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Land use and land cover changes in Zêzere watershed (Portugal) — Water quality implications

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HIGHLIGHTS

- LUCCs for artificial soils constitute a reduction factor of water quality.
- The wastewater drainage into watercourses is an aggravating factor of water quality.
- Forestry areas in upstream of the dams have higher importance to water quality.
- Maintenance and preservation rules are important to the improvement of water quality.

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ABSTRACT

To understand the relations between land use allocation and water quality preservation within a watershed is essential to assure sustainable development. The land use and land cover (LUC) within Zêzere River watershed registered relevant changes in the last decades. These land use and land cover changes (LUCCs) have impacts in water quality, mainly in surface water degradation caused by surface runoff from artificial and agricultural areas, forest fires and burnt areas, and caused by sewage discharges from agroindustry and urban sprawl. In this context, the impact of LUCCs in the quality of surface water of the Zêzere watershed is evaluated, considering the changes for different types of LUC and establishing their possible correlations to the most relevant water quality changes. The results indicate that the loss of coniferous forest and the increase of transitional woodland-shrub are related to increased water's pH; while the growth in artificial surfaces and pastures leads mainly to the increase of soluble salts and fecal coliform concentration. These particular findings within the Zêzere watershed, show the relevance of addressing water quality impact driven from land use and should therefore be taken into account within the planning process in order to prevent water stress, namely within watersheds integrating drinking water catchments.

1. Introduction

The study of land use and land cover changes (LUCCs) has been developed in recent times in many countries (e.g. Portugal, Spain, France, and others), mainly to understand the impacts of these changes in the territory, in the economy and in the environment and also and mainly to understand the implications on achieving sustainability within development strategies.

These LUCC studies include those that analyze the implications on water resources (Zhang et al., 2014), in particular to understand the cause–effect of these LUCCs in the reduction of water quality and the implications on hydrological processes (Vale, 2002; Seeboonruang, 2012; Warburton et al., 2012; Erol and Randhir, 2013).

The land use and land cover (LUC) and water resources are linked (Vale and Painho, 1999; Gyawali et al., 2013). Water stress is influenced by LUC type in a certain area and from the intensity of use that each type of LUC requires, namely the surface water quality and quantity variation is highly correlated with inadequate anthropogenic practices or vegetation cover degradation processes (e.g. forest fires) (Wang, 2001; Casalí et al., 2010; Hong et al., 2011; Meneses, 2013; Smith et al., 2013).

On the other hand, water bodies reflect these LUCCs, especially when there is a reduction in water quality resources, in many cases caused by population growth, industrial expansion, land use conflicts and/or changes in land management policies (Ahearn et al., 2005; Mouri et al., 2011; Teixeira et al., 2014; Vale and Saraiva, 2012; Valle Junior et al., 2014b, 2015a).

Soil erosion is among the causes of reduction of water quality due to the amount of sediment that arrives to the watercourses and to water reserves (Nunes et al., 2011; OEH, 2012; Meneses, 2014). This is quite relevant in regions where land use intensity combined with land

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occupation type is not in line with soil capabilities (Pacheco et al., 2014; Valle Junior et al., 2014a).

Chemical substances dragged by runoff, depending on their concentration in water, can also reduce water quality (Mouri et al., 2011; Wan et al., 2014). This contamination can also occur if there is leaching of these chemical elements or compounds by sub-surface runoff and the same also arrives in water reservoirs (Valle Junior et al., 2014b).

Due to the shortage of this natural resource in certain places and the high cost associated to water treatment, it is necessary to identify pollution sources, in order to prevent certain types of contamination or deterioration (Meneses, 2013; Yu et al., 2013).

Watersheds that include relevant water catchments used for domestic, agricultural and industrial purposes, require an efficient and well balanced LUC planning, that minimizes negative impacts of certain types of LUC or LUCCs on water, in terms of quality decrease and quantity captured and retained in the soil, or generally available in rivers, lakes or dams (Vale, 2002). In complement, municipalities should account for the intrinsic vulnerability of groundwater reservoirs (Pacheco et al., 2015; Pacheco and Sanches Fernandes, 2013) in their territorial management plans (Valle Junior et al., 2015b).

In the context of LUCCs, guidelines have emerged, most notably in the definition of places to be protected. Providing information from these places and their manipulation by all actors, is increasingly important for the creation of services and new opportunities. These areas are the so-called Smart Regions, that involve public bodies, researchers, companies (also small and medium enterprises) and citizens, following the Linked Open Data orientations currently in implementation (Bauer and Kaltenböck, 2012; Charvat et al., 2014; Dimou et al., 2014; Vale et al., 2015).

2. Main objectives

In this research LUCC assessment was performed using the CORINE land cover (CLC), and water quality variations assessment using water quality data from automatic water sampling stations in a network under governmental supervision.

The main goal of this research is the assessment of the impact of LUCCs in the quality of Zêzere surface waters. Other objectives are as follows: to relate LUCCs with water quality data; to demonstrate the usability LUCC methods in assess of waters impacts in different sectors of a watershed, in this case Zêzere watershed. These techniques can be seen as complementary to identify the potential areas that contribute the most to water quality degradation.

3. Research area

The study area is the Zêzere watershed (area covering 5063.9 km^2), where some of the most important dams of Continental Portugal are located, namely the Castelo de Bode Dam (Fig. 1). This dam supplies drinking water to Lisbon and Western regions of the country covering around ¼ of the Portuguese population. The main watercourse of this watershed is the Zêzere River, it flows into the Tagus River and has as tributaries the Nabão and Unhais rivers.

In the basin upstream sector cambisols predominate, with small areas of fluvisols along the Zêzere River and rankers in the Northwest. The center of the basin is characterized by the predominance of lithosols, with some areas of cambisols. In downstream areas of the basin there are areas of lithosols interleaved with cambisols and luvisols (soil map of Portugal).

The north of study area is located at the Estrela Mountain (Serra da Estrela), with the maximum elevation of 1993 m. Here the annual average precipitation exceeds the 1500 mm (data of Covilhã meteorological station: 1948–2005), while in the areas to the south (minimum elevation 20 m), rainfall is lower (783 mm obtained by data of Tomar meteorological station: 1948–2005).

4. Data, tools and methods

4.1. Water quality data

In the area of study there are automatic stations (St) which register certain water related chemical and physical parameters. These and

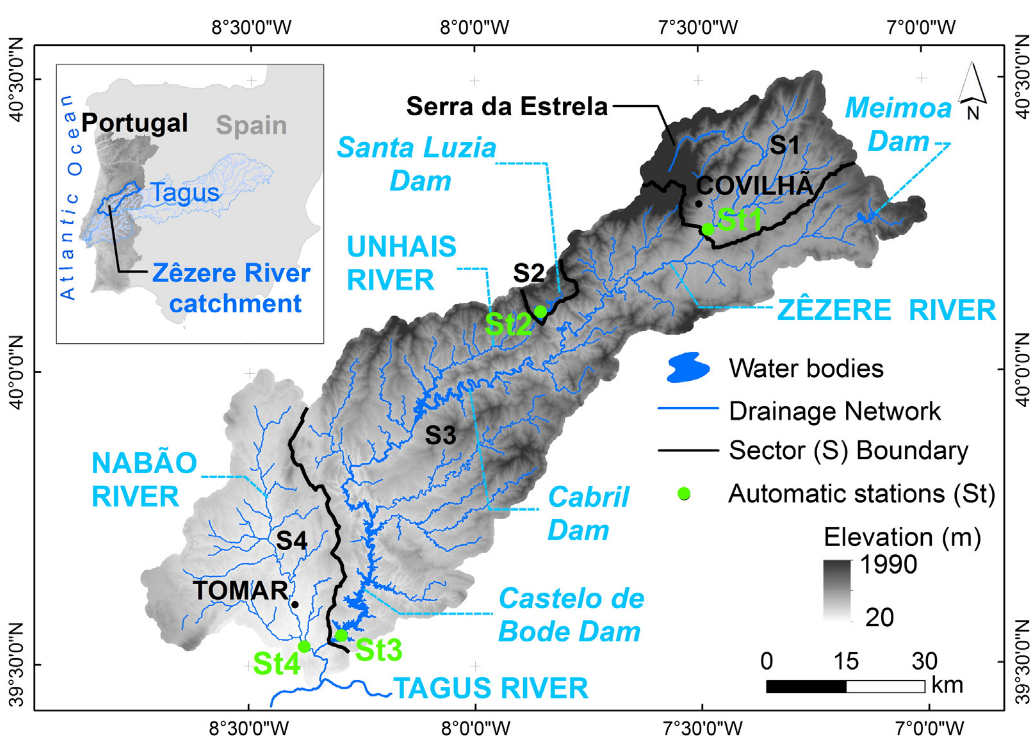

Fig. 1. Zêzere watershed (study area).