

# **Arsenic Removal Using Aged Rapid Sand Filter Media**

by

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# OUTLINE

## ■ BACKGROUND

## ■ RESEARCH OBJECTIVE

- Assess coating characteristics of 'aged' rapid sand filter media.
- Quantity Arsenic removal potentials using "aged" rapid sand filter.
- Evaluate interferences associated with the adsorption capacity of the metal oxide coating.

## ■ CONCLUSION

# BACKGROUND

- Reduction/Elimination of Arsenic
  - Ion exchange
  - Coagulation / Filtration
  - Membrane filtration (Reverse Osmosis)
  - Innovative adsorbents, e.g. metal oxides

# BACKGROUND

- Conventional Water Treatment (Pathogen Removal)
  - Coagulants
    - Aluminum Sulfate
    - Ferrous Sulfate, Ferric Sulfate, and Ferric Chloride
  - Slow sand filtration process

# BACKGROUND

- Natural Aging of Metal Hydroxides to More Stable Metal Oxides



## REMOVAL ENHANCEMENT POSSIBILITY!!!

Make use of metal oxide coatings that form 'naturally' over many **years** on filter media in WTP from carryover of metal hydroxide flocs produced from "sweep-floc" coagulation

# RESEARCH OBJECTIVES

Explore the Arsenic removal potential of 'naturally' coated, regenerable sand filter media.

- 1) Assess coating characteristics of 'aged' rapid sand filter media.
- 2) Quantify Arsenic removal potentials using 'aged' sand filter media.
- 3) Evaluate interferences associated with the adsorption capacity of the metal oxide coating.

# METHODOLOGY

## ■ Materials used for Objective 1

### ■ Filter Media

- Portsmouth, NH WTP sand
- Philadelphia, PA WTP sand

### ■ Characterization Methods

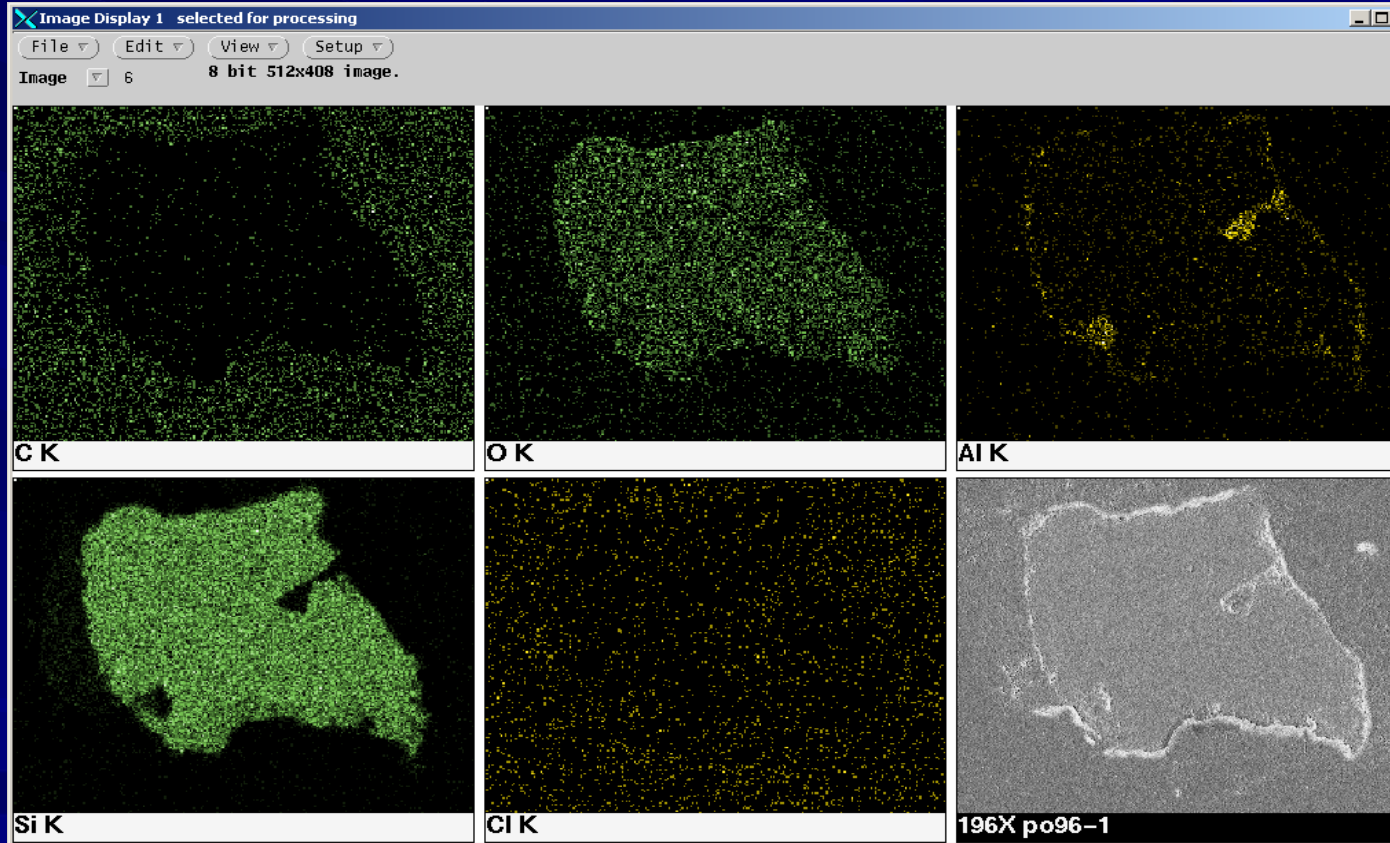
- SEM analysis
- Electron microprobe analysis



Portsmouth, NH   Philadelphia, PA



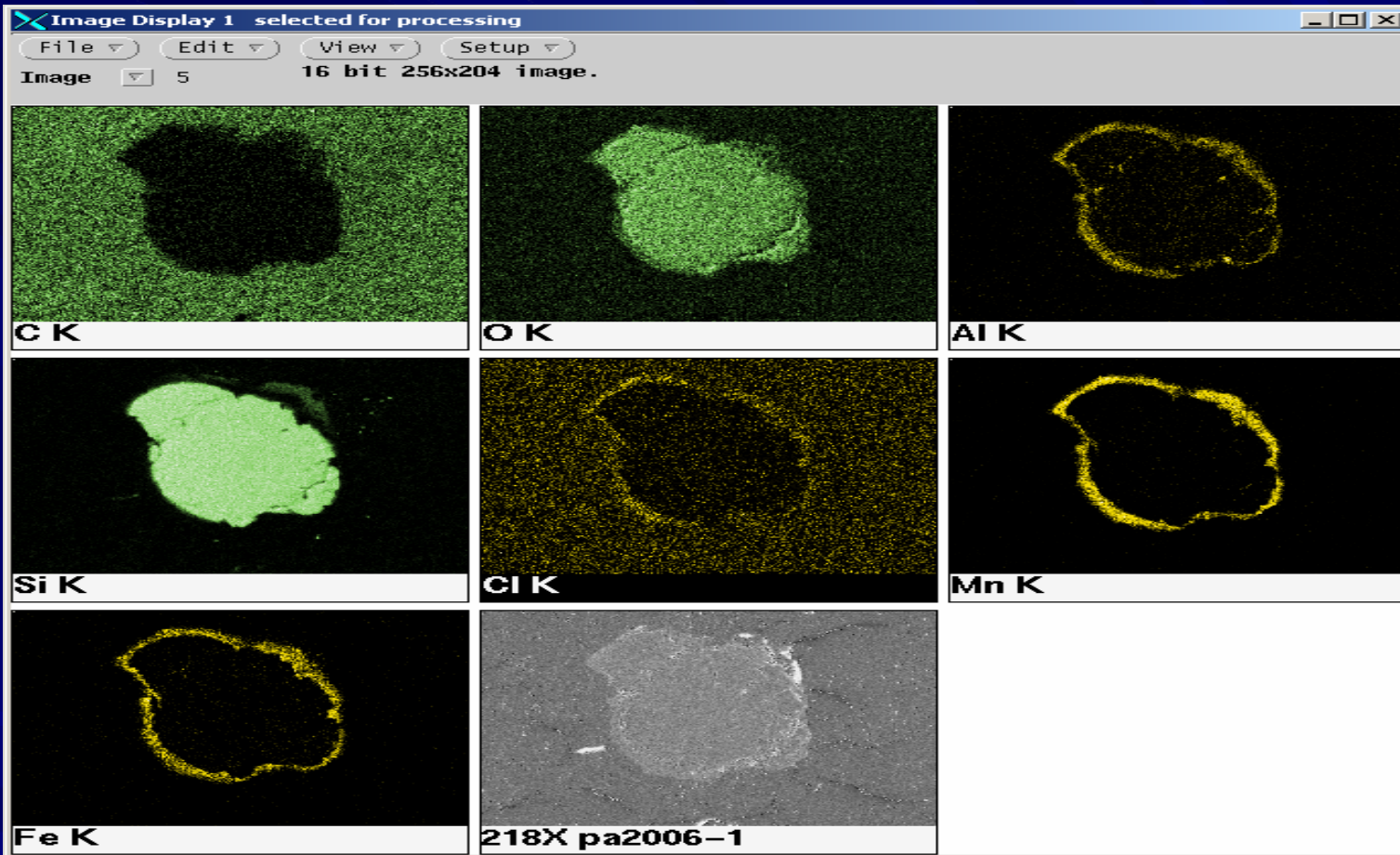
# Average Metal Coating Content of Selected Rapid Sand Filters – SEM picture



Portsmouth, 1996

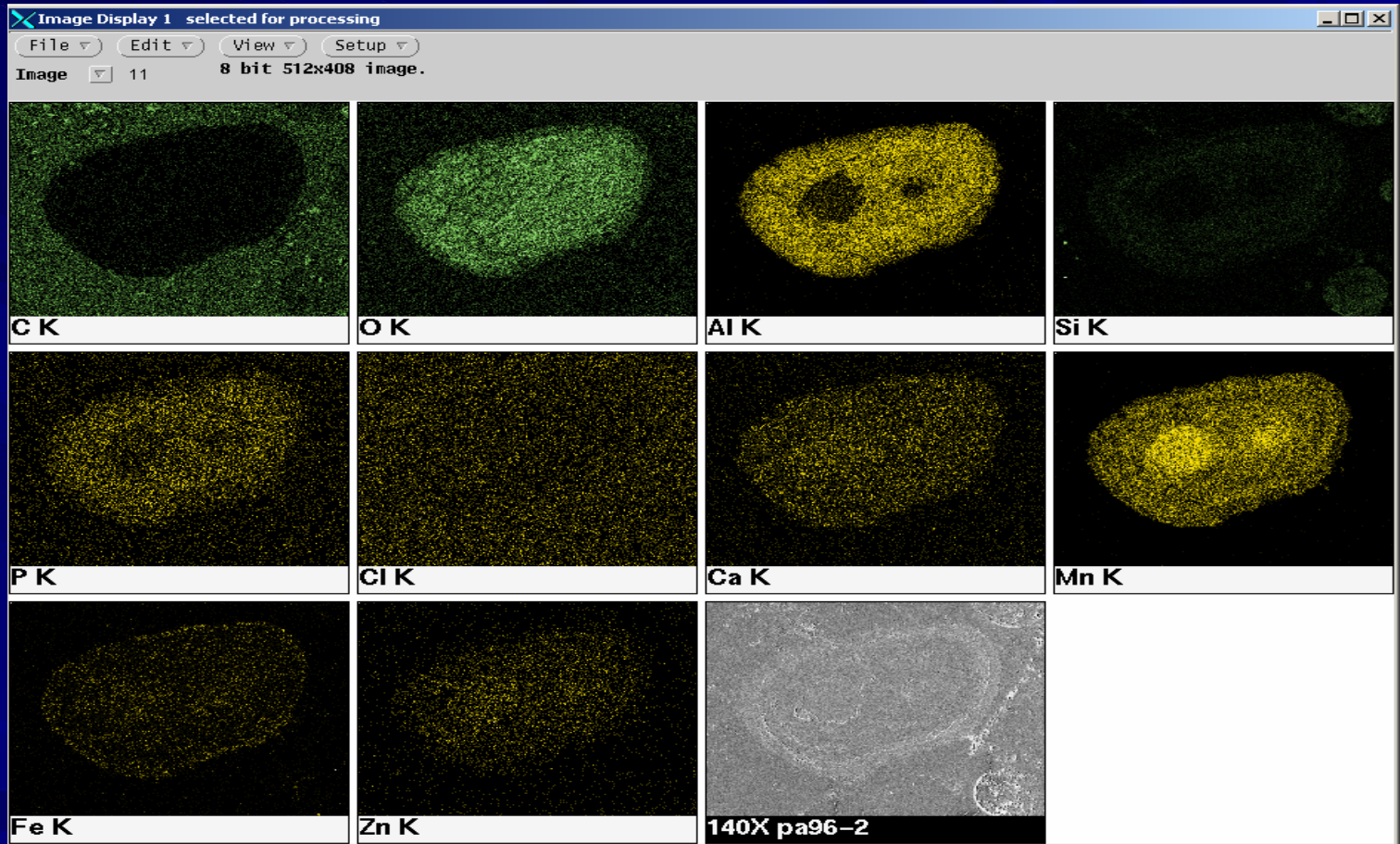


# Average Metal Coating Content of Selected Rapid Sand Filters –SEM picture



Philadelphia, 2006

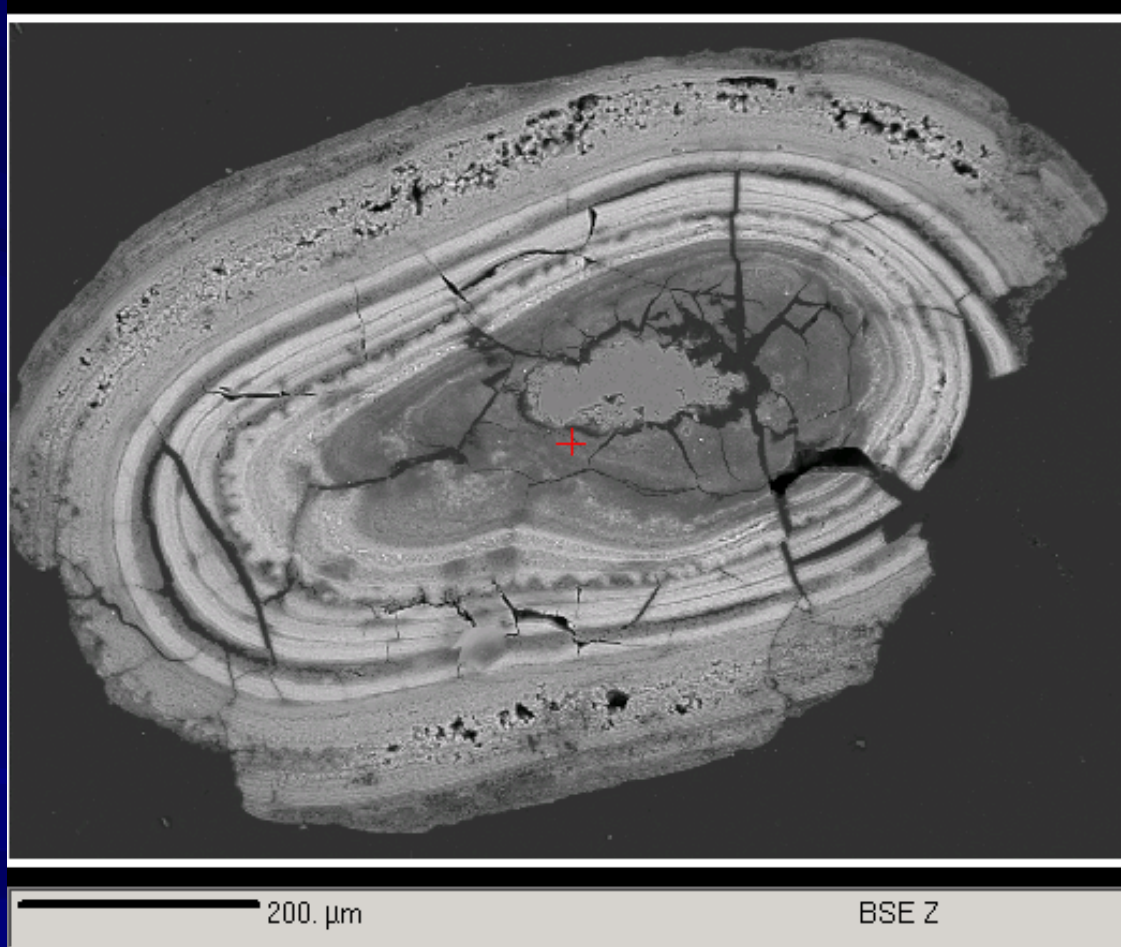
# Average Metal Coating Content of Selected Rapid Sand Filters –SEM picture



Philadelphia, 1996



# Average Metal Coating Content of Selected Rapid Sand Filters

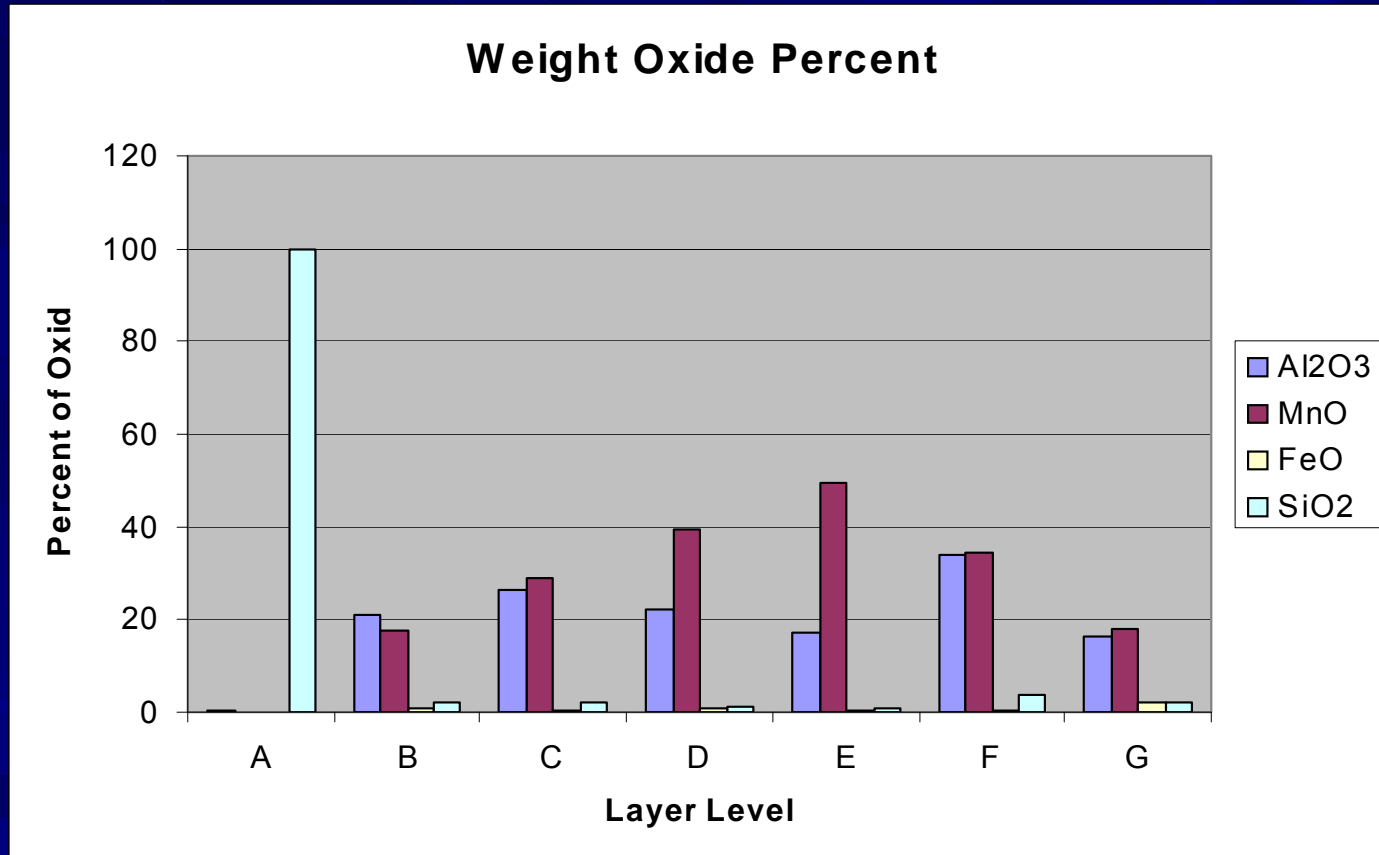


Electron Microprobe picture

Silica grain

Philadelphia, 1996

# Average Metal Coating Content of Selected Rapid Sand Filters



Philadelphia, 1996

# RESEARCH OBJECTIVES

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- 1) Assess coating characteristics of 'aged' rapid sand filter media.
- 2) Quantify Arsenic removal potentials using 'aged' sand filter media.
- 3) Evaluate interferences associated with the adsorption capacity of the metal oxide coating.

# METHODOLOGY

## ■ Experimental Set-Up

### ■ Backwash (BW) Procedure

- 50/100 mL sand in 500/1000 mL buffered water
- Backwash at target pH's for 1 hour

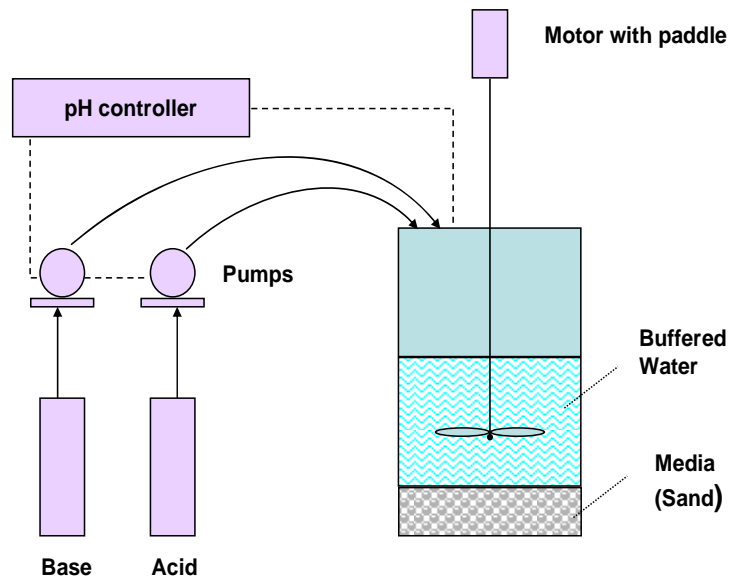
### ■ Equilibration Procedure

- Buffered water at the pH of the Challenge solution

### ■ Challenge Procedure

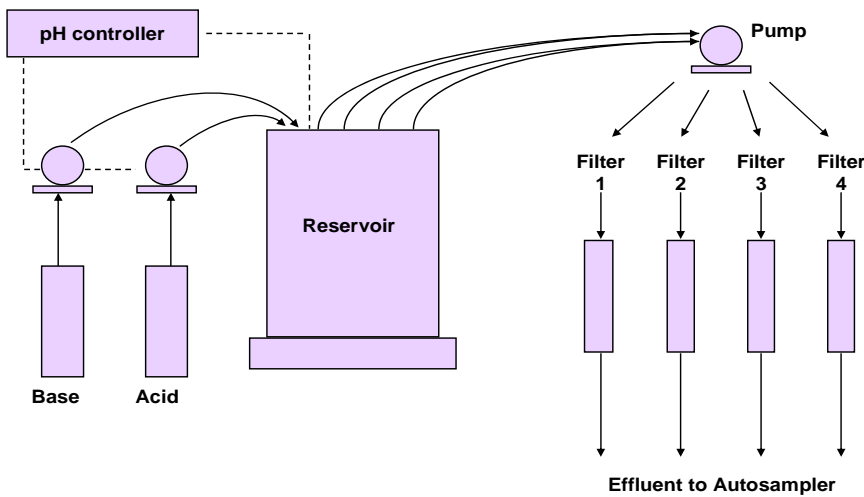
- Arsenic Solution according to the array

# Backwash/Regeneration Set-Up





# Challenge Set-Up



# RESEARCH OBJECTIVES

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# METHODOLOGY

## ■ L 16 ORTHOGONAL ARRAY

### ■ 5 parameters

- EBCT
- pH of the challenge solution
- Presence of sulfate
- Presence of natural organic matter
- pH of the backwashing

### ■ 2 levels

# RESULTS

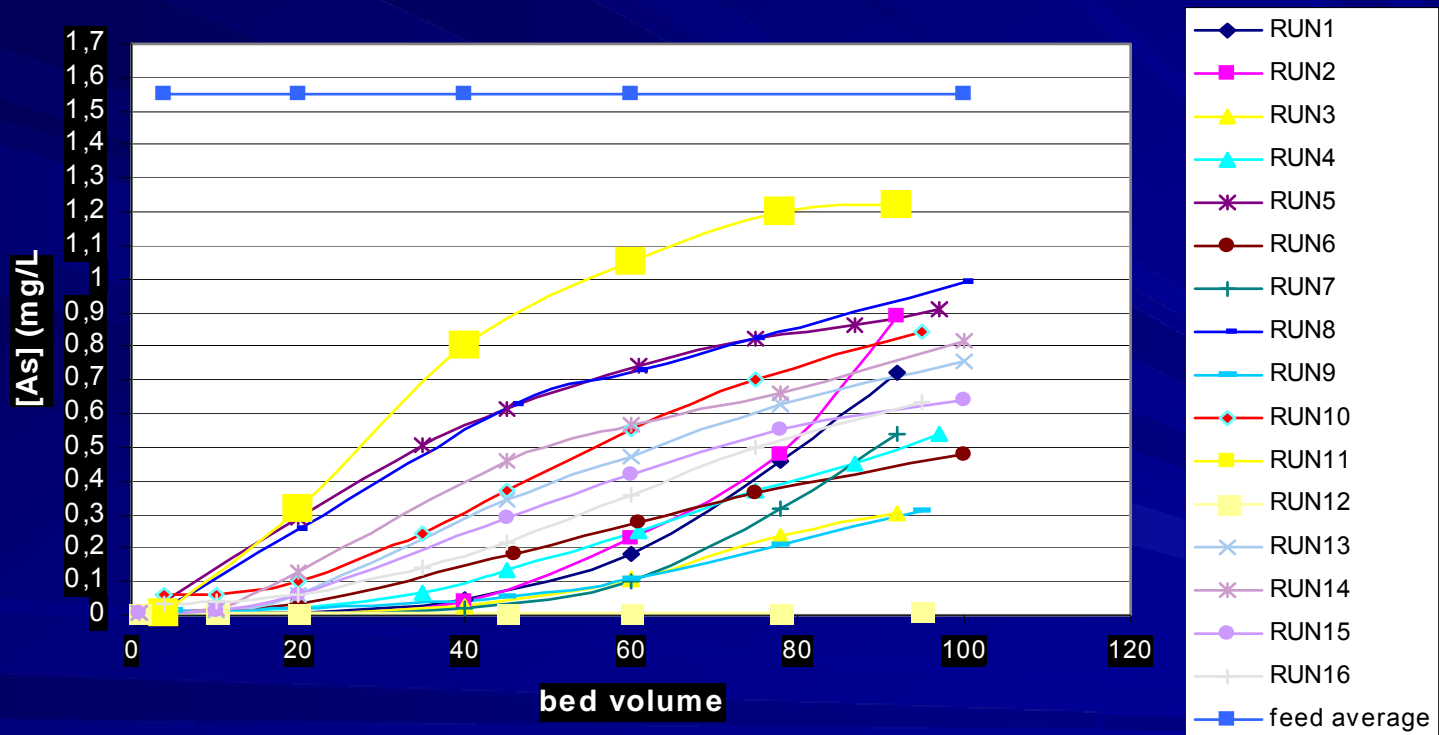
ARSENIC REMOVED / BED VOLUME at 95 BV (g/m<sup>3</sup>)

RUN/BV	EBCT	pH	SO4	NOM	BW	[As]removed/ BV 95
RUN1	2.5	6	0	0	8	3363
RUN2	2.5	6	0	6	8	3176
RUN3	2.5	6	200	6	8	3593
RUN4	2.5	6	200	6	11	3502
RUN5	2.5	8	200	6	11	2302
RUN6	2.5	6	200	0	8	3361
RUN7	2.5	6	0	0	11	3521
RUN8	2.5	8	0	0	8	2351
RUN9	5	6	200	6	11	3413
RUN10	5	8	200	6	8	3011
RUN11	5	8	0	6	11	1755
RUN12	5	6	0	0	8	5873
RUN13	5	8	0	0	8	4216
RUN14	5	8	0	0	11	3980
RUN15	5	8	200	0	11	4531
RUN16	5	8	200	6	11	3327

# RESULTS

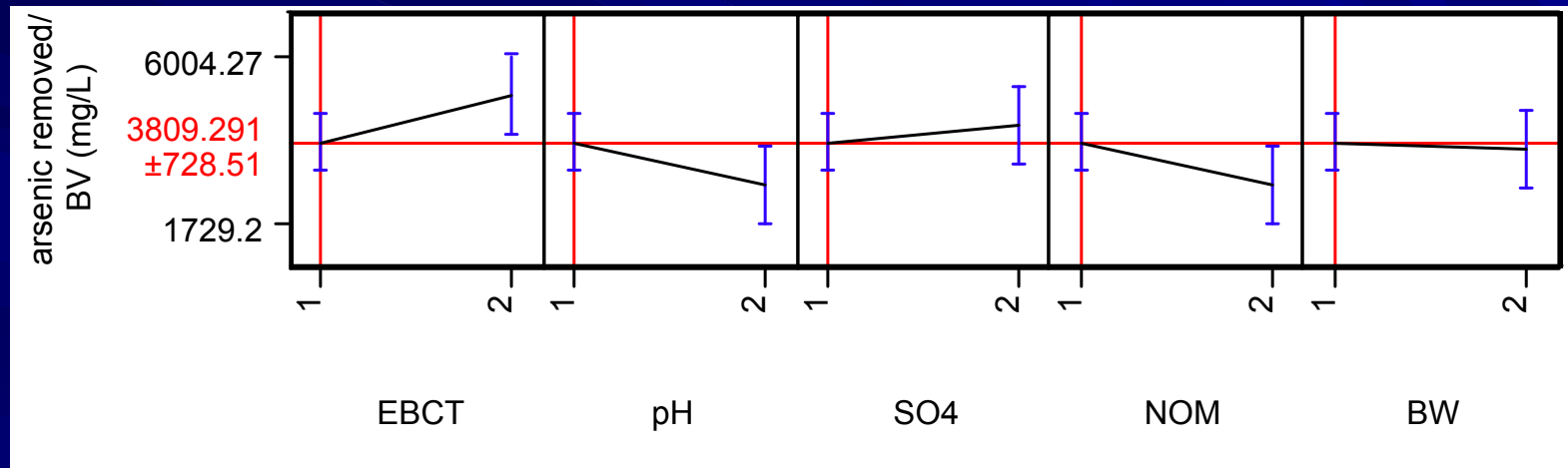
## ARSENIC REMAINING VERSUS BED VOLUME

arsenic restant vs bed volume



# INTERPRETATION

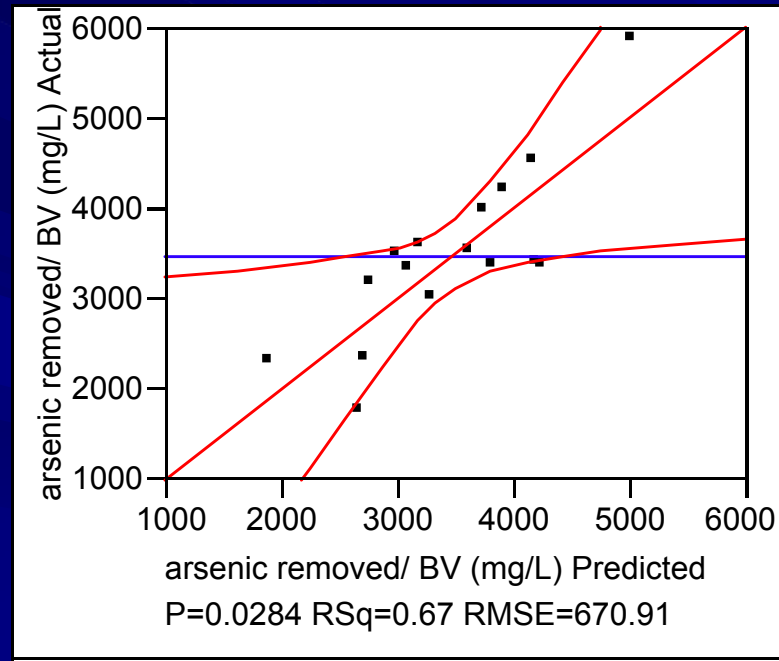
## PREDICTION PROFILER



**EBCT(0.0113) > pH (0.0186) > NOM (0.0227) >> SO4 (0.3028) > BW (0.6037)**

# INTERPRETATION

## MODEL EQUATION



$$Y = - 608,5*EBCT + 549,8*pH + (-213,7*SO4) + 526,7*NOM + 99,7*BW + 3454,6$$



# SUMMARY

- Sand coating composed mainly with aluminum, manganese oxide with a beginning of small ratio of iron oxides
- EBCT, pH and NOM: most important effect
- Slight positive impact with the presence of sulfate
- No significant effect of BW pH: in the range of recommended pH for aluminum coated sand

# Recommendations

- Additional experiments to analyze more precisely effect of sulfate but also others anions like phosphate
- Additional experiments to determine durability of coatings, test raw water
- Pilot or Full scale demonstration
- Analyse Portsmouth sand with Electron microprobe