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Baseline

Assessing sewage impact in a South-West Atlantic rocky shore intertidal algal community

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ABSTRACT

The spatial and seasonal variation of the specific composition and community parameters (abundance, diversity, richness and evenness) of the intertidal algal assemblages was studied at four coastal sampling sites, distributed along an environmental gradient from the sewage water outfall of Mar del Plata, Buenos Aires, Argentina. Two of them were located close to the sewage outfall (<800 m) (impacted area) and the two other were 8 and 9 km distant (non-impacted area). The algal abundance was monthly analyzed from October 2008 to May 2009. The algal assemblages varied according to the pollution gradient in spring, summer and autumn, being autumn the season when the highest difference was observed. *Ceramium uruguayense* was recognized as an indicator species for the non-impacted areas, while *Berkeleya* sp. represented an indicator species for the sewage outfall impact. *Ulva* spp. did not reflect the typical pattern observed for other sewage pollution areas.

The structure of intertidal macroalgal communities changes along the coastline in relation to environmental salinity gradients, wave action, and the slope and texture of substrates (Lobban et al., 1985). Human activity impacts on benthic macroalgal communities through waste waters, urban runoff or chemicals spilled in coastal areas, which can lead to a decrease in macroalgal species richness and abundance; with a consequent simplification of the community structure (Borowitzka, 1972; Littler and Murray, 1975; Díez et al., 1999). Inversely, the abundance of opportunistic species with high reproductive capacity and a wide tolerance range to pollution is expected to increase (Murray and Littler, 1978; Fairweather, 1990; Gorostiaga and Díez, 1996; Soltan et al., 2001; Dongyan et al., 2007). Contamination by sewage outfall is the main anthropogenic stressor in many intertidal macroalgal communities of rocky shores around the globe (Borowitzka, 1972; Littler and Murray, 1975; López Gappa et al., 1990, 1993; Díaz et al., 2002; Arévalo et al., 2007; Dongyan et al., 2007). High nitrogen input from sewage outfalls was observed to promote the development of early successional stages of macrophytes in the surrounding communities (Soltan et al., 2001; Bokn et al., 2003; O′ Shanahan Roca et al., 2003) because of their high nutrient requirement (Karez et al., 2004; Kraufvelin, 2007).

European countries adopted the Water Framework Directive (WFD) in 2000 in order to protect and manage European water bodies. The WFD identified macroalgae as a suitable biological indicator for the water quality and suggested that they provide an appropriate statistical tool for the assessment of the ecological status of coasts (Soltan et al., 2001; Pinedo et al., 2007; Patrício et al., 2007; Juanes et al., 2008). The use of macroalgae as bio-indicators in water bodies was based on their prolonged exposure to adverse conditions, altering the structure of communities. Several pollution indexes were used in the Northern Hemisphere, mainly based on the relative abundance of some macroalgal indicator species (Orfanidis et al., 2001; Orfanidis et al., 2003; Ballesteros et al., 2007; Wells et al., 2007; Neto et al., 2012). A systematic assessment of macroalgal communities is required to properly evaluate the level of pollution of any waterbody, and to understand the relationship between abundance, diversity and richness of macroalgal communities and environmental factors, as was previously observed for several areas of the European coast (Krause-Jensen et al., 2007; Ballesteros et al., 2007; Wells et al., 2007; Puente and Juanes, 2008).

Several studies were conducted in the Southwestern Atlantic in order to evaluate different types of coastal impacts, mainly the sewage impact on littoral communities (López Gappa et al., 1990; Díaz et al., 2002; Vallarino et al., 2002; Elías et al., 2006; Torres and Caille, 2009; Muniz et al., 2011; Jaubet et al., 2011; Sánchez et al., 2013). Most of them were focused on the intertidal macrofauna, rejecting the macroalgae species response to that impact.

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In this study, we compared the algal assemblages in the rocky shore intertidal communities nearby the sewage outfall of Mar del Plata city with two non-impacted control areas; with respect to their specific composition and community parameters (abundance, diversity, richness and evenness). The aim of the study was to provide a valuable tool for the assessment of the wastewater pollution impact on the mid-littoral communities in the area by means of the intertidal algal assemblage composition.

Mar del Plata city is placed at the Southwest Atlantic coast of Argentina (38° 00′S; 57° 32′W) (Fig. 1).The shoreline is characterized by many sandy open beaches alternating with abrasion platforms of consolidated loess, forming cemented sandstones (Amor et al., 1991). The coastline is influenced by a littoral current, predominantly flowing from South, and undergoes severe wind storms (from the SSE sector) mainly during autumn and winter. Tides have a semidiurnal regime, with a tidal amplitude range around 0.8 m; and 1.6 m during exceptional tides. Sea surface temperature ranges between 9.3 °C in winter and 20 °C in summer (Guerrero and Piola, 1997), while seawater pH stays between 7 and 8.5 (Isla et al., 1998).

Mar del Plata has a sewage pre-treatment plant since 1989. The sewage is first screened to remove large particulates (>0.5 mm) and finally delivered to the intertidal sector of the coast (Scagliola et al., 2006). Mar del Plata is one of the major seaside resorts of Argentina, being visited by over 2,000,000 people during the summer season (December to February) (Bouvet et al., 2005). Consequently, the sewage average discharge increases from 2.8 m^3 seg^{-1} in winter to 3.5 m^3 seg^{-1} in summer (Scagliola et al., 2006). The environmental features in the study area were previously analyzed by Sánchez et al. (2013). They observed that both sediment organic matter and water turbidity in impacted areas were 1% and 50% respectively higher than in non-impacted areas.

Four sampling sites were distributed at the intertidal loess platforms with different distances from the sewage outfall (Fig. 1). Two of them were located 125 m (site E) and 800 m (site I1) south from the outfall, and the two other were located 8 km (site C1) and 9 km (site C2) north from the outfall. Sampling sites C1 and C2 were considered as non-impacted areas according to previous studies (Elías et al., 2009; Vallarino et al., 2014). Only rocky substrates with similar slope, orientation and wave exposure were compared. Two transects perpendicular to the coastline and ca. 50 m far from each other, were sampled at each site. All transects comprised the mid-littoral level of the local eulittoral zone (about 6 m long) (Raffaelli and Hawkins, 1999). The relative abundance of algae was assessed within each transect using a 0.5 × 0.5 m sampling unit, placed at regular intervals of 1.5 m, where the cover (%) of individual species was visually estimated. A total of 5 sampling units were sampled at each transect. The species were identified to the lowest possible taxonomical level. A preliminary identification was made in situ in order to estimate the different species coverage. The species were collected and latter identified at the laboratory. Even though the study was focused on the macroalgal community, the diatom *Berkeleya* sp. was considered in the data analysis as it was present with very high abundance near the sewage outfall, forming an evident biofilm on the substratum. Although the species was present at the non impacted area, biofilm was never observed. Sampling was performed during low tides in spring (October, November and December 2008), summer (January and February 2009) and autumn (April and May 2009).

The total abundance of algae (N), species richness (S), Shannon–Wiener diversity index (H′) (Shannon and Wiener, 1963) and evenness index (J′) (Pielou, 1969) were calculated for each sampling unit. The variation of these indexes between sampling sites was tested using

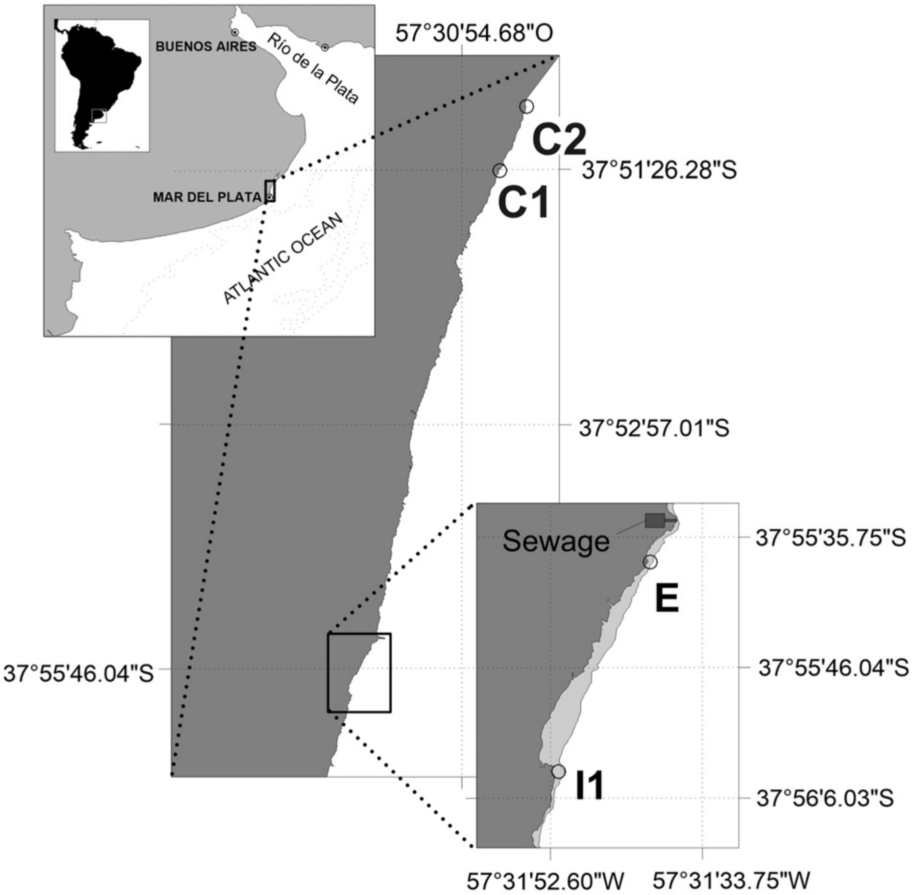

Fig. 1. Distribution of sampling sites and sewage outfall location in the study area.