Science of the Total Environment 524–525 (2015) 246–259

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Review

Which lesson can be learnt from a historical contamination analysis of the most polluted river in Europe?

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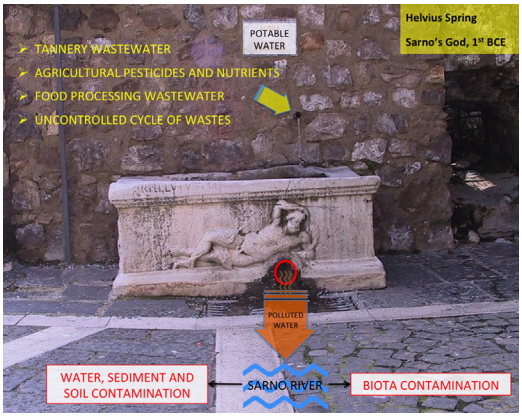
HIGHLIGHTS

- Sarno River is far from reaching the 2015 goal of Water Framework Directive.
- A full knowledge of the health status of Sarno River was provided.
- Poor wastewater management and agricultural pressures as main weaknesses
- Restoration of vital flow and river contracts as immediate and low cost solutions

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 26 December 2014
Received in revised form 8 April 2015
Accepted 8 April 2015
Available online xxxx

Editor: D. Barcelo

Keywords:
Sarno River
DPSIR model
Historical contamination
Water quality
Water management

ABSTRACT

The Sarno River trend analysis during the last 60 years was traced focusing on the socio-economic and environmental issues. The river, originally worshiped as a god by Romans, is affected by an extreme level of environmental degradation, being sadly reputed as the most polluted river in Europe. This is the "not to be followed" example of the worst way a European river can be managed. Data about water, sediment, soil, biota and air contamination were collected from scientific papers, monitoring surveys, and technical reports depicting a sick river. Originally, the river was reputed as a source of livelihood, now it is considered a direct threat for human health. Wastewater can still flow through the river partially or completely untreated, waste production associated with the manufacture of metal products and leather tanning continues to suffer from the historical inadequacy of regional wastewater treatment plants (WWTPs), associated with the partial or no reuse of effluents. All efforts should be devoted to solving the lack of wastewater and waste management, the gap in land planning, improving the capacity of existing WWTPs also via the construction of new sewer sections, restoring Sarno River minimum vital-flow, keeping to a minimum uncontrolled discharges as well as supporting river

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http://dx.doi.org/10.1016/j.scitotenv.2015.04.030

contracts. The 2015 goal stated by the Water Framework Directive (2000/60/EC) is still far to be reached. The lesson has not been learnt yet.

Contents

1. Introduction

When considering the state of rivers, a long history emerges in association with urban ecology, disposal of wastewater and societal and cultural traditions (Libralato et al., 2010a, 2010b; Lofrano and Brown, 2010; Vita-Finzi, 2012; Pinto and Maheshwari, 2014). Decreasing precipitation and (mis-)management combined with administrative and structural constraints, poor environmental planning and inspection and, frequently, a lack of environmental awareness imposed significant pressures on rivers (Skoulikidis, 2009). For a long time, according to the principle "*the solution to pollution is dilution*", dispersion has been the dominant strategy for wastewater management, but not the best habit. Unfortunately, it continues to be practiced in many developed and developing countries (Libralato et al., 2009, 2012; Lofrano and Brown, 2010). The self-depurative capacity of water bodies enabled tolerating the discharge of natural and synthetic chemicals for centuries. Nowadays, water bodies must be protected preventing further degradation of their environmental quality, being the self-depurative capacity compromised by prolonged massive discharges, as in the case of the River Thames (London, UK) (Halliday, 1999; Arienzo et al., 2001; Vita-Finzi, 2012).

The complex network of interactions that binds surface water and groundwater suggests that poor river quality can affect human health and the environment due to the presence of substances and microorganisms with potentially (eco-)toxic effects, thereby leading also to biodiversity loss (Motta et al., 2008; Montuori et al., 2013; Albanese et al., 2013a, 2013b, 2015). Despite strong fragmentation, most rivers are liable to flash floods and low summer flow (Skoulikidis, 2009). Generally, lowland river sections are hydro-morphologically modified, presenting the highest risk of contamination, while upstream areas mostly retain their natural conditions. International treaties and European Union (EU) directives, such as the Water Framework Directive (WFD, 2006/60/EC), have highlighted the urgent need for integrated river basin management. Nevertheless, the WFD aimed to achieve a 'good chemical and ecological quality status' of water bodies by 2015, and its application was occasionally disregarded, with no actions being taken at the local or regional scales (IMPRESS, 2002).

The Sarno River plain (40° 46′ 1.12″ N, 14° 33′ 46.04″ E) in the Campania Region (Italy) is the chief example of how uncontrolled development can affect the future of a land (De Pippo et al., 2006; Albanese et al., 2015). The Sarno flatland is one of the most fertile flatlands in Italy due to the high agronomic quality of its soil, constituted by layers of volcanic and alluvial origins, the presence of water and the favourable climatic conditions (Loiudice et al., 1995; Allevato et al., 2012; Albanese et al., 2013a). In the upper part of the Sarno River basin, tannery has been favoured by pastoralism and freshwater availability since pre-historic times; the third Italian leather tannery district (*Solofra* town) is still located in this area (UNIC, 2013).

In the Sarno basin, human activities have significantly impacted the riverine ecosystem and the water quality of the Gulf of Naples. The first attempt of Sarno River decontamination was in 1973 with the Special Project 3 (SP3) sponsored by *Cassa del Mezzogiorno*, a public body that was created to support the development of southern Italy. The purpose of this attempt was to restore good environmental conditions in the Gulf of Naples after a violent cholera epidemic; this restoration was primarily achieved through wastewater management. Thus, wastewater treatment plants (WWTPs) and the relative wastewater collection system were built. After approximately 40 years and 700 Million €, wastewater is still of great concern (Parliamentary Commission of Inquiry, 2006).

Currently, few scientific papers exist regarding the Sarno River. These studies have investigated environmental riverine issues (Arienzo et al., 2001), as well as the neighbouring lands (Adamo et al., 2003), discussing hydrogeological conditions (De Pippo et al., 2008) or health risks that are associated with living near this river (Motta et al., 2008; Vigliotta et al., 2010). A comprehensive evaluation of environmental criticisms, their origin and future trends on this "not-to-be followed" example of the worst way a European river can be managed is currently missing.

The authors assessed the river catchment development in the last 60 years (1951–2014), considering socio-economic and environmental issues, collecting information from scientific papers, public datasets, and technical monitoring reports, highlighting an extreme case of environmental problems within the EU. The impacts of a range of environmental pressures were described in detail along with the