Arsenic Removal Using Aged Rapid Sand Filter Media

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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
  - $Al(OH)_3 \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow Al_2O_3$
  - $Fe(OH)_3 \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow Fe_2O_3$

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.

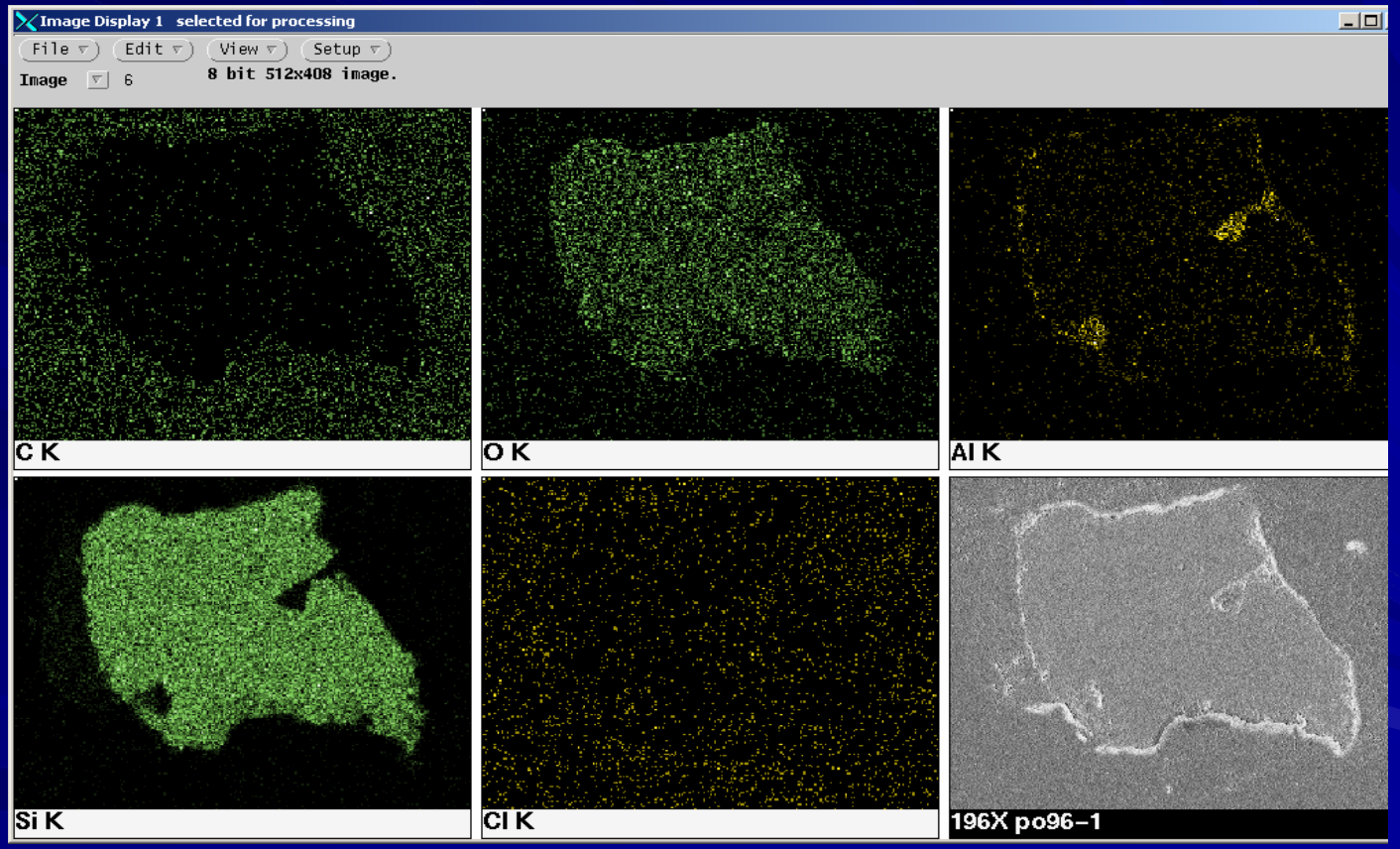
1) Assess coating characteristics of ‘aged’ rapid sand filter media.
2) Quantify Arsenic removal potentials using ‘aged’ sand filter media.
3) Evaluate interferences associated with the adsorption capacity of the metal oxide coating.

METHODOLOGY

- Materials used for Objective 1
  - Filter Media
    - Portsmouth, NH WTP sand
    - Philadelphia, PA WTP sand
  - Characterization Methods
    - SEM analysis
    - Electron microprobe analysis

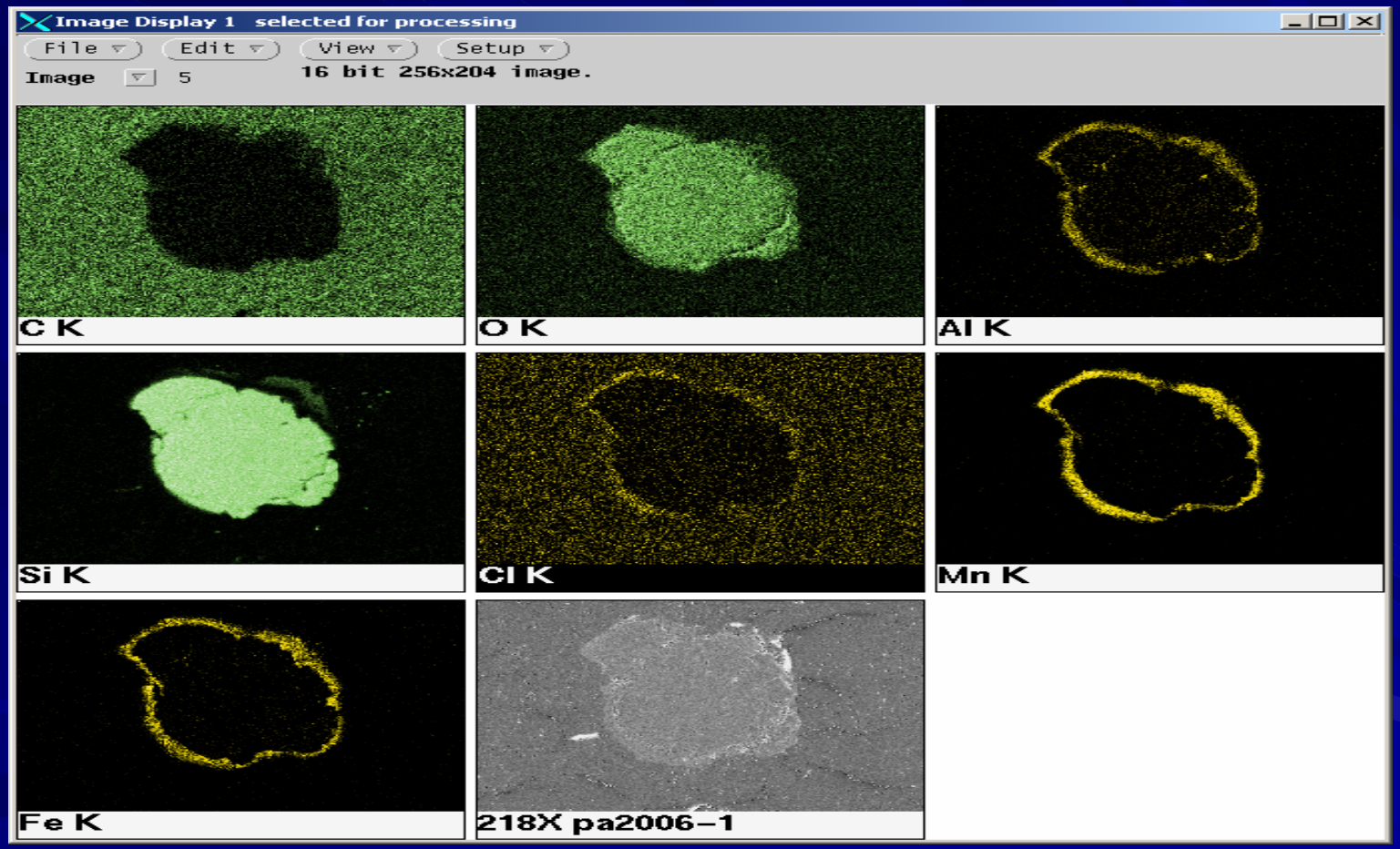
Portsmouth, NH Philadelphia, PA

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



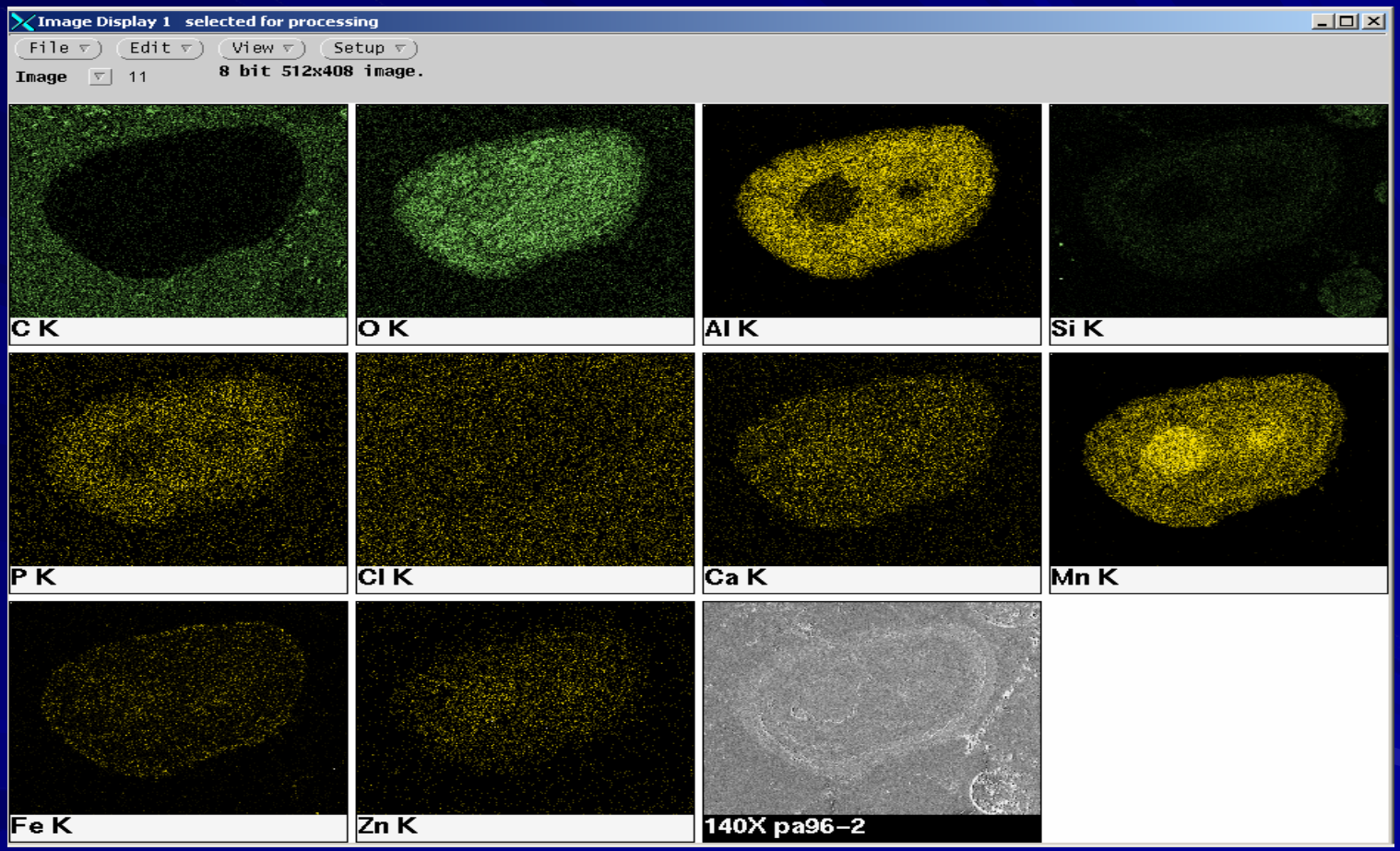
Portsmouth, 1996

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



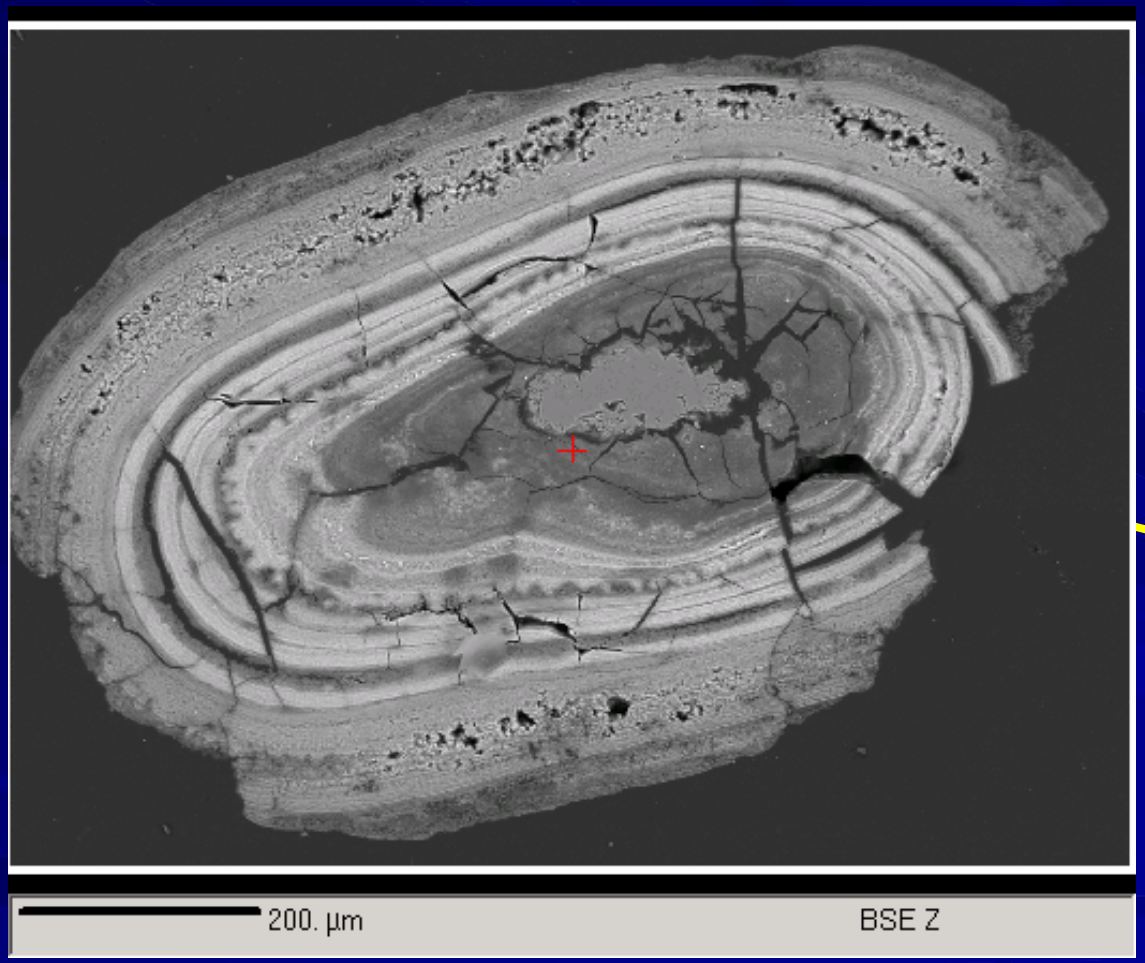
Philadelphia, 2006

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



Philadelphia, 1996

Average Metal Coating Content of Selected Rapid Sand Filters

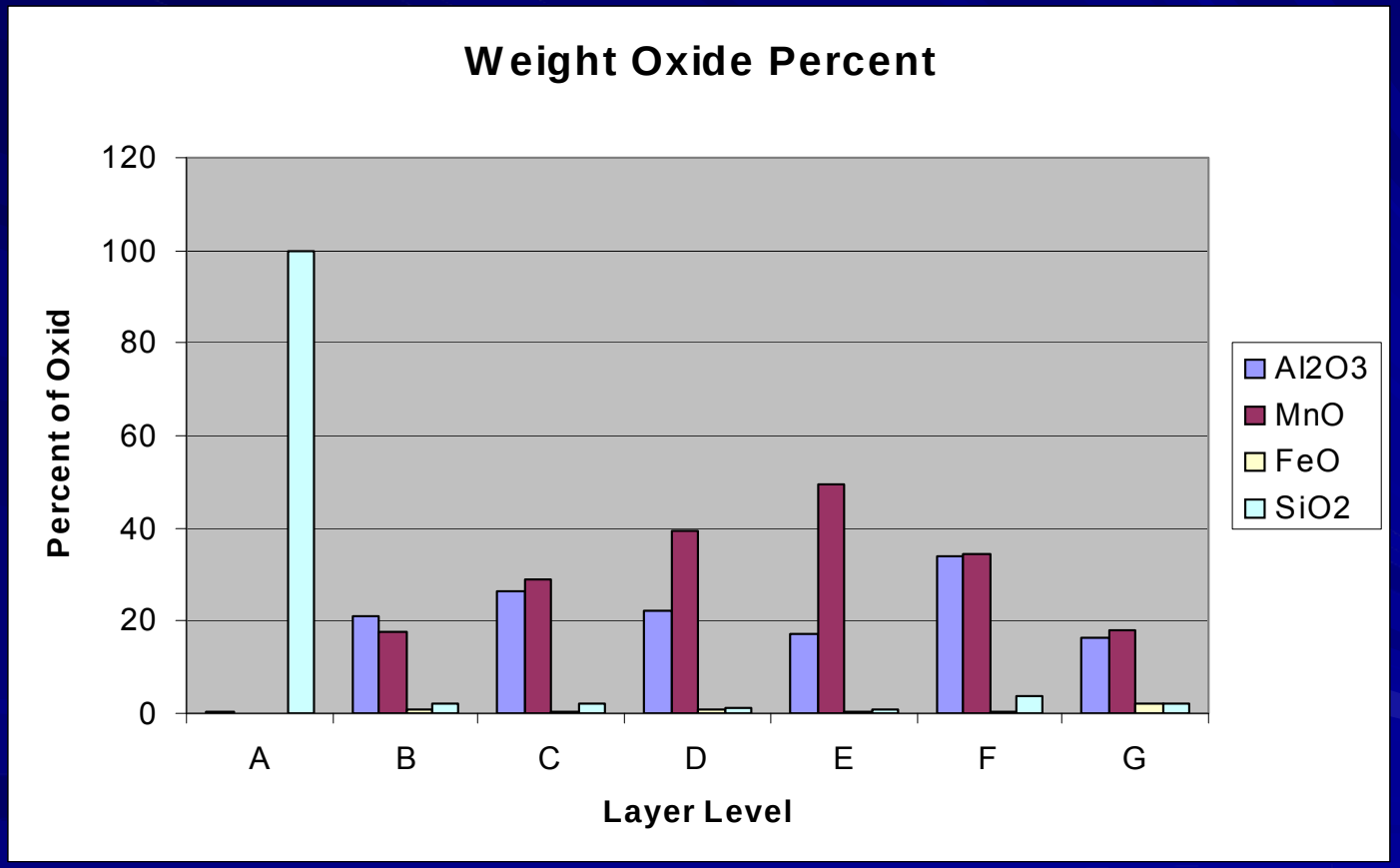


Electron Microprobe picture

Silica grain

Philadelphia, 1996

Average Metal Coating Content of Selected Rapid Sand Filters



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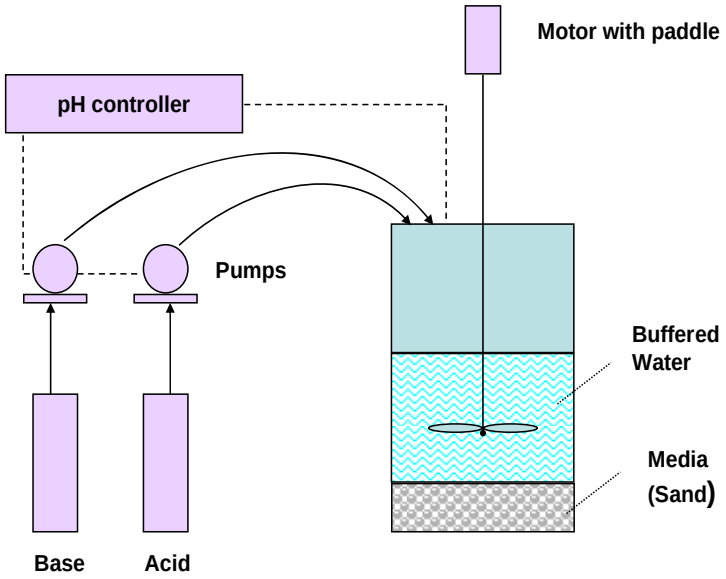
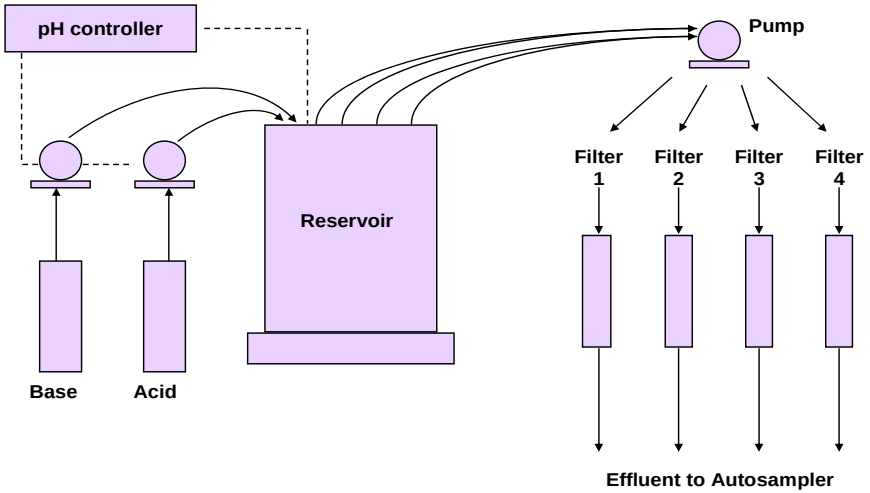
METHODOLOGY

- 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



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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

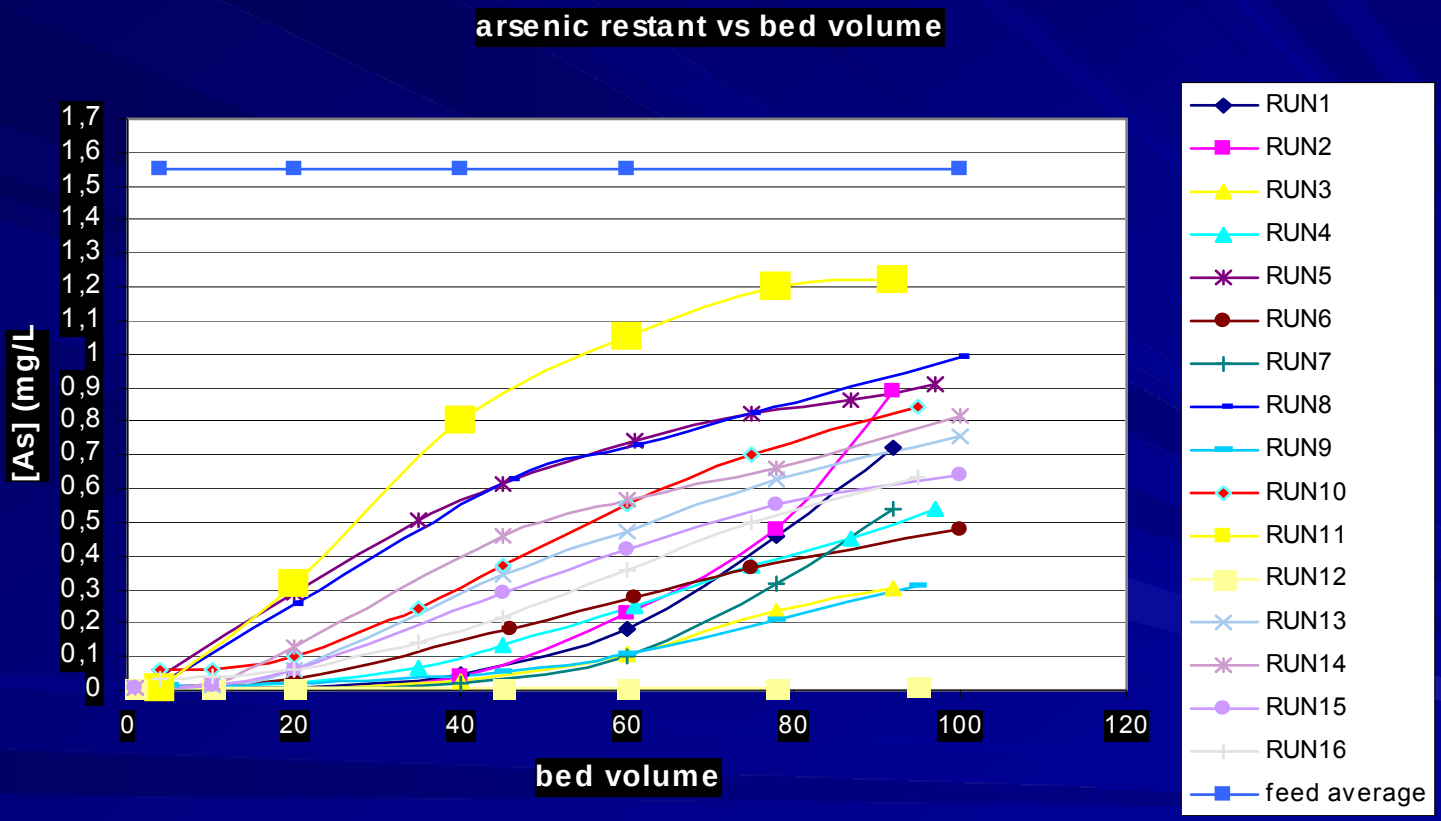
RESULTS

ARSENIC REMOVED / BED VOLUME at 95 BV (g/m^3)

						[As]removed/ BV
RUN/BV	EBCT	pH	SO4	NOM	BW	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

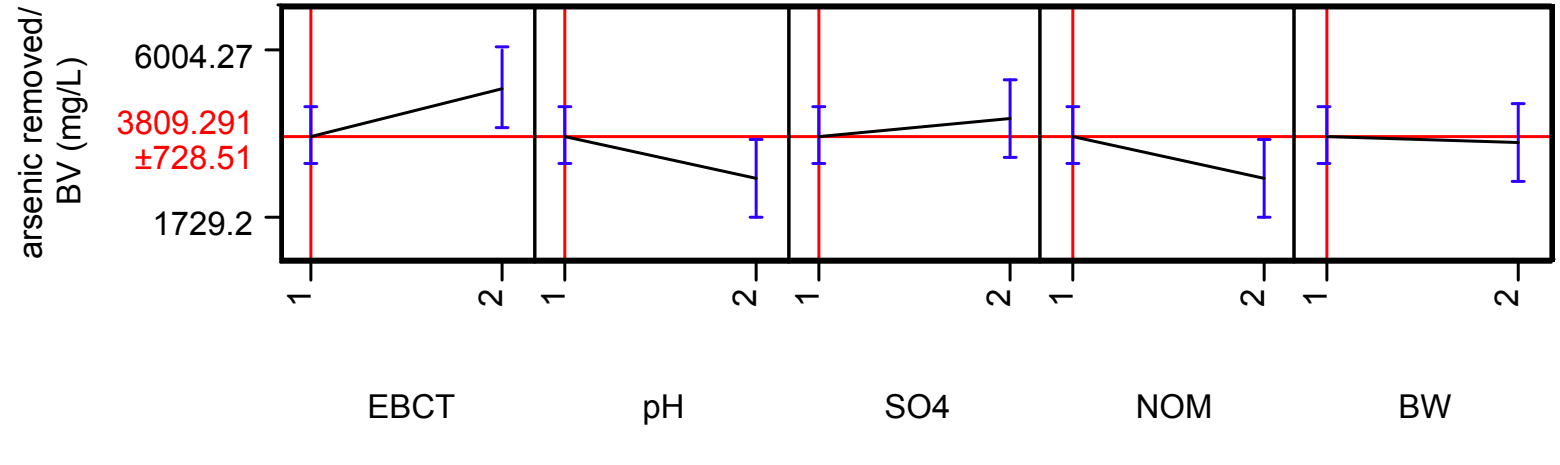
RESULTS

ARSENIC REMAINING VERSUS BED VOLUME



INTERPRETATION

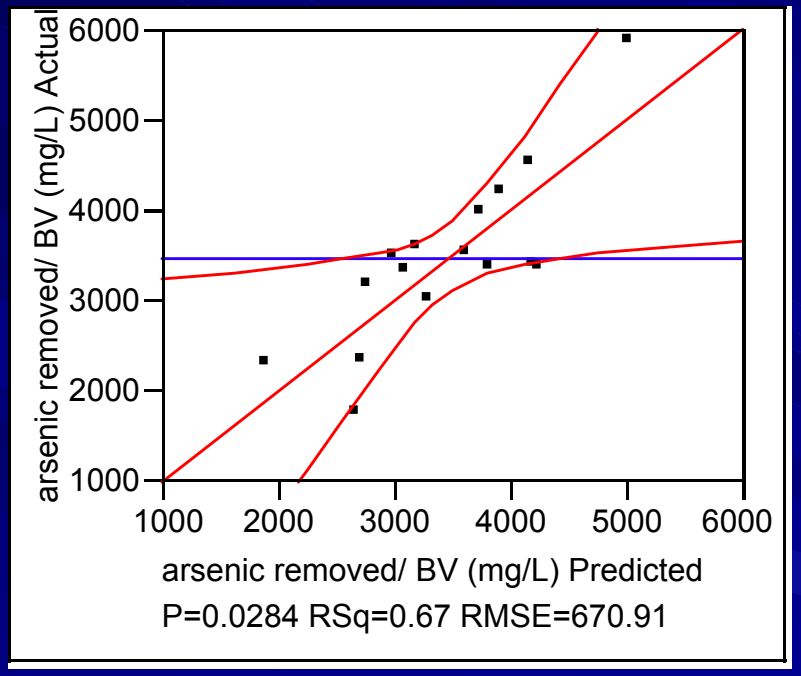
PREDICTION PROFILER



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