Biotechnology for air pollution control- A case study on Volatile organics removal

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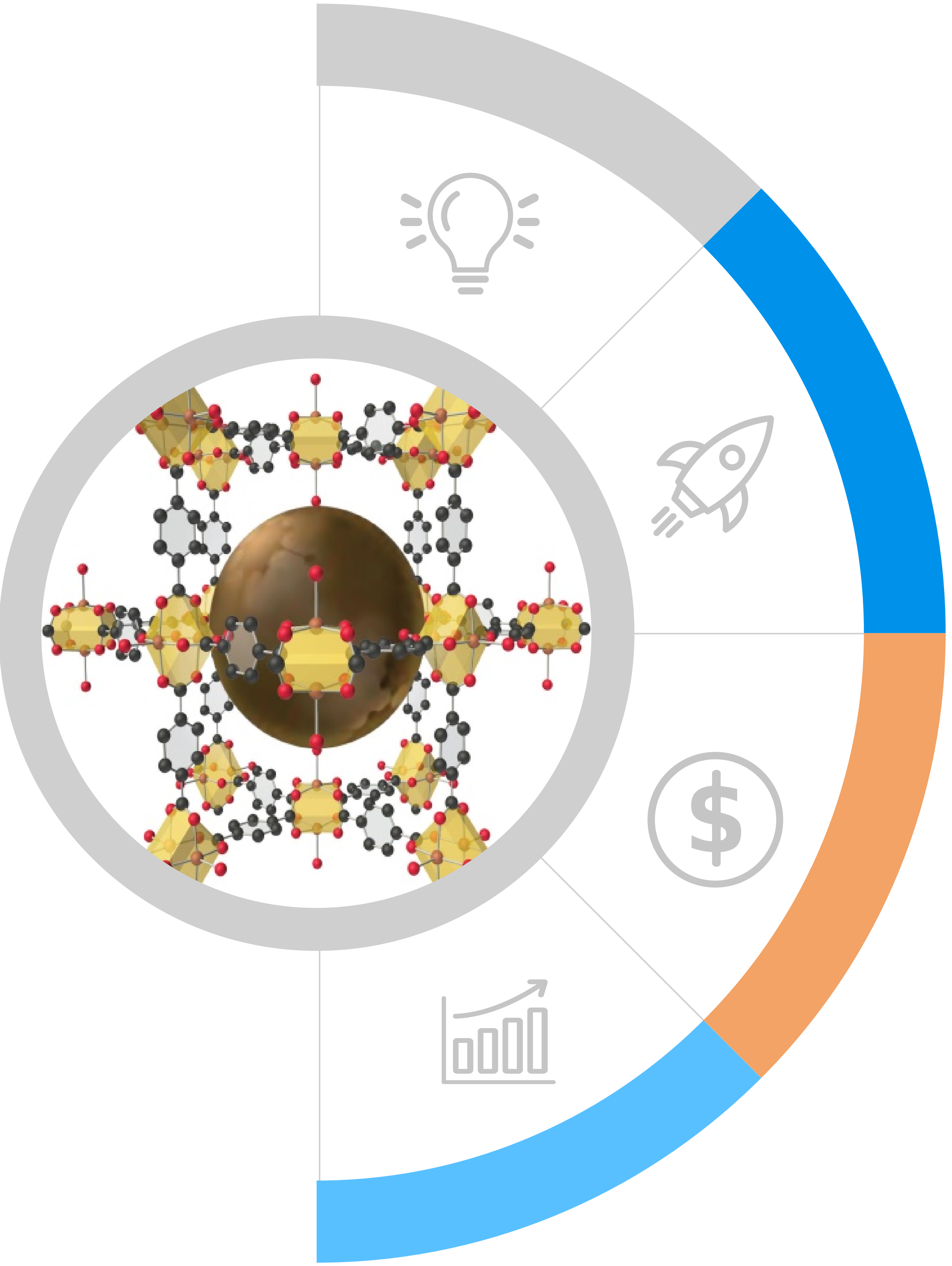
What are Volatile Organics?

Volatile Organic Compounds (VOCs)



01

VOCs are organic chemicals that have high vapour pressure and low water solubility at room temperature

02

Most of them are man-made and are produced in the manufacture of paints, pharmaceuticals and refrigerants

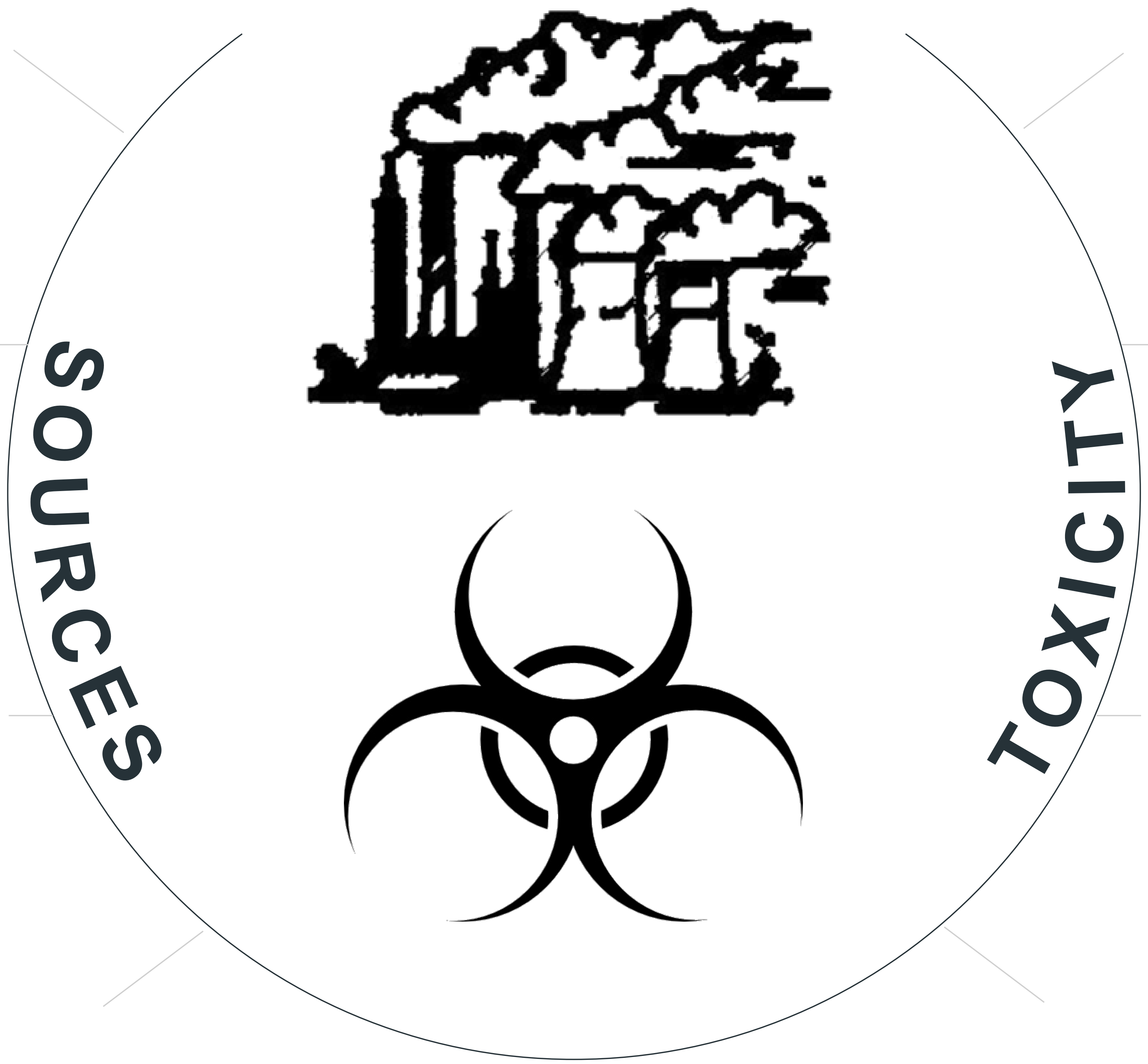
03

VOCs include compounds like Benzene, Toluene, Xylene etc and industrial solvents, such as trichloroethylene; fuel oxygenates, methyl tert-butyl ether (MTBE); or by-products produced by chlorination in water treatment, such as chloroform

04

Some of them are dangerous to human health and cause harm to the environment.

Sources and Toxicity of of VOCs in air



Sources

B

Benzene

Gas stations, motor vehicle exhaust, and industrial emissions

T

Toluene

Motor vehicle exhaust, toluene based solvents, and thinners

X

Xylene

Petroleum, coal tar, forest fires, and paint/polish industrial emissions

E

Ethylbenzene

Gasoline, motor vehicle exhaust, solvents, pesticides, printing ink, varnishes, coatings, and paints industrial emissions

Toxicity

B

Benzene

Creates smog, potential water and soil contaminant, slows plant growth, skin and eye irritant, harms nervous system

T

Toluene

Creates smog, leaf membrane damage, eye and nose irritation, tiredness, confusion, headache, dilated pupils

X

Xylene

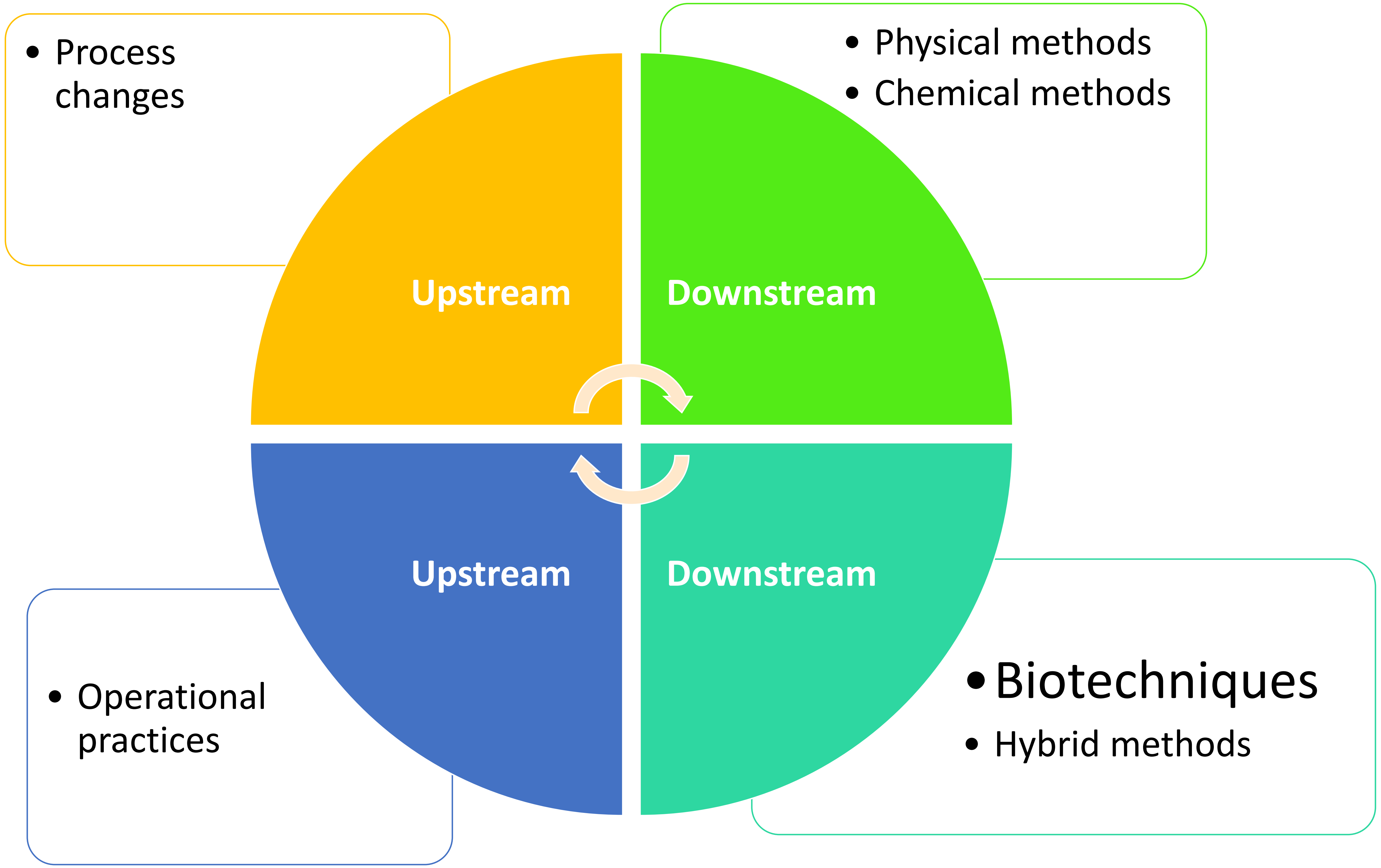
ENT irritant, affects CNS, causes loss of muscle coordination, and contaminates soil/water

E

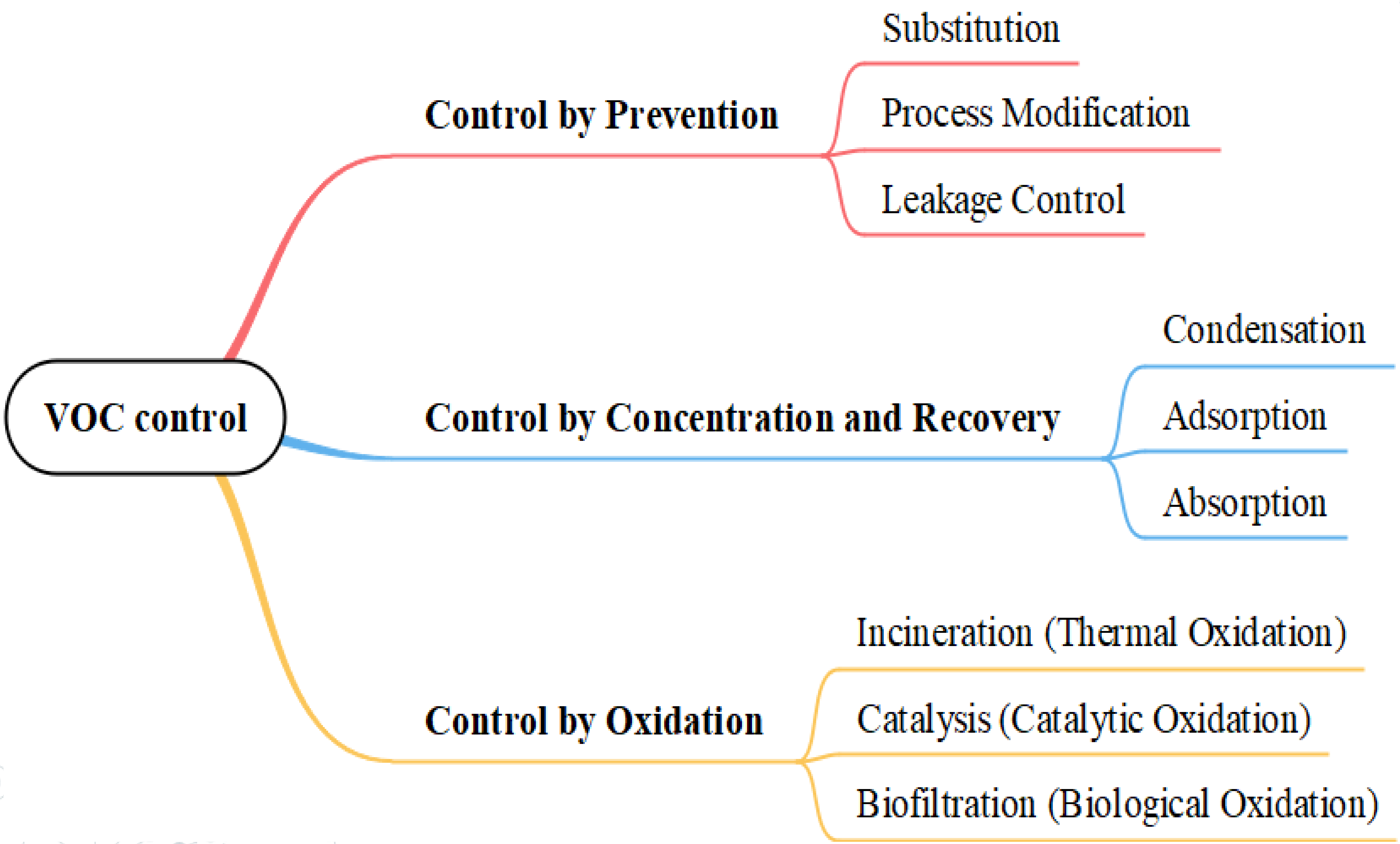
Ethylbenzene

ENT irritant, slows plant growth, causes dizziness and unconsciousness

Strategies to mitigate Air pollution



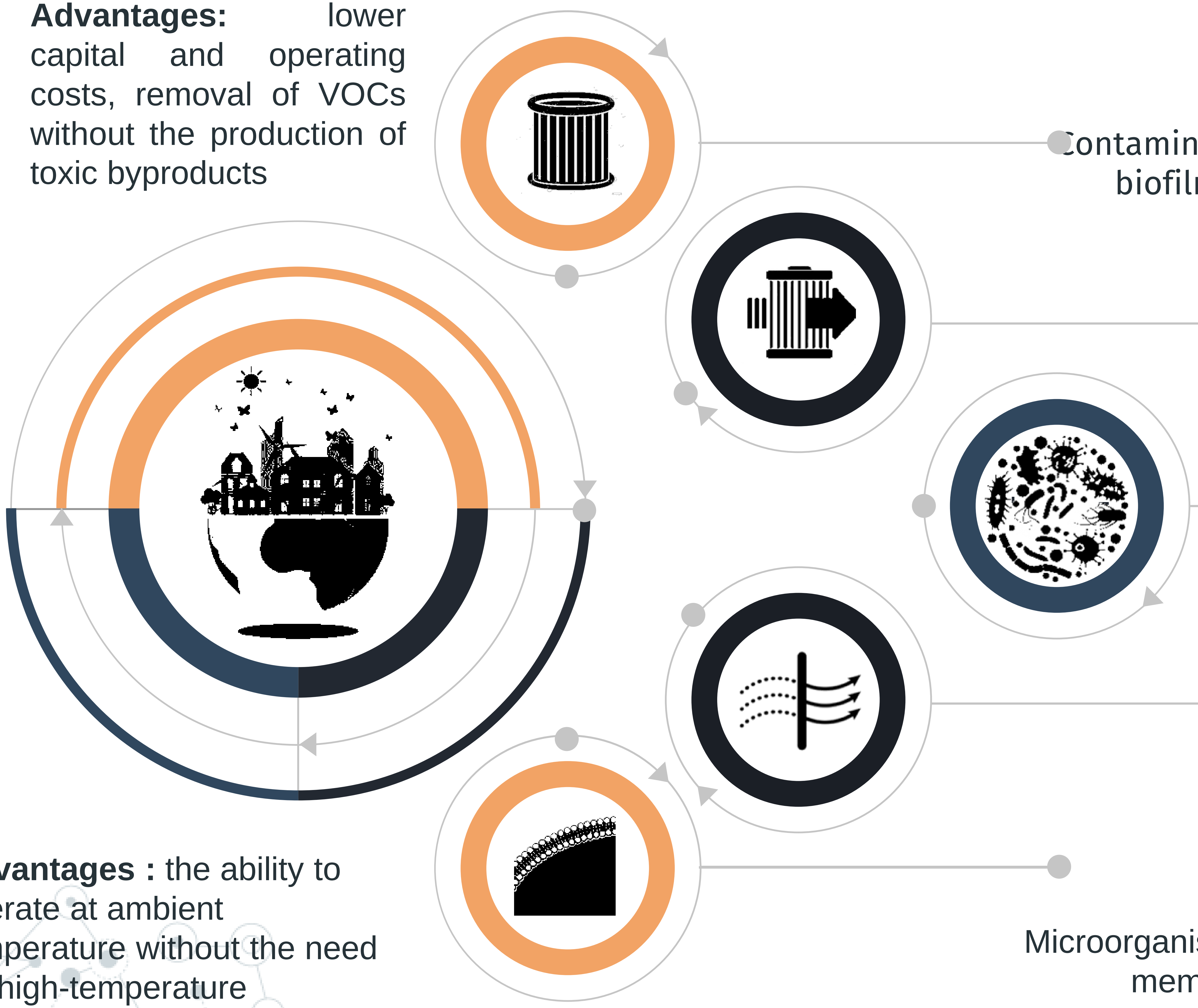
VOC CONTROL



VOC control
Control by Prevention
Substitution
Process Modification
Leakage Control
Control by Concentration and Recovery
Condensation
Adsorption
Absorption
Control by Oxidation
Incineration (Thermal Oxidation)
Catalysis (Catalytic Oxidation)
Biofiltration (Biological Oxidation)

Biological methods to treat VOCs

Advantages: lower capital and operating costs, removal of VOCs without the production of toxic byproducts



Biofiltration

Contaminant is adsorbed directly to the biofilm, or dissolved in the aqueous layer

Biotrickling filtration

Biofilters with water trickling down the packing are used

Suspended growth reaction

The reactor contains a nutrient medium with microorganisms in a suspended state

Bioscrubbing

A successful bioscrubber application is the treatment of water-soluble VOC emissions from the industry

Membrane bioreaction

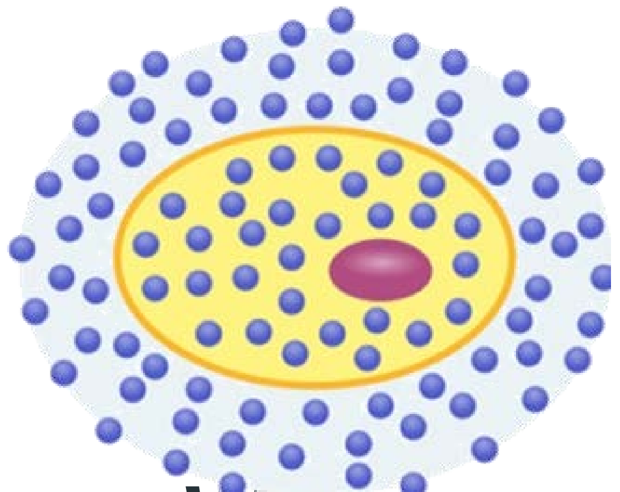
Microorganisms grow on the liquid side of the membrane, where water and nutrients required for growth are available

Advantages : the ability to operate at ambient temperature without the need for high-temperature regeneration steps

Biofiltration: Mechanism

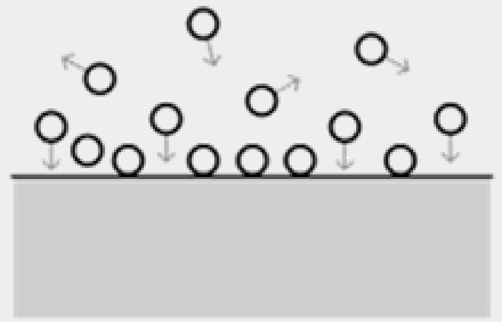
Gas Transfer

Transfer of contaminant from air stream to the water phase



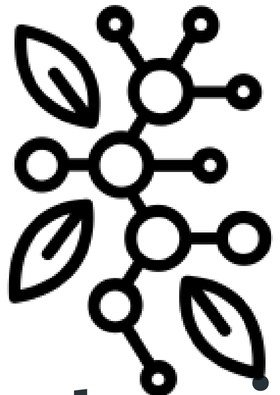
Water phase

Biodegradation starts as contaminant diffuses towards the support and the products diffuse out



Contaminant adsorption

Contaminants are adsorbed on the surface of medium or taken up by living cells



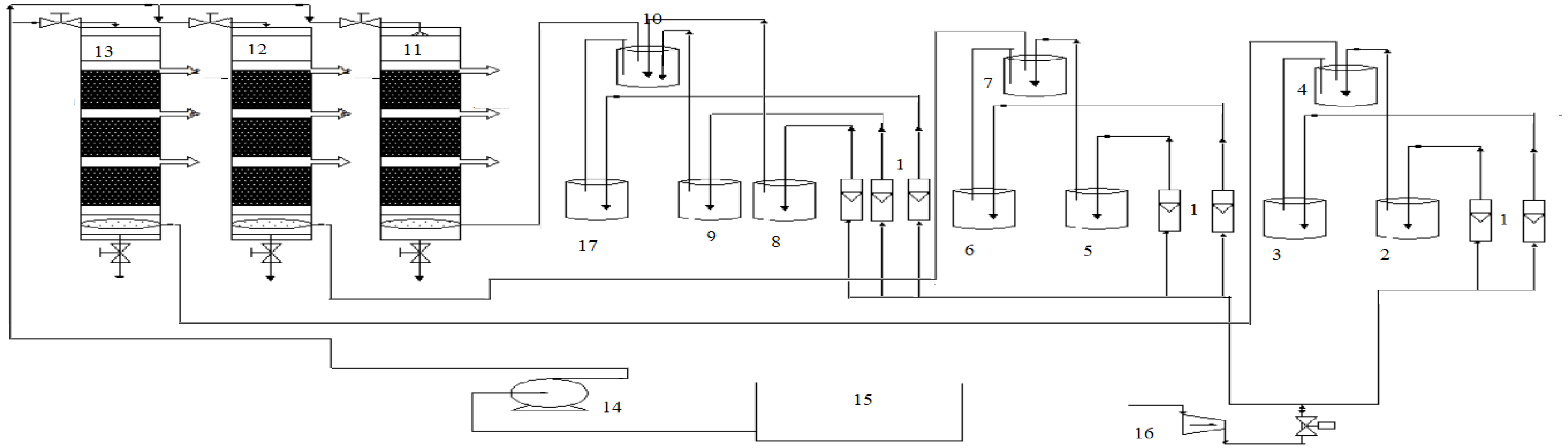
Contaminant biodegradation

The mass of microbes perform their metabolic activities which transform contaminants to harmless products

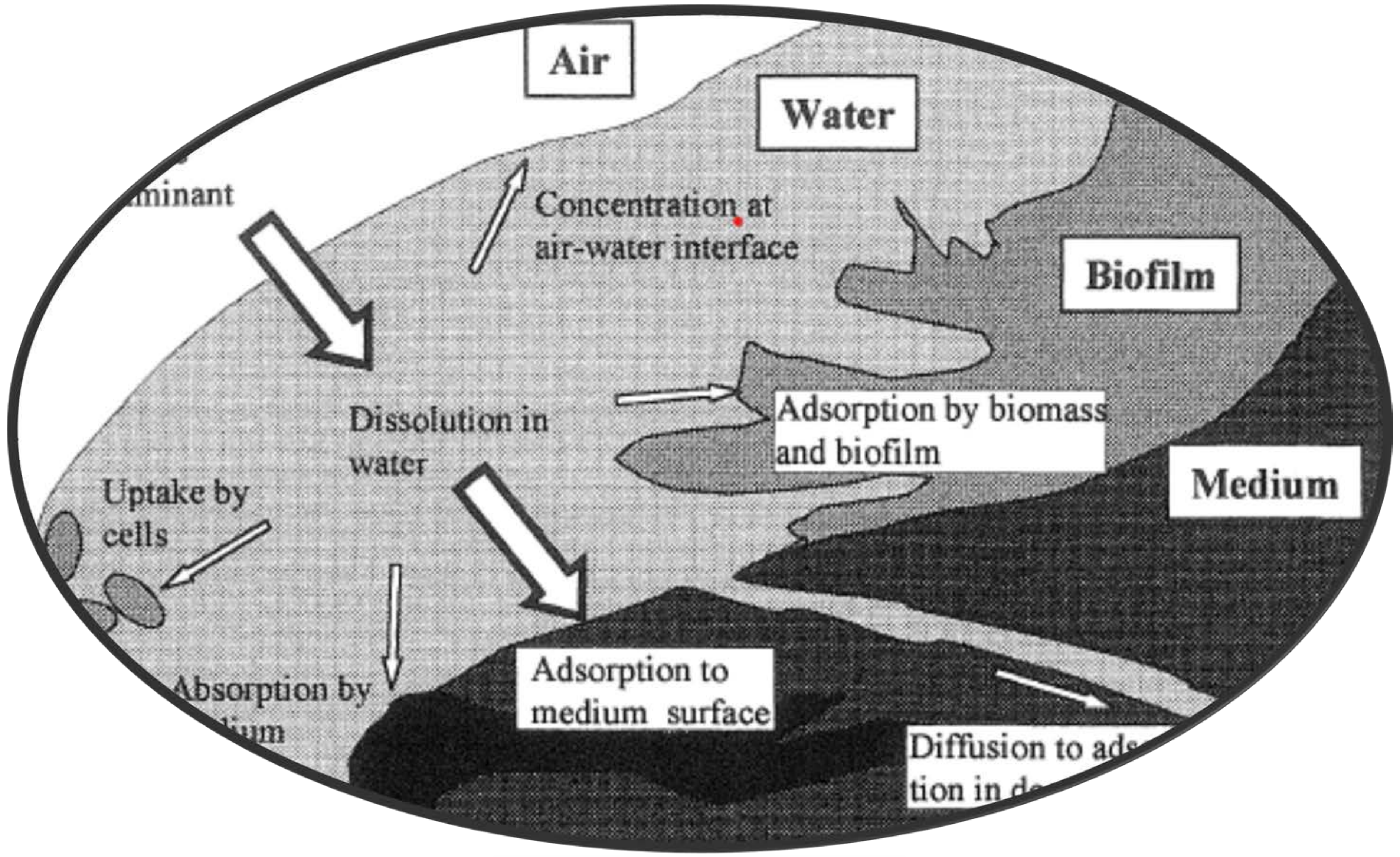
Product generation

The contaminant VOCs get converted to CO_2, H_2O or sulphates/nitrates

Bio filtration- operating principle and mechanism



A bio filter with microorganism biofilm fixed onto support media



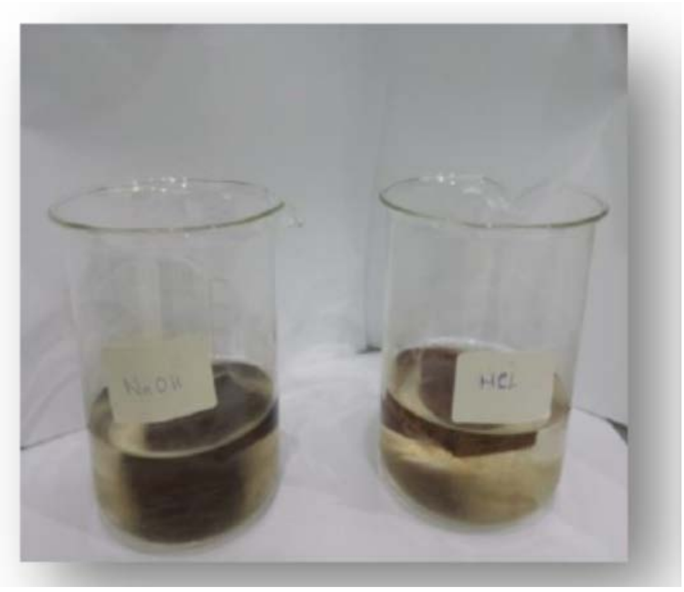
Mechanism in bio filters

RESEARCH FUNDED BY TRC, MOHERI, SULTANATE OF OMAN

Treatment of BTEX contaminated industrial emissions using a Biofilter

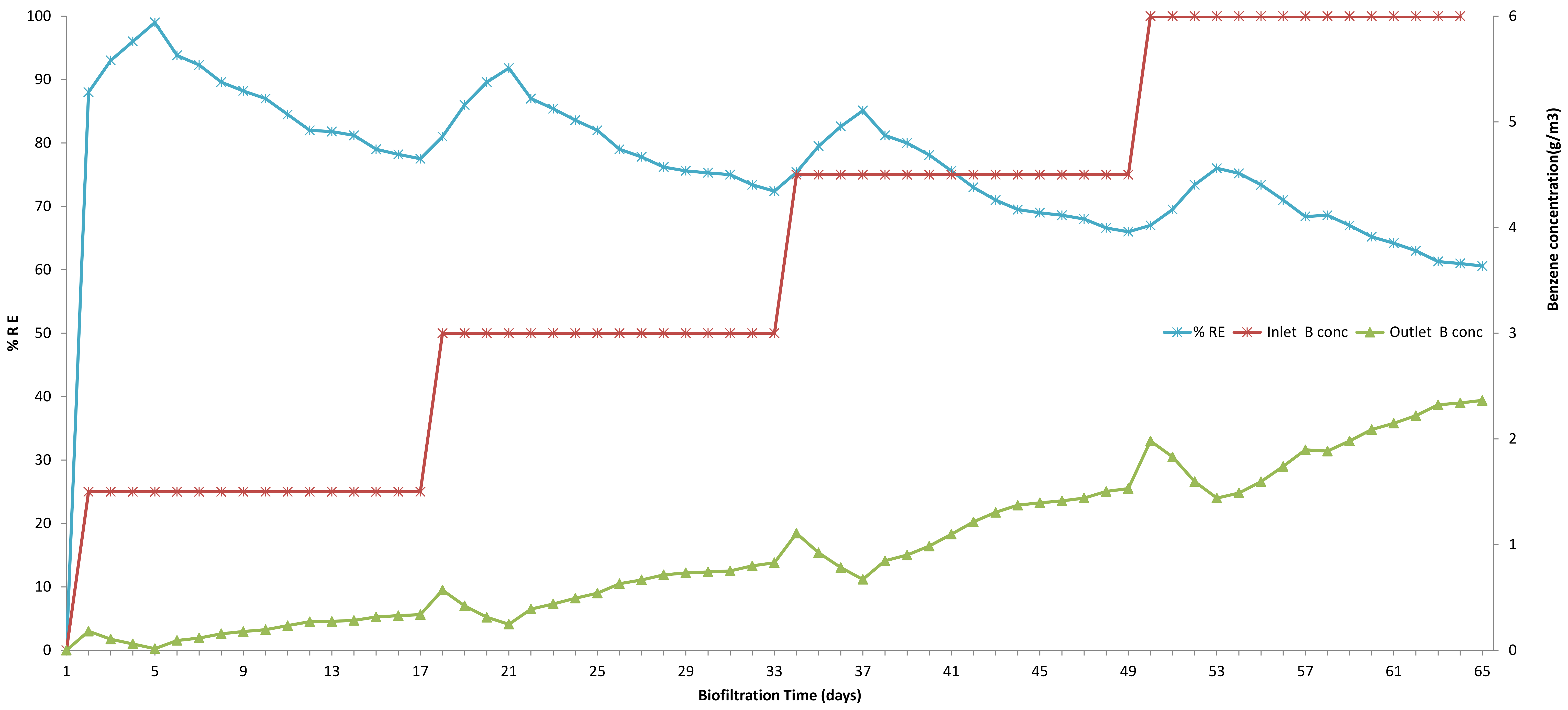
Microbial culture and filter media

- Date palm tree barks, produced from the tree *Phoenix dactylifera,* found commonly in the Oman, as the Bio filter media.
- Bio filter was inoculated using a mixed microbial culture collected from Sohar Municipal Waste water treatment plant.

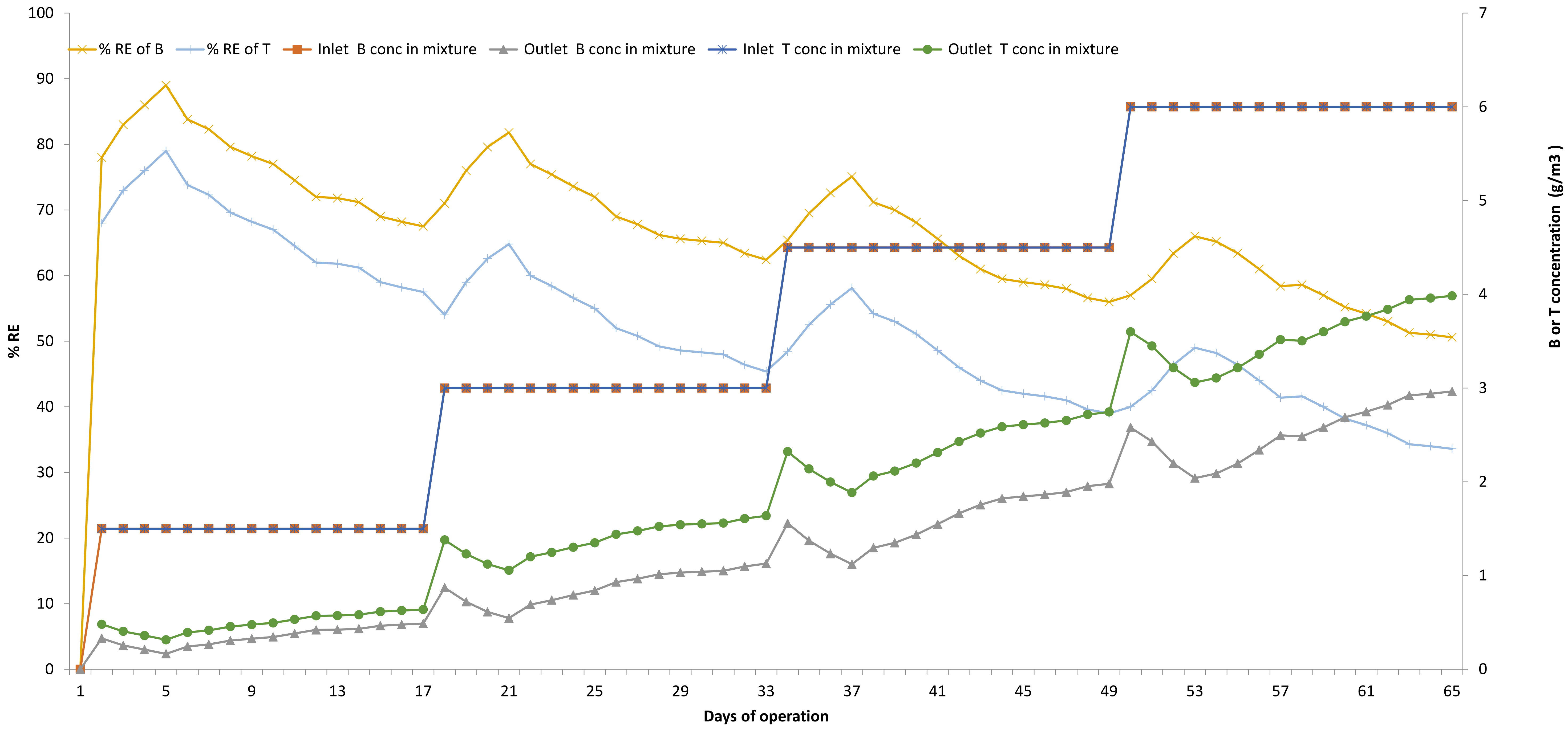


BIOFILTER REACTOR SET UP USED FOR THE EXPERIMENTS at SU

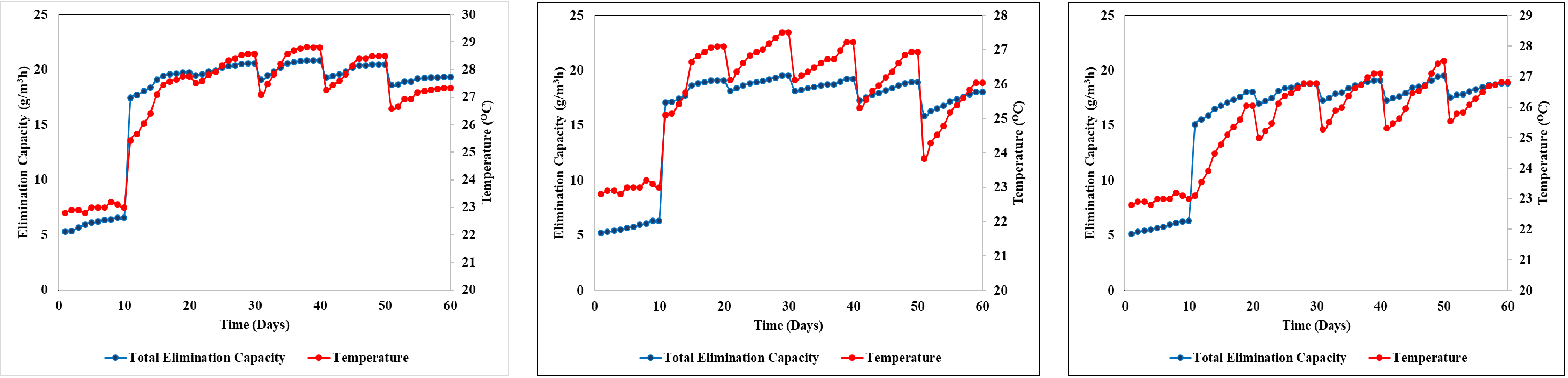
Results/ findings
Bio filtration of pure components- B,T,E and X



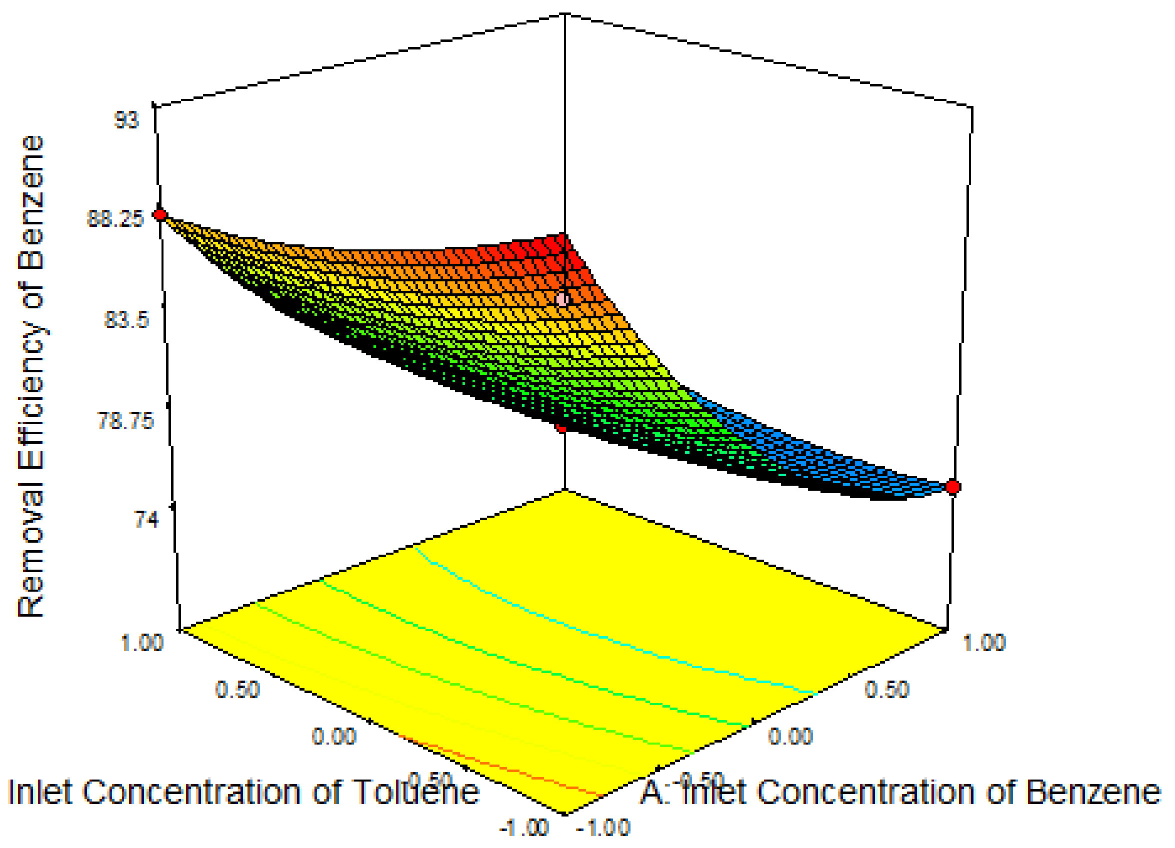
Results/ findings
Bio filtration of mixtures-B,T,E and X

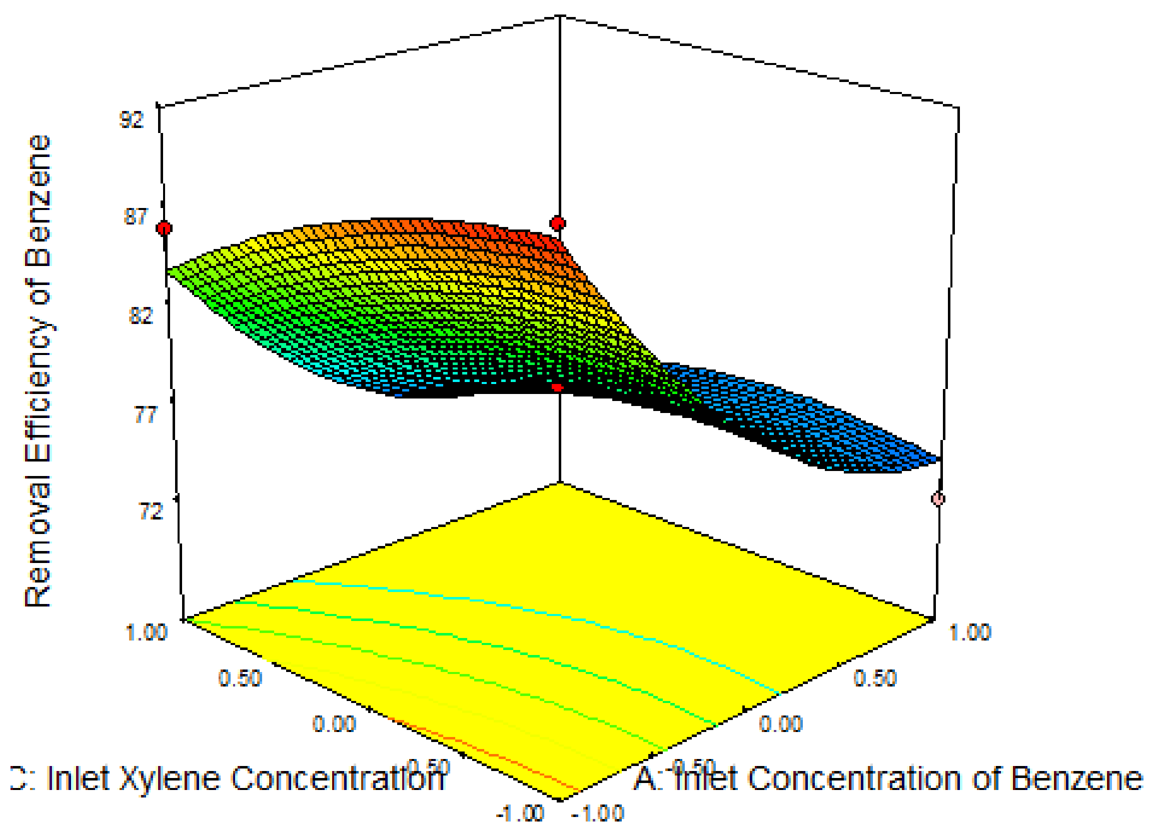


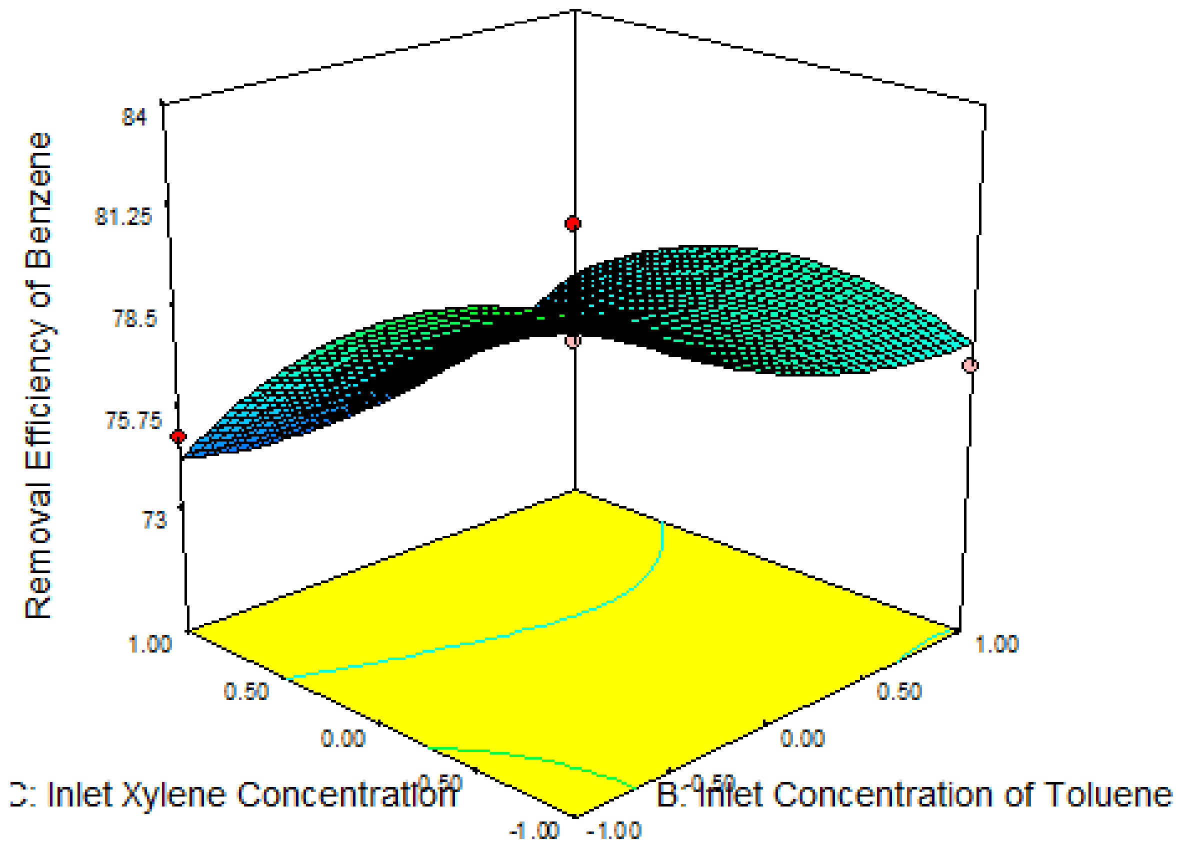
Elimination capacity versus bed temperature during the biofiltration studies of Mixed a) BT, b) BX, c) TX



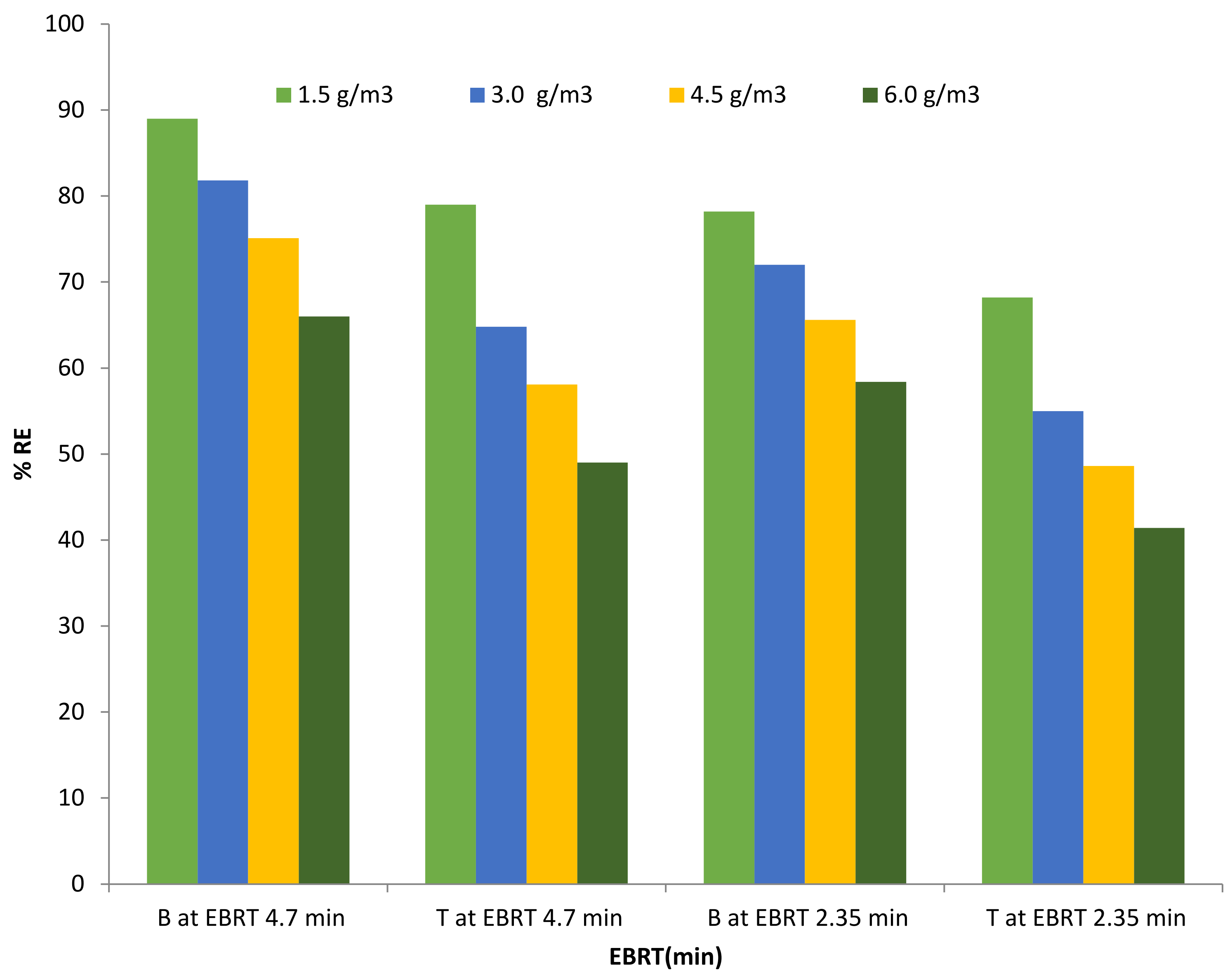
Combined effects of benzene, toluene and xylene concentrations on removal efficiency of Benzene

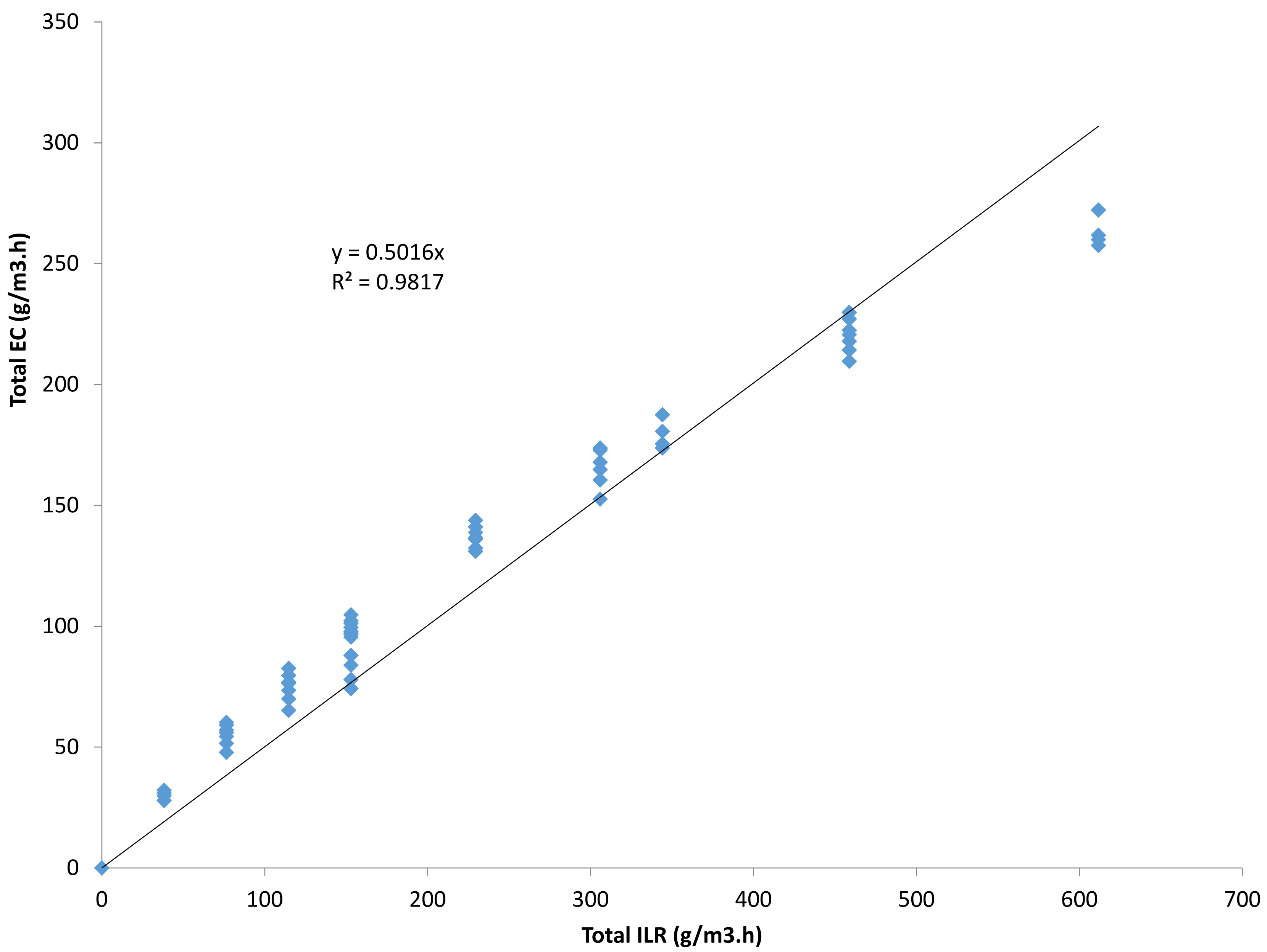






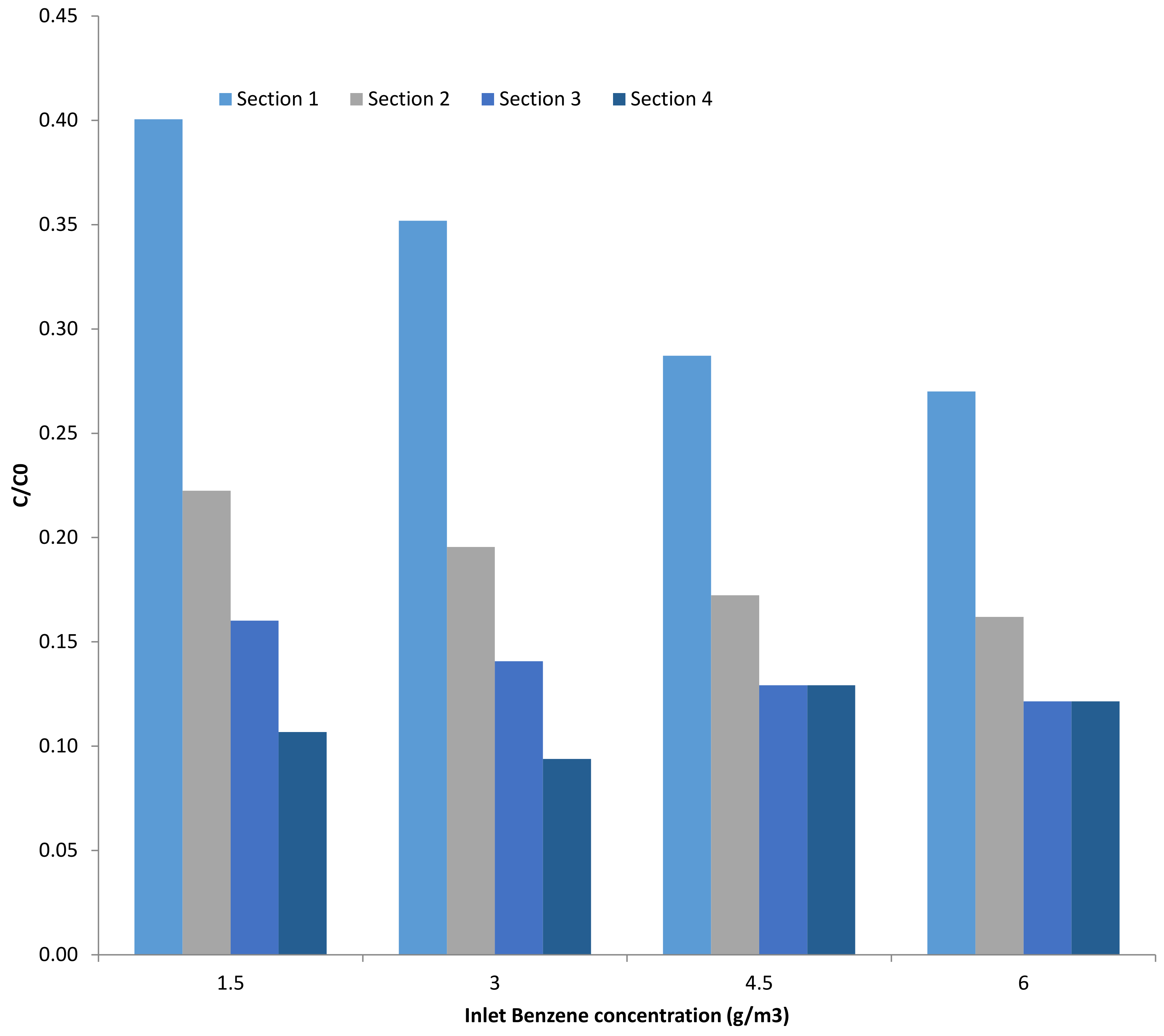
Results/ findings
Effect of EBRT

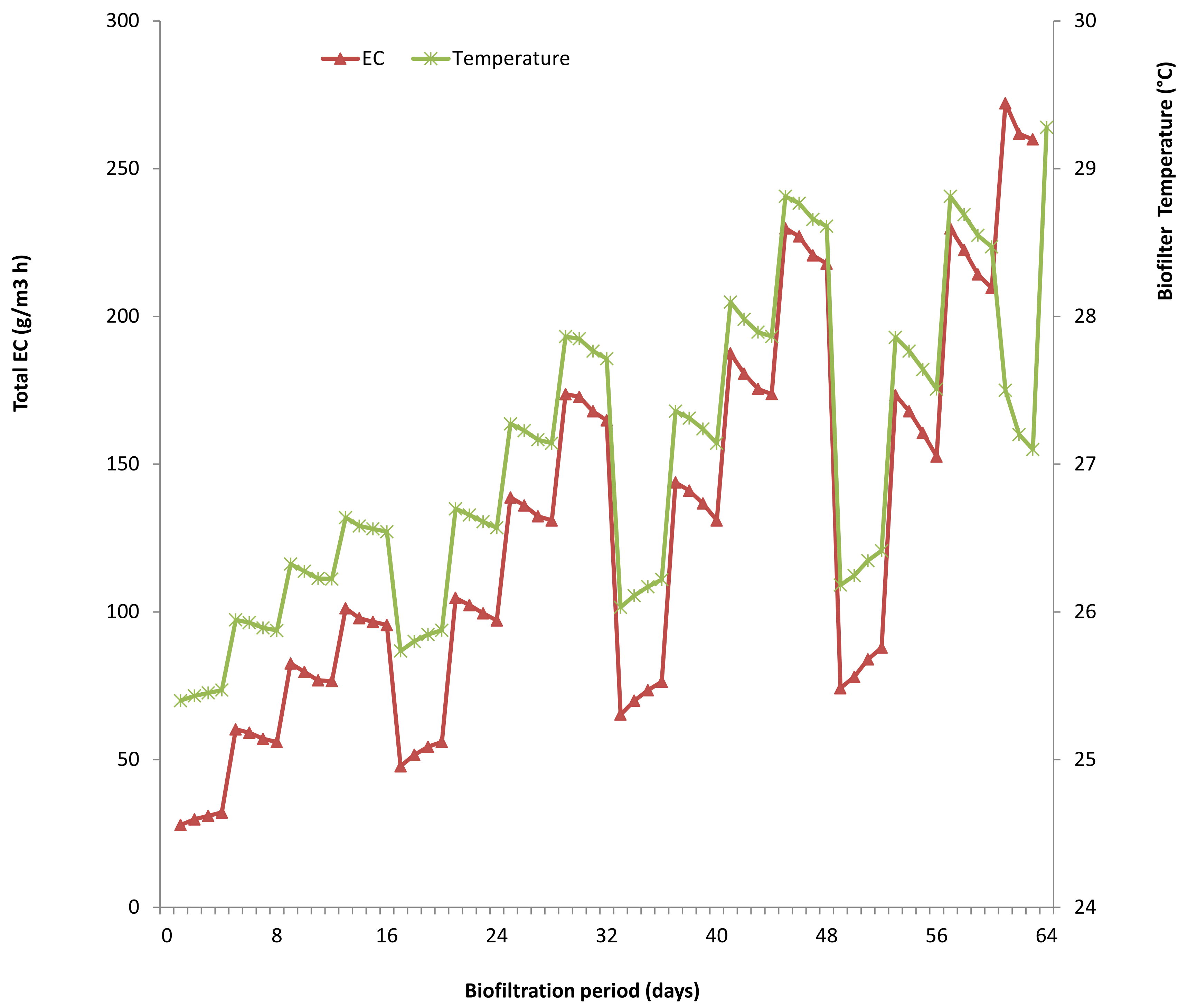




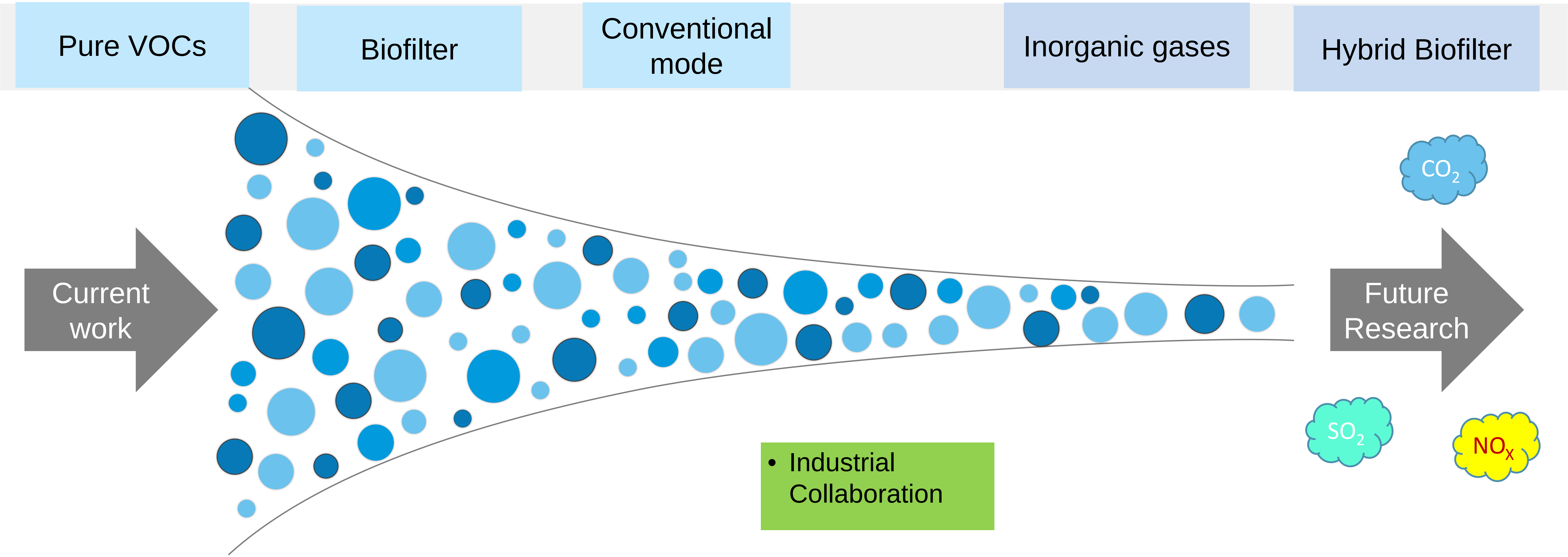
Results/ findings

Effects of bed height and Temperature profile





Future Research



Conclusions

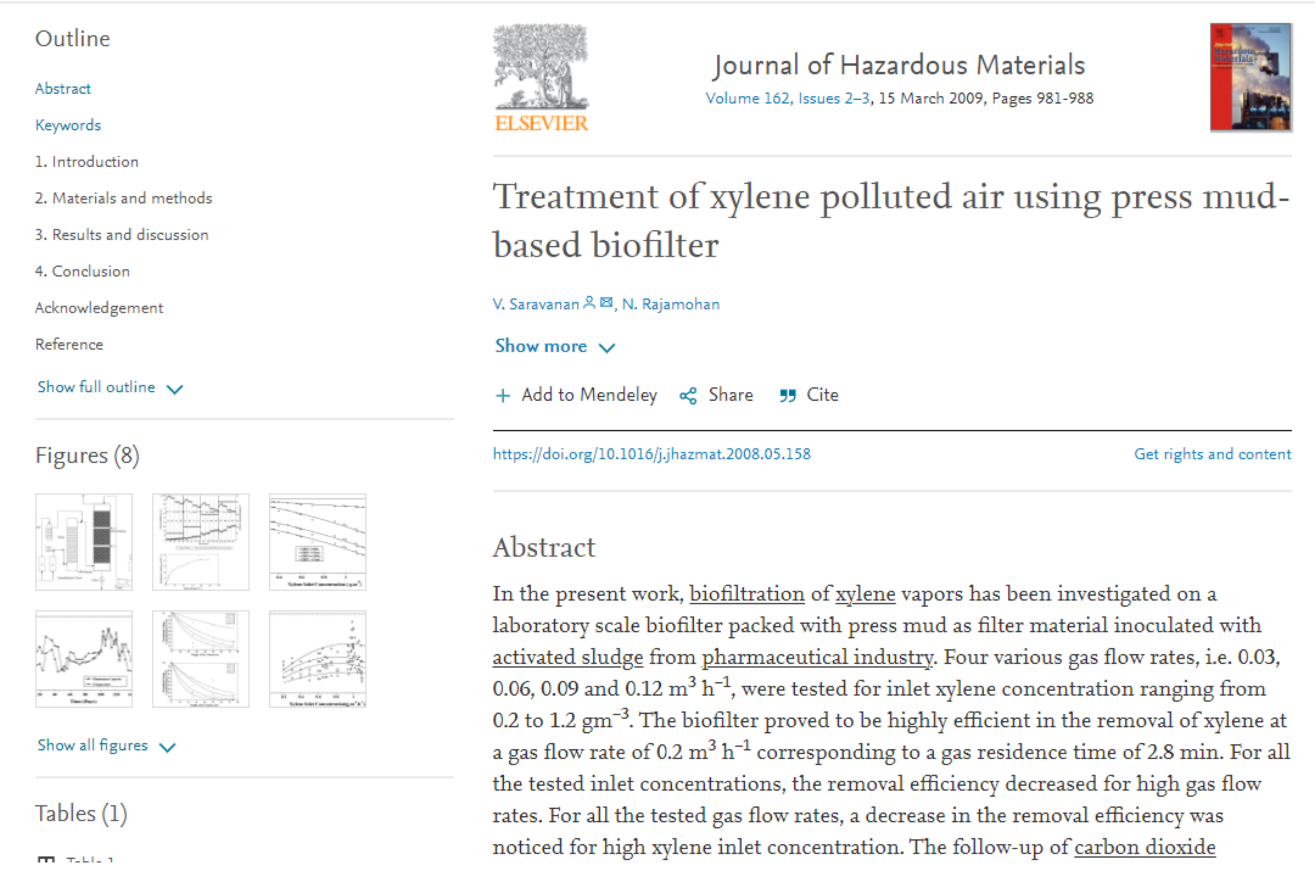
- This experimental research study has successfully demonstrated the removal potential of mixture of air pollutants namely, Benzene, Toluene, Ethyl Benzene and Xylene using a novel (locally available and untried) packing material, date palm (***Phoenix Dactylifera***) tree barks.

- The impact of inlet loading on biofilter performance and its effect on removal rates, elimination capacity, variation of temperature and carbon dioxide production was studied and the interpretations were analyzed with graphical plots.

- The removal efficiency of the biofilter is decreased when the gas flow rate and inlet concentration are increased.

Publications in international/indexed Journals

- **N. Rajamohan ,** 2020 . Performance evaluation of biodegradation of isoprene- acetone mixture in an integrated biofilter, Journal of Environmental Engineering, ,146(6);pp. 1-6.
- **N.Rajamohan**,Jamila Al-Sinani,V.Saravanan, M.Rajasimman, 2017. Biodegradation of ethyl benzene and xylene contaminated air in an up flow mixed culture bio filter , International Biodeterioration & Biodegradation, 119 ; pp. 309-315.
- S. Ashokkumar, Aprana.S Nair, V. Saravanan, M. Rajasimman, **N. Rajamohan,** 2016. Kinetics studies on the removal of Methyl ethyl ketone using cornstack based biofilter, Ecotoxicology and Environmental Safety, 134(2); pp. 377-382
- **N.Rajamohan,**Jamila Al-Sinani, 2015. Biodegradation of Benzene, Ethylbenzene, and Xylene Mixture in a Date Palm Tree Bark-based Upflow Biofilter, BioResources, 10(4); pp.6730-6740
- **N.Rajamohan,** Jamila Al-Sinani,V.Saravanan, 2015. Performance evaluation and kinetic studies on removal of benzene in up-flow tree bark based biofilter, Chemical Industry & Chemical Engineering Quarterly, 21(4); pp.537-545.
- **N.Rajamohan,**Jamila Al-Sinani,V.Saravanan, 2015. Performance of Mesophilic Biofilter for the Treatment of Ethyl Benzene Polluted Air: Effect of Process Parameters, Asian Journal of Water, Environment and Pollution, 12(1) ; pp. 29–35.
- **N.Rajamohan**,Jamila Al-Sinani,V.Saravanan, 2015. Effect of concentration, residence time and shock load studies on the degradation of toluene in a biofilter with novel filter media, Asian Jr. of Microbiol. Biotech. Env. Sc. 17 (1) ;pp 63-70.
- V.Saravanan, M.Rajasimman, **N.Rajamohan,** 2015.Performance of packed bed biofilter during transient operating conditions on removal of xylene vapour, International Journal of Environmental Science and Technology,pp 1625-1634,
- V.Saravanan, M.Rajasimman, **N.Rajamohan** , 2013. Biofiltration of volatile organic compound using two packing materials: Kinetics and modeling, Korean Journal of Chemical Engineering, 30(10); pp 1918-1928


Outline
Abstract
Keywords
1. Introduction
2. Materials and methods
3. Results and discussion
4. Conclusion
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Journal of Hazardous Materials
Volume 162, Issues 2–3, 15 March 2009, Pages 981-988

Treatment of xylene polluted air using press mud-based biofilter

V. Saravanan, N. Rajamohan

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Abstract

In the present work, biofiltration of xylene vapors has been investigated on a laboratory scale biofilter packed with press mud as filter material inoculated with activated sludge from pharmaceutical industry. Four various gas flow rates, i.e. 0.03, 0.06, 0.09 and 0.12 $m^3 h^{-1}$, were tested for inlet xylene concentration ranging from 0.2 to 1.2 gm^{-3}. The biofilter proved to be highly efficient in the removal of xylene at a gas flow rate of 0.2 $m^3 h^{-1}$ corresponding to a gas residence time of 2.8 min. For all the tested inlet concentrations, the removal efficiency decreased for high gas flow rates. For all the tested gas flow rates, a decrease in the removal efficiency was noticed for high xylene inlet concentration. The follow-up of carbon dioxide

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I thank the Organizing committee of this conference for having given me an opportunity to share my thoughts and experience to the elite audience.

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