How can we check and safeguard the quality of waters of river Po?

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Abstract

Considering the importance of the river Po for our city, it seemed interesting to us to go and investigate, with our research team (***Water keepers***), in which ways the relevant authorities take charge of the control and monitoring of the water quality. We will be going with biologists of ARPA (Agenzia Regionale per la Protezione Ambientale / Regional Agency of Environmental Protection) to collect the Po water and samples of its organisms, in three different stations and in different seasons, in and near Turin to recognise and study macro-benthos, macro-phyta and diatoms, indicator species of the water quality.

The purpose is also to understand how the samples have to be analysed and in which way the collected data have to be integrated and processed with specific software to obtain a result in terms of water quality evaluation, according to the European Water Framework Directive (WFD) dated from the end of 2000.

This team will focus on the theme of Biodiversity (Bio-remediation, ecosystems, biodiversity) and partially on the theme of Engineering and Technology (Water quality, treatment, monitoring and water waste management).

Keywords

Water quality, macro-benthos, macro-phyta, WFD

1 Introduction

Water (Fig.1) [12]: **two hydrogen atoms bound with an oxygen one**; there is not even carbon, the fundamental atom in the organic chemistry and biochemistry. Nevertheless, without the presence of water none of us would be here today. First of all, farmers could not irrigate their fields from which food is produced and secondly you could not even drink nor cook a plate of pasta.

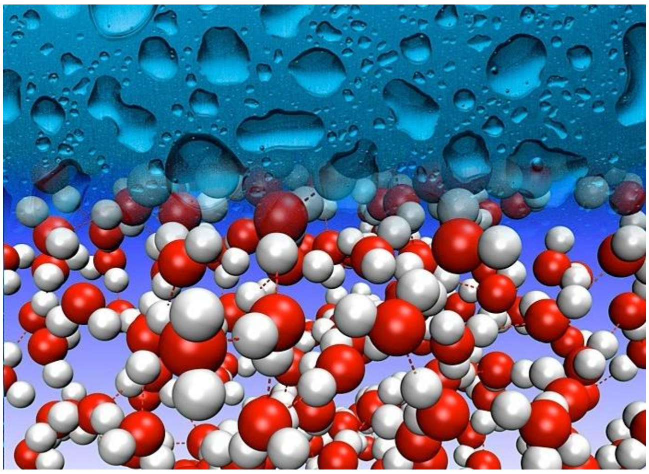


FIGURE 1: WATER MOLECULES

However, water is not everywhere and always the same: there are different qualities of it with related indexes of goodness.
Biologists, like those who work in Piedmont ARPA, as well as the ones throughout the rest of Europe, are committed to monitor the level of quality of the rivers and transmit the collected data to political authorities. They have, as their main goal, to keep this quality index at the minimum level of "good", after the European Directive approved for the new millennium.
Even if in Italy, and in particular in Piedmont, water is a quite abundant resource, we have to remember the importance of preserving it for our life and that of the future generations, as well as for the entire Earth.

2 Content

The water monitoring, conducted in Italy by ARPA regional sections, consists in sampling some of the living beings (Macro-benthos, Macro-phytes and Diatoms) that inhabit a particular stream, the analysis of which, together with the various chemical and physical analyses, allows determining the overall quality of the watercourse concerned. In particular, the presence of macro-invertebrates organisms, predominantly insect larvae, constitutes a valid biological indicator of quality due to the following factors [1, 3]:

- these organisms have a high sensitivity to pollution, so that the whole community is able to promptly react to its effects;
- they have long life cycles, so their stable presence in the watercourse allows to bind them to the ecosystem constant conditions;
- many of the organisms are sedentary in their substrates, and from here comes their ability to reflect the local conditions of the waters in which they live;
- many communities include representatives from different taxa with different sensitivity to pollution, and therefore the study of the whole benthic community is representative of the level of quality of the whole river stretch;
- last but not least, the macro-benthos are made up of organisms present in very high amounts, simple to be sampled and identified, even to the naked eye by experts.

The Italian hydro-ecoregions are 24, 7 of them are located in Piedmont (see Fig. 2); each one is identified by a code: HER 1: Inner Alps; HER 56: Po Plain; HER 62: Monferrato; HER 63: Piedmont Apennines; HER 64: Northern Apennines; HER 107: Southern Inner Alps; HER 122: Ligurian Alps (Table 1).
The typing work [2] led to identify more than 40 river types only in Piedmont, which were then combined into a smaller number of macro-types: for each of them it was then studied the macro-benthic community of reference, composed by all taxa found in the period 2000-2005 with a percentage larger than 10%, for each monitoring point of the Regional network. From the comparison between the biological communities sampled and the reference one, it is possible to reach the definition of the ecological status of the Water Body (Corpo Idrico, indicated with CI), a stretch of water belonging to a single type, homogeneous in its physical characteristics, in the natural and anthropic pressures that insist on it, and the quality status.

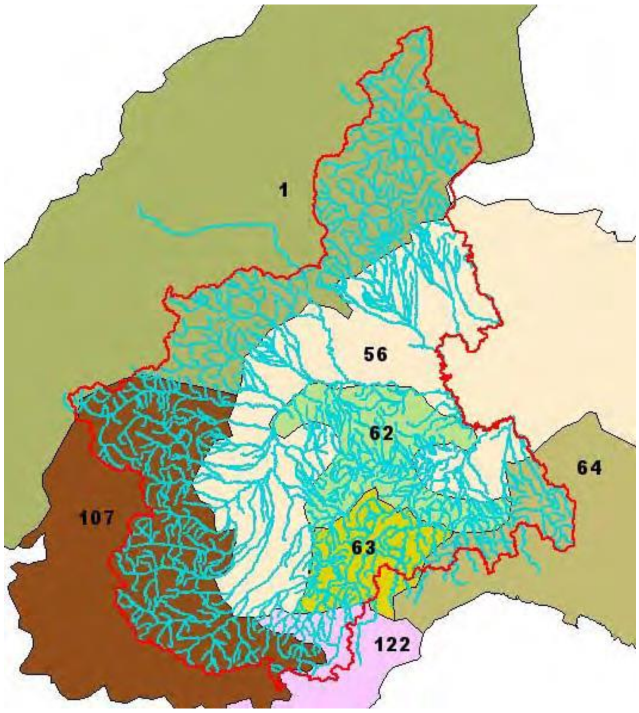


FIGURE 2: HYDRO-ECOREGIONS IN PIEDMONT (NW ITALY), ARPA

Our activities were carried out in the HER 56, the Po Plain one, in particular in four different stations (Fig.3): a pre-town station, in the Carignano nearby, a city station, Murazzi in Turin’s downtown, and two post-town stations, in the Brandizzo and Lauriano surroundings (Fig.3).

TABLE 1: HYDRO-ECOREGIONS IN PIEDMONT (ITALY)

Code HER	Name HER	Description	Altitude	Geology	Climate
1	Inner Alps	alpine high mountains	High mountains	high mountains	alpine mountain
56	Po Plain	temperate warm alluvial plains	Plains	alluvial plains	temperate warm
62	Monferrato	temperate warm detritus hills	Hills	detritus hills	temperate warm
63	Piedmont Apennines	Mediterranean heterogeneous mountains	Middle mountains	sedimentary middle mountains	Mediterranean
64	Apennines N	temperate mountains	mountains	Carbonated sedimentary mountains	temperate mountain
107	Inner Alps - S	alpine high mountains	High mountains	high mountains	alpine mountain
122	Ligurian Alps	temperate mountains	mountains	Mountains Carbonated sedimentary	temperate mountain

FIGURE 3: CARIGNANO STATION, P. SPERONE

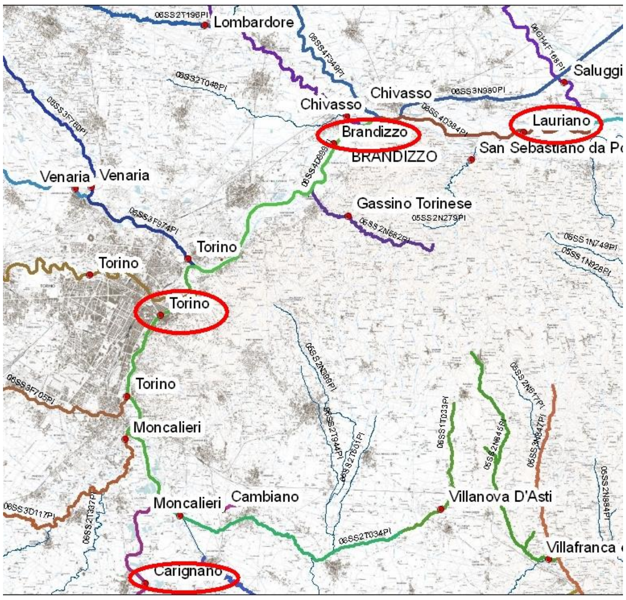


FIGURE 4: IN RED FOUR STATIONS WHERE WE COLLECTED SAMPLINGS, ARPA

In the map above (Fig.4) we can see in violet, green and brown three water bodies in which the river Po is divided and, circled in red, the positions of the stations where we carried out our work in field.

2.1 Legislative framework

Water Framework Directive (**2000/60/EC**), hereafter mentioned as WFD, establishes a legal framework to protect and restore clean waters across Europe and ensure its long-term, sustainable use. WFD introduces an innovative approach for water management based on river basins and considering an eco-systemic approach [7]. The directive concerns inland surface waters, transitional waters, coastal waters and groundwater. It establishes several innovative principles for water management, including public participation in planning and the integration of economic approaches, including the recovery of the cost of water services. WFD places clear responsibilities on national authorities. They have to identify individual river basins on their territory, designate authorities to manage these basins in line with the EU rules, analyse the features of each river basins, including the anthropic impact, produce and implement "river-basin management plans" to prevent pollution and preserve protected areas.

In Italy, WFD has been converted in some Legislative Decrees, later amended and supplemented.

DLgs 152/06: it takes care of soil conservation and contrast to desertification, protecting waters from pollution; in particular [8], it looks at the promotion of quality levels of human life, to be achieved through the protection and improvement of environmental conditions and the prudent and rational utilization of natural resources. In each geographical entity many watersheds (rivers, lakes) are included; there is a common administration of the water in case of danger (for example floods) or in presence of different activities (agricultural, livestock and agroforestry) to ensure water quality.

DLgs 131/08: it [9] makes changes to Annexes 1 and 3 of Part 3 of the previous decree (152/2006). The implemented changes concern the monitoring criteria and classification of surface and groundwater bodies.

Article 2 of this decree states that different geographical entities, after identifying and characterizing different water bodies (on the surface and underground) in different categories (rivers, lakes, coastal marine waters), must provide for the typing and revision according with factors unforeseen or occurring.

DM 17 July 2009: its goal [10] is an improvement of identification and exchange of territorial information relating to the characterization, monitoring and classification of surface and ground waters.

DLgs 260/10: it provides only a change of the point 2 letter A.4 of the DLgs 152/06 about technical criteria for classification of superficial water bodies [11].

In order to implement control and protection of water quality, in Italy, especially in Piedmont, from 2006, they made a typing of waterways, in two phases:

- definition of hydro-ecoregions (HER), geographical areas in which the streams have a limited variability of chemical, physical and biological features, according to orography, geology and climate of the territory;
- definition of river types (Fig. 4) within the hydro-ecoregions, on the basis of some variables (for example, the size, linked to the upstream-downstream gradient indicated with a progressive numeric code) that do not include those used for the definition of the HER.

The rivers have been divided, according to their different characteristics:

- in perennial or temporary (the Po is a perennial river);
  - the source of the stream, which can be: from runoff of rain or melted snowfields, large lakes, glaciers, springs or groundwater;
  - the distance from the source (in our case 75-150 km, so big distance);
  - the influence of the upstream basin: in fact if the river crosses more than one HER, it is necessary to estimate and take into account the influence of the mountain section on the downstream (the Po stretch we considered is influenced by HER 1 and 107).

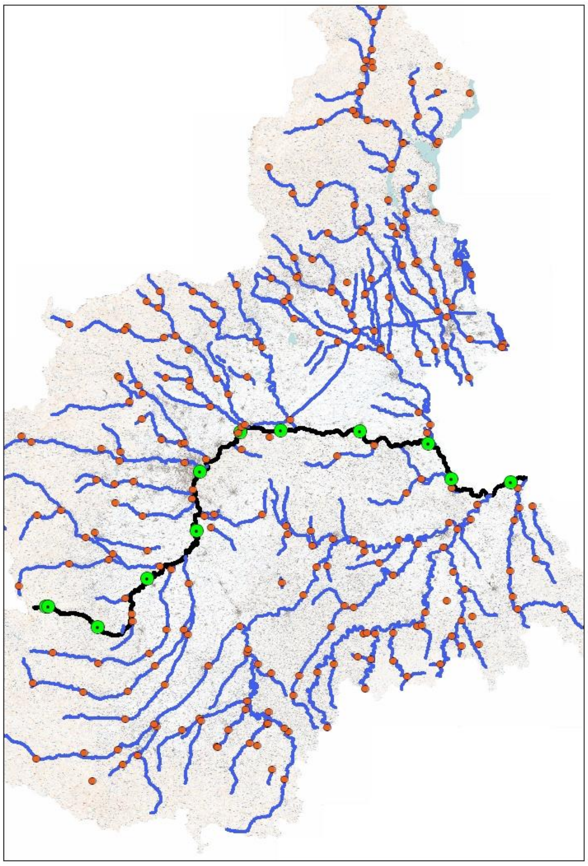


FIGURE 5: HYDRIC NETWORK IN PIEDMONT; IN RED MONITORING STATIONS ALONG ALL HYDRIC BODIES; IN BLACK PO RIVER; IN GREEN MONITORING STATIONS ALONG PO RIVER, ARPA

2.2 The purpose of the investigation

The purpose of our project was to understand how the monitoring of surface waters is done, and to produce and interpret a quality index based on the ecological communities of the different sites. We collected samples in four different sites of the Po: Carignano (upstream of Turin), Murazzi (downtown of Turin), Brandizzo (in Torino valley) and Lauriano.

FIGURE 6: MACRO-BENTHOS SAMPLING IN BRANDIZZO, E. AMENDOLARA

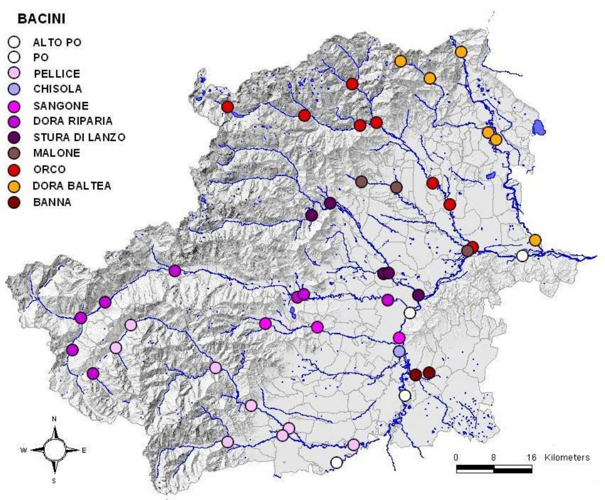


FIGURE 7: MONITORING STATIONS (49) IN THE PROVINCE OF TURIN IN DIFFERENT HYDRIC BODIES, ARPA

The water quality evaluation is based on different components: the chemical one, the macro-benthos one (macro-organisms), the macro-phythes one (algae and plants) and the diatoms one.
STAR_ICMi, resulting from macro-benthos, contributes with **ICMi**, resulting from Diatoms, **IBMR**, resulting from macro-phytes, **ISECI**, resulting from fish, **LIMeco**, with reference to nutrients and water's oxygenation, and **SQA** (specific pollutants) to define the overall Status of the considered hydric body (CI).
Our project has taken into consideration only the last three components and in particular has been focused on macro-benthos. We tried to understand how different indexes are calculated, what their meaning is, also comparing the results related to the sampling we participated in with the previous data referred to the years 2010-2014.
The figure below (Fig.7) shows, in different colours (**light blue**, yellow and **black**), the subdivision in three water bodies of the line of river Po considered in our research, between the confluence of the stream Pellice and the river Dora Baltea.

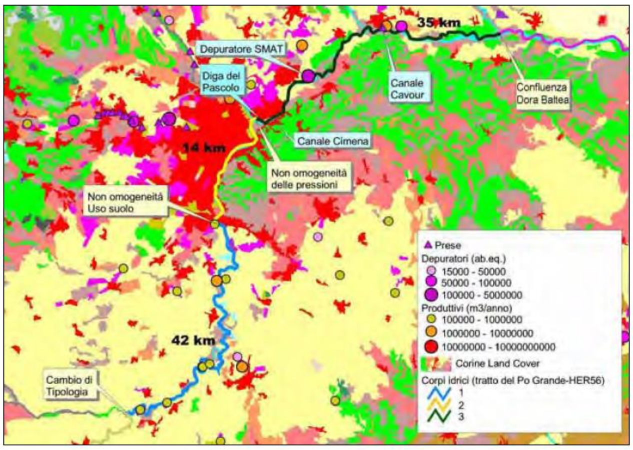


FIGURE 8: WATER BODIES OF THE LINE OF RIVER PO NEAR TURIN, ARPA

2.3 Instruments used during the sampling and during the activity in laboratory

FIGURE 9: HALFTONE FOR MACRO-BENTHOS SAMPLINGS, P. SPERONE

During the sampling carried on the river Po in the sites of Carignano, Murazzi, Brandizzo and Lauriano we used the following instruments:
- halftone (Fig.8) for the sampling of macro-invertebrates. It is made of a long handle linked to a frame in steel with a nylon net; the last of the halftone consists in a plastic cylinder of collection used to catch the macro-invertebrates that lived in cramped conditions between submerged stones, in residues organics, on the trunks, on water plants or in thin sediments.
- high waterproof boots (Fig.9), used for the sampling in the place where the water is deep and there is a lot of current;

- waterproof gloves, to protect the hands so as to avoid the skin contact with river water and the organisms;
- bowl and bucket to divide and observe the organisms collected more easily;
- plastic pipettes and tweezers to catch the organisms and divide them in various bowls;
- cans with ethyl alcohol (75%) to carry the organisms collected to Arpa's laboratory to identify them. The ethyl alcohol was useful to kill the organisms and to preserve them until the determination day.

FIGURE 10: PREPARATION BEFORE ENTERING IN PO RIVER TO COLLECT SAMPLES, P. SPERONE

FIGURE 11: MACRO-PHYTES SAMPLING IN MURAZZI (TO), E. AMENDOLARA

The instruments we used during the Arpa's laboratory activity are:
- stereo-microscope and optical microscope used to analyse the withdrawn macro-organisms during the sampling (in different strokes of the river Po);
- slide-holder object and slide cover slips;
- tubes;
- Encyclopaedias and scientific tests used for the classification of organisms through specific dichotomous keys (or single-access keys).

2.4 Method of the investigation

This project has been made possible thanks to the biologists who work for the ARPA who have come to our school to present the topic of biomonitoring of water. Then they have been available to show us their work in the field and let us participate in it in small groups (5-6 students with our Science teacher for each sampling). We participated to six different samplings in four different stations in two seasons, in autumn and winter 2015, while they usually do samplings in three seasons, one every three or six years according to the operational or surveillance monitoring. After collecting the organisms needed to produce a quality index of those waters, we analysed them together with biologists of ARPA (Regional Agency for Environmental Protection), partially on the field and then in laboratory using dichotomous keys and optical stereomicroscopes. After completing the taxonomic identification, the biologists entered data in a dedicated software; in the end, they obtained some different indexes, that should be comparable to the others obtained in Italian and European rivers, which represent the quality of the course of water concerned. They made the results available and we could draw some conclusions about the water quality of river Po.

2.4.1 Macro-benthos sampling

In order to proceed with the laboratory observations we had to collect macro-benthos samples in the chosen stations areas of the river Po. The goal of these observations is to understand, through the analysis of the data, changes in the number of specimens of different systematic groups (families) of macro-benthos according to the stroke taken into consideration and the period of the year. The data collected will be used, after appropriate computer processing and integration, to determine the state of health of the river.
Before starting the activity, we wore the appropriate clothing like fisherman boots and gloves (Fig.10). To enter the water we looked for a low ground spot where the current was not too fast for security reasons.
Once in the water we observed the sub-layer of the river, made up of pebbles, smoothed by river currents, that were different in their size, varying between 1-6 cm for the smaller, 6-20 cm for the medium ones and more than 20 cm for the larger ones. To take samples [1], we gathered the pebbles from the riverbed and rubbed them with our hands at the opening of the hand net to make the current bring the macro-benthos in the capsule at the bottom of it. The procedure for this kind of sampling, according to the WFD, includes 10 repetitions (Fig. 12) moving for each one and changing the sublayer of the river according to its composition and the size of pebbles. In this way, every sample comes from an area of $1m^2$, since the area of the hand net is approximately 33 cm^2.

Figure 12: Umberto is rubbing pebbles with his hands at the entrance of the hand net, with Pierre's help, P. Sperone

After such collection, we washed the halftone to collect all the organisms trapped in (Fig. 13), then reached shore and set up a mobile laboratory to count or estimate as accurately as possible the number of organisms for each different taxonomic groups (families). (Fig.14)

Figure 13: Alberto is washing the halftone to collect all the organisms, P. Sperone

In case it was difficult to individuate the family, we put a sample and placed it in a plastic container filled with ethyl alcohol to maintain the structure of the sample intact until a later laboratorial determination [4].

Figure 14: Macro-benthos determination and counting in the field, E. Amendolara

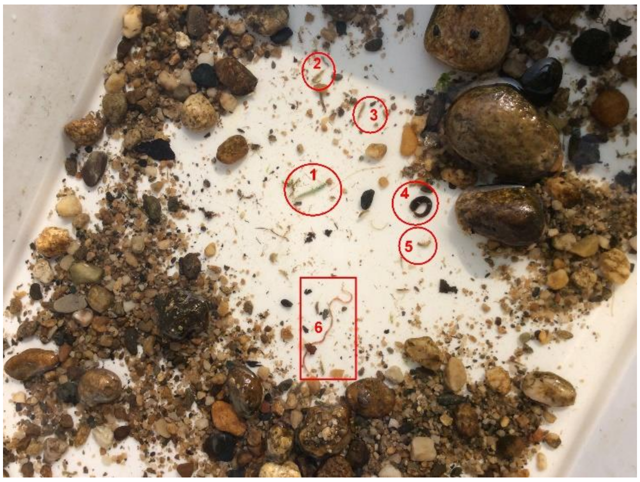


Figure 15: some recognisable organisms, P. Sperone

During the activity in the field, the content of the net was picked up in a plastic bucket and then it was divided into different plastic bowls with white bottom to identify, with the essential help of the biologists; finally, the organisms present in the collected sample were counted. We found (Fig. 15), for example:

1 → Order: Trichoptera, Family: Rhyacophilidae
2, 3 → Order: Efemeroptera, Genus: Baetis
4 → Bloodsucker (*Dina sp*. or *Erpobdella sp*.): the difference can be seen only under stereomicroscope because it is based on the distribution of rings and/or the number of rings through male and female gonadic pores.
5 → Order: Trichoptera, Family: Hydropsichidae
6 → Subclass: Oligochaetae, Family: probably Lumbriculidae, but it could be also Tubificidae; the difference is based on the number of bristles assembled into little dorsal and ventral groups, visible only under stereomicroscope or optical microscope.

Figure 16: *Ephemera sp*., P. Sperone

In Fig.16 we can see a larva of *Ephemera sp.*, recognisable for its lateral eyes, its body shape without dorsal-ventral flattening typical in other species like *Ecdyonurus sp*. The key character to identify correctly is the presence of mandibular processes with divergent apexes, while the other similar organism, *Ephoron sp.,* shows convergent apexes.

During our experience on the field, we learnt that some groups of organisms were easily distinguishable because of specific characteristics such as movement, colour.

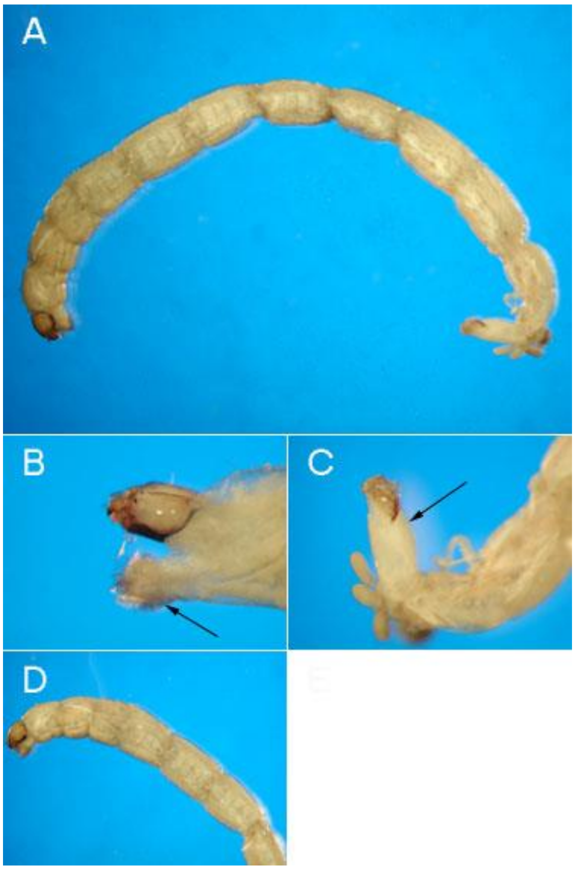


FIGURE 17: WHITE CHIRONOMIDAE LARVA

Midge larvae (Fig.17, [13]) have a distinct, sclerotized head that is separated from the thorax (Fig. B). The body has a pair of prolegs located on the prothorax and a pair of terminal prolegs (Figs. B & C) with the thorax and abdomen about equal in diameter (Fig D), except in the case of some mature larvae which have expanded thoracic segments.

FIGURE 18: RED CHIRONOMIDAE LARVA

Larvae of some species of Chironomidae are bright red in colour (Fig. 18, [14]) due to a haemoglobin analogue for the transport of oxygen; these are often known as "bloodworms". Their ability to capture oxygen is further increased by their making undulating movements. The adults are usually known as non-biting midges.

FIGURE 19: LIMONIDAE LARVA

Limoniidae (Fig. 19, [15]) is a large cosmopolitan family of insects, which belongs to the order Diptera. The larva is cylindrical with retractable head. It has not showy appendages, but simple little detected processes, of different form according to the position. The posterior extremity finishes with a pentagonal anal disk, where there are tracheal spiracolis. The doll is provided with two wisps of guts (dorsal respirators structures), brought on the chest.

FIGURE 20: PLANARIAN ADULT

Dugesidae, also commonly named planarians, are large, plate worms, 20-35 mm long, the frontal extremity of their body ends with a wide angle, on the sides can be located some expansions ("ears") and there are often recognizable spots on the eyes (Fig.20, [16]). They live in both current and stagnant waters.
Before the approval of WFD and its following applications, in Italy water quality was based on **I.B.E**. (Biotic Extended Index). I.B.E. [1, 3], a qualitative index, was determined by the presence of the more sensible taxon and by the number of U.S. (Systematic Units) in the environment. I.B.E values were in the range 0-12; they allowed to divide water quality in 5 classes indicated with different colours:
blue I.B.E.= 10-11-12
green I.B.E.= 8-9
yellow I.B.E.= 6-7
orange I.B.E.= 4-5
red I.B.E.= 0-1-2-3
WFD introduced a new approach to the study of macro-benthos: it became an eco-systematic approach, which considers the research of specific microhabitats, riffle or pool, based on the speed of the flow, and dimensions of

pebbles of the substratum (such as megalithal, macrolithal, mesolithal or microlithal) involving a quantitative analysis of sampled macro-benthic population.

Samplings results of macro-benthos are useful to calculate **STAR_ICIMi (Sta**ndardisation of **R**iver **C**lassifications **I**tercalibration **M**ultimetric **i**ndex) [1]. It is a multimetrical index according to which the judgement on the quality of water relatively to the macro-benthos is given (for Diatomaceous and seaweed and seagrass other indexes are used). This index is calculated combining **six metrics** referred to the category of tolerance, abundance/habitat and diversity/richness.The choice of metrics took place according to the following criteria: they have to be conformant to the indications of WFD; metrics have to be valid for a wide range of geographical contexts, so they cannot be specific for a single place; they must allow a description of different grades of environmental alteration or pollution, matching to five quality classes. In the table below (Table 2) we can find the six metrics that give contribution to STAR_ICMi, related information, taxa considered for each one and their weight inside STAR_ICMi.

TABLE 2: STAR_ICM INDEX, ARPA

Information type	Metric type	Metric name	Taxa considered	References	Weight
Tolerance	**Index**	**ASPT**	**The entire community (family taxa)**	e.g. Armitage et al., 1983	**0,333**
Abundance/ Habitat	**Abundance**	**Log10 (∑ EPDT+1)**	**Log10 (sum of Heptagenidae, Ephemeridae, Leptophlebiidae, Brachycentridae, Goeridae, Polycentropodidae, Limnephilidae, Odontoceridae, Dolichopodidae, Stratyomidae, Dixidae, Empididae, Athericidae e Nemouridae +1)**	Buffagni et al., 2004; Buffagni & Erba, 2004	**0,266**
Abundance/ Diversity	**Abundance**	**1-GOLD**	**1- (relative Abondance of Gasteropoda, Oligocheti e Diptera)**	Pinto et al.,2004.	**0,067**
	Number of Taxa	**Total number of families**	**all families in the site**	e.g. Ofenboch et al., 2004.	**0,167**
	Number of Taxa	**Number of families of EPT**	**Sum of families of Ephemeroptera, Plecoptera, Trichoptera**	e.g. Ofenboch et al., 2004; Bohmer et al., 2004.	**0,083**
	Diversity Index	**Shannon - Wiener Diversity index**	**DS-W= - ∑ [n_i/A] • ln [n_i/A]**	e.g. Hering et al., 2004; Bohmer et al., 2004.	**0,083**

The **ASPT index** is calculated dividing the value of **BMWP** (Biological Monitoring Party Score System) by the number of families. The **BMWP index** is based on the tolerance towards pollution of different families: the larger the tolerance the less the score is, as we can see in the table below. (Table 3)

TABLE 3: TOLERANCE SCORE FOR MAIN FAMILIES, ARPA

Taxa (family)	Score
Ephemerellidae, Heptagenidae, Chloroperlodidae, Leuctridae, Perlodidae, Odonthoceridae	10
Philopotamidae	8
Nemouridae, Rhyacophilidae, Polycentropodidae, Limnephilidae	7
Hydroptilidae	6
Tipulidae, Simuliidae, Elmidae, Dytiscidae, Planariidae	5
Baetidae, Empididae, Limoniidae, Hydracarina	4
Chironomidae, Thaumaleidae	2
Oligochaeta	1

1-GOLD index is calculated with this equation, Eq. (1):

$$1-\frac{n^\circ\ organisms\ of\ Gasteropoda, Oligocheta, Diptera}{n^\circ\ all\ organisms} \quad (1)$$

Diversity of Shannon-Weaver index: it is the probability that an organism, taken at random from the population, belongs to a different kind from a drawn out kind in a previous hypothetical collecting.
Firstly, after having loaded the data, the system calculates raw values of the six metrics, secondly the value calculated is divided by the reference one, obtaining the Ecological Quality Ratio (EQR). The next step consists in calculating the weighted average of the EQR obtained; finally the system proceeds to the normalization of the value obtained, dividing the value of the sample by the STAR_ICMi index in reference conditions. According to STAR_ICMi, the index of the quality of river waters can be classified in five classes: high, good, moderate, scarce, low.

2.4.2 Macrophytes sampling

Aquatic macro-phythes form a large group that includes plants visible to the naked eye present in the aquatic environments that characterize the river areas. This group consists of herbaceous Angiosperms, Pteridophytes, Bryophytes and filamentous Algae.
Several factors influence the development of river macro-phytes. Most important are the depth, the intensity of the light rays received by the vegetation and the levels of pollution.
We have to take into consideration that macro-phytes play an important ecological role in the river corridor, as important constituents of different habitats, contributing to the hydraulic homeostasis and to the mechanical stabilization, working from filter towards the diffused pollution and increasing the abilities of self-purification of the water.
Usually two samplings are made during growing year, the first one between April and June, the second one between July and October: at least seven weeks must pass between a sampling and the other one. Each sampling must be done between a period of soft current and another of thin current or only during the thin current; if it had been a plain of the river we need to wait at least two or three weeks before sampling.
To carry out sampling, we followed a procedure, which consists in the choice of the station, the collection, the compilation of the sampling sheet (Fig. 21), which will follow the identification of samples in the laboratory. Into the sampling sheet it is important to annotate the information that characterises the station: its exact location, a schematic sketch of the sampling line and the river bed, the hydro-morphological characteristics, such as dimensions, substratum and structure of the river bed, speed of the current, height of the water, shadowing of the wet river bed, transparency of the water, coverage of the vegetable in the corridors river, erosive phenomena (artificial transformations in the river), state of the surrounding territory.

FIGURE 22: MURAZZI (TO): *POTAMOGETON FILIFORMIS*, P. SPERONE

FIGURE 21: CARIGNANO: PIERRE IS EXPLAINING TO FRANCESCA, GIULIA, DANIELE, PAOLO AND FABRIZIO HOW TO COMPLETE THE WORK SHEET ON FIELD, P.SPERONE

For sampling macro-phytes, biologists run through a stretch of river between 50 to 100 meters long, making a sinusoidal motion. it is important to try to remove only the completely submerged vegetation and to estimate the percentage of coverage for each group, annotating it in the field sheet.

FIGURE 23: MURAZZI (TO) *MIRIOPHYLLUM SPICATUM*, P. SPERONE

For laboratory analysis, they eradicate from the riverbed only a sample for each species (Fig. 22-23). On the field, a summary identification of macro-phytes is carried out thanks to the experience of biologists, giving them general, but easy to remind names, as moss, algae, grasses, elodea; those species that are not recognizable on the field are brought to the laboratory to be classified.
During the laboratory activity, the samples have been observed under a microscope to be classified through the dichotomous keys coming up to the determination of the species. Algae are determined up to the genre, while other macro-phytes must be determined up to the species. It is necessary to verify the applicability of the index in different sites. This assessment is made taking into consideration the achievement of abundance thresholds (>10%) in terms of total coverage of the community.
The quantitative estimation of the vegetation coverage on the river substrate considered is converted with a dedicated table to obtain the data for the allocation of coverage ratios from real coverage values. After that, through a mathematic formula, a specific software calculates the **IBMR** (**I**ndice **B**iologique **M**acrophytique en **R**ivière, Afnor, 2003) [1] and then assigns a correspondent meaning useful to assess the trophic status of rivers (Table 6). It has been developed, therefore, a numerical scale of trophic index that should quantify the qualitative characteristics of trophic levels of the water in each pickup station.
The **IBMR** code is calculated using this equation, Eq. (2):

$$\mathbf{IBMR} = \frac{\boldsymbol{\Sigma}\,[\,\mathbf{Ei} * \mathbf{Ki} * \mathbf{Csi}\,]}{\boldsymbol{\Sigma}\,[\,\mathbf{Ei} * \mathbf{Ki}\,]} \quad (2)$$

Ei = stenoecia coefficient, referred to species' ecological range, the larger is its ecological range, the lower is this coefficient (=1) because that species is not bio-indicator; the less its ecological range is the higher this coefficient (=3) is because that species is a good bio-indicator.
Ki = coverage ratio (see Table 4)
Csi = sensitivity coefficient (0-20); 0 for hetero-trophic species; 1 for hyper-trophic species; 20 for oligo-trophic species
n = number of indicator taxa

TABLE 4: IBMR PARAMETER (KI), ARPA

Effective coverage	Coverage coefficient Ki	Meaning according IBMR
< 0,1	1	only presence
0,1 < coverage < 1	2	low coverage
1 < coverage < 10	3	discrete coverage
10 < coverage < 50	4	good coverage
coverage > 50	5	high coverage

TABLE 5: EXCEL SHEET RELATIVE TO MACRO-PHYTES RESULTS IN A SPECIFIC STATION, ARPA

REGIONE	Piemonte	Data Campionamento / Num verbale	20/10/2015 2015MF13	
Provincia	Torino	Operatori Campionamento	Lefebvre P.	Rossi A.
Comune	Carignano			
Fiume/Torrente	Po	*copertura totale macrofite in A*	10	
Corpo Idrico	'06SS4D382PI	*copertura algale*	10	
Stazione	001065	*copertura MF escluse le alghe*	+	
nome di campo	%Campo	*taxa*	Csi	Ei
Alga 1	100	*Vaucheria*	4	1
		Diatomee	no ibmr	no ibmr
Muschio 1	+	*Cinclidotus sp.*	no ibmr	no ibmr
Muschio 2 Fontinalis	+	*Fontinalis antypiretica*	10	1
Crescione	+	*ND (materiale insufficiente)*	no ibmr	no ibmr
Callitrica	+	*Callitriche sp.*	no ibmr	no ibmr
Cyperus	+	*Cyperus sp.*	no ibmr	no imbr
Graminacea	+	*Phalaris arundinacea*	10	1
Crucifera siliquetta	+	*Barbarea sp.*	no ibmr	no ibmr
Elodea	+	*Elodea canadensis*	10	2
Polygonum	+	*Polygonum mite*	no ibmr	no ibmr
Prezzemolo	+	*ND (materiale insufficiente)*	no ibmr	no ibmr
Bidens	+	*Bidens frondosa*	no ibmr	no ibmr
IBMR Calcolato	7,0	Ecoregione	06: Pianura Padana	
Trofia	MOLTO ELEVATA	Macrotipo	Cc: Regione Centrale, Grand	
IQR	0,67	IBMR di riferimento	10,5	
Giudizio di qualità	SUFFICIENTE			

This is an example of the result sheet (Table 5) that you fill out after the taxonomic determination of macro-phytes and the data entering:

- in the box with **red border**, at the top on the left, we find the station code and name in which sampling has been done
and that of the water body that has been carried out. In this case, it refers to Carignano in Piemonte.
- in the box with **green border**, at the top on the right, we find the indication of the sampling date and the name of the biologists who carried out.
- below, in the box with **orange border,** we find the total coverage ratio of macro-phyta and the coverage of algae.
- in the box with **blue border**, in centre on the left, the name of the species classified in laboratory with their percentage coverage in the field; **+** stays for unquantifiable presence, less than 10%, depending on the season, summer or autumn, the species found changed.
- in the box with **violet border**, in the centre on the right, we find the coefficients for each specie, which then have been used for the calculation of IBMR. If the material available is not enough, these coefficients are not considered in the final calculation.
- in the box with **brown border**, at the bottom on the right, we find the ecoregion of the station and the IBMR benchmark index, which corresponds, in this case, to 10.5.
- in the last highlighted in **yellow box,** at the bottom on the left, the index IBMR calculated with the reference to get the quality index (IQR), obtaining the judgement quality of the river, in this case SUFFICIENT.

TABLE 6: IBMR, TROPHIC LEVEL, WATER QUALITY, ARPA

IBMR value	Trophic level	Water quality (colour)
IBMR ≥ 14	VERY LOW	Blue
12 ≤ IBMR ≤ 14	LOW	Green
10 ≤ IBMR ≤ 12	MEDIUM	Yellow
8 ≤ IBMR ≤ 10	HIGH	Orange
IBMR ≤ 8	VERY HIGH	Red

2.4.3 Diatoms sampling

Diatoms are unicellular of very small dimensions, brown algae, which can live isolated or forming some colonies [5]. Two types of diatoms, the benthonic and planktonic ones, exist. The benthonic ones are divided into epilithic, epiphytic and epipelic, according to the substratum (rocky, vegetable or sedimentary) in which they grow. The ones usually used in samplings concerning the river waters quality are the benthonic epilithic diatoms because they are present during all the year, in all the streams. Diatomaceous are used as bio-indicators, because they are easy to be sampled. Their development depends on the current speed, the temperature, pH, the light and the chemical composition of water where they live. Despite being very sensitive to the changes in some physical and chemical stream parameters, they have short time of resilience (2-4 weeks); in other words, they have a high rate in which a community is able to restore its stability after having suffered perturbations. The diatom sampling can be made during every season of the year. However, there are some more suitable periods according to each hydro-ecoregion, based on the speed of the current, the shading and the depth of water: in the stations we have considered Arpa's biologists take samplings 2 times (January-February or August-September, April-May) every 3 years.
Firstly, to start sampling it is necessary to choose a determinate station (riffle) and an adequate type of substratum: hard, natural and movable at the same time. It is necessary to come into the river and take a cobble to collect the sample on its surface. Using a toothbrush to rub the surface, diatoms will remain carefully entrapped in the small brush bristles (Fig.24); then they are inserted in a containing 4% formaldehyde solution jar, which allows the conservation; the sampling is repeated 5 times on various cobbles.

FIGURE 24: PROCEDURE FOR DIATOMS SAMPLING, ARPA

Samples are taken to the laboratory, where the taxonomic determination job will be done.

EPI-D (Indice Diatomico di Eutrofizzazione/Polluzione; Eutrophication/Pollution Index –Diatom based)

The diatomic index is based on the sensitivity of the diatoms to the nourishing, the organic substances and the degree of mineralization of the water body, with special reference to the chlorides that can represent a powerful factor of pollution of internal water.
EPI-D is based on the Zelinka and Marvan's mathematical formula, Eq. (3):

$$\mathbf{EPI-D} = \frac{\sum_{j=1}^{n} aj * rj * ij}{\sum_{j=1}^{n} aj * rj} \quad (3)$$

where:
$\mathbf{a_i}$ = abundance of the species j;
$\mathbf{r_i}$ = reliability of species j (r = 1 sufficient indicator, r = 3 good indicator, r = 5 very good indicator);
$\mathbf{i_i}$ = integrated weighted index of sensibility of specie j (from 0 = very sensible specie, indicator of very good environmental quality, to 4 = specie very tolerant, indicator of very degraded environment): it considers the species' reactivity to organic pollution, mineral pollution and trophic level of hydric body.
Therefore, Diatomic index expresses global judgement on the quality of the hydric body, summing natural and anthropic eutrophication, natural and anthropic pollution.
Thanks to this index, we can distinguish five classes of quality of water:

Class I:	0.0 < EPI-D < 1.0 →	**excellent**
Class II:	1.0 < EPI-D < 1.7 →	**good**
Class III:	1.7 < EPI-D < 2.3 →	**moderate**
Class IV:	2.3 < EPI-D < 3.0 →	**bad**
Class V:	3.0 < EPI-D < 4.0 →	**very bad**

Threshold values (e.g. 1.0 ± 0.05) indicate transition class between two consecutive classes.

2.4.4 Activity in laboratory

During the activity in laboratory, at ARPA headquarters, we could learn in which way the samples collected during the previous activity on the field would have been used. First, we observed with the stereomicroscope (Fig. 25) some macro-benthonic organisms we had collected before and we learnt to use dichotomous keys [4] to identify the main taxonomic groups.

FIGURE 25: SARA, BESSIM AND DANIELE ARE OBSERVING UNDER THE STEREOMICROSCOPE TO IDENTIFY A MACRO-BENTHONIC ORGANISM, P. SPERONE

Initially we were guided by Biologists to observe and compare some useful characteristics to match the samples to the correct name of different Families; then we could do this activity in groups by ourselves, asking the biologists only for confirmations or doubts. As you can see in Fig.26, on the left we recognised larva, member of Order Trichoptera, Family Rhyacophilidae, with lateral tufts of trachea-gills (typical of Rhyacophilidae). On the right, we recognised another larva, member of same Order (Trichoptera), but of different Family: Glossosomatidae, with a dorsal, little sclerotic plate on the last abdominal tranche, while first abdominal tranches are fatter than the other ones. Larvae of Trichoptera are usually found almost bare because they lost their weak cartons and then acquire their curved shape.

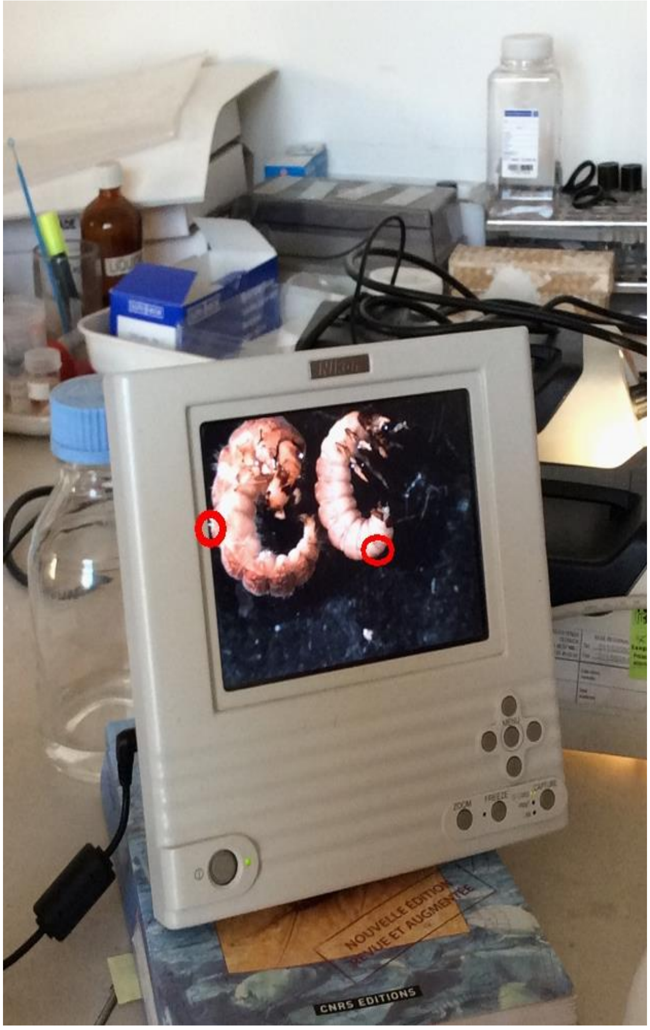


FIGURE 26: COMPARISON BETWEEN RYACOPHYLIDAE AND GLOSSOMATIDAE LARVAE, OBSERVED UNDER STEREOMICROSCOPE, P. SPERONE

Using the dichotomous keys [4] (books that contain specific questions, thanks to which it is possible to determine the membership taxon of the captured sample), optical microscopes, stereomicroscopes, and all the equipment that ARPA provided us, we tried to identify the taxonomic group of the samples, preserved in ethylic alcohol.

One of the most present exemplars is Hydropsychidae larva. To catalogue this organism, and the rest of macro-benthos in a similar way, we needed to continue in the way explained below.

Key 1 (Fig.27)→ the right feature is number 1 (in red): *"Animal without shell and not living inside a case box"*.

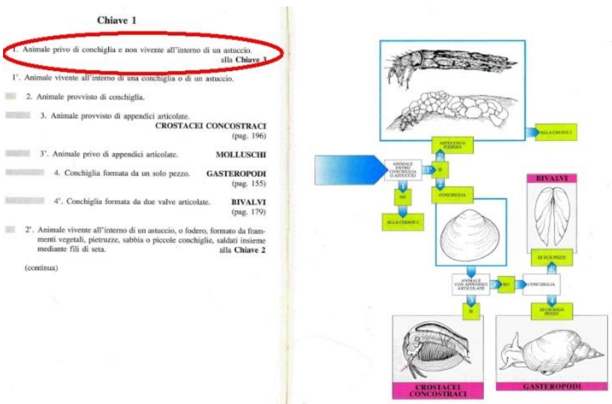


FIGURE 27: KEY 1

Key 3 (Fig.28) → to continue correctly we needed to choose the option number 2: *"Torso with a series of 3 pairs of articulated appendixes"*

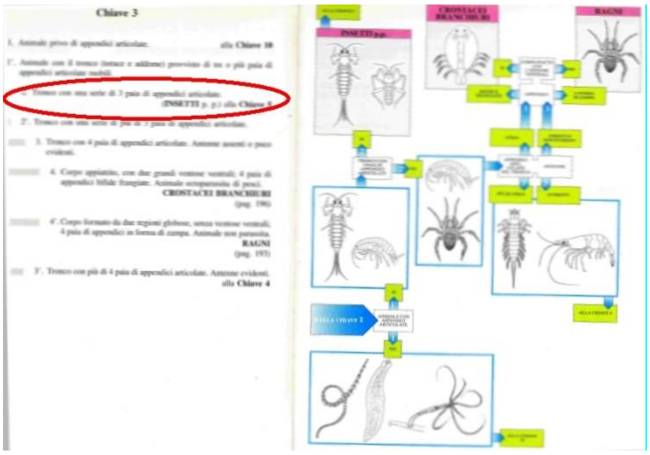


FIGURE 28: KEY 3

Key 5 (Fig. 29) → the right answers in this key are number 1': *"Non hidden abdomen dorsally from the wings: these can be present or absent"* and 3': *"Rudimentary or absent wings: it doesn't look like a wasp"*

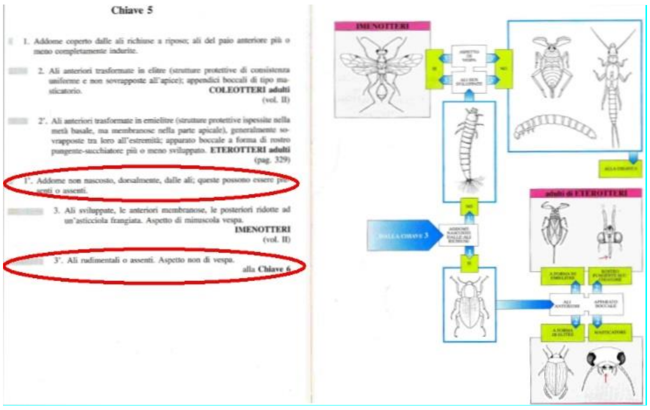


FIGURE 29 KEY 5

Key 6 (Fig. 30) → the correct options are number 1: *"Extremity of the abdomen provided of terminal appendixes"*, then 2': *"Finishing abdomen in 2-5 appendixes"*.

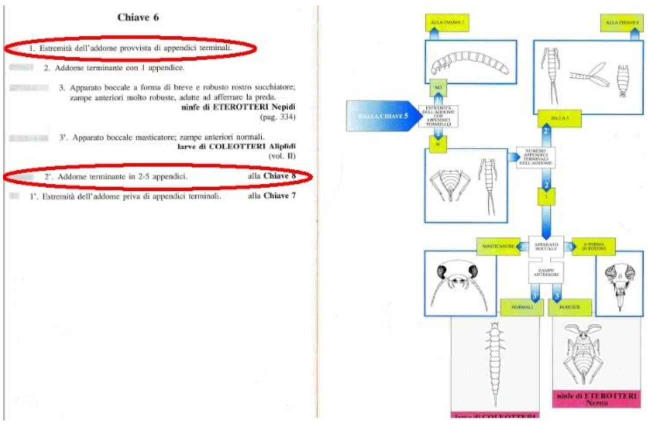


FIGURE 30: KEY 6

Key 8 (Fig. 31) → the correct options are numbers 1: *"Finishing abdomen in 2-4 appendixes"*, then 2: *"Terminal appendixes of the abdomen in form of hook"* and finally 3: *"Finishing abdomen with 2 hooks"* → Tricoptera larvae

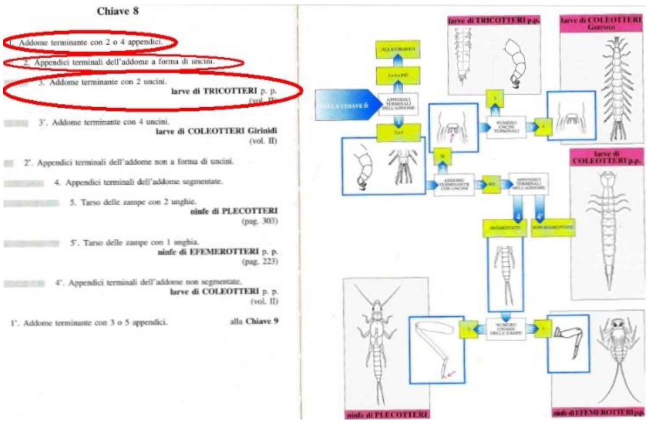


FIGURE 31: KEY 8

Key of the families, MATURE LARVAE Tricoptera (Fig. 32)**:**

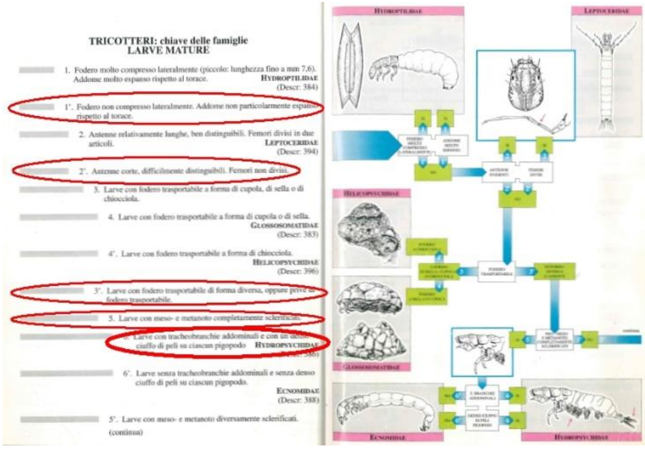


FIGURE 32: KEY MATURE LARVAE TRYCOPTERA

The pathway is: 1' *"Case not compressed sideways. Abdomen not particularly expanded in comparison to the chest"* → 2' *"Short spars, hardly distinguishable. Non separated femurs"* → 3' *"Larvae with transportable sheath of different form, or deprived of transportable sheath"* → 5 *"Larvae with mesonoto and metanoto completely stiffen"*→ 6 *"Larvae with abdominal trachea-gills and with a dense lock of hair on every pigopodos"* = **fam. Hydropsichidae**

During the second laboratory, activity biologists explained us how they had kept the macro-phytes samples: algae in formalin, mosses dried and other plants dried, stored in a special way and assembled into herbarium. (Fig. 33)

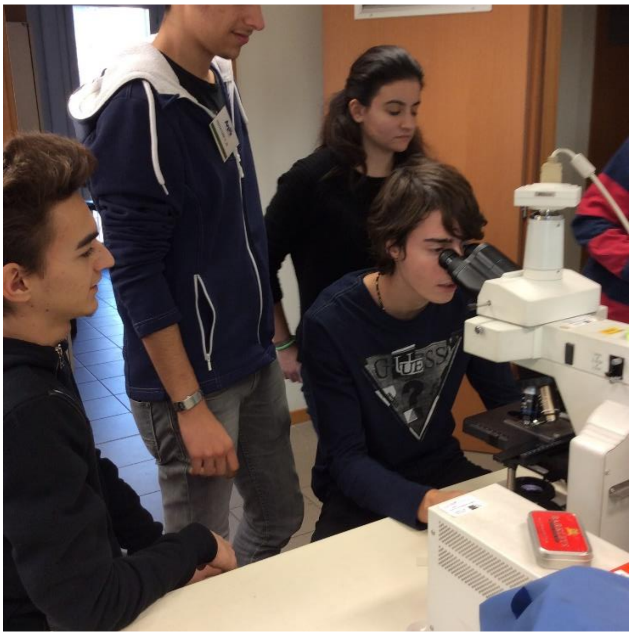
FIGURE 33: PIERRE IS SHOWING THE HERBARIUM, P. SPERONE

We learnt which characters were the most useful to observe and tried to determine one or two specimens with dichotomous keys [6].

Arianna, the biologist specialized in Diatoms, explained us (Fig. 34) in which way these micro-organisms are prepared and guided us showing some examples of different types, under the optic microscope.

FIGURE 34: ARIANNA EXPLAINS WHAT IS IMPORTANT TO LOOK FOR TO IDENTIFY DIATOMS SPECIES UNDER M.O., P. SPERONE

To examine Diatomaceous [5], biologists must prepare a sample beforehand that they spin-dry to get more concentrated. Then, using oxidising substances, the organic part of these organisms is degraded: it remains only the frustule structure. They add resin (Naphrax) with a high refractive rate to the material obtained, to facilitate microscopic observation.



For the identification, we observed (Fig.35) under optical microscope with different magnificence (10x, 40x, 100x in oil drop) the characteristics of the cell wall, called frustule that had been preserved thanks to its siliceous composition:

- shape and dimension;
- absence or presence of the raphe (a slight lengthwise interrupted to form central nodules sometimes thick and visible sometimes thinner and less visible);
- shape and position of the raphe;
- ornamentation of the valves;
- position and density of the ornamentation of the valves, that is the density of the pores, constant for each species.

Besides the identification of the various species that must be made by experts, it is necessary to count the organisms found for each species. All data are inserted in an Excel sheet that allows the calculation of one of the indexes used to obtain the status of water quality, in accordance with European legislation (WFD). Therefore, we can establish the level of pollution of water, especially the chlorides one: the most contaminated water tends to accommodate species in a more tolerant way.

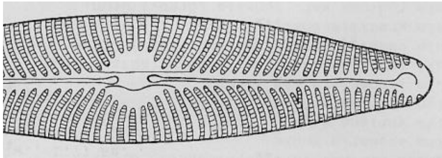


FIGURE 36 *NAVICULA LANCEOLATA*

In the picture above (Fig. 36) we can see some characters, which are useful for the taxonomic determination: the raphe, from which stem many curved stripes, polar and central nodules, round central area.

FIGURE 37 PREPARATION OF ALGAE'S SLIDES

FIGURE 35: STEFANO IS OBSERVING UNDER M.O. A DIATOMACEOUS SLIDE, P. SPERONE

3. Results of the experiment

3.1 Macrobenthos

In the pages below, we have included tables (Tables 7-8-9-10) and graphs relative to macro-benthos samplings in each station: in each one, we can find the list of main taxa (Families) and relative numbers of organisms for every sampling. At the end of this paragraph, you can find a chart collecting STAR_ICMi values for each station in each sampling and the results referred to the medium value for each station jointed to the quality water judgement (Table 11).

TABLE 7: MACRO-BENTHOS IN CARIGNANO, 2015, MAIN TAXA, ARPA

PO Carignano R COD C.I. 06SS4D382PI COD STAZIONE: 001065	**15/12/2015**	**01/07/15**	**20/10/15**	
Taxa found	**n. organisms**	**n. organisms**	**n. organisms**	**total n. organisms**
Acentrella sp.	**36**			**36**
BAETIDAE *Baetis sp.*	**225**	**1**	**234**	**460**
HYDROPSYCHIDAE	**67**	**3**	**294**	**364**
SIMULIIDAE	**123**		**32**	**155**
TIPULIDAE	**1**		**11**	**12**
GAMMARIDAE	**409**	**4652**	**266**	**5327**

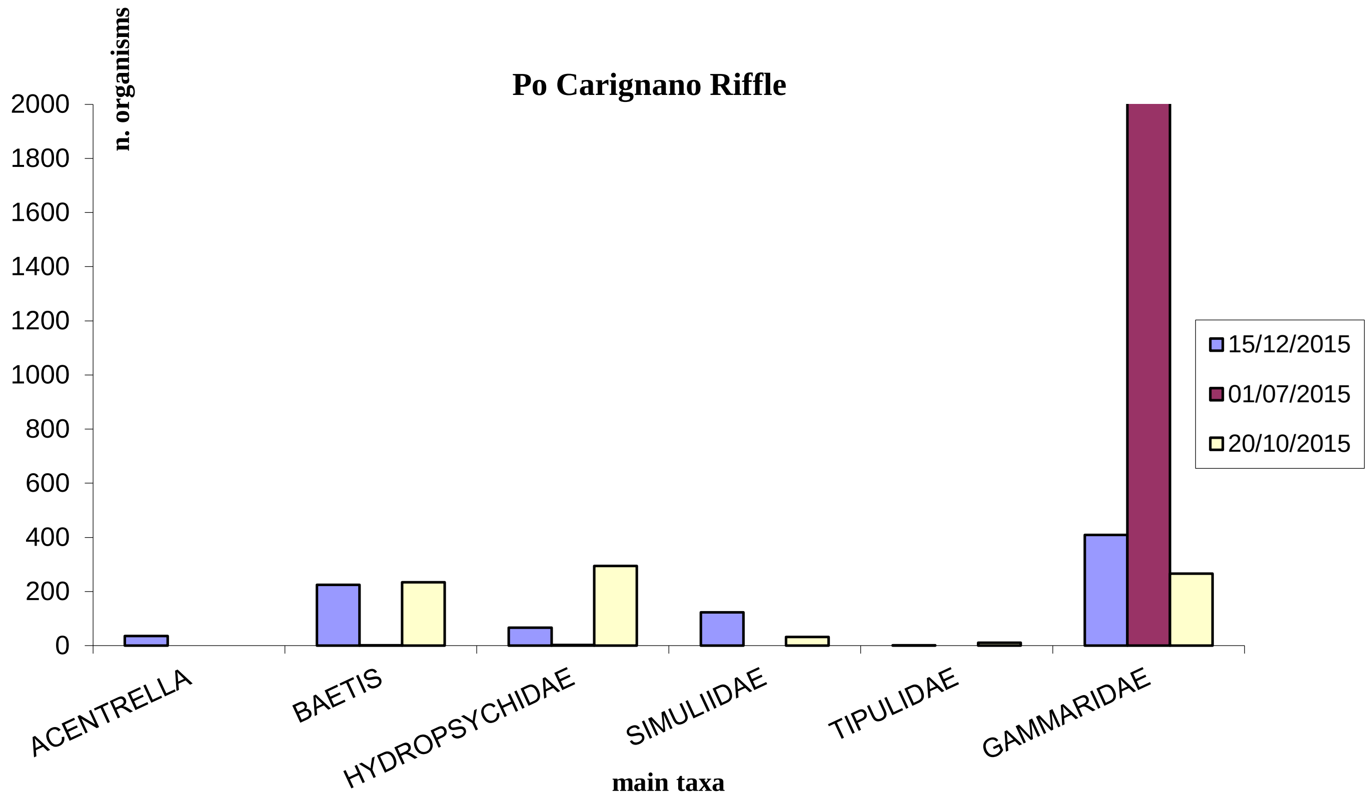


TABLE 8: MACRO-BENTHOS IN MURAZZI (TO), 2015, MAIN TAXA, ARPA

PO **Murazzi** **COD C.I. 06SS4D383PI** **COD STAZIONE: 011095**	**22/10/2015**	**30/06/2015**	**16/12/2015**
Taxa found	**n. organisms**	**n. organisms**	**n. organisms**
BAETIDAE *Baetis sp.*	**86**	**38**	**576**
EPHEMERELLIDAE *Ephemerella sp.*	**1**	**63**	**1**
HYDROPSYCHIDAE	**533**	**49**	**730**
CHIRONOMIDAE	**4**	**5**	**182**
SIMULIIDAE	**0**	**8**	**229**
GAMMARIDAE	**86**	**4318**	**71**
CORBICULIDAE	**251**	**0**	**663**
SPHAERIIDAE	**94**	**7**	**0**
n. taxa	**23**	**21**	**18**
n. organisms	**1055**	**4488**	**2452**

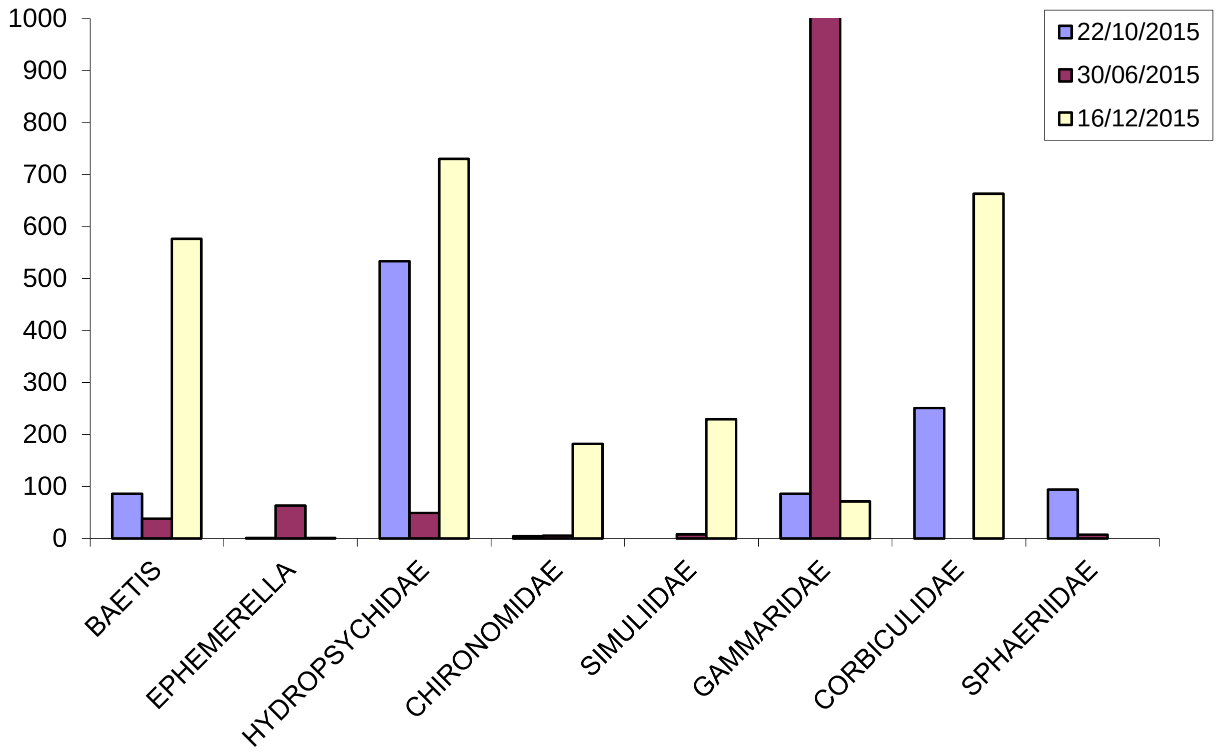


TABLE 9: MACRO-BENTHOS IN BRANDIZZO, 2015, MAIN TAXA, ARPA

Po **Brandizzo** **COD C.I.: 06SS4D999PI** **COD STAZIONE: 001160**	R 05/06/2015	R 02/09/2016	R 02/12/2015
Taxa found	**n. organisms**	**n. organisms**	**n. organisms**
BAETIDAE – *Baetis sp.*	**326**	**185**	**651**
CAENIDAE – *Caenis sp.*		**72**	
EPHEMERELLIDAE – *Ephemerella sp.*	**211**		**4**
HYDROPSYCHIDAE	**5**	**194**	**278**
CHIRONOMIDAE	**260**	**305**	**88**
SIMULIIDAE	**6**		**162**
NAIDIDAE	**208**	**1**	**3**
GAMMARIDAE	**195**	**47**	
n. taxa	**18**	**22**	**13**
n. organisms	**1272**	**910**	**1203**

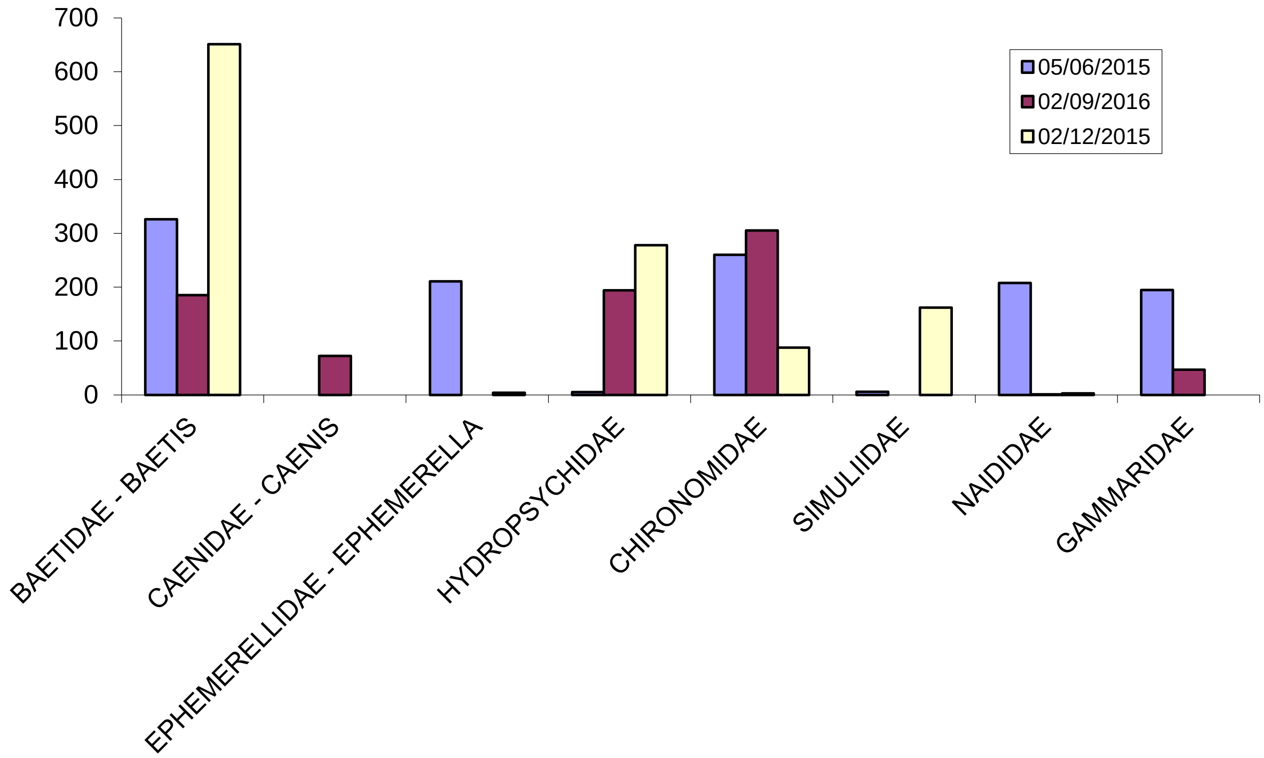


TABLE 10: MACRO-BENTHOS IN LAURIANO, 2015, MAIN TAXA, ARPA

PO **LAURIANO** **COD. C.I.: 06SS4D384PI** **COD STAZIONE: 001197**	R1 22/05/2015	R2 22/05/2015	27/10/2015	02/12/2015
Taxa found	**n. organisms**	**n. organisms**	**n. organisms**	**n. organisms**
Plecotteri				
BAETIDAE *Baetis sp.*	**493**	**84**	**67**	**414**
HEPTAGENIIDAE *Ecdyonurus sp.*	**118**	**59**	**3**	**38**
EPHEMERELLIDAE *Ephemerella sp.*	**370**	**190**	**1**	**0**
HEPTAGENIIDAE *Heptagenia sp.*	**118**	**0**	**1**	**0**
HYDROPSYCHIDAE	**186**	**44**	**385**	**327**
CHIRONOMIDAE	**247**	**106**	**26**	**598**
NAIDIDAE	**113**	**71**	**0**	**19**
GAMMARIDAE	**1060**	**210**	**12**	**131**
n. organisms	**2809**	**802**	**510**	**1535**

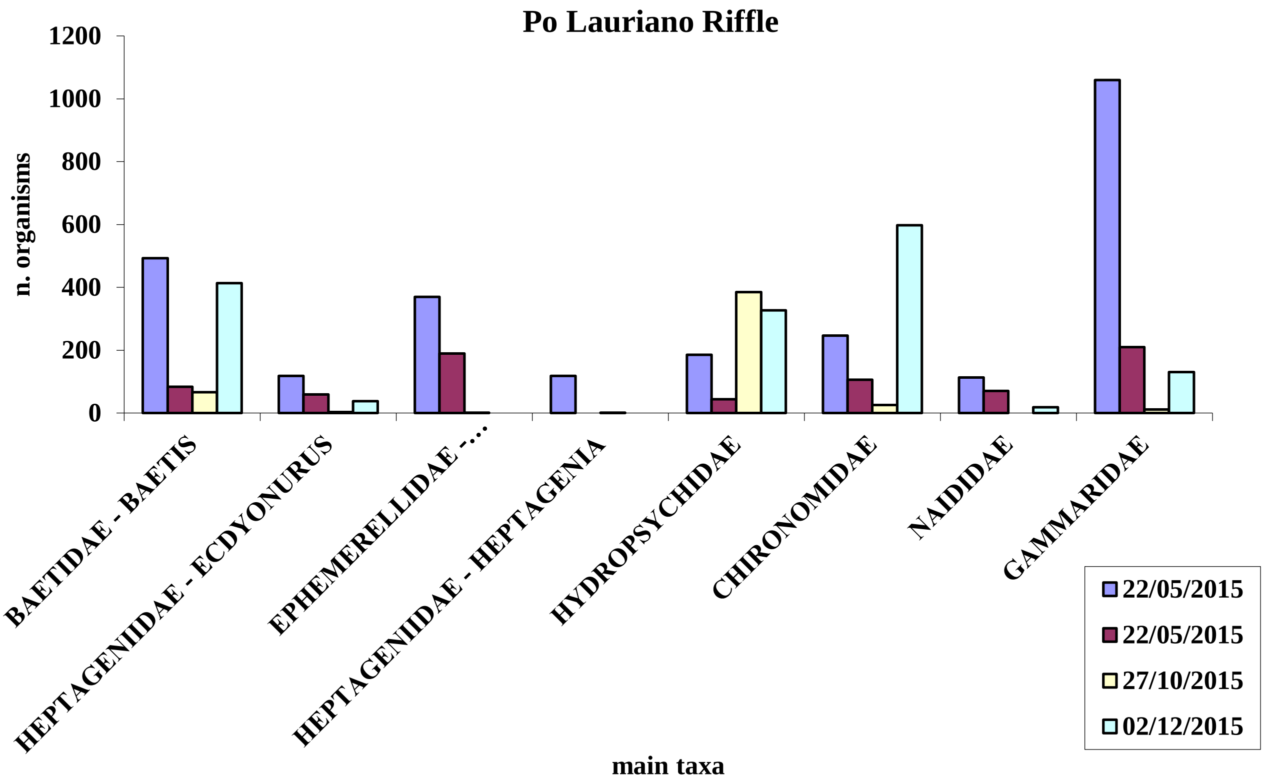


TABLE 11: STAR_ICMI VALUES AND QUALITY WATER, ARPA

CAMPAIGN	SITE	VALUE STAR_ICIMi	ECOLOGICAL STATUS	CLASS
I	**BRANDIZZO**	0,650	SUFFICIENT	3
II	**BRANDIZZO**	0,561	SUFFICIENT	3
II	**BRANDIZZO**	0,804	GOOD	2
III	**BRANDIZZO**	0,396	POOR	4
III	**BRANDIZZO**	0,631	SUFFICIENT	3
AVERAGED FINAL JUDGEMENT (among 5)				
	BRANDIZZO	**0,608**	**SUFFICIENT**	**3**
I	**CARIGNANO**	0,874	GOOD	2
I	**CARIGNANO**	0,831	GOOD	2
II	**CARIGNANO**	0,468	POOR	4
II	**CARIGNANO**	4,474	POOR	4
III	**CARIGNANO**	0,907	GOOD	2
III	**CARIGNANO**	0,599	SUFFICIENT	3
AVERAGED FINAL JUDGEMENT (among 6)				
	CARIGNANO	**0,692**	**SUFFICIENT**	**3**
I	**LAURIANO**	0,766	GOOD	2
II	**LAURIANO**	1,049	HIGH	1
II	**LAURIANO**	0,851	GOOD	2
III	**LAURIANO**	0,671	SUFFICIENT	3
AVERAGED FINAL JUDGEMENT (among 4)				
	LAURIANO	**0,834**	**GOOD**	**2**
I	**TORINO**	0,649	SUFFICIENT	3
II	**TORINO**	0,729	GOOD	2
III	**TORINO**	0,553	SUFFICIENT	3
AVERAGED FINAL JUDGEMENT (among 3)				
	TORINO	**0,644**	**SUFFICIENT**	**3**

The quality water of the river Po, based on macro-benthos samplings and related STAR_ICMi indexes, during 2015, resulted on average sufficient in all the different stations taken into consideration (Lauriano, Brandizzo, Murazzi e Carignano). In particular, we can note a slight improvement in Lauriano, where the ecological status reaches a good level.

As shown in the table above (Table 12), we can understand why it is important to collect almost three samples during the same year and to calculate the average values. In fact, with a single sample for each station we could obtain different results affected by a larger degree of error, dependent on the operators who made the sampling and on specific conditions as the seasonal ones or others.

3.2 Macrophytes

In the pages below, we include charts related to macro-phythes samplings in each station. From this data, we could deduce the water quality only based on IBMR.

TABLE 12 MACRO-PHYTES RESULTS IN CARIGNANO, 2015, ARPA

REGIONE	**Piemonte**	Data Campionamento / Num verbale	13/07/2015	2015/MF/08
Provincia	**Torino**	Operatori Campionamento	Lefebvre P	Rossi A
Comune	**Carignano**			
Fiume/Torrente	**Po**	copertura totale macrofite in A	40	
Corpo Idrico	**'06SS4D382PI**	copertura algale	40	
Stazione	**001065**	copertura MF escluse le alghe	0	
IBMR Calcolato	**10,3**	Ecoregione	06: Pianura Padana	
Trofia	**MEDIA**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**0,98**	IBMR di riferimento	10,5	
Giudizio di qualità	**ELEVATO**			
REGIONE	**Piemonte**	Data Campionamento / Num verbale	20/10/2015	2015MF13
Provincia	**Torino**	Operatori Campionamento	Lefebvre P.	Rossi A.
Comune	**Carignano**			
Fiume/Torrente	**Po**	***copertura totale macrofite in A***	**10**	
Corpo Idrico	**'06SS4D382PI**	***copertura algale***	**10**	
Stazione	**001065**	***copertura MF escluse le alghe***	**+**	
IBMR Calcolato	**7,0**	Ecoregione	06: Pianura Padana	
Trofia	**MOLTO ELEVATA**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**0,67**	IBMR di riferimento	10,5	
Giudizio di qualità	**SUFFICIENTE**			

In the sampling carried out in the station of Carignano we found the following results (Table 12): in summer (13/07) a medium trophic level linked to a high level of quality judgement, while in autumn (20/10) a very high trophic level was linked to a judgement of sufficient quality.

TABLE 5: MACRO-PHYTES RESULTS IN TORINO, 2015, ARPA

REGIONE	**Piemonte**	Data Campionamento / Num verbale	08/07/2015	2015/MF/07
Provincia	**Torino**	Operatori Campionamento	Guala P	Lefebvre P
Comune	**Torino**			
Fiume/Torrente	**Po**	***copertura totale macrofite in A***	**80**	
Corpo Idrico	**06SS4D383PI**	***copertura algale***	**75**	
Stazione	**001095**	***copertura MF escluse le alghe***	**5**	
IBMR Calcolato	**11,8**	Ecoregione	06: Pianura Padana	
Trofia	**MEDIA**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**1,13**	IBMR di riferimento	10,5	
Giudizio di qualità	**ELEVATO**			
REGIONE	**Piemonte**	Data Campionamento / Num verbale	23/09/2015	2015MF10
Provincia	**Torino**	Operatori Campionamento	Rossi A.	Lefebvre P.
Comune	**Torino**			
Fiume/Torrente	**Po**	***copertura totale macrofite in A***	**60**	
Corpo Idrico	**06SS4D383PI**	***copertura algale***	**25**	
Stazione	**001095**	***copertura MF escluse le alghe***	**35**	
IBMR Calcolato	**7,0**	Ecoregione	06: Pianura Padana	
Trofia	**MOLTO ELEVATA**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**0,67**	IBMR di riferimento	10,5	
Giudizio di qualità	**SUFFICIENTE**			

In the sampling carried out in the city of Turin (Table 13), we found in summer (08/07) a medium trophic level linked to a high level of quality judgement; in autumn (23/10) a very high trophic level linked to a judgement of sufficient quality.

TABLE 14: MACRO-PHYTES RESULTS IN BRANDIZZO, 2015, ARPA

REGIONE	**Piemonte**	Data Campionamento / Num verbale	07/07/2015	2015/MF/06
Provincia	**Torino**	Operatori Campionamento	Guala P	Rossi A

Comune	**Brandizzo**		Lefebvre P	
Fiume/Torrente	**Po**	***copertura totale macrofite in A***	**60**	
Corpo Idrico	**'06SS4D999PI**	***copertura algale***	**55**	
Stazione	**001160**	***copertura MF escluse le alghe***	**5**	
IBMR Calcolato	**7,2**	Ecoregione	06: Pianura Padana	
Trofia	**MOLTO ELEVATA**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**0,68**	IBMR di riferimento	10,5	
Giudizio di qualità	**SUFFICIENTE**			
REGIONE	**Piemonte**	Data Campionamento / Num verbale	26/10/2015	2015MF14
Provincia	**Torino**	Operatori Campionamento	Cisaro C.	Guala P.
Comune	**Brandizzo**		Rossi A.	Lefebvre P.
Fiume/Torrente	**Po**	***copertura totale macrofite in A***	**70**	
Corpo Idrico	**'06SS4D999PI**	***copertura algale***	**40**	
Stazione	**001160**	***copertura MF escluse le alghe***	**30**	
IBMR Calcolato	**9,1**	Ecoregione	06: Pianura Padana	
Trofia	**ELEVATA**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**0,87**	IBMR di riferimento	10,5	
Giudizio di qualità	**BUONO**			

In the sampling carried out in the station of Brandizzo (Table 14), we found in summer (08/07) a very high trophic level linked to a sufficient level of quality judgement, while in autumn (23/10) a high trophic level linked to a judgement of good quality.

TABLE 15: MACRO-PHYTES RESULTS IN LAURIANO, 2015, ARPA

REGIONE	**Piemonte**	Data Campionamento / Num verbale	07/07/2015	2015MF05
Provincia	**Torino**	Operatori Campionamento	Guala P	Rossi A
Comune	**Lauriano**		Lefebvre P	
Fiume/Torrente	**Po**	***copertura totale macrofite in A***	**40**	
Corpo Idrico	**06SS3F381PI**	***copertura algale***	**40**	
Stazione	**001197**	***copertura MF escluse le alghe***	**0**	
IBMR Calcolato	**10,0**	Ecoregione	06: Pianura Padana	
Trofia	**MEDIA/ELEVATA**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**0,95**	IBMR di riferimento	10,5	
Giudizio di qualità	**ELEVATO**			
REGIONE	**Piemonte**	Data Campionamento / Num verbale	27/10/2015	2015MF15
Provincia	**Torino**	Operatori Campionamento	Lefebvre P.	Rossi A.
Comune	**Lauriano**			
Fiume/Torrente	**Po**	***copertura totale macrofite in A***	**0**	
Corpo Idrico	**06SS3F381PI**	***copertura algale***	**0**	
Stazione	**001197**	***copertura MF escluse le alghe***	**0**	
IBMR Calcolato	**???**	Ecoregione	06: Pianura Padana	
rofia	**???**	Macrotipo	Cc: Regione Centrale, Grande	
IQR	**???**	IBMR di riferimento	10,5	
Giudizio di qualità	**???**			

In the sampling carried out in the station of Lauriano (Table 15) we found in the summer (07/07) a medium/high trophic level linked to a high level of quality judgement, while in

autumn (27/10) we have not collected enough data to draw up neither an estimation of trophic level nor of quality judgement. Comparing all these results, we can conclude that macro-phytes suggest higher water quality during summer sampling and lower water quality in autumn samplings, except for Brandizzo, with an opposite situation. At the beginning of July macro-phytes are at the maximum of their growing season, while in the last autumn we had in Italy a particular dry season with a significant and unusual reduction of the flow in the river Po: this situation could have affected negatively the quality judgement in second samplings.

3.3 Diatoms

In the pages below, we have included the chart (Table 16) relative to Diatoms samplings in each station. From this data, we could deduce the water quality related to EPI-D/4. Before the chart, we inserted two pictures that show two different and ecological representative species, found in our samplings.

FIGURE 36: *ACHNANTHIDIUM MINUTISSIMUM* (KÜTZ.) CZARNECKI(1994)

Achnanthidium minutissimum (Fig.36, [17])*:* elliptic, linear-elliptic or linear lanceolate valves with broadly rostrate or sub-rostrate ends. Central area indistinct - on the raphe less valve it is little more than a slight broadening of the axial area and more broadly placed stripes whilst on the raphe valve it is elliptical or rounded. It is a very widespread and abundant diatom, common in well-oxygenated streams with low or moderate concentrations of nutrients and organic pollution. It can be abundant in streams affected by heavy metal pollution.

Mayamaea permitis (Fig. 37, [18])**:** little elliptic valves with stripes in high density, which cannot be counted under Optical Microscope. We can distinguish the border of valve and the raphe, which shows three thickening at the extremities and in the central node. This specie shows a large distribution, generally in waters rich in nutrients and pollutants.

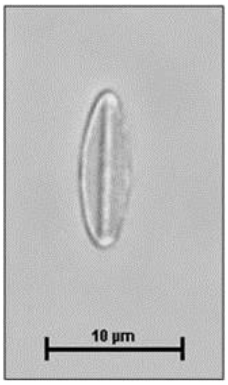


FIGURE 37: *MAYAMAEA PERMITIS* (HUSTEDT) BRUDER & MEDLIN, 2008

TABLE 16 DIATOMS: SPECIES, EPI-D/4 INDEX, WATER QUALITY, 2015, ARPA

	morbida	magra	morbida	magra	morbida	magra	morbida	magra
ARPA Piemonte - 28/01/2016	**Carignano**		**Torino**		**Brandizzo**		**Lauriano**	
Amphora copulata (Kütz) Schoeman & Archibald	0	3	0	0	0	0	0	0
Achnanthidium gracillimum (Meister)Lange-Bertalot	0	0	1	0	0	0	0	0
Achnanthidium minutissimum (Kützing) Czarnecki	26	39	48	17	12	21	12	29
Achnanthidium pyrenaicum (Hustedt) Kobayasi f. anormale	26	10	0	0	0	0	0	0
Achnanthidium pyrenaicum (Hustedt) Kobayasi	297	225	64	37	274	33	45	52
Amphora pediculus (Kützing) Grunow	0	6	10	13	0	6	0	76
Cymbella excisa Kützing var. Excisa	0	0	0	0	0	3	0	1
Cocconeis euglypta Ehrenberg emend Romero & Jahn	0	4	55	20	10	8	100	2
Caloneis lancettula (Schulz) Lange-Bertalot & Witkowski	0	0	0	0	0	1	0	0
Cyclotella meneghiniana Kützing	1	0	2	0	1	0	0	0
Cocconeis pediculus Ehrenberg	3	3	16	0	3	3	0	1
Cocconeis placentula Ehrenberg var.lineata (Ehr.)Van Heurck	12	0	0	0	42	0	113	0
Conticribra weissflogii (Grunow) Stachura-Suchoples & Williams	0	0	1	0	0	0	0	0
Diatoma ehrenbergii Kützing	4	0	0	0	0	0	1	1
Diatoma moniliformis Kützing ssp.moniliformis	3	2	15	0	0	3	0	0
Discostella pseudostelligera (Hustedt) Houk et Klee	0	0	1	0	0	0	0	0
Diatoma vulgaris Bory	0	0	5	0	5	15	0	2
Encyonema minutum (Hilse in Rabh.) D.G. Mann in Round Crawford & Mann	0	1	0	1	0	4	1	2
Encyonema ventricosum (Agardh) Grunow in Schmidt & al.	4	2	4	1	0	23	5	9
Eolimna comperei Ector Coste et Iserentant in Coste & Ector	0	0	0	0	0	2	0	0
Eolimna minima (Grunow) Lange-Bertalot	0	4	11	0	0	8	0	3

Eolimna subminuscula (Manguin) Moser Lange-Bertalot & Metzeltin	0	8	5	12	2	3	0	22
Encyonema silesiacum (Bleisch in Rabh.) D.G. Mann	2	0	0	2	6	0	2	2
Fragilaria recapitellata Lange-Bertalot & Metzeltin	0	0	0	0	0	0	0	3
Fistulifera saprophila (Lange-Bertalot & Bonik) Lange-Bertalot	0	0	0	0	2	0	0	0
Fragilaria vaucheriae (Kützing) Petersen	4	0	0	2	4	5	0	0
Gomphonema elegantissimum Reichardt & Lange-Bertalot in Hofmann & al.	0	0	0	5	0	0	14	0
Gomphonema lagenula Kützing	4	0	0	0	0	0	0	0
Gomphonema minutum (Ag.)Agardh f. minutum	0	0	13	1	5	8	0	4
Gomphonema olivaceum (Hornemann) Brébisson var. olivaceum	0	0	0	0	0	0	0	3
Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	3	2	0	9	0	6	0	16
Gyrosigma sciotense (Sullivan et Wormley) Cleve	0	0	1	0	0	0	0	0
Gomphonema tergestinum (Grunow in Van Heurck) Schmidt in Schmidt & al	0	0	0	0	0	0	0	1
Hippodonta capitata (Ehr.)Lange-BertalotMetzeltin & Witkowski	0	0	1	0	0	0	0	0
Lemnicola hungarica (Grunow) Round & Basson	0	0	0	0	0	1	0	0
Mayamaea permitis (Hustedt) Bruder & Medlin	0	0	2	230	0	0	0	9
Melosira varians Agardh	5	1	9	0	2	21	0	1
Nitzschia amphibia Grunow f.amphibia	0	0	8	2	0	11	0	0
Navicula antonii Lange-Bertalot	0	0	7	1	0	6	0	5
Nitzschia capitellata Hustedt in A.Schmidt & al.	0	0	0	0	0	3	0	0
Navicula capitatoradiata Germain	2	0	0	1	0	0	0	0
Navicula cryptotenella Lange-Bertalot	6	15	38	17	11	56	0	18
Nitzschia dissipata (Kützing) Grunow ssp.dissipata	0	2	15	4	0	71	0	38
Nitzschia fonticola Grunow in Van Heurck	3	36	11	3	1	0	1	0
Navicula gregaria Donkin	0	0	15	1	0	16	2	9
Nitzschia hantzschiana Rabenhorst	0	0	0	0	0	4	0	0
Nitzschia archibaldii Lange-Bertalot	0	0	0	0	0	1	0	0
Nitzschia inconspicua Grunow	0	2	1	10	0	4	2	28
Nitzschia linearis (Agardh) W.M.Smith var.linearis	0	0	4	0	0	3	0	0
Nitzschia palea (Kützing) W.Smith var.debilis(Kützing)Grunow in Cl. &	0	0	0	26	0	0	0	2
Nitzschia palea (Kützing) W.Smith var. palea	4	0	0	0	0	0	0	1
Navicula reichardtiana Lange-Bertalot var. reichardtiana	0	1	3	1	2	4	0	5
Navicula striolata (Grun.) Lange-Bertalot in Reichardt	0	0	1	0	0	0	0	0
Navicula tripunctata (O.F.Müller) Bory	3	1	23	1	1	16	0	2
Navicula tripunctata (O.F.M.) Bory f. anormale	0	0	0	0	0	0	2	0
Nitzschia costei Tudesque, Rimet & Ector	0	0	0	0	0	15	0	42
Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot	0	0	2	0	2	0	13	2
Planothidium rostratum (Oestrup) Lange-Bertalot	0	2	0	0	0	0	0	0
Planothidium lanceolatum (Brebisson ex Kützing) Lange-Bertalot	1	0	0	0	1	0	0	0
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot	5	1	7	1	13	2	0	0
Reimeria sinuata (Gregory) Kociolek &	9	30	0	0	5	14	102	0

Stoermer								
Reimeria uniseriata Sala Guerrero & Ferrario	0	0	0	4	0	0	0	12
Surirella brebissonii var.kuetzingii Krammer et Lange-Bertalot	1	0	2	2	0	1	0	6
Staurosira mutabilis (Wm Smith) Grunow	0	0	0	1	0	0	0	0
Tryblionella constricta (Kützing) Poulin in Poulin & al.	0	0	0	0	0	0	1	0
Ulnaria ulna (Nitzsch) Compère	2	0	1	0	0	0	2	2
TOTAL	401	411	425	400	0	402	430	404
Number of species	24	23	17	28	21	35	34	34
EPI-D/4 index	**0,62**	**0,83**	**1,05**	**2,65**	**0,67**	**1,68**	**1,41**	**1,64**
QUALITY	**excellent**	**excellent**	**good**	**bad**	**excellent**	**good**	**good**	**good**

According to Table 17, considering the results obtained from diatomic samplings and the related index EPI-D/4, we can make the following observations: in general, in 2015, the quality of the river Po, in the hydric body we have considered, is significantly good. It resulted only very low during the second sampling (during a particular dry Autumn) in the station of Murazzi in Torino. Paying attention to the numbers of taxa found, we understand that the river quality does not depend on the presence of many taxa. In fact, in the stations where the quality of water is excellent, there is a lesser number of species than in the stations with a good level, which, in turn, have less species than those stations whose water has a low (or bad) quality.

4 Conclusion

At the end of our project, we got interested in doing some comparisons through the data obtained with our research and the previous data we found online in Arpa's website. The purpose was to discover if the results coming from samplings done during last year (2015), in which we have been involved directly, were equal, better or worse than the previous ones. This is the reason why we have reported some tables useful to do these comparisons below.

TABLE 17 MACRO-BENTHOS AND STAR_ICM INDEX 2009-2014, ARPA

Macrobenthos:
STAR_ICMi (*Standardisation of River Classifications_Itercalibration Multimetric Index*) 2009-2014

C.I. (River Body) codex	Point codex	River	Comune	2009	2010	2011	2012	2013	2014
06SS4D382PI	001065	PO	Carignano	**GOOD**	-	-	**SUFF.**	-	-
06SS4D383PI	001095	PO	Torino	**LOW**	-	-	**SUFF.**	-	-
06SS4D999PI	001160	PO	Brandizzo	-	**SUFF.**	-	**SUFF.**	-	-
06SS4D384PI	001197	PO	Lauriano	**SUFF.**	-	-	**SUFF.**	-	-

According to STAR_ICMi data [19] shown in the table above (Table 17), the condition of waters of the Po in the Carignano station in 2009 was GOOD, while a slow worsening was recorded during the years so it reached the level SUFFICIENT in 2012, then the water conditions remained stable until the last samplings in 2015 (Table 11). While STAR_ICMi values improved in the stations of Turin (Murazzi), from a LOW level to SUFFICIENT one, and Lauriano, which achieved a GOOD level in 2015, the conditions of the Po in Brandizzo station remained stable (SUFFICIENT). We can notice that the downstream water quality has improved during the last six years, and slightly deteriorated in the upstream waters. The reason for this worsening in Carignano is not actually known, but this is why Carignano is a site in which Arpa carries out a monitoring of surveillance, with samplings every three years, not only six as in stations that are in better conditions.

On the other end, the improvement in the downstream waters (Brandizzo and Lauriano) could be linked to a better functioning of Turin's largest water treatment plant sited in Castiglione Torinese, near Brandizzo, which discharges the purified waste waters into the Po.

TABLE 18 MACRO-PHYTES AND IBMR INDEX, 2009-2014, ARPA

Macrophytes:
IBMR (*Index Macrofitique Biologique en Rivière*) 2009-2014

C.I. (River Body) codex	Point codex	River	City	2009	2010	2011	2012	2013	2014

06SS4D382PI	001065	PO	Carignano	-	-	-	**SUFF.**	-	-
06SS4D999PI	001160	PO	Brandizzo	-	**GOOD**	-	**SUFF.**	-	-
06SS4D384PI	001197	PO	Lauriano	-	-	-	**HIGH**	-	-

In the station of Carignano the overall judgment in the year 2012 is SUFFICIENT (Table 18), while in the samples that have been made this year the overall judgement is GOOD.
In the station of Brandizzo the overall judgment in the year 2012 is SUFFICIENT, while in the samples that have been made this year the overall judgement is GOOD.
In the station of Lauriano the overall judgement in the year 2012 is HIGH, while in the samples that have been made this years the overall judgement cannot be determined because we don't have enough data for winter. For the summer, we find a HIGH judgement.
We do not have results regarding the station of Turin during 2012: anyway, the results we obtained proved a good judgement for last year. Globally, in the four stations we considered the macro-phythes index IBMR shows an improvement [20].

TABLE 19 DIATOMS AND ICIMI INDEX, 2009-2014, ARPA

Diatoms:
ICMi *(Intercalibration Common Metric Index*) 2009-2014

C.I. (River Body) codex	Point codex	River	City	2009	2010	2011	2012	2013	2014
06SS4D382PI	001065	PO	Carignano	**HIGH**	-	-	**HIGH**	-	-
06SS4D999PI	001160	PO	Brandizzo	**-**	**SUFFICIENT**	-	**LOW**	-	-
06SS4D384PI	001197	PO	Lauriano	**GOOD**	-	-	**GOOD**	-	-

In the station of Carignano the results obtained in 2015 are not better than the results obtained in the previous years. In the station of Brandizzo the results obtained in 2015 are better than the results obtained in the previous years and in the station of Lauriano the results obtained in 2015 are very similar to the results obtained in the previous years. For the station of Murazzi in Turin there are not previous data.
Therefore, we have to remind that the results of the years 2009-2014 [21] are not directly comparable with those of 2015 because the index EPI-D calculated for the last year is only a part of the ICMi index (Table 19).

TABLE 20 LIMECO, 2009-2014, ARPA

LIMeco C.I. (Livello di Inquinamento dai Macrodescrittori per lo stato ecologico) (Pollution Level from Macro-descriptors relative to ecological status) 2009-2014 and three years periods									
C. I. codex	**Description**	**2009**	**2010**	**2011**	**2009-2011**	**2012**	**2013**	**2014**	**2012-2014**
06SS4D382PI Carignano	PO_56SS Big/Weak 107	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**SUFF.**	**SUFF.**
06SS4D383PI Murazzi	PO_56SS Big/Weak 107	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**
06SS4D384PI Lauriano	PO_56SS Big/Weak 107	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**
06SS4D999PI Brandizzo	PO_56SS Big/Weak 107	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**	**SUFF.**

LIMeco (Table 20) is a synthetic index that describes the running waters quality. In fact, it considers the percentage of oxygen (O_2) saturation in water, the concentration of NH_4^+, NO_3^- and the total phosphorus. LIMeco values [22] come from the average of different values relative to all the samplings done in the same year of monitoring. From this table (Table 20) it seems clear that basic chemical and ecologicalparameters are the same in all four stations, with a worsening in the last year (2013-2014) in Carignano.

TABLE 21 SQA, 2099-2014, ARPA

SQA (specific pollutants) in the years 2009-2014									
C. I. codex	**C. I. Station**	**River**	**Site**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
06SS4D382PI	001065	PO	Carignano	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**
06SS4D383PI	001095	PO	Torino	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**

06SS4D999PI	001160	PO	Brandizzo	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**
06SS4D384PI	001197	PO	Lauriano	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**

The determination of SQA is done with the average annual concentrations of Specific Pollutants (organic compounds), listed in WFD. It is determined basing on the worst data during the year. As we can see in Table 21 [23], all specific pollutants are under limits and this is the reason why the quality judgement is stable and GOOD in all four stations.in the last six years (Table 21).

TABLE 22 CHEMICAL STATUS, 2009-2014, ARPA

Chemical Status in the years 2009-2014									
C. I. codex	**C. I. Station**	**River**	**Site**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
06SS4D382PI	001065	PO	Carignano	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**
06SS4D383PI	001095	PO	Torino	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**
06SS4D999PI	001160	PO	Brandizzo	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**
06SS4D384PI	001197	PO	Lauriano	**NOT GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**

The Chemical Status of a water body can be only not good or good, according to the overcoming or not in the 33+8 specific pollutants (SQA), calculated as provided in WFD and in national DLgs 260/10. Also for SQA [24] all four stations are stable and GOOD since 2010 (Table 22).

TABLE 23 ECOLOGICAL STATUS, 2009-2011, 2012-2014, ARPA

Ecological Status of Water Body – three years 2009-2011, 2012-2014			
C. I. codex	**Description**	**2009-2011**	**2012-2014**
06SS4D382PI Carignano	PO_56SS Big/Weak 107	**GOOD**	**SUFFICIENT**
06SS4D383PI Torino	PO_56SS Big/Weak 107	**LOW**	**SUFFICIENT**
06SS4D999PI Brandizzo	PO_56SS Big/Weak 107	**SUFFICIENT**	**LOW**
06SS4D384PI Lauriano	PO_56SS Big/Weak 107	**SUFFICIENT**	**SUFFICIENT**

In the end, we have to remember that the Ecological Status (Table 23) [25] of a specific Water Body is defined with the integrated estimation of different ecological indexes (STAR_ICMi, ICMi, IBMR, ISECI, LIMeco) along with the verification of Quality Standards for specific pollutants (SQA). There are five possible classes, as shown in Table 24 [25]. If we consider the Ecological Status in the last two/three years periods, the water quality judgement appears different and hardly ever good. Consequently, we could understand better why it is important to consider not only chemical conditions, that could be more positive, but also the ecological ones with different components to achieve a more precise and reliable estimate of quality in a specific water body.

Considering that the established objective in WFD is the achievement of a GOOD overall Status, based on comparison between Ecological and Chemical State, we can conclude that further studies should be carried out to discover which are the most dangerous pollution sources and to suggest politicians some interventions in order to achieve the European goal.

During our experience, we mainly focused on biomonitoring, so on the sampling and observation of the biological components of some sections of the river Po. In the future, a possible expansion of our project could be the extension of the analysis also to the chemical components of the sites observed, visiting the laboratory in Grugliasco (in Turin's vicinity), which could provide us with additional useful information about the comprehensive monitoring of the Po. We might also take into consideration the water basins around the city of Turin (eg. Dora Riparia, Dora Baltea) to have the possibility of comparison between different rivers, also belonging to the Piedmont and Turin context in which we live.

TABLE 24 CLASSES OF QUALITY, ARPA

Classes of Ecological State

	HIGH
	GOOD
	SUFFICIENT
	LOW
	BAD

The End

THE PROTAGONISTS

De afbeelding kan momenteel niet worden weergegeven.

FIGURE 38 CLASS 4 H: EUGENIO, ANDREA, SIMONA, DANIELE, CARLOTTA, ELISA, LORENZO, BESSIM, SAMUELE, PAOLO, ALESSANDRO, ALBERTO, UMBERTO, STEFANO, (ENRICO WAS ABSENT), FRANCESCA, SARA, GIULIA WITH THEIR TEACHERS,

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Links for Tables and pictures:

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