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Dioxin pollution in Vietnamese hotspots and degradation activity of isolated bacteria in microcosms

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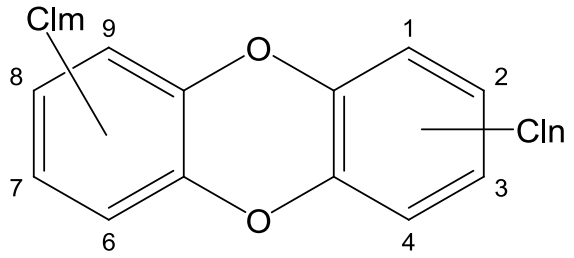
Formation and behavior of dioxins

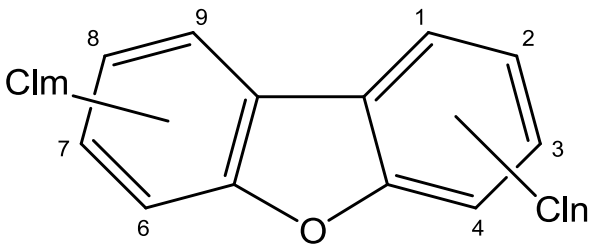
- Pesticide manufacture
- Paper manufacture
- Waste incineration
- Forest fire



Polychlorinated dibenzo-*p*-dioxins (PCDDs)

Behaviour of dioxins in soil

- Adsorbed on soils
- Very resistant in the environment
- Accumulate in fat tissues and concentrate in the food chain.



Polychlorinated dibenzofurans

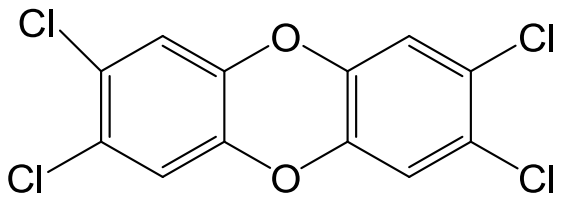
PCDFs

Effect of dioxins on human health

- Cause cancer, birth defects, reproductive, developmental and immunological problems.

Agent Orange and Dioxins in Vietnam

- Agent Orange (AO) defoliant: mixture 2,4 dichlorophenoxyacetic acid (2,4-D) and 2,4,5 tricholorophenoxyacetic acid (2,4,5-T)
- 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) in Agent Orange: 0.05 to 50 mg/L
- 72 M liters of AO sprayed



2,3,7,8-TCDD the most toxic among PCDDs

Objectives

- Determine the dioxin residue in soils/sediments at hotpots.

- Examine the potential of microbial detoxification of dioxin-polluted soils/sediments sprayed with Agent Orange.

Sampling sites

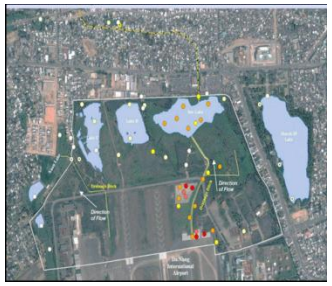
- At heavily sprayed area, Cua of Quang Tri province: sediments of water reservoirs, ponds and top soils of paddy and upland fields.
- At Aluoi of Hue: soils of former military airbase Aso, soils of paddy and upland crop field, sediments of lake and ponds.
- Da Nang former military airbase
- Bien Hoa former military airbase

Cua, Quang Tri prov.

A Luoi, Hue

Da Nang, former military airbase

Bien Hoa,former military airbase



Dioxin residues in soils/sediments at study sites

A Luoi: 2,3,7,8-TCDD at former air-base:

- Topsoil in A Luoi air-base: ~ 900 pg/g
- Duck and fish fats: 40-60 pg/g
- Human blood: 14-40 pg/g

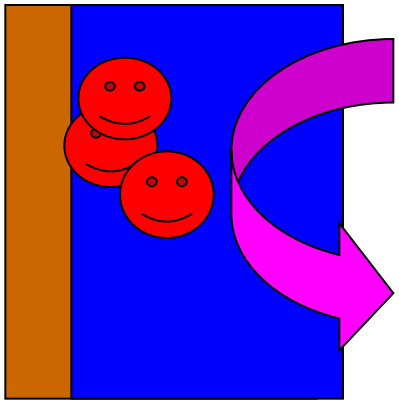
(Source: Dwernychuk & Hoang D.C, 2002)

Da Nang and Bien Hoa former military air-bases pg/g

Site	Sample type	2,3,7,8-TCDD
Da Nang	Sediment	271
	Soil 01	633
	Soil 02	7095
Bien Hoa	Sediment	100
	Soil 01	115

Microbial detoxification of dioxins

Anaerobic condition

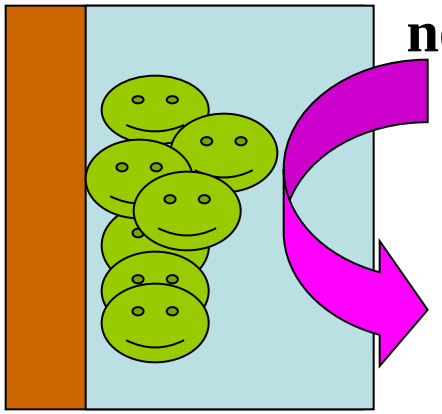


High chlorinated dioxins

less chlorinated or non-chlorodioxin

Reductive dechlorination done by *Dehalococcoides*:

Aerobic condition



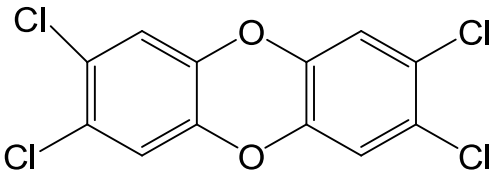
non-, mono- or di-chlorodioxins

$CO_2 + H_20$

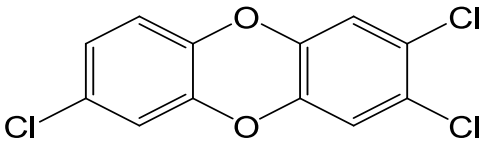
Degradation (breaking the aromatic ring)

Electron donor: organic acid ⟶ H_2

Electron acceptor:



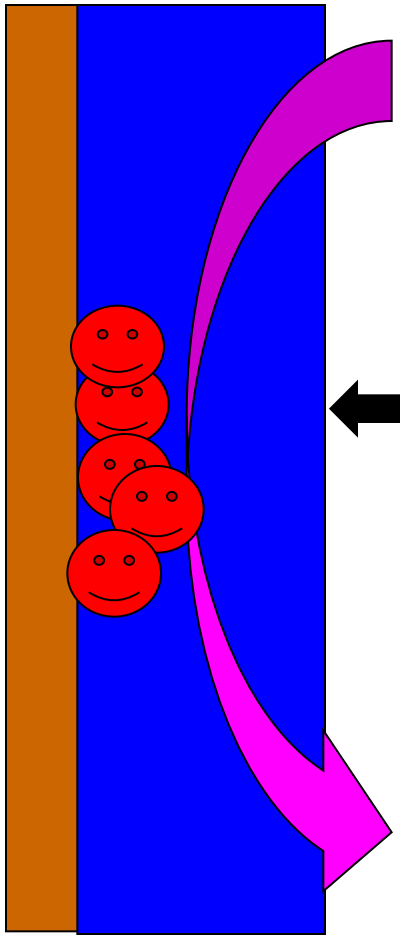
+ 2H $\xrightarrow{rdh}$



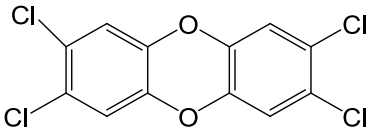
+ HCl

Reductive microbial dehalogenation of halogenated aromatic compounds

Dehalococcoides with reductive dehalogenase genes



Highly halogenatted aromatic compounds

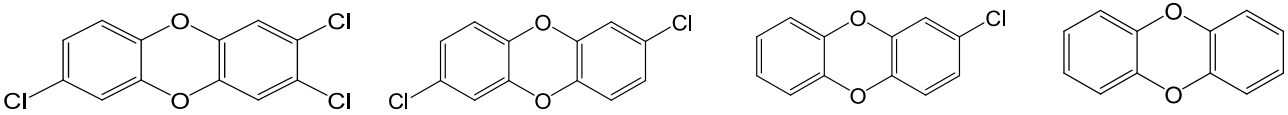


Function as electron acceptor

Electron donor: organic acids

Anaerobic condition

Less halogenated or non-halogen aromatic compounds



Anaerobic microcosm set up

Examine 1,2,3,4-TCDD / 2,3-DCDD dechlorination:

spike soils/sediments with:

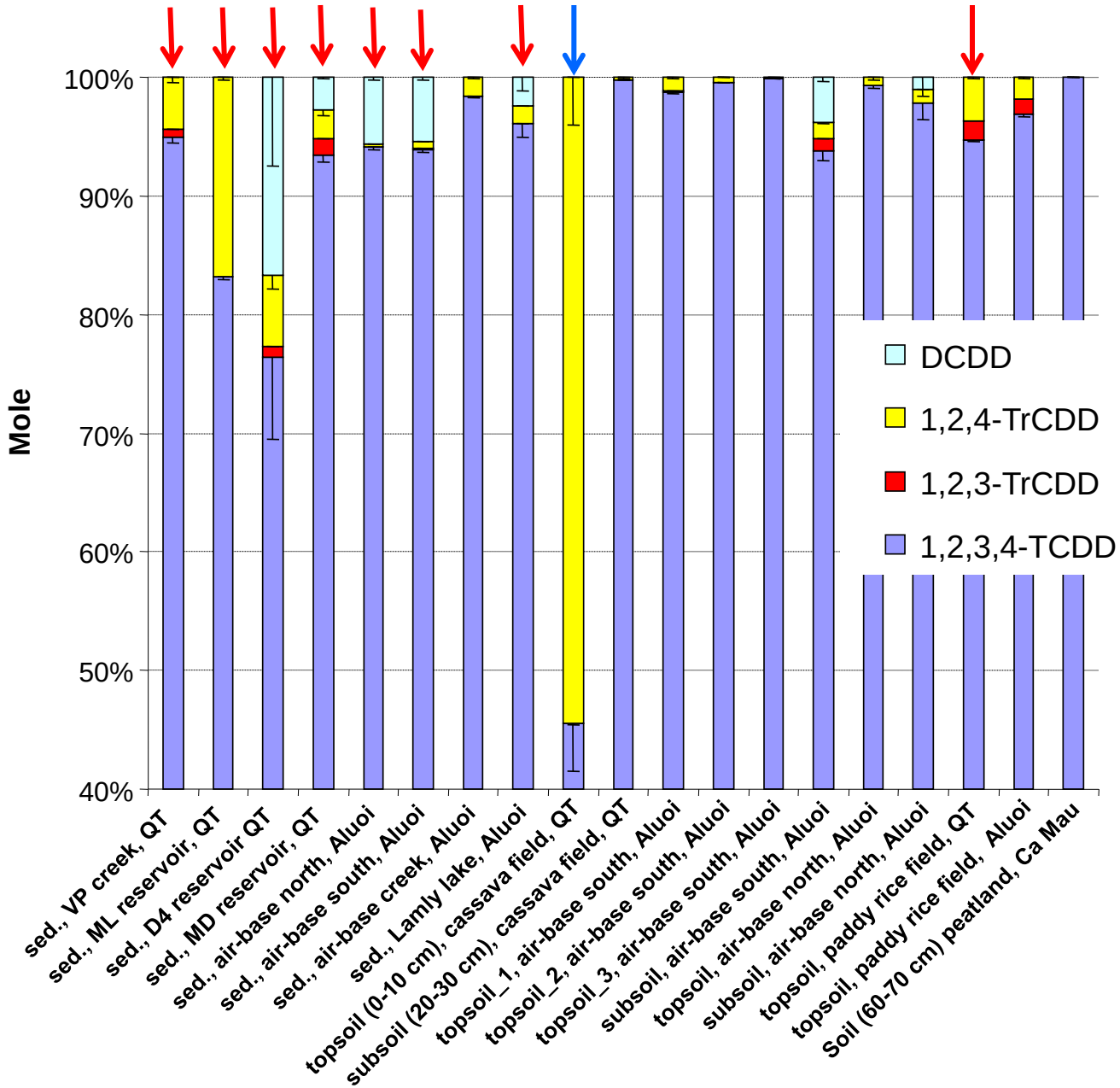
+ 1,2,3,4-TCDD or 2,3-DCDD

+ electron donors (lactate + butyrate + pyruvate + propionate)

Examine dechlorination of 2,3,7,8-TCDD:

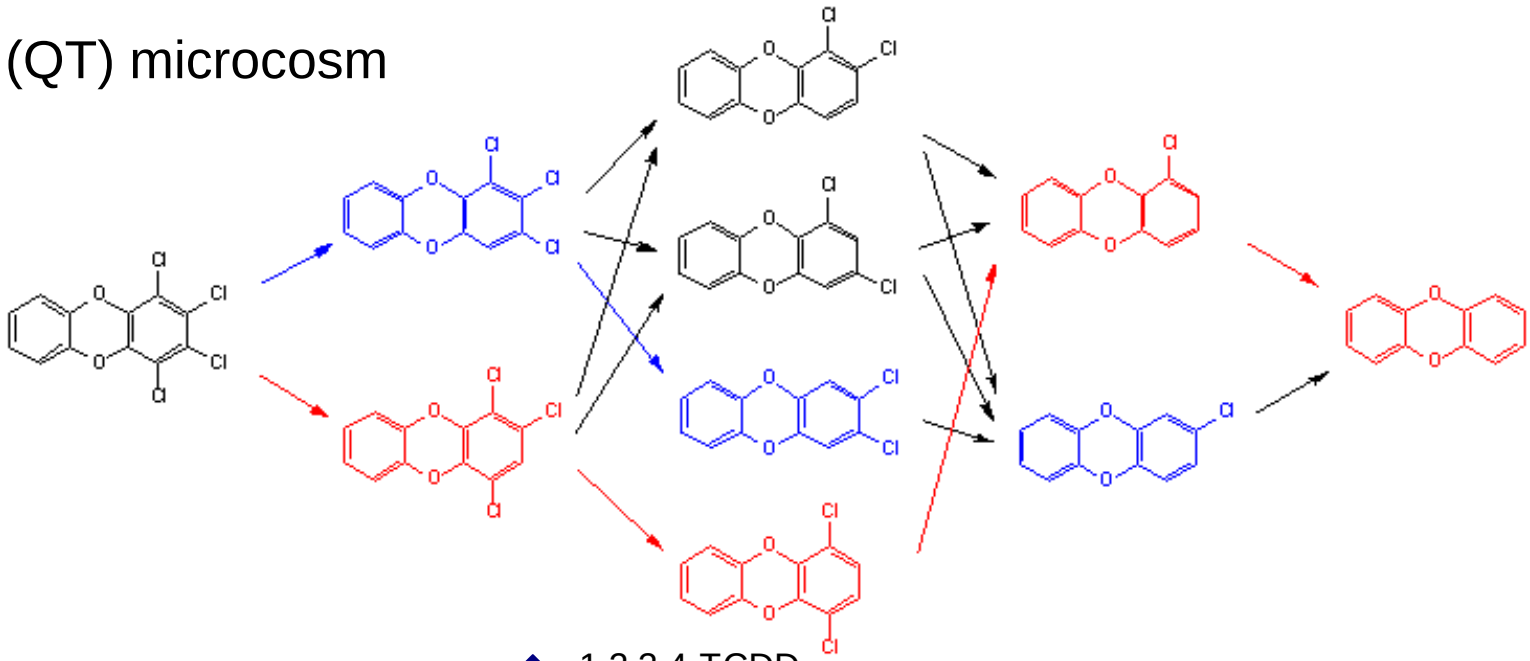
Spike 2,3,7,8-TCDD to positive 2,3-DCDD dechlorinating microcosm.

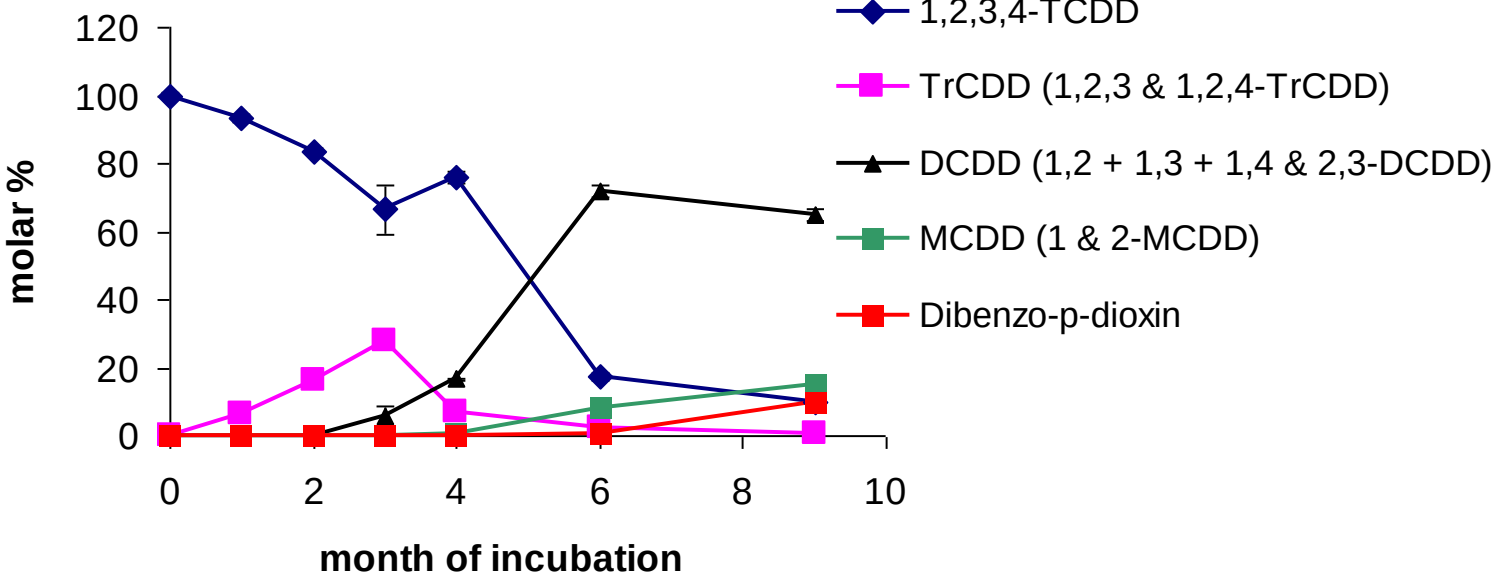
Dechlorination activity after 4-month incubation



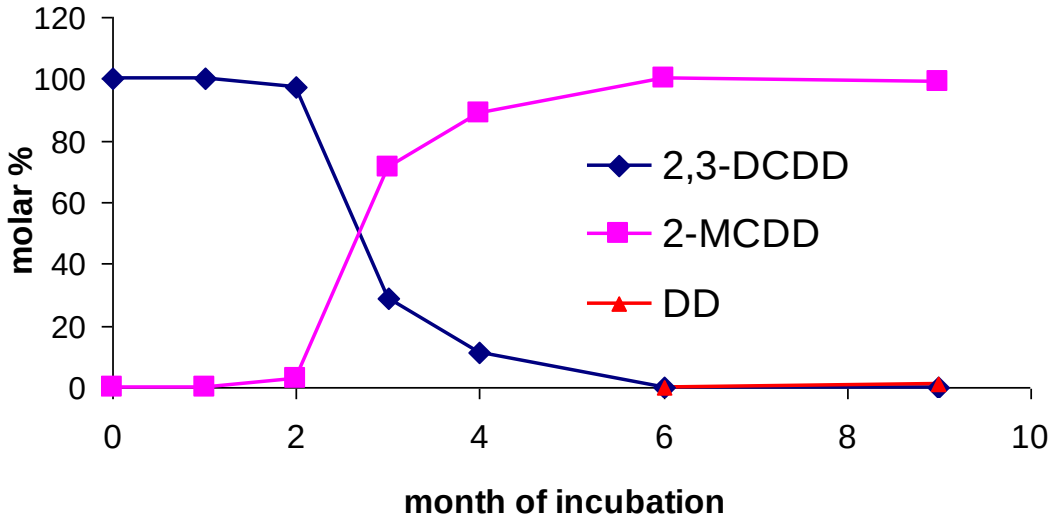
Lateral and angular dechlorination pathways

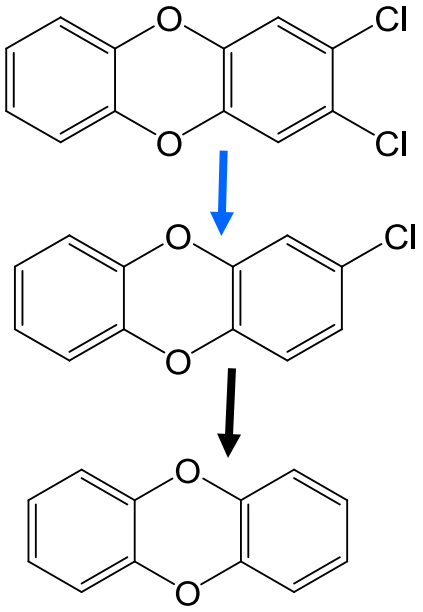
D4 sediment (QT) microcosm

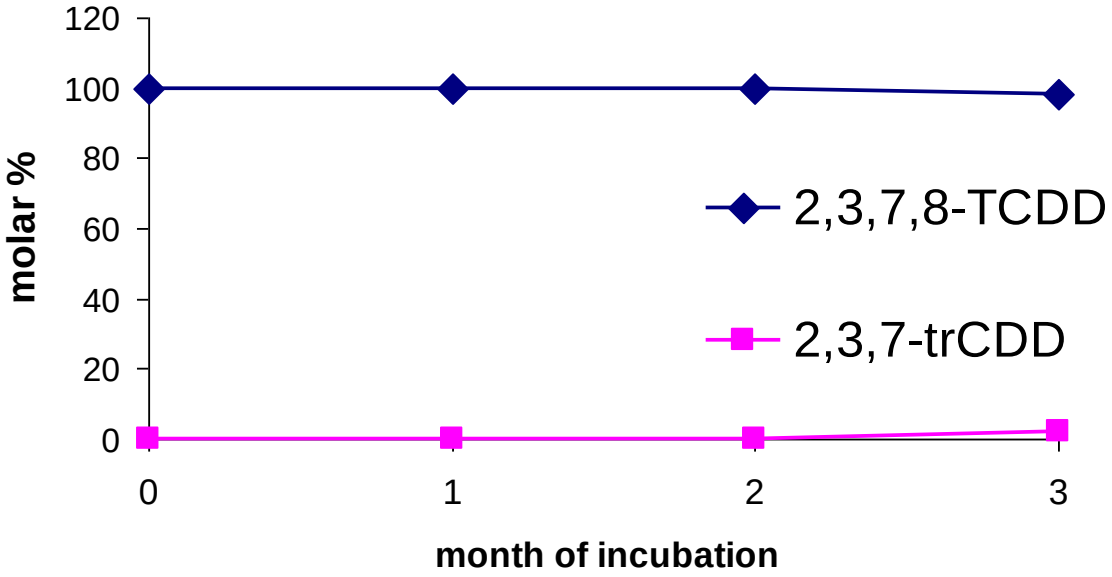


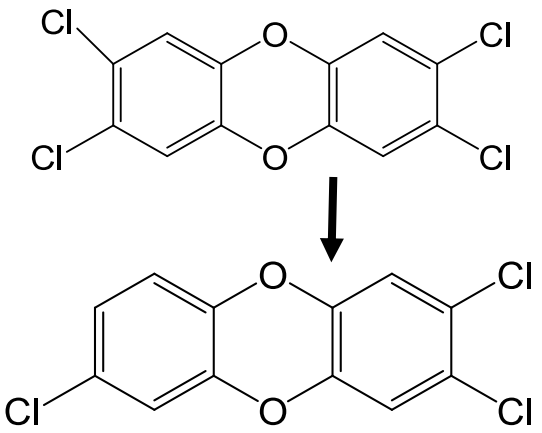


2,3,7,8-TCDD dechlorination by positive 2,3-DCDD dechlorinating community

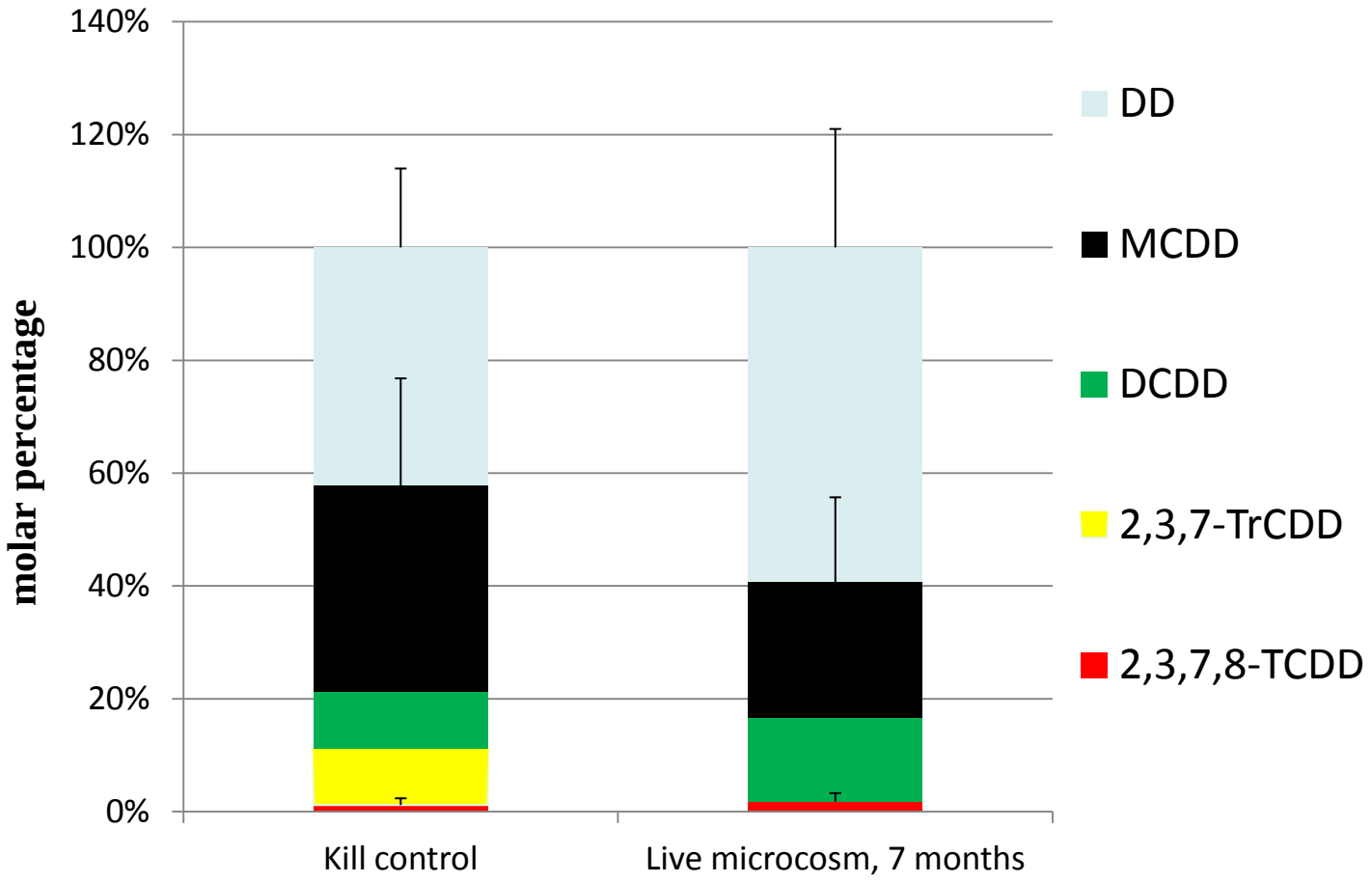








Enhancing dechlorination of PCDDs in Danang sediment by anaerobic incubation

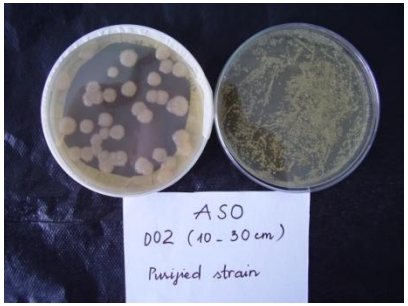


Isolation of Dibenzofuran-degrading aerobic bacteria

Soil/sediment sample

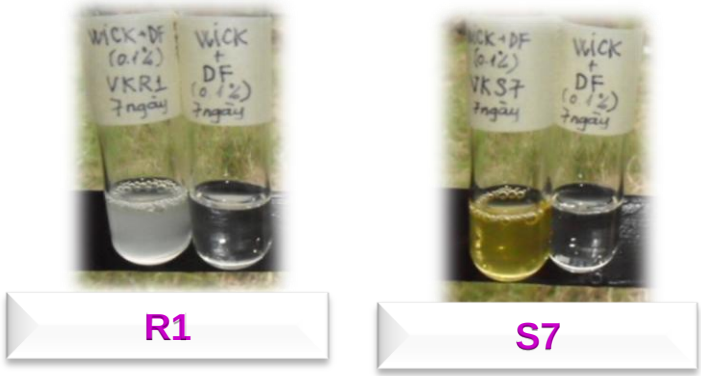
Soil extraction

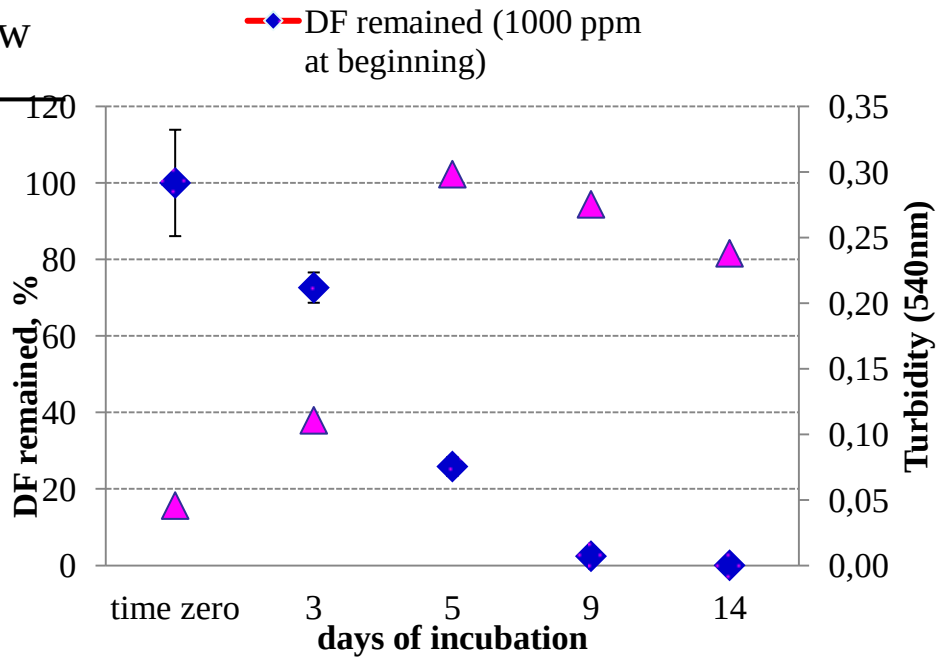
Several times



Aerobic dibenzofuran degardation of isolates

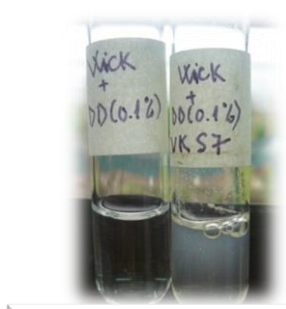
Isolating site/19 samples	Time getting turbid in liquid media, days	Media color
Đất lúa HươngLâm (R1)	5	white
Đất rẫy HươngLâm (S7)	5	yellow
Đất sân bay Aso (ĐAS)	20	yellow
Bùn Mai Đàn (BMĐ)	16	yellow
Đất lúa Mai Lộc (ĐML)	14	yellow





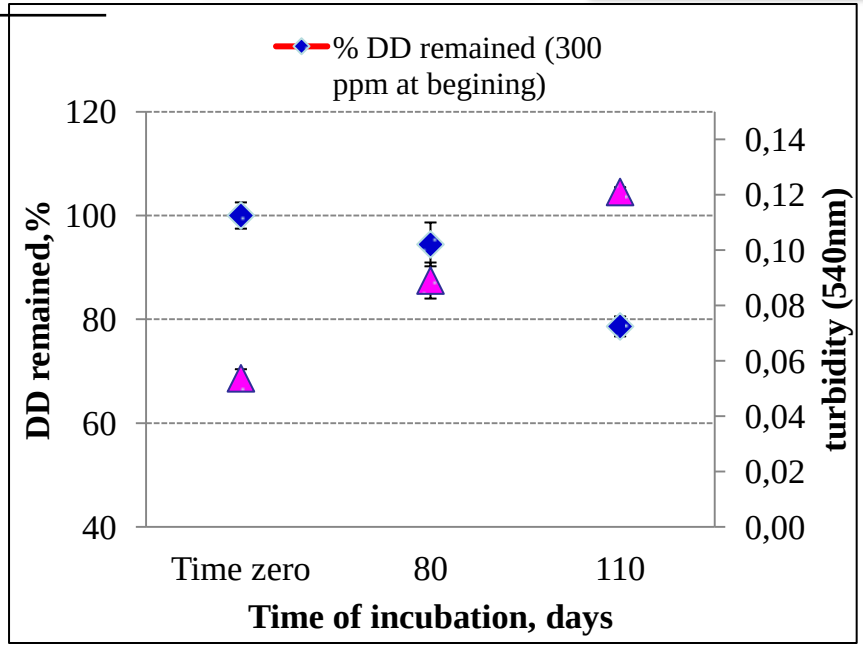
Aerobic dibenzo-*p*-dioxin degardation of isolates

Isolating site/19 samples	Time getting turbid in liquid media, days	Media color
rice field, A Luoi (R1)	60	white
A Luoi (S7)	80	white
Cua, Mai Đàn (BMĐ)	20	white
Aso, stock place (BAS)	30	white
Cua, Mai Lộc (ĐML)	35	white



S7

BMĐ



Conclusions

- After more than 40 years, the residues of dioxins in soils/sediments in some hotpots are still high.
- Both reductively polychlorinated dibenzo-*p*-dioxin (PCDD) -dechlorinating and aerobic Dibenzofuran-degrading bacteria appear to be ubiquitous in soils/sediments after 40-year contamination by spraying with Agent Orange
- Activities of PCDD reductive dechlorination and dibenzofuran degradation in microcosms show a potential of using indigenous bacteria to detoxify dioxins and the need to create appropriate environmental conditions for enhancing microbial detoxification of dioxins.

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