The times are changing….
New Regulations force us to look at new options to manage:
*By-products

Any differences between the chemicals we use and how to get improved results?
TTHM and HAA5 Reduction

Stage 2 DBPR……IT’S HERE…… and has been put into effect to reduce potential cancer, reproductive and developmental health risks from disinfection byproducts (DBP’s) in drinking water. Research on the use of H2O2 for this application is documented as early as the 1970’s, with actual implementation in North American municipalities over the past several years.
As simple as it may seem, the treatment of contaminated waters is as diverse and complicated as the operations from which it comes. In today's environment, where merely transferring contaminants from one medium to another is no longer acceptable.
It is no surprise that a powerful oxidizer that looks like water -- in its appearance, chemical formula and reaction products -- should be so widely used. This is hydrogen peroxide (H2O2) -- a powerful yet versatile oxidant that is both economical & effective.
H$_2$O$_2$ ADVANTAGES

- *Powerful* - H$_2$O$_2$ is one of the most powerful oxidizers known -- stronger than chlorine, chlorine dioxide, and potassium permanganate. And through catalysis, H$_2$O$_2$ can be converted into hydroxyl radicals (·OH) with reactivity second only to fluorine.
<table>
<thead>
<tr>
<th>Oxidant</th>
<th>Oxidation Potential, V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorine</td>
<td>3.0</td>
</tr>
<tr>
<td>Hydroxyl radical</td>
<td>2.8</td>
</tr>
<tr>
<td>Ozone</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Hydrogen peroxide</strong></td>
<td><strong>1.8</strong></td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>1.7</td>
</tr>
<tr>
<td>Chlorine dioxide</td>
<td>1.5</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Safe to the Environment - Despite its power, H2O2 is a natural metabolite of many organisms, which decompose the H2O2 they produce into oxygen and water. H2O2 is also formed by the action of sunlight on water -- a natural purification system for our environment.
H₂O₂ has none of the problems of gaseous release or chemical residues that are associated with other chemical oxidants. And since H₂O₂ is totally miscible with water, **the issue of safety is one of concentration**.
Municipal wastewater applications in the 1970's; industrial waste/wastewater applications in the 1980's; and more recently, air applications in the 1990's. Today, H2O2 is readily available throughout the U.S. in drum, tote, mini-bulk, and bulk quantities in concentrations of under 35%, 35% or 50% by weight.
End Uses for Hydrogen Peroxide

- Landfills
- Food processing
**Organic oxidation** - Hydrolyzes formaldehyde, carbon disulfide, carbohydrates, organophosphorus and nitrogen compounds, and various water-soluble polymers; and (with catalysis) destroys phenols, BTEX pesticides, solvents, plasticizers, chelants, and virtually any other organic requiring treatment.
Metals oxidation - Oxidizes ferrous iron, manganese....(be careful), arsenic, and selenium to improve their adsorption, filtration, or precipitation from process waters and wastewaters.
Enhancement (Combination) Applications

*Flocculation|precipitation* - Oxidizes metal complexes and improves the performance of inorganic flocculants
Activation of H2O2 in these applications may be affected by

> adjustment/control of pH,
> temperature
> reaction time.
The primary factors contributing to H2O2 decomposition include:

> Increasing temperature
  (2.2 factor increase for each 10 deg-C)
> Increasing pH (especially at pH > 6-8)
> Increasing contamination
  (especially transition metals such as copper, manganese or iron)
> To a lesser degree, exposure to ultraviolet light.
Catalytic H2O2 - The more difficult-to-oxidize pollutants may require the H2O2 to be activated with catalysts

> iron, copper, manganese, and other transitional compounds
• Solution catalysis
  > The most commonly used solution catalyst is iron
  > when used with H2O2 is referred to as Fenton's Reagent. The reaction requires a slightly acidic pH
  > results in the formation of highly reactive hydroxyl radicals (\cdot \text{OH}) which are capable of degrading most organic pollutants.
The effect of pH on reaction efficiency is illustrated below:

The optimal pH occurs between pH 3 and pH 6. The drop in efficiency on the basic side is attributed to the transition of iron from a hydrated ferrous ion to a colloidal ferric species.
Many metals have special oxygen transfer properties that improve the utility of hydrogen peroxide.

➢ Most common of these is iron (e.g. Fe+2) which, when used in the prescribed manner, results in the generation of highly reactive hydroxyl radicals (•OH).
Lower PH??
...isn’t that corrosive?

How do I get the best possible reaction and protect my Water from corrosion?

- Side stream addition
- Use of Polyphosphate
- Clarus successes (fe/mn/corrosion management)
Thank you for your time and attention
Carbon

.....Just the Polish your system may need
RAW MATERIALS FOR ACTIVATED CARBON

Any substance having a high carbon content can be used.

* Peat
* Hard Woods
* Lignite Coal
* Wood Chars
* Nut shells

* Olive Stones
* Soft Woods
* Bituminous Coal
* Coconut Shells
* Fruit Pits
AN OVER-SIMPLIFIED CARBON POROUS
RAW MATERIAL & PORE SIZE DISTRIBUTION

CARBON SOURCE AND TYPICAL PORE SIZE DISTRIBUTION

Pore Volume (cm$^3$ P.V. / cm$^3$ Carbon)

Coconut Shell
Coal Based
Lignite Based

Micropores
Mesopores
Macropores
MOLECULAR & RELATIVE SIZE

- 2Å, $\text{Cl}_2$ (Chlorine) or $\text{I}^-$ (Iodine) molecule
- 4Å, CO (carbon monoxide) molecule
- ~ 9Å, MIB and Geosmin molecule
- 13Å, 1000 MW compound (NOM & TOC)
AN OVER-SIMPLIFIED CARBON PORE
Most Common Causes:

**Geosmin**  (trans-1.10-dimethyl-trans-9-decalol)

**MIB**  (2-methylisoborneol)

They are metabolites of actinomycetes and blue-green algae with a human odor threshold of 10 parts per **TRILLION**

They contribute an earthy musty flavor and odor in surface water sources such as lakes and reservoirs.

They are a major problem during in warm seasons.
80 ng/L MIB, 0 mg/L TOC water
COMPETITIVE ADSORPTION
MIB ADSORPTION W/ BACKGROUND TOC

Performance ranking at 20 ppm PAC

(80 ng/L MIB, 12 mg/L TOC water)
COMPETITIVE ADSORPTION
GEOSMIN ADSORPTION W/O BACKGROUND TOC

Performance ranking at 20 ppm PAC

(80 ng/L Geosmin, 0 mg/L TOC water)
COMPETITIVE ADSORPTION

GEOSMIN ADSORPTION W/BACKGROUND TOC

(80 ng/L Geosmin, 12 mg/L TOC water)
### Advantages

<table>
<thead>
<tr>
<th>C Long Contact Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>C No Flocculant Effect</td>
</tr>
</tbody>
</table>

### Disadvantages

<table>
<thead>
<tr>
<th>D Competitive adsorption w/ NOM’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>D Location often Remote</td>
</tr>
<tr>
<td>D Oxidant Reduction and oxidant effecting adsorption</td>
</tr>
</tbody>
</table>
COMMON FEED POINTS FOR POWDERED ACTIVATED CARBON (PAC)

RAPID MIX

Advantages

C Best Mixing

C Convenience

Disadvantages

D Maximum flocculant interference

D Oxidant reduction
# Common Feed Points for Powdered Activated Carbon (PAC)

## Clarifier

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Good contact</td>
<td>D Late in treatment process</td>
</tr>
<tr>
<td>C Minimal competitive adsorption</td>
<td>D Carryover to filter <em>(see notes)</em></td>
</tr>
<tr>
<td>C Less flocculant effect</td>
<td>D Poor mixing</td>
</tr>
<tr>
<td></td>
<td>D Biological regrowth ?</td>
</tr>
</tbody>
</table>
COMMON FEED POINTS FOR POWDERED ACTIVATED CARBON (PAC) FILTERS

Advantages

C Most effective use of carbon
C Highest capacity utilization

Disadvantages

D Breakthrough
D Pressure drop
D Frequent backwashing
SURFACE AREA

Iodine Number

- Milligrams of iodine adsorbed per gram of carbon at 80% removal from a 0.1N iodine solution.
- Correlates to surface area
- Adsorptive capacity test, isotherm test, near equilibrium test, uses milled carbon.
- Indicates carbon’s ability to adsorb very low molecular weight compounds.
FORMS OF ACTIVATED CARBON IN WATER TREATMENT

**Powdered Activated Carbon (PAC)**

Activated Carbon milled to particles <100 mesh (0.15 mm)
Particle sizes can be extremely fine similar to baby powder

**Features/Benefits**

- Limited capital costs (dosing equip)
- Low cost per pound
- Dosage can be varied to meet treatment needs
- Used seasonally
- Greater flexibility of treatment (injection) point

**Drawbacks**

- Can be messy and difficult to store and use
- Becomes sludge
MAKE YOUR JOB A LITTLE MORE SIMPLIFIED WITH THORNSORB LIQUID CARBON
Proper management using the right monitoring tools and control Systems can help with obtaining the desired results

- Use what you can to reduce precursors
- Corrosion control products/polyphosphates
- Ph adjust using approved chemicals & control system
- Streaming current monitors
- Organic monitoring equipment
Last but not Least.....
Now it is time to put it all together & know where we at in our efforts to secure the results we Want & Need
Response Factors

- RW TOC: increasing
- SCD signal: dropping
- Alum dose: increased, leveling off SCD signal

Data provided by Scott Rovanpera, from the City of Benicia
UV 254nm is an indicator of natural organic matter (NOM) due to the strong absorption properties of most dissolved organics at UV 254nm.
Thank You for your time and attention