MONITORING OF THE WATER AND ENVIRONMENT REQUALIFICATION ACTIONS OF THE "FOSSETTA DEI MORTI" (CARPI, ITALY)

MONITORAGE DE L'INTERVENTION DE RENOUVELLEMENT HYDRAULIQUE-ENVIRONNEMENTAL DE "FOSSETTA DEI MORTI" (CARPI, ITALIE)

MONITORAGGIO DELL'INTERVENTO DI RIQUALIFICAZIONE IDRAULICO-AMBIENTALE DELLA "FOSSETTA DEI MORTI" (CARPI, ITALIA)

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Abstract

The Istituto d'Istruzione Superiore (High School) "Antonio Zanelli" from Reggio Emilia, Italy, has carried out research activities on an artificial water body called "Fossetta Dei Morti", within the agreement signed with the "Consorzio di Bonifica dell'Emilia Centrale". Such water body, located in the municipality of Carpi (Modena), had previously been the target of hydraulic-environmental requalification actions, carried out by the Consorzio di Bonifica itself within the European Project LIFE ECOnet, aiming at securing the banks and at the creation of a riparian vegetation strip. The High School has undertaken the following actions: characterizing/monitoring the waters from a chemical, chemical-physical and microbiological points of view; characterizing/monitoring the sediment from a chemical and physical-chemical point of view; establishing the biological quality through the analysis of the macrozoobenthos community (application of the IBE method); and establishing the hydro-ecological functionality (application of the IFF method). The goal of this project was to identify and to quantify the changes introduced by the Consorzio di Bonifica requalification actions.
Keywords: *requalification, monitoring, artificial water body*

Résumé

L'institut d'enseignement secondaire "Antonio Zanelli" de Reggio Emilia, dans le cadre de la convention signée avec le Consortium de Bonification de l'Emilie Centrale, a réalisé une enquête sur un milieu aquatique artificiel s'appelant "Fossetta dei Morti". Ce milieu aquatique, situé dans la municipalité de Carpi (MO), a précédemment été l'objet d'une intervention de renouvellement hydraulique-environnemental effectué par le Consortium de Bonification dans le cadre d'un projet Européen LIFE ECOnet, visant à la consolidation des berges et à

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la création d'une bande de végétation riveraine. L'activité de cet Institut s'est déroulée en quatre types d'actions: la caractérisation /monitorage des eaux des points de vue chimique, physico-chimique et microbiologique, la caractérisation / monitorage du sédiment du point de vue chimique et physico-chimique, la determination de la qualité biologique par l'étude de la communauté macrozoobenthique (application de la méthode IBE) et la détermination de la fonctionnalité hydroécologique (application de la méthode IFF), visant à l'identification des changements causés par l'intervention de renouvellement.
Mots-clés: *renouvellement, monitorage, milieu aquatique artificiel*

Riassunto

L'Istituto d'Istruzione Superiore "Antonio Zanelli" di Reggio Emilia, nell'ambito della convenzione firmata con il Consorzio di Bonifica dell'Emilia Centrale, ha svolto una campagna d'indagini su di un corpo idrico artificiale denominato Fossetta dei Morti. Detto corpo idrico, ubicato nel Comune di Carpi (MO), è stato in precedenza oggetto di un intervento di riqualificazione idraulico-ambientale, svolto dallo stesso Consorzio di Bonifica nell'ambito di un Progetto europeo LIFE ECOnet, finalizzato al consolidamento delle sponde e alla creazione di una fascia vegetale riparia. L'attività dell'Istituto si è svolta tramite quattro tipologie di azioni: la caratterizzazione/monitoraggio delle acque dal punto di vista chimico, chimico-fisico e microbiologico, la caratterizzazione/monitoraggio del sedimento dal punto di vista chimico e chimico-fisico, la determinazione della qualità biologica mediante lo studio della comunità macrozoobentonica (applicazione della metodica IBE) e la determinazione della funzionalità idroecologica (applicazione della metodica IFF), finalizzate a identificare e quantificare parte dei cambiamenti indotti dall'intervento di riqualificazione.
Parole chiave: *riqualificazione, monitoraggio, corpo idrico artificiale*

Introduction

The Fossetta dei Morti is an artificial water body of the promiscuous type and is part of the surface hydrographic network managed by the Consorzio di Bonifica dell'Emilia Centrale. This water body, located in the municipality of Carpi (Modena), had previously been the target of hydraulic-environmental requalification actions carried out by the Consorzio di Bonifica itself within the European Project LIFE ECOnet. The intervention aimed at securing the bank situated on the hydrographic right and at the creation of a riparian vegetation strip, for a total extension of about 500 linear metres. The objectives were achieved through the realization of a pilewall with chestnut poles and the planting of cuttings of *Salix alba* at the level of the right bank of the Fossetta dei Morti.
The Istituto d'Istruzione Superiore "Antonio Zanelli" of Reggio Emilia carried out research activities within the agreement signed with the "Consorzio di Bonifica dell'Emilia Centrale", with four types of actions: characterization/monitoring the waters from a chemical, chemical-physical and microbiological point of view;

characterization/monitoring the sediment from a chemical and physical-chemical point of view; establishing the biological quality through the analysis of the macrozoobenthos community (application of the IBE method); and establishing the hydro-ecological functionality (application of the IFF method). The goal of this project was to identify and to quantify parts of the changes determined by the requalification actions, analysing them through multidisciplinary prospects.

Materials and methods

A sampling plan was developed through a preferential-type strategy, which led to the identification of three stations located as follows: in the section before the works, in the middle section and in the final section of the requalification actions (Table 1). The stations were characterized through geo-referencing, collecting of field data relative to structural characters and periodic field data collection relative to hydraulic, functional and biological conditions.

Table 1

Sampling Station	Distance from previous station	Code	Location
Station 1	-	FM1	**Before** the hydraulic-environmental requalification actions
Station 2	~ 230 m	FM2	In the **middle section** of the hydraulic-environmental requalification actions
Station 3	~ 460 m	FM3	In the **terminal section** of the hydraulic-environmental requalification actions

The frequency of water sampling for the chemical, chemical-physical and microbiological analysis was two-monthly, corresponding to the seasons and the start/end of the irrigation period in the rice fields. Two of the six samples were collected at the same time as the sediment samples. The frequency of sediment sampling for the chemical and chemical-physical analysis was six-monthly, corresponding to the start/end of the irrigation period in the rice fields. The study of the macrozoobenthos community was carried out through the use of artificial substrates placed inside the water body during the spring/summer period, while the evaluation of the hydro-ecological functionality of the water body was made a single time, during full vegetation season.

The sampling was made through the direct collection of instantaneous samples of water, with the use of appropriate containers, and the collection of mean samples - the first 150 millimeters being of sediment - with the use of a steel corer.

Water samples were kept at +4 °C and analysed within the following 24 hours. For the analytical determinations to be made on filtered samples, syringe nitrocellulose membrane filters were used, with pores of 0,45 µm. Ultrapure nitric acid was used to acidify water samples intended to elementary analysis. Sediment samples were dehydrated in a thermostat heater for 72 hours at a temperature of 40 °C; they were

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then ground, divided in four parts, one of which was kept and preserved in filterbottles, inside a dryer, until the analysis was made. The preparation of the sediment samples, as indicated in the methodology explained in "Metodi ufficiali di analisi chimica del suolo" (Supplement issue to G.U. n. 248 of 21st October 1999), was made through the solubilization of the heavy metals present in the sediment by a nitrous-hydrochloric attack in a microwave digester (pseudo-total digestion) and employing "ultrapure" agents and water.

The water and sediment analysis were made employing methods of both nationally (APAT e IRSA-CNR, 2003) and internationally (UNI-EN) proven scientific reliability. The total suspended solids were determined *ex situ* by gravimetric measurement. The temperature was determined *in situ* with the use of a thermocouple thermometer. The pH was determined *in situ* by potentiometric measurement, with the use of a portable pHmeter with temperature compensation. Electrical conductivity was determined *in situ* with the use of a portable conductometer with temperature compensation. The content of the dissolved oxygen and the saturation of oxygen into water were determined *in situ* by amperometric measurement, with the use of a portable oximeter. The concentration of nitric nitrogen was determined *ex situ* by spectrophotometric measurement with 2,6-dimethylphenol. The concentration of nitrous nitrogen was determined *ex situ* by spectrophotometric measurement with sulfanilic acid. The concentration of ammoniacal nitrogen was determined *ex situ* by spectrophotometric measurement with blue indophenol. The total concentration of phosphorus was determined *ex situ* by spectrophotometric measurement (with blue phosphomolybdate) through hot acid mineralization. The concentration of ortophosphoric phosphorus was determined *ex situ* by spectrophotometric measurement with blue phosphomolybdate. The COD was determined *ex situ* through oxidation in a chromium sulfuric mixture, in hot acid environment. The concentration of chloride was determined *ex situ* by spectrophotometric measurement through ferric thiocyanate. The concentration of carbonates and bicarbonates was determined *ex situ* by tritation with indicator. The concentration of solfates was determined *ex situ* by atomic emission spectrophotometry (ICP-OES). The concentration of Aluminium, Antimony, Silver, Arsenic, Barium, Beryllium, Boron, Cadmium, Cobalt, Chromium, Iron, Lithium, Manganese, Mercury, Molybdenum, Nickel, Lead, Copper, Selenium, Tin, Strontium, Tellurium Thallium, Uranium, Vanadium, Zinc, Calcium, Magnesium, Sodium, Potassium in water and in the sediment extract was determined *ex situ* by atomic emission spectrophotometry (ICP-MS). The content of organic carbon in the sediments was determined *ex situ* by the Walkley-Black method. The content of *E. coli*, fecal coliforms and fecal streptococci was determined *ex situ* through the counting of the micro-organisms present in a known volume of water sample.

The study of the macrozoobentic community was carried out through sampling with artificial substrates, by the use of basket samplers laid during the spring and summer for a period of time longer than forty days, and the analysis of the samples according to the IBE methodology (Ghetti, 2001). The choice of this sampling

method was due to the impossibility to carry out the research with the use of the techniques usually employed in fordable lotic environments (by using small nets with handle or the Surber's net) because of the excessive structural simplicity of the water body and the very low operating space.
The study of the hydro-ecological functionality was carried out with the application of the Fluvial Functionality Index (Indice di Funzionalità Fluviale - IFF 2007 method), by which it is possible to estimate a water body both analysing structural and functional aspects and biotic/abiotic aspects. As the "Fossetta dei Morti" waterbed is less than 5 meters wide, the Minimum Trait Detectable (Tratto Minimo Rilevabile - TMR) to apply the IFF 2007 methodology is 30 linear meters.

Results

Below are shown the results of the most significant physical, chemical-physical and microbiological analytic determinations from a qualitative and quantitative point of view, relative to the samples of water and sediments collected. Because of the strong linear association observed between the stational variation from upstream to downstream and the average values of the single parameters, the results will be summarized in terms of relative change from station 1 (FM1) to station 3, the terminal section of the intervention (FM3) – (Fig. 1 and Fig. 2).

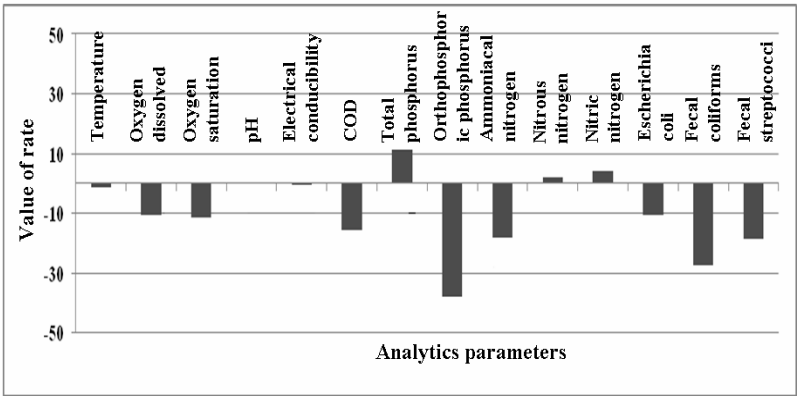

Figure 1

Variation in relative terms of the average values taken by the most significant analytical parameters of waters between FM1 and FM3.

As for the results concerning the macrozoobenthos, the riverbed high homogeneity, already observed during the preliminary survey, has strongly influenced the community structure. The community of macro-invertebrates seems to be very simple for its structural profile (very low biodiversity) and consisting uniquely of "tolerant organisms" (very low sensitivity), like larvae of Chironomidae Diptera and Crustaceans belonging to the invasive allochthonous species *Procambarus clarkii*.
Thanks to the use of the double entry table of the employed methodology (Ghetti, 2001) it was possible to calculate the IBE score and its related Quality Class for each station (Table 2). From the results no differences have been observed among

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the various stations, either qualitative or quantitative; in fact, the IBE scores are identical both in the pre-intervention section and in the one object of works.

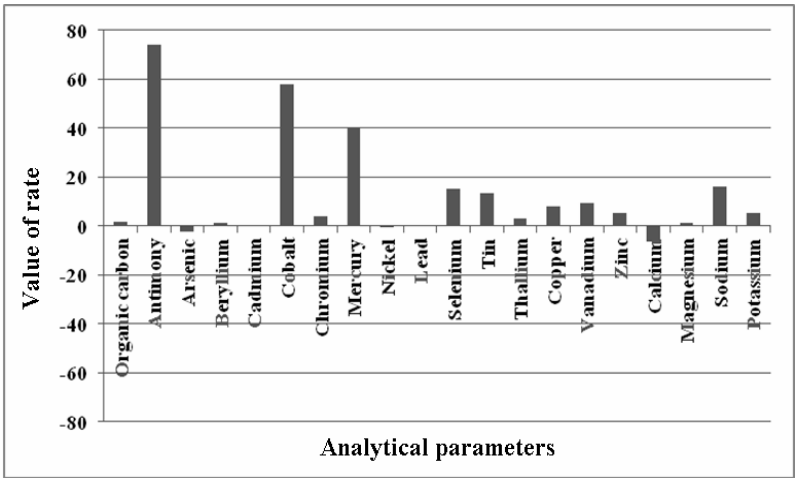

Figure 2

Variation in relative terms of the average values taken by the various analytical parameters of sediments between FM1 and FM3.

Table 2

References Station	IBE Score	Quality Class
FM1	1	Class V
FM2	1	Class V
FM3	1	Class V

The results of the fluvial functionality index relative to the single stations are shown below (Table 3). There are no IFF score variations between the left and the right bank of the analyzed sections, because of the development, on the hydrographic left, of a spontaneous hygrophitic grass strip, a few metres wide, derived from the agricultural abandonment of the surface. Besides, there are no IFF score variations along the whole section object of the requalification actions (from FM2 to FM3). The IFF score increases, in relative terms, of 98% between the non redeveloped section and the two following sections object of requalification. As direct result, the estimated functionality passes from Level IV-V to Level III-IV, so increasing the functionality of a whole level.

Table 3

Observed Section Reference Station	IFF Score - right bank	Level of Functionality – right bank	IFF Score – left bank	Level of Functionality – left bank
FM1	52	Class IV-V	52	Class IV-V
FM2	103	Class III-IV	103	Class III-IV
FM3	103	Class III-IV	103	Class III-IV

Below are listed the aspects by which we do or do not observe improvements in the hydro-ecological functionality of the section which was object of the requalification actions. (Table 4 and Table 5).

Aspects by which we can appreciate improvement of the hydro-ecologic functionality	Motivations
Characteristics of the riparian vegetation strip (vegetation, width and continuity)	Presence of continual bordures of high-shrubs riparian species and hygrophilous grasses
Characteristics of the riverbed substrate and presence of retention structures of the trofic intakes	Presence of macro-hydrophytes and other retention structures
Characteristics of the riverbed cross-section	Minor anthropic disturbance (maintenance)
Fish suitability	Higher presence of areas of refuge (for small fish) and of food production (for herbivorous); intense shading
Characteristics of the plant component in wet riverbed	Minor periphyton coverage and thickness and increase of mesotrophic macro-hydrophytes
Characteristics of the organic debris	Quantity increase of fibrous fragments in the debris

Table 4

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Aspects by which we can <u>not</u> appreciate improvement of the hydro-ecologic functionality	Motivations
State of the surrounding land	Presence of agricultural land with intensive cultures
Hydric conditions	Artificial water supply
Overflowing efficiency	Artificial water supply
Erosion events	Uniformly very low
Hydro-morphological characteristics	Artificial and linear water body
Characteristics of the macrozoobenthos community	Rectilinear water body with "simple" and homogeneous water body

Table 5

Conclusions

From the results processing, many changes emerge in the chemical, chemical-physical and microbiological characteristics of water and sediments and of the biological and hydro-ecological characteristics of the water body between the section located upstream of the intervention and the section which was object of requalification. Some of these variations, mainly the environmental and landscape ones, were expected as out come of the actions, while others, especially those relative to the irrigation water quality, emerged as unexpected. As for the analytical results, we can infer the following.

The strong shading caused by thick riparial vegetation at the level of the "Fossetta dei Morti" narrow riverbed determines, mainly in summer, a decrease of the water

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average temperature and a very strong reduction of the periphytic coverage in the trait of the intervention. To this reduction corresponds a decrease in the concentration of oxygen dissolved into water and a major colonization of mesotrophic macro-hydrophytes which slow the water speed, increase the retention of the organic debris in the waterbed, causing a greater structural complexity of the waterbed. The presence of macro-hydrophytes, besides the root absorption actions of the riparian vegetation, could be the cause of the dramatic reduction of the concentration of orto-phosphoric phosphorus in the water flowing in the section of waterbed object of the intervention. The reduction of the reactive forms of phosphorus has a limiting effect on the development of algal communities, restricting phenomena of surface water eutrophication and improving the irrigation quality of the water itself. The slowdown of water speed, together with the greater structural complexity of the waterbed, are the most likely cause of the significant reduction of ammoniacal nitrogen values, of COD and of the presence of bacteria of fecal origin like *Escherichia coli*, fecal coliforms and fecal streptococci, with a consequent improvement in water quality both from an environmental and from an irrigational point of view, as for the aspects of distribution capability and sanitation.

From the station of pre-intervention to the following stations it is possible to observe an increase of the organic debris, mostly retained in the period between May and November, as confirmed by a gradual increase of the content of organic carbon in the sediment. Together with this increase it is possible to see the increase, more or less pronounced in percentage, of the majority of the chemical elements determined at sediment level, probably because made complex by the organic material and so temporarily immobilized.

The results obtained from the study of the marozoobenthos communities have confirmed the state of reduced ecosystemic complexity of the waterbed, which is uniformly linear on the whole water body (also the one which was object of the intervention), regular in its width and with a mobile river bottom, finely textured, strongly homogeneous. The simplicity of the ecosystemic mosaic expresses itself in a small number of microhabitats and in a consequent low macrozoobenthonic biodiversity.

The study of the hydro-ecologic functionality done through the Fluvial Functionality Index has allowed to detect which morfo-functional aspects of the water body have actually been influenced by the intervention and which have remained unchanged. The IFF has also made it possible to quantify the requalification of the “Fossetta dei Morti” from the ecological point of view, showing a modest improvement of the functionality level despite the actions aimed, as anticipated in the introduction, mainly at obtaining physical-mechanical results at river bank level. Great environmental improvements have also emerged from the study, as for the increased number of the riparial habitats and for the landscape requalification.

In conclusion, the activities allowed to confirm the achievements of some of the prospected results coming from the requalification actions, in addition showing the

achievement of other positive effects, mostly unexpected, linked to the irrigation quality of the waters. At the same time the actions have revealed those aspects on which it would be possible to intervene more specifically to obtain determined environmental results and of irrigation quality, optimizing the planning of possible future actions on similar water bodies.

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