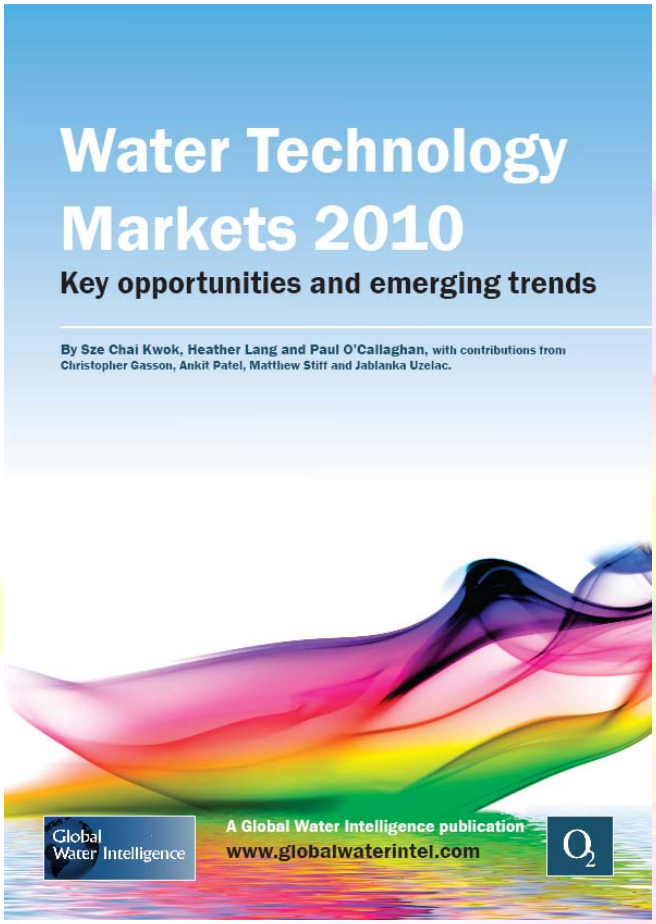

Advanced Water Treatment Technology Markets

Dr. Andreas Kolch

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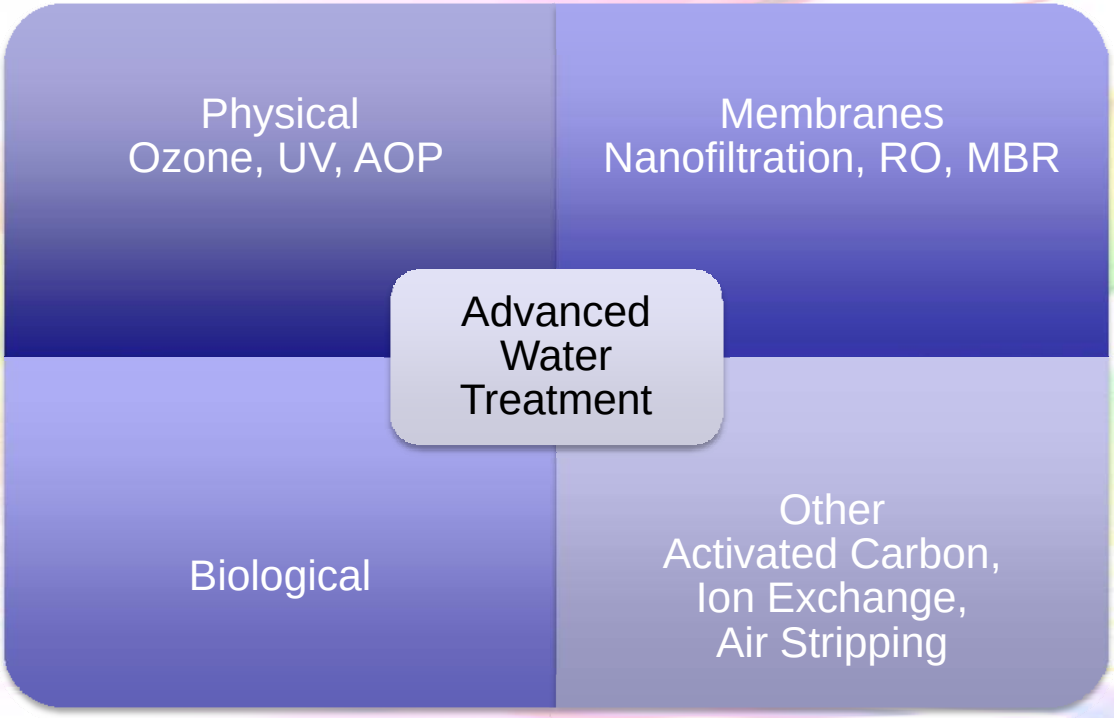
Whatever you do:
Don‘t look at your Smartphones, please !!

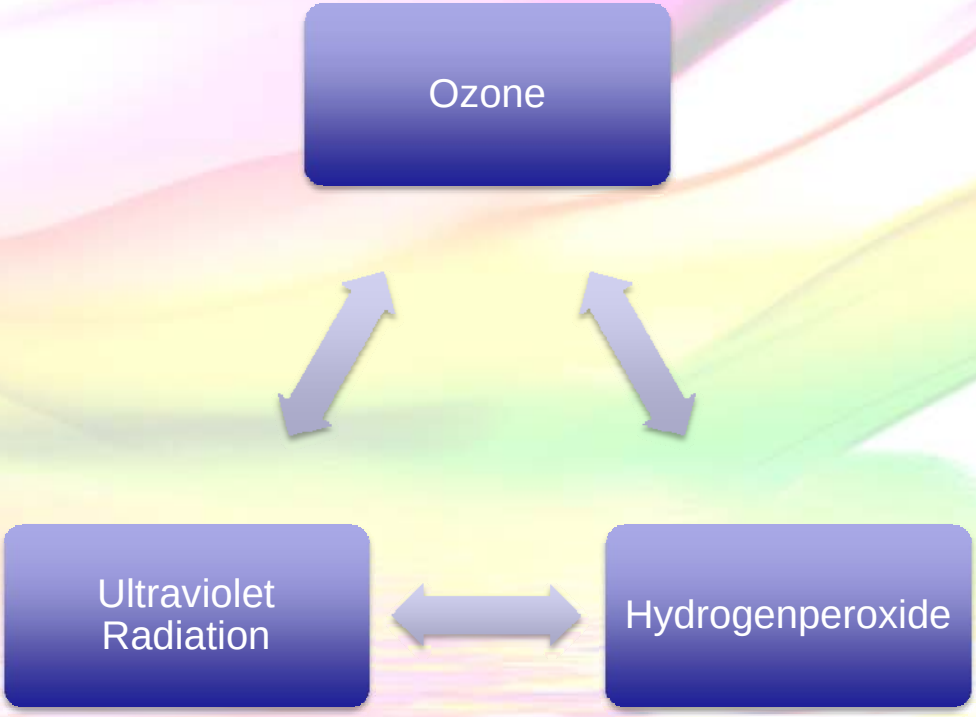
What it is

Water Treatment Technology Arenas

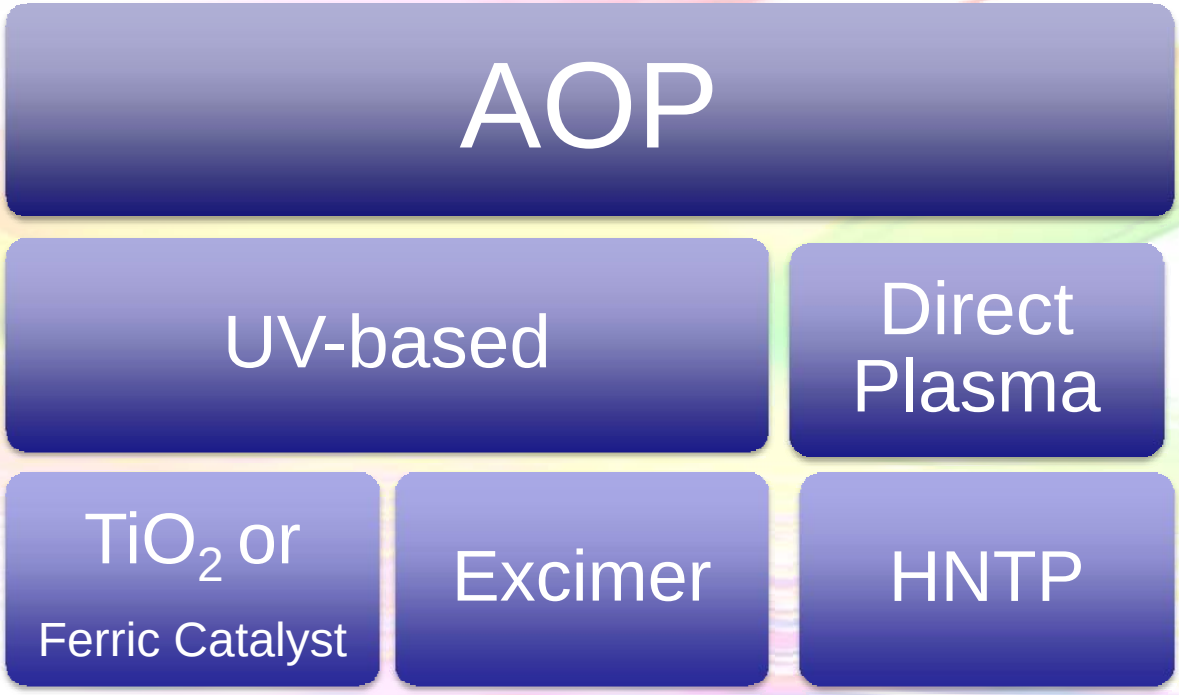
Advanced Water Treatment Technologies



Advanced Oxidation Processes



Other AOP Processes; non commercialized yet



Water Treatment Technology Arenas

Drivers

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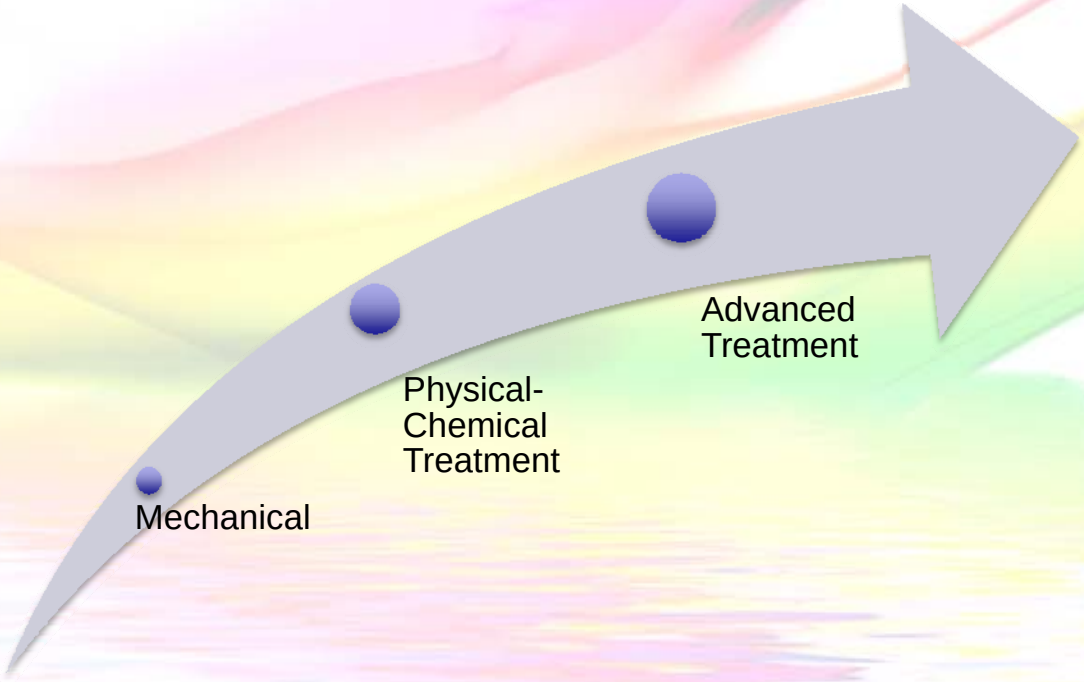
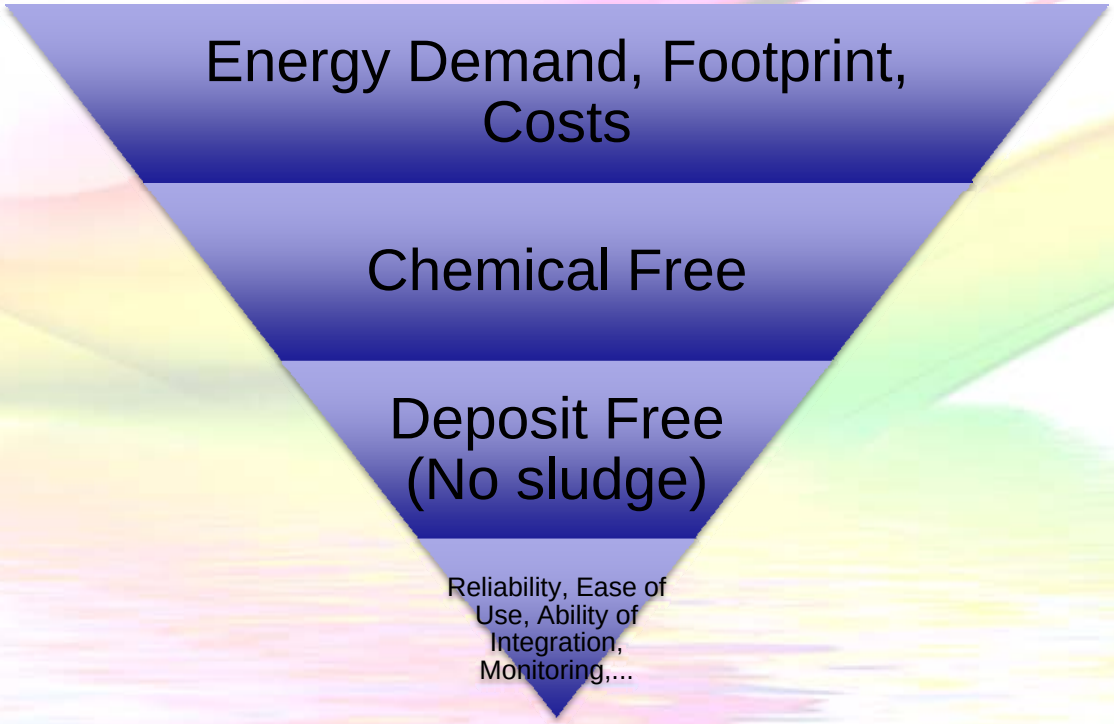
Development of Innovation



Key Success Criteria



Summary of Drivers

- Legislation
- Water scarcity together with closed wells
- Re-use requirements
- Fantasy: Pharmaceuticals, Endocrine Disrupting Components

Why do customers chose AOP ?

- Good history over last decade, especially with disinfection
- Excellent removal performance
- High degree of integration into existing water treatment trains, e.g. can provide disinfection and oxidation at the same time
- Chemical, sludge and brine free
- Plasma technologies are perceived as being highly innovative
- Low footprint and civil cost requirements
- Other cost elements highly site specific

Market Size

Step Back: What is the market ?

Regulated Organics	Regulated Inorganics	Non Regulated Organics
• Pesticides • TCE, MTBE, Phenol, NDMA	• N and P removal • Metals	• T&O (Geosmin, MIB) • Endocrine Disruptors

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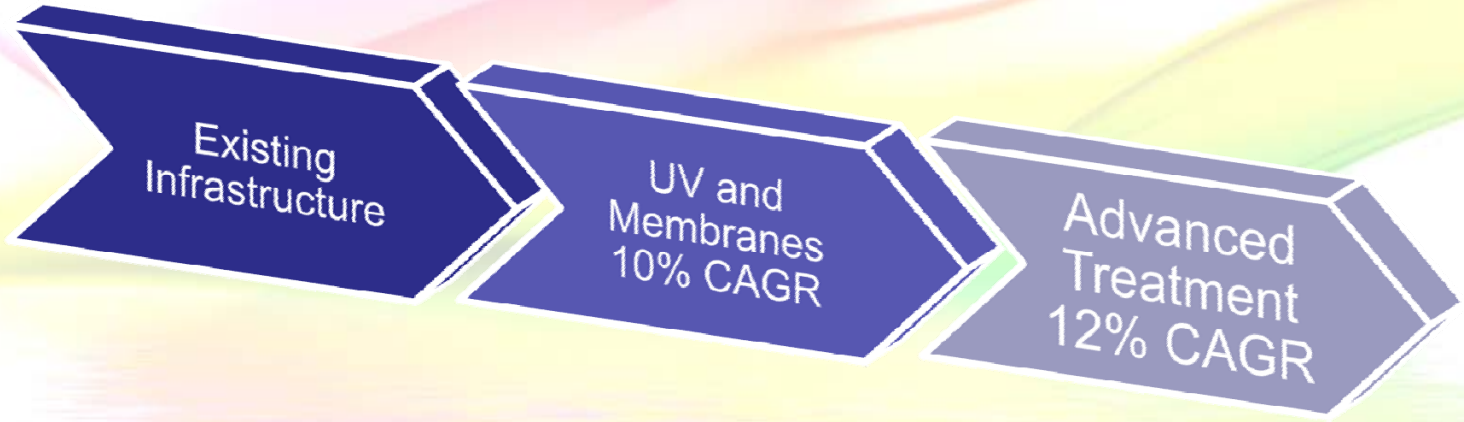

MTBE Market
AWWA Water Utility Council, 2005

- **25 Bill $ for the US at 5 ppb MTBE (odor and taste threshold; SMCL in CA)**
- **85 Bill $ for lower treatment goals**
- **Costs are including public wells only; excluding private wells and leaking underground storage tanks (LUST)**
- **Private wells and LUST would increase the market by a factor of 3.5**

Completed and ongoing projects are reported at:
www.cluin.org/products/mtbe

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Other Figures

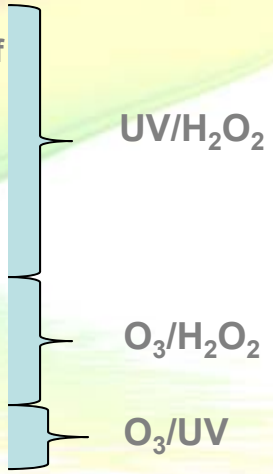
GWI 5.6 Bill$ for AT until 2015

GWI 270 Mill $ for AOP until 2016

Own estimate: 120-150 Mill $ now

AOP Project Examples

- 100 MGD system installed for reuse at OCWD for removal of NDMA and 1,4 Dioxane
- 50 MGD system installed for drinking water treatment at City of Aurora, CO for removal of various contaminants. CH2MHill picked UV/H2O2 in favor of RO
- 20 MGD system installed at Andijk, PWN, The Netherlands for removal of pesticides. This is the largest system in Europe
- 26 MGD system installed at Cornwall for removal of MIB (T&O application)
- 5 MGD system installed at Salt Lake City for NDMA removal
- MTBE and TBA removal for Lake Tahoe
- 1,4 Dioxane removal for San Gabriel Basin Water Quality Authority's Ground an Drinking Water Supply
- 30 MGD Wichita, Kansas removal of endocrine disrupting compounds and disinfection of surface water



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New Projects ?

Cincinnati is probably looking for 240 MGD (MTBE).

City of Duebendorf, Switzerland undertakes WW pilot trials with ozone.

Thames Water and Severn Trent Water assessing risk of endocrine disrupting substances and potential treatment options.

Verona WWTP Italy published study about AOP for the removal of endocrine disrupting compounds in Water Science and Technology; 61, No 7 2010

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Trends from Water Science and Technology: AOP within the last 12 months

- **Tertiary treatment of SLAUGTHERHOUSE EFFLUENT: degradation kinetics applying UV radiation or H_2O_2/UV; 60/7, 2009**
  BRAZIL AND GERMANY
- **The impact of groundwater quality on the REMOVAL OF MTBE using advanced oxidation technology; 60/8, 2010**
  SAUDI ARABIA
- **Advanced oxidation for INDIRECT POTABLE REUSE: a practical application in Australia; 60/9, 2009**
  AUSTRALIA
- **Photo degradation of CLOROFIBRIC ACID by ultraviolet light irradiation at 185 nm; 60/11, 2009**
  CHINA
- **Efficiency, costs and benefits of AOPs for REMOVAL OF PHARMACEUTICALS from the water cycle; 61/4, 2010**
  GERMANY
- **Oxidation of COSMETIC WASTEWATERS with H_2O_2 using a Fe/γ-AlO_3 catalyst; 61/6, 2010**
  SPAIN

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Market Players

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Advanced Water Treatment Companies

Ozone	AOP	Membranes	Activated Carbon	Biological	Ion Exchange
•ITT, Fuji, Degremont	•Trojan, Calgon Carbon, APT, Purifics	•Dow, ITT, Suez, Koch, GE, Hydronautics	•Calgon Carbon, Norit, Siemens	•Kurita, GE, Wehrle, Doosan, Bluewater Bio	•Lanxess, Orica, Remco, Dow

Advanced Water Treatment Companies
Blue Tech Tracker

BlueTech Tracker™ - Examples of Advanced Water Treatment Companies

Company	Technology Offering	Concept	Disrupto-meter			Development Stage		
			Not Disruptive	Moderately Disruptive	Highly Disruptive	Proof of Concept	Demonstration Scale	Commercial
APT Water	HiPox Advanced Oxidation	Advanced Oxidation Using Ozone	O					O
Puralytics	Shield UV LED	Photocatalytic treatment system using UV LED and Titanium Dioxide for Point-of-use treatment to destroy organics, provide disinfection and metals removal.		O			O	
AquaPure Technologies	Non Thermal Plasma	Advanced Oxidation using a non-thermal plasma to create hydroxyl radicals.		O			O	O
Enpar Technologies Inc.	AmmEL, NitrEL, ESD & ExtrEL	The use of electro-chemical treatment systems for a range of applications including electro-de-ionisation, ammonia and nitrate removal and metals recovery.						O

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Business Models

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AT / AOP is a component / single process sale

Customers can be both end-users and system integrators

Big companies use AOP within own systems

Additional sales can be generated with spares and services

BOT / BOOT / etc. schemes not common

Summary and Conclusion

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Conclusion

Market momentum and growth

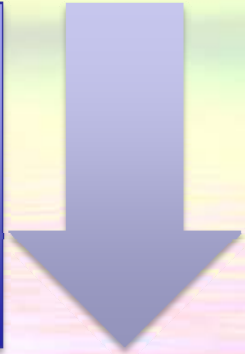
Good exit opportunities in light of big player's strategy swing to reuse

Good add-on to a system integrator

Relative small market overall for AOP only

Strong competition

Not fully regulated market



Advanced treatment has a good growth perspective

Market sizes vary depending on source (AWWA 25 Bill. $ for MTBE only, GWI 5.6 Bill $ for AT until 2015,...); however the market is big enough for every suitable technology and opens room for innovation

Projects costs are very site specific; there is no single "silver bullet" technology

AOP is evolving since it can be combined with other treatment purposes. Innovations have been made and there is still room for more.

Current AOP market in the US per year ca. 100 Mill $. ?!

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Emerging Advanced Treatment Technologies

BlueTech Tracker™ - Examples of Advanced Water Treatment Companies

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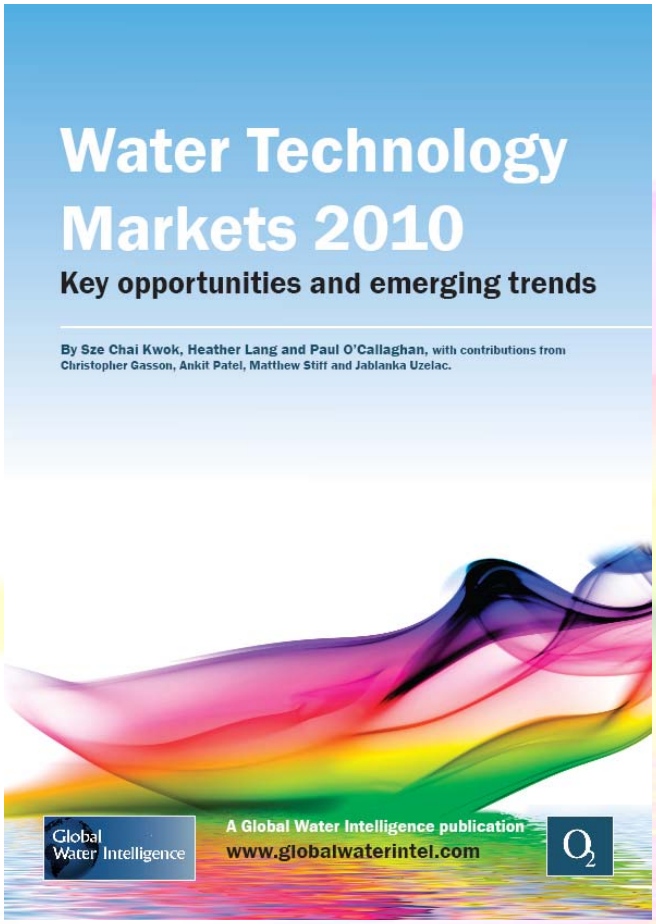

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Backup

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Cost Comparison
MTBE Research Partnership,

Technology	60 gpm,	600 gpm	6000 gpm
Air stripping	1.66-3.2	0.3-1.09	0.13-0.64
Adsorption	2.3-4.61	0.77-2.37	0.30-2.22
Oxidation	2.18-4.11	0,57-2.08	0.32-1.59

$ per 1000 gal MTBE

Cost Comparison
Sutherland et al. Wat. Res. 2004

- **Very similar findings**
- **Air-stripping had the best economy with large flow rates; however not considered was fouling, lower efficiency at lower temperatures and off-gas treatment costs**
- **Activated carbon had highest costs always**
- **Ozone/H_2O_2 were better in 4 of 5 cases in comparison to UV/H2O2; but AOP were able to "win" at lower flow rates**
- **Economic assessment is highly depending on site specific conditions**

Evaluation from City of Pasadena, 1988 (!!)

Cost from low to high:

- **Air Stripping**
- **UV/H_2O_2**
- **Air Stripping and GAC**
- **GAC**
- **UV/Ozone**

Cost from low to high for combinations thereof

- **Air Stripping + Off-Gas AOP**
- **Air Stripping + GAC**
- **Ozone/H_2O_2 + Air Stripping + GAC**
- **Ozone/H_2O_2 + GAC**
- **GAC alone**

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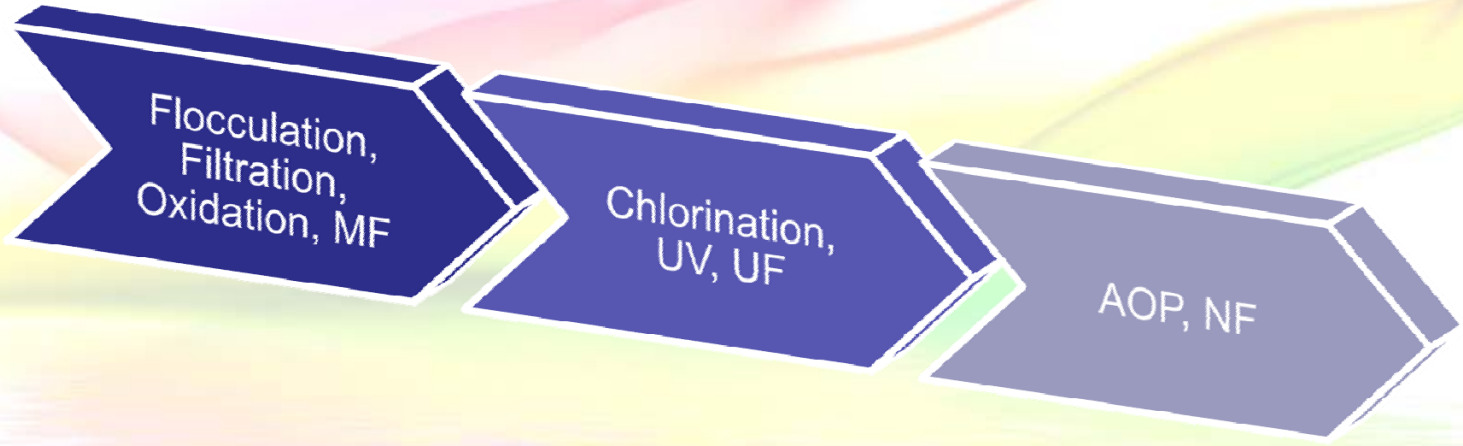
Water Treatment Technology Arenas



Options for Advanced Water Treatment