



Arsenic Removal (Small Drinking Water Systems)

**Ramesh Kashinkunti, P.E., DEE
Greater Cincinnati Water Works**

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Outline

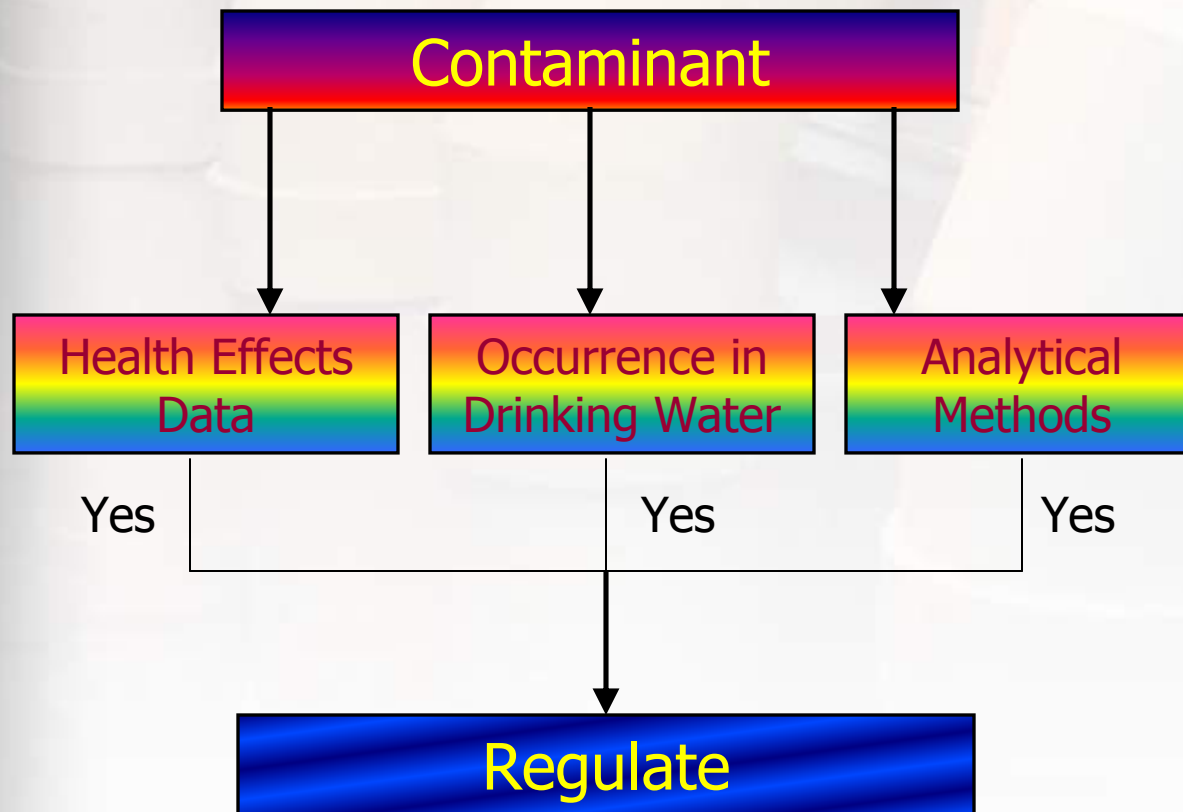
- What is arsenic?
 - Health effects of arsenic
 - MCLG, MCL, public health benefits, and monitoring requirements
 - Treatment Technologies for Arsenic removal
 - Oxidation
 - Oxidation/filtration
 - Adsorptive media
 - Anion exchange
 - Piloting requirements
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Arsenic

- Arsenic is a toxic chemical element that is unevenly distributed in the Earth's crust in soil, rocks, and minerals
 - How does arsenic get into PWS
 - Arsenic occurs naturally in the environment and as by-product of some agricultural and industrial activities
 - It can enter drinking water through ground or
 - As runoff into surface water sources
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Setting Drinking Water Limits





Health Effects of Arsenic

- Thickening and discoloration of skin, stomach pain, nausea, vomiting, diarrhea, and liver effects.
 - Cardiovascular, pulmonary, Immunological, reproductive, and endocrine effects.
 - Cancer of the bladder, lungs, skin, kidney, liver, and prostate.
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MCLG, MCL, public health benefits, and monitoring requirements

- MCLG goal for arsenic is zero ppb
 - MCL for arsenic was lowered from 50 ppb to 10 ppb and it became effective on January 23, 2006.
 - Initial monitoring
 - Surface water systems annually
 - GW systems one sample between 2005-2007
 - Reduced monitoring (if the initial results is less than the MCL)
 - SW systems one sample annually
 - GW systems one sample every three years
 - Increased monitoring (if results are >MCL)
 - At least one sample quarterly, until the system is consistently and reliably below the MCL
 - NOTE: entry point to the distribution system and compliance is based on a running annual average
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Arsenic Treatment Technologies

- **Principle:** Reduced inorganic arsenic (As(III, Arsanite) should be converted to the oxidized (As(V) Arsanate) form to facilitate subsequent removal
 - Each technology has its own issues:
 - Cost (capital and O&M)
 - Stoichiometric requirements
 - Each oxidant has advantages and disadvantages
 - DBP formation or other regulatory impacts
 - Certified operator requirements
 - Safety
 - Compatibility with downstream treatment processes (units)
 - Waste-disposal (if and when generated)
 - Piloting requirements
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Arsenic Treatment Technologies

OXIDATION

- Effective Oxidants:
 - Chlorine
 - Permanganate
 - Ozone
 - Solidphase oxidants (e.g., pyrolusite)
 - Ineffective oxidants
 - Aeration
 - Chlorine dioxide
 - Monochloramines
 - UV light
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Oxidation/Filtration (Co-removal of Arsenic with Iron)

- Many arsenic containing ground waters also contain iron and manganese due to natural geochemistry
 - Arsenic removal is achieved through two primary mechanisms: adsorption and co-precipitation
 - Adsorption involves the attachment of As to the surface of ferric particles and
 - Co-precipitation involves adsorption and entrapment with ferric particles by inclusion, occlusion, and adsorption
 - Iron to arsenic ratio of 20:1 or greater are potential candidates for this technology
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Anion Exchange

- Ion Exchange is a physical/chemical process in which ions are swapped between a solution phase and a solid resin phase.
 - Arsenic (V) can be removed through the use of a strong-base anion exchange resin (SBA) in a chloride form.
 - Pre-oxidation is required prior to SBA IX
 - Sustained effectiveness of this treatment is highly dependent on chemistry of source water.
 - Regeneration frequency needed to ensure consistent arsenic removal without breakthrough is critical to establish.
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Non-Centralized Treatment (POE and POU)

- In Ohio, this method of treatment can be used only for non-transient, non-community water systems.
 - Reverse Osmosis (RO) membranes must be certified per ANSI/NSF standard 58 (NSF-2004b)
 - Adsorptive media such as activated alumina or iron-based sorbents, must be certified per ANSI/NSF standard 53 (2004a)
 - Distillation units must be certified per ANSI/NSF 62 (NSF 2004c)
 - Water quality is extremely important for POE/POU use
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Disposal of Arsenic Residuals

- Waste disposal is an important consideration in the treatment selection process
 - Typical residual generated include: sludges, brine streams, backwash slurries, and spent media.
 - Wastes have the potential of being classified as hazardous
 - Appropriate OEPA offices should be contacted for all waste disposal requirements and permits.
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Typical Disposal Options

- Liquid residuals
 - Sanitary sewer
 - Direct discharge to receiving streams
 - Evaporation pond/lagoon
 - Deep well injection
 - Solid residuals
 - Landfill
 - Hazardous waste landfill
 - Return to the vendor
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Piloting needs and requirements

- Emerging arsenic treatment technologies, new filter media, and other technologies considered to be non-conventional in Ohio will require piloting for approval until they are proven effective in OH
 - Piloting is required for (until proven effective):
 - Centralized anion exchange
 - Adsorptive media technology
 - Any POU device
 - Piloting protocol must be submitted to OEPA
 - There are treatment verification and long-term monitoring requirements to ensure proper trt.
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Piloting requirements for Rapid Rate Gravity or Pressure Filters

- Deviations from (RSWW-2007) recommended standards water works must be explained by documentation demonstrating equivalency which is acceptable to OEPA.
 - Background and objectives
 - Pilot procedure
 - Goals for finished water
 - Media specifications
 - Specific data collection and analysis required
 - 8-hrs, 5-days/week, for a total of 4-weeks (at least 160-hrs of filter operation required)
 - Design approval: Approval of detail plans will be required prior to construction
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Piloting Guidelines for Anion Exchange

- Currently falls the category of non-conventional technology, therefore requiring piloting
 - A Professional Engineer must be involved in preparing pilot protocol, oversight, and in preparing final report. PE must also prepare final detailed plans for approval by OEPA
 - Pilot study should be performed for three regeneration cycles should be performed.
 - Timing of regeneration shall be based on volume treated and not on time alone.
 - A safety factor (~1.5 times the volume) should be determined prior to establishing pilot-regeneration cycle.
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Piloting for Non-Centralized Treatment Devices

- Point of Entry Devices
 - Raw water quality should be evaluated to see which device is appropriate
 - Backflow prevention device should be installed on the pilot influent line.
 - Any maintenance or replacement of the unit should be recorded and reported to OEPA in the report and consultation on how to proceed
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Piloting for Non-Centralized Treatment Devices

In regards to Point of Use (POU) devices

- Results from an acceptable demonstration study are required for approval of POU device
 - Piloting a proposed POU device on a single tap is required before choosing a POU strategy for compliance with As MCL is required.
 - Operation of the device should mimic water use patterns (on/off cycles)
 - 120% of the expected average daily demand at the tap should be simulated.
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Conclusions and recommendations

- The emphasis of this presentation was for small water systems.
 - There are several other options available for large systems to comply with Arsenic MCL including:
 - Optimization and enhanced coagulation/filtration
 - Optimization of lime softening
 - Optimization of iron and manganese filtration
 - Membrane processes including RO
 - Coagulation assisted micro-filtration
 - Coagulation assisted direct filtration
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Conclusions and recommendations

- Arsenic removal is dependent several water quality factors
 - It is site specific
 - Careful evaluation in needed before selecting appropriate technology
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Additional References

- http://www.epa.gov/safewater/arsenic/pdfs/handbook_arsenic_treatment-tech.pdf
 - http://www.epa.gov/safewater/smallsys/pdfs/guide_smallsystems_pou-poe_june6-2006.pdf
 - http://www.epa.gov/safewater/arsenic/pdfs/treatments_and_costs.pdf
 - http://www.epa.state.oh.us/ddagw/Documents/rules/draft/Arsenic_manual_IPR.pdf
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