

**Assessment of potential nitrate pollution sources in the Marano Lagoon (Italy) and its
catchment area using a multi isotope approach**

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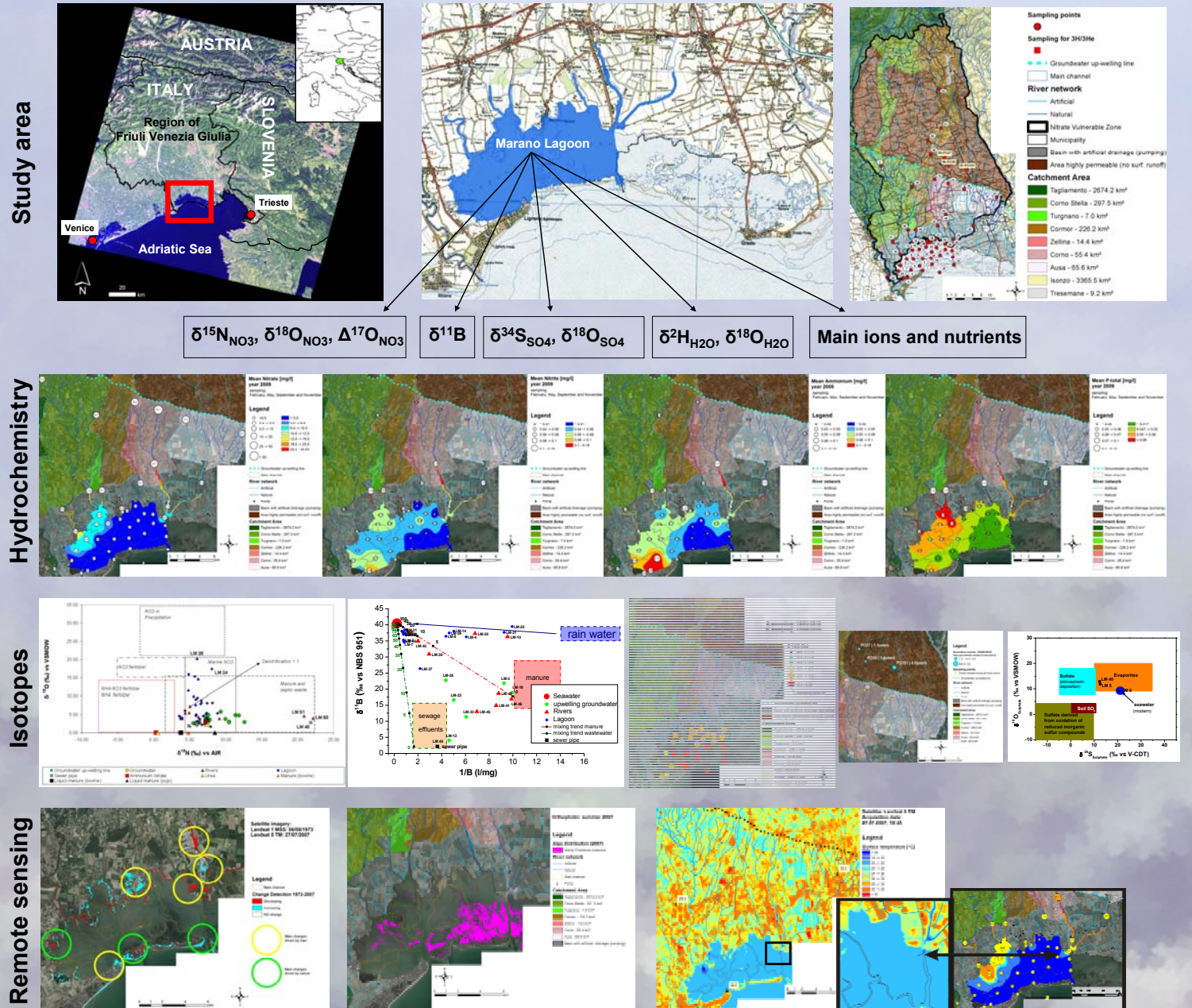
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Introduction. The aims of this study were mainly: (i) the identification and differentiation of the main anthropogenic nitrogen sources in the Marano Lagoon (Italy) and its catchment area; and (ii) the assessment of the intra-lagoonal water circulation, the morphological development of the lagoon and its anthropogenic pressure by applying a combined approach of hydrochemical, isotopic and remote sensing techniques. To achieve the aforementioned targets analyses of stable isotope signatures of nitrate, boron, water and sulphate have been used. Moreover the residence times of groundwater were determined by the tritium-helium dating method. To characterize the chemical composition of the different water types the concentrations of the major ions and nutrients as well as the physicochemical parameters have been measured. Remote sensing techniques have been applied to assess the spatial distribution of most superficial algal flora, water temperature as well as the key environmental and morphological changes of the lagoon since the beginning of the 1970s.



Conclusions. Nitrates detected in groundwater and along the groundwater up-welling line are mainly related to the use of manure (both liquid and solid), while other nitrate sources come from urban waste water as detected in some rivers like Cormor and Corno rivers. In the lagoon it was possible to identify that nitrate can be formed in the lagoon itself by nitrification processes of ammonium coming from both anthropogenic sources as well as from remineralization. Therefore, it can be concluded that the nitrate load in the lagoon, as detected during the monitoring period 2009-2010, was not only derived from agriculture activities but also from other sources like urban waste water, nitrification processes in the lagoon itself as well as from atmospheric deposition. Due to the fact that boron represents a co-migrant of nitrate in anthropogenic pollution sources boron isotopes have been used as an additional tracer to identify different human impacts on aquatic ecosystems. Manure, urban waste water and seawater were the three end-members used for this analysis. The distribution of $\delta^{11}\text{B}$ in the Marano Lagoon and its catchment area was resulting from mixing of anthropogenic boron from urban wastewater and manure (liquid and solid) as well as from boron in seawater. The measured data indicate that most of the samples were influenced by both pollution sources: agriculture and urban waste water. The isotopic compositions in water have been used to characterize the mean altitude of the recharge area of the freshwater samples as well as to identify the origin of groundwater along the groundwater up-welling line. Additionally the water isotopes were used to identify mixing processes between freshwater and seawater within the lagoon. From these results it was possible to confirm that the sampled water along the groundwater up-welling line come from local groundwater. The isotopic signature of sulphate confirmed the influence of Tagliamento river in the western lagoon sector through the Bevazzana artificial channel. Moreover, the analysis conducted in three groundwater irrigation wells in the Upper Friulian Plain has shown that groundwater age is very young in the range between 1.3 and 4.0 years.