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Examples of Application in Arsenic Removal

Arsenic Removal and the Role of the MPSF: More than 13 million people in the United States routinely obtain water from public sources that are above the maximum contaminate level for arsenic. This is a treatment segment where Oasis could have a dominant position due to a number of relative advantages including an ability through using the Manz Polishing Sand Filter™ (MPSF) to completely eliminate the arsenic laden waste water disposal problem.

There are many countries in the world where arsenic prone drinking water has been detected at a concentration greater than the Guideline Value, 0.01 mg/L or the prevailing national standard: Argentina, Australia, Bangladesh, Cambodia, Chile, China, Hungary, India, Laos, Mexico, Myanmar, Nepal, Pakistan, Peru, Slovak Republic, Taiwan, Thailand, the United States and Vietnam have a very significant portion of their population affected.

A table is provided comparing the MPSF to current arsenic removal technologies. This table is intended to highlight the advantages of the MPSF as an alternative and to illustrate the difficulties encountered by smaller communities in sourcing an appropriate technology. The nine competitive technologies each have impediments: many require media regeneration chemicals which are very expensive; problems associated with handling hazardous waste; the technologies may generate large quantities of waste; or, many are able to only handle limited water quality conditions or require a number of chemical adjustments to pre-condition various water qualities encountered before treating. In general the other technologies are complex treatment technologies requiring a significant capital investment with high operating costs. Most importantly, due to these impediments the systems are more at risk to periods of interruption of service for a myriad of reasons.

As of January 2006 all community, non-transient and non-community water systems, regardless of size in the United States were expected to comply with the final Arsenic Rule in the Federal Register published in January 2001, which fixed the maximum contaminant level for arsenic at 0.010 mg/L. The number of people and communities directly affected by the Arsenic Rule is very large and distributed across the entire United States. The USEPA (United States Environmental Protection Agency) published several handbooks, design guides, engineer and vendor selection guides and several other guides to assist small communities to deal with the problem. Once a community has established that they are not in compliance with the Arsenic Rule they have a number of suggested mitigation strategies from which to select their course of action. Of particular importance is that **communities are <u>not</u> restricted to choosing from known technologies.** Communities may choose treatment technologies and systems that are innovative technologies such as the MPSF. The MPSF has not been evaluated for use in the USA. This however does not limit its use although the USEPA recommends that all treatment systems be piloted before adoption.

The MPSF may operate in a stand alone fashion; however more complex water situations may require secondary technology support. The MPSF offers significant advantages over the arsenic removal technologies listed by the USEPA based on ease of operation, effectiveness, reliability, capital cost and operating cost. The MPSF removal process incorporates the introduction of coagulants (usually iron or aluminum salts) using the MPSF as a polishing filter to remove all particulates including arsenic that is adsorbed by the coagulant. A removal efficiency of 99% can be expected. The

MPF is able to work in a wide range of water quality conditions. The backwash may be recycled and the solid waste generated is very stable and can be disposed of at a landfill site. The level of waste generated is low and the MPSF operating characteristics for general water treatment still apply in the arsenic removal application: simple operation with low operating and capital cost.

MPSF Compared to Other Technologies In Terms of Arsenic (As) Removal

Characteristic	**Manz Polishing Sand Filter™ (MPSF)**	**Ion Exchange**	**Activated Alumina**	**Iron Based Sorbents**	**Reverse Osmosis**	**Enhanced Lime Softening**	**Enhanced (Conventional) Coagulation Filtration**	**Coagulation-Assisted Micro-Filtration**	**Coagulation Assisted Direct Filtration**	**Oxidation Filtration**
Removal Process	Coagulants (usually iron or aluminum salts) with polishing filtration provided by the MPF that removes all particulates, including those that have adsorbed As.	Removal of As as part of ion exchange process using synthetic resins. Media usually regenerated on site.	Adsorption of As on particles of activated alumina Regeneration on site is possible	Adsorption of As on fixed media that is not usually regenerated on site	Nano-filtration process that removes almost all dissolved solids including As.	Enhanced lime softening usually followed by filtration	Coagulation – filtration. As removal achieved by removal of all flocculated particles that will have adsorbed As attached. Typically requires clarification and conventional filtration.	Coagulants (usually iron or aluminum salts) with micro-filtration that removes all particulates, including those that have adsorbed As.	Coagulants (usually iron or aluminum salts) with conventional filtration that removes all particulates, including those that have adsorbed As.	There are usually iron salts that are or can be oxidized to form micro-flocs that can be removed by conventional or micro-filtration
Removal Efficiency	Up to 99%	95%	95%	Up to 98%	More than 95%	90%	95%(w/ $FeCl_3$) Less than 90% (w/ Alum)	90%	90%	50-90%
Central System Size (pop. Served)	25 and greater	25-10,000	25-10,000	25-10,000	501-10,000	25 and greater	25 and greater	25 and greater	25 and greater	25 and greater
Optimal Water Quality Conditions for Tech. to Perform	pH 5.5-8.5	pH 6.5-9 <5 mg/L NO_3^- <50 mg/L SO_4^{2-} <500 mg/L TDS < 0.3 mg/L NTU turbidity	pH 5.5-6 pH 6-8.3 <250 mg/L CL^- <2 mg/L F^- <360 mg/L SO_4^{2-} <30 mg/L Silica <0.5 mg/L Fe^{-3} <0.05 mg/l Mn^{-2} <1000 mg/L TDS <4 mg/L TOC <0.3 NTU Turbidity	pH 6-8.5 <1 mg/L PO_4^3 <0.3 NTU Turbidity	Requires no particulates in the water	pH 10.5-11 >5mg/L Fe^{3+}	pH 5.5-8.5	pH 5.5-8.5	pH 5.5-8.5	pH 5.5-8.5 >0.3mg/l Fe Fe:As Ratio $> 20:1$
Chemical Requirements (Pre and Post Treatment)	May require pre-oxidation. May require addition of Fe_2SO_4 (ferric sulphate) or other iron salt	Requires pre-oxidation and pre-filtration. May require pre and post pH adjustment Media regeneration chemicals	Requires pre-oxidation May require pre-filtration May require media regeneration chemicals	Requires pre-oxidation May require pre-filtration and removal of TOC (total organic carbon) May require media regeneration chemicals	Requires pre-filtration (polishing) May require pre-oxidation, removal of TOC (total organic carbon) and other chemical conditioning	Requires pre-oxidation Uses lime and treated water will require pH adjustment and filtration Other chemicals may be used to assist in clarification of water	Requires pre-oxidation Uses conventional iron and aluminum coagulants and various polymers as required. May require pre- and post-treatment pH adjustment	Requires pre-oxidation Uses conventional iron and aluminum coagulants and various polymers as required. May require pre- and post-treatment pH adjustment	Requires pre-oxidation Uses conventional iron and aluminum coagulants and various polymers as required. May require pre- and post-treatment pH adjustment	Pre-oxidation

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Liquid Waste Generated Type	Backwash water that is recycled	Backwash water and Potentially hazardous brine waste	Backwash water and Potentially hazardous brine waste	Backwash water and Potentially hazardous brine waste	Reject water that has high TDS and As concentration	Backwash water that can be recycled	Backwash water that can be recycled	Backwash water that can be recycled	Backwash water that can be recycled	Backwash water that can be recycled
Liquid Waste Generated Volume	0 Backwash water can be recycled.	1-2%	1-2%	1-2%	15-75%	0	0	5%	1-2%	1-2%
Relative Cost of Liquid Waste Disposal	0	High	High	High	Medium	Low	Low	Low	Low	Low
Solid Waste Generated Type	Dewatered coagulant containing As (sludge) Very stable	Spent resin.	Spent media	Spent media	Solids from pre-filter if used	Sludge that is usually very stable	Sludge that is usually very stable	Sludge that is usually very stable	Sludge that is usually very stable	Sludge that is usually very stable
Solid Waste Generated Volume	Very Low to Low	Low	Low	Low	Very low	High	High	Medium	Medium	Very Low
Relative Cost for Solid Waste Disposal	Very Low to Low	High	High	High	Very low	Medium	Medium	Medium	Medium	Very Low
Relative Size of Footprint of Treatment System Incorporating Technology	Very large	Very small.	Very small.	Very small.	Small	Very large	Very Large	Medium	Large	Medium
Complexity of Treatment Technology	Simple	Very complex	Somewhat complex (can be very complex if includes media regeneration)	Complex	Very complex	Complex	Complex	Complex	Somewhat complex	Somewhat complex
Operator Skill Required	Low	High	Medium (High if there is site regeneration of media)	Medium (Depends on operator involvement in maintenance)	Medium to High	High	High	High	High	Medium
Relative Capital Cost of Centralized System	Low	Medium	Medium	Medium	High	Low	Low	High	Medium	Medium
Energy Requirements	Very Low	Medium	Medium	Medium	Very High	Low	Low	Medium	Medium	Medium

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Relative Capital Cost of POU/POE (point of use/point of entry) System	Low	High	Low	High	Low	N/A	N/A	N/A	N/A	N/A
Relative Operating Cost	Low	High	High	High	Very High	Low	Low	Medium	Medium	Medium
Relative Maintenance Cost	Low	High	High	High	Very High	Low	Low	Medium	Low	Low
Risks	May be difficult to dispose of sludge in unusual water quality circum-stances	Difficulty in managing regeneration chemicals and process, and the handling and disposing of brine waste	Difficulty in managing regeneration chemicals and process, and the handling and disposing of brine waste. May be difficulties in disposing of media if media replacement strategy used.	Media may be very expensive, have a short life and be difficult to dispose of.	Reject water may be very difficult to dispose of. May be complex if pre-and post-treatment become excessive. Expensive to operate.	Sludge volumes are large and may represent a disposal problem.	Sludge volumes are large and may represent a disposal problem.	Micro-filtration technologies can be sophisticated and their maintenance can be complex. May be difficult to dispose of sludge.	Most conventional filtration technologies require development of well developed flocs or filtration will be inadequate. May be difficult to dispose of sludge.	Simple oxidation may not be sufficient to capture As or flocs that are formed will not be easily removed by filtration process. May be difficult to dispose of sludge.