Evaluation of technologies for sequestering carbon by using organic filter underdrains

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An agricultural approach to mitigating global warming

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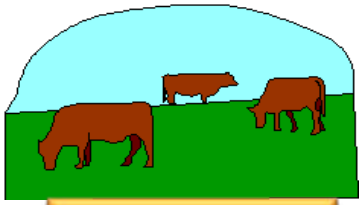
Kyoto Accord: absorption of agricultural CO_2 emissions

Forestry

Vegetation



Grazing

Cropland management

Canada

Denmark

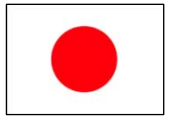
Portugal

Spain

Cropland management

Efforts to reduce CO_2 emissions through cropland management (no-till farming, etc.)

Japan



Currently no farmland-related efforts

Need method suitable for Japan

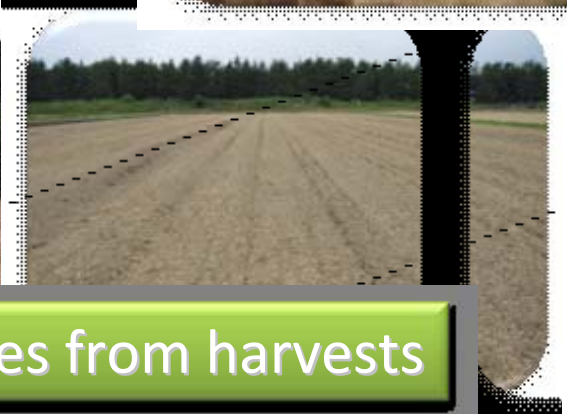
Under study in Japan: management of soil carbon sequestration with crop residue and other organic materials

Adding organic materials to farmland: examples

Composted crop residue, other organic materials

Crop improvement through soil enrichment

Increasing carbon sequestration (organics) in the soil



Stems and leaves from harvests

Green manure

Carbon Sequestration – which is more efficient?

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Mulching organics (surface)

- Simple and easy
- Much biological activity, ease of foraging
- Quick microbiological decomposition (oxidation)

Mulching

Good for small annual additions

Burying organics (deep)

- Burial can be troublesome, time consuming
- Little biological activity, difficulty of foraging
- Slow microbiological decomposition (reduction)

Burial

Good for large additions once every few decades

Carbon sequestration in underdrainage system

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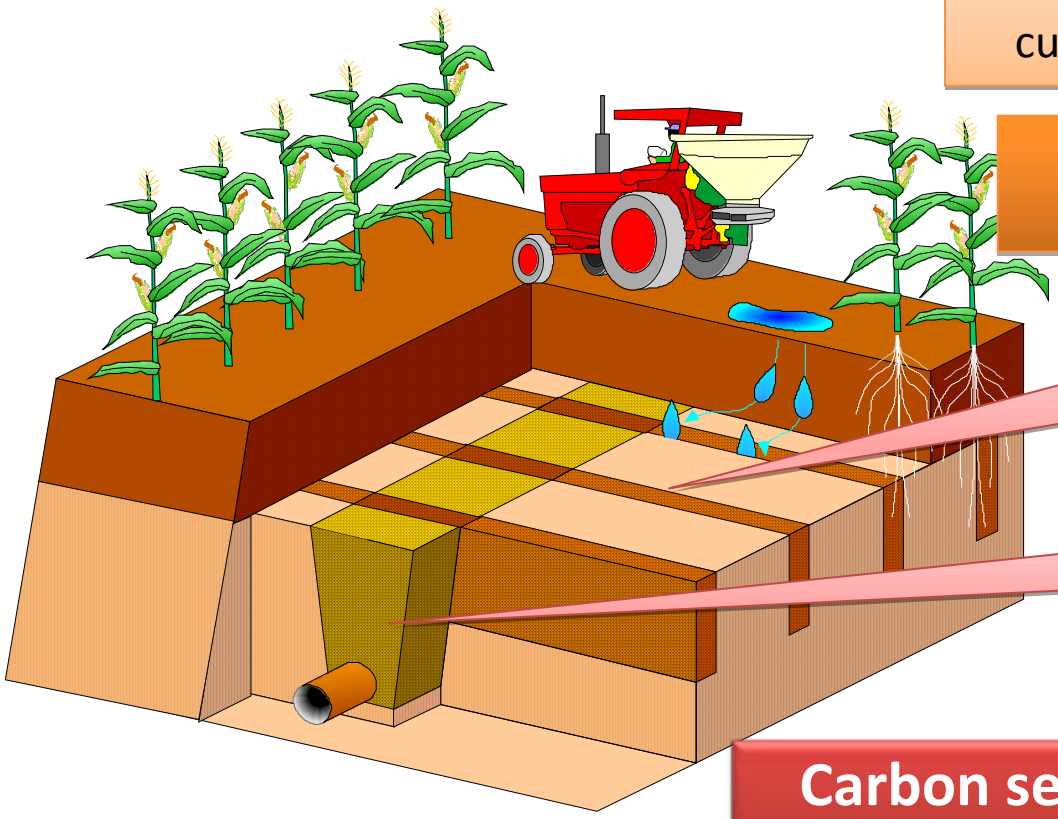
New technology — placement of organic materials within underdrainage system to sequester carbon while improving productivity



underdrainage system
Better drainage raises productivity, facilitates cultivation, enhances farmland versatility

Enhanced performance
Better drainage, higher durability

Use of durable, easily obtainable organics as burying filter materials

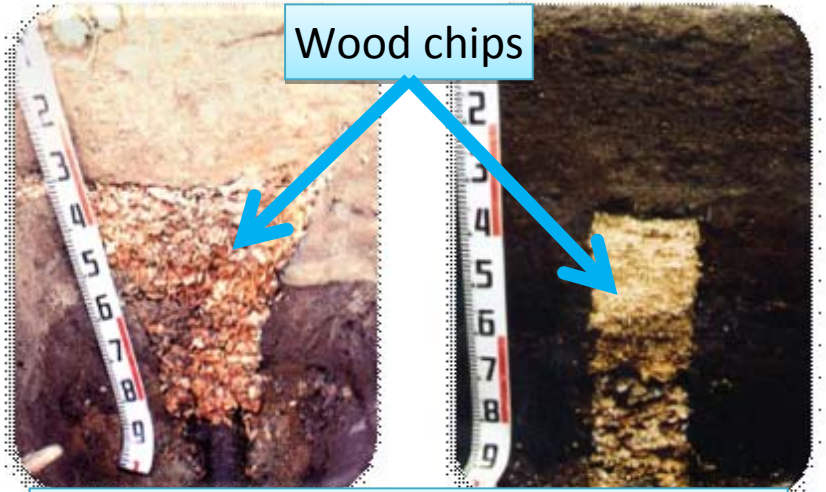
Use of highly durable organics for main underdrain

Carbon sequestration by using organic materials in subsurface drainage system

Types of organic filter underdrains

Underdrains

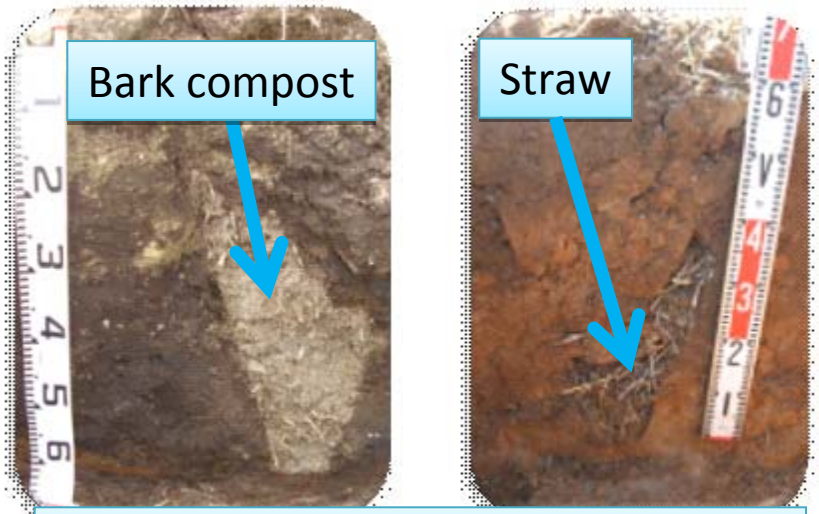
Area: 18,000 ha/yr



Use of highly durable wood chips

Supplementary drains (subsoil improvement)

Area: several kha/yr



Use of various filter materials

Assessment
— carbon sequestration in organic materials

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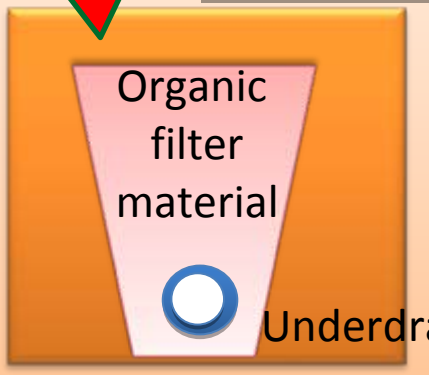
Carbon sequestration



Decomposition characteristics of various materials

Assessment of quantity of residual carbon in the material

Construction

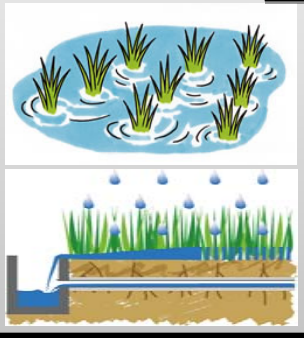
LCA

Greenhouse gases from construction

Greenhouse gases from using materials

Emissions during installation of underdrainage system

Soil



Greenhouse gases from soil, materials

Effect of underdrain on greenhouse gas emissions

Assessment of carbon sequestration in underdrainage systems

Determining carbon sequestration in underdrains

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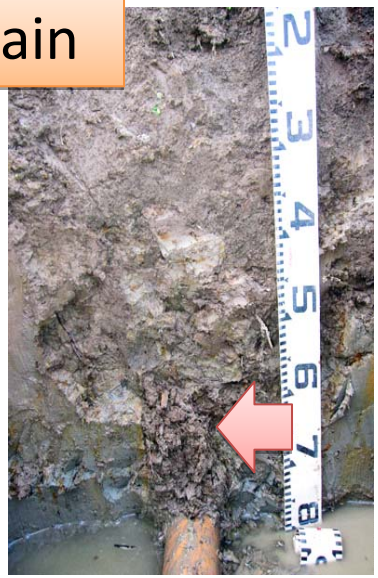
Wood chip filter underdrain

After 7 years

After 16 years

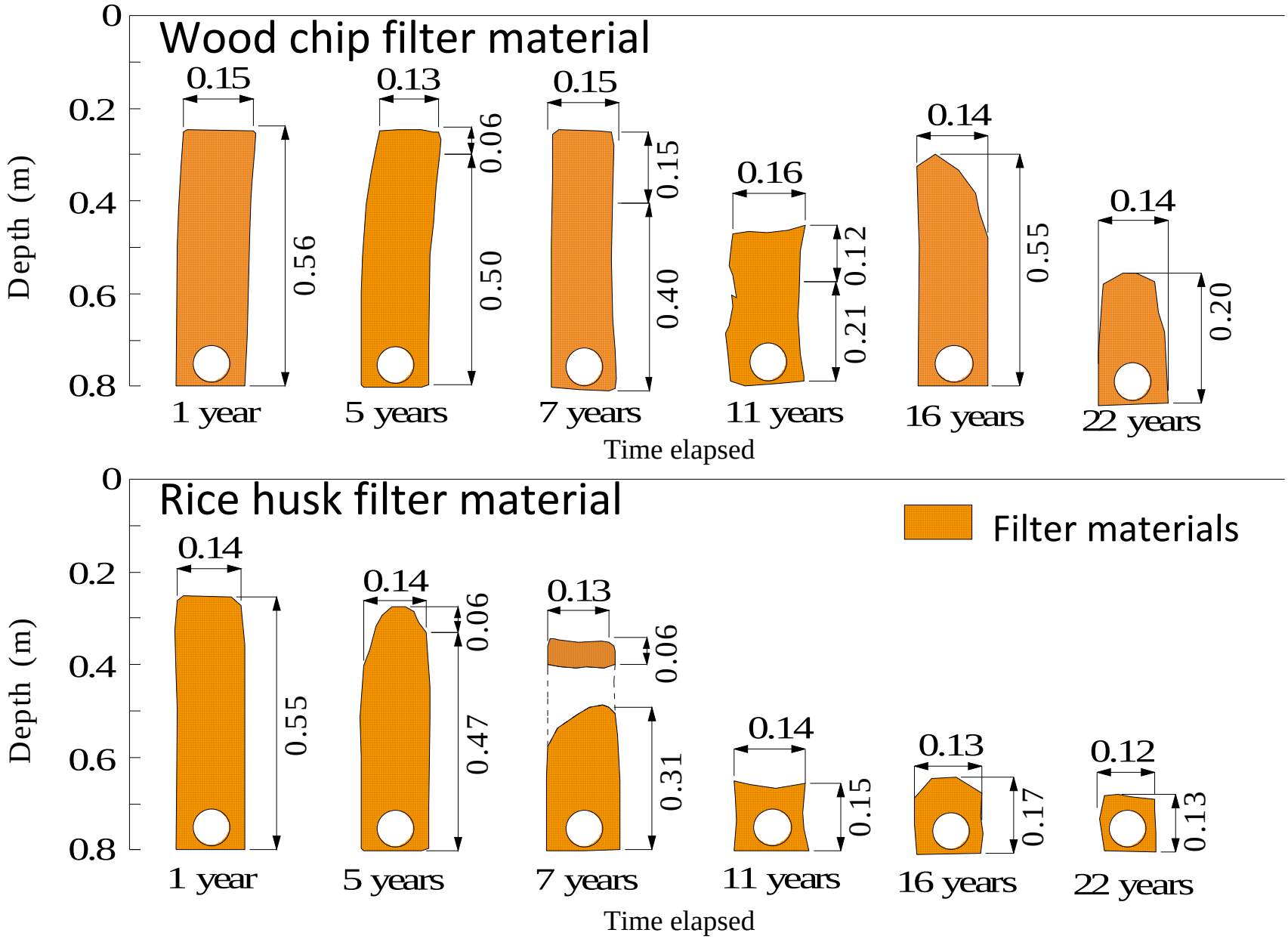


After 22 years

Rice husk filter underdrain

- Examined nearby paddy fields having underdrains with wood chips or rice husks
- Collected data extending back 22 years
- Study area: central Hokkaido, a snowy region in northern Japan

Decay of organic filter materials over time



Carbon sequestration in organic filter materials over time

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Filter type	Parameter	Years elapsed				
		Initial	5 y	7 y	11 y	15 y (estimate)
Wood chips	Carbon content (%)	48.6	48.0	48.0	46.0	—
	Material area (%)	100	98.2	86.7	62.4	—
	Dry density（t/m^3）	0.17	0.16	0.16	0.16	—
	Retained carbon (tCO_{2eq}/ha)	**23.1**	21.1	18.6	12.9	**11.4**
	Retained carbon (%)	100	91.3	80.6	55.9	**49.5**
Rice Husks	Carbon content (%)	39.2	41.4	47.1	25.9	—
	Material area (%)	100	84.8	45.5	14.0	—
	Dry density（t/m^3）	0.10	0.09	0.09	0.08	—
	Retained carbon (tCO_{2eq}/ha)	**11.0**	8.8	5.4	0.8	**0.6**
	Retained carbon (%)	100	80.5	49.1	7.4	**5.4**

Note: Figures pertain to the trencher-dug rice paddy field

Carbon sequestration in filter materials (paddy fields)

- Percentage of residual carbon within organic material filter underdrain after 15 years is estimated at 49.5% for chips and 5.4% for husks — a big difference
- Greenhouse gas equivalent: 11.4 tCO_{2eq}/ha for wood chips and 0.6 tCO_{2eq}/ha for rice husks
- Rice husks decompose more readily than wood chips
- Filter material selection is important

Assessment — CO_2 emissions during installation of organic filter material underdrains

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Example from Hokkaido, furthest north of the Japanese islands

Carbon sequestration

Decomposition characteristics of various materials

Assessment of quantity of residual carbon in material

Construction

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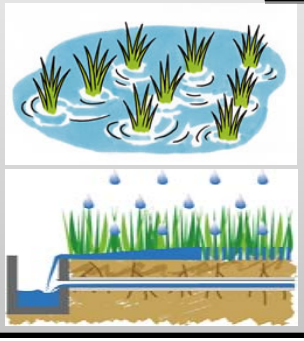
Greenhouse gases from construction

Greenhouse gases from using materials

Emissions during installation of underdrainage system

Soil



Greenhouse gases from soil, materials

Effect of underdrain on greenhouse gas emissions

Assessment of carbon sequestration in underdrainage systems

CO_2 emissions during installation of underdrains

Parameter	Wood chips		Rice husks		Unit CO_2 emissions
	Amount used (L) or direct cost(¥1000/ha)	CO_2 emissions (tCO_{2eq}/ha)	Amount used (L) or direct cost(¥1000/ha)	CO_2 emissions (tCO_{2eq}/ha)	
					($kgCO_{2eq}$/L)
Gasoline（L）	0.1	0.0002	0.1	0.0002	2.34
Diesel fuel (L)	577	1.52	564	1.49	2.64
Direct emissions	—	1.52	—	1.49	
(¥1000/ha)					($kgCO_{2eq}$/¥1000)
Gasoline Products	46	0.21	45	0.21	4.57
Plastic pipe, etc.	296	1.35	296	1.35	4.56
Wood chips	238	0.45	—	—	1.90
Rice husks	—	—	174	0.29	1.69
Construction machinery wear	139	0.47	139	0.47	3.40
Dump truck wear	12	0.04	9	0.03	3.46
Work/admin costs	595	0.60	539	0.54	1.01
Indirect emissions	—	3.13	—	2.90	
Total	1,326 (110)	4.65 (107)	1,202 (100)	4.36 (100)	

CO_2 emissions during installation of underdrains

- CO_2 emissions during installation of organic filter underdrains
  - Wood chips: 4.65 tCO_{2eq}/ha
  - Rice husks: 4.36 tCO_{2eq}/ha
  - Difference: only 7%

- Greenhouse gas equivalent: 4–5 tCO_{2eq}/ha
  - Little difference between the two filter materials

Assessment — effect of organic filter underdrains on greenhouse gas emissions (paddy fields)

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Example from Hokkaido, furthest north of the Japanese islands

Carbon sequestration

Organic filter material

Underdrain

Decomposition characteristics of various materials

Assessment of quantity of residual carbon in material

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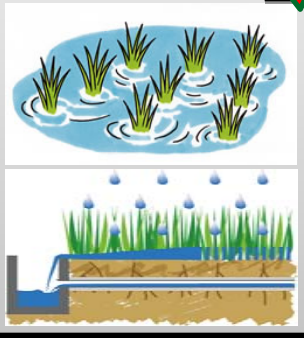

Greenhouse gases from soil, materials

Effect of underdrain on greenhouse gas emissions

Assessment of carbon sequestration in underdrainage systems

Effect of organic filter underdrains on greenhouse gas emissions (paddy field)

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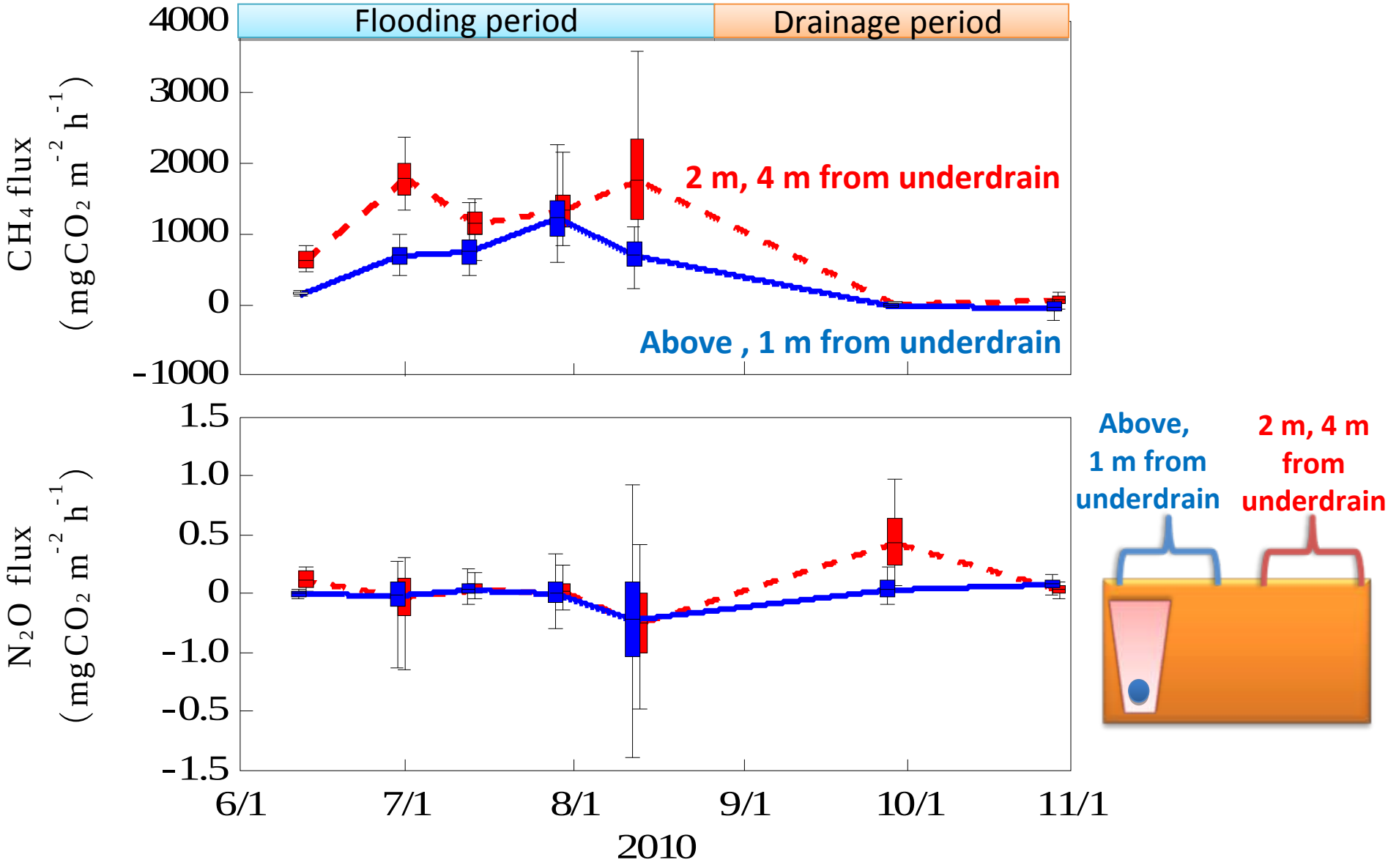

Assessment — effect of organic filter underdrains on greenhouse gas emissions (paddy fields)

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- Determine effectiveness in reducing greenhouse gas emissions
  - Measured CH_4 and N_2O flux (flow through a unit cross section)
  - Measurement points near and far from underdrains

- CH_4 flux
  - Clearly less at points near underdrains during flooding season
  - Does not increase

- N_2O flux
  - slight at both sets of points
  - essentially the same at both sets of points

- Organic filter underdrains don't increase emissions of either greenhouse gas (CH_4 and N_2O) in paddy fileds.

Assessment
— carbon sequestration in organic filter underdrains

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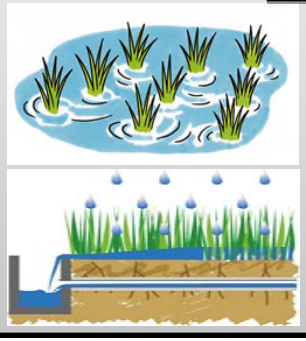

Greenhouse gases from soil, materials

Effect of underdrain on greenhouse gas emissions

Assessment of carbon sequestration in underdrainage systems

Carbon sequestration in organic filter material (paddy fields)

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Parameter	Wood chips	Rice husks	Difference by material
a. Carbon sequestration in filter material 15 y after burial (tCO_2/ha)	11.41	0.59	-
b. CO_2 emitted during basic construction (one-time; tCO_2/ha)	4.65	4.36	-
c. Increase in greenhouse gas emission from soil as result underdrain installation (tCO_2/ha)	0.00	0.00	-
a - b - c = carbon sequestered in organic filter material (tCO_2/(ha 15yr))	6.76	-3.77	10.53
Carbon sequestered per year (tCO_2/(ha yr))	0.45	-0.25	0.70

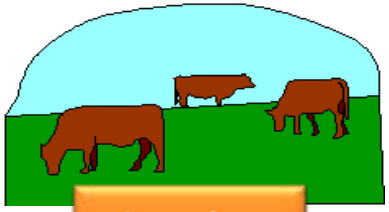
Carbon sequestration by activity

Forestry

0.15 (Canada) ～1.9 (Japan) tCO_2/(ha yr)

Vegetation

1.7～3.0 tCO_2/(ha yr) (permanent pasture)



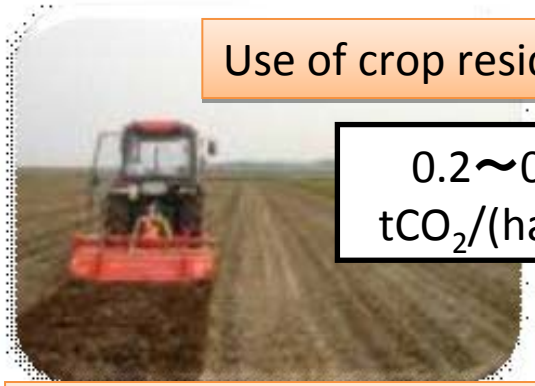
Grazing

0.11～0.81 tCO_2/(ha yr)

Farming

No-till farming (fields)

0.1～0.7 tCO_2/(ha yr)



Use of crop residue

0.2～0.7 tCO_2/(ha yr)

Soil diagnostics (optimal use of fertilizers, amendments)

0.3～0.6 tCO_2/(ha yr)

Organic filter underdrains (paddy fields)

-0.3～0.5 tCO_2/(ha y) (trencher-dug underdrains)

Assessment
— carbon sequestration by subsurface drainage system

- Carbon sequestration by using organic filter underdrains currently has the same level of effectiveness as no-till farming and other such methods based on cropland management.
- This approach thus has sufficient potential for practical application.
- When building a underdrainage system for carbon sequestration, it is important to consider not only the method, but also the filter material.

Thank you for your attention

Hokkaido: Installing supplementary drain to be filled with straw; digging is done with a specially developed attachment (green)