THE OVERLOOKED & REVEALED: EVIDENCE FOR MICROBIAL BIODEGRADATION ON ACTIVATED CARBON

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WHAT ABOUT ACTIVATED CARBON (AC) AND SUBSURFACE MICROBIAL COMMUNITIES?

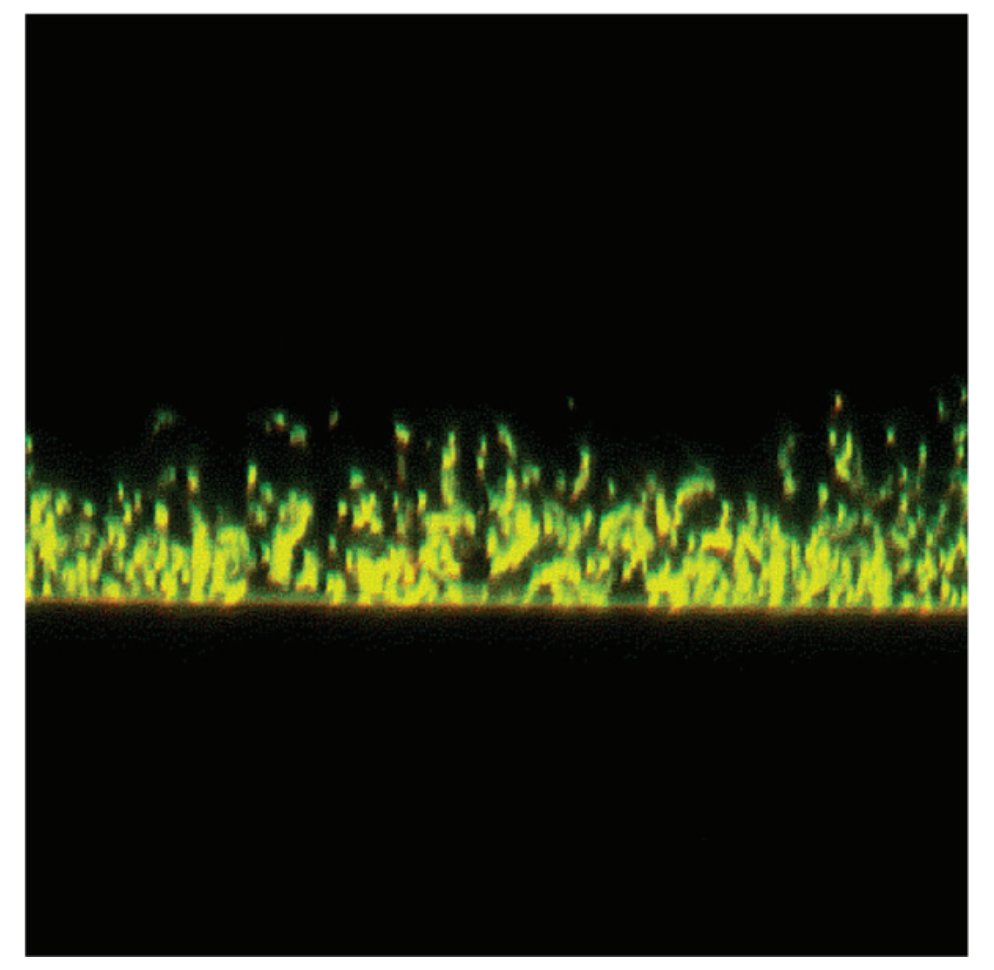
- Biodegradation of contaminants
- Contaminant Bioavailability

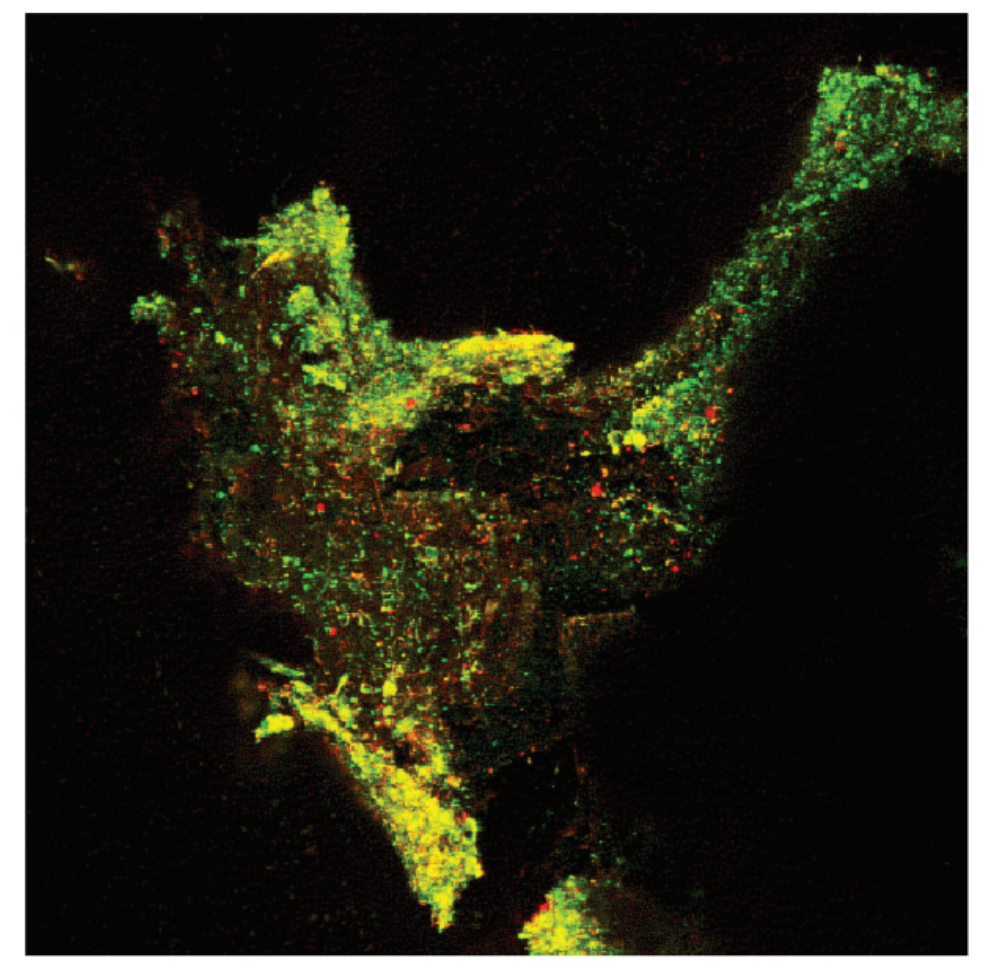
DOES AC HELP OR HINDER MICROBIAL FUNCTION AND BIODEGRADATION?

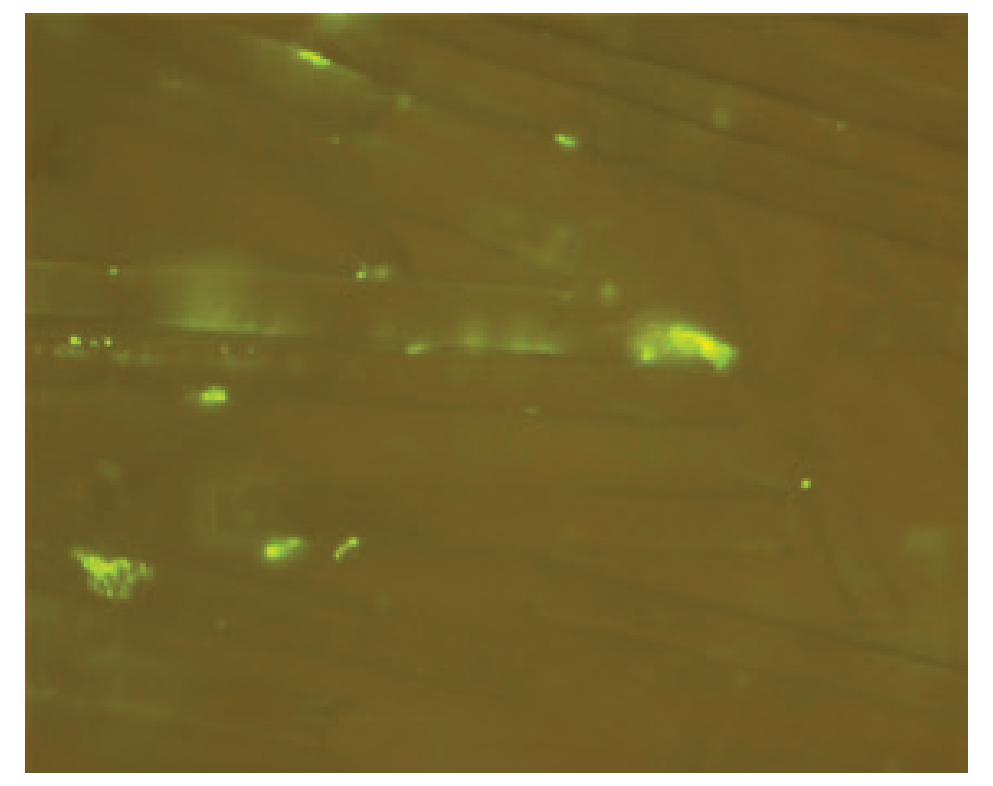
- There has been significant research characterizing the various mechanisms and drivers of microbial biotransformation and degradation in the subsurface. Specifically, it is known what makes the cell operate:
- The availability of a suitable carbon and energy source.
- The availability of a terminal electron acceptor.
- Temperature and pH conditions conducive to growth.
- The availability of trace nutrients.
- The removal of inhibiting metabolites.
- A suitable substratum for growth.

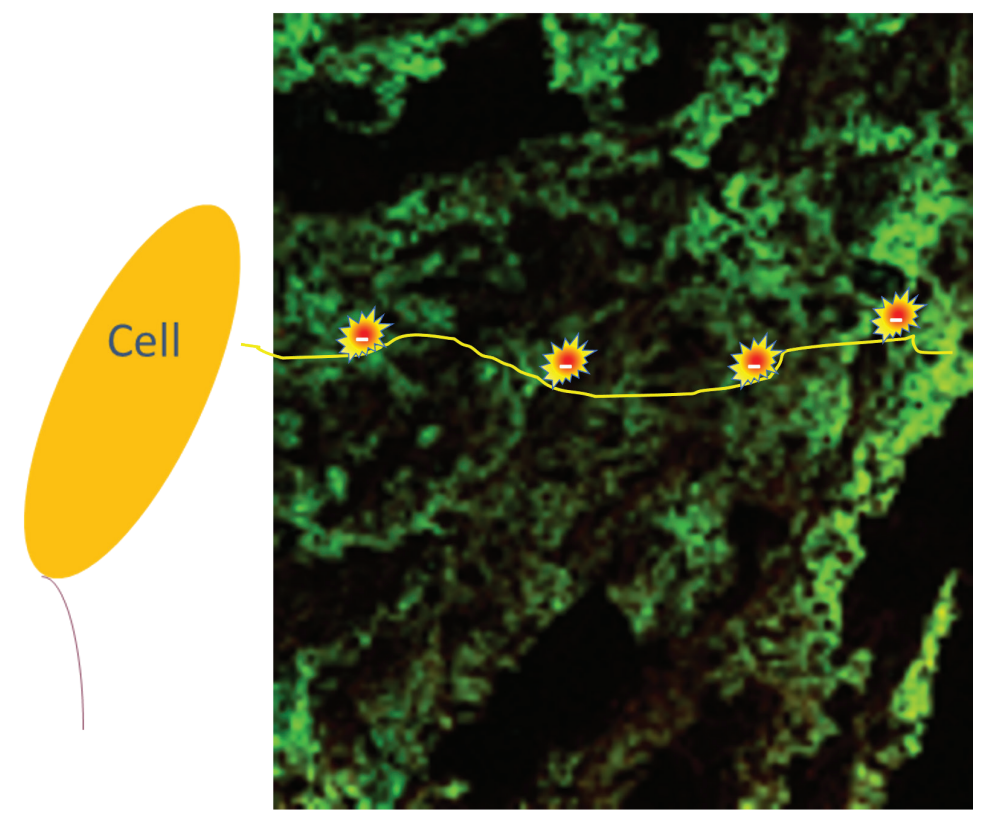
ACTIVATED CARBONS "ACS" ARE ESSENTIALLY POROUS, ADSORPTIVE POLYMERIC BIOCATALYSTS THAT SUPPORT AND FACILITATE THE GROWTH OF MICROBIAL POPULATIONS.

- AC provides a wealth of benefits to the microbial community including:
- The adsorption of organic contaminants and other organic nutrients;
- The control of contaminant metabolites and toxicity;
- The facilitation of electron transfer, DIET, and e-communities;
- Large surface area for microbial colonization;
- Low sheer stress for better attachment and protection from predation.









McCormick and Baxter Superfund Site

MECHANISMS FOR INTERSPECIES ELECTRON TRANSFER WITH EMPHASIS ON DIET.

Potential DIET mechanisms include:

a. electron transfer through electrically conductive pili;

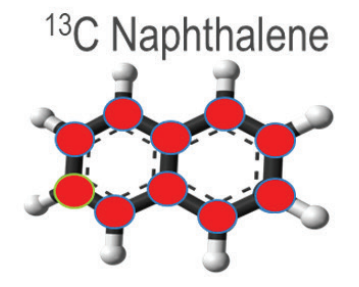
b. electron transfer through electrically conductive materials;

c. electron transfer between electron transport proteins associated with outer cell surfaces;

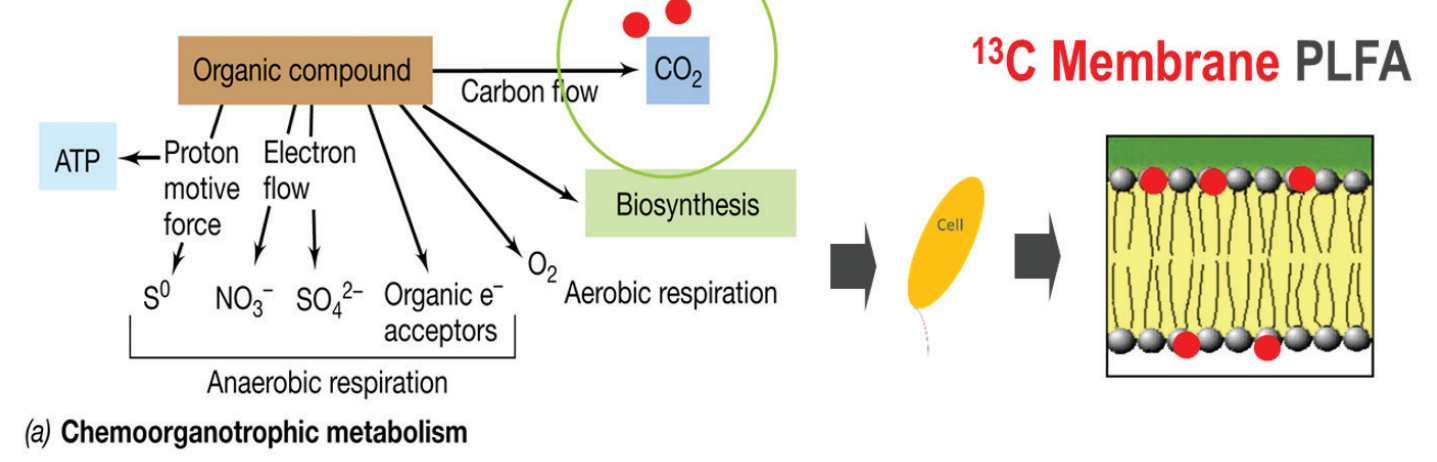
d. DIET contrasts with the diffusive exchange of electrons between species through soluble electron shuttles such as H2.

- **The ability of the microbial community to degrade naphthalene at the McCormick and Baxter Site appears to be (is) widespread.**
- ^{13}C incorporation from Naphthalene above the acceptance threshold in microbial biomass was recorded in all 18 locations.
- ^{13}C incorporation from Naphthalene above the acceptance threshold in CO_2 was recorded in 7 of the 18 locations.
- No ^{13}C incorporation was observed in methane.
- TEAPs and physical Location both influenced the microbial community biomass, composition, physiological status and the resulting naphthalene degradation.

^{13}C Naphthalene



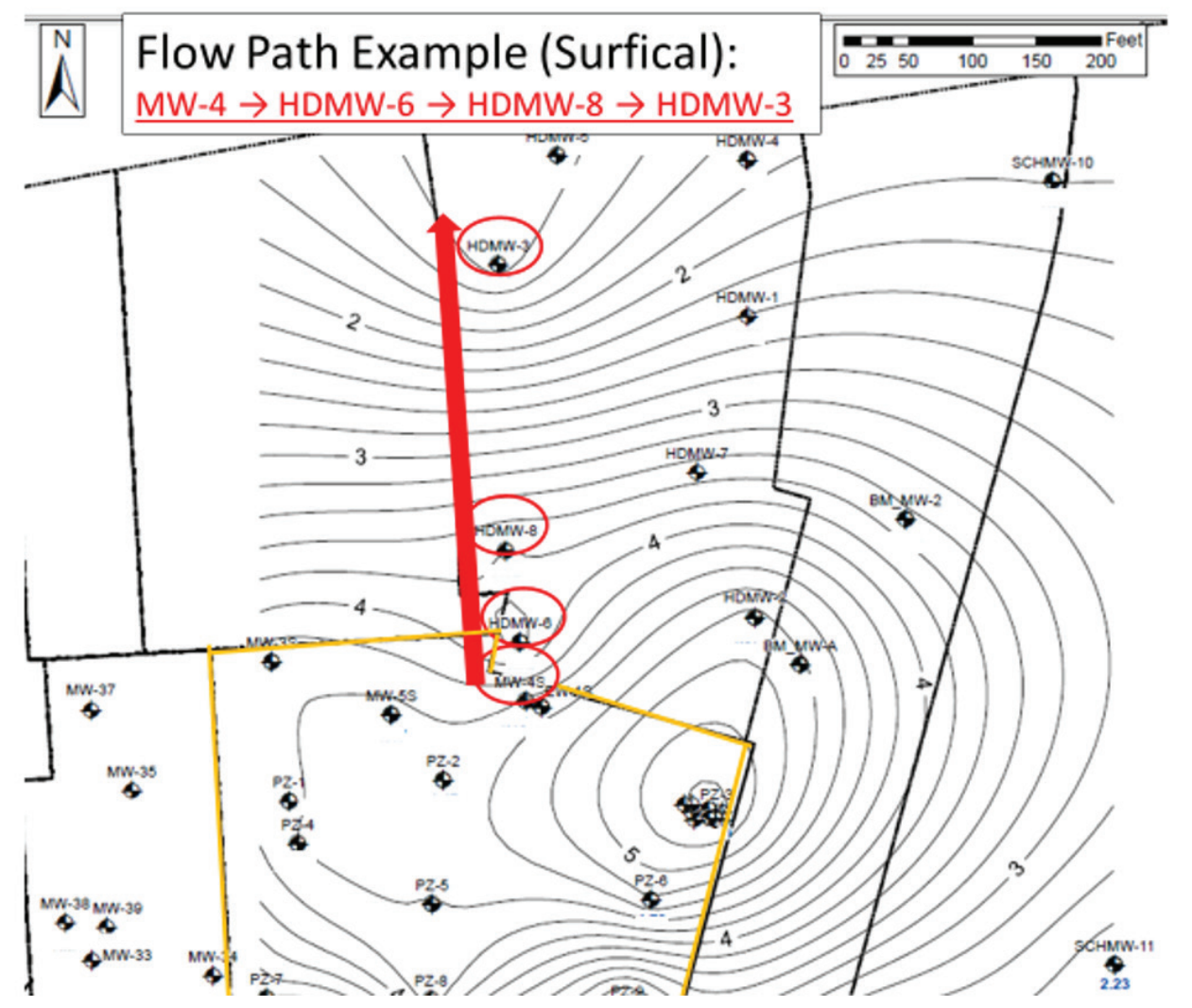
- **The coupling of molecular methods along with stable isotopic compounds provides a way to link biodegradation to the responsible organisms**



Demonstration of Naphthalene Biodegradation Decision Rules

- Detection of carbon-13 in **phospholipid fatty acids** (microbial biomass).
- Detection of carbon-13 in **carbon dioxide** (microbial metabolic activity).
- Detection of carbon-13 in **methane** (microbial metabolic activity).
- Decision criteria was based on establishing the background carbon-13 levels for each compound and then calculating the 99% upper tolerance limit. Carbon-13 levels above the 99% upper tolerance limit were accepted as carbon-13 enrichment.

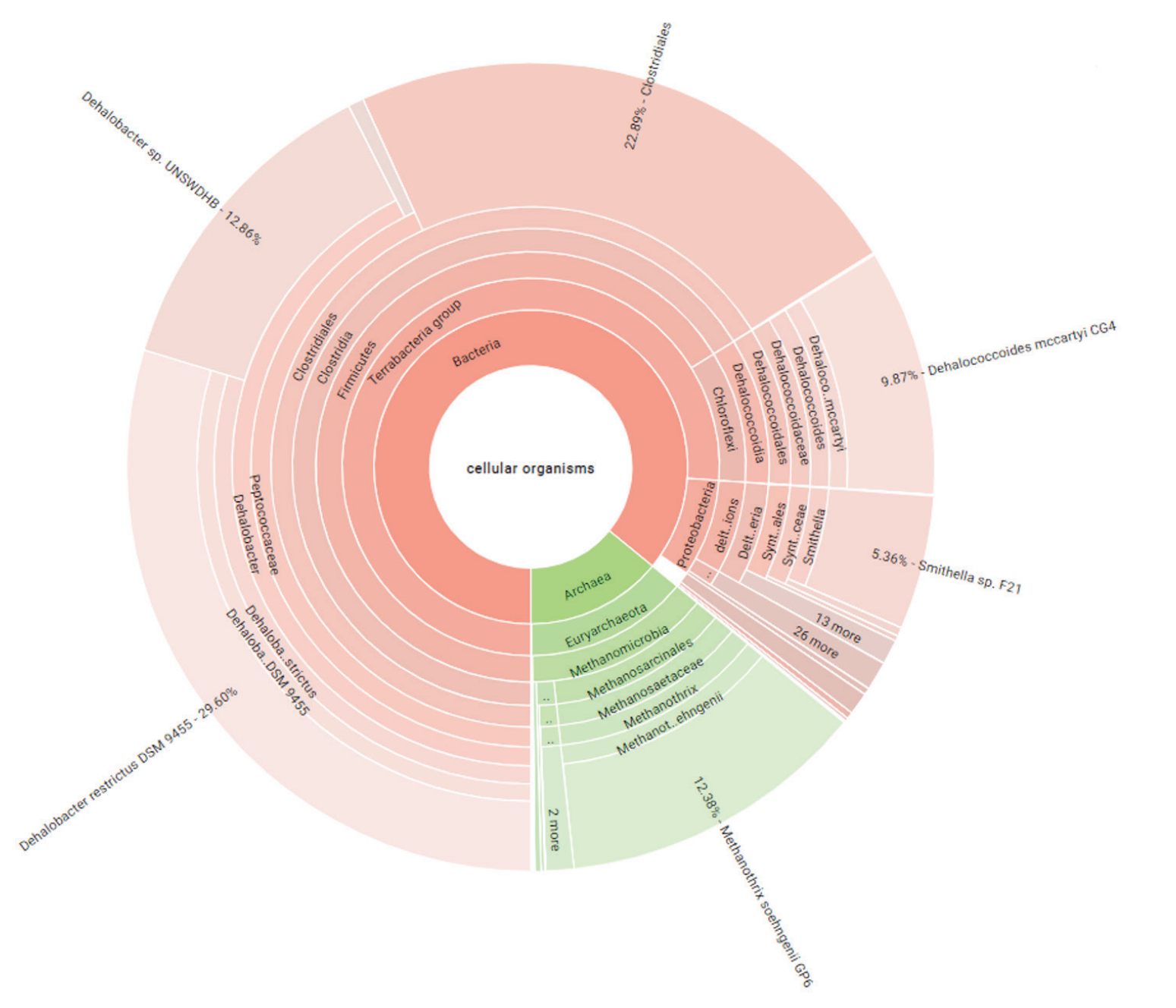
NATURAL PEAT CONTAINING SITE



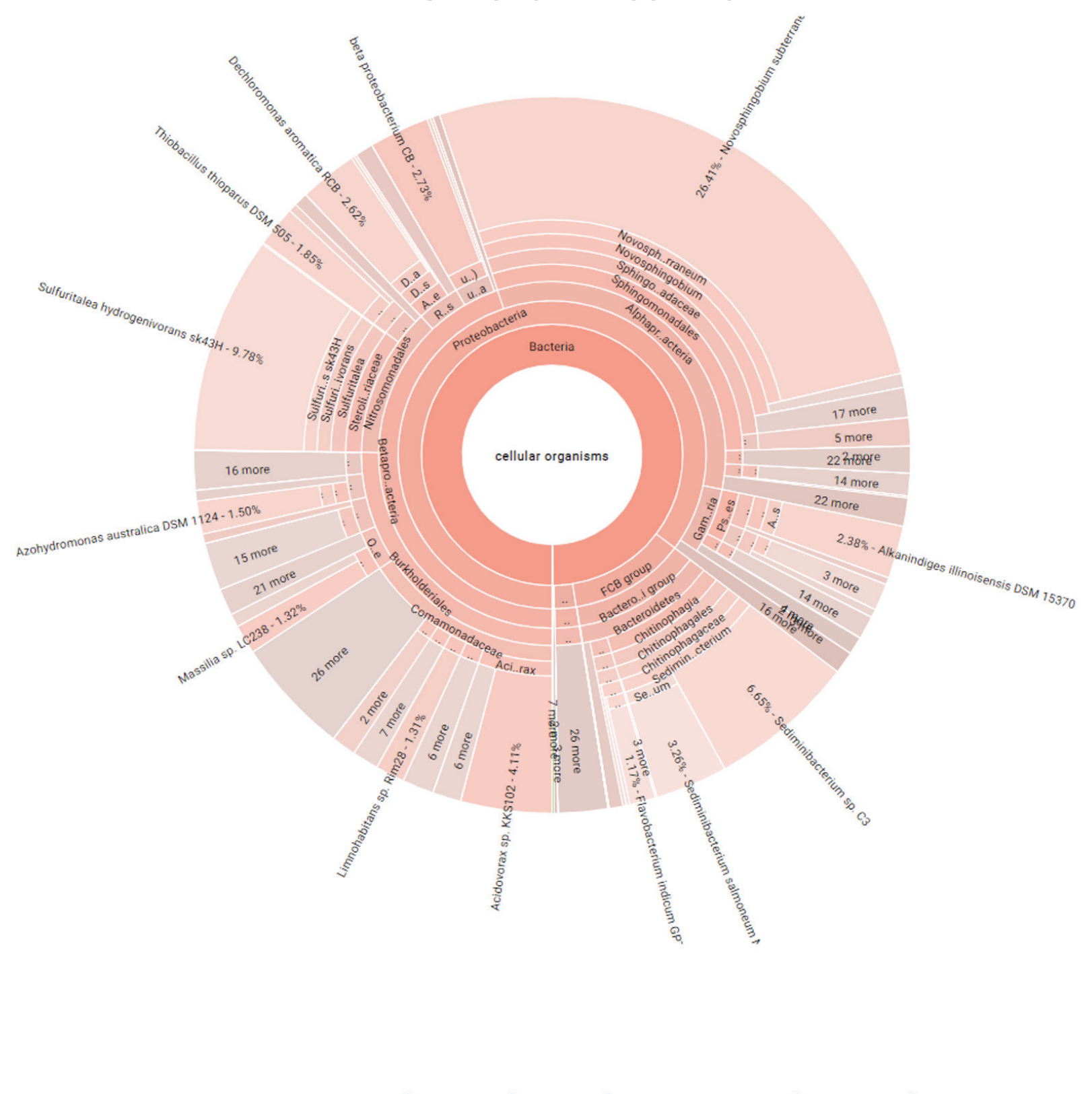
Sampling Results - Together
(Surficial Flow Path)

Well	MW-4	HDMW-6	HDMW-8	HDMW-3
DISTANCE (from MW-4)	-	50'	113'	338'
BENZENE (µg/L) March 2016	7,520	125	< 1	NS
BENZENE (µg/L) August 2016	9,200	150	1	4.1
CHLOROBENZENE (µg/L) Mar 2016	28,800	1,680	84	NS
CHLOROBENZENE (µg/L) Aug 2016	37,000	3,200	90	300
DO (mg/L)	0	0	0	NS
Carbon Dioxide (mg/L)	230	220	96	NS
Methane (mg/L)	3.6	16.0	23.0	NS
TOC (mg/L)	27	20	19	NS
ORP (mV)	-65	-55	-60	NS
CSIA δ^{13}C Benzene	-24.95	-22.57	-	NS
CSIA δ^{2}H Benzene	-153	-109	-	NS
CSIA δ^{13}C Chlorobenzene	-24.55	-24.40	-22.34	NS
CSIA δ^{2}H Chlorobenzene	-105	-92	-65	NS

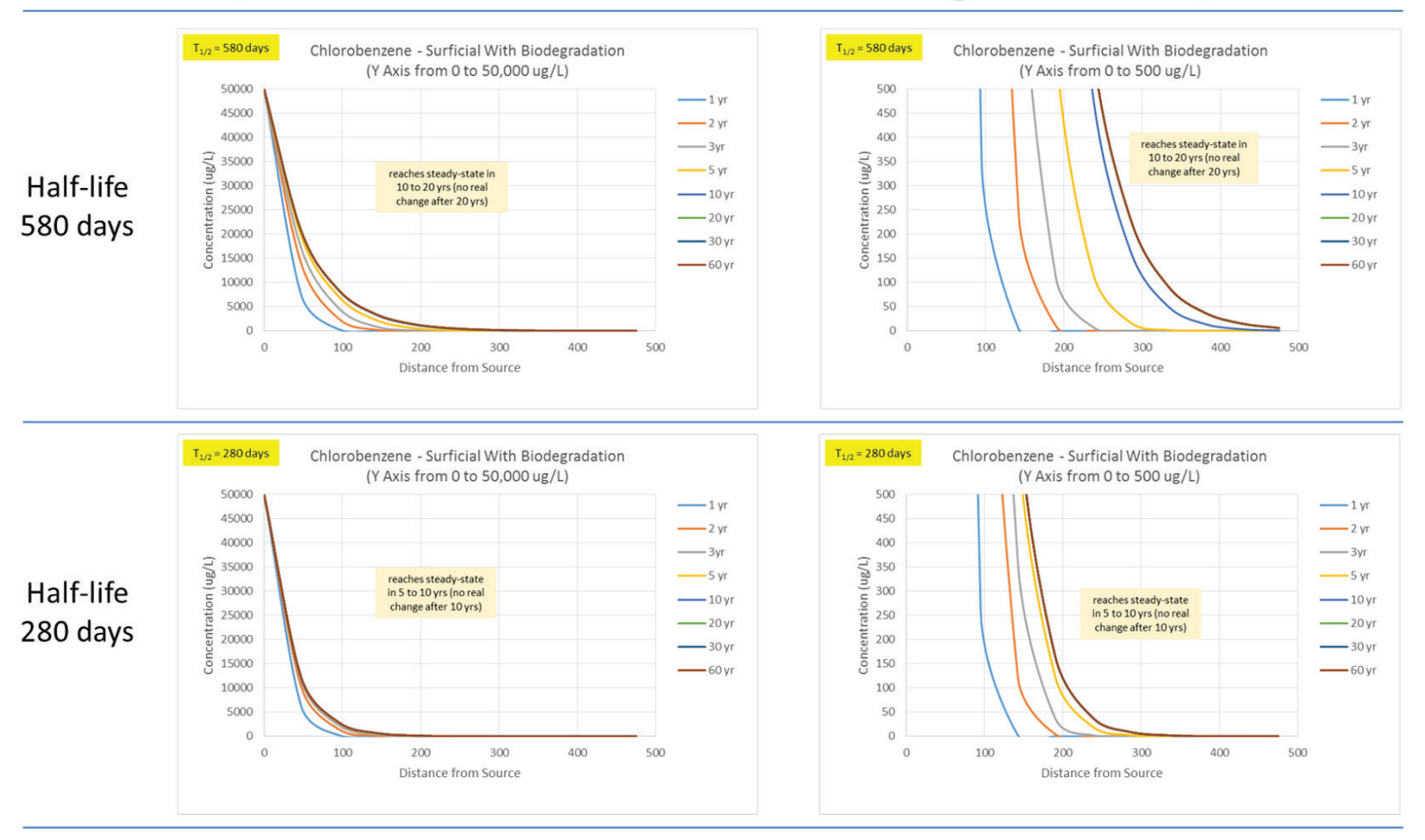
MW-4 MICROBIAL COMMUNITY



HDMW-8 MICROBIAL COMMUNITY



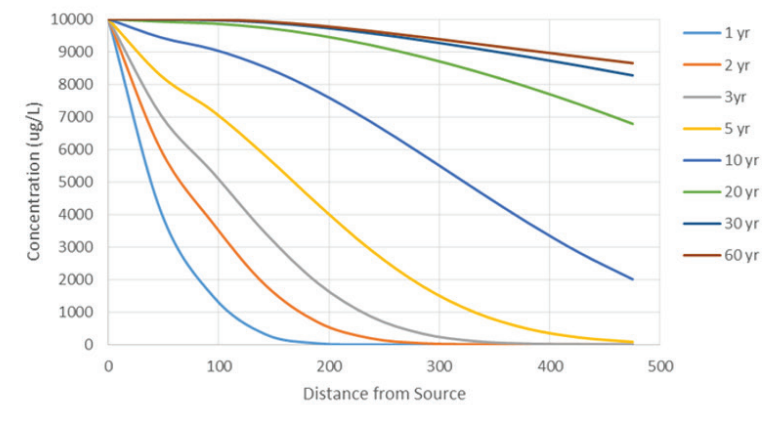
Simulated Concentrations – Surficial
(Chlorobenzene With Biodegradation)



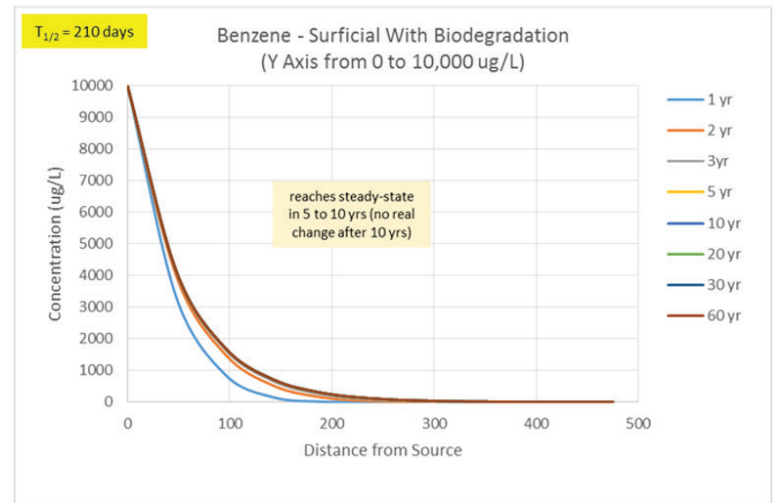
- Based on observed versus simulated concentrations, half-life is less than 280 days
- Concentrations stabilize within 5-10 years at most given that half-life

Comparison With and Without Biodegradation
(Surficial - Benzene)

Without Biodegradation



With Biodegradation Half-Life 210 Days



Observed data are consistent with simulated results that include biodegradation, with respect to magnitude of concentrations and stability of concentrations over time

C-3 In Situ Activated Carbon-Based Amendments: Assessing Effectiveness and Performance