Identification and characterization of pit lakes at catchment scale using satellite imagery

Nicola Ghirardi[1,2], Filippo Sidoti[2], Mariano Bresciani[1], Daniele Nizzoli[2], Pierluigi Viaroli[2]

[1] CNR - Institute for Electromagnetic Sensing of the Environment; ghirardi.n@irea.cnr.it; bresciani.m@irea.cnr.it.
[2] University of Parma - Department of Chemistry, Life Sciences and Environmental Sustainability; nicola.ghirardi@unipr.it; filippo.sidoti@studenti.unipr.it; daniele.nizzoli@unipr.it; pierluigi.viaroli@unipr.it.

Abstract. This study focuses on the historical analysis of satellite imagery in order to assess the occurrence of pit lakes in the Po River Basin. The primary aim is to quantify the number, distribution, and major morphometric characteristics of these lakes/waterbodies in order to assess under what conditions they can provide ecosystem services previously supplied by natural lakes and waterbodies which were lost due anthropogenic pressures.

Key words: Po River basin, Remote sensing, Aquatic ecosystems.

1 Introduction

In Italy, about 68×10^6 tons of sand and gravel were extracted in 2014, of which ca. 60% was mined in the Po River basin, corresponding to approximately 300 m^3 km^{-2} y^{-1} [1]. The quarrying activity determines the formation of depressions that modify the morphology and the drainage system in the hydrographic basins. In general, these artificial ecosystems can have both positive and negative impacts on the territory, depending on morphology and morphometry, location and anthropogenic pressures in the watershed. In the last decade, a renewed interest has been growing on quarry lakes as tools for restoring rivers and their floodplains, in order to exploit their ecological functions compared to pristine riverine wetlands and small lakes which were lost due to anthropogenic pressures. In this regard, the primary aim of this study is to quantify the number, distribution, and major morphometric characteristics of these aquatic environments, in order to assess their relevance and suitability for ecological restoration purposes.

2 Material & Methods and future aims

The first step was to find information related to all aquatic environments in the Po River basin through regional geographic information systems [2,3,4,5] and medium-

resolution satellite imagery [6]. This analysis provided an initial screening of the area of interest and allowed the identification of more than 10'000 lentic ecosystems of anthropogenic origin. Of these, more than 2050 have been identified as pit lakes. The classification of active pit lakes was based on the presence of quarry yards and piles of sand and gravel visible from satellite imagery, while the identification of ceased pit lakes was based on their regular morphology, proximity to a watercourse, and the presence of clear residuals of artificial land transformations. Once identified, shapefiles were created in order to obtain information such as perimeter and area. Finally, thanks to an archive of Landsat images from the 1980s to the present day [6], it was possible to establish the beginning and end of the mining activity. Approximately, 430 active pit lakes and 1620 ceased pit lakes have been identified (Fig. 1). Future aims of this study will focus on identifying a subsample of pit lakes on which the analysis of remotely sensed data will be integrated/complemented with data on land use changes and concurrent on site monitoring. Medium-high spatial resolution satellite images will be analysed: Landsat constellation (30 m), Sentinel-2 (10 m) and PRISMA (5 m using the panchromatic band). The images will be atmospherically corrected and the color of the water will be analyzed through Forel-Ule index [7]. After that, neural networks (ACOLITE) [8] and bio-optical modeling (BOMBER) [9] will be applied to the satellite images, in order to obtain water quality parameters (chlorophyll-a and total suspended solids) and information such as bathymetry and type of bottom coverage. Finally, the possible relationships between the color of the water and the different chemical-physical and morphological parameters of the pit lakes and surrounding areas (e.g. land use) will be evaluated.

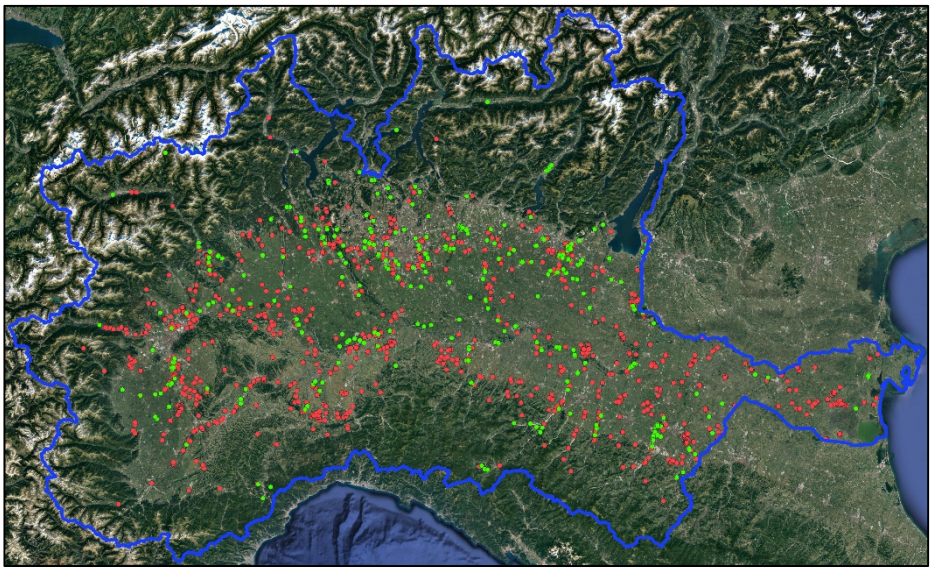

Fig. 1. Po River basin (blue line) from satellite image (Google Earth). Red and green dots represent ceased and active pit lakes, respectively.

References

1. Istituto Nazionale di Statistica. Le attività estrattive da cave e miniere. (2017).
2. Geoportale Valle d'Aosta, https://geoportale.regione.vda.it/
3. Geoportale Piemonte, https://www.geoportale.piemonte.it/cms/
4. Geoportale Lombardia, http://www.geoportale.regione.lombardia.it/
5. Geoportale Emilia-Romagna, https://geoportale.regione.emilia-romagna.it/
6. Global Surface Water Explorer, https://global-surface-water.appspot.com/map
7. Wernand M.R., Hommersom A., Van der Woerd H.J. MERIS-based ocean colour classification with the discrete Forel-Ule scale. Ocean Science. 9(3), 477. (2013).
8. Vanhellemont Q., Ruddick K.: Acolite for Sentinel-2: Aquatic applications of MSI imagery. Proceedings of the 2016 ESA Living Planet Symposium. 9-13. (2016).
9. Giardino C., Candiani G., Bresciani M., Lee Z., Gagliano S., Pepe M.: BOMBER: A tool for estimating water quality and bottom properties from remote sensing images. Computers & Geosciences. 45, 313-318. (2012).