THE RHONE SEDIMENT OBSERVATORY (OSR):
A MULTI-PARTNER PLATFORM FOR BASIC AND
APPLIED RESEARCH ON THE RHONE RIVER VALLEY
(FRANCE)

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The Rhone river

One of the largest European rivers
First freshwater input to the western Mediterranean basin

560 km in France
(800 km in total)
Watershed: 98 000 km²

Mean discharge at the mouth:
1700 m³/s

Annual flood:
4000 m³/s

J.M. Olivier et al., 2009
Flash-flood events (few hours to days) occur regularly on the Alps and Massif Central Mountains (≈ 60% of the annual discharge).

Poor knowledge of the time and spatial scales and fluxes of sediment transported or stored within the river!
Regulated between 1850 and 1930 for navigation purposes... (embankments, groynes, walls)

... then dammed for producing electricity (1948-1986: 19 hydroelectric dams)

Embanked reach

Hydroelectric power plant

« Old Rhone » or by-passed reach
Why an observatory on sediments?

Stakes and questions related to the sediment transfer and morphology.

- What is the impact of the river geometry and existing infrastructures on the flooding risk or the ecological potential of the river?
- How has the geometry of the channel evolved over the last two centuries?
- What is the annual bedload transport?
- What is the impact of development and management activities such as dredging, channel maintenance or sediment flushing?
- What suspended sediment and contaminant fluxes are transferred to the Mediterranean Sea? Where do they come from and what are their temporal patterns? Are they stored on the continuum and do they affect the geometry of the bed?
- Can we predict the sediment transfer and deposition?
- How can we share data and information for public?
Objectives jointly built by scientists and managers

Multidisciplinary scientific team

Hydrologists
Geochemists
Geomorphologists
Sedimentologists
Modelers
Geophysicians
Database managers

Europe

Water agency and stakeholders

Regional councils
Workpackages and related issues – OSR 4

WP I – Bedload and river channel geometry
  Benthic habitats, flood, channel restoration
  (dredging, sediment replenishment)

WP II – Sedimentation and floodplain morphology
  Benthic habitats, restoration of channel banks and re-erosion, stock of past contaminants in the overbank fine sediments

WP III – Fluxes of suspended particulate matter and associated contaminants
  Past and present SPM fluxes
  Contributions from tributaries

WP IV – Sources of contaminants
  Tracking contaminant sources
  Knowledge on emerging pollutants

WP V.a – Modelling and web tools
  Prediction and construction of scenario for decision
  Database and metadatabase

WP V.b – Coordination/Dissemination
  Communication, dissemination of scientific knowledge
WP I – Evaluate the bedload transfer: sand and pebbles

Development of technics to quantify and understand the bedload transfer

Creation of artificial pebbles with passive and active RFID to monitor their transport

Evaluation of the efficiency of gravel or sand augmentations

SPM extracted from ADCP signal

Claping area
WP I – Understand the long term evolution of river bed elevation

Reconstruction of the talweg altitude from bathymetric charts to evidence the influence of the various phases of management

Navigation infrastructures:
- Mean incision: 1.7 cm/yr

Dams constructions:
- 1.2 cm/yr

LYON

MEDITERRANEAN SEA
WP I – Understand the deposition of sand on delta and adjacent coasts

Development of a hydrosedimentary model to predict the transport and deposition of sands on the delta, including the influence of floods and marine storms

Simulation of particle transport for a decadal flood combined with a marine storm (5m height wave)
WP II – Define the long term evolution of the river morphology

Reconstruction of the surface of the active channel from 1860 to present using historical maps and pictures

Reduction of ≈ 50 % during the period of regulation for navigation (1860-1954)
Reduction of 10-20 % during the period of dam construction (1954-2008)
WP II – Knowledge of sediment and contaminants stored in the river network

Geophysical surveys, sediment coring and geochemistry to better evaluate the volume of sediments and contaminants stored in the alluvial margin and the risk in case of margin reactivation.

1. Post 1980’s slow decrease of contaminants
2. 1980’s, peak of contaminants (PCB, Zn, Pb, Cu)
3. Early 20th, progressive increase of chronic contaminants
4. 19th only rare contaminant peaks (Zn)
WP III – Evaluate the fluxes of suspended particulate matter and associated contaminants along the whole river

A network of permanent and temporary stations has been developed to measure SPM transfer and to collect samples for the analyses of contaminants and geochemical tracers.

- Precise estimation of the annual SPM flux (85% of SPM flux at the mouth is transported during floods = 5% of the time)
- Good evaluation of the interannual variability: 2 – 8 Mt/yr
- Evaluation of the inputs from tributaries
- Compare the influence of floods vs flushing operations

2 automated stations with centrifugation

- 5 stations with sediment traps (one month sampling)
- 7 sites for temporary collection by traps or manual sampling on tributaries (floods or month sampling)
- Continuous Turbidity measurement
The SPM values and contaminants concentrations are available through a specific website ([https://bdoh.irstea.fr](https://bdoh.irstea.fr)) where fluxes can be calculated and data exported.

**Period of interest**

**Selection of station**

**Selection of dataset**
Contaminant concentrations are combined with SPM data for the calculation of fluxes. Anyone (including partners and public) may now use the same values.

Flux of particulate Cd (g/s)
WP III-IV  Expertise on the state of contamination

Contaminants provided into BDOH:

- Co, Cr, Ni, Cu, Zn, Pb, Cd, Hg
- PCB
- artificial radionuclides associated to the nuclear power plants ($^{134}$C, $^{137}$Cs, $^{54}$Mn...)

Other contaminants or tracers measured:

- Numerous TME, rare earth elements, methylHg
- PHA
- PBDE
- Pesticides
- « Urban tracers » : pharmaceutics + pesticides
The important dataset for metals (>500 samples of SPM) allowed to distinguish those associated to the geochemical background from those still affected by anthropic inputs.

Natural: Co, Ni, V, U, Th, Cr

«Anthropic»: Pb, Ag, Sn, Sb, Zn, Cu, Cd, Hg
• PAH mainly issued from road traffic and house heating system
• PCB issued from atmospheric deposit and waste water treatment plants (urban and industrial)

The characterisation (diagnostic ratios) of PAH and PCB signatures help to understand their origins.
The objective is to model water and SPM transfer and fluxes over the whole river:

- 545 km
- 21 hydroelectric dams
- 6 major and 26 minor tributaries.

1D hydraulic model: MAGE
1D sediment model: ADIS-TS

Very fast calculation!

5mn running time for a 16 days simulation over 300 km (Lyon → sea)
Another objective is to reproduce the transfer and deposition during floods or flushing operations.

Simulation of the SPM content in Arles compare to real measures X during a flood in 2008 due to Isere and Durance tributaries.
A final objective will be to combine three hydrosedimentary models to get a source-to-sink simulation: RIVER \(\rightarrow\) ESTUARY \(\rightarrow\) CONTINENTAL MARGIN.
A metadatabase allows to find the producers of data and products: http://elvis.ens-lyon.fr
A webmapping system provides an access to some geographical informations: maps and figures

Specific areas

Bathymetric profiles through time

Alluvial margin
Main chanel
D50 values of the sediment

Pdf figures of some results
The results presented here were obtained by the numerous scientists involved in OSR 1 to 4.