Profiting from your Air Pollution

An update on environmental enforcement, new air pollution modelling & control requirements, and control technologies

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Agenda

- A summary of the latest federal and Ontario environmental enforcement actions with respect to air pollution and odour issues;
- A discussion on new regulatory instructions and interpretations with respect to air pollution;
- Overview of odour & air pollution control technologies.

CHAR technologies

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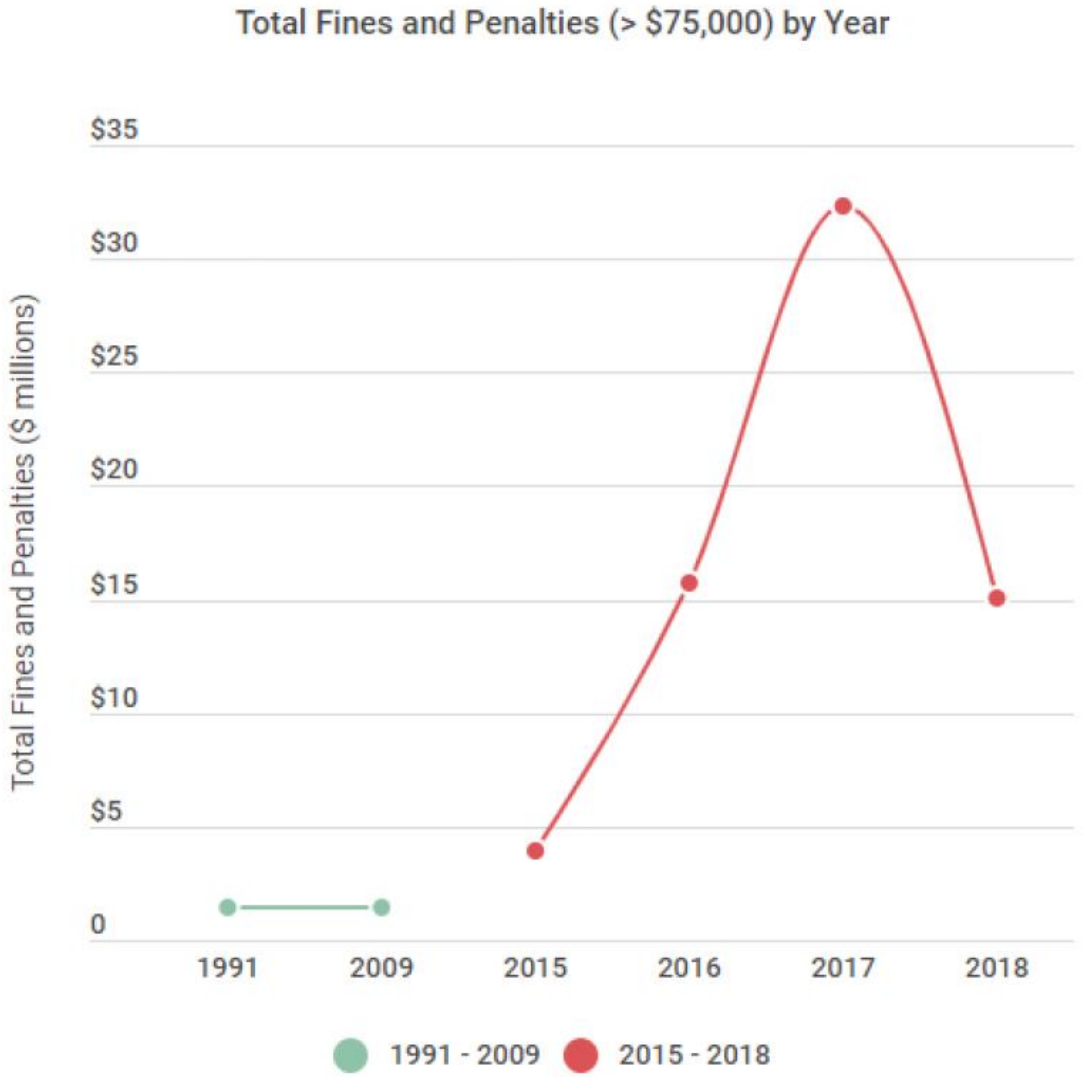
Environmental Enforcement

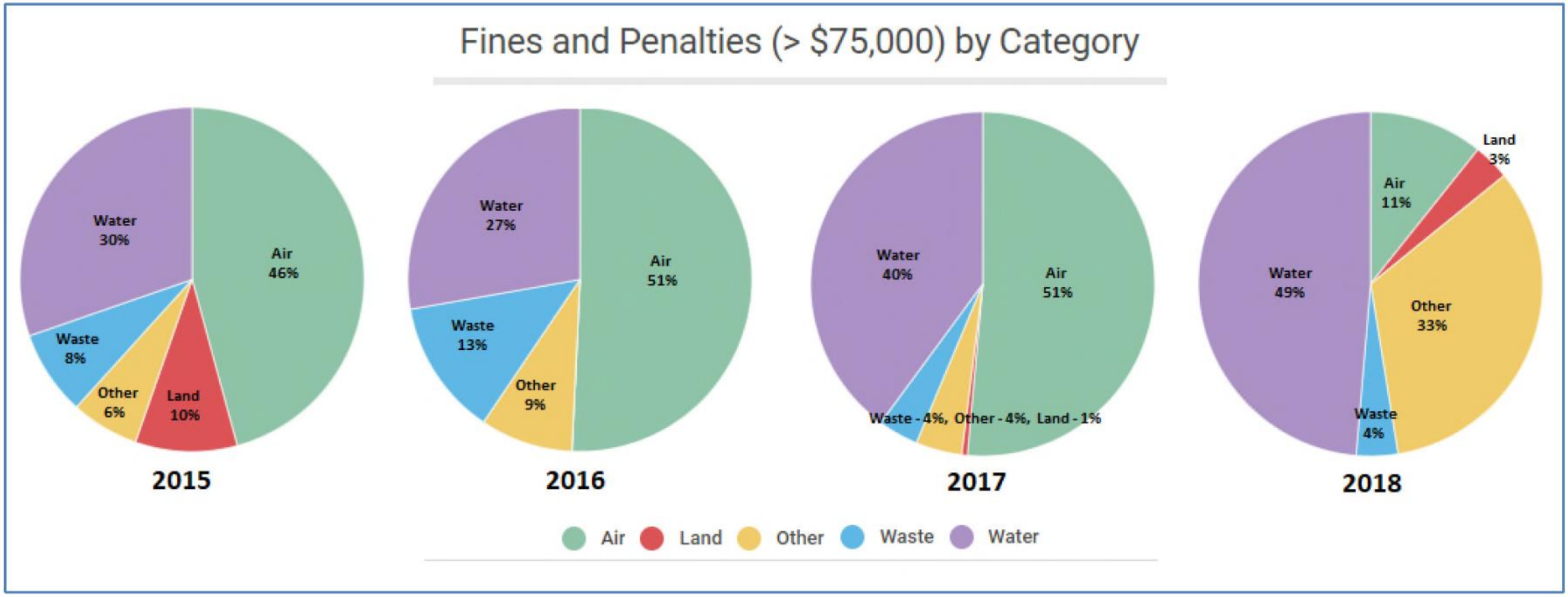
Canada: Environmental Enforcement Actions

- LNG storage facility fined $750,000 in 2015
  - Estimated mortalities in excess of 7,500 birds resulted from direct or indirect contact with burning natural gas from a flare stack



**Environmental Fines and Penalties 2018 Update Report, Berkley Canada*

Canada: Environmental Enforcement Trends*



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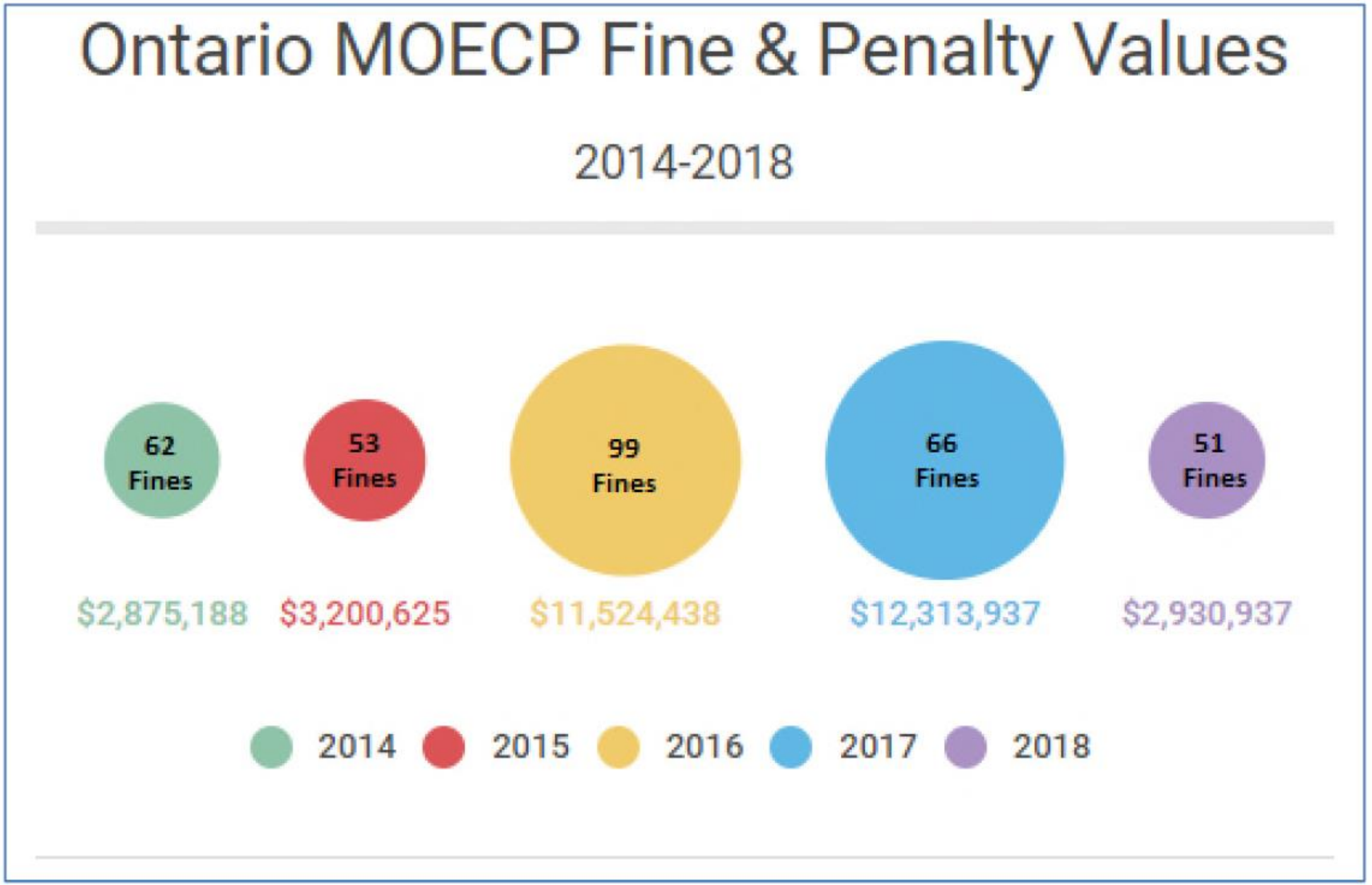
Ontario: Environmental Enforcement Trends*



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Ontario: Environmental Enforcement Actions

- Asphalt Company Fined $175,000, Dec. 2019
  - Discharged Benzo(a)Pyrene above permitted limited and violated three ministry approval conditions, and for alteration of equipment without ministry approval
- Organics Processing Facility Fined $50,000, Dec. 2019
  - Discharged odour into the natural environment that was always likely to cause an adverse effect and for failed to comply with a ministry approval by failing to keep facility doors closed
- Waste Management Company Fined $100,000, Dec 2019
  - Permitted the discharge of a contaminant (smoke) into the natural environment that may cause an adverse effect

Ontario: Environmental Enforcement Actions …

- Waste Oil Refinery fined $100,000, Nov. 2019
  - During the transfer of spent oil derivatives from a distillation tank into a vacuum truck, sulphur compounds contained in the oil generated odours that were discharged to the air
- Waste Management Company and Director fined $30,000, July 2019
  - Discharge of wood dust and failure to meet specific ministry approval conditions
- Food Manufacturer fined $25,000, May 2019
  - Operating, altering and extending its facility without the required ministry approval

Ontario: $1M fine for odour issues at organics processing facility

- In 2017, an industrial composting facility was fined $900,000 plus a victim surcharge of $225,000
- The fine was the result of two separate investigations related to incidents involving the discharge of odours that caused an adverse effect
- The adverse effects included the following:
  - loss of enjoyment by neighbours to the normal use of their properties
  - Material discomfort as the odour affected a neighbour’s ability to breathe
  - Interfering with the normal conduct of business of nearby businesses
- Odour issues at the facility occurred from 2014 through 2017

Environmental Penalty Creep?

- The federal Environmental Enforcement Act, 2009 created a new fine regime that established mandatory minimum fines for individuals and corporation, as well as higher maximum fines for a new category of “designated offences”
- The Ontario, the provincial government enacted new rules in 2019 that gives provincial environmental officers wider scope to issue fines. The maximum fine is now $200,000, double the previous limit.

Government initiatives on air pollution control

Canadian Government Air Pollution Control Initiatives

- Proposed Multi-Sector Air Pollutants Regulations Amendment Regulations (Part 1 - Biomass)
- Proposed Regulations Respecting Reduction in the Release of Volatile Organic Compounds (Petroleum Sector)
- Proposed Formaldehyde Emissions from Composite Wood Products Regulations
- Proposed Update to Canadian Ambient Air Quality Standards for ozone

Canada

Ontario Government Air Pollution Control Initiatives

- New technical standard for the asphalt mix industry – draft proposal
  - Relates to emissions of benzo(a)pyrene and includes a requirement for a air scavenging system
- Industrial Emission Performance Standards (EPS)
  - EPS encourages the industrial sector to reduce greenhouse gas emissions
- Repeal the Toxics Reduction Act, 2009 and all associated regulations by December 31, 2021
- New regulation for vehicle emissions
  - clarifies on-road vehicle emissions requirements and sets out rules around the testing of emissions from heavy diesel commercial vehicles

Innovative air pollution and odour control technologies

Common Air Pollution Issues

ALTECH and CHAR TECH Expertise

- Odours
- Particulates
- Regulatory Compliance
- Emergency and Fugitive Emissions
- Complex air issues requiring research and investigation

CHAR TECH

Air Treatment Technologies

- Venturi scrubber - Sub-Micron Particles and Gas Flows
- Packed tower wet scrubber - Gas Treatment
- Patented quench system - Quenching Hot Gases in a Small Space
- Jet venturi scrubbers - Passive and Fugitive Emissions
- Particulate cyclones - Larger Particles and Variable Gas Flows
- Adsorption media systems – VOC’s and odour-causing compounds

Odour Issues and Abatement

1) Odour are often a mixtures of contaminants (chemicals)
2) May need different control technologies to treat different contaminants
3) Consider performance, reliability as well as life cycle cost

Introduction: Biorem Corporate Profile

- North America's oldest and most experienced biological odour control company
- Established in 1991
- Over 1,400 Installations in nineteen countries (> 50 Ontario)
- Two proprietary engineered inorganic medias (20 year media life, effective for Total Odour Removal)
- Preferred by Customers that require:
  - proven long term reliable performance and;
  - a company that will be around in 10 -20 years

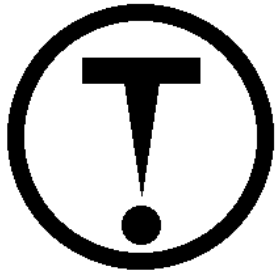
Odour Abatement Technologies

Odour Abatement Technologies

- Chemical Scrubbers
- Activated Carbon
- Biological Approaches
  - Biotrickling Filters
  - Biofiters
    - Organic
    - Inorganic
  - Multistage
- Emerging Technologies

Chemical Scrubbers: Overview

- Chemical scrubbing technology is based on mass absorption followed by a chemical oxidation reaction
- Typically use a two stage process with NaOH and NaOCl solutions
- H_2SO_4 is used for NH_3 removal



Chemical Scrubbers: Pros and Cons

- Conventional technology
- Historically, was used extensively
- Very good at removing single compounds per stage (for example H_2S or NH_3)
- Small Footprint (uses velocities up to 1.5 m/s)
- Low capital cost
- Short contact times (0.5-3.0 seconds)

Chemical Scrubbers: Pros and Cons

- High operating costs (chemical consumption, maintenance)
- Operationally, a complex technology
- Health & Safety concerns with handling and storage of chemicals
- Best selected for applications that:
  - Single compounds (H2S or NH3)
  - are properly staffed,
  - away from sensitive neighbors,
  - and less than 15 ppm H_2S

Chemical Scrubbers: Performance

Contaminant	Performance
Hydrogen sulfide	99%
Ammonia	99% (separate stage required)
Reduced sulfides	20 – 50%
Odour	50 - 75 % measured as OU 85% - 90% if only hydrogen sulfide present 1500 - 3000 OU typical outlet
Volatile organic compounds	negligible

Activated Carbon: Overview

- Activated carbon technology is based on a physical removal mechanism: adsorption. Compounds are attracted to the high surface area and chemical structure of the carbon
- Non-destructive technology. Once carbon is 'spent', must be disposed of. Must be monitored.

Carbon Type	H_2S Capacity
Standard Carbon	0.01-0.03 g/cc
Impregnated Carbon	0.12-0.14 g/cc
Blended Carbon	0.14-0.27 g/cc
Catalytic Carbon	0.09-0.63 g/cc

Activated Carbon: Pros and Cons

- Can be used for a broad spectrum of odours.
- There are many different types of adsorption materials (zeolites, caustic impregnated carbon, catalytic, blended)
- Use short contact times, 3-6s, small foot prints
- Some cannot handle humidity well (>55% RH)
- Improved H_2S adsorption comes at a price: less affinity for other compounds

Activated Carbon: Pros and Cons

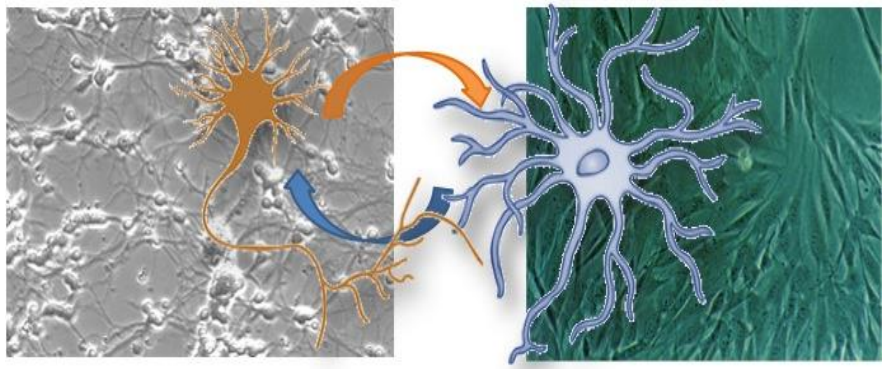
- Bed fires
- Good for small / intermittent flows or low contaminants concentration
- Excellent as a “polish” after other treatment technologies
- Requires continual and costly monitoring to determine when carbon will be spent
- Removal and replacement can be costly
- Hard to predict carbon life with mixtures
- Most spent carbon ends up in landfill

Activated Carbon: Performance

Contaminant	Performance
Hydrogen sulfide	98 - 99% (large volumes required)
Ammonia	60 - 70%
Reduced sulfides	50 - 85% (depends upon type)
Odour	>90% 100 - 500 OU typical outlet
Volatile organic compounds	>95%

Biological Odour Removal Systems: Removal Mechanism

- Typically a two stage process:
- Removal of contaminant from the gaseous phase (absorption, solubilization, adsorption)
- Oxidation of the contaminant (chemical reaction with an enzyme)



Biological Odour Removal Systems: Biotrickling Filters

- Biological fixed film oxidation reactors using a continually wetted matrix
- Typically, a two stage process, absorption or solubilization, followed by oxidation (biological)

Biotrickling Filters: Pros and Cons

- Excellent for H_2S removal
- Small footprints
- Acclimation phase and response to variations in concentrations
- Does not perform well on other organic sulphur compounds or VOCs
- Best selected for applications that have H_2S as predominant odour constituent (collections and headworks); are staffed; do not have sensitive neighbors; or as a roughing filter prior to a second treatment stage (BF or carbon)
- Cost effective for H_2S treatment
- Can achieve 99% (and greater) removal of H_2S

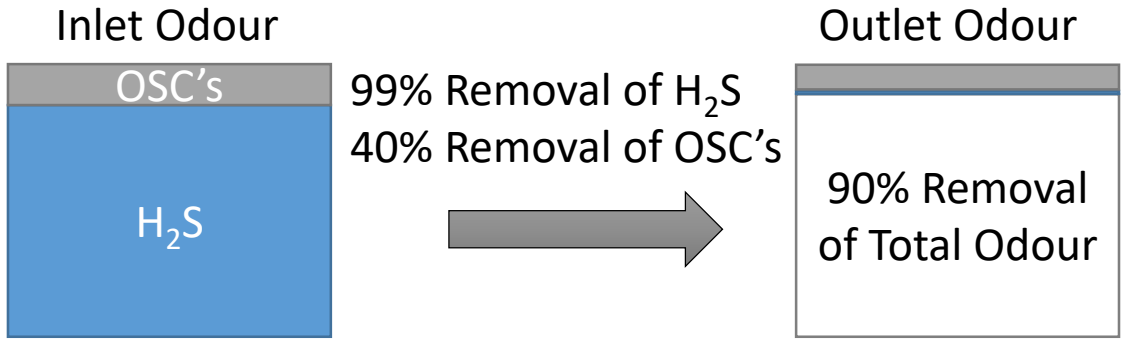
Biotrickling Filters: Performance

Contaminant	Performance
Hydrogen sulfide	>99%
Ammonia	negligible
Reduced sulfides	20% for most compounds 70 - 85% for methyl mercaptan
Odour	>75 - 90% if H2S is primary constituent ~1000 OU typical outlet 40% - 70% if OSC present 3,000 – 5,000 OU at outlet
Volatile organic compounds	negligible if water insoluble

Biotrickling Filters: Odour Removal Performance

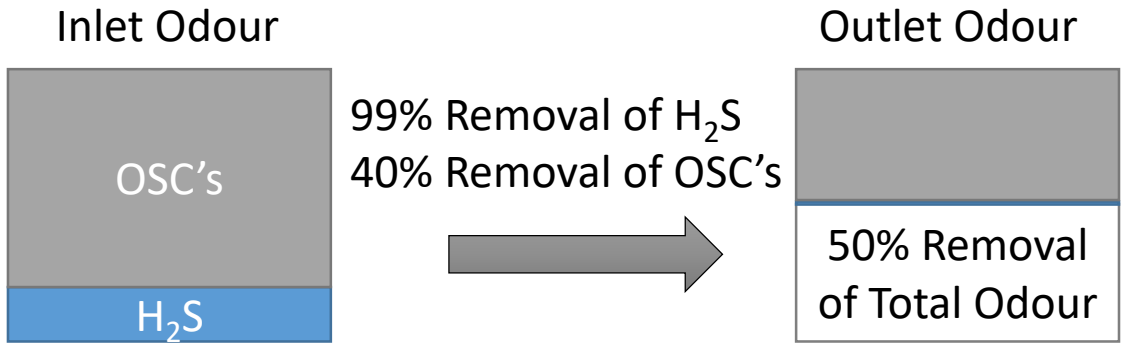
Scenario 1:
Low OSC's
High H_2S

85% From H_2S
15% From OSC's



Scenario 2:
High OSC's
Low H_2S

20% From H_2S
80% From OSC's



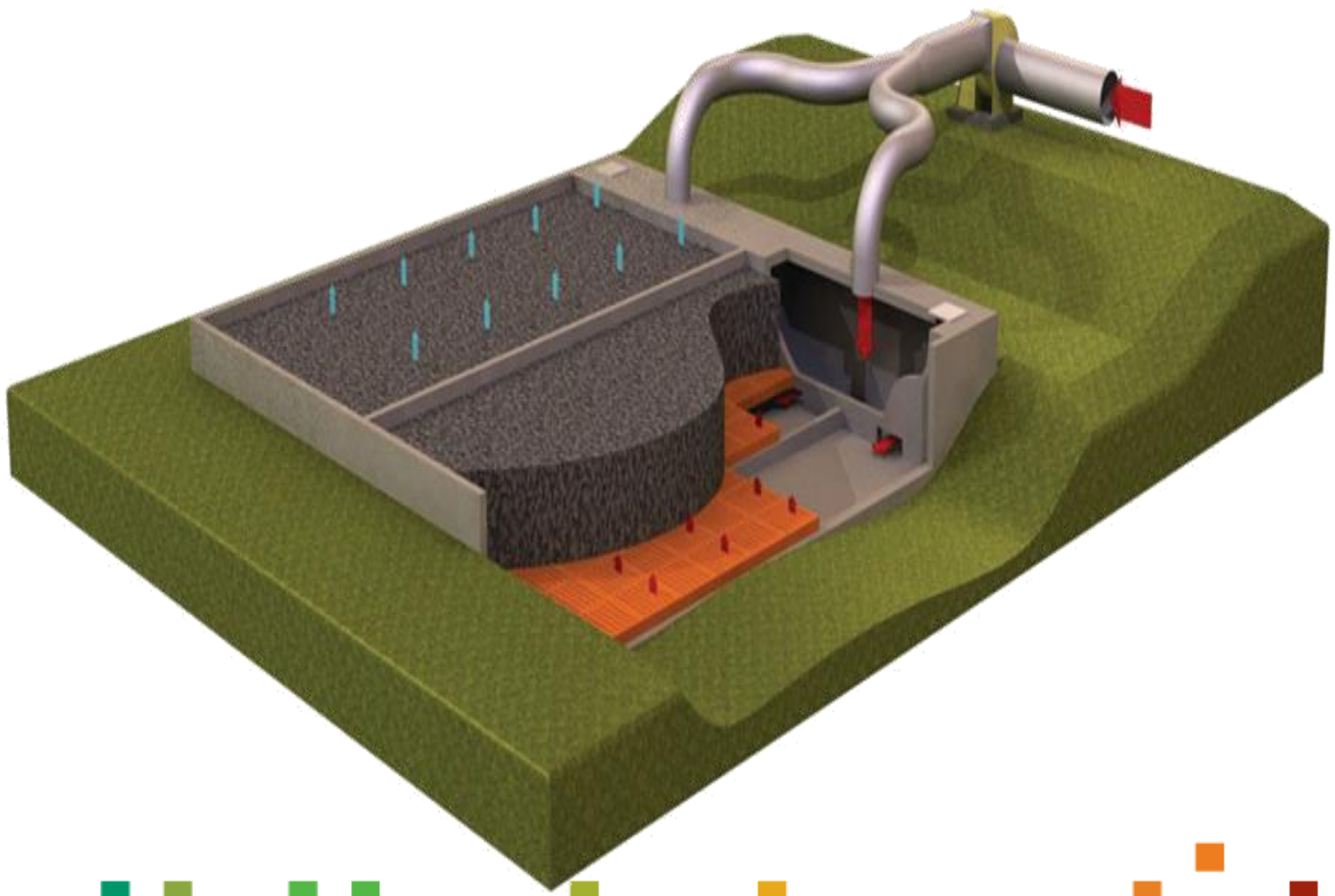
Biological Odour Removal Systems: Biofilters

- Biological fixed film oxidation reactors using intermittent surface irrigation
- Typically, a two stage process, absorption/adsorbtion or solubilization, followed by oxidation (biological)
- Advanced systems using engineered inorganic medias have additional properties

Biofilters: Pros and Cons

- Biofilters are the simplest systems to operate out of all the odour control technologies
- They also require the least amount of maintenance (lack of moving parts)
- Engineered inorganics media systems are very robust to changing inlet conditions and provide a 20 year media life.
- Biofilters require the largest amount of space of any odour control technology
- Initial capital expense can be higher than other technologies
- Operating costs are the lowest of any technology (engineered medias)
- Select this technology for demanding odour applications; reliability; unmanned facilities; total odour removal

Biofilters: Schematic

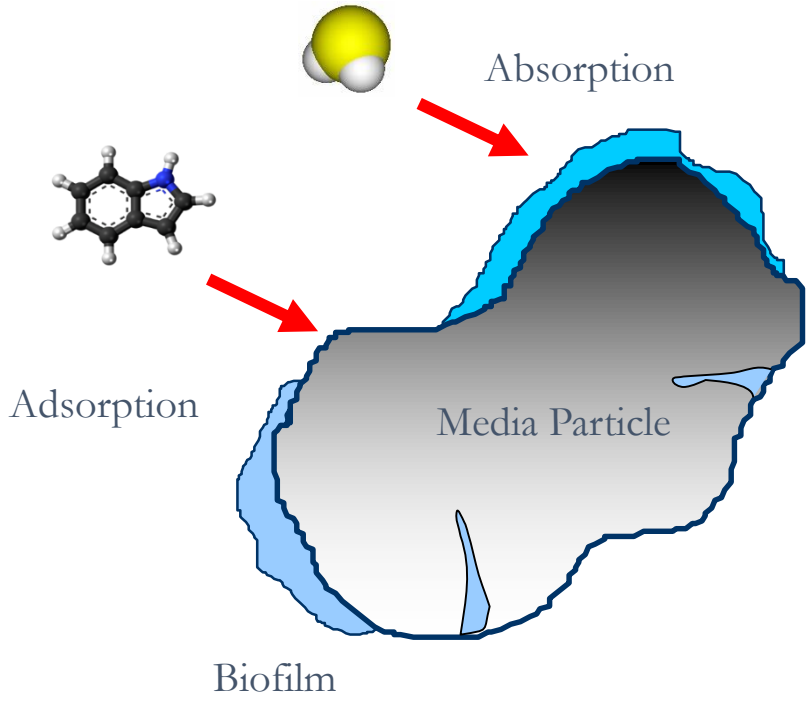


Biofilters: Performance

Contaminant	Performance (Engineered)
Hydrogen sulfide	>99%
Ammonia	90%
Reduced sulfides	75 - 98%
Odour	Up to 98% (90% typical guarantee) 300 - 500 OU typical outlet
Volatile organic compounds	Up to 95%

Engineered Medias: Overview

- Permanent
- Low Energy Consumption
- Specific Surface Properties
- High Available Surface Area
- Predictable Performance
- Low Background Odour



Engineered Medias: Biosorbens® Media

Custom Configurations

Single Stage BF

Single Stage BTF

Dual Stage BTF + AC

Biological Odour Removal Systems: Technology Selection

Criteria	BTF	BTF + AC	BF (Organic Media)	BF (Engineered Media)	BTF + BF (Eng. Media)
Capital Cost	Low	Moderate	Moderate	Moderate-High	High
Operating Cost	Low	Moderate	Moderate	Low	Low
Maintenance	Moderate	High	High	Low	Moderate
Performance - H2S Removal	99%	99%	>95%	99%	99%
Performance -Total Odour	50% - 90%	> 90%	>75%	>90%	>95%
Note:	Full Range of H_2S	H2S, peak H2S, OSCs and VOCs	Low H_2S, some OSCs	Low H2S, Full Range of OSCs and VOCs	Elevated levels of H_2S, OSCs and VOCs

Emerging Technologies

- When considering a new technology, look for a proven track record on your application
- In the absence of reference sites, consider an onsite pilot
- Many “new” technologies have carbon as the final stage
  - Evaluate removal performance “before” carbon
- Ask for Financial Bonds to guarantee performance / carbon life over 2 – 3 years of operation

- BIOREM has tested a number of new technologies at current sites
  - Poor to inconsistent results

Odour Abatement Technologies: Key Learning

- Select the abatement device depending upon the source of air and required performance
- H_2S removal is not total odour removal
- OSCs & VOCs contribute to odour and require alternative treatment stages
- Not all biological solutions are created equal: experience matters

Odour Abatement Technologies: Key Learning

- What are the important criteria in the selection of your odour control system?
  - **Performance – proven, reliable, long term**
  - Service and Technical Support
  - Ease of Operation & Maintenance
  - Cost – Capital or Life Cycle Cost

Biological Odour Removal Systems: Custom Configurations

BTF + BF Concrete Reactor

Concrete Reactors

Modular Reactor

Questions?

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