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Sources of bathing water pollution in northern Tuscany (Italy): Effects of meteorological variables

Ileana Federigi, Marco Verani, Annalaura Carducci *

Laboratory of Hygiene and Environmental Virology, Department of Biology, University of Pisa, Via S. Zeno 35/39, 56127 Pisa, Italy

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ABSTRACT

This study was carried out in a popular tourist destination located in Italy, where short-term pollution posed the problem of low quality status of bathing waters (according to European Directive) owing to the fecal contamination caused by drainage ditches. Our goal was to understand the role of meteorological conditions on freshwater and seawater bacterial indicator levels, and the impact of polluted streams on seawater contamination. To this aim, results from surface waters were analyzed during five bathing seasons, from 2011 to 2015. Our results demonstrated a relationship between bacterial densities and rainfall amount and a time-dependent dilution effect of the sea between the two halves of each bathing season. This analytical survey confirmed the strategic role of meteorological variables in bathing waters quality, and it could be a support for generation and development of predicting models of indicator levels for bathing area.

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1. Introduction

Numerous water-borne diseases can be acquired by swimmers after exposure to pathogen-polluted recreational waters, commonly termed recreational waterborne illness (RWI) (WHO, 2005; Dorevitch et al., 2010). Gastroenteritis is the most common illness, although other diseases can occur, such as infections of the upper respiratory tract, ears, eyes, nasal cavity and skin. The true incidence of the outbreak counts and cases are underestimated, many infections go unreported to surveillance system due to self-limiting symptoms, small outbreak size and transient nature of water contamination, as reported by Hlavsa and coworkers in a recent report on illness associated with recreational water in United States (CDC, 2015). The World Health Organization places in two classes the pathogens involved in recreational exposure diseases: autochthonous pathogens are free-living organisms that include harmful algae, species in the genus *Vibrio* and *Aeromonas*, and some protozoa such as *Naegleria fowleri*, whereas allochthonous pathogens are enteric pathogens which are introduced to recreational water bodies through human or animal fecal contamination discharged into the sea by raw or insufficiently treated wastewaters (Grassi et al., 2010; Boehm and Soller, 2013). Among these two groups, allochthonous pathogens such as enteric viruses (especially Noroviruses and HAV), bacteria (*Salmonella* spp., *Shigella* spp.) and protozoa (*Giardia* and *Cryptosporidium* spp.) are the main etiological agents of waterborne diseases associated with recreational activities, responsible for 90% of

etiologically confirmed cases over the past decade in the United States (CDC, 2006, 2008, 2011, 2014, 2015). This is because coastal areas have always been attractive for developing of human activities (e.g. settlement, tourism, agriculture, fisheries), but rapid urbanization nearby and on coastline represent a pollution pressure on marine water quality, with point and diffuse source of fecal contamination (Verhougstraete et al., 2015). Hence, many bathing waters suffer from elevated levels of fecal microorganisms (Wright et al., 2009; Love et al., 2014).

For this reason the ongoing legislations on bathing water quality are based on fecal bacteria monitoring, *Escherichia coli* and intestinal enterococci, as settled e.g. in the European regulation (BWD, 2006/7/EC) and USA recommendation (USEPA, 2012). The limit value and classification are based on epidemiological studies that demonstrate a link between fecal-contaminated waters and water-borne diseases, gastroenteritis and acute febrile respiratory illness (Kay et al., 1994; Fleisher et al., 1996; Wiedenmann et al., 2002). Besides the significance for public health, recreational water quality is an important indicator of tourism development. Clearly, beach advisories and closures due to lack of compliance with bathing suitability requirements or low quality status of bathing waters (according to European Directive) have a negative impact on economy of coastal areas. From literature, water quality impairment is often associated with meteorological conditions: several studies conducted worldwide on coastal environment under anthropic pressure, from China (e.g. Zhang et al., 2013) to the USA (e.g. Tilburg et al., 2015) and Europe (e.g. De Donno et al., 2003; Viegas et al., 2012), demonstrate high fecal contamination of river waters during wet periods and subsequently degeneration of bathing waters quality in which rivers flow. During periods of heavy rainfall, the amount of both point and non-point fecal contamination enhanced, due to the increasing of

* Corresponding author at: Department of Biology, University of Pisa, Via S. Zeno 35/39, I-56127 Pisa, Italy.

E-mail address: annalaura.carducci@unipi.it (A. Carducci).

total surface runoff or overload of sewer systems that are into communication with urban storm drainage system, depending on the specific feature of each coastal area. In a complex system such as anthropized coastal areas, it is extremely difficult to assign microbial densities to a specific source of contamination, mainly under different weather conditions.

The aim of this work has been to study the dynamic of the main sources of pollution and the role of meteorological conditions in a marine urban area located in Central North of Italy, which bathing waters are interested by short term pollution episodes. To this aim, Municipality started in 2011 routine analytical controls along the course of the two rivers flowing into the sea in this area. In the meantime, to improve quality status of recreational waters a series of sanitation measures were undertaken, such as improvement of wastewater treatment and disinfection of drainage pump tanks. Time trend of microbial contamination in freshwater and seawater was investigated, and effect of rainfall on bacteriological parameters were also taken into account, using historical data of bathing seasons from 2011 to 2015.

2. Materials and methods

2.1. Study location and sampling sites

Monitoring area is a popular tourist destination situated in the north of Tuscany, densely populated with 160,000 residents along a 20 km seacoast. Urbanized area is built on a alluvial plain, with a complex storm water drainage system and municipal sewer. Rivers passing through the urban area collect several different sources of

contamination from sewage and non-sewage related sources, due to matters in drainage and wastewater management, with combination of sewage with storm water runoff in the same pipe. Marine waters used for recreational purpose are sometimes interested by episodes of fecal contamination, and for this reason about 2 km of seawaters have been classified as “sufficient” for 2015 bathing season (according to the BWD, 2006/7/EC). In this bathing area, the most important sources of fecal contamination are the riverine discharges of two ditches, which are outputs of the entire catchment areas draining to nearshore recreational waters. These drainage ditches receive polluted waters from wastewater treatment plants (WWTPs) and surface runoff, thus they represent a source of fecal contamination for seawater in which they flow. The location of the study area and the detail of the sample collection sites for each river are shown in Fig. 1.

2.2. Microbial and meteorological data

In a five years study (from 2011 to 2015), data on fecal contamination were collected during bathing seasons. Monthly samples from the sea at the river mouths were obtained from Environmental Protection Agency Tuscany Region (ARPAT, recreational water database) and weekly sampling from several monitoring points along watercourses were kindly donated by Municipality: 10 sampling points for River No1 and 13 for River No2. Samples were analyzed for bacterial indicators (*Escherichia coli* and intestinal enterococci), determined by international standard methods: ISO 9308–3 and ISO 7899–1, respectively. Rainfall amount was also recorded for the sampling dates from Tuscany Hydrological Service website (SIR, daily rainfall database).

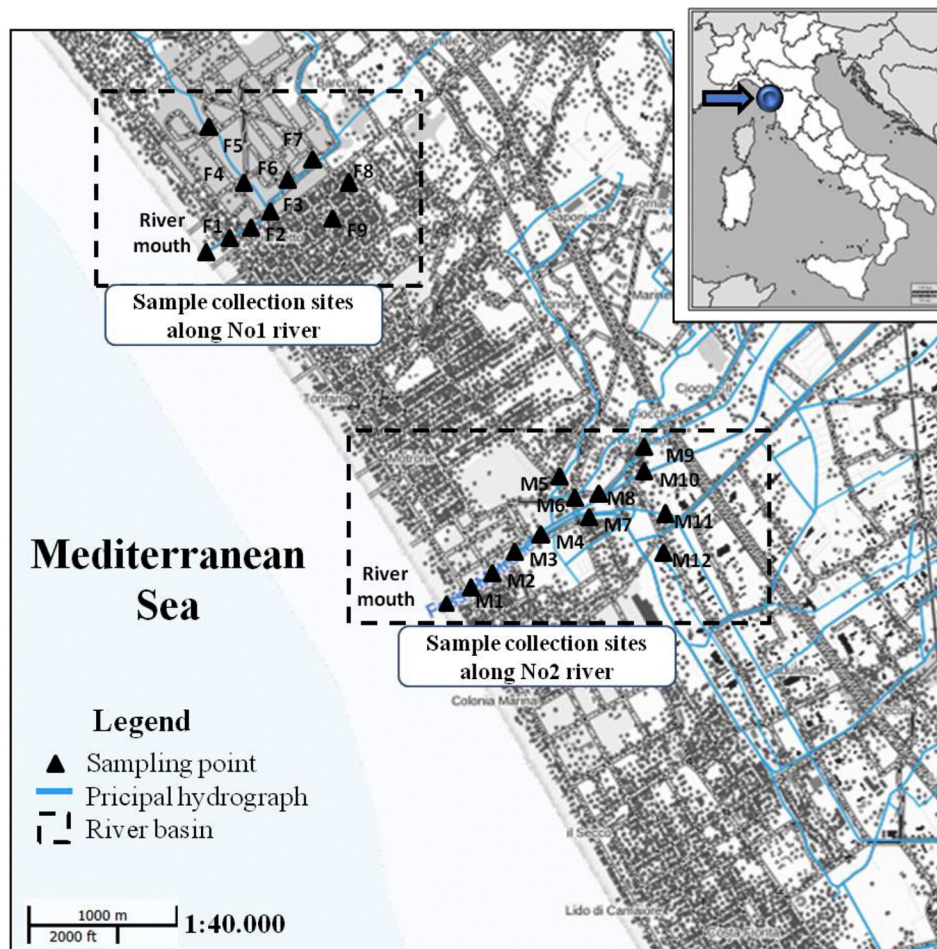


Fig. 1. Location of the study area indicating the river mouths and sampling sites for each river.

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