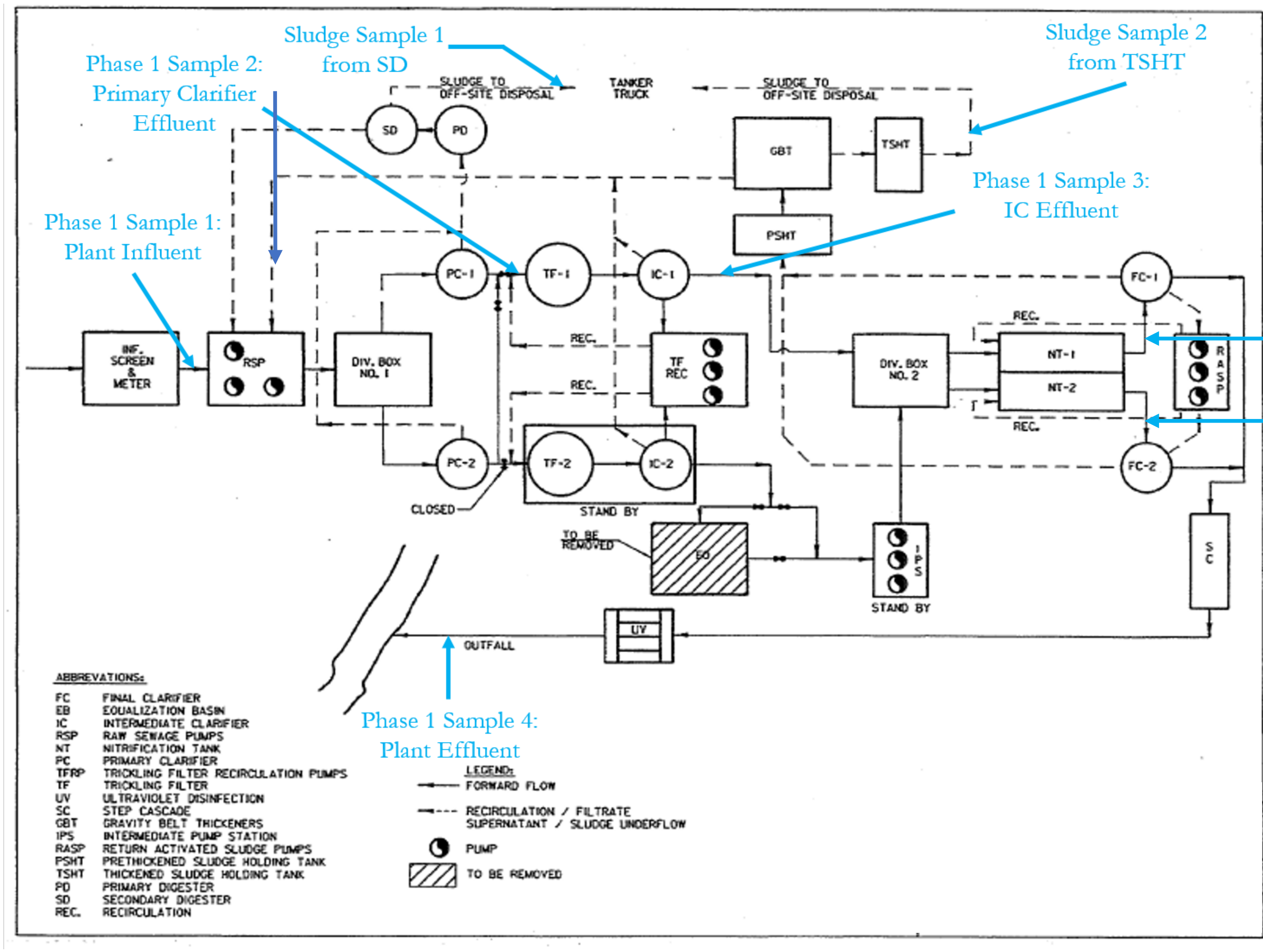
Plant influent

Primary clarifier effluent

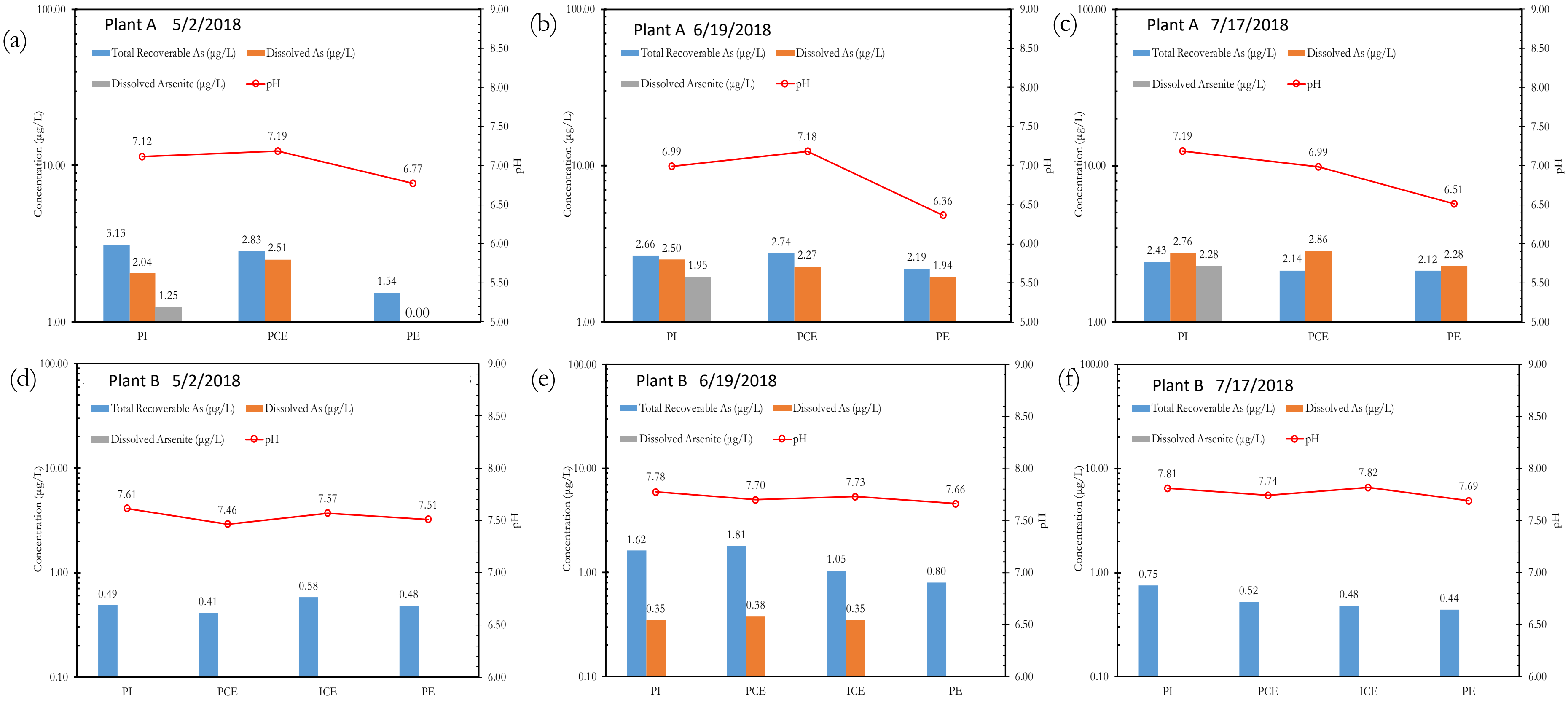
Plant effluent



Wastewater Treatment Plant B



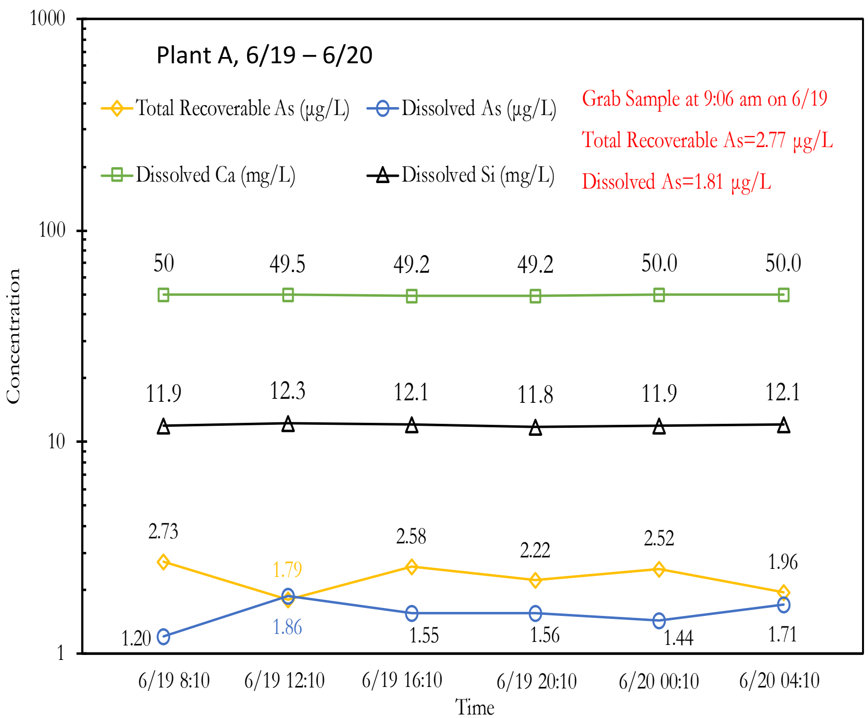
Arsenic Concentration in Plants A and B

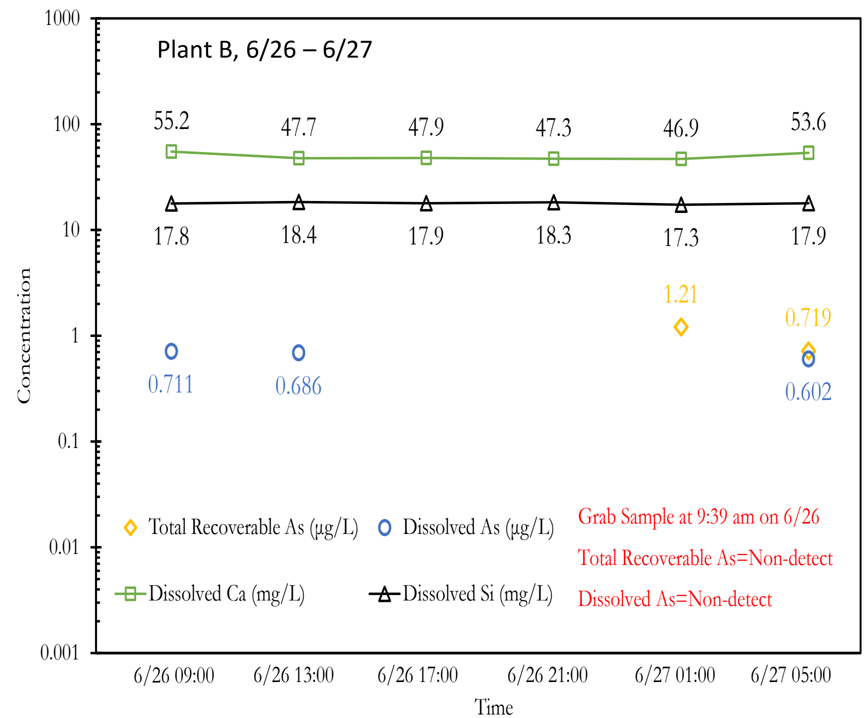


Biological water treatment processes are not effective for As removal.
Soluble As was removed on 6/19 possibly by alum at Plant B.

Note: 1). analysis was performed by Stevens; detection limit=0.30 µg/L; reporting limit=1.00 µg/L.

Diurnal Changes of Arsenic, Calcium and Silicate

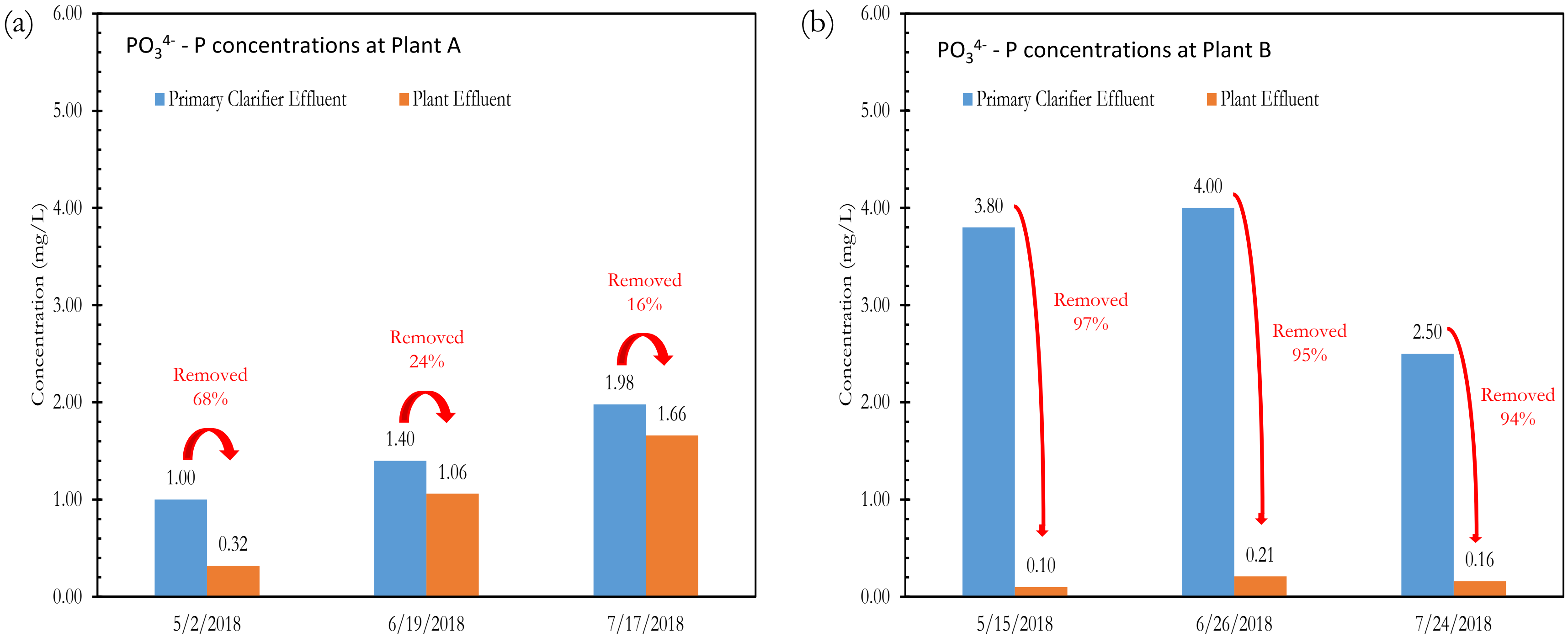




There were no obvious diurnal changes in As, Si, and Ca.

Note: Analyses were performed by NJDOH lab.

Removal of Dissolved Orthophosphate at Plants A and B



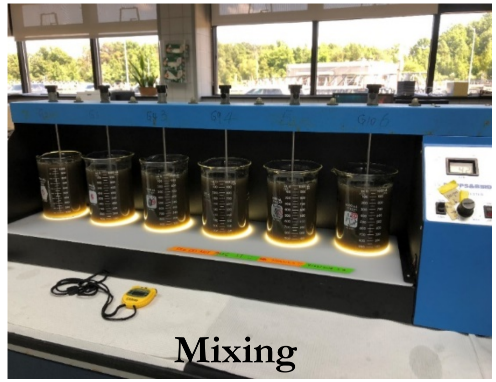
Alum was added to wastewater before the final clarifiers to remove P at Plant B.
P treatment was not required at Plant A.

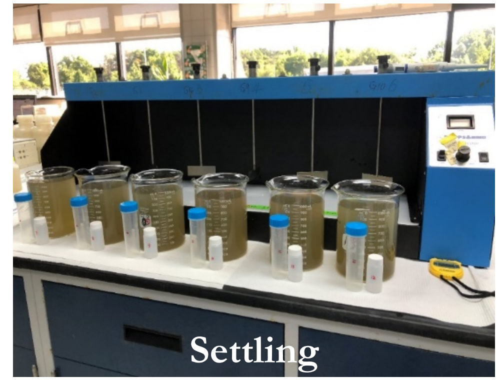
Note: Analysis was performed by Stevens; detection limit=0.02 mg-P/L; reporting limit=0.10 mg-P/L

Phase 2: Coagulation Treatment of Wastewater - Jar Tests

Treated Samples on site:

1. Primary clarifier effluent
2. Mixed liquor
3. Mixed liquor supernatant
4. Plant effluent



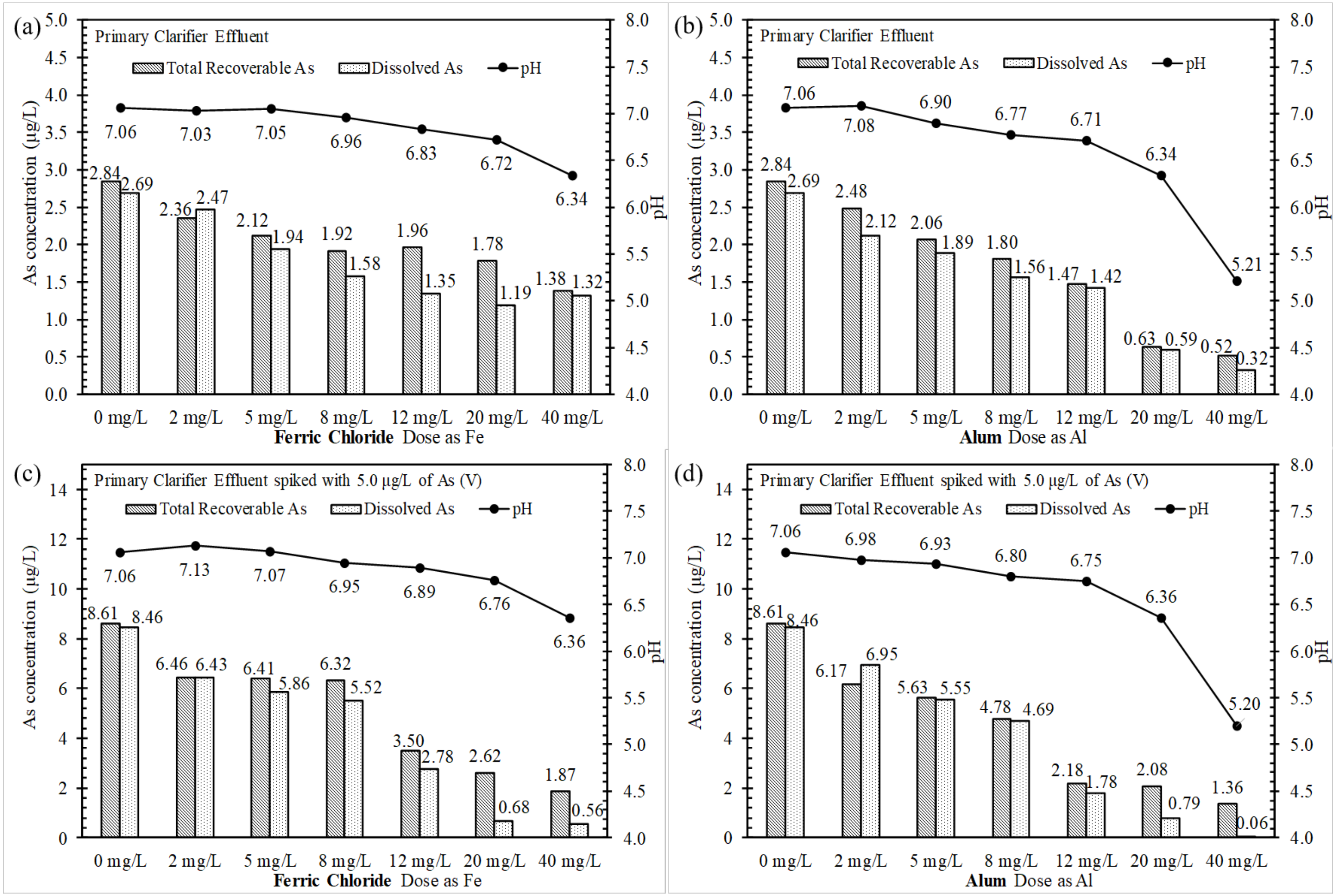


- ❑ Addition of $FeCl_3$ or alum during mixing
- ❑ 1 min of stirring at speed of 120 rpm
- ❑ 4 min of stirring at speed of 40 rpm
- ❑ 1 hr. of settling

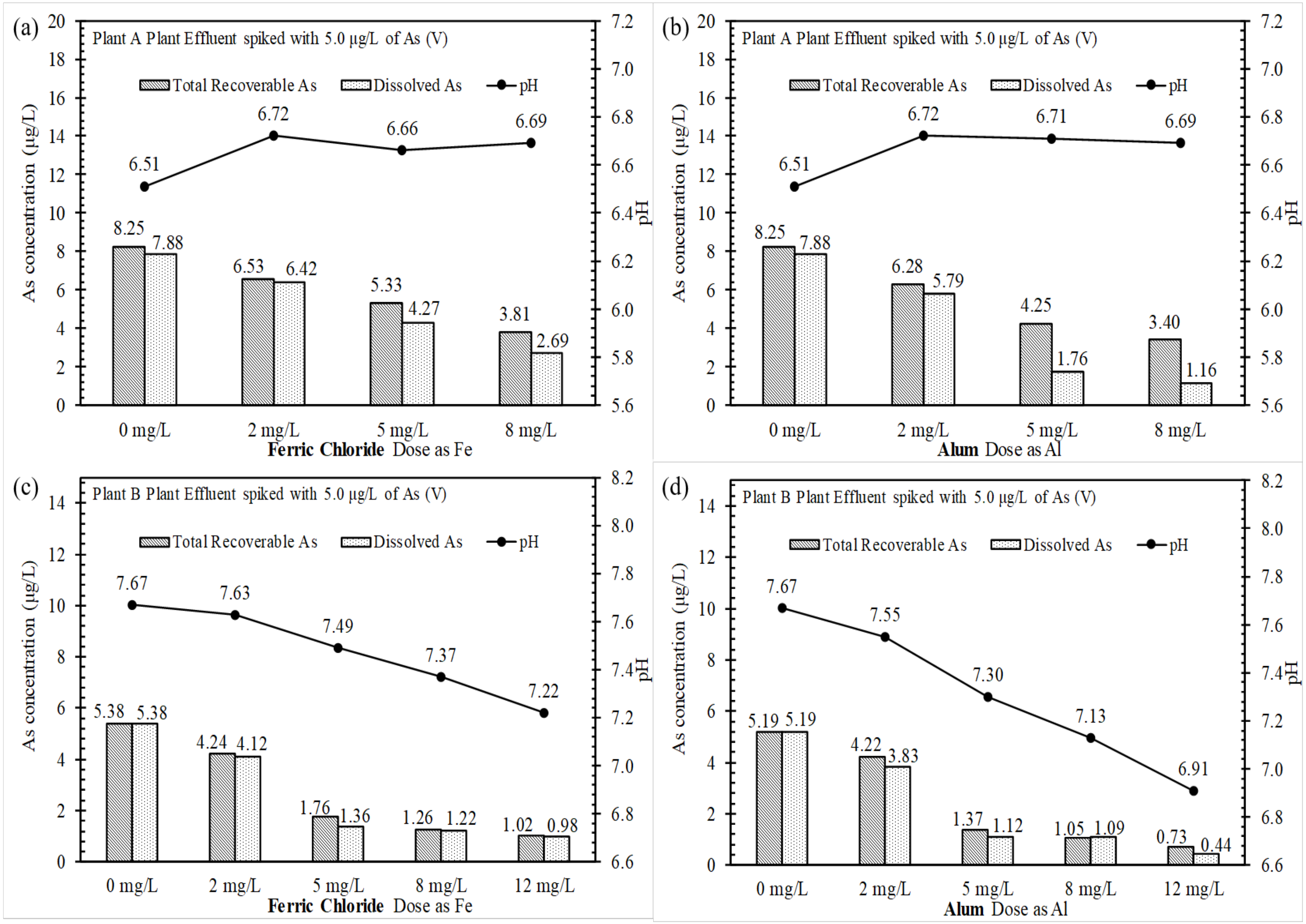
Supernatant: total recoverable arsenic

Filtered Supernatant (0.45 μm): dissolved arsenic

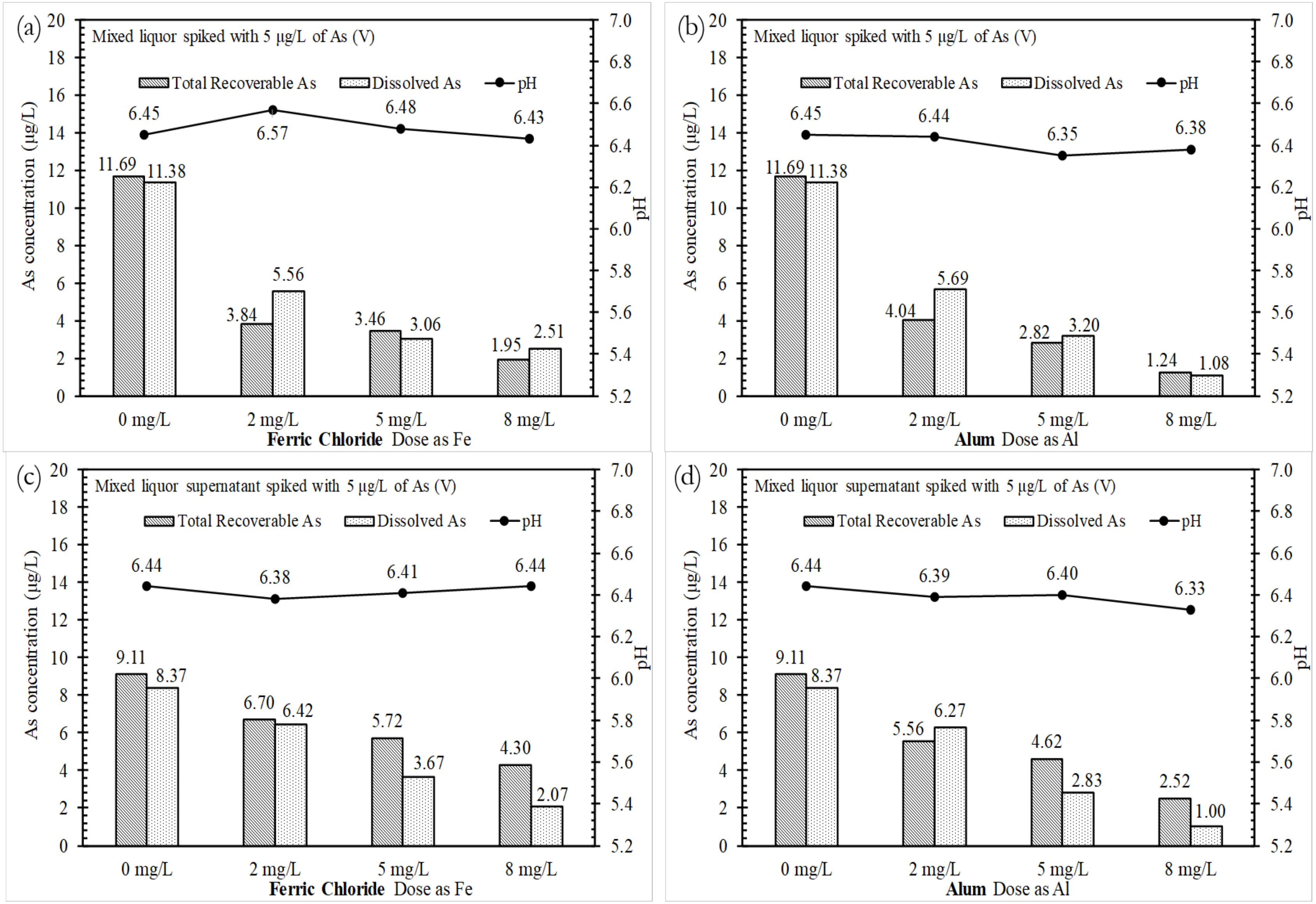
As Removal from Primary Clarifier Effluent of Plant A



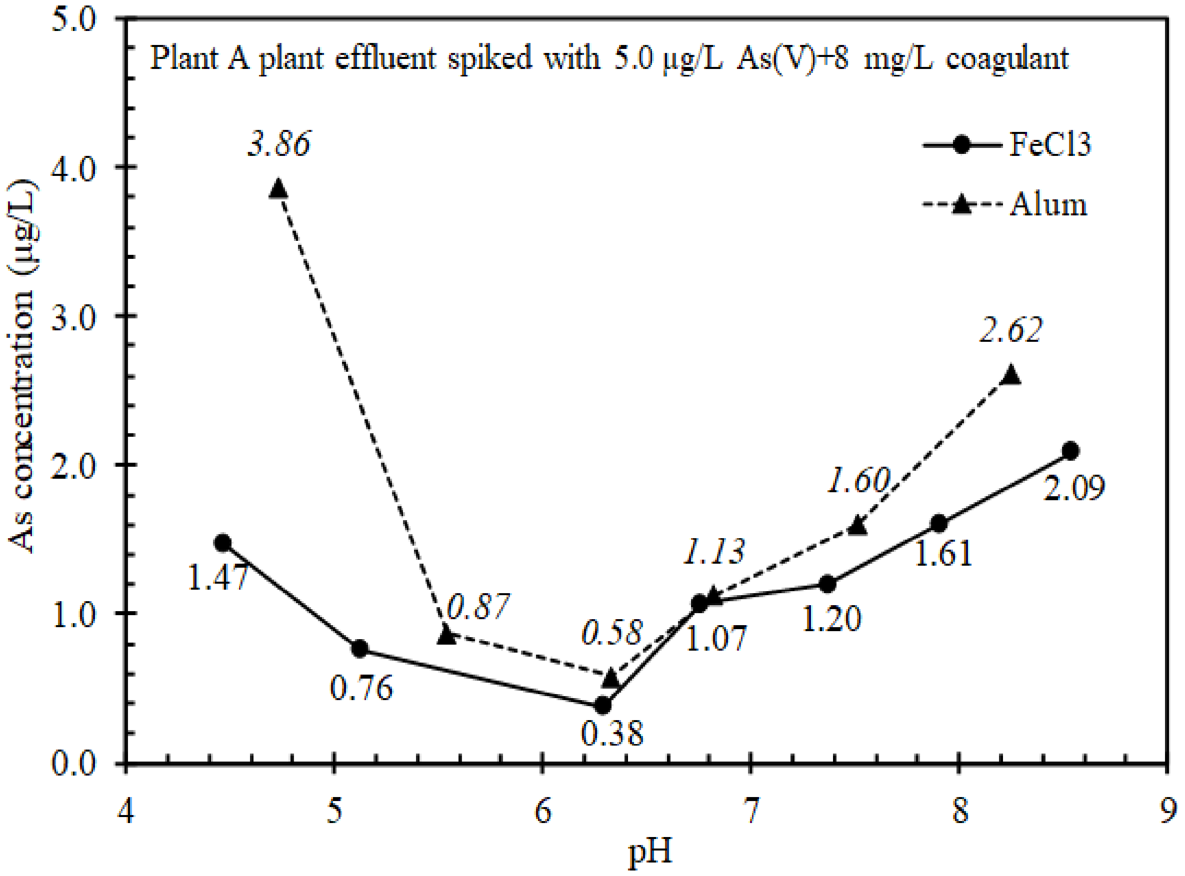
As Removal from As-spiked Effluents of Plants A and B



Arsenic Removal from Mixed Liquor and Supernatant of Plant A

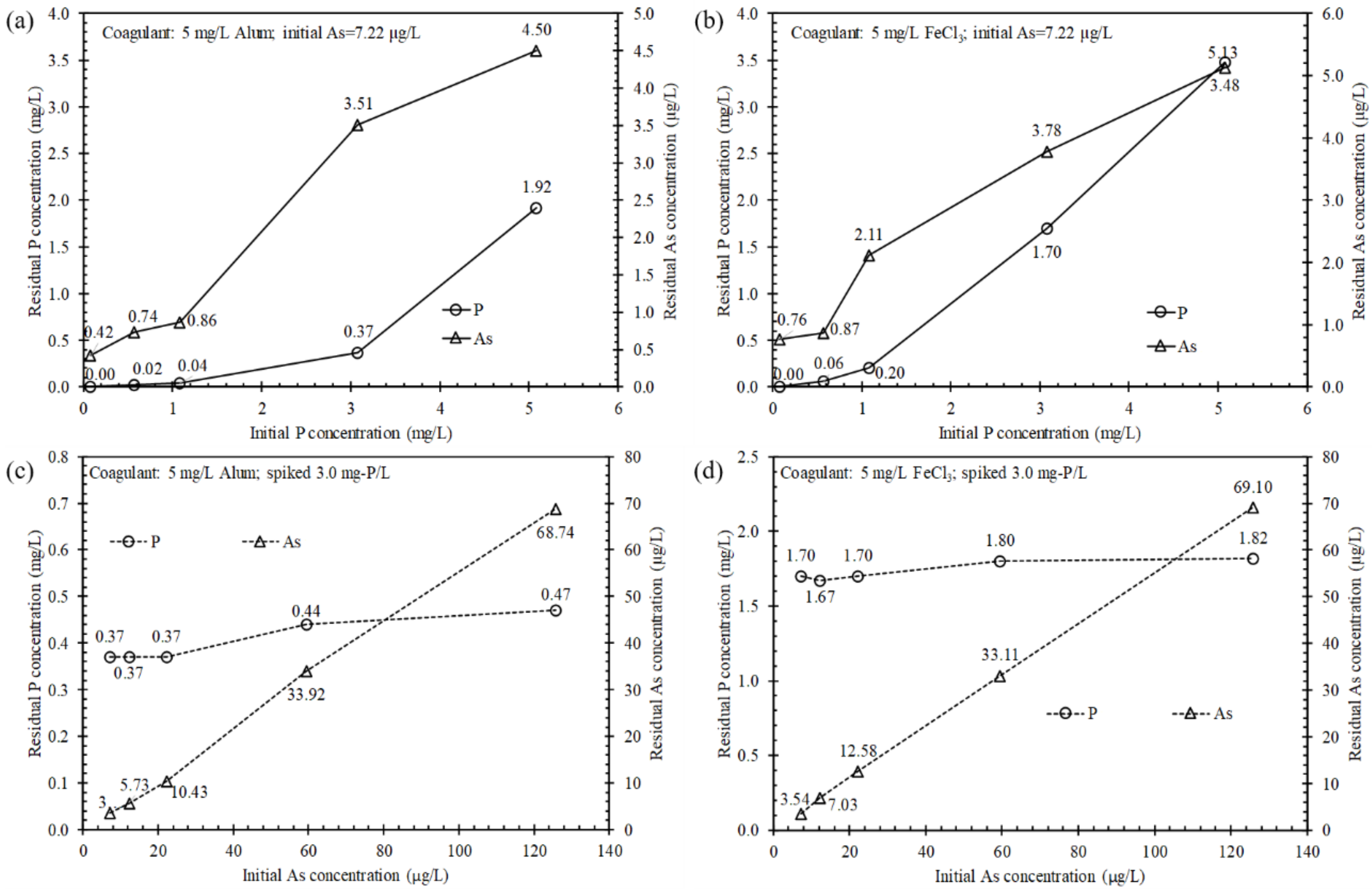


Effect of pH on As Removal from As-spiked Effluent of Plant A



8 mg/L of coagulants, initial As concentration = 7.26 µg/L.

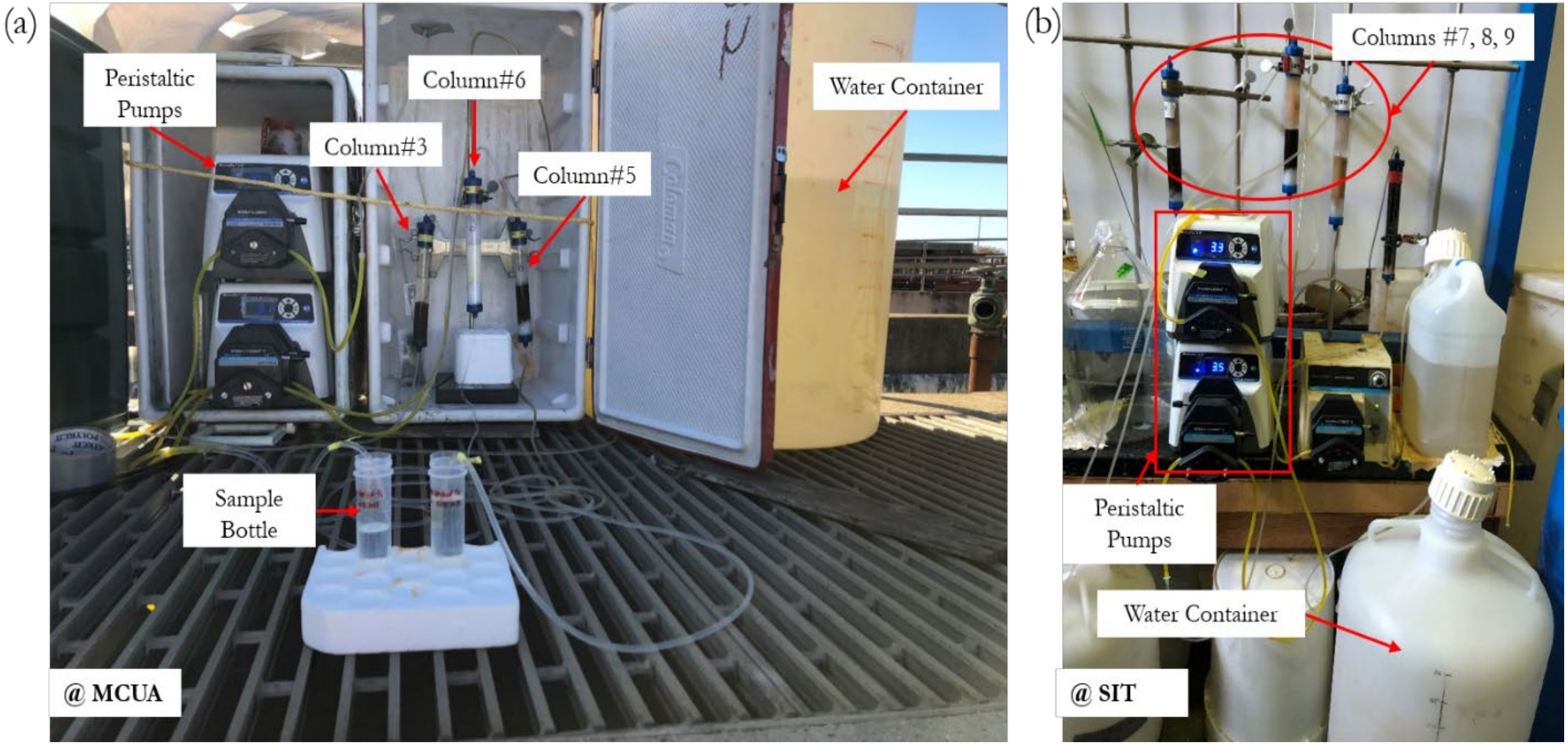
Competing Adsorption As and PO_4^{3-} for Fe and Al in As(V)- and PO_4^{3-}- spiked Plant A Effluent



Initial dissolved PO_4^{3-}= 0.08 mg-P/L, initial DOC=6.38 mg-C/L.

Phase 3. Filtration Removal of As in Plant A Effluent

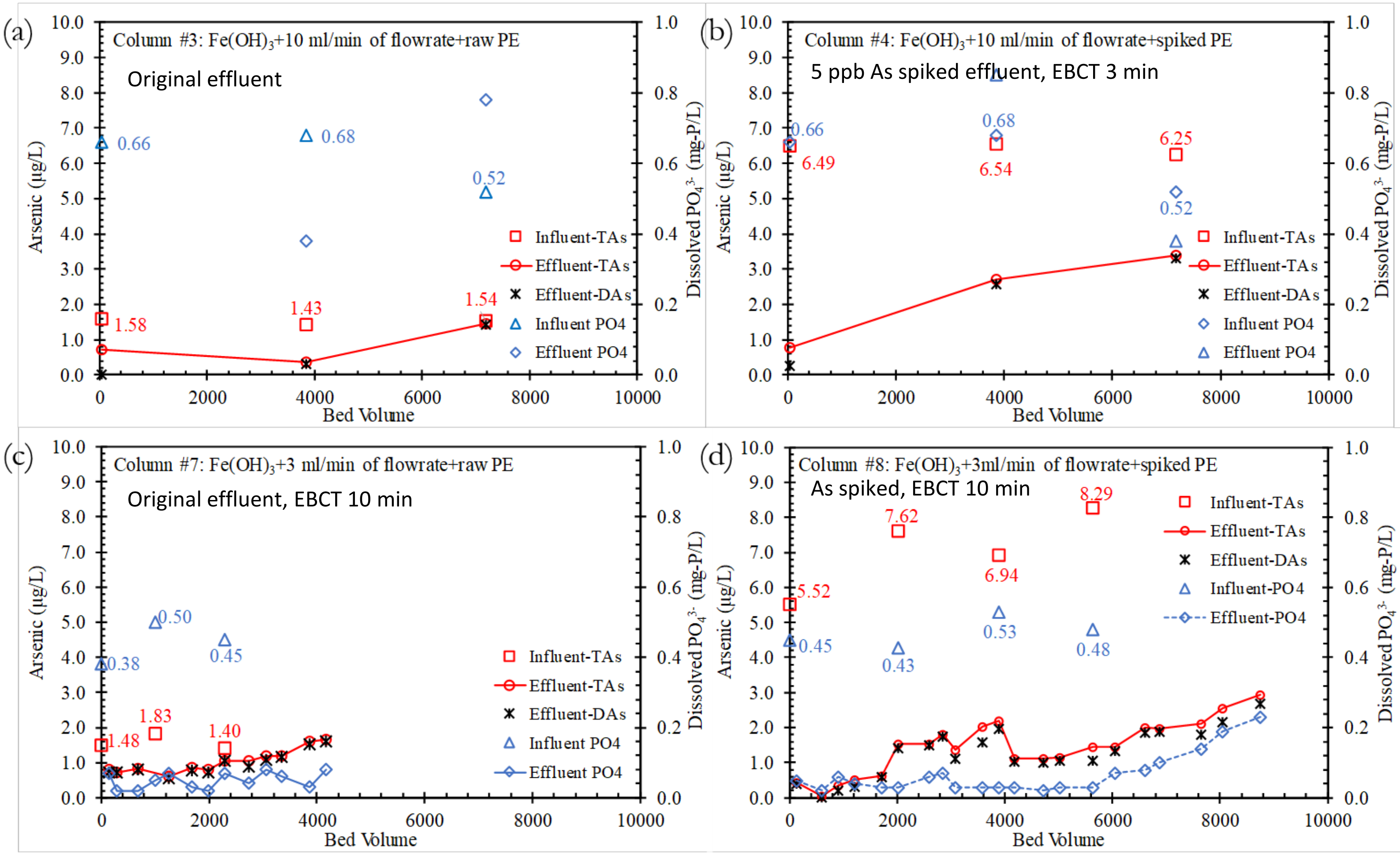
a) Adsorptive Filtration



	Column #1	Column #2	Column #3	Column #4	Column #5	Column #6	Column #7	Column #8	Column #9
ColumnType[*1]	A	A	B	B	B	B	B	B	B
Medium	Iron oxide	Iron oxide	Iron oxide	Iron oxide	Iron oxide	Titanium dioxide	Iron oxide	Iron oxide	Titanium dioxide
Medium Size (mesh)	10~35	10~35	10~35	10~35	10~35	16~60	10~35	10~35	16~60
Volume of Medium (ml)	30	30	30	30	30	30	30	30	30
Mass of Medium (g)	16.73	16.56	16.94	16.99	16.92	20.54	16.08	15.87	18.92
Column Influent	Raw PE[*2]	Spiked PE[*3]	Raw PE	Spiked PE	Spiked PE	Spiked PE	Raw PE	Spiked PE	Spiked PE
Flow rate (ml/min)	10	10	10	10	3	3	3	3	3
Flow direction	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward	Downward
EBCT[*4] (min)	3	3	3	3	10	10	10	10	10
Location	MCUA	MCUA	MCUA	MCUA	MCUA	MCUA	SIT	SIT	SIT

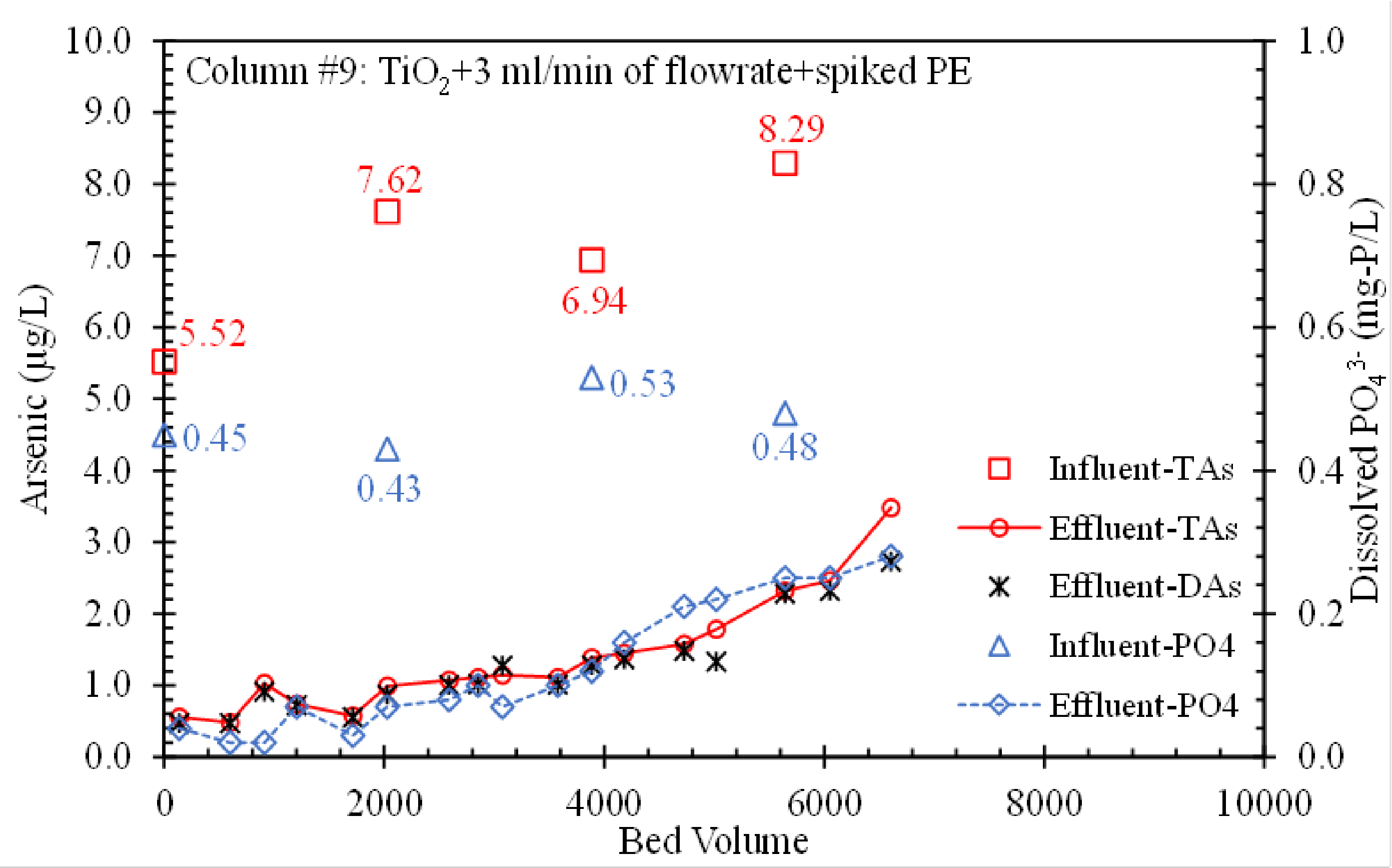
NOTE: *1: column type A with an inner diameter of 15 mm and a height of 300 mm and column type B with an inner diameter of 25 mm and a height of 200 mm; *2: PE=plant effluent; *3: raw PE spiked with 5 μg/L As(V); *4: EBCT=empty bed contact time, determined by volume of medium and flowrate.

Iron Oxide Adsorptive Filtration



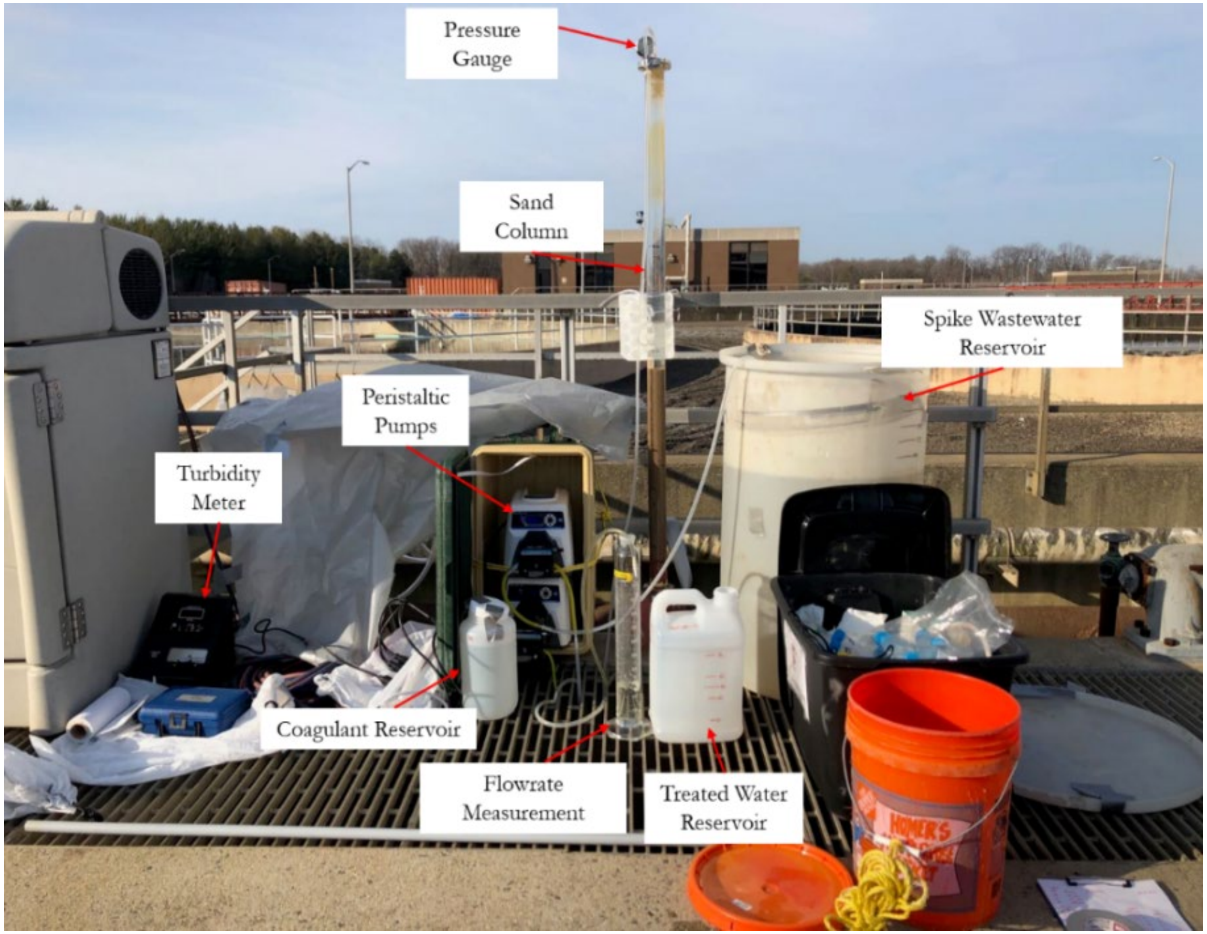
Adsorbent media: iron oxide. a) raw effluent (PE) as column influent, EBCT=3 min, flowrate=10 ml/min; b) PE spiked with 5.0 μg/L As(V) as column influent, EBCT=3 min, flowrate=10 ml/min; c) PE as column influent, EBCT=10 min, flowrate=3 ml/min; d) PE spiked with 5.0 μg/L As(V) as column influent, EBCT=10 min, flowrate=3 ml/min.

TiO_2 Adsorptive Filtration Results



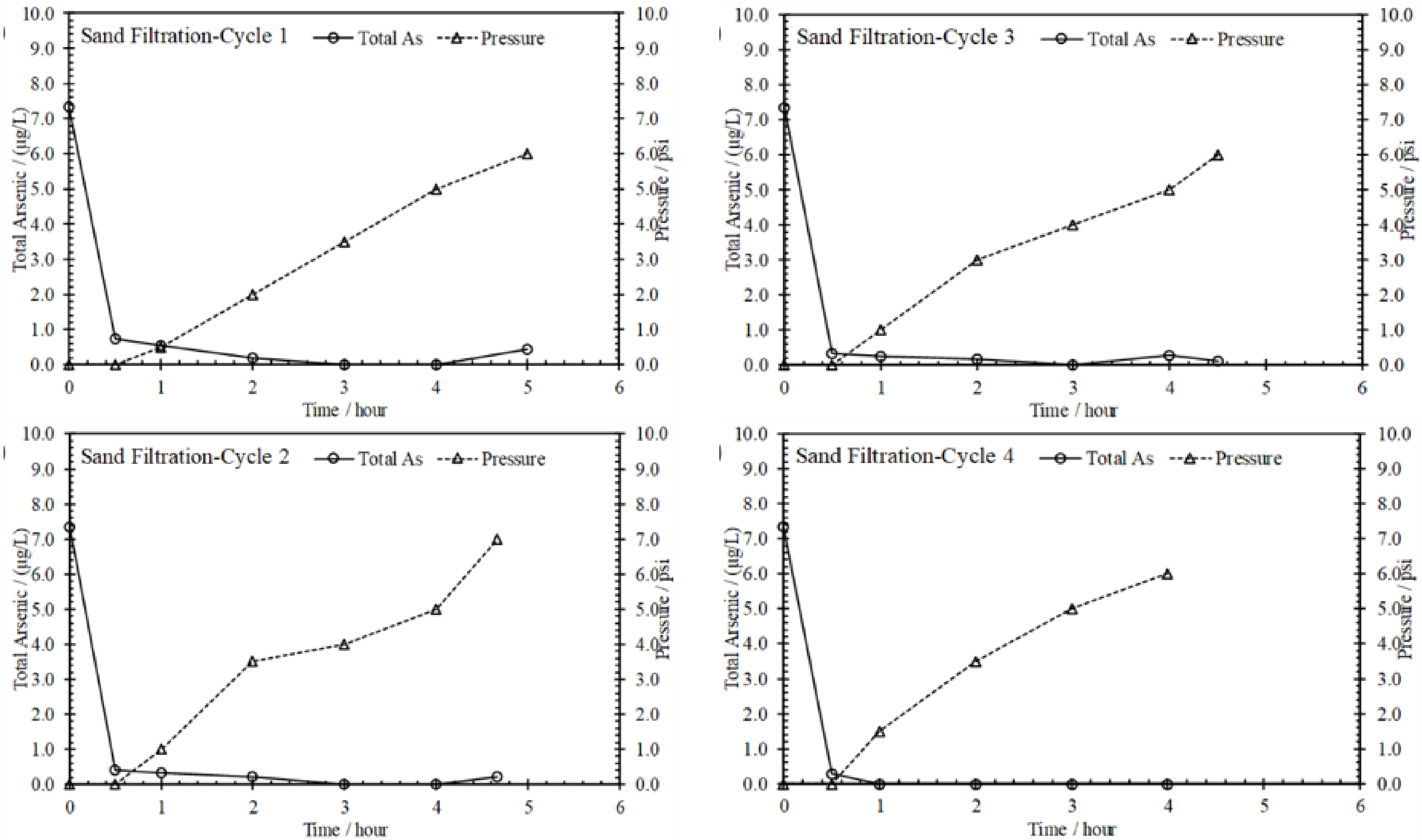
Adsorbent media: adsorbent media=TiO_2; plant effluent (PE) spiked with 5.0 µg/L As(V) as column influent, EBCT=10 min, flow rate=3 ml/min.

b) Direct Co-precipitation Filtration



Rapid sand filtration 1.6 $m^3/m^2/h$. Sand colum: ID = 5.56 cm, H = 152 cm, sand 61 cm of filter sand (mass=2.0 kg).

Direct Co-precipitation Filtration Results



Plant effluent (PE) spiked with 5.0 µg/L As(V) as column influent, wastewater flow rate=65 ml/min, coagulant flowrate=1 ml/min, alum dosage= 8 mg-Al/L

Summary

a) The total recoverable As (TAs) concentration in the influent and effluent of Plant A was in the range of 2.00-3.00 µg/L and 1.50-2.30 µg/L, respectively. The TAs in the influent and effluent of Plant B was about 0.95 and 0.57 µg/L, respectively.
b) The Biological wastewater treatment processes were not effective for As removal.
c) Ferric and alum coagulation treatment could not effectively remove As from the municipal wastewater. Very high doses of the coagulants (8 and 40 mg/L of Fe(III) or Al(III)) were required to reduce the TAs from 2.84 and 8.61 µg/L in the primary clarifier effluent and arsenate-spiked effluent samples to less than 2.00 µg/L.
d) Adsorptive filtration with iron oxide and TiO_2 could only filter less than 8000 bed volumes of Plant A effluent spiked with 5 µg/L As.
e) Direct co-precipitation and rapid sand filtration with 8 ppm Al could effectively remove As from Plant A effluent spiked with 5 µg/L As.

Acknowledgment

NJDEP managers: Bruce Friedman, Kimberly Cenno, Nicholas Procopio, and Gary Brower.

HMUA: Kathleen Corcoran and her staff

Stevens Institute of Technology: Dr. Amalia Terracciano, Dr. Jinshan Wei