AD26 Systems for Iron, Manganese, Sulfide and Arsenic Removal

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Q: What is the AdEdge AD26 System?

A: The AD26 system is a pre-engineered, packaged treatment system specifically designed as a new alternative for iron, manganese and arsenic removal from drinking and process waters. It utilizes AdEdge's AD26 solid phase manganese dioxide media in conventional pressure vessels similar to AdEdge's Adsorption Package Units for contaminant removal. The systems are skid mounted packaged or modular systems with integrated with automatic backwashing, control valves, and a control panel with pressure gauges, flow meters / totalizers, sampling valves, and other instruments for a complete treatment unit. The technology is being deployed for a variety of contaminants including Iron, Manganese, Arsenic, Sulfide, and Radium.

Q: How does it differ from other iron removal processes such as Manganese Greensand, Conventional iron Filtration methods, or Water Conditioning?

A: The process incorporates a well graded, clean, NSF 61 certified solid phase oxidation mineral with a high catalytic activity for oxidation and removal of the target contaminants. The systems offer:

- Significantly smaller footprint and space requirements compared to other technologies;
- Higher design flow rates of 9-12 gpm / square foot of bed area, typically 3 times that of conventional technology;
- The technology does not require long contact time, large volume contactors, coagulants, or permanganate addition/regeneration;
- No brine or salt is required that adds unwanted dissolved solids (TDS) to the water;
- Process does not generate hazardous waste that must be disposed off-site; and
- Less backwash water volume than conventional approaches.

Q: What is the primary mechanism of removal for Iron and Manganese?

A: Iron and manganese are often naturally occurring in a dissolved form in normal groundwater pH ranges as Mn^{+2} and Fe^{+2}. In the presence of an oxidant, these ions are oxidized. Hypochlorite in conjunction with the AD26 catalytic media can further assist in increasing the rate of natural oxidation of these dissolved species to form insoluble products, namely $Fe(OH)_3$, and MnO_2 that can be filtered as shown in the following examples:

$$Mn^{+2} + NaOCl + H_2O \xrightarrow{MnO_2\,(media)} MnO_2\,(s) + Cl^- + 3H^+$$

$$2Fe^{+2} + NaOCl + 5H_2O \xrightarrow{MnO_2\,(media)} 2Fe(OH)_3\,(s) + Cl^- + 5H^+$$

Q: How is Arsenic removed concurrently with Iron & Manganese?

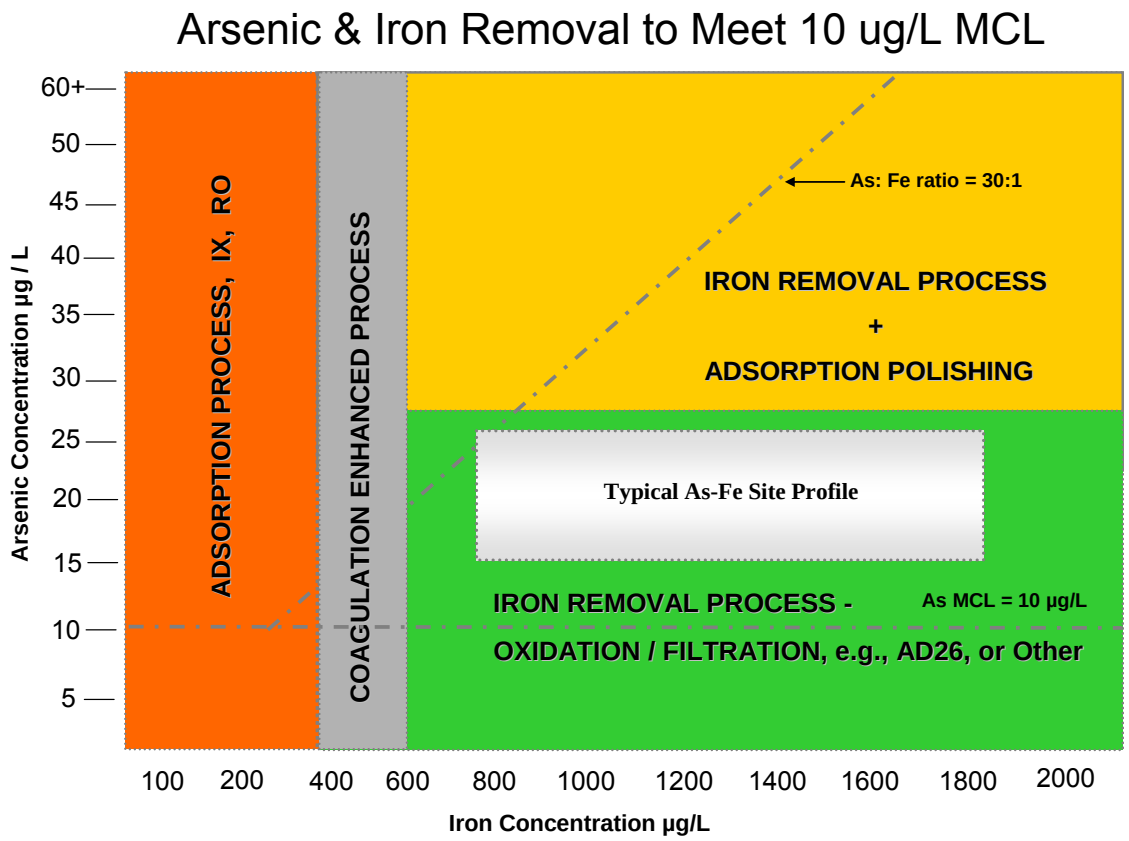
A: Arsenic has a natural affinity for oxidized iron in groundwater. If not designed properly, iron in concentrations above typically 0.3 mg/L can easily foul or inhibit arsenic adsorption media-based processes. The AD26 system provides an oxidizing interface for this natural process to be accelerated and enhanced for removing multiple contaminants. AD26 will readily oxidize Arsenite (As^{+3}) to arsenate (As^{+5}) facilitating removal with iron ($Fe(OH)_3$) to form ferric arsenate $FeAsO_4$.● $2H_20$. This insoluble precipitate is then amenable to removal via filtration by the AD26 media. The efficiencies for arsenic removal are based on the specific water chemistry.

Typically, the higher the iron to arsenic ratio, the greater the removal efficiency. Iron to arsenic ratios of 30:1 with the AD26 process even with a very short contact time can often reduce arsenic by 75-95% (see AdEdge AD26 performance chart in literature). This allows the system to be used as a stand-alone

arsenic treatment solution for situations where relatively low arsenic (10-30 ppb typically), and iron to arsenic ratios and water chemistry is favorable. Where higher arsenic (>30 ppb) and iron concentrations are prevalent, a two-step process using AD26 pretreatment in combination with a Granular Ferric Oxide (GFO) Adsorption module for polishing will be the preferred alternative, particularly to attain the EPA's new drinking water MCL of 10 ppb for arsenic. The following table shows the comparison of AD26 System to a conventional Greensand system:

MEDIA PARAMETERS	**AdEdge AD26 System**	**Manganese Greensand System**
Composition	A natural mined and processed mineral with >80% MnO_2 active ingredient; a non-coated solid matrix with exceptional hardness with superior abrasion and attrition characteristics.	Manganese Greensand is manufactured by coating particles of a mined mineral, glauconite, with manganese oxides. The coating provides the catalytic properties. The coating slowly wears off over time, reducing the capacity of the media.
Certifications	NSF 61	None
Density	120 lbs/cu ft	85 lbs/cu ft
Mesh size	20x40	16x60
Typical Media depth	30-36 inches	28 inches
pH range	6.5 to 9.0	6.5 to 8.5
Media preparation required	None	4 hour regeneration with Potassium Permanganate ($KMnO_4$) chemical and long rinsing period and backwash to remove excess chemical and media fines.
SYSTEM PARAMETERS		
Service Flow rate (design sizing)	8 to 12 gpm/ft^2	2 to 5 gpm/ft^2
Approx Footprint of a 150 gpm system	45 sq feet (average 60% less area)	120 sq ft
Preoxidation required for continuous process	Chlorine only; immediately before the AD26 media based on Fe, Mn, S content; provides disinfection also. No hazardous $KMnO_4$ chemical required.	Potassium permanganate ($KMnO_4$) and chlorine recommended for best results. Chlorine is required for iron and disinfection.
Potassium Permanganate	None required, not used	Required continuous or intermittent
Potassium Permanganate concerns	None	Haz. material requires special handling; strong oxidizer, consistent dosing can be issue, Mn bleed & red water
Backwash flow	18-20 gpm/ft^2)	12-16 gpm/ft^2)
Backwash rate for typical 150 gpm system	98 gpm	214 gpm
Backwash duration	10 minutes	12-15 minutes
Rinse following BW	1-2 minutes	3-5 minutes
Total Quantity of BW Water per event for 150 gpm system (example)	3,504 gallons (12 min cycle) (average 61% less water)	9,600 gallons (15 min cycle)
Media Contact time (typical)	1.5 to 2.5 minutes @ Fe < 5 mg/L	3.5 to 8.5 minutes (Fe < 5 mg/L)
Additional media needs	None	0.35 to 0.4 m layer of anthracite on top of manganese greensand recommended for best results.
Key Water Quality Parameters	pH, Fe, Mn, As, Hardness, Alkalinity, TOC, TSS	pH, Fe, Mn, As, Hardness, Alkalinity, TOC, TSS
Useful life	>10 years typical	Not given
Performance Guarantee	Yes	No

When using the AD26 technology for co-contaminant arsenic and iron removal, the following application chart can be used for guidance:



Q: Is Backwashing required and how frequently is this performed?

A: Like other filtration technologies where iron and manganese are removed, periodic backwashing of the media is a function of throughput over time and incoming concentrations of iron and manganese. Backwashing serves the main purpose of evacuating the bed of co-precipitated (insoluble) and filterable iron and manganese particulates. If not backwashed, the system can experience pressure losses and reduced performance. Typical backwashing frequency is 2-3 times per week for 10 minutes per vessel. Backwashing is performed automatically by the system controls based on a set number of days, gallons, or differential pressure. Specific backwashing parameters for AD26 systems are configured in the field based on water quality and usage patterns; however, backwashing typically is performed when differential pressure of 8 psi is reached across the bed. Backwashing is normally performed at a rate of 18-20 gpm / square foot (see Table). Either feed water or treated water can be utilized for backwashing purposes. *The AD26 process generates significantly less quantity of backwash water compared to conventional methods of iron/manganese removal.*

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Q: What are the physical/chemical characteristics of the backwash water?

A: The backwash water consists of two phases: a filterable solid precipitant or oxide and a liquid portion. Since the feed water is typically used for backwashing, the backwash water liquid portion (99+%) will bear similar qualities to the feed water. Very little soluble iron, manganese or arsenic is present. The other fraction consists of a filterable and co-precipitated ferric hydroxide, manganese oxides, and ferric arsenate where arsenic is co-occurring. The Table below is an analysis of various parameters from

actual full scale adsorption or AD26 systems where iron, manganese or arsenic were present in the feed water with the vessels being backwashed on a periodic basis. Soluble constituents (as seen from the backwash data) are typically very low and often at or below incoming concentrations.

Backwash Water Composition
Iron, Manganese, and Arsenic Co-Occurance

Site	Analysis - Raw Water Influent			Analysis - Backwash Water (filtered)		
	Fe (PPB)	**Mn** (PPB)	**As** (PPB)	**Fe** (PPB)	**Mn** (PPB)	**As** (PPB)
Site A	80	< 50	51	18	NR	< 25
Site B	898	135	39	25	23	21
Site C	240	230	N/A	310**	300**	N/A
Site D	126-260	15	14	< 25	13	7
Site E	1,300	25	35	< 30	7	2

** Unfiltered Backwash sample only available

Q: What are appropriate ways to manage the backwash water?

A: First, the backwash water itself is non-hazardous per RCRA hazardous waste regulations since it does not exhibit the characteristic of toxicity (leachable arsenic > 5 mg/L per the TCLP test).

The three most common methods for managing backwash water from iron/manganese plants are as follows:

1. Direct discharge to sanitary sewer or Publicly owned Treatment Works if available;
2. Discharge to a septic drain system, drainage ditch or wastewater surface impoundment or plant following filtration (separation of filterable suspended solids); or
3. Recycle of the backwash water.

All three options have been implemented successfully by AdEdge on full scale projects. Option 1 is the simplest and preferred if a sewer connection exists. However, many rural small system locations do not have sewer connections and must consider other options.

Options 2 and 3 are easily implemented, but will require an interim filtration step to remove filterable suspended solids (iron or manganese complex). As mentioned, the backwash water will contain a small fraction of solid, insoluble, and mostly settleable suspended solids which can be removed in several ways: For options 2 and 3, the backwash water is most often directed first to an aboveground storage tank where temporary storage is provided and gravity separation can occur. Alternatively, bag filters can be used to remove suspended material before entering the tank. The size of this backwash tank is typically the total volume of a single backwash event and calculated as follows:

(Design backwash flow rate per vessel) x (# vessels in train) x (minutes per backwash/rinse cycle)

Once the settleable solid fraction is separated or settled (less than one hour typically) or otherwise removed, the aqueous portion of the backwash water is generally very acceptable for direct discharge to on-site septic systems, leach fields or other options (state specific guidance applies). Virtually all iron and manganese (and in the case for arsenic removal, the arsenic) is associated with the solid insoluble

fraction rendering the water acceptable. Due to the very low levels of soluble constituents, the water quality should present little to no concern for direct or indirect discharge.

The settled portion (solids) can subsequently be removed from the tank and managed in several acceptable ways as a non-hazardous solid waste. The quantity of this residual will depend on incoming concentrations of iron and other constituents. As mentioned above, the co-precipitated solids will consist of insoluble metal oxides that will not leach arsenic above the TCLP threshold for hazardous waste. Industry experience and testing with similar residuals indicates these solids are suitable for disposal in a non-hazardous municipal landfill. Local regulations should always be consulted as the final authority.

Option 3 involves backwash recycle. This is a viable option whereby filtration and storage is provided similar to option 2, but the supernatant (aqueous portion) is 100% recycled to the head of the treatment system. This can be accomplished manually or completely automatically. The result is 100% of the filtered water re-routed to the treatment system with zero discharge.

Below are pictures of various backwash management systems deployed by AdEdge. Key components include tanks, backwash recycle pumps, bag filters, and controls or PLC.

AD26

Iron, Manganese & Arsenic Removal

AD26 SYSTEM FEATURES AND OPTIONS

Standard Features

* Twin Composite Vessels
* Carbon Steel Skid Mounted System
* Parallel Tank Configuration
* Hub and Lateral Collection System
* Gravel Underbedding
* AD26 Manganese Dioxide Media
* Automatic Flow Control Valves
* SCH 80 PVC Piping
* Sample Valve Ports
* Pressure Gauges & Differential Pressure Switch
* Automatic Backwashing and Manual Isolation
* Programmable Timer or Pressure Differential Activated Backwash
* Instrument Panel for Mounted Instruments
* Flow Meters and Totalizer
* Epoxy Lined Vessels

Skid Mounted with Composite Tanks and PLC

Modular with Composite Tanks

Optional Features

* Carbon Steel Vessels
* Modular Systems with Smaller Footprint
* Lead / Lag Series Configuration
* Stainless Steel, Galvanized & Carbon Steel Piping
* Programmable Control Logic (PLC)
* Influent Y-Strainer(s)
* Triple or Quadruple Treatment Train
* Manual Flow Control Valves
* Chlorine or pH Adjustment Modules
* Sediment or Pre-filtration Modules
* Remote Monitoring, Telemetry, or Alarms
* Optional Backwash Recycle System
* Other process component integration with PLC

Skid Mounted With Carbon Steel Vessles and Automated Valve Harness

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