Estudo do efeito da descarga de duas ETAR's na estrutura da comunidade de macroinvertebrados bentónicos do rio Tinto (Portugal)

Study of the effect of two WWTP's discharges on benthic macroinvertebrate communities structure of the river Tinto (Portugal)

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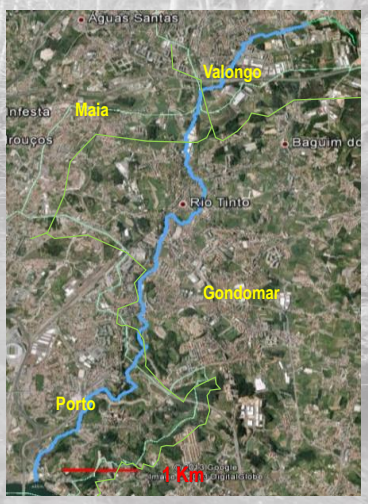
The Project: Study of the ecological status of the Tinto river

- is a project proposed by LIPOR, an inter municipal company and developed by the Fernando Pessoa University with the support of:
  - ✓ the four municipalities which integrates the river basin;
  - ✓ three water companies;
  - ✓ and the Portuguese Environmental Agency;
- The study is carried out taking account the stablished by the WFD.



Main objectives:

- Characterization of the Tinto river ecological state;
- Detection of the main sources of environmental disturbance;
- Preparation of proposals for measures to improve the ecological status of the river.

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Tinto river

- Is a small urban watercourse in the north of Portugal belonging to the Douro river basin with about 11 km long;
- Has many sources of environmental disturbance such as: channelization, waste disposal, effluent reception of wastewater treatment plants and of untreated urban and industrial effluents.

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Main objectives

- Study of some parameters related to the ecological state of Tinto river;
- Study the effect of two wastewater treatment plants (WWTPs) discharges on the structure of the benthic macroinvertebrate communities of the Tinto River;
- Relate the composition of the macroinvertebrate communities and the environmental conditions.

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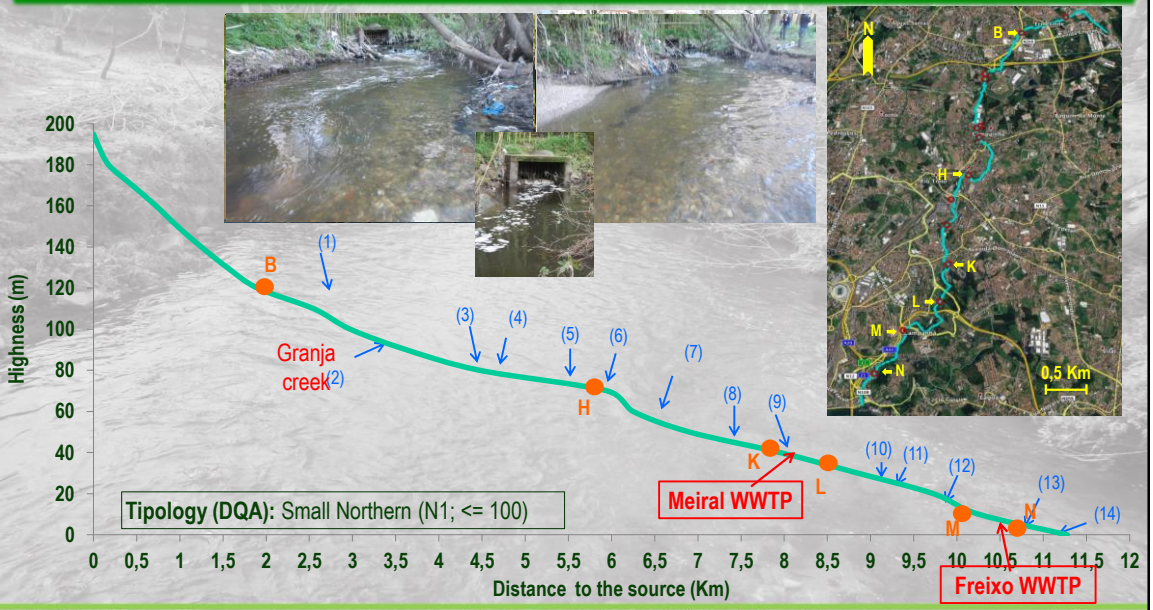
The sampling sites



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Methodology

Environmental parameters

➢ **Hydro-morphological parameters** (every six months, between oct'15 and jul'17):

✓ substrate composition, habitat quality, macrophytes (%), canopy (%) and flow

➢ **Physical and chemical parameters** (every months between oct'15 and jul'17):

✓ pH, conductivity, oxygen saturation, BOD_5, NH_4^+, NO_3^-, NO_2^-, P_{total}

Benthic macroinvertebrates

➢ **Sampling:**

✓ With a hand net

✓ Every 3 months between december'15 and july'17 (dec'15, mar'16, jun'16, sep'16, dec'16, mar'17 and jun'17)

Parameters

Data analysis

Index and metrics:

➢ **Hydromorphological parameters:**

✓ Habitat quality (AVH and QBR)

➢ **Macroinvertebrate communities:**

✓ Some metrics
✓ Biotic indexes: RQE and IBMWP
✓ Shannon´s diversity index and Pielou evenness index
✓ Classification of organisms into their functional and ecological groups

➢ Spatial variation of all parameters

➢ N-MDS analysis of macroinvertebrates grouped according a CLUSTER analysis into functional groups and taxa and with the validation of the number of clusters by ANOSIM analysis

➢ Ordination of the sampling sites made by a PCA attending the mean values of the environmental parameters and the metrics calculated with the macroinvertebrate data

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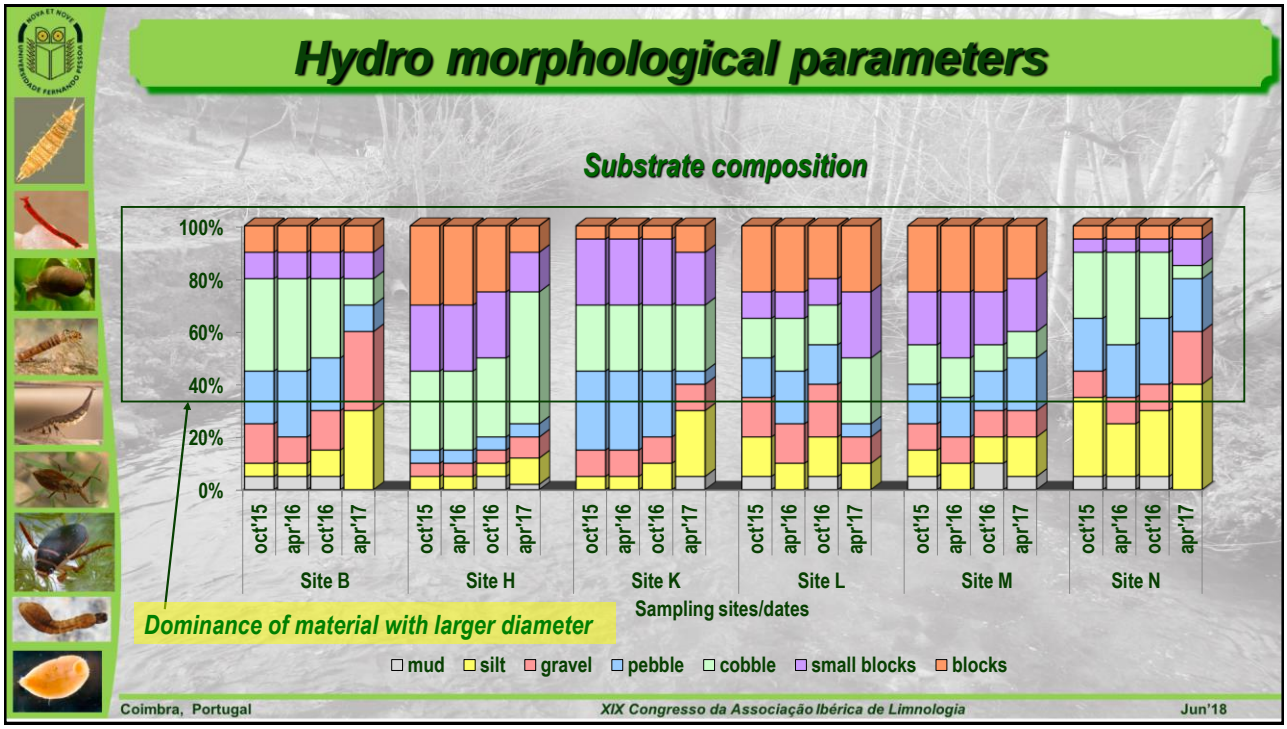
Hydro morphological parameters
Substrate composition
100%
80%
60%
40%
20%
0%
oct'15
apr'16
oct'16
apr'17
Site B
Site H
Site K
Site L
Site M
Site N
Sampling sites/dates
Dominance of material with larger diameter
mud
silt
gravel
pebble
cobble
small blocks
blocks
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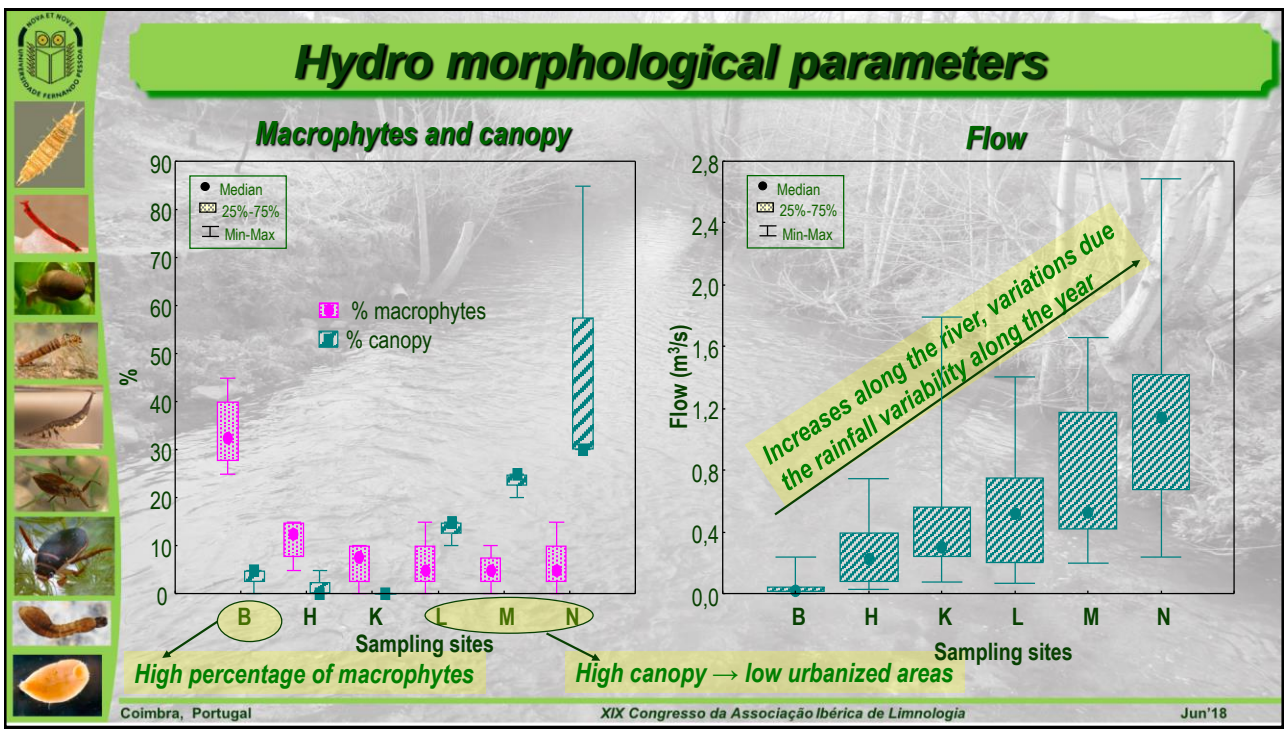
Hydro morphological parameters
Macrophytes and canopy
Median
25%-75%
Min-Max
% macrophytes
% canopy
%
B
H
K
L
M
N
Sampling sites
High percentage of macrophytes
Flow
Flow (m³/s)
Increases along the river, variations due the rainfall variability along the year
High canopy → low urbanized areas
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Habitat Quality

Some potencial to suport aquatic life, even with some disturbance of natural features

		B	H	K	L	M	N
AVH	oct'15	101	130	115	129	138	128
	apr'16	103	132	117	131	136	124
	oct'16	78	138	115	150	155	123
	apr'17	84	115	91	136	147	108
QBR	oct'15	5	20	15	30	40	45
	apr'16	5	20	15	30	40	45
	oct'16	0	15	0	40	45	45
	apr'17	0	20	0	35	60	60

Bad and very bad quality → urban character of watercourse

Very Good | Good | Medium | Bad | Very bad

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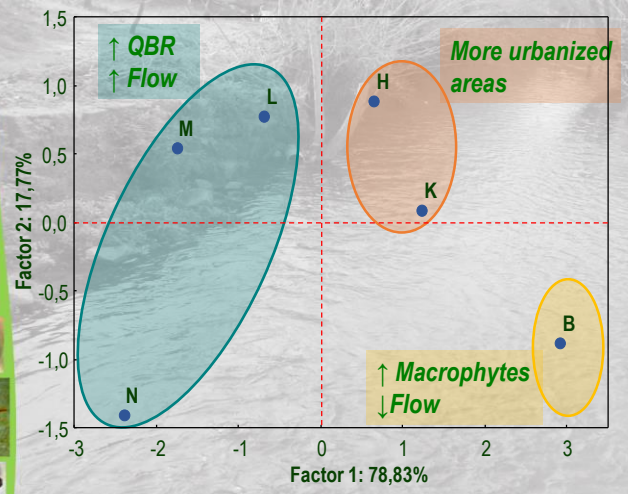
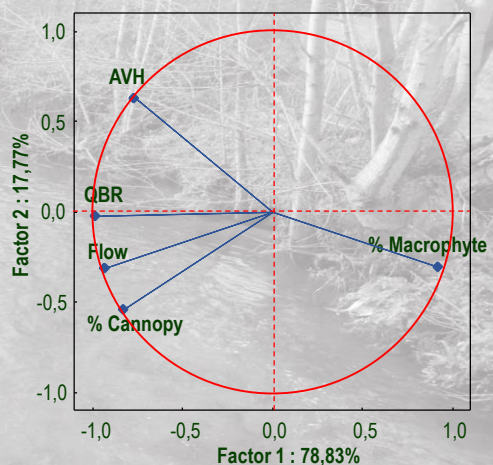
Hydro morphological parameters





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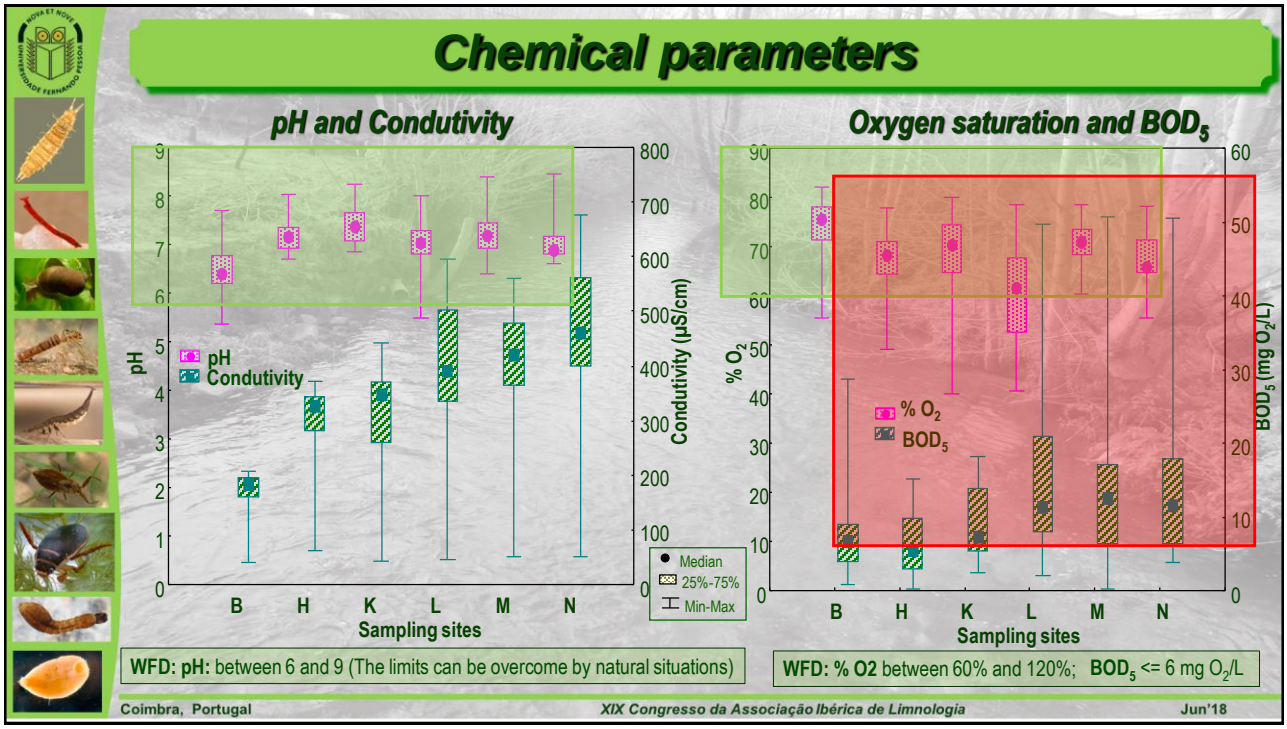
Chemical parameters
pH and Condutivity
pH
Condutivity
Condutivity (µS/cm)
Sampling sites
B H K L M N
Median
25%-75%
Min-Max
WFD: pH: between 6 and 9 (The limits can be overcome by natural situations)
Oxygen saturation and BOD5
% O2
BOD5
BOD5 (mg O2/L)
WFD: % O2 between 60% and 120%; BOD5 <= 6 mg O2/L
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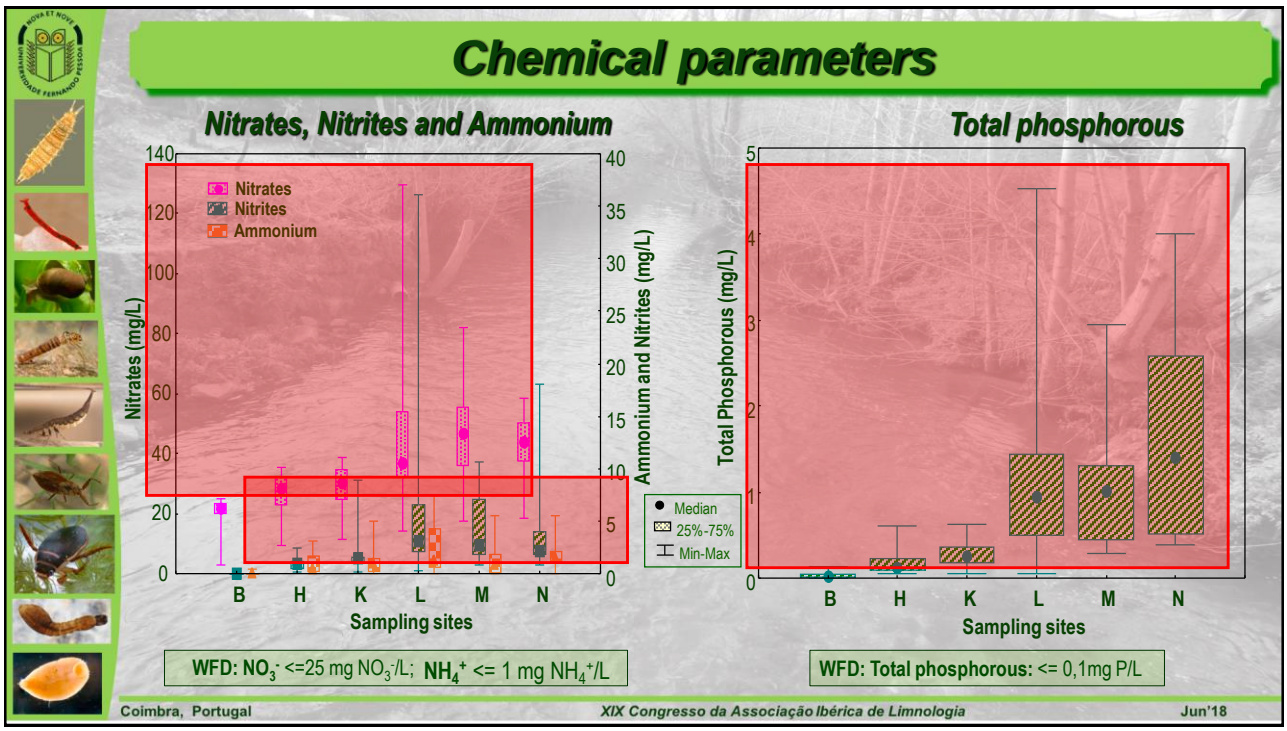
Chemical parameters
Nitrates, Nitrites and Ammonium
Nitrates
Nitrites
Ammonium
Nitrates (mg/L)
Ammonium and Nitrites (mg/L)
Sampling sites
B H K L M N
Median
25%-75%
Min-Max
WFD: NO3- <=25 mg NO3-/L; NH4+ <= 1 mg NH4+/L
Total phosphorous
Total Phosphorous (mg/L)
WFD: Total phosphorous: <= 0,1mg P/L
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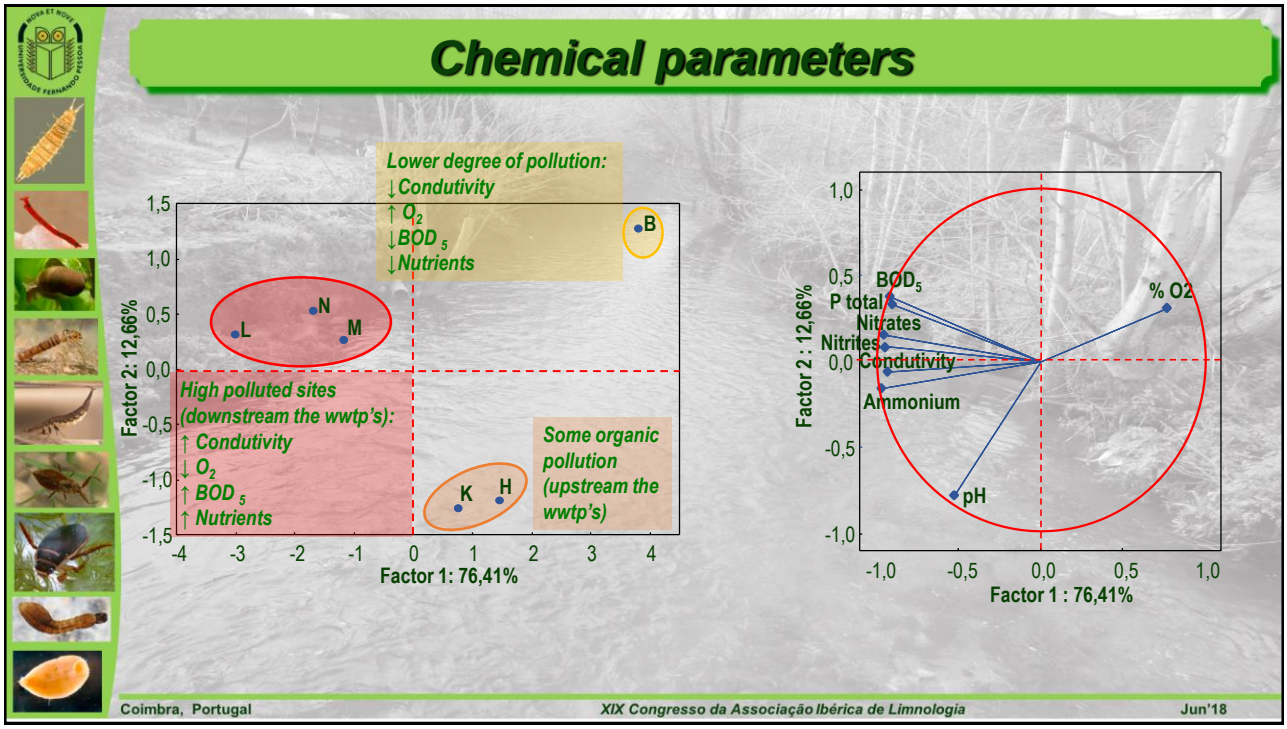
Chemical parameters
Lower degree of pollution:
↓Condutivity
↑ O_2
↓BOD_5
↓Nutrients
High polluted sites (downstream the wwtp's):
↑ Condutivity
↓ O_2
↑ BOD_5
↑ Nutrients
Some organic pollution (upstream the wwtp's)
B
N
L
M
K
H
Factor 2: 12,66%
Factor 1: 76,41%
BOD5
P total
Nitrates
Nitrites
Condutivity
Ammonium
% O2
pH
Factor 2 : 12,66%
Factor 1 : 76,41%
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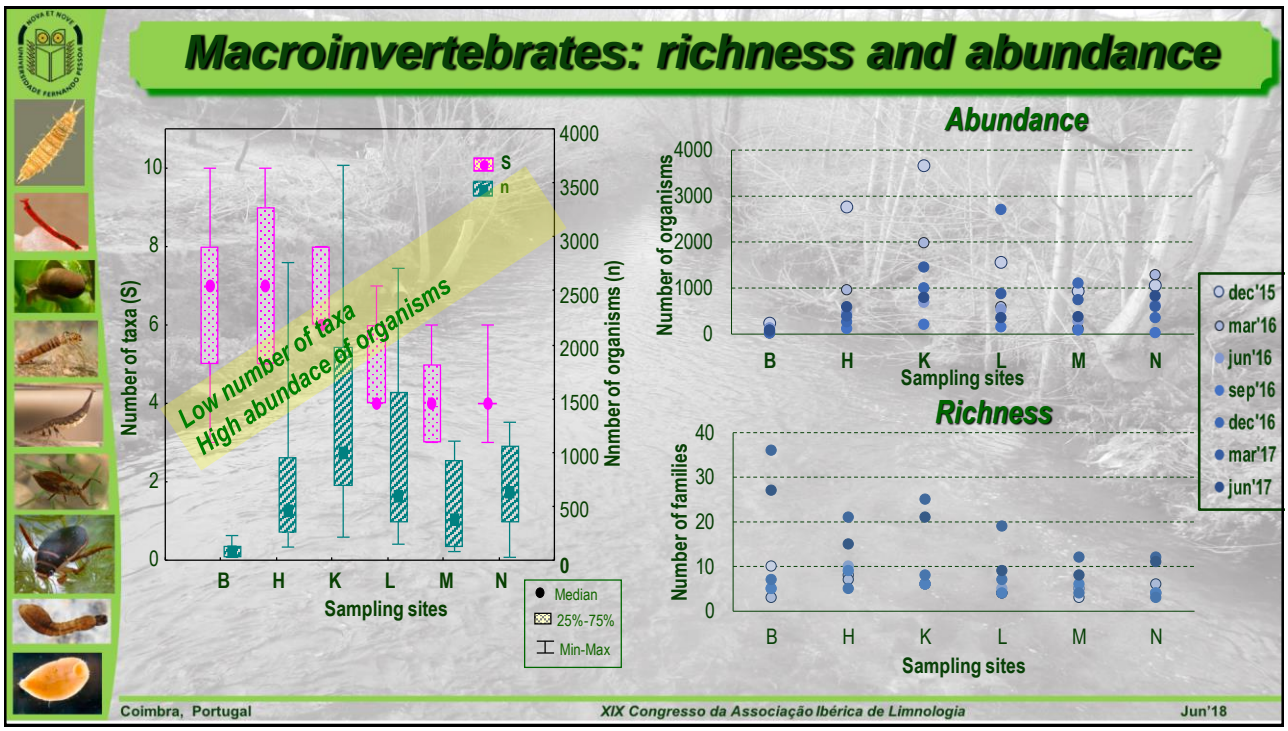
Macroinvertebrates: richness and abundance
Low number of taxa
High abundace of organisms
Number of taxa (S)
Nnmber of organisms (n)
S
n
Sampling sites
Median
25%-75%
Min-Max
Abundance
Number of organisms
Richness
Number of families
dec'15
mar'16
jun'16
sep'16
dec'16
mar'17
jun'17
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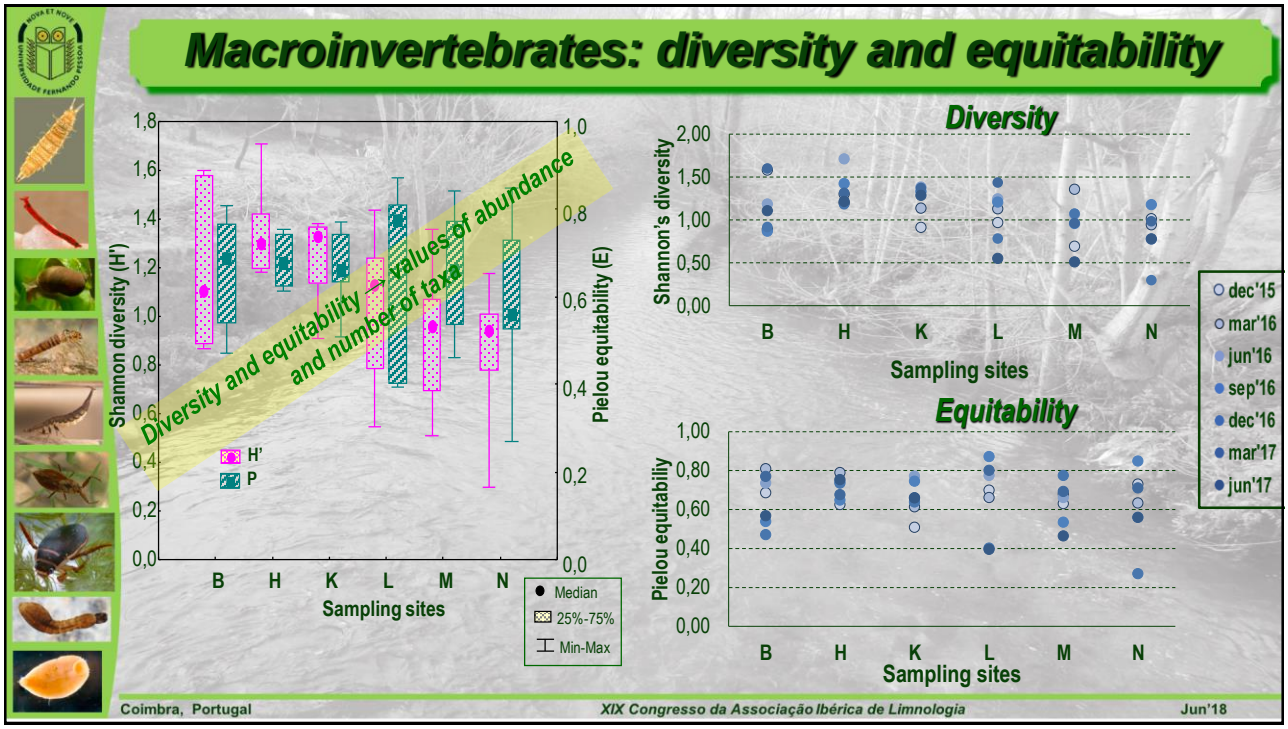
Macroinvertebrates: diversity and equitability
Shannon diversity (H')
Pielou equitability (E)
H'
P
Diversity and equitability ↗ values of abundance and number of taxa
B H K L M N
Sampling sites
Median
25%-75%
Min-Max
Diversity
Shannon's diversity
Equitability
Pielou equitability
dec'15
mar'16
jun'16
sep'16
dec'16
mar'17
jun'17
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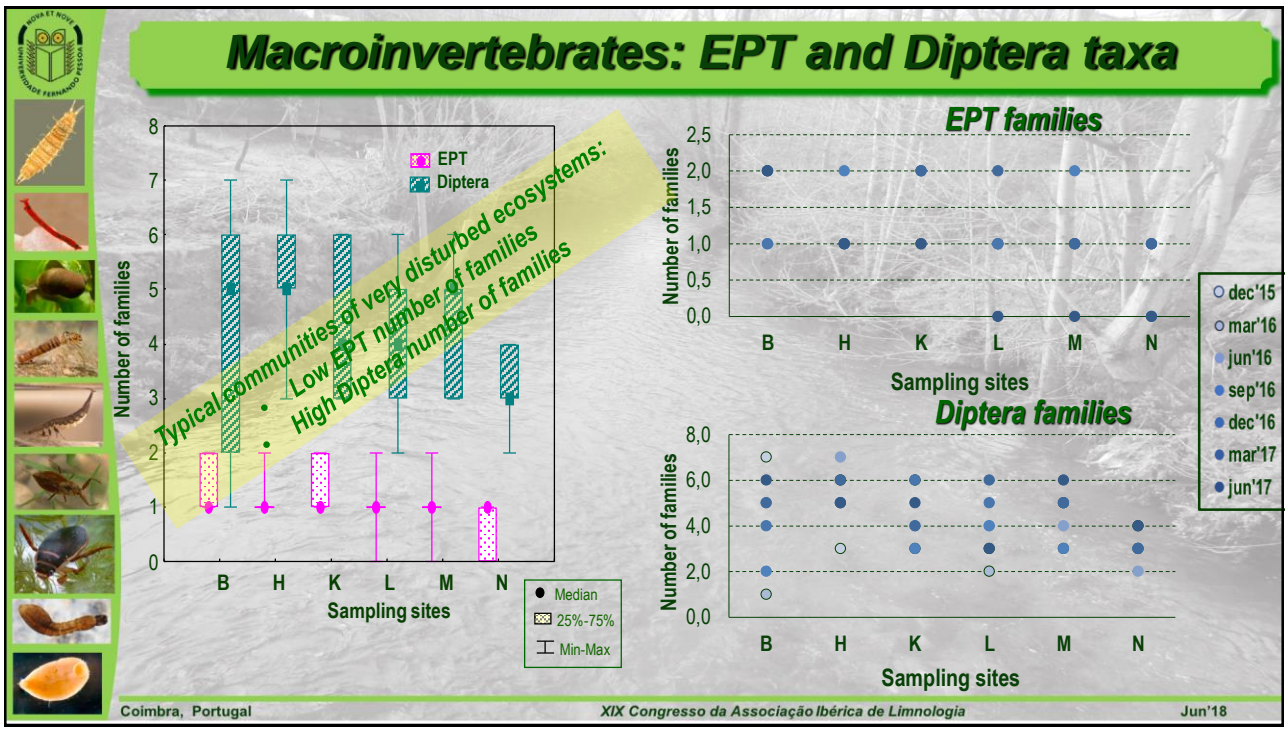
Macroinvertebrates: EPT and Diptera taxa
Number of families
EPT
Diptera
Typical communities of very disturbed ecosystems:
Low EPT number of families
High Diptera number of families
B H K L M N
Sampling sites
Median
25%-75%
Min-Max
EPT families
Diptera families
dec'15
mar'16
jun'16
sep'16
dec'16
mar'17
jun'17
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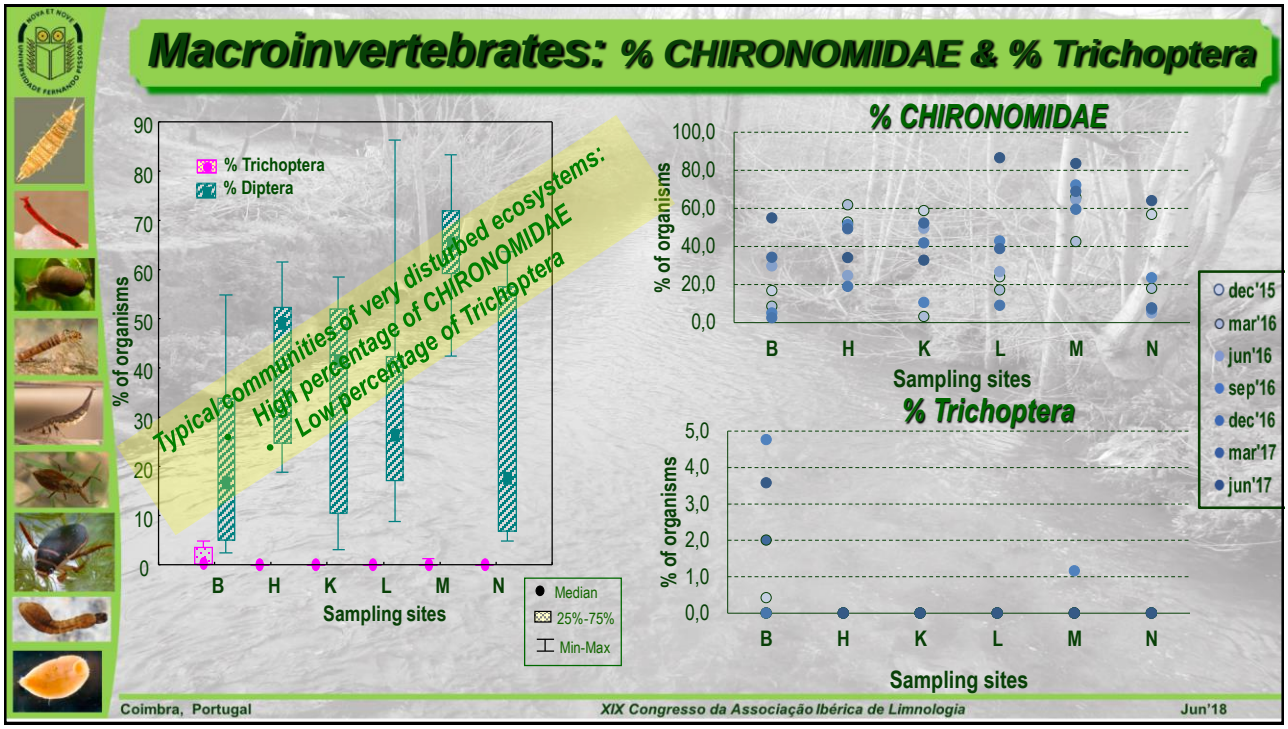
Macroinvertebrates: % CHIRONOMIDAE & % Trichoptera
% Trichoptera
% Diptera
% of organisms
Sampling sites
B H K L M N
Median
25%-75%
Min-Max
Typical communities of very disturbed ecosystems:
High percentage of CHIRONOMIDAE
Low percentage of Trichoptera
% CHIRONOMIDAE
% Trichoptera
dec'15
mar'16
jun'16
sep'16
dec'16
mar'17
jun'17
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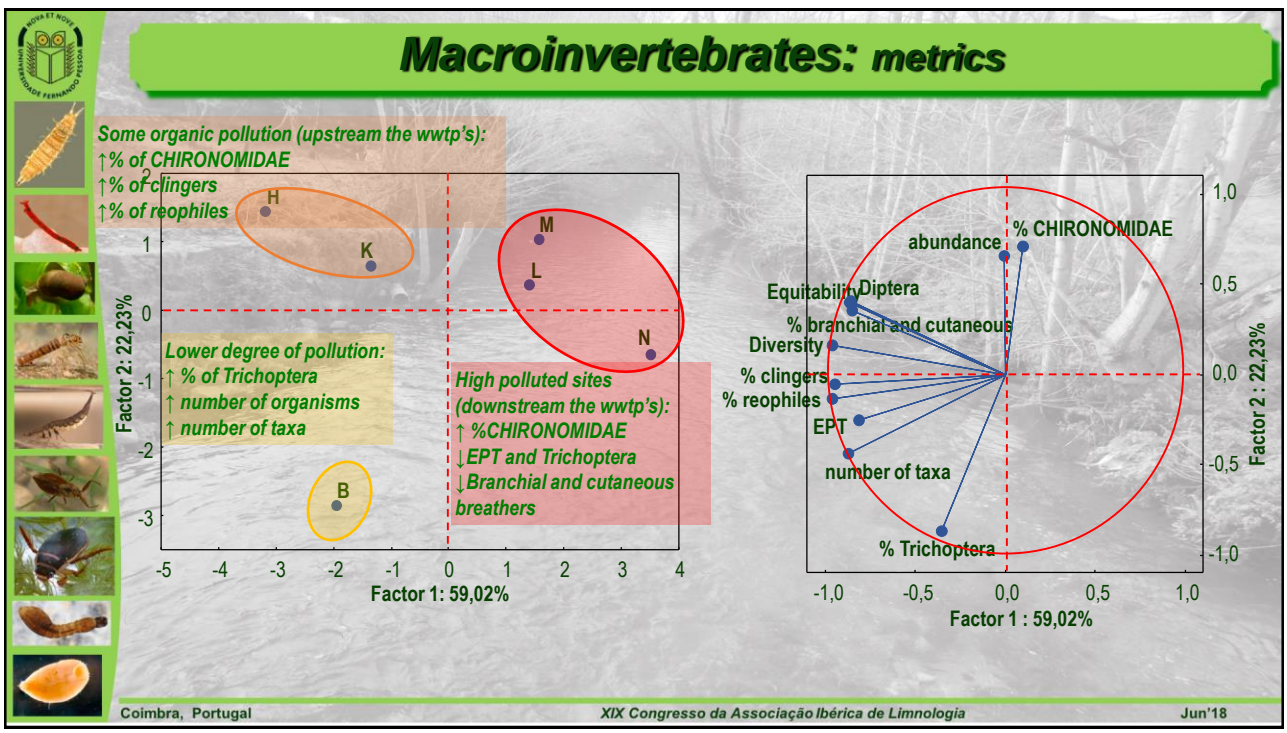
Macroinvertebrates: metrics
Some organic pollution (upstream the wwtp's):
↑% of CHIRONOMIDAE
↑% of clingers
↑% of reophiles
Lower degree of pollution:
↑ % of Trichoptera
↑ number of organisms
↑ number of taxa
High polluted sites
(downstream the wwtp's):
↑ %CHIRONOMIDAE
↓EPT and Trichoptera
↓Branchial and cutaneous
breathers
Factor 2: 22,23%
Factor 1: 59,02%
abundance
% CHIRONOMIDAE
Equitability
Diptera
% branchial and cutaneous
Diversity
% clingers
% reophiles
EPT
number of taxa
% Trichoptera
Factor 1 : 59,02%
Factor 2 : 22,23%
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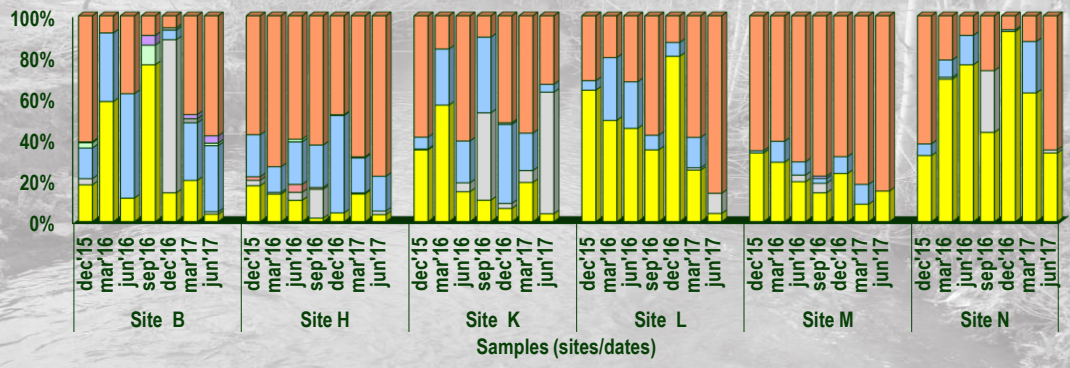
Macroinvertebrates: taxa Composition



- *Communities constituted by a great amount of Annelida and Diptera with presence of some Ephemeroptera (Baetis) and Mollusca*
- *Downstream the WWTP there are a decrease of the Ephemeroptera and of diversitity*

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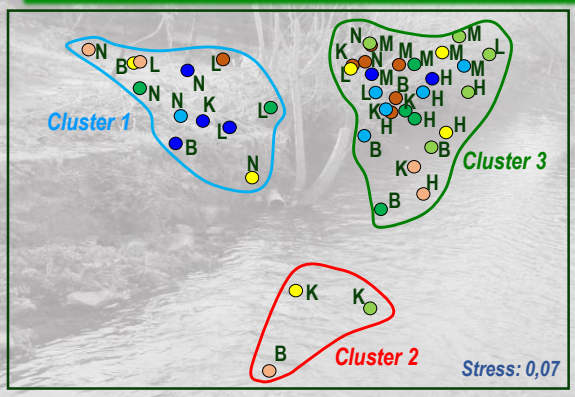
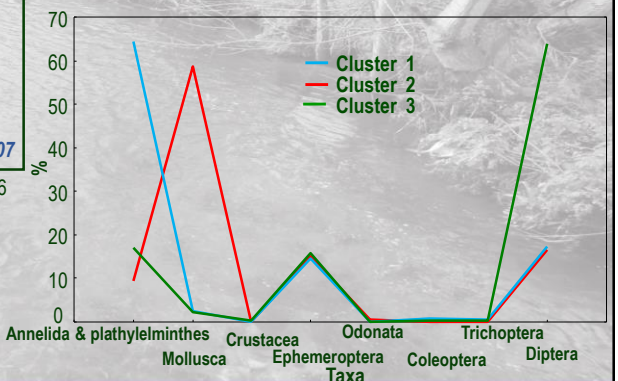
Macroinvertebrates: taxa Composition



dec'15 dec'16 mar'16 mar'17 jun'16 jun'17 sep'16

ANOSIM test: R_{global} = 0,96

Mean of each taxa in each cluster



Cluster 1: Dominance of Diptera and presence of some Ephemeroptera and Diptera

Cluster 2:
- Dominance of Mollusca and presence of some Ephemeroptera and Diptera
- Only samples collected at sites B and K (upstream the WWTP)

Cluster 3:
- Most samples collected at sites H and M (downstream the WWTP)

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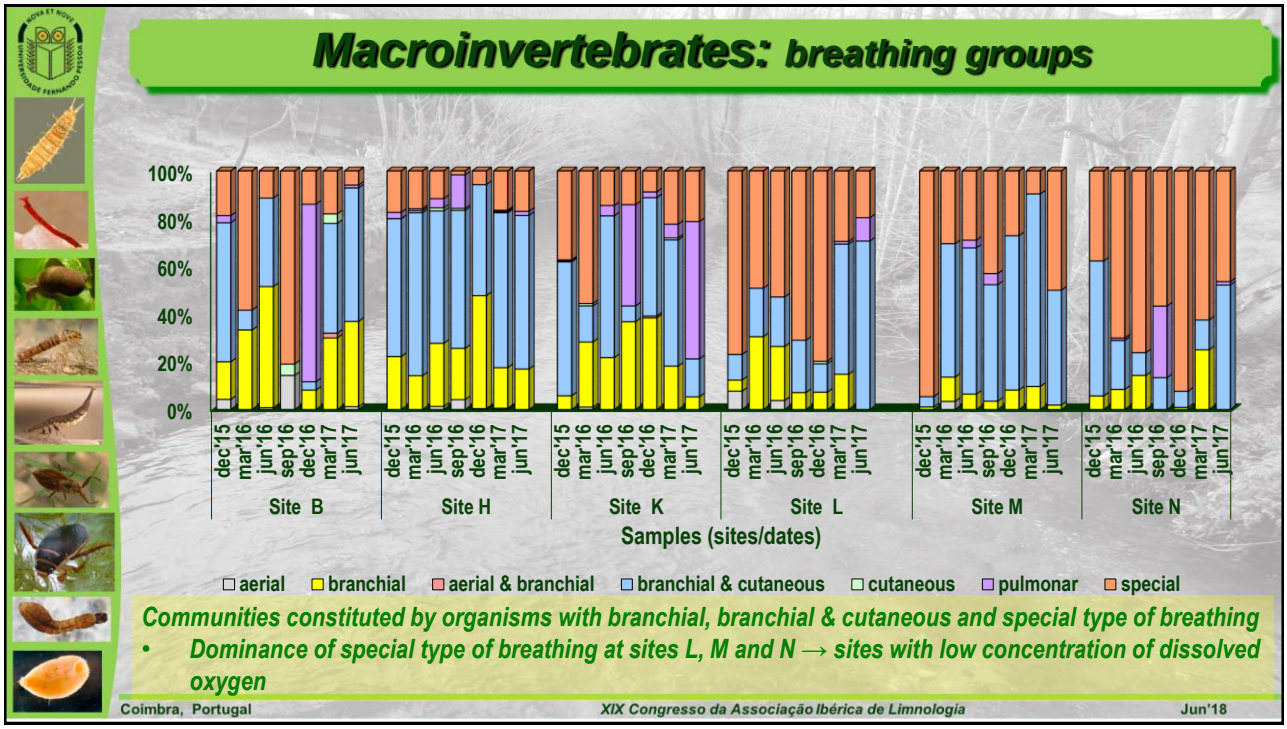
Macroinvertebrates: breathing groups
100%
80%
60%
40%
20%
0%
dec'15 mar'16 jun'16 sep'16 dec'16 mar'17 jun'17
Site B
Site H
Site K
Site L
Site M
Site N
Samples (sites/dates)
aerial
branchial
aerial & branchial
branchial & cutaneous
cutaneous
pulmonar
special
Communities constituted by organisms with branchial, branchial & cutaneous and special type of breathing
• Dominance of special type of breathing at sites L, M and N → sites with low concentration of dissolved oxygen
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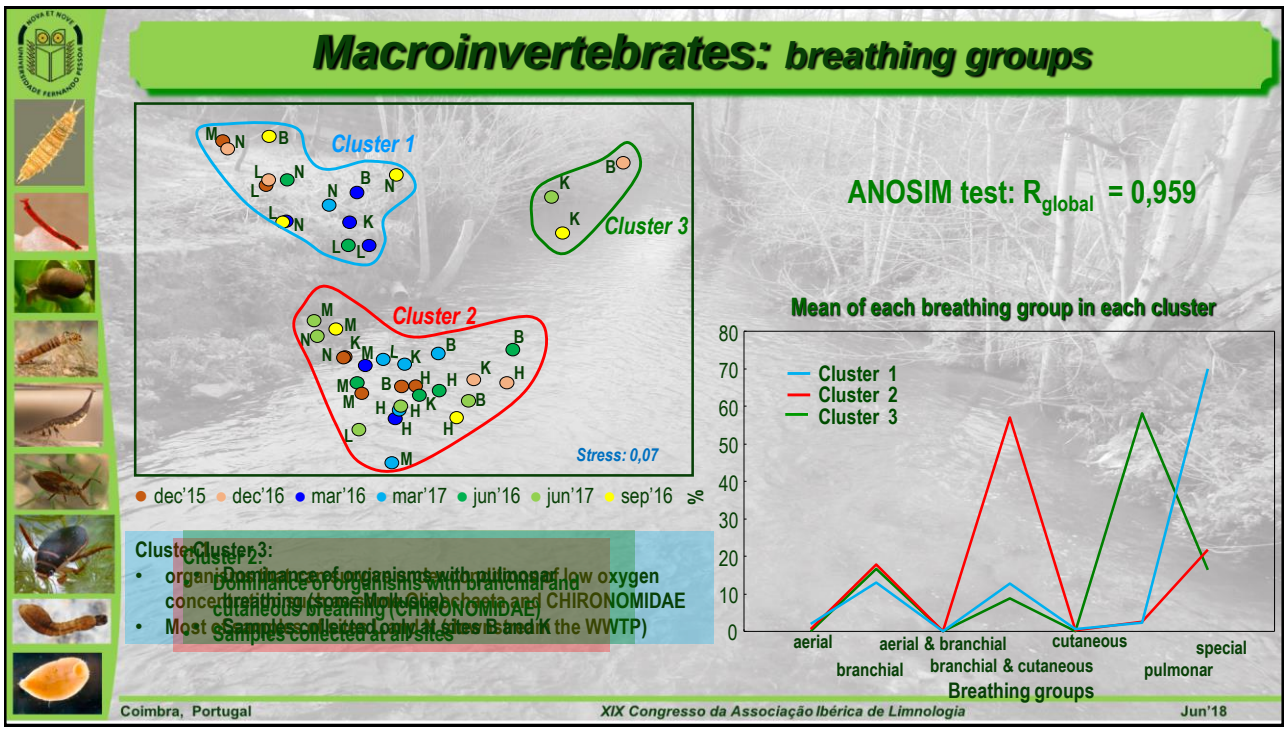
Macroinvertebrates: breathing groups
Cluster 1
Cluster 2
Cluster 3
Stress: 0,07
dec'15 dec'16 mar'16 mar'17 jun'16 jun'17 sep'16
ANOSIM test: R global = 0,959
Mean of each breathing group in each cluster
Cluster 1
Cluster 2
Cluster 3
aerial
branchial
aerial & branchial
branchial & cutaneous
cutaneous
pulmonar
special
Breathing groups
Cluster 2:
Dominance of organisms with branchial and cutaneous breathing (some Mollusca taxa and CHIRONOMIDAE
Samples collected at all sites
Cluster 3:
Dominance of organisms with pulmonar
Most samples collected only at sites B and K (close to the WWTP)
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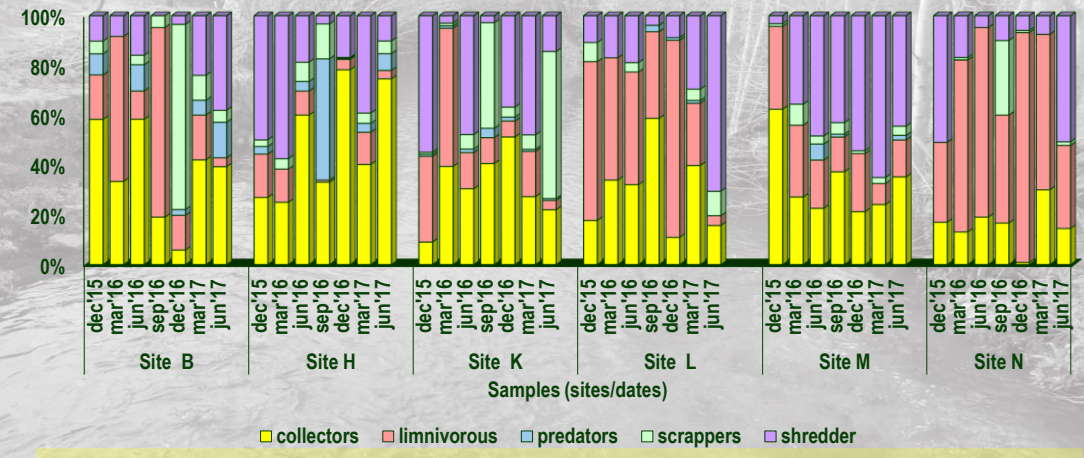
Macroinvertebrates: feeding groups



No great difference between the sampling sites:

- *Downstream the WWTP discharges (sites L and N) there are an increase of limnivorous → increase of organic matter on the river bed*

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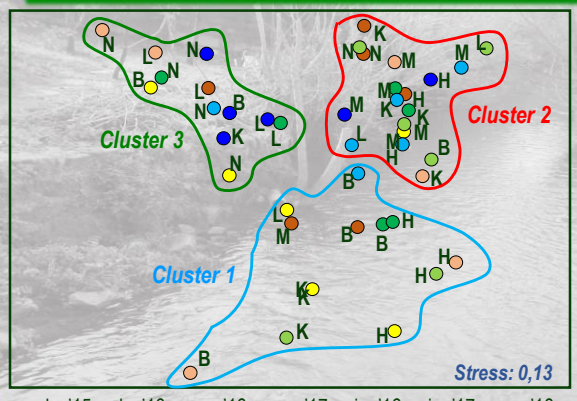
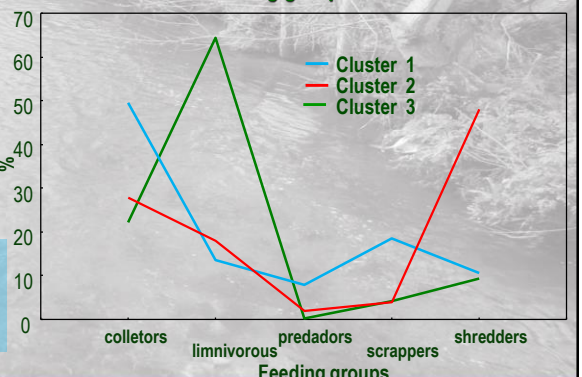
Macroinvertebrates: feeding groups



ANOSIM test: R_{global} = 0,8

Mean of each feeding group in each cluster



Cluster 3:

- Dominance of collectors (major diversity of feeding types
- Most of samples collected downstream the WWTP (sites L and N)

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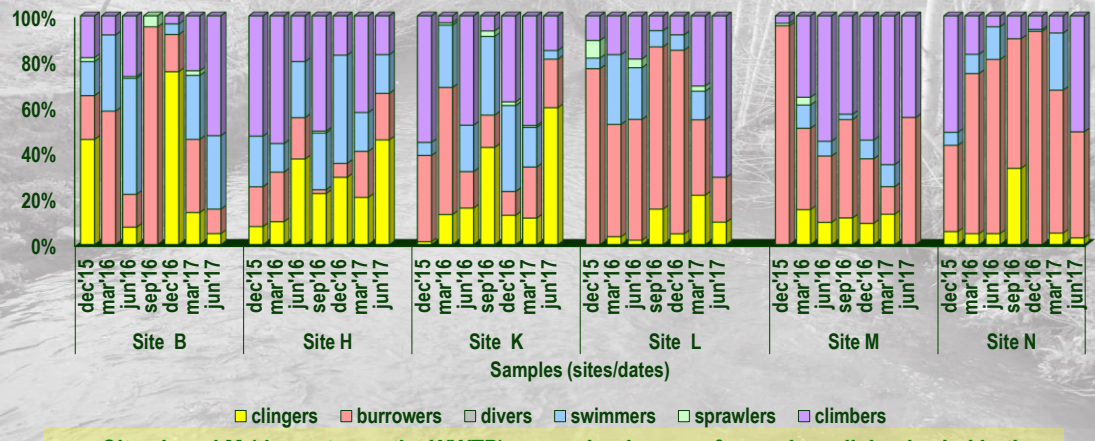
Macroinvertebrates: habitat/locomotion preferences



- *Sites L and M (downstream the WWTP) → predominance of organisms living buried in the substrate*
- *Other samples: clingers, swimmers and climbers*

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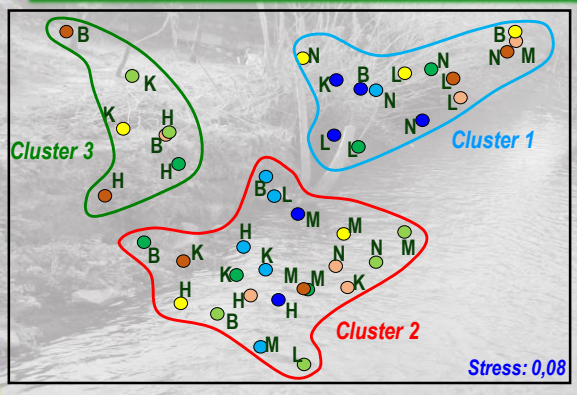
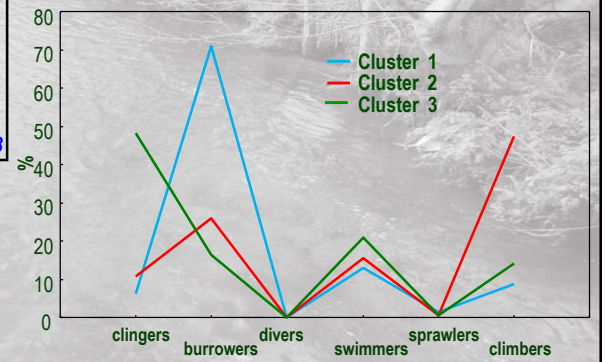
Macroinvertebrates: habitat/locomotion preferences



ANOSIM test: R_{global} = 0,879

Mean of each habitat/locomotion group in each cluster



Cluster 1:
- The greatest diversity of organisms
- Most of samples collected at sites B, H and K (upstream of WWTP) and
- dominance of swimming sites

Cluster 2:
- Dominance of burrowers and presence of some
- Most samples collected at sites L and M

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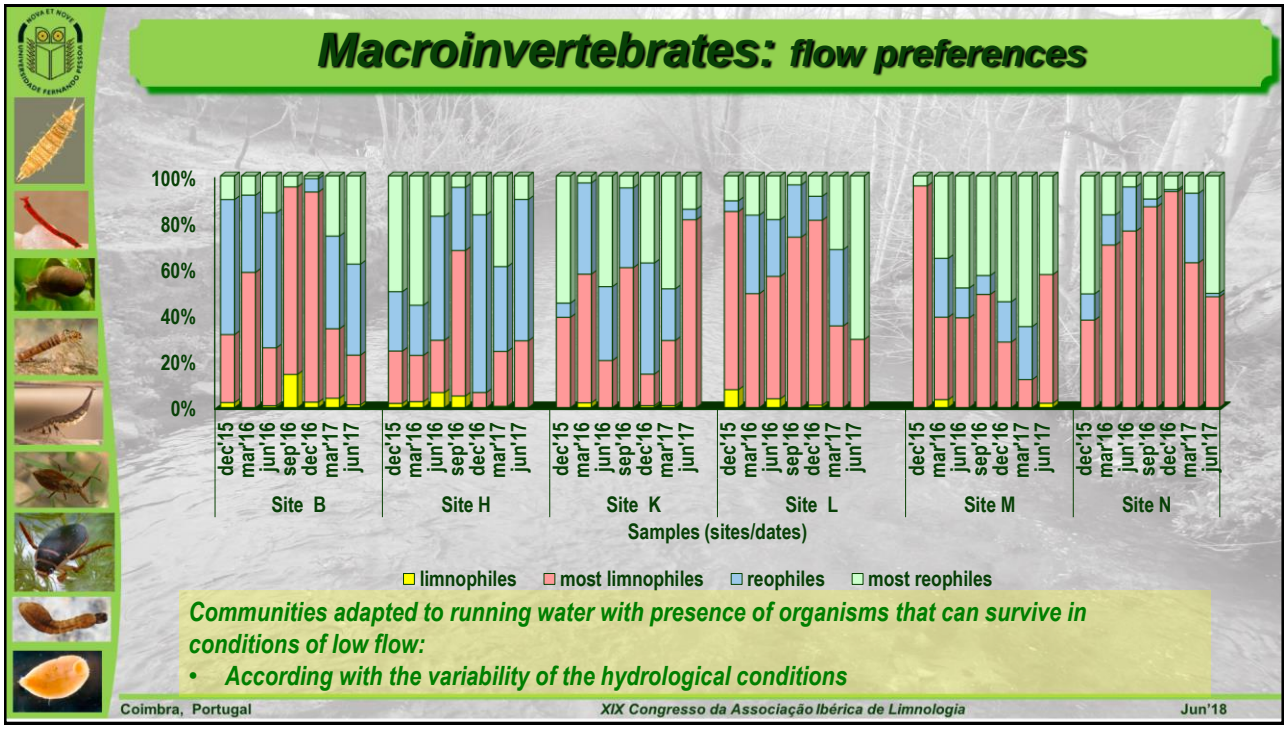
Macroinvertebrates: flow preferences
100%
80%
60%
40%
20%
0%
dec'15 mar'16 jun'16 sep'16 dec'16 mar'17 jun'17
Site B
Site H
Site K
Site L
Site M
Site N
Samples (sites/dates)
limnophiles
most limnophiles
reophiles
most reophiles
Communities adapted to running water with presence of organisms that can survive in conditions of low flow:
• According with the variability of the hydrological conditions
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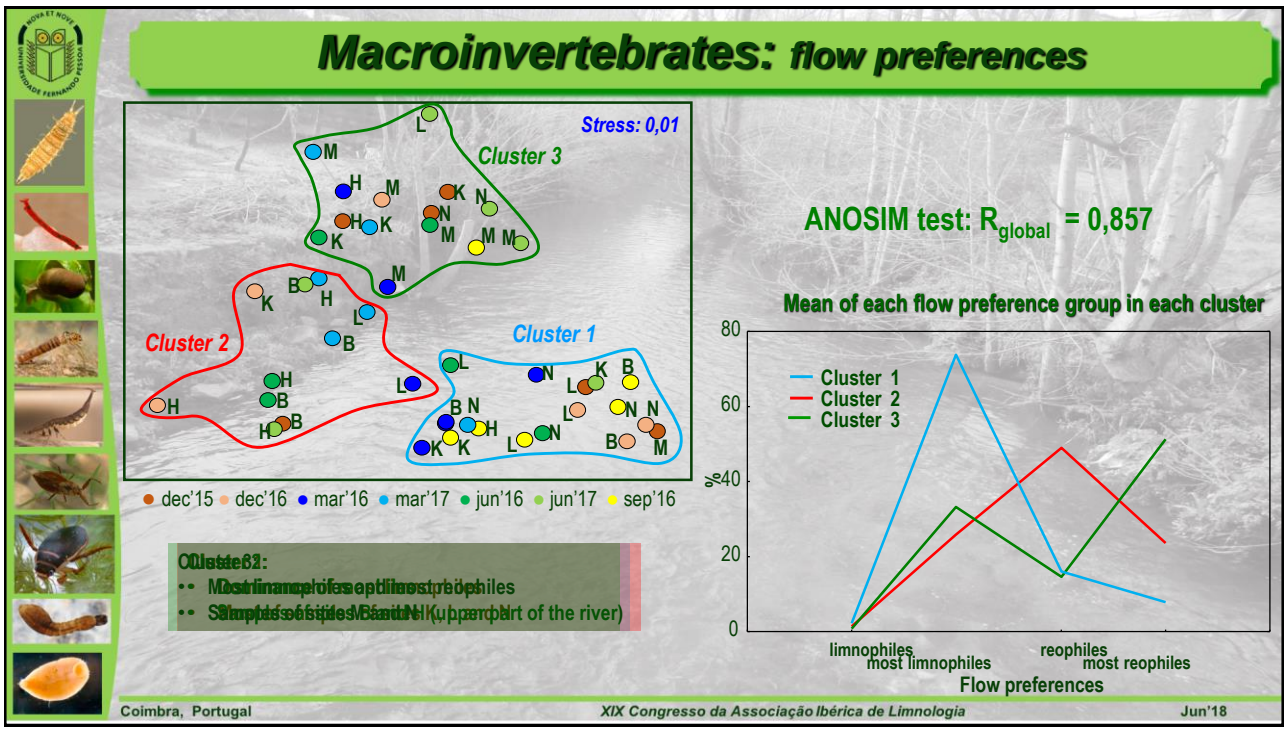
Macroinvertebrates: flow preferences
Stress: 0,01
Cluster 1
Cluster 2
Cluster 3
dec'15 dec'16 mar'16 mar'17 jun'16 jun'17 sep'16
ANOSIM test: R global = 0,857
Mean of each flow preference group in each cluster
80
60
%40
20
0
Cluster 1
Cluster 2
Cluster 3
limnophiles
most limnophiles
reophiles
most reophiles
Flow preferences
Coimbra, Portugal
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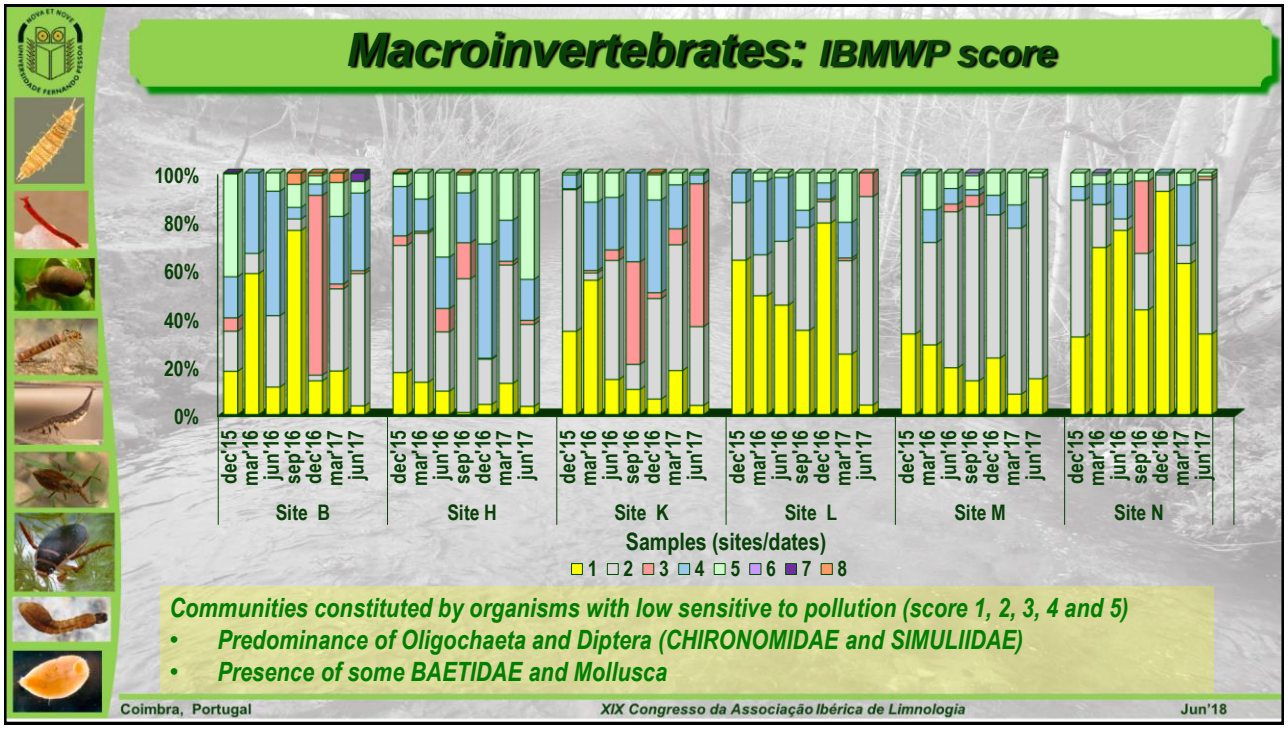
Macroinvertebrates: IBMWP score
100%
80%
60%
40%
20%
0%
dec'15 mar'16 jun'16 sep'16 dec'16 mar'17 jun'17
Site B
Site H
Site K
Site L
Site M
Site N
Samples (sites/dates)
1 2 3 4 5 6 7 8
Communities constituted by organisms with low sensitive to pollution (score 1, 2, 3, 4 and 5)
• Predominance of Oligochaeta and Diptera (CHIRONOMIDAE and SIMULIIDAE)
• Presence of some BAETIDAE and Mollusca
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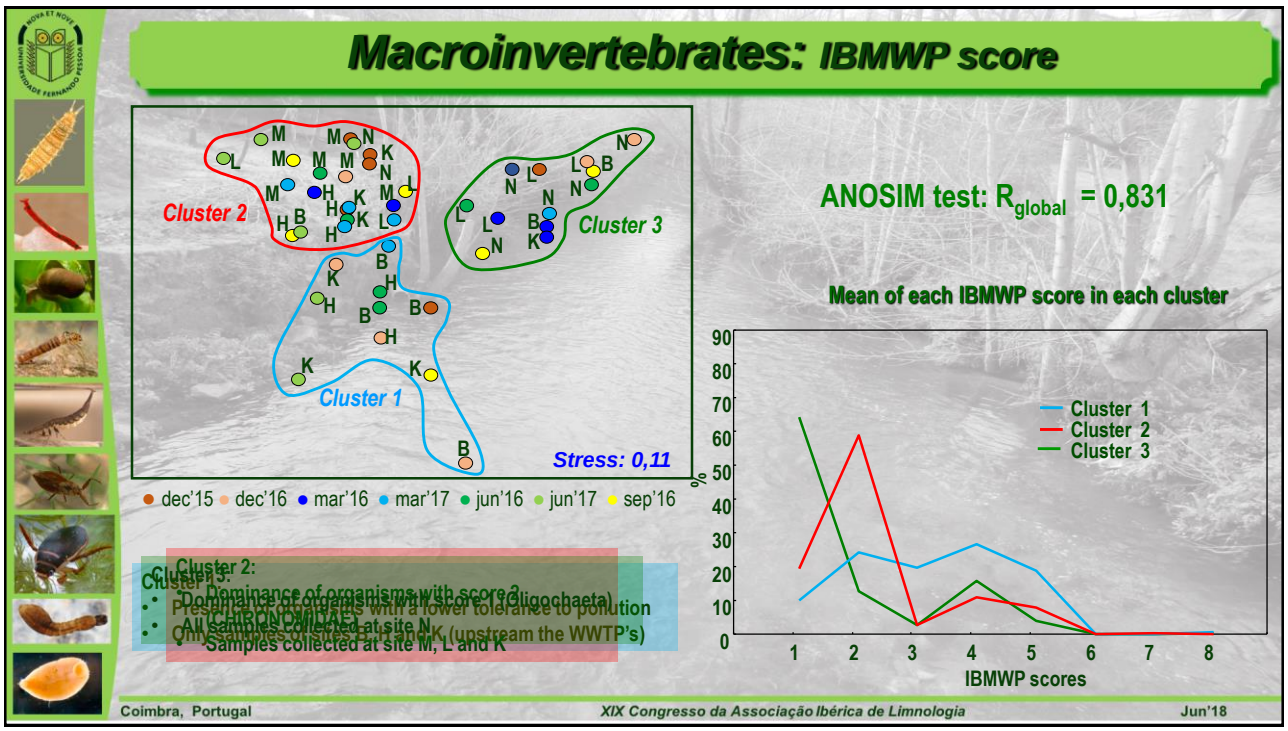
Macroinvertebrates: IBMWP score
Cluster 2
Cluster 3
Cluster 1
Stress: 0,11
dec'15 dec'16 mar'16 mar'17 jun'16 jun'17 sep'16
ANOSIM test: Rglobal = 0,831
Mean of each IBMWP score in each cluster
%
Cluster 1
Cluster 2
Cluster 3
IBMWP scores
Cluster 1:
• Dominance of organisms with score 1 (Oligochaeta)
• Presence of organisms with a lower tolerance to pollution
• All samples collected at site N
Cluster 2:
• Dominance of organisms with score 2
(CHIRONOMIDAE)
• Samples collected at site M, L and K (upstream the WWTP's)
Cluster 3:
• Samples collected at site M, L and K
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Macroinvertebrates: biological quality

		B	H	K	L	M	N
IBMWP	dec'15	36	29	20	11	7	12
	mar'16	7	24	19	12	16	21
	jun'16	16	33	19	16	15	12
	sep'16	20	32	17	12	21	11
	dec'16	28	15	30	23	12	7
	mar'17	36	21	25	19	12	12
	jun'17	27	15	21	9	8	11
EQN	dec'15	0,32	0,27	0,22	0,19	0,14	0,21
	mar'16	0,17	0,24	0,22	0,22	0,24	0,23
	jun'16	0,23	0,28	0,35	0,23	0,21	0,18
	sep'16	0,25	0,27	0,22	0,23	0,23	0,20
	dec'16	0,26	0,22	0,29	0,21	0,21	0,09
	mar'17	0,34	0,22	0,25	0,25	0,20	0,20
	jun'17	0,27	0,22	0,22	0,10	0,13	0,30

Very Good | Good | Medium | Bad | Very bad

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Conclusions

- After analyzing the data collected it turns out that the ecological status along the Tinto river varies between insufficient and bad due to:
  - Problems on the water quality level as seems to indicate the analysis of physical-chemical parameters and benthic macroinvertebrate communities;
  - Sectors of the Tinto river in which the "natural" hydro-morphological characteristics are quite changed (channelization, urban occupation of the banks);
  - The communities of macroinvertebrates are:
    - ✓ Poor of the taxonomic point of view and presents relatively low values of diversity;
    - ✓ Are dominated by organisms belonging to Annelida and Diptera with some presence of other faunal groups such as Ephemeroptera and Mollusca that are organisms that:
      - ✓ are adaptated the all levels of dissolved oxygen in the water;
      - Collectors, shredders and limnivorous;
      - prefer living buried in the substrate or in the water column (swimmer organisms)

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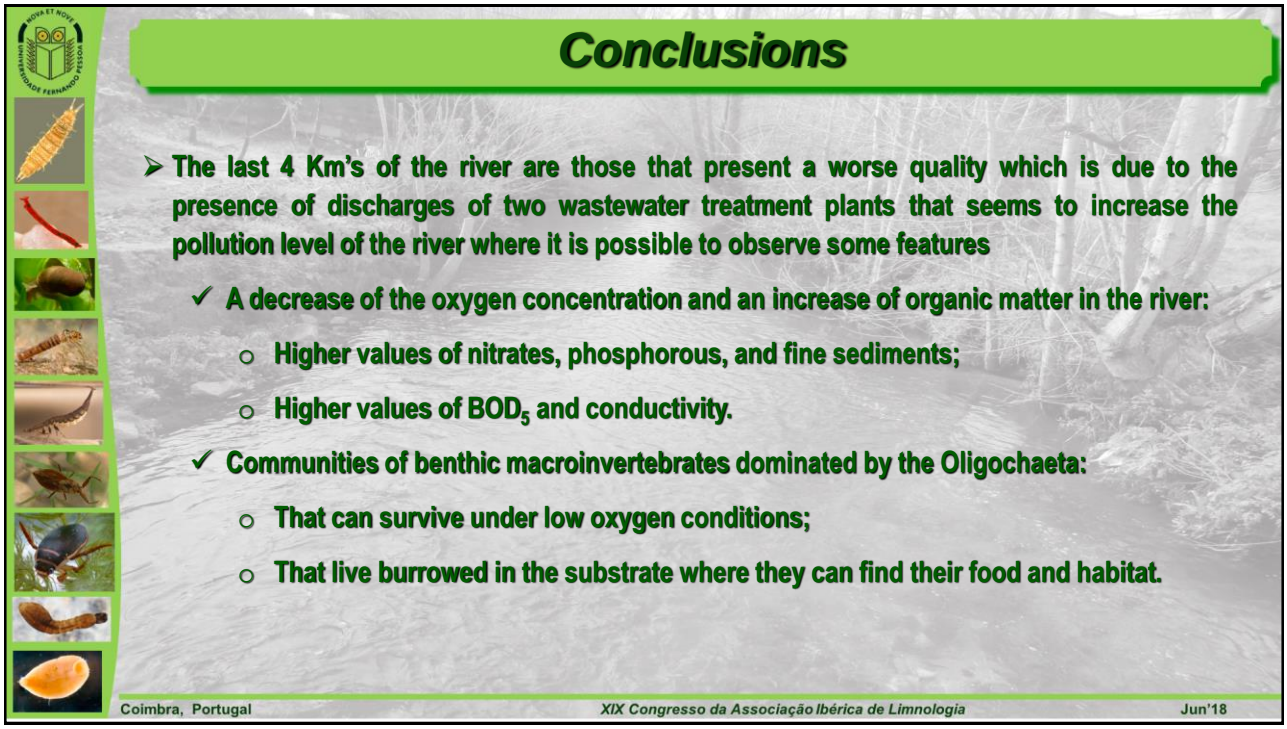
Conclusions
➢ The last 4 Km's of the river are those that present a worse quality which is due to the presence of discharges of two wastewater treatment plants that seems to increase the pollution level of the river where it is possible to observe some features
✓ A decrease of the oxygen concentration and an increase of organic matter in the river:
o Higher values of nitrates, phosphorous, and fine sediments;
o Higher values of BOD_5 and conductivity.
✓ Communities of benthic macroinvertebrates dominated by the Oligochaeta:
o That can survive under low oxygen conditions;
o That live burrowed in the substrate where they can find their food and habitat.
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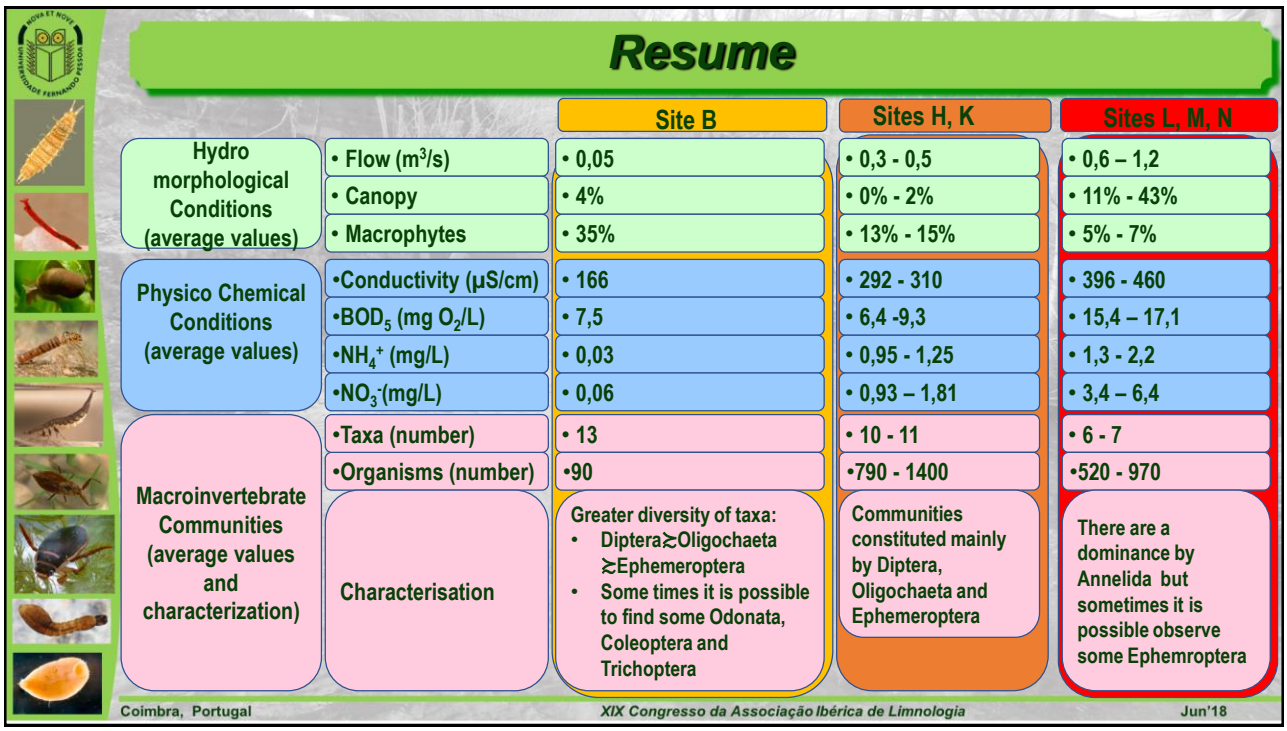
Resume
Site B
Sites H, K
Sites L, M, N
Hydro morphological Conditions (average values)
• Flow (m^3/s)
• 0,05
• 0,3 - 0,5
• 0,6 – 1,2
• Canopy
• 4%
• 0% - 2%
• 11% - 43%
• Macrophytes
• 35%
• 13% - 15%
• 5% - 7%
Physico Chemical Conditions (average values)
•Conductivity (µS/cm)
• 166
• 292 - 310
• 396 - 460
•BOD_5 (mg O_2/L)
• 7,5
• 6,4 -9,3
• 15,4 – 17,1
•NH_4^+ (mg/L)
• 0,03
• 0,95 - 1,25
• 1,3 - 2,2
•NO_3^-(mg/L)
• 0,06
• 0,93 – 1,81
• 3,4 – 6,4
Macroinvertebrate Communities (average values and characterization)
•Taxa (number)
• 13
• 10 - 11
• 6 - 7
•Organisms (number)
•90
•790 - 1400
•520 - 970
Characterisation
Greater diversity of taxa:
• Diptera≳Oligochaeta ≳Ephemeroptera
• Some times it is possible to find some Odonata, Coleoptera and Trichoptera
Communities constituted mainly by Diptera, Oligochaeta and Ephemeroptera
There are a dominance by Annelida but sometimes it is possible observe some Ephemroptera
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The future

- In order to solve the main problems founded the following works are being performed:
  - ✓ repair of one lifting station that causes discharges of effluents in one of the first tributaries of the Tinto river amd which is a responsible for the decrease of qulity between sites B and H
  - ✓ Construction of an interceptor that will receive the effluents from the WWTP's and that will take them after treatment to a river with a much higher flow rate (the Douro River)
    - These discharges are the responsible for the great decrease of quality of rio Tinto
  - ✓ rehabilitation of the banks and the creation of a green corridor along most of the course of the river




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