Land use, soil erosion and water quality: implications for the transport and storage of nutrients and contaminants

Pierret A., Ribolzi O., Huon S., Chaplot V., Rumpel C., Thiebaux, J.-P, de Rouw, A., Sengtaheuanghoung, O. and Valentin, C.

Mekong River Commission

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Land use, soil erosion and water quality: implications for the transport and storage of nutrients and contaminants

- Water quality from the "big picture" to the actual situation along a small tributary of the Mekong

- Soil erosion and carbon transport in sloping lands
  - Impact of agricultural practices
  - Impact on mineralization processes and GHG emissions…

Water quality: the big picture

- In 1998, the UNs reported that, in Lao PDR

human activities have little effect on rivers water quality

due to:
- Low population density
- Limited wastewater discharge
- Self-purification before entering the rivers

Conclusions based on 34 observation points on **main rivers**

Do large river-based surveys reflect the community level reality ?

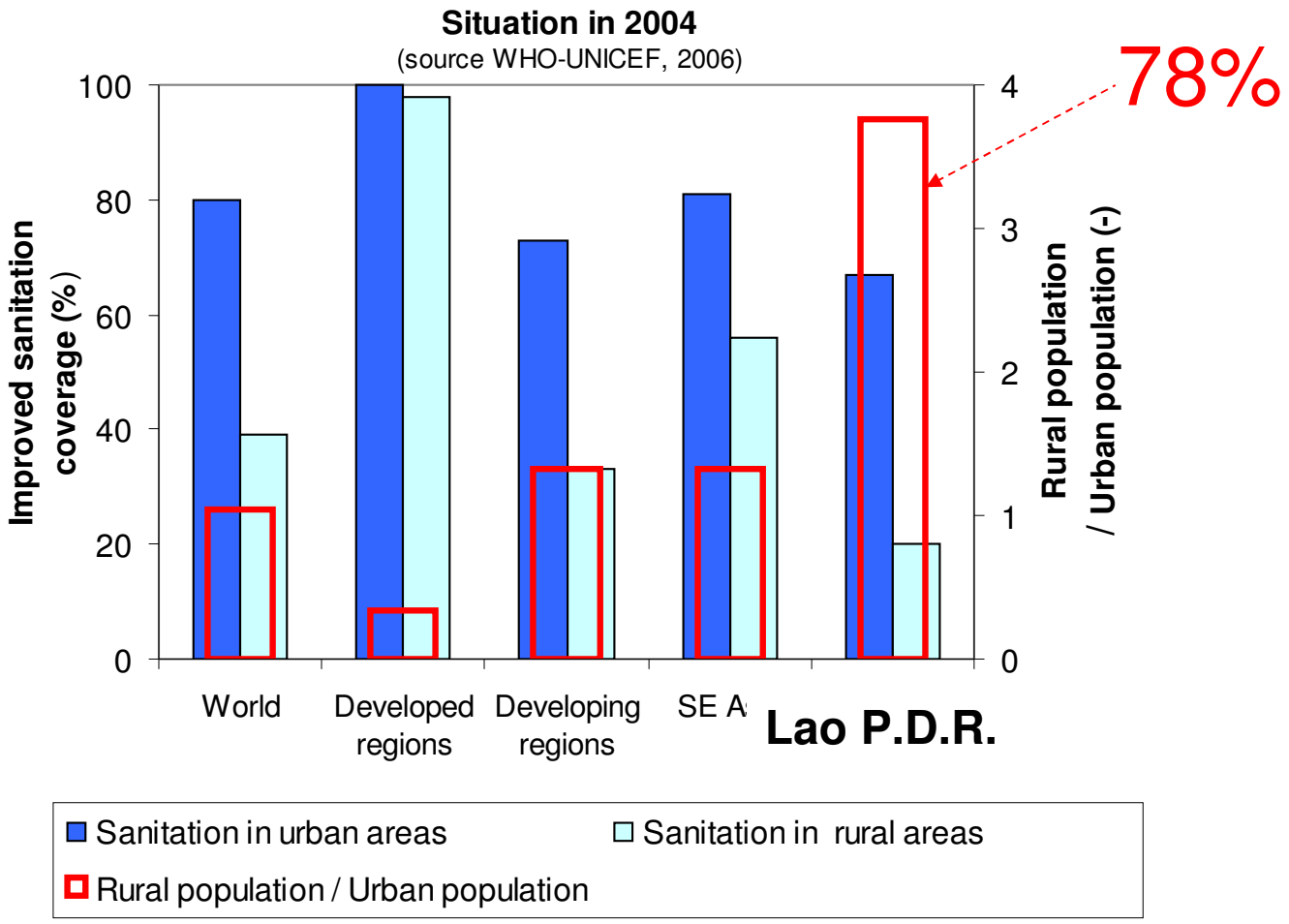
- Besides the major tributaries of the Mekong, there are hundreds of small order streams that are used by many people…

Do large river-based surveys reflect the community level reality ?

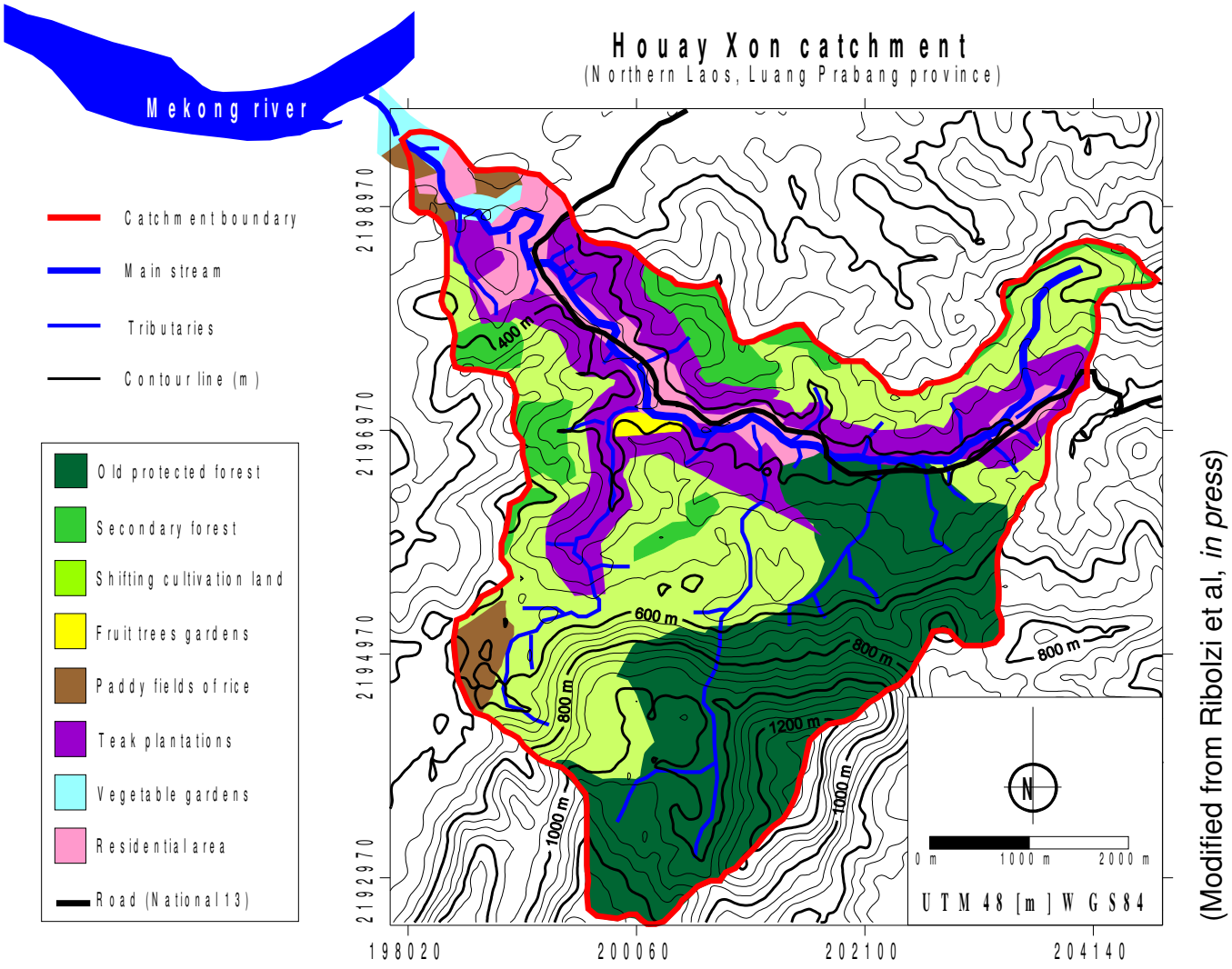
Main contaminants in runoff and drainage from agricultural land:

- nutrients,
- suspended solids,
- fecal coliforms,
- bacteria,
- pesticides.

In Lao PDR, the population is mostly rural with limited access to sanitation infrastructures



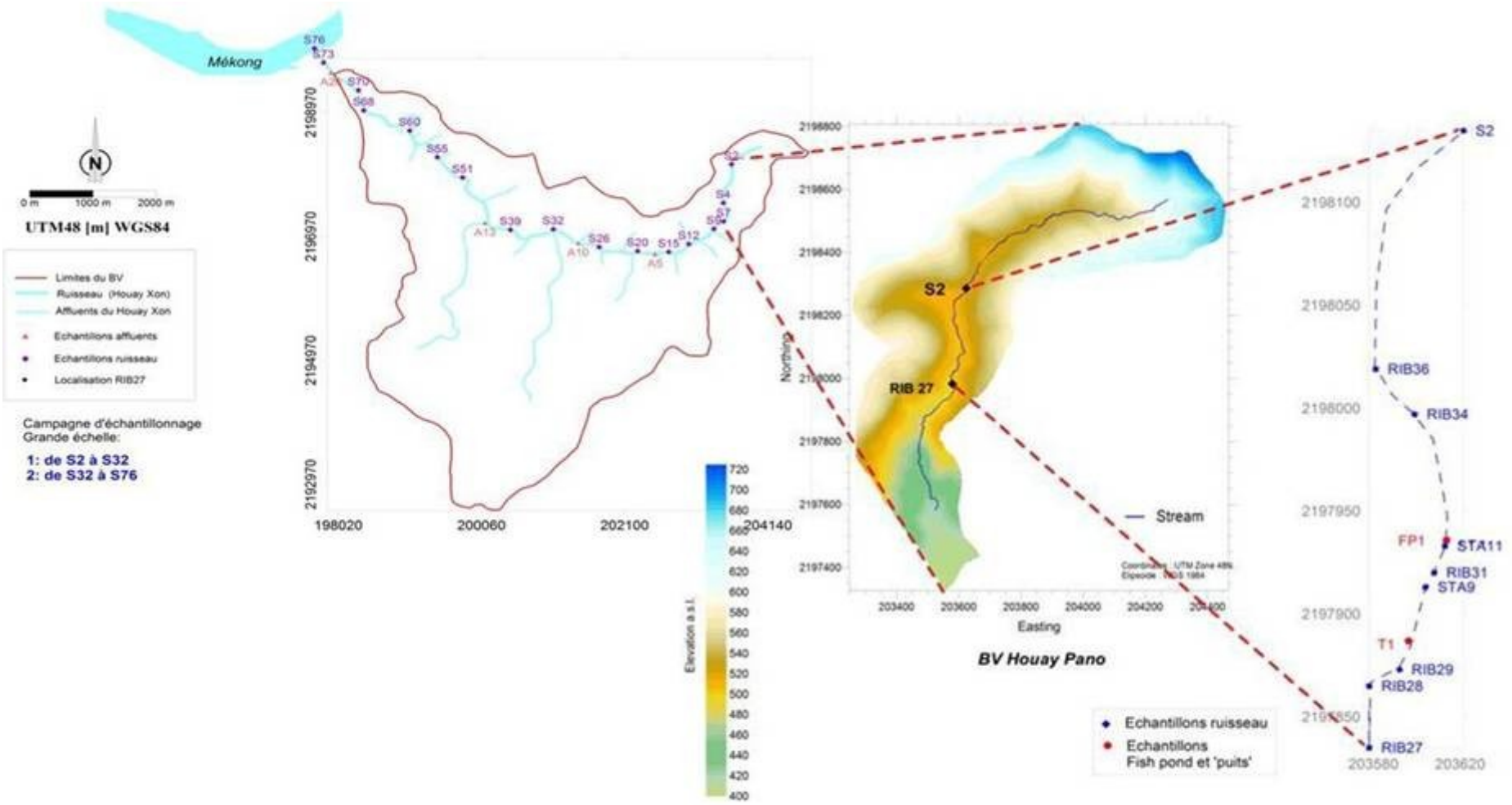
The Houay-Xon catchment: a mosaic of land-uses



(Modified from Ribolzi et al, *in press*)

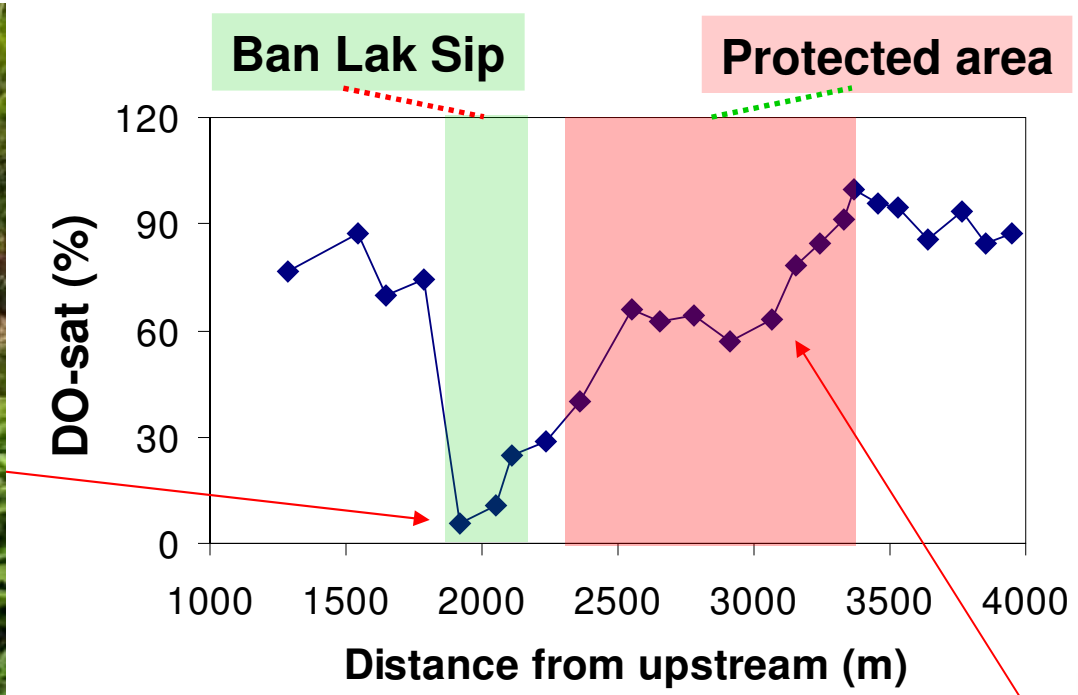
Ribolzi, O., Cuny, J., Sengsoulichanh, P., Pierret, A. Thiébaux, J.P., Huon, S., Bourdon, E., Robain, H., Sengtaheuanghoung, O. - Water quality along a tributary of the Mekong River in a mountainous mixed land-uses environment of Lao PDR. The Lao Journal of Agriculture and Forestry (ongoing).

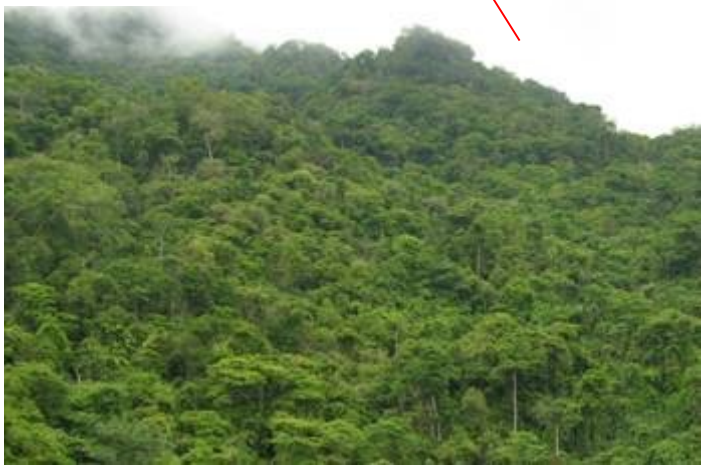
Location of the sampling points within the Houay Xon and Houay Pano catchments



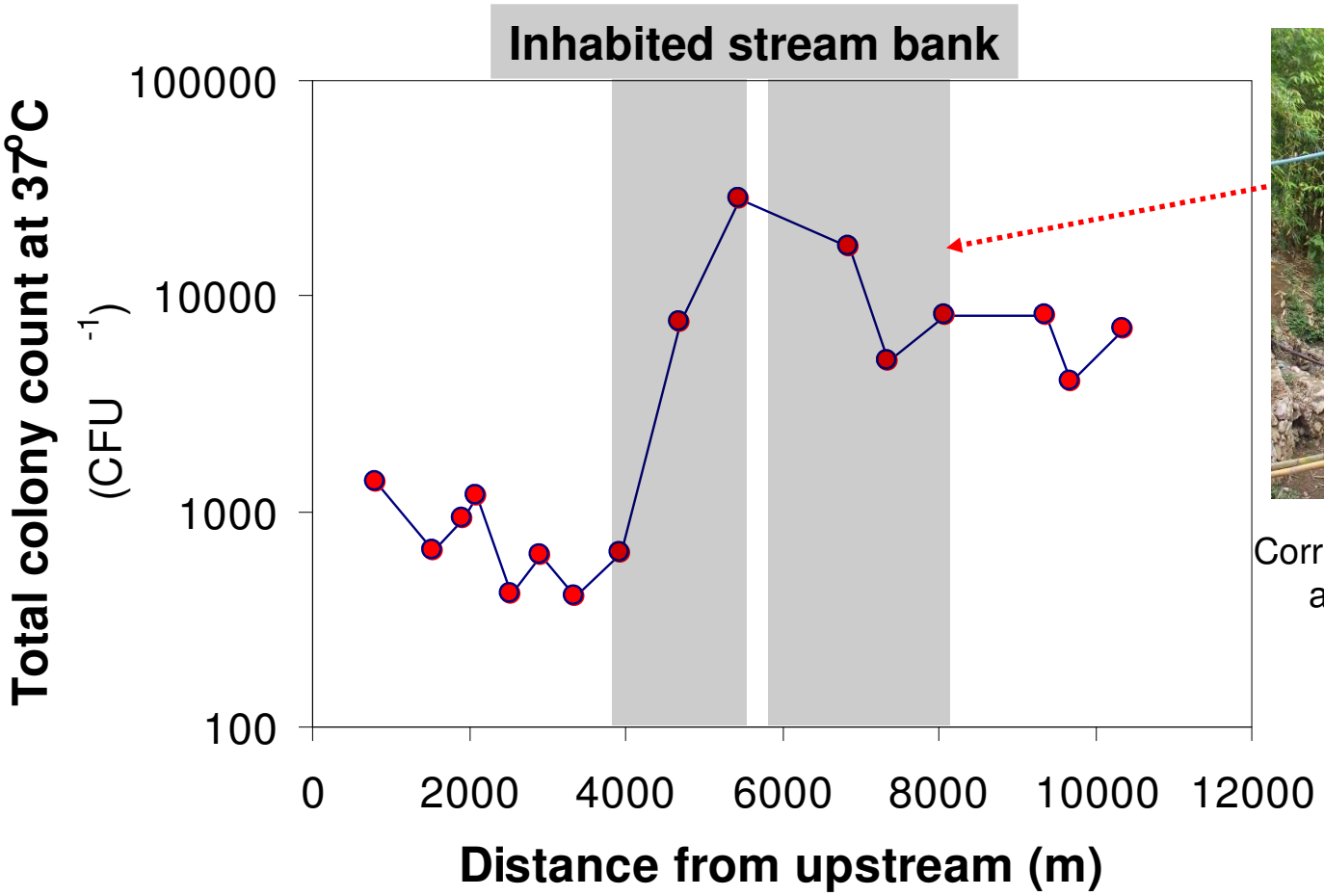
Effect of solid waste disposal and wastewater discharge on oxygen content

Waste disposal in stream bed



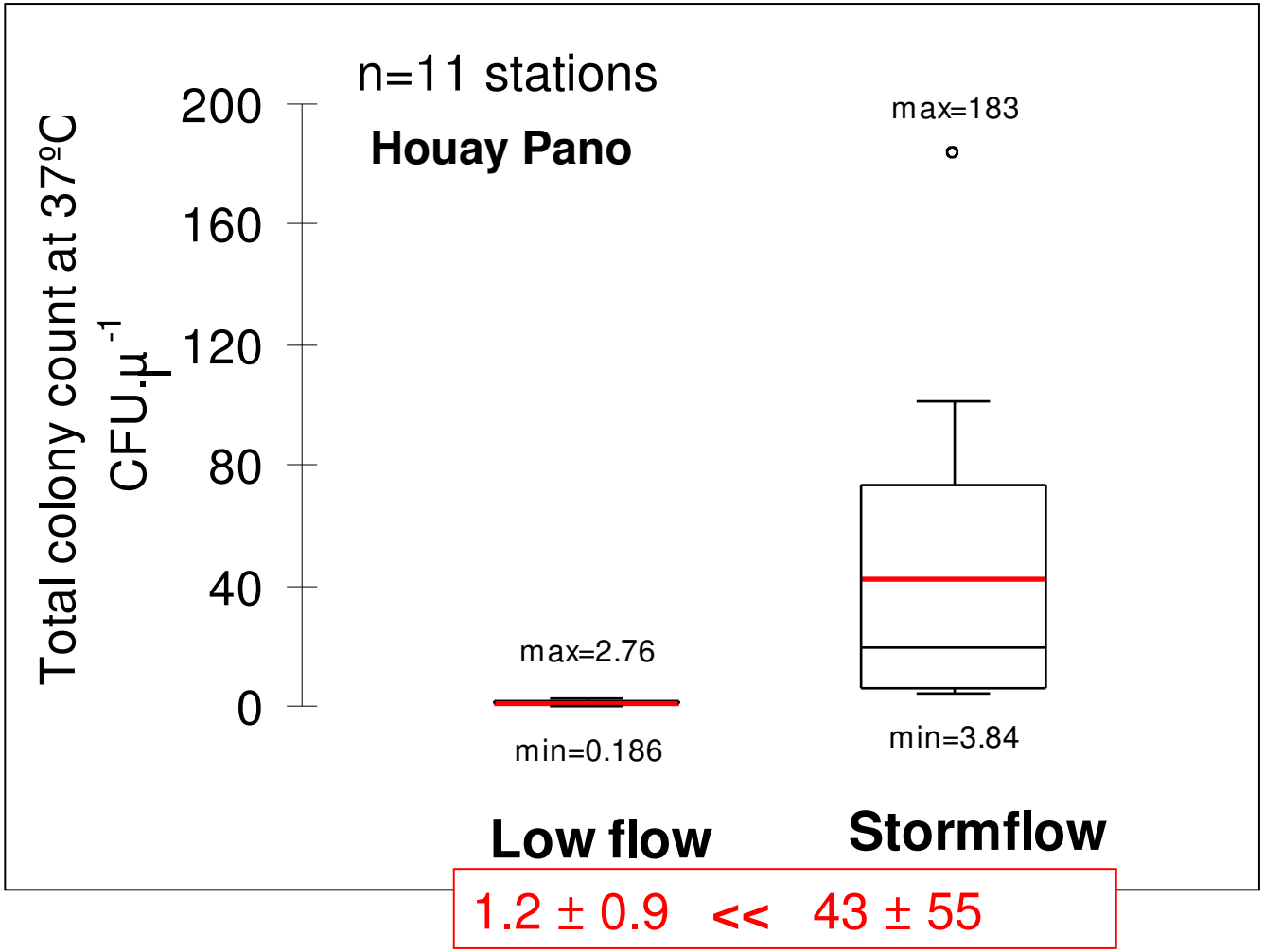


Effect of continuous urbanization of the riparian zone on total bacteriological flora



Corridor of residential blocks along the Houay Xon

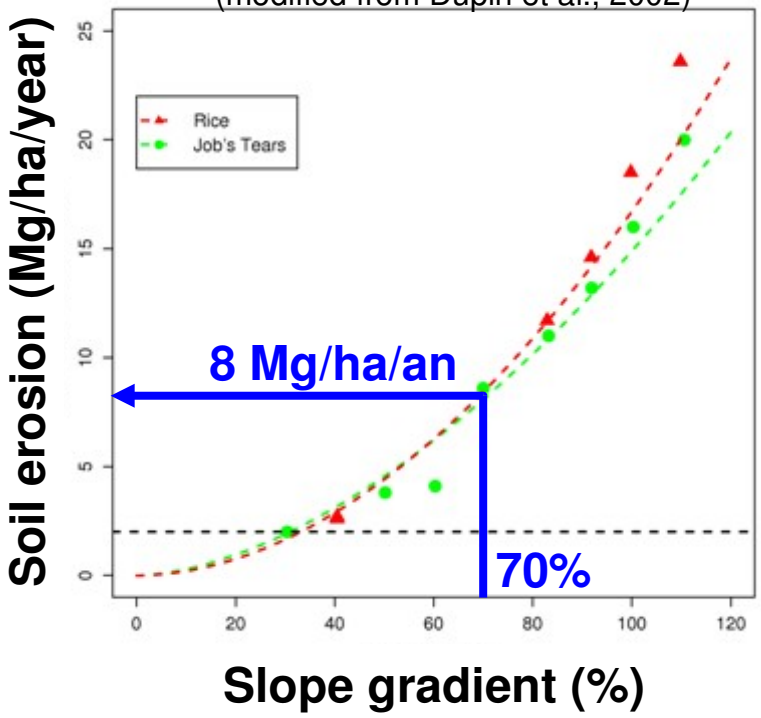
Baseflow *vs* stormflow bacterial loads



Ribolzi, O., Cuny, J., Sengsoulichanh, P., Pierret, A. Thiébaux, J.P., Huon, S., Bourdon, E., Robain, H., Sengtaheuanghoung, O. - Water quality along a tributary of the Mekong River in a mountainous mixed land-uses environment of Lao PDR. The Lao

Riparian zone management and tillage erosion

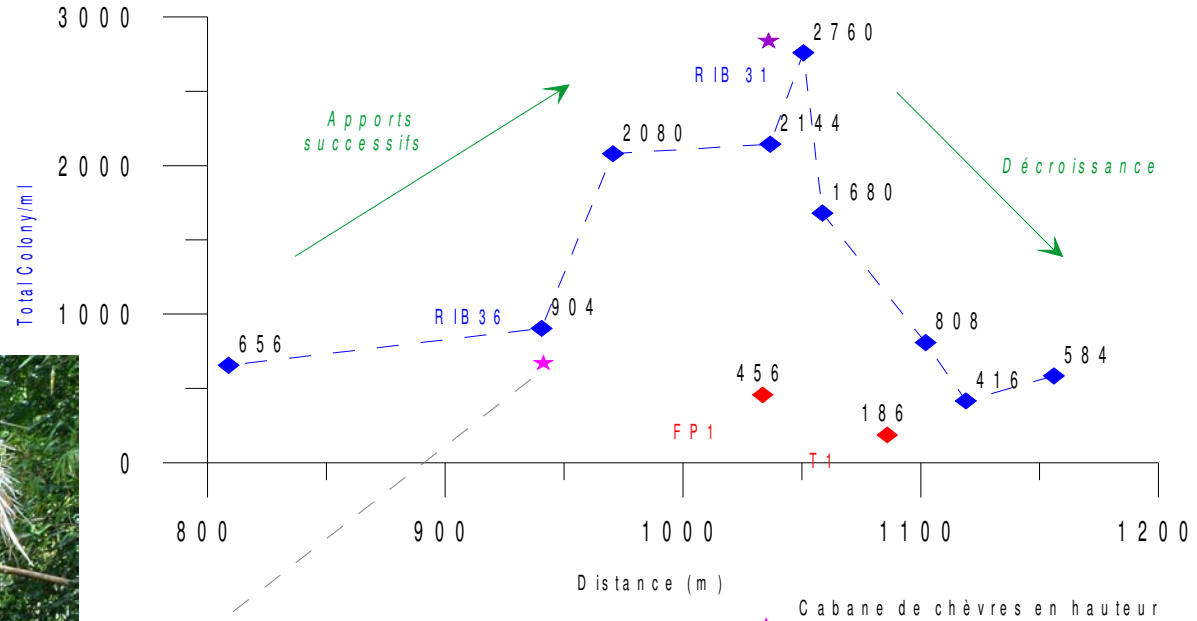
(modified from Dupin et al., 2002)



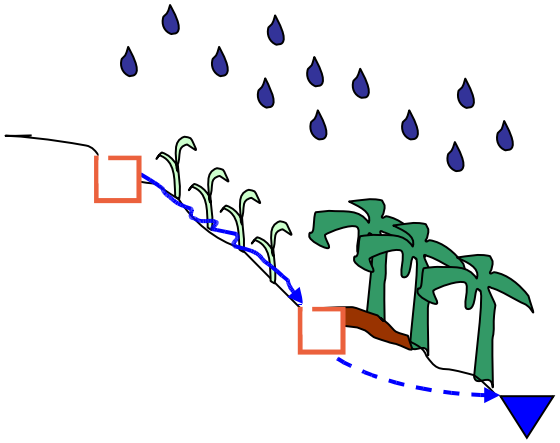
Dupin B., Phanthavong K., Chanthavongsa A., Valentin C., 2002. Assessment of tillage erosion rates on steep slopes in the northern Lao PDR. The Lao Journal of Agriculture and Forestry. 4:52-59.

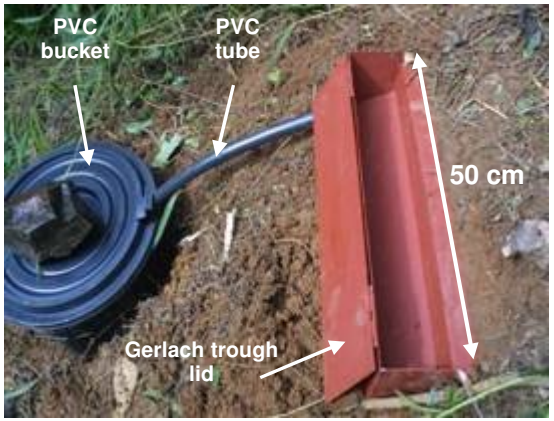
Upstream bacterial load during baseflow

Tas de déjections qui arrivent dans le ruisseau
(à proximité des rives de RIB 36)

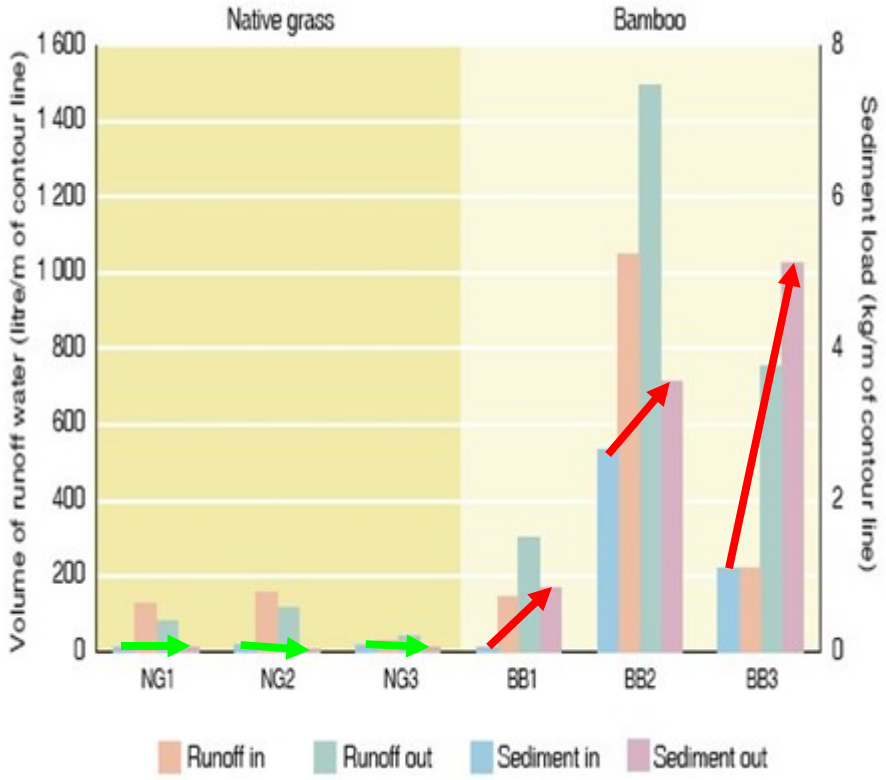


Sediment trapping vs riparian vegetation





Gerlach trough system



O. Vigiak, O. Ribolzi, A. Pierret, C. Valentin, O. Sengtaheuanghoung and A. Noble. 2007.
Filtering of water pollutants by riparian vegetation: bamboo versus native grasses and rice in a Lao catchment. **Unasylva 229,** Vol. 58,

Agricultural Soil Erosion and the Global C Cycle

Agricultural soil erosion: a source or sink of 10^9 tC $year^{-1}$

Source ???

- 20-30% mineralisation during transport
(e.g., Lal, 2005)

Sink ???

- Trapping of sediments from tillage erosion
(Van Oost et al., 2004; 2007)

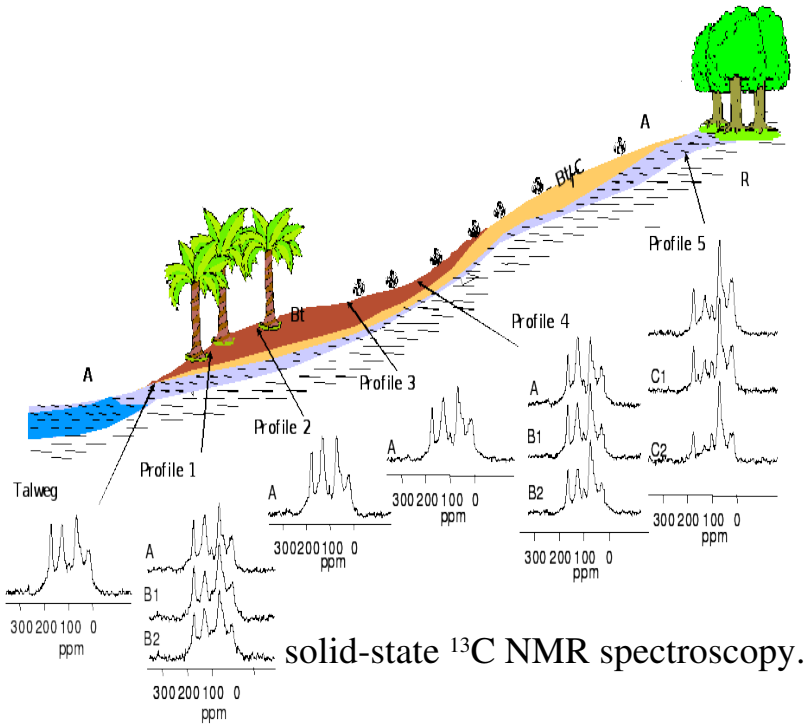
- Exported labile carbon
(Rumpel et al., 2006)

C source or sink ??

Mineral bound organic carbon

from the m² to the ha

Soil organic C: • 30% linked to mineral phase,
• 15% mineral bound black (MBB) carbon
(charcoal, soot, and other forms of pyrogenic C)



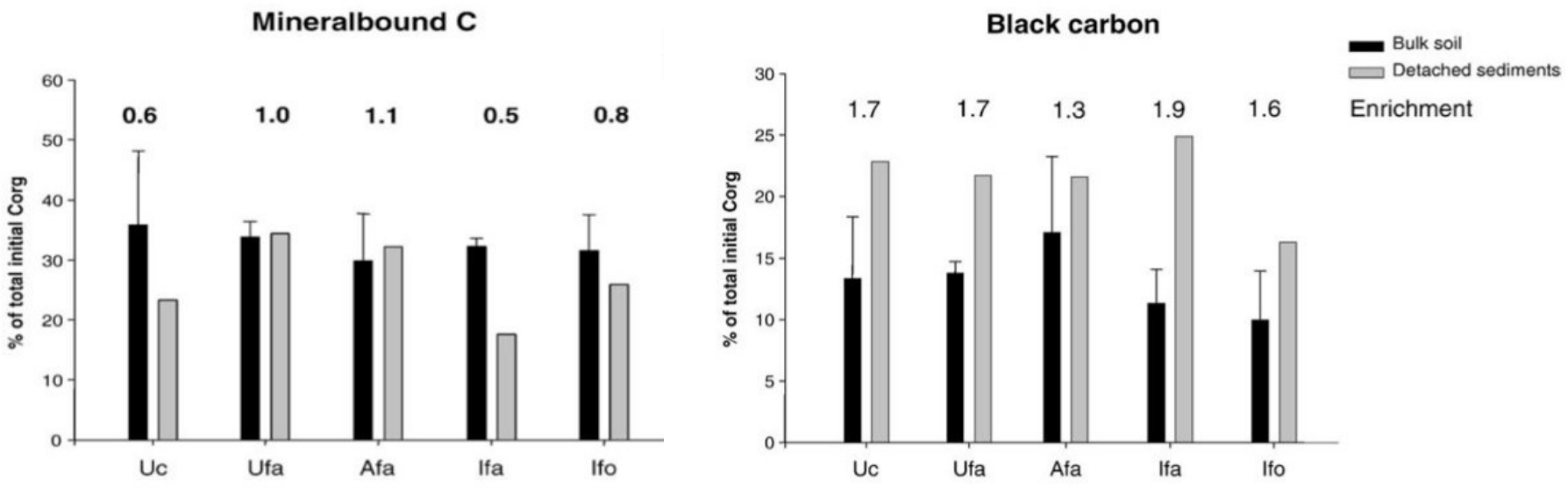
solid-state ^{13}C NMR spectroscopy.

- Sediments/soil C ratio:
  - 1 m² : 2.2
  - 0.6 ha : 1.5
- MBB carbon /soil C ratio:
  - 1 m² : 1.1-1.8
  - 0.6 ha : 2.3
  - Easy to detach and transport resistant to biodegradation

➔ C Sink ?

Chaplot V. et al. 2005. *Global Biogeochemical Cycles.*
Rumpel C. et al 2006 *Catena.*
Rumpel C. et al. 2006. *Geoderma.*
Rumpel C. et al. 2007. *Organic Geochemistry*

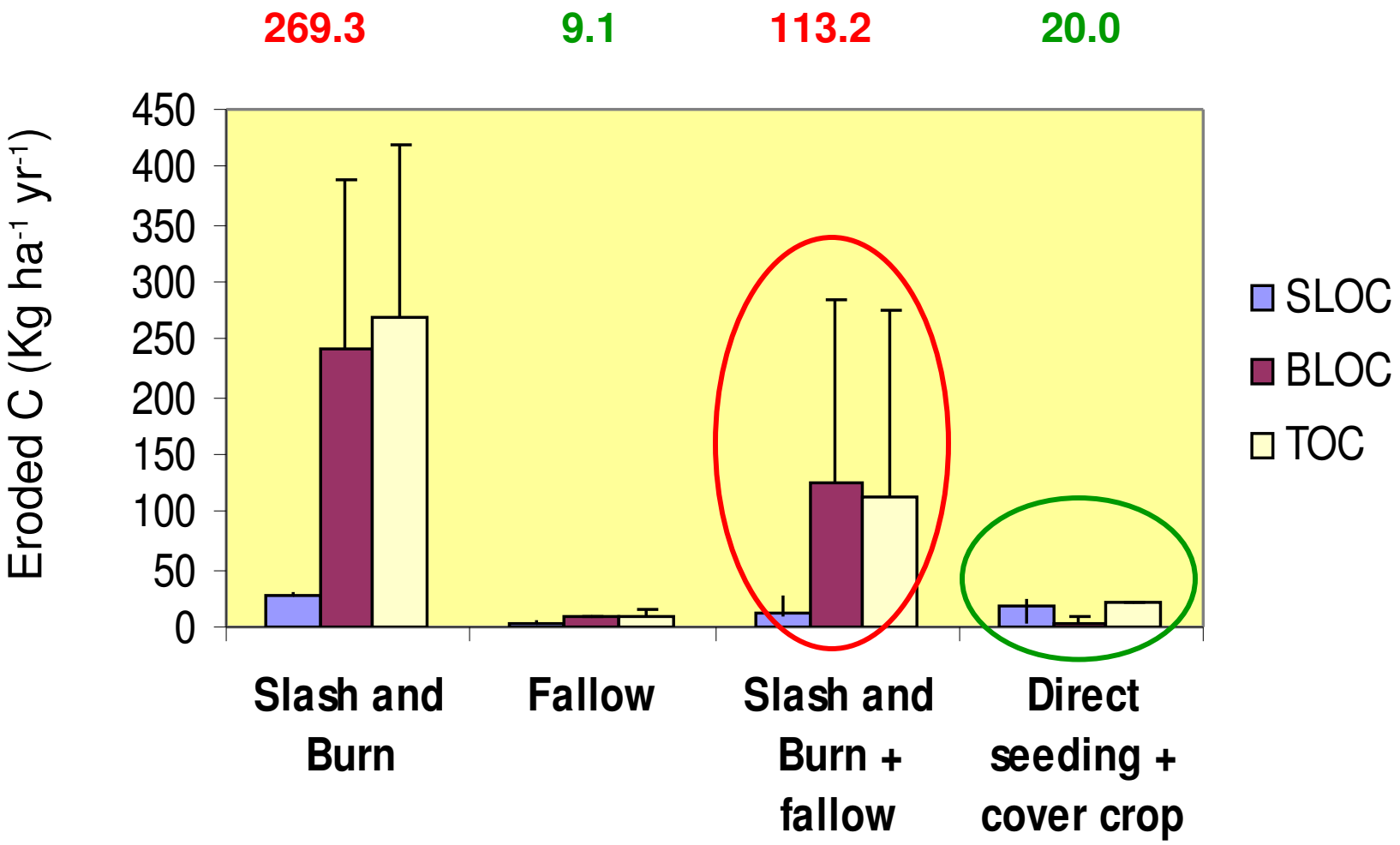
Preferential erosion of black carbon



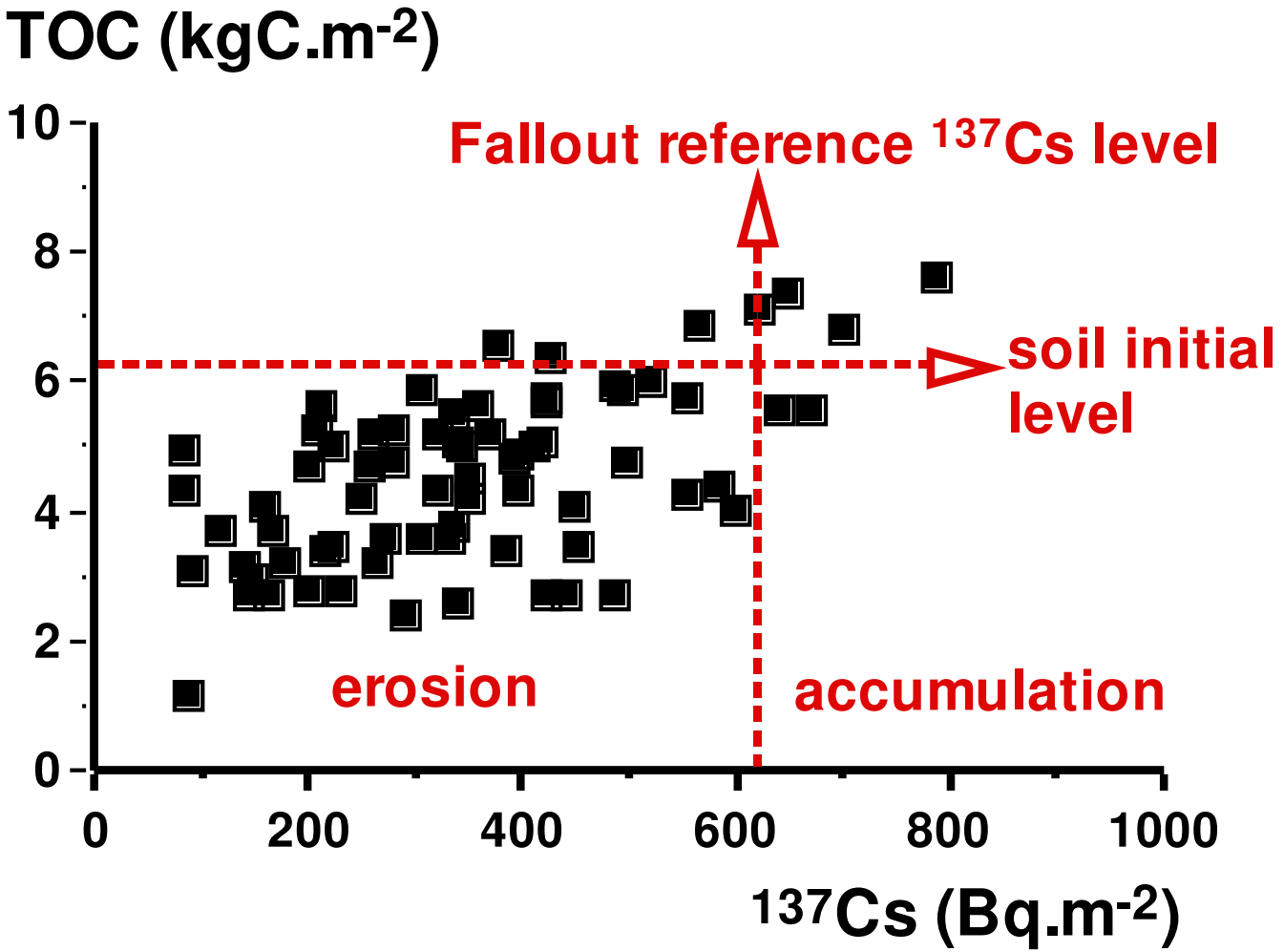
At the watershed scale, black carbon represents 30% of carbon in eroded sediments.

Rumpel C. et al 2006 *Catena*.

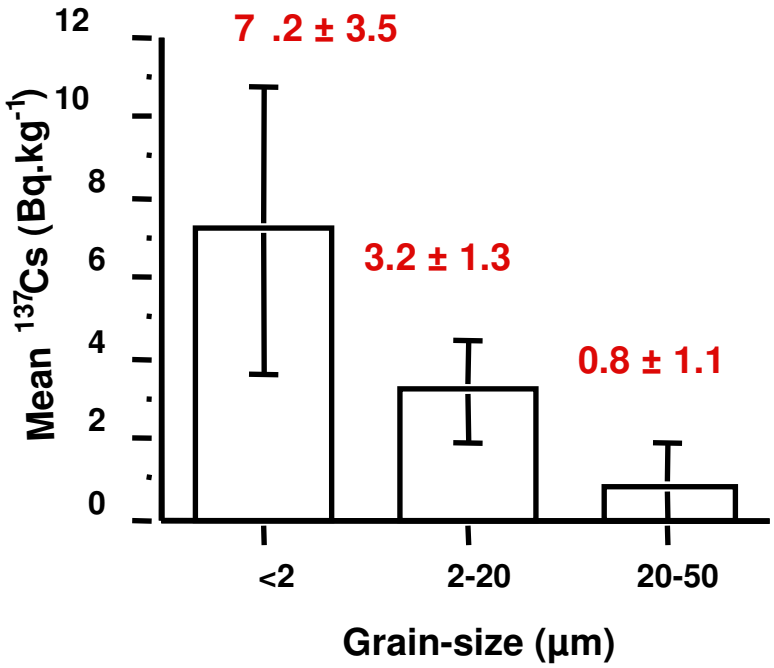
Effect of cropping systems on organic C erosion

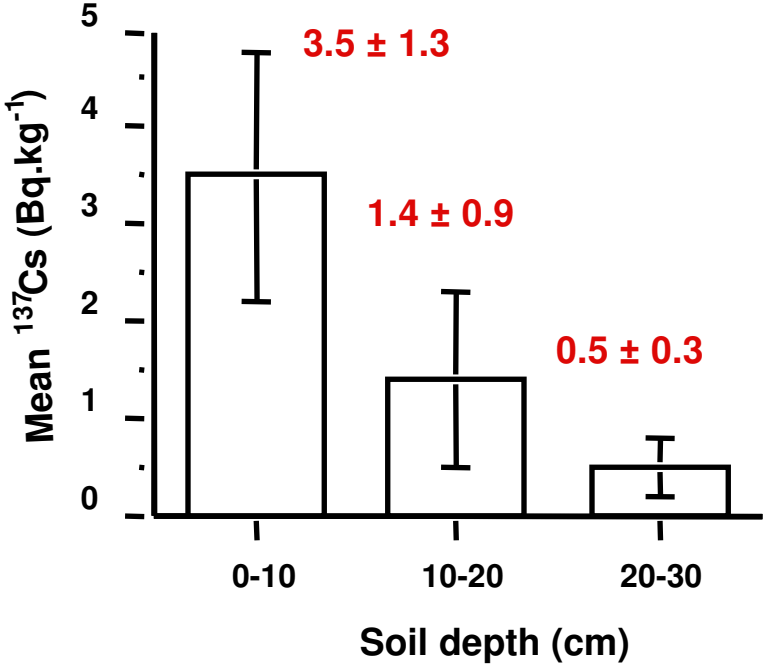


Residual ^{137}Cs activity and carbon stocks in 60 upland cultivated soil



Residual ^{137}Cs activity of soils as a function of particle size distribution and depth

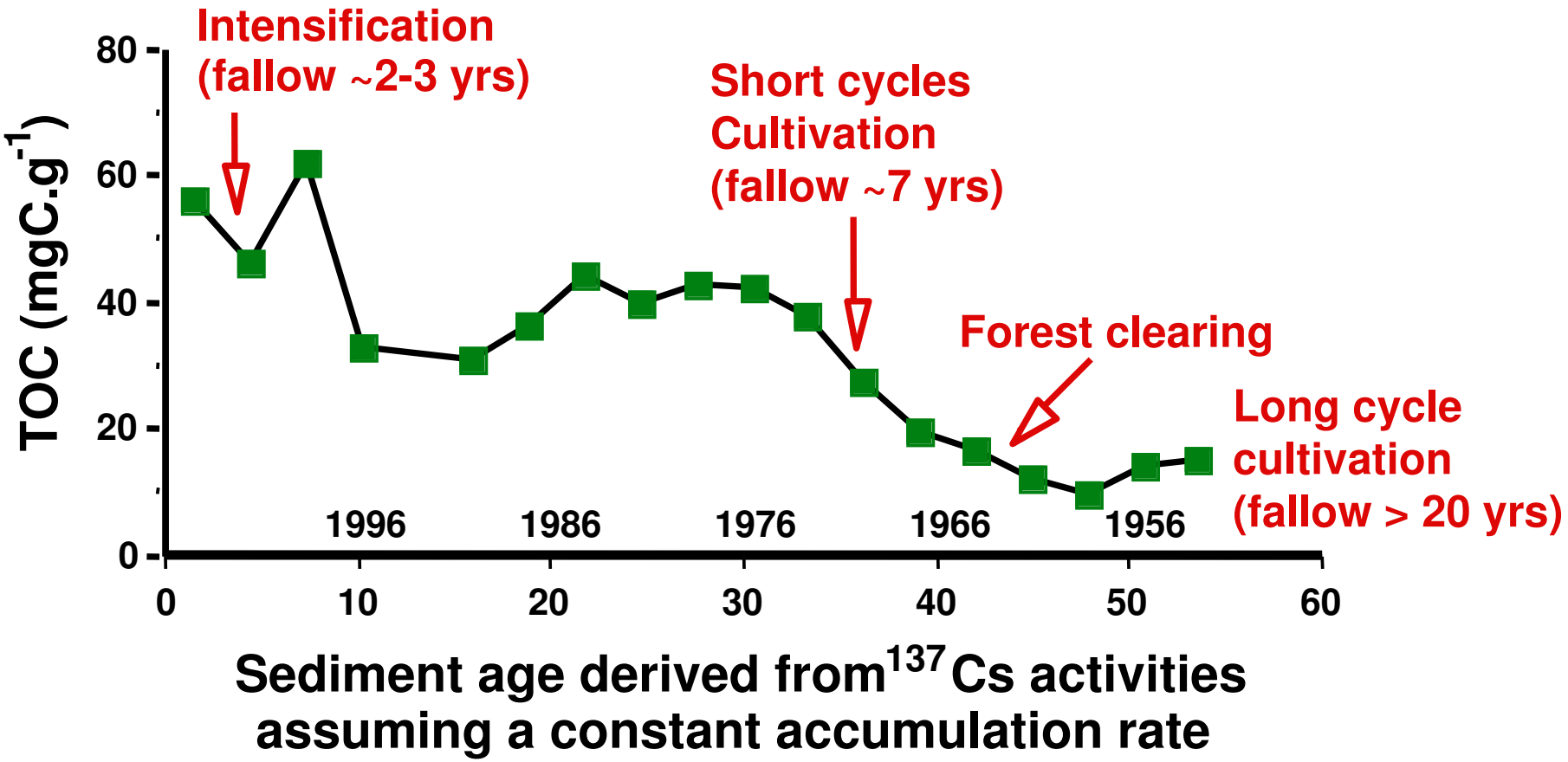




=> No ^{137}Cs below 30 cm in the studied catchment's soils

=> Exported matters are clays from the surface horizons (0-10 cm) where ^{137}Cs has accumulated.

Recent increase in sediments TOC based on residual ^{137}Cs activity



Soil organic carbon storage and conservation agriculture

5-years experiment :
comparison direct seeding w/no-tillage *vs.* slash-and-burn
In 2 sub-catchments (1 ha): maize (+ Brachiaria)

Depth (cm)	ΔTOC (gC.m^{-2})
0-10	0 ± 580
0-30	530 ± 698

Conservation agriculture:

=> ↑ soil protection, ↓ erosion and ↑ C-storage

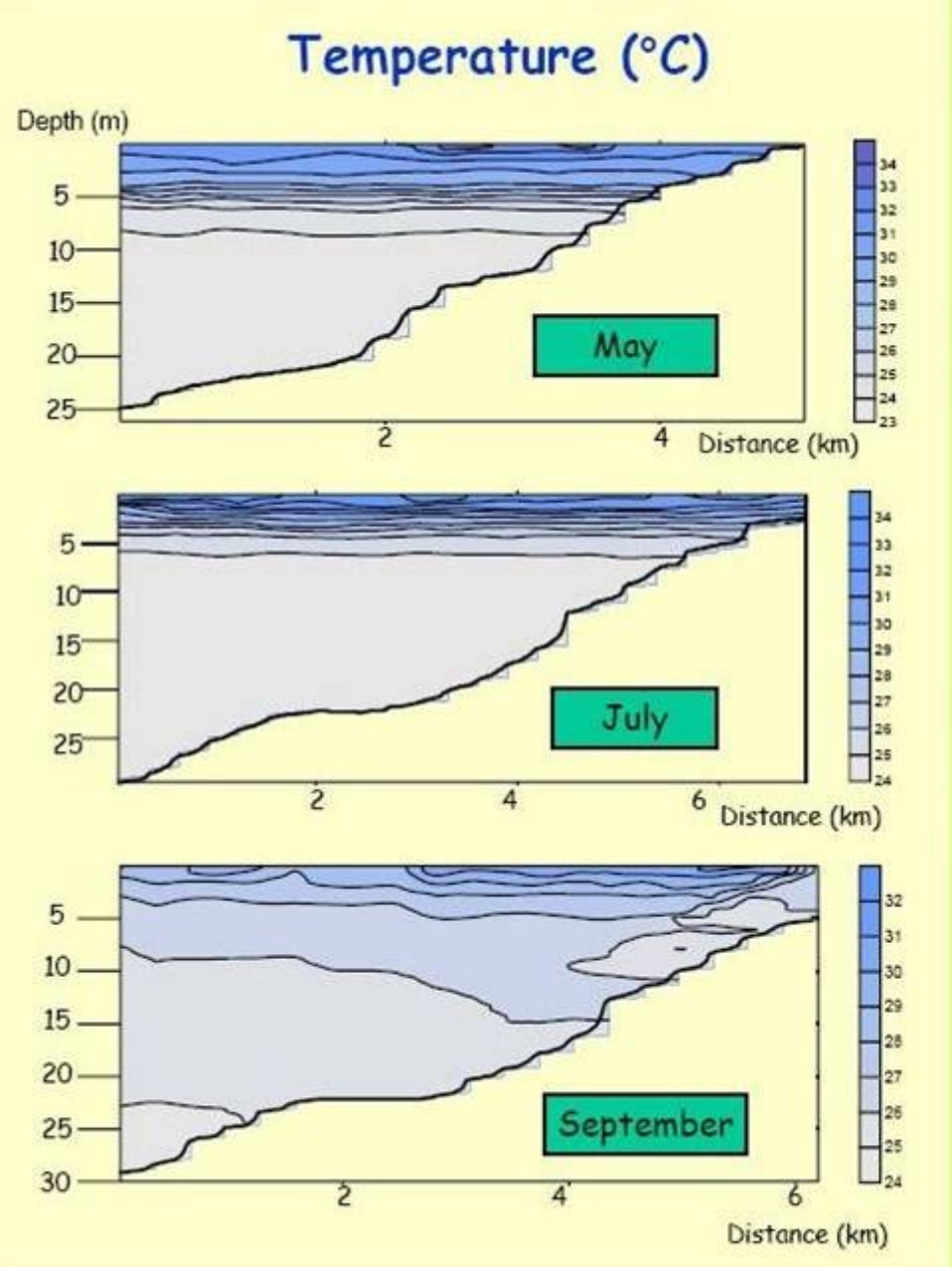
Mae Thang reservoir (Northern Thailand)

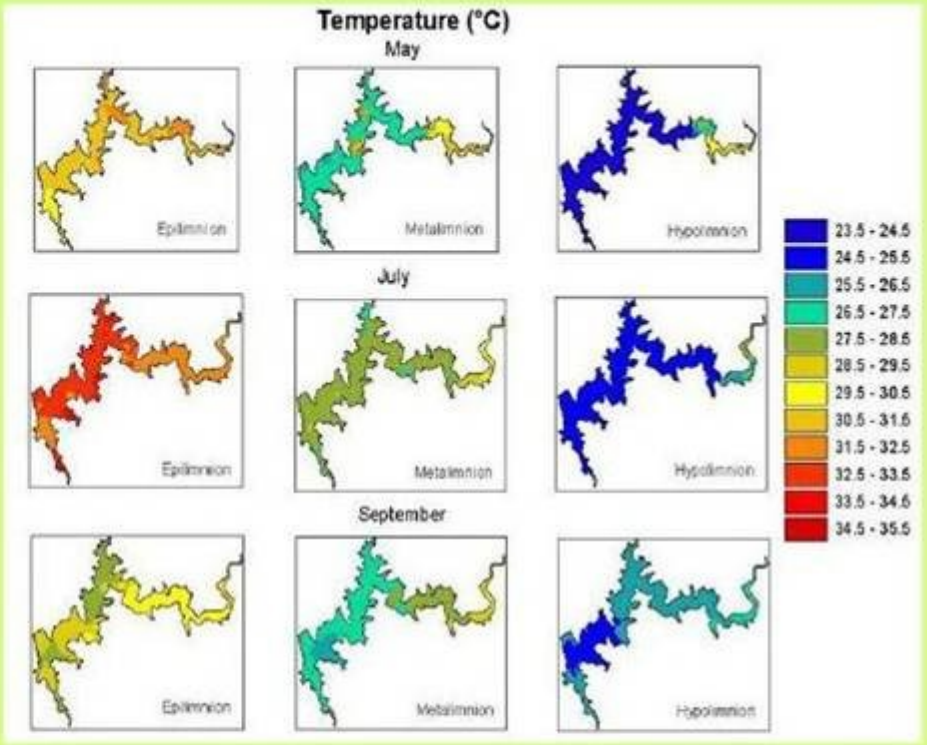
a Secondary forest + fallows + annual crops

b Cash crops : maize, soya, mung bean

c Aquaculture

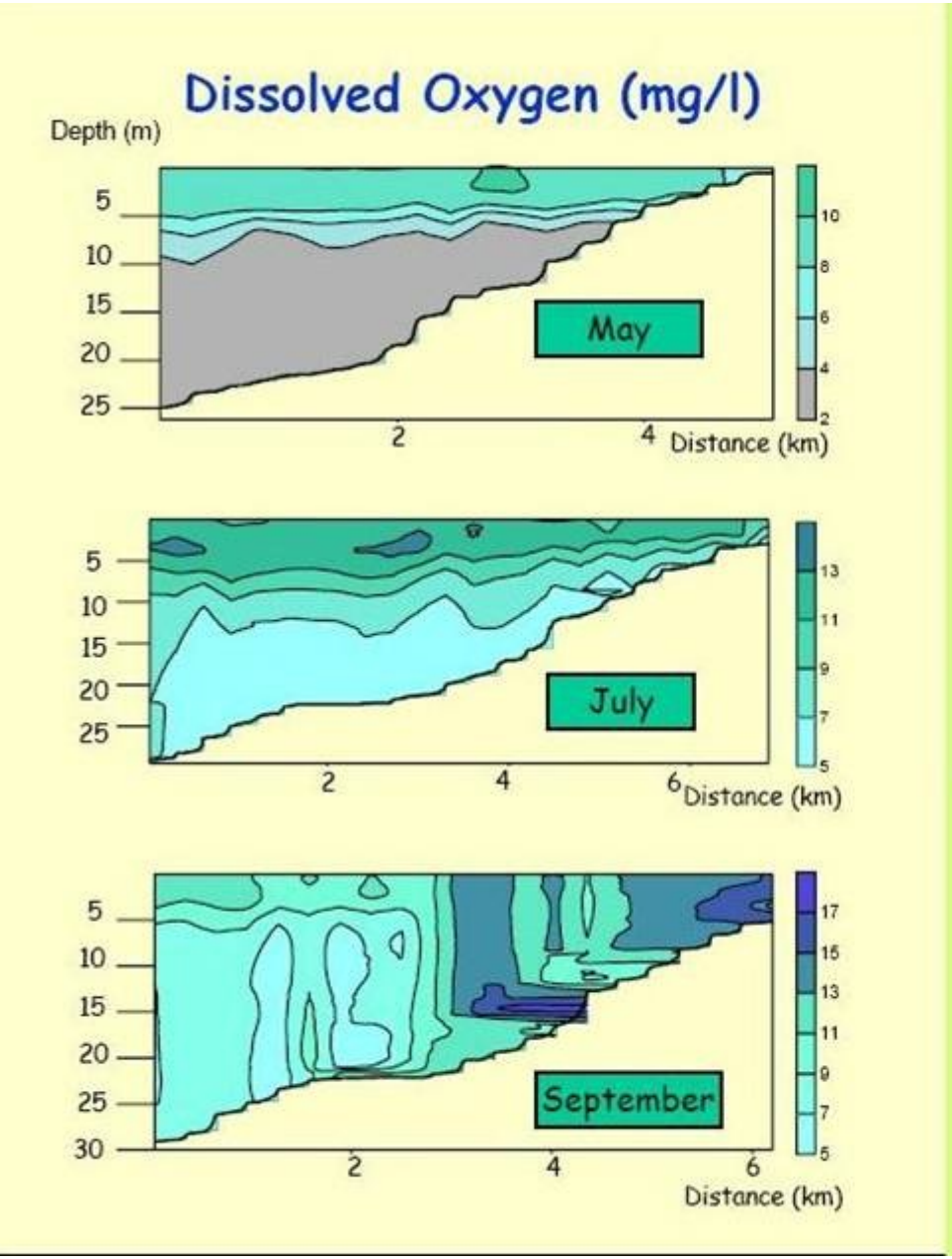
d Rice during rainy season and mung bean in dry season

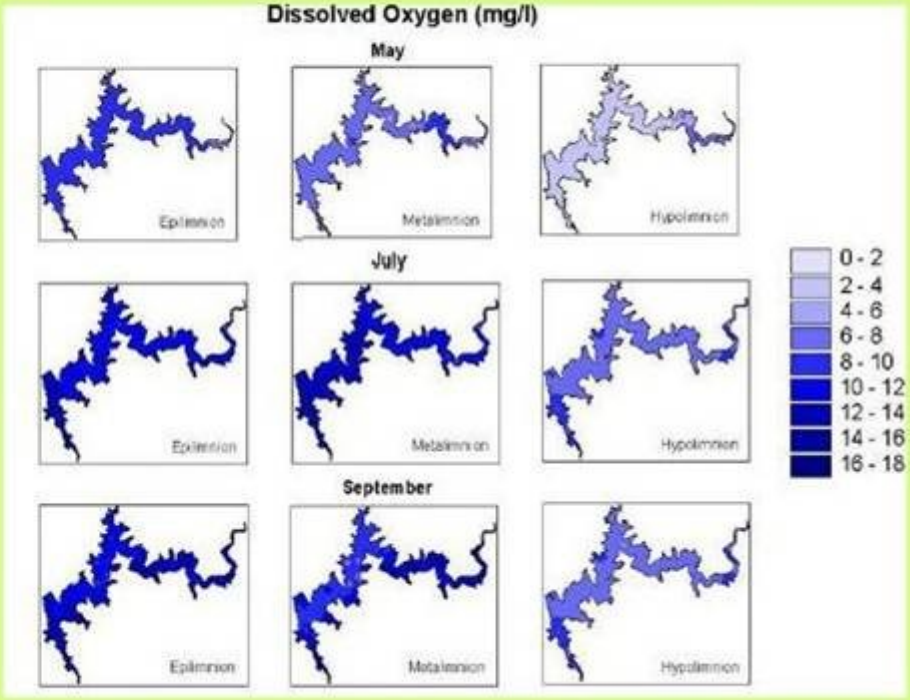




	May	July	September
Epilimnion	31,1	32,6	29,2
Metalimnion	27,7	28,1	27,3
Hypolimnion	25,0	25,0	26,0

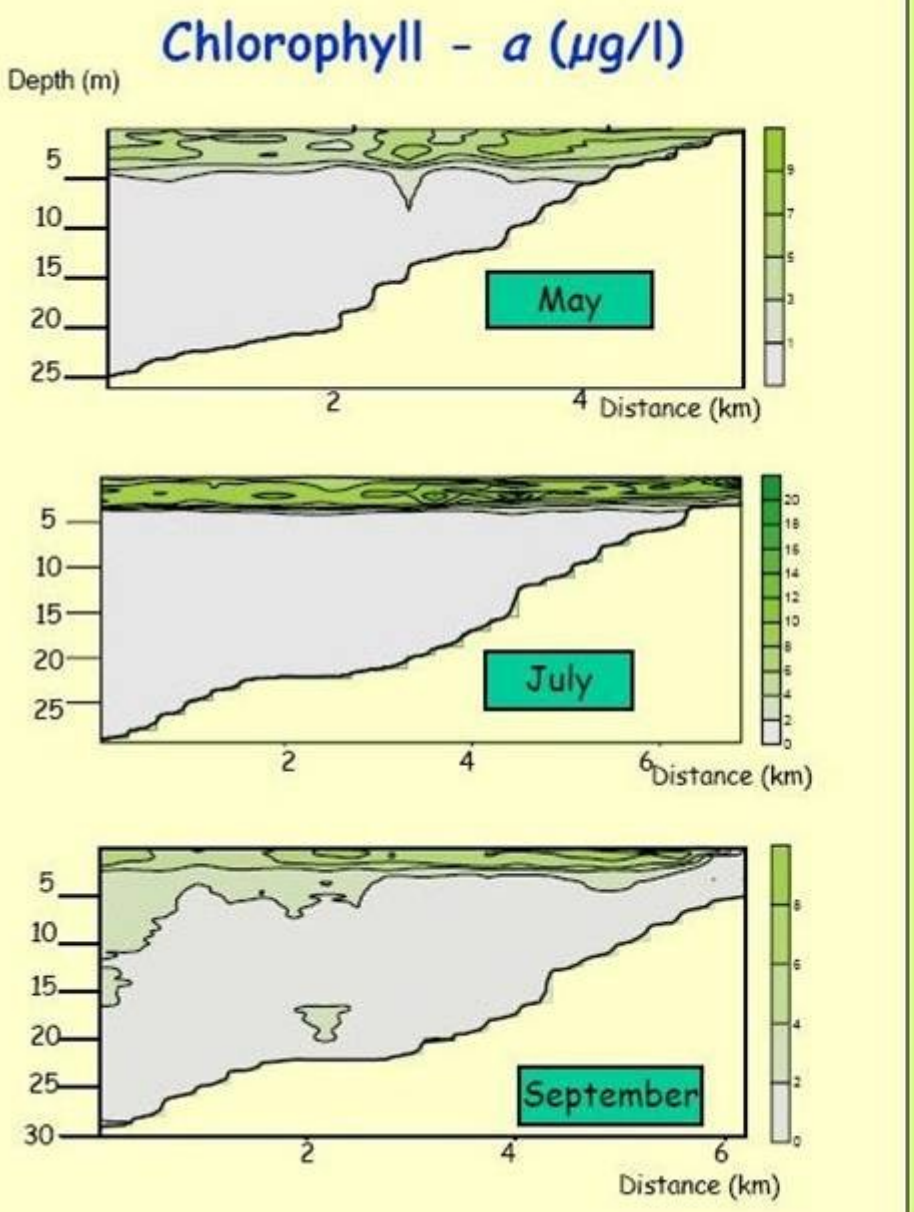
Thothong W., Huon S., Ten-Hage L., Janeau J.-L., Boonsaner A. 2004

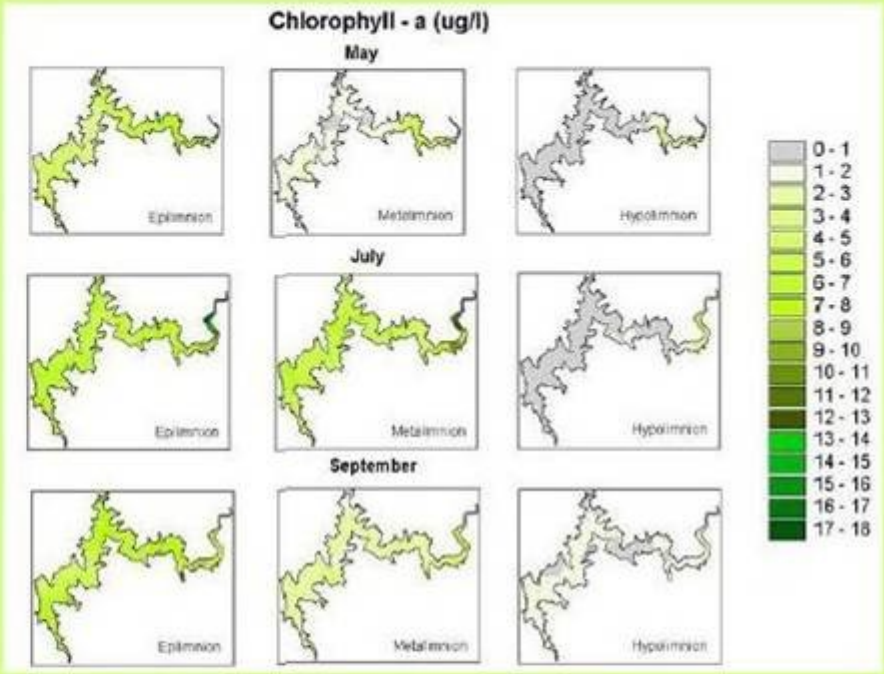




	May	July	September
Epilimnion	8,6	11,6	12,3
Metalimnion	7,2	12,0	11,2
Hypolimnion	3,9	7,7	10,3

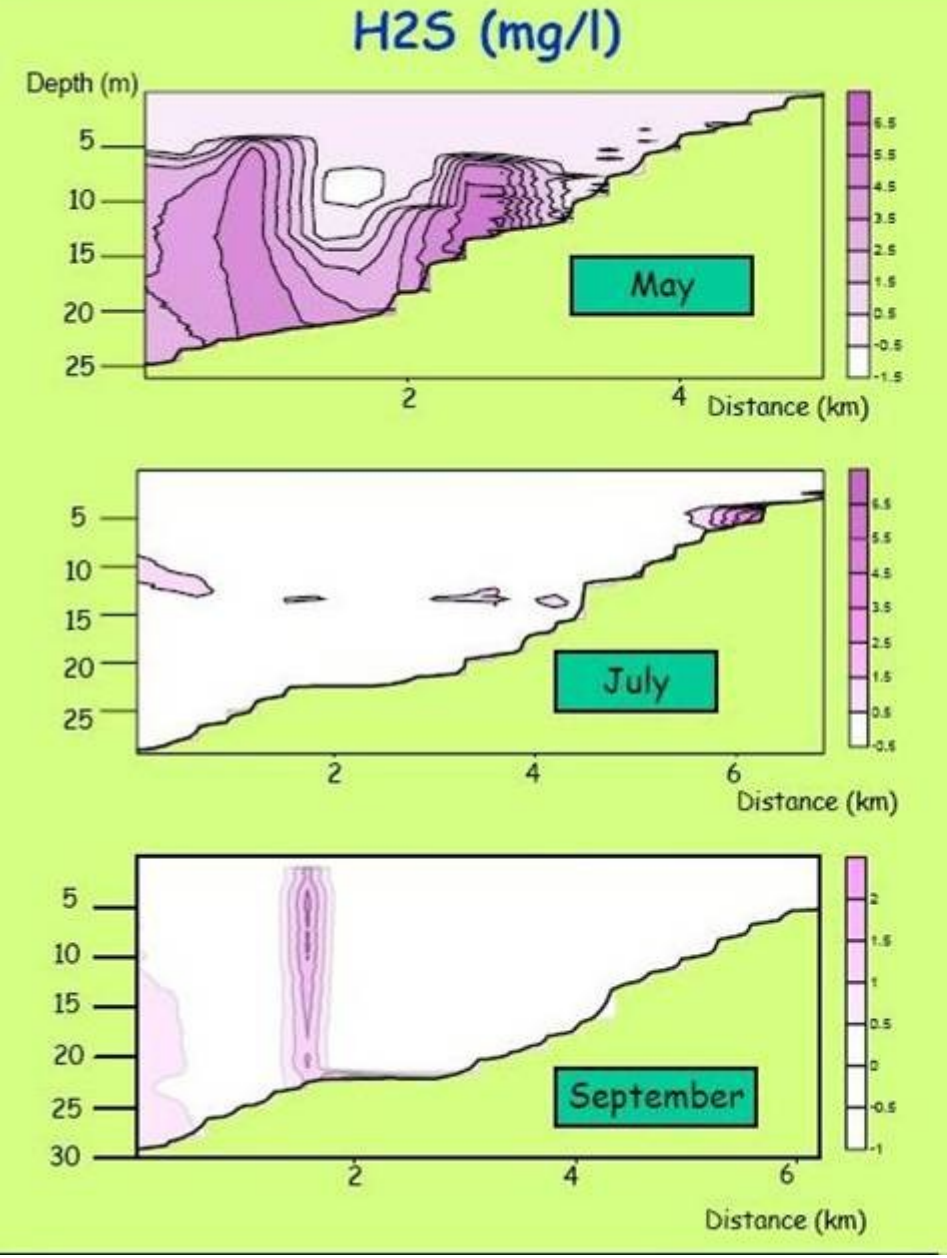
Thothong W., Huon S., Ten-Hage L., Janeau J.-L., Boonsaner A. 2004

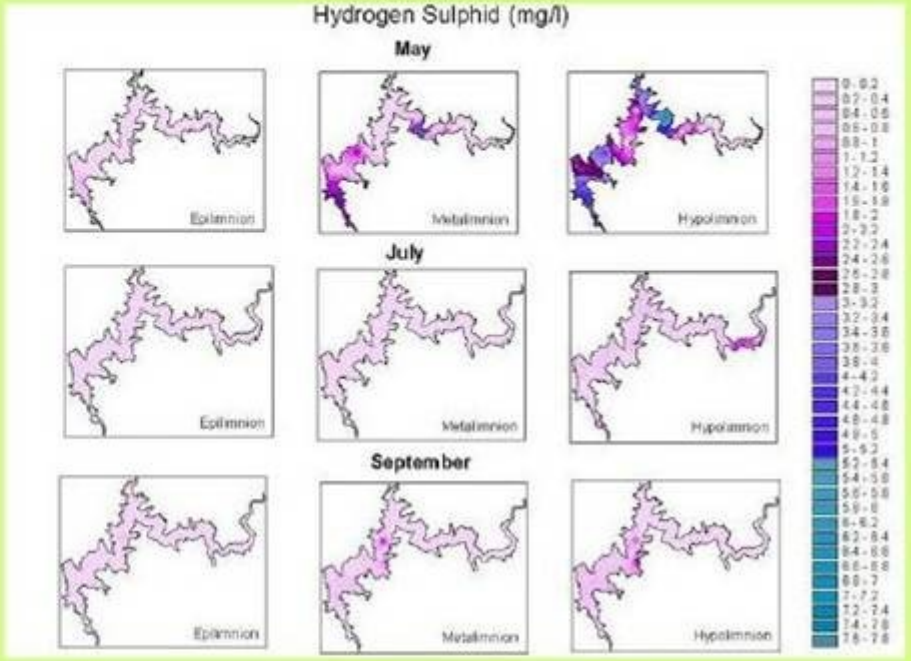




	May	July	September
Epilimnion	5,6	7,1	6,6
Metalimnion	2,3	6,1	3,1
Hypolimnion	0,9	1,1	1,5

Thothong W., Huon S., Ten-Hage L., Janeau J.-L., Boonsaner A. 2004



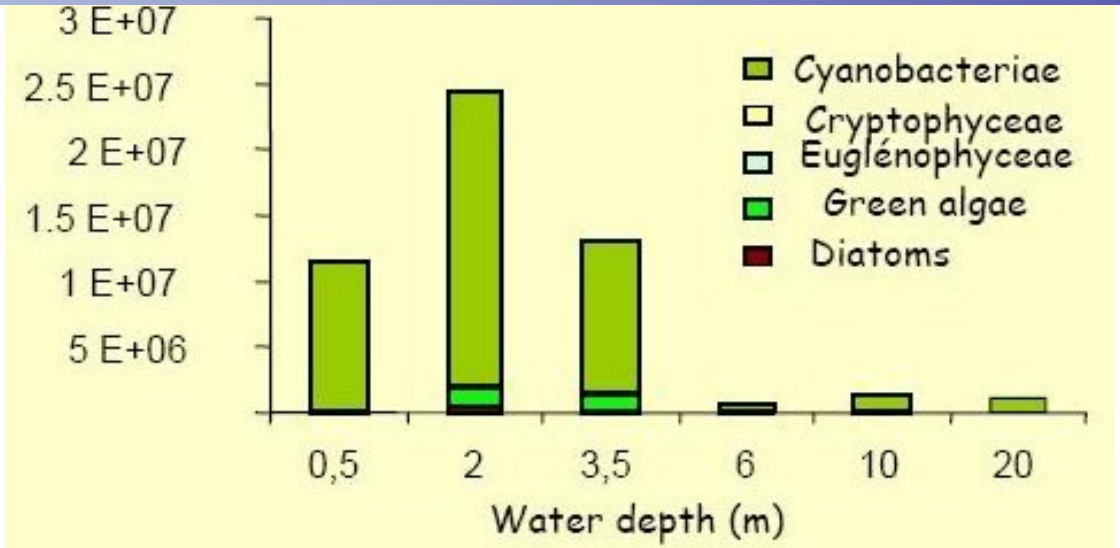


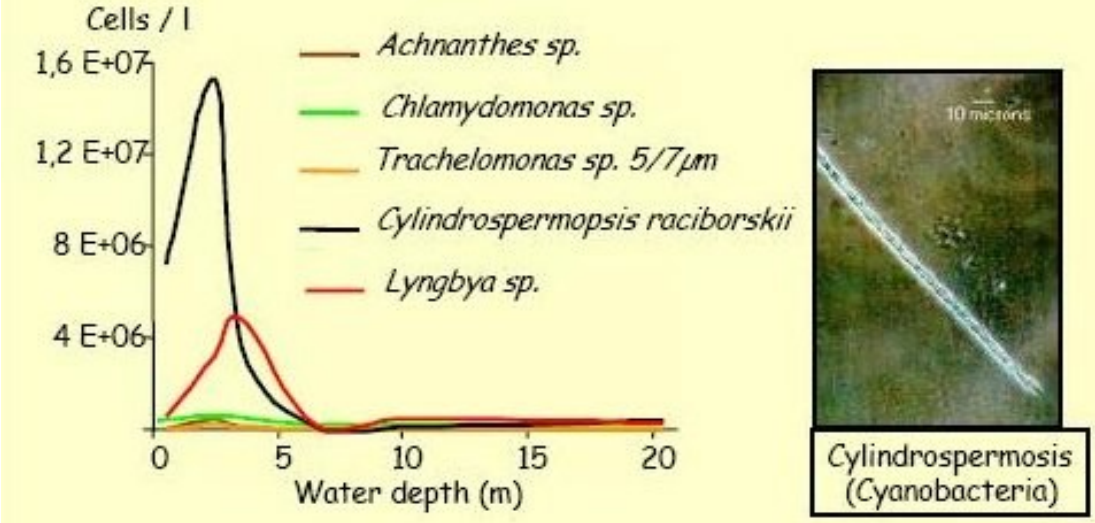
	May	July	September
Epilimnion	0,11	0,00	0,01
Metalimnion	1,01	0,03	0,16
Hypolimnion	2,52	0,39	0,24

Thothong W., Huon S., Ten-Hage L., Janeau J.-L., Boonsaner A. 2004

Impact on human health?

Phytoplanktonic communities – 28 May 2004

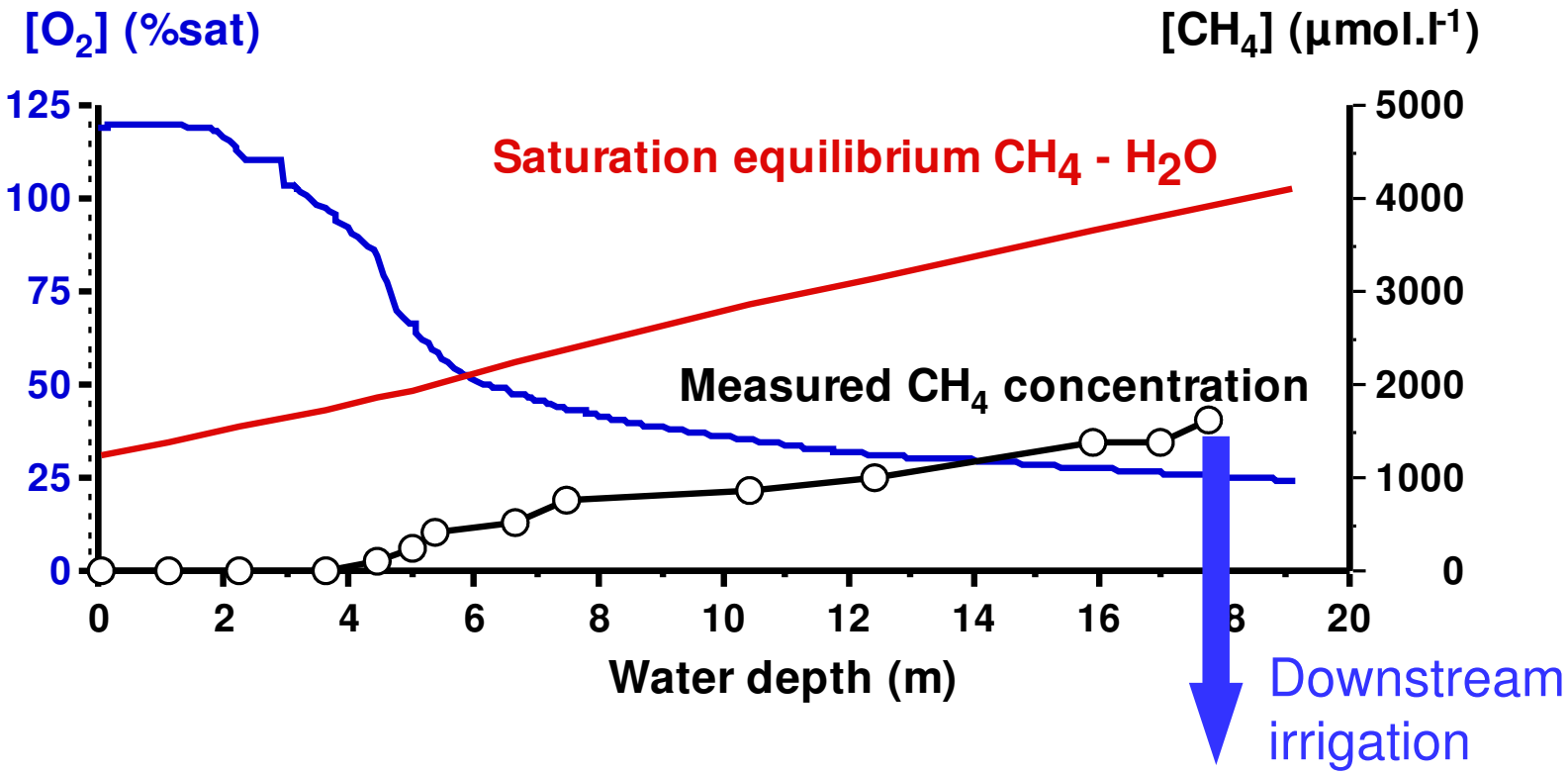




- Pathogenic cyanobacteriae
- Leptospirosis

Thothong W., Huon S., Ten-Hage L., Janeau J.-L., Boonsaner A. 2004

Methane emission from a reservoir located at the outlet of cultivated watershed
(Mae Thang watershed, Thailand, Juy 2008)



Soil erosion => excess of OM to sediments => CH_4 production

Estimated water uptake 100 $l.s^{-1}$ => 80 $tCH_4\ year^{-1}$

Concluding remarks

- Human activities along small streams have an impact on soil erosion and nutrient/contaminants transport
- Different cropping systems induce different soil/nutrient/contaminant loss regimes
- Carbon losses related to agriculture can be high
- At the catchment scale, stable forms of carbon are preferably eroded
- Some of this eroded carbon may remain « trapped » along slopes
- Some may contribute to downstream mineralization processes

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