

Mining Waste-Water Treatment

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PASSION FOR CHEMISTRY

Types of Mining

Mining operations require large amounts of water and they produce large amounts of waste water that needs to be treated for recycling or before discharge to the environment.

Mineral/metal type	Water use
Coal 	
Copper 	
Diamond 	
Gold 	
Nickel 	
Iron ore 	
Platinum 	

Key:  High  Medium high  Medium low

Basic Pollutants

- Sediment
- Heavy Metals (Cu, Zn, Hg, As, Cd,)
- Sulphuric acid/nitrates in case of rocks containing Sulphides/nitrates
- Cyanide pollution in Gold processing/mining
- TDS
- Acids

- The target water pollutants include high pH, toxic metals (i.e. lead, mercury, cadmium, and hexavalent chromium) and metalloid (i.e. arsenic), radionuclides (i.e. uranium and selenium), organic contaminants (i.e. chlorinated organic pollutants, benzene and polycyclic aromatic hydrocarbons), and nutrients (i.e. nitrogen and phosphorus).

Basic Treatment Processes

Leachate/Wastewater can be treated by:

1. Biological processes, such as aerobic activated sludge to remove BOD and/or nitrify ammonia
2. Physicochemical and electrochemical processes are used to remove metals, SULPHIDES, among other pollutants.
3. Membrane separation (MBR) is an effective method for clarifying mixed liquor produced during biological treatment.
4. RO technology is effective for removing TDS (dissolved salts) and heavy metals
6. pH correction
7. Pond Settling
8. Adsorbents

Screening/Micro-filtration/Sediment Removal

- Screening is the first step in the treatment process to remove larger rocks
- Sediment needs to be removed, lamella clarifiers/decanter are used
- Sulphides can be removed via precipitation
- pH can be adjusted using alkaline chemicals
- Ceramic membranes can remove SS and some colloids and tolerate extreme pH
- Sometimes DAF Dissolved Air Floatation is used

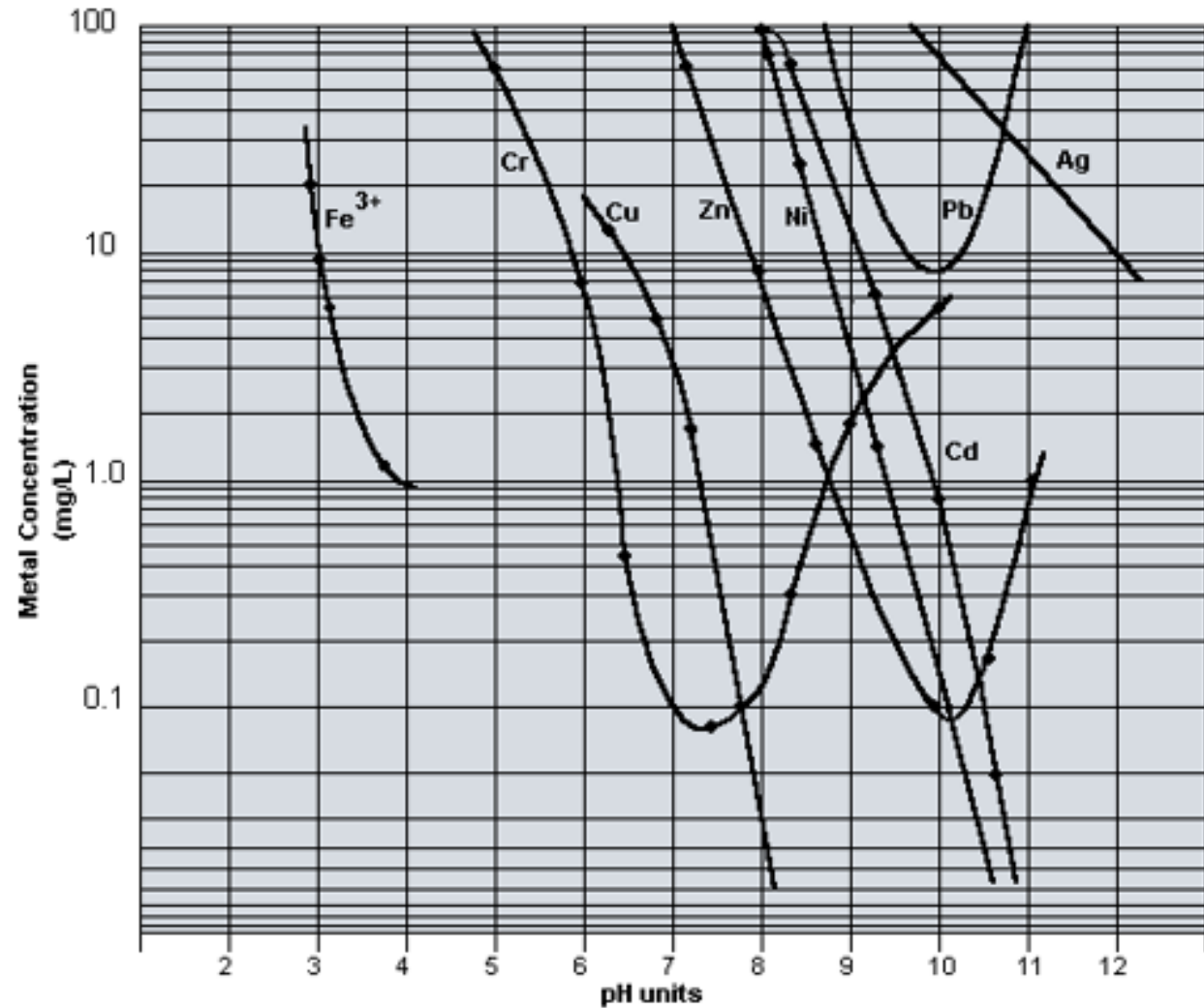
Oil Water Separation

- For removal of oil/BTEX from MINING waste-water, gravity separation processes can be used such as API/CPI filters
- Ceramic membrane filtration is also an effective polishing technique to remove colloidal Oil/SS
- DAF = Dissolved Air Filtration is also a very effective technique for separating oils and FOG from leachate waste water

Coagulation/Flocculation/Settling Clarification

- Coagulants are effective chemicals to coagulate colloidal suspended substances
- Flocculants are effective polymers for coalescing coagulated solids into larger heavier settleable particles as well as thickening sludges
- High pH clarification is an effective technique for removing heavy metals and hardness from the wastewater
- Settling is improved using lamella

pH Curves for Metal Hydroxides



Biological Treatment

- Biological treatment is very effective at using bacteria to break down biodegradable organic pollutants
- A variety of technologies are available such as:
 - ASP: activated sludge process
 - MBR: a combination of ASP and Membrane filtration to separate the solids
 - RBC: Rotating Biological Contactors
 - SBR: Sequence Batch Reactors
 - Trickling Filters
 - Aerated lagoons if land is available

Electrochemical Heavy Metal/Anion Removal

- P2W.co : Pollution To Water – reduce heavy metals in water and deposit them on electrodes
- Gothenburg Centre for Sustainable Development
- Reactions Competing:
 - $\text{H}^+ + \text{e}^- \rightarrow \text{H}_2$ gas (reduction on the cathode)
 - $\text{M}^+ + \text{e}^- \rightarrow \text{M}(\text{s})$ (reduction on the cathode)
 - $\text{SO}_4^{2-} \rightarrow \text{S} + \text{O}_2 + \text{e}^-$ (oxidation on the anode)
 - $\text{CN}^- \rightarrow \text{C} + \text{N}_2 + \text{e}^-$ (oxidation on the anode)
 - $\text{OH}^- \rightarrow \text{O}_2 + \text{H}^+ + \text{e}^-$ (oxidation on the anode)

Ion Exchange

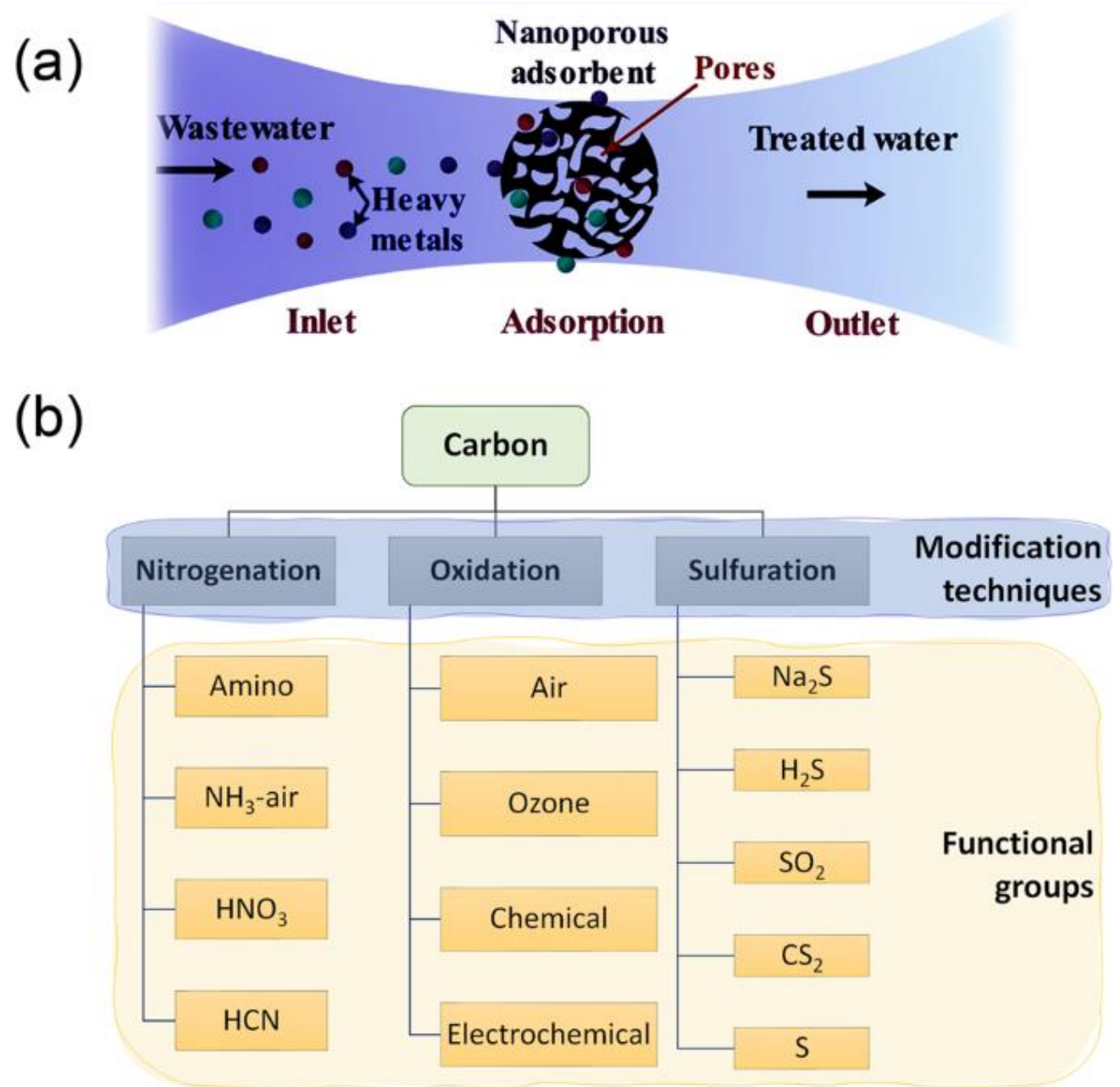
- Ion exchange is a proven method to remove cations and anions from water
- Heavy metals are exchanged for Na^+
- Resin Requires regeneration with NaCl

GAC Filtration/PAC

- GAC filtration is very effective in removing smaller organic molecules such as persistent organic compounds/emerging chemicals of concern/colour molecules that are hard to remove through coagulation/flocculation/settling clarification
- PAC can also be added to clarifiers to remove COD
- Active Carbon also has the ability to adsorb some heavy metals

Adsorption

Different adsorbents can be used
Such as Active Carbon,
Zeolites, Clays
Chitosan, Green sand.



Reverse Osmosis

- RO is a proven technology that can remove TDS and heavy metals from leachate waste-water
- However, careful pre-treatment or OEM technologies for bio-fouling/fouling control are needed otherwise the OPEX costs will spiral out of cost for membrane replacement/CIP.

pH Correction

- If after clarification/settling with high pH, the pH needs to be lowered, an acid needs to be dosed.
- Several acids are possible to use:
 - H₂SO₄ – cheap but adds Sulphates to the water
 - HCl – cheap but adds chlorides to the water
 - CO₂ bubbling -expensive but environmentally friendly
 - Acetic acid/citric acid – environmentally friendly and biodegradable
 - Phosphoric acid – relatively cheap but adds P in the water
- If the waste water is acidic, basic chemicals can be added such as Lime, Calcium Carbonate or NaOH

Cyanide Removal

- Cyanide can be removed from wastewater using a variety of methods, including adsorption (AC), chemical or electro oxidation, precipitation, and ion exchange.

Chemical Method (simplified): $\text{CN}^- + \text{OCl}^- \rightarrow \text{CNO}^- + \text{Cl}^-$

pH dependence: This reaction occurs most efficiently at high pH levels (typically above 10) where the hypochlorite ion is readily available.

Further oxidation:

Second stage: To completely destroy cyanide, the formed cyanate can be further oxidized with additional chlorine at a slightly lower pH to produce carbon dioxide (CO_2) and nitrogen gas (N_2) as final products.

Bio-recovery of Copper

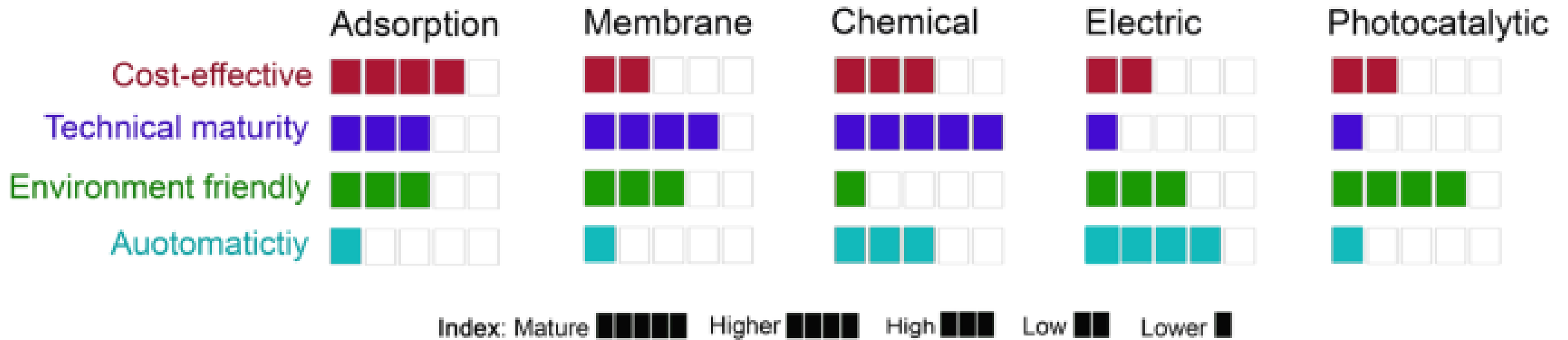
- *Acidithiobacillus ferro-oxidans* is a major participant in consortia of microorganisms used for the industrial recovery of copper (bioleaching or biomining). It is a chemo-litho-autotrophic, γ -proteobacterium using energy from the oxidation of iron- and sulfur-containing minerals for growth.

Sludge Treatment

- Silt removal through settling, Coagulation/Flocculation and Biological processes produce large amounts of sludge
- Sludge is thickened using polymers
- The Sludge is then dewatered using filter presses or centrifuges.

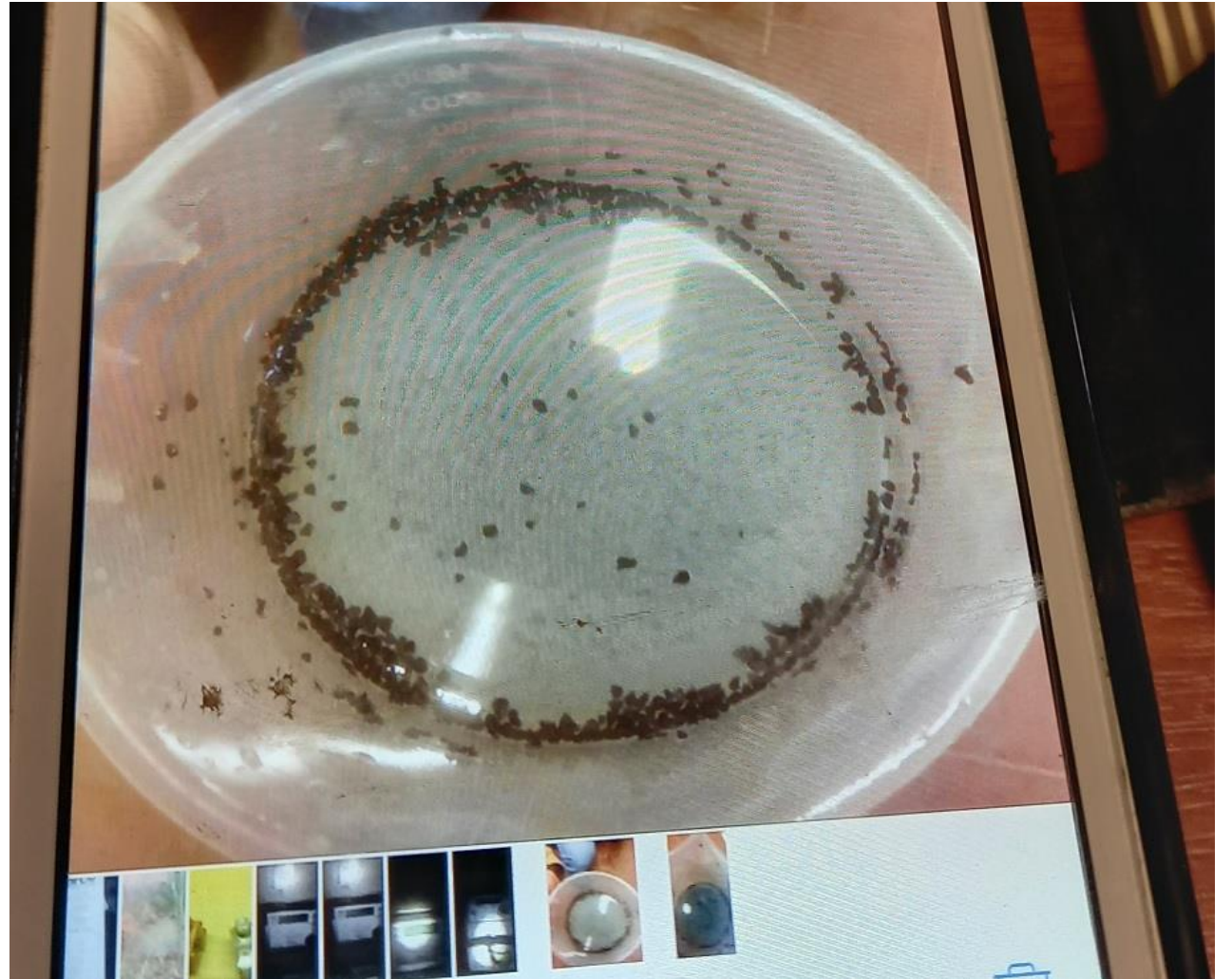
Comparison of Different Techniques

Methods of wastewater treatment



KEC Pilot Testing at Pink Bank Landfill Site, Midlands UK

- Onsite Experiment Conducted on Saturday 20th February 2021 – United Utilities Pink Bank Landfill Site
- Excellent colour/COD removal and floc formation with jar test single pot reaction with GAC and NaOH
- The feed water was a yellowish, murky sample.
- Ammonia can be degassed at high pH



References

- https://en.wikipedia.org/wiki/Sulfate-reducing_microorganism
- <https://arviatechnology.com/wastewater-treatment/> - Nyex Technology – Adsorption and in-situ electrochemical oxidation using .OH radicals.
- <https://ide-tech.com/en/blog/mine-the-gap-mine-water-treatment-solutions/>
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For More Information

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