D4.1.1 –
Monitoring System

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1. Introduction

The objective of the WP is to identify and map needs and barriers in the management of coastal fresh groundwater systems. To achieve this scope, two critical and representative areas were chosen in Italy as specific case studies: 1) Fano (Marche Region) and Ravenna (Emilia-Romagna Region). For each area, the key points are:

- Risk assessment and mapping of salt intrusion in fresh water aquifers for the peculiar hydrogeological conditions, through the measurement of water chemical-physical parameters and the collection of water samples for chemical and isotopic analyses.
- Identification of possible criticalities starting from the analysis of the management and regulative framework through a cooperation network of subjects with different competences.

Main specific targets are:

- Improvement of the conceptual models for the two coastal aquifer systems by updating the saltwater distribution in the aquifers and understanding the present mechanisms of seawater intrusion.
- Development of groundwater flow and transport numerical model for one of the two studied coastal aquifer systems, by i) considering the possible scenarios of marine intrusion evolution (taking also into account the sea level and hydrology scenarios from WP3) and ii) carrying out possible actions for minimizing the phenomenon and its effects.

Considering the robust basis for the characterization of marine intrusion to be investigated by application-oriented approaches in both the selected coastal systems, the finite-difference groundwater flow and transport model will be applied to the Fano shallow aquifer. The collected geochemical and physical data will be processed by using Modflow software and related codes (MT3DMS and/or SEAWAT CODE of USGS). To this purpose, continuous monitoring of piezometric level and physical-chemical parameters is in progress in three selected wells by means of installed probes.

2. Fano: case study for new numerical modelling

The points were selected from a monitoring network used in a previous work ("Studio Geologico del Basso Metauro"), mainly consisting of domestic wells and wells operated by the local water management company (ASET) for the supply of drinkable water. The study was also extended to selected surface waters (e.g. Metauro River). The selection was made to obtain a distribution as homogeneous as possible over the territory. Well depth and well conditions were other two parameters that were taken into account. In particular, the selected wells are representative of the aquifer system hosted in recent alluvial deposits above the impermeable substrate at the depth between 6 and 45 m.

To achieve the intended purposes, field campaigns were performed for the measurement of piezometric levels and physical-chemical parameters (T, pH and electrical conductivity), which are scheduled every two months, as well as the collection of aliquots for subsequent chemical and isotopic analyses, that are to be performed in both dry and wet periods to account for the presence of possible geochemical variations due to the influence of the climatic conditions. Here below, the sampling surveys from June 2019 are reported, as follows:

- 18-20 June 2019 – water sampling and piezometric and physical-chemical measurements
- 18-25 September 2019 – piezometric and physical-chemical measurements
- 2-4 December 2019 – piezometric and physical-chemical measurements

Two non-filtered and two filtered (0.45 μm) and acidified (with ultrapure HCl and ultrapure HNO_3, respectively) water samples were collected in polyethylene bottles for the analysis of anions (and NH_4) and water isotopes ($\delta^{18}O$-H_2O and δD-H_2O) and cations and trace species, respectively. Alkalinity was measured directly in the field and then, checked in the lab by acidimetric titration (AT) with 0.01 N HCl. The analytical error for AT analysis was ≤5%. The main anions (Cl^-, SO_4^{2-}, NO_3^-, Br^- and F^-) and cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) were analyzed by ion chromatography (IC) using Metrohm 761 and Metrohm 861 chromatographs, respectively. The analytical error for the analysis of NH_4^+ (Nessler method) was ≤5% while that of NO_2^- (Hach-Nitriver 3 method) was <3%. The N-species were determined by molecular spectrophotometry using a HACH DR2100 with detection limits were of 0.01 (NH_4^+) and 0.001 (NO_2^-) mg/L. Trace species were determined by ICP-MS (inductively coupled plasma-mass spectrometry) with an analytical error <10%. Water isotopes were measured by liquid water isotope analysis based on the off-axis integrated cavity output spectroscopy. The uncertainties on the $\delta^{18}O$ and δD values were ±0.05‰ and ±1‰, respectively.

The monitoring network points were implemented during the surveys and presently, 46 sites were considered, even if occasionally some points were not accessible (e.g. in December 2019 a well was buried). For each point, the elevation of the reference point (RP) was defined as accurately as possible by using a Leica Geosystems GPS. As part of the September 2019 campaign, multi-parametric probes were installed in three selected wells for continuous monitoring of piezometric level and physical-chemical parameters (electrical conductivity and temperature), plus pressure measurement by means of a baro-thermometric sensor in one of the three wells. After completing the project, two multi-parametric probes will be left into two wells to keep acquiring data under the responsibility of the local personnel and transmitted on a monthly basis to the WP4 components, in order to verify whether the evolution of the considered parameters is fitting with the predicted scenario(s).

An additional "extended" campaign is expected to be carried out in the forthcoming months, i.e. including chemical-isotopic sampling (April 2020), as well as three other bi-monthly campaigns (February, April, June 2020).

3. Ravenna: case study for conceptual model updating

The sites were selected starting from the monitoring networks of previous works ("CSI", "RER, ARPA monitoring network" and "San Vitale, PhD Giambastiani") and related to the shallow groundwater aquifer. In particular, most points were homogeneously distributed in the area of Pineta San Vitale (north of Ravenna), whilst a limited number of points were selected in an innermost area and near the coast. The monitoring network was consisting of 32 points (mostly wells), which were also including specific sampling sites from surface waters. According to very first surveys, the next campaigns will be focused on a selection of sites arranged along two main transects orthogonal to the coastline. In the study area, 25 “buffers” were identified, distributed as homogeneously as possible over the territory, and within each of them the point to be sampled was selected.

In the study area, there were not installed continuous monitoring points of the piezometric level and not water sampling activity. However, in the aforementioned works, some field campaigns were carried out in the study area from 2004 to 2015, in some cases on a monthly basis. These data were acquired and will be used for finalizing the conceptual model of the Ravenna coastal area.

Field campaigns were performed with the same procedures as those in Fano, as follows:

- 23-25 July 2019 – water sampling and piezometric and physical-chemical measurements
- 3-4 December 2019 – piezometric and physical-chemical measurements

The analytical methods for chemical and isotopic analyses were the same as those described for Fano.

An additional “extended” campaign is expected in the forthcoming months (April 2020), as well as three other bi-monthly campaigns (February, April, June 2020) for piezometric and physical-chemical measurements.

4. Neretva Delta Valley: case study for conceptual model updating

The main river-bed of the Neretva river in the downstream part of the system is under the strong influence of the Adriatic Sea and is subject to tidal fluctuations that extend from the river mouth to about 25 km inland. It is an intensely cultivate floodplain delta whose extension has been restricted to 12,000 ha thanks to the activities of numerous land-reclamation projects. The most specific feature of the terrain comprises the lower-laying parcels of predominantly polder-type land, formed in the past by intensive land reclamation and hydro-amelioration. The functionality of the polder-type land system is preserved by the network of pumping stations, which prevents the area from flooding. Due to the high risk of soil salinization and the reduction of crop yields by saline water irrigation and nutrient leaching from the agricultural fields, a soil and water quality monitoring network was established in the Neretva Valley by the public body of Croatian watershed in 2009. The monitoring network was consisting of 22 monitoring points: 15 surface water monitoring points and 7 groundwater monitoring points. These surface water-monitoring points cover three different categories of water bodies:

i) river streams (fed by rainfall, by run-off from upstream fields and by small tributaries and springs that transmit water to the main river streams and lateral canal);

ii) pumping stations (refers to the water supplied at the pumping stations within the polders; groundwater level and the level of water in canals are defined by the flood control project);

iii) drainage canal

Groundwater monitoring points - piezometers positioned at the depth of 4 m, at the location within the polder which represents the dominant land use.

Surfacewater samples were collected on a monthly basis by directly filling a hand-held bottle sampler. Groundwater samples were collected by tube samplers from piezometers, constructed specifically for water sampling.

The following chemical and physical parameters are analyzed in water samples in the laboratory:

Parameter	Method
Ukupne suspendirane tvari	Određivanje ukupne suspendirane tvari s membranskim filterom
pH	ISO 10523:2008 Water quality — Determination of pH
electrical conductivity (EC_w)	HRN EN 27888, 2008. Water Quality - Determination of Electrical Conductivity. International Organisation for Standardisation. Croatian Standard Institute
NO_3-N, NO_2-N, NH_4-N	HRN EN ISO 11732, 2008. Water Quality - Determination of Ammonium Nitrogen - Method by Flow Analysis (CFA and FIA) and Spectrometric Detection. International Organisation for Standardisation. Croatian Standard Institute HRN EN ISO 13395, 1998. Water Quality - Determination of Nitrite Nitrogen and Nitrate Nitrogen and the Sum of both by Flow Analysis (CFA and FIA) and Spectrometric

	Method. International Organisation for Standardisation. Croatian Standard Institute.
dissolved phosphorus	HRN EN ISO 15681-2, 2008.Water Quality - Determination of Orthophosphate and Total Phosphorus Contents by Flow Analysis (FIA and CFA) - Part 2:Method by Continuous Flow Analysis (CFA). International Organisation for Standardisation. Croatian Standard Institute.
K	Water quality — Determination of sodium and potassium — Part 3: Determination of sodium and potassium by flame emission spectrometry
HCO_3^-	Determination of bicarbonate by acid-base titration with H_2SO_4
Ca, Mg	ISO 11885:2009 Water quality — Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES)
Cl and SO_4	ISO 15682:2000: Water quality — Determination of chloride by flow analysis (CFA and FIA) and photometric or potentiometric detection Water quality — Determination of sulphate by flow analysis (CFA)
Na	Water quality — Determination of sodium and potassium — Part 3: Determination of sodium and potassium by flame emission spectrometry
TOC	ISO 20236:2018 Water quality — Determination of total organic carbon (TOC), dissolved organic carbon (DOC), total bound nitrogen (TNb) and dissolved bound nitrogen (DNb) after high temperature catalytic oxidative combustion

The River Neretva is characterized by typical inter-seasonal discharge fluctuations. Hence, two additional sampling campaigns will be performed: in the summer (dry) season (the end of august 2020) and winter (wet) season (December 2020). Ten sampling points along the transect (figure 1) of the Neretva river valley were selected for these additional sampling campaigns. In addition, isotope analysis will be performed in the collected samples (in collaboration with CNR-IGG).

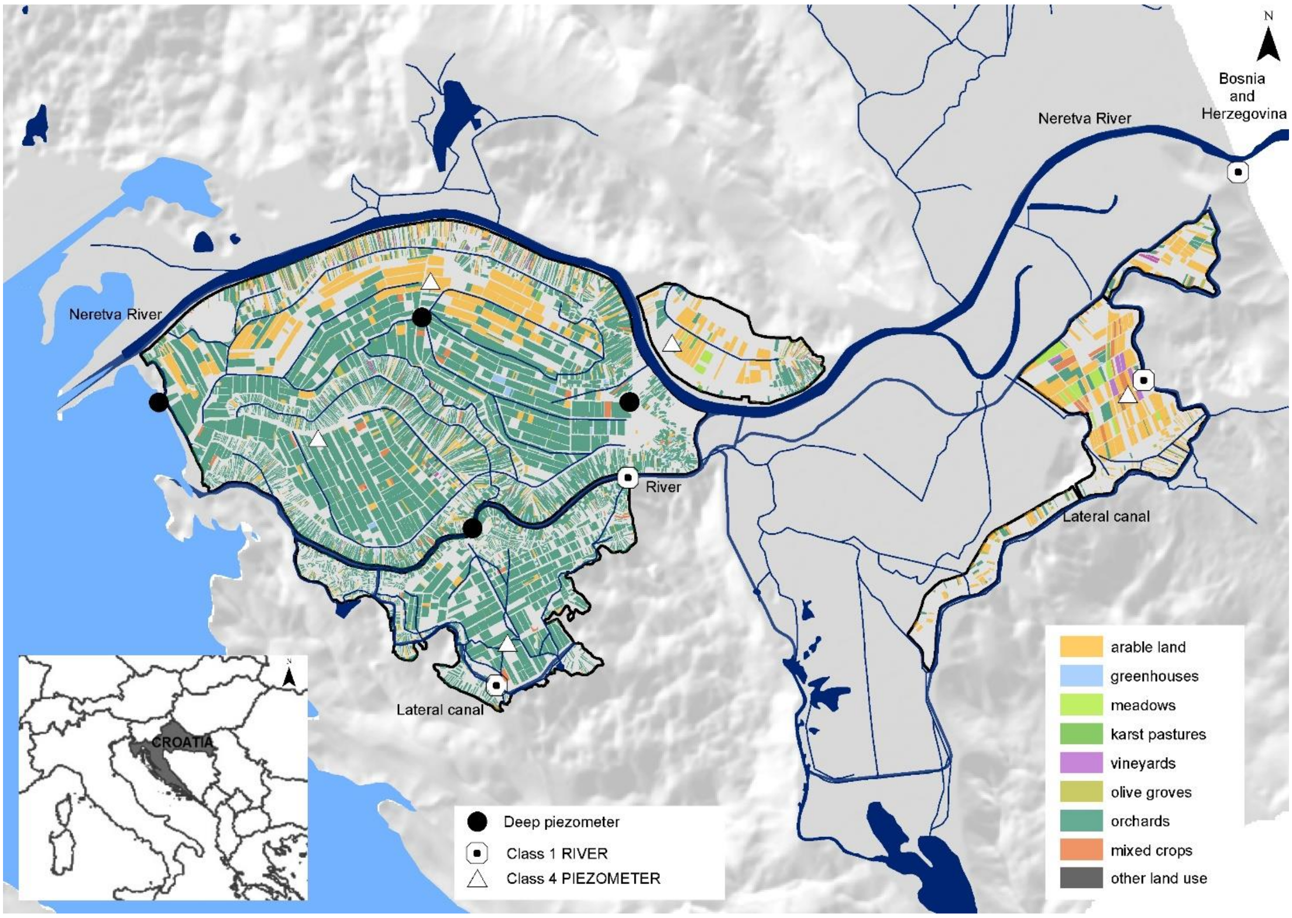

Figure 1. Sampling scheme in the Neretva river valley selected for these additional sampling campaigns