



**Early diagenetic processes in an  
eutrophic estuarine system: indices of  
sediment contribution to summer  
hypoxia of the Loire?**



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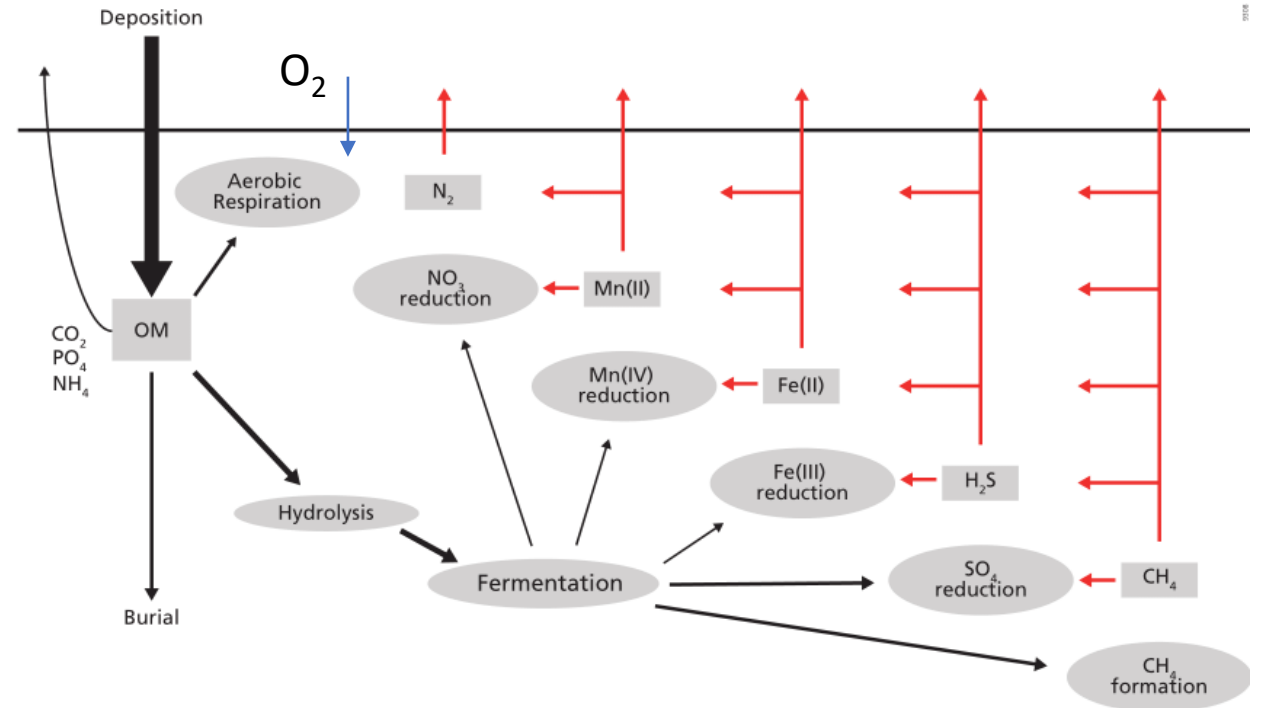


# INTRODUCTION

## Sediment and hypoxic events

### Iron oxides as driver of eutrophic process in aquatic systems:

- Phosphorus (DRP) is produced during all mineralization step.
- DRP phyto-availability : the key-stone role of iron oxides
- Dissolution of iron curtain during induces phosphorus (DRP) efflux from sediment



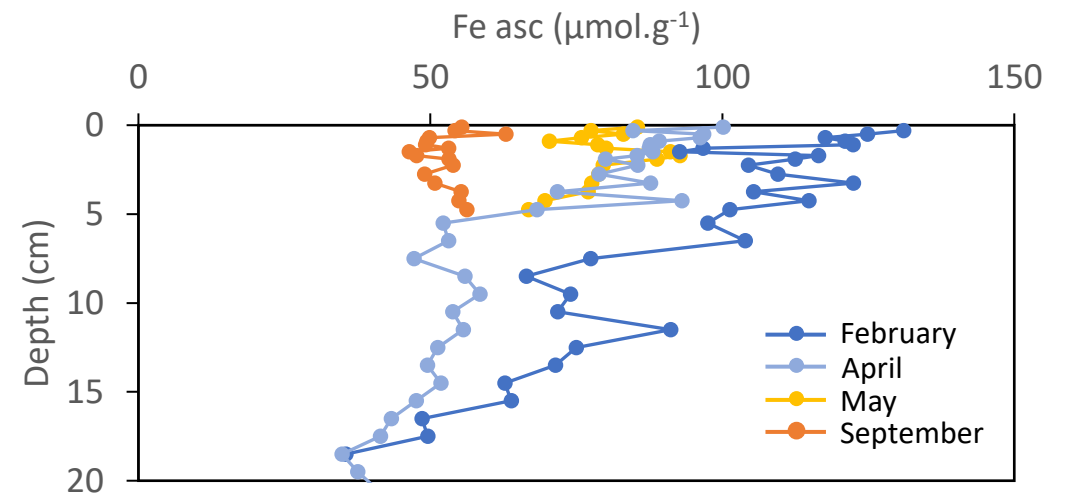
Middleburg and Levin 2009

# INTRODUCTION

## Iron curtain in Loire estuarine system

Importance of benthic flux in Loire estuary and hypoxic events (OXYMORE project) :

- The paradox of water-quality of Loire estuary and hypoxia events (Minaudo et al., 2015; Etcheber et al., 2013)
- Contribution of legacy phosphorus and diagenetic process to water-column eutrophication ?
- Dissolution of iron curtain as key-stone driver ? (Thibault de Chanvalon et al., 2016)

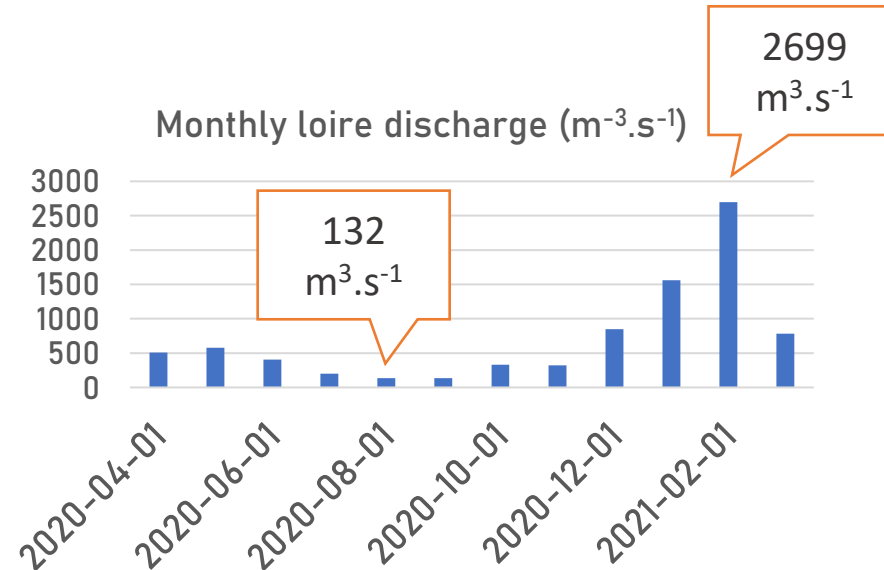
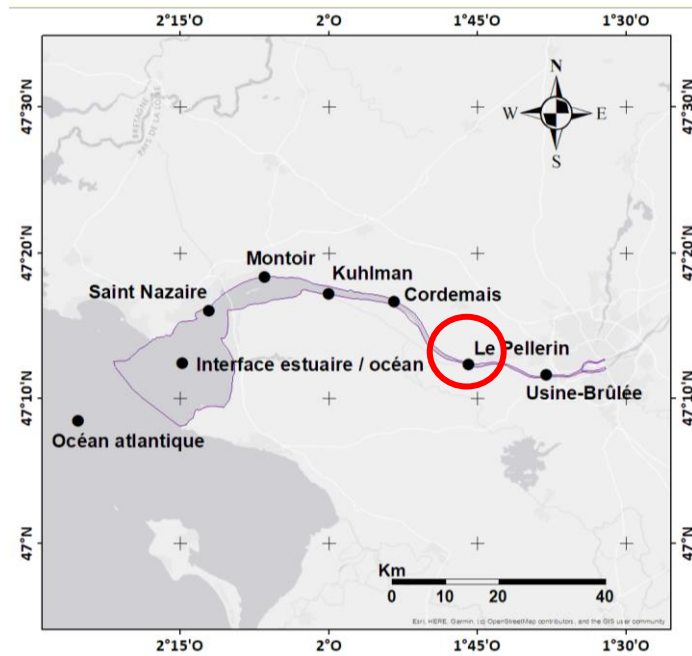


Thibault De Chanvalon et al., 2016

# METHODOLOGY

An comparative approach

- 1 Site (Le Pellerin)
- 2 Contrasted hydrological situations



Low-discharge period (Hypoxia)

VS

High-discharge period (Normoxia)

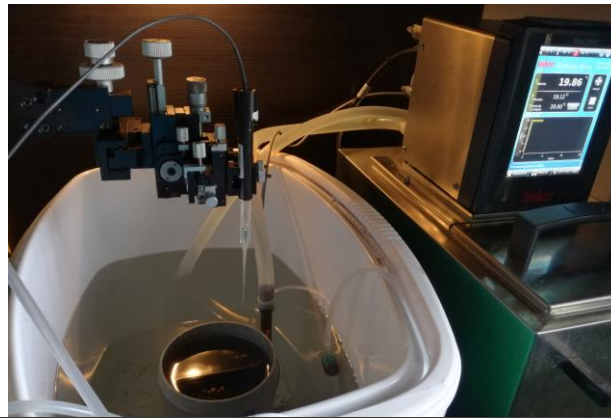
# METHODOLOGY

Estimation of benthic sediment flux (DRP + O<sub>2</sub>) and its drivers

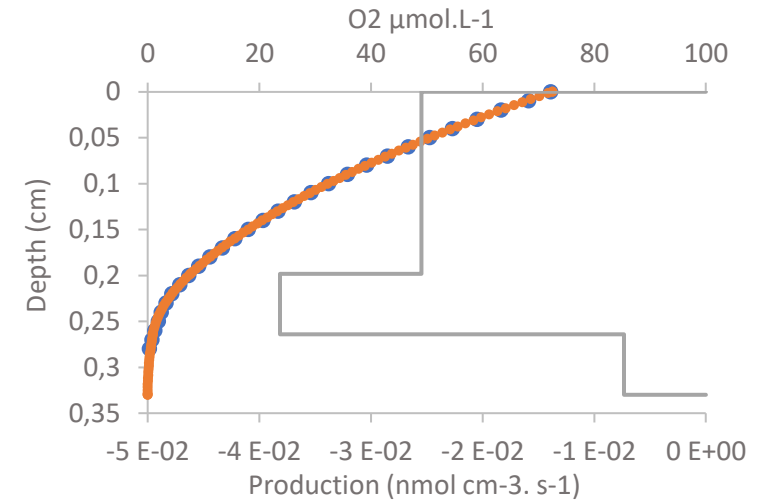
1. Diffusive flux

$$F_{\text{Diffusion}} + F_{\text{advection}} = F_{\text{total}}$$

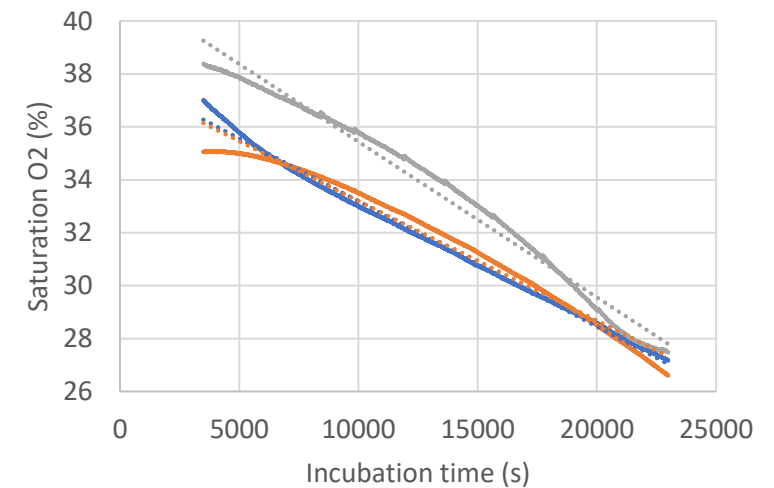
2. Total flux



Profiling + Modelling (Berg et al., 1998)



Sediment incubation

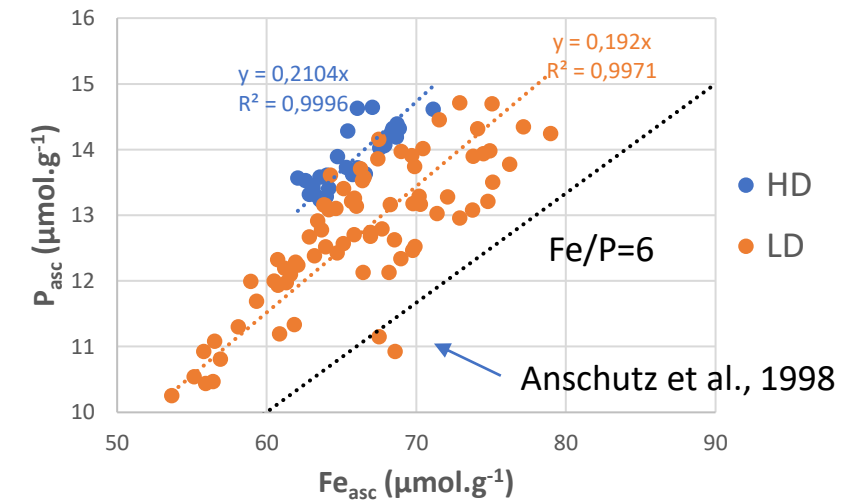
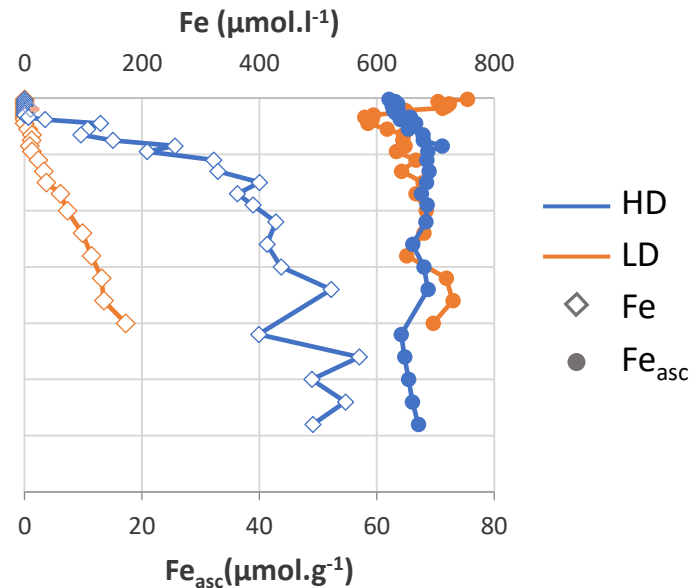
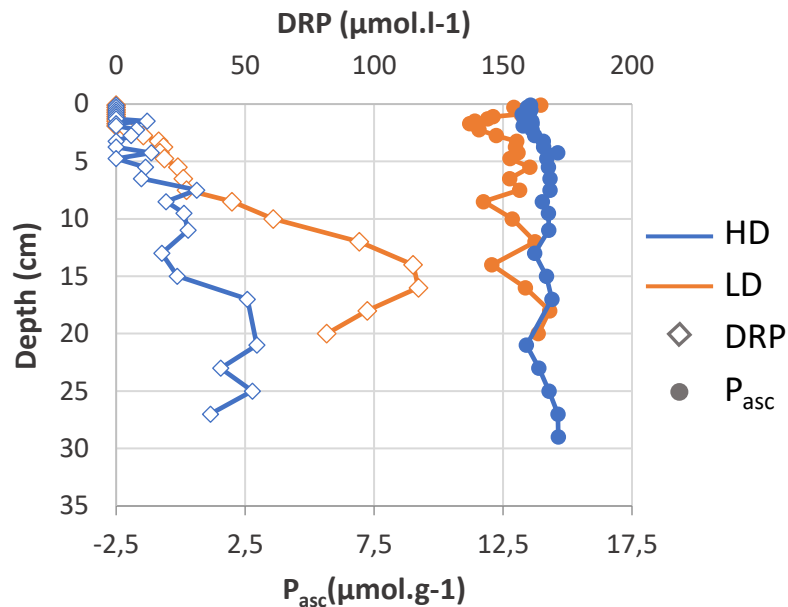


# RESULTS AND DISCUSSION

## Iron and phosphorus relationship

### Evidence of iron oxides control :

- Important internal DRP remobilization during high-discharge period (HD)
- Similar bounded  $P_{asc}$  stock during high and low-discharge period (LD)
- Strong iron oxides control of P stock (Anschutz et al., 1998; Thibault de Chanvalon et al., 2016)



# RESULTS AND DISCUSSION

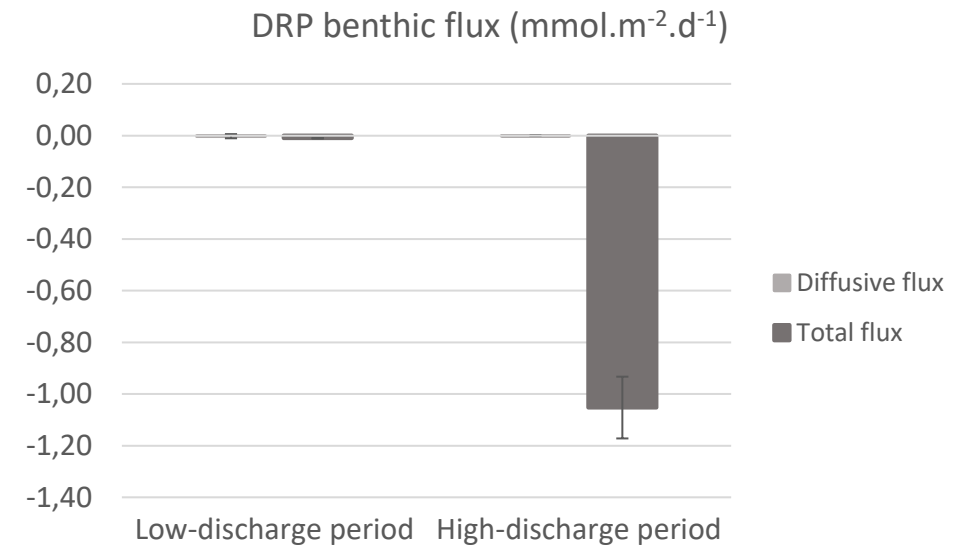
## Diffusive and total benthic flux (DRP)



Mud cracking observed

### Seasonal comparison of water-sediment DRP flux :

- Undetectable flux during low-discharge period
- Only significant efflux during high-discharge period
- Importance of non-diffusive drivers in benthic DRP flux
- Gas induced mud cracking likely acting as breach through iron curtain

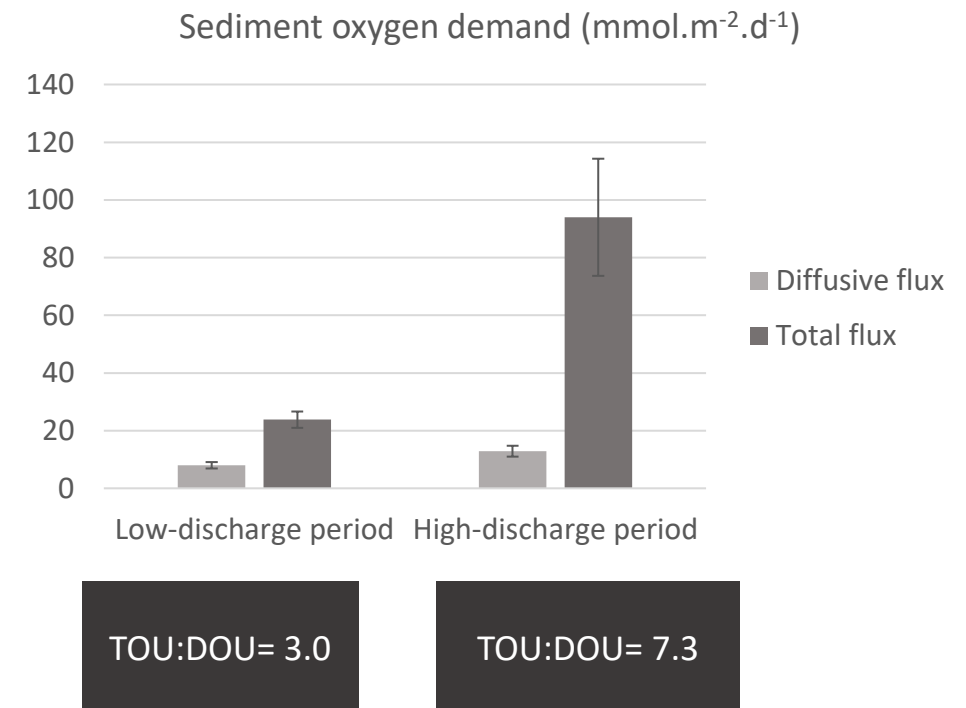


# RESULTS AND DISCUSSION

## Diffusive and total benthic flux ( $O_2$ )

### Seasonal comparison of sediment oxygen uptake :

- Important  $O_2$  consumption during high-discharge period
- Total (TOU) and diffusive (DOU) oxygen uptake ratio underline importance of advection processes
- Advection processes likely animated by mud cracking created by gas ebullition





# CONCLUSION AND PERSPECTIVES

## Gas ebullition in Loire estuary



Gas evidence in muddy surface sediment (June 2021)

### Minor role of sediment in hypoxia maintain :

- An iron curtain capable of retaining DRP efflux despite hypoxia condition
- Low DRP flux and SOD during installed hypoxia (low-discharge period)

### Effect of degasing of benthic fluxes :

- Gas ebullition causes multiple breaches in iron curtain permitting DRP efflux during high-discharge period
- Identification of gas and ebullition drivers ?
- Consequences of gaz ebullition on hypoxia process ?



Thanks !

