Desalination 291 (2012) 94–100

Contents lists available at SciVerse ScienceDirect

Desalination

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

Variability of macrofaunal assemblages on the surroundings of a brine disposal

Rodrigo Riera [a,*], Fernando Tuya [b], Eva Ramos [a], Myriam Rodríguez [a], Óscar Monterroso [a]

[a] Centro de Investigaciones Medioambientales del Atlántico (CIMA SL), Arzobispo Elías Yanes, 44, 38206 La Laguna, Tenerife, Canary Islands, Spain
[b] BIOGES, Universidad of Las Palmas de G.C., 35017 Las Palmas de Gran Canaria, Canary Islands, Spain

ARTICLE INFO

Article history:
Received 14 September 2011
Received in revised form 22 December 2011
Accepted 2 February 2012
Available online 23 February 2012

Keywords:
Macrofauna
Amphipoda
Polychaeta
Brine discharge
Desalination
Canary Islands

ABSTRACT

Desalination plants generate large volumes of hypersaline brine, likely affecting recipient communities. We aimed to assess whether proximity to a brine discharge point altered the abundance, assemblage structure and diversity of macrobenthic fauna. Collection of samples took place twice (May 2008 and January 2009) at 0, 15 and 30 m away from a brine discharge point. Total macrofaunal abundance increased with increasing distance from the brine discharge point, though the magnitude of differences was inconsistent between successive years, probably as a result of a change in particle size distribution. Proximity to the brine discharge point also altered patterns in macrofaunal assemblage structure. The macrofaunal species density was higher at 15 and 30 m than at 0 m. In conclusion, proximity to a brine discharge point significantly altered the ecological pattern of macrobenthic fauna, though disentangling the effect of the increase in salinity from particle size distribution remains undetermined.

1. Introduction

The number of desalination plants in regions with freshwater limitations has been increasing over the last decades, particularly in the southern countries of the northern hemisphere, to cover the necessities of their populations and industrial and agricultural activities as well [1,2]. Irrespective of whether the process used is reverse osmosis' or distillation', desalination plants generate notable volumes of hypersaline brine, which are then discharged back into the sea and may, therefore, affect recipient biological communities [15]. The reverse osmosis' method is the preferred desalination process, mainly due to the low energy and space consumption and the reduction in the cost of obtained potable water [17,30,34].

When the brine is discharged into the sea, the density difference between the brine and the seawater induce the formation of a stratified system. As a result, the brine creates a bottom layer that can subsequently affect benthic communities living in environments under natural salinity conditions [13,19]. The release of brine (~44–90 PSU salinity) is generally accompanied by different chemical products (e.g. antiscalant, antifouling, hydrochloric acid, ferric chloride, sodium hexametaphosphate, etc.) used during desalination processes [26,33]. The magnitude of the impact over those biological communities living in the surroundings of any brine discharge point depends on both the volume of the brine disposal, which typically depends on the size of the desalination plant, as well as on the sensitivity of those communities that are recipient of the effluent [7,26]. Available information on the effects of these hypersaline effluents over faunal assemblages are, however, extremely limited [9,10,35]. These potential impacts may be minimised by selecting an appropriate discharge location, and/or through a previous dilution of the effluent. It is also important, moreover, to establish a carefully designed monitoring plan to assess the dispersion of any brine plume over time, in order to adopt appropriate measurements whenever necessary [17,18,25]. The aim of this study was, therefore, to assess the effect of proximity to a brine discharge point over the abundance, assemblage structure and diversity of macrobenthic faunal assemblages living on soft bottoms.

2. Materials and methods

2.1. Study area and sampling design

This study was conducted around Las Burras desalination plant, located south off Gran Canaria (27º45´55 N, 15º33´01 W), which began to operate in 1999 (Fig. 1). The plant has a brine outfall approximately 300 m long running offshore. The diameter of the outfall is ~60 cm, and discharges through an open mouth' at 7 m depth on a soft bottom. The volume of seawater collected for desalination is approximately 42,000 m^3 day^{-1}, with an estimated production of potable water of ca. 25,000 m^3 day^{-1}. As a result, the volume of brine discharged everyday is ca. 17,000 m^3 day^{-1}. Salinity at the brine discharge point ranged between 47 and 50 PSU throughout the entire study (Table 1). At 30 m away from the brine disposal

* Corresponding author.
E-mail address: rodrigo@cimacanarias.com (R. Riera).

0011-9164/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.desal.2012.02.003

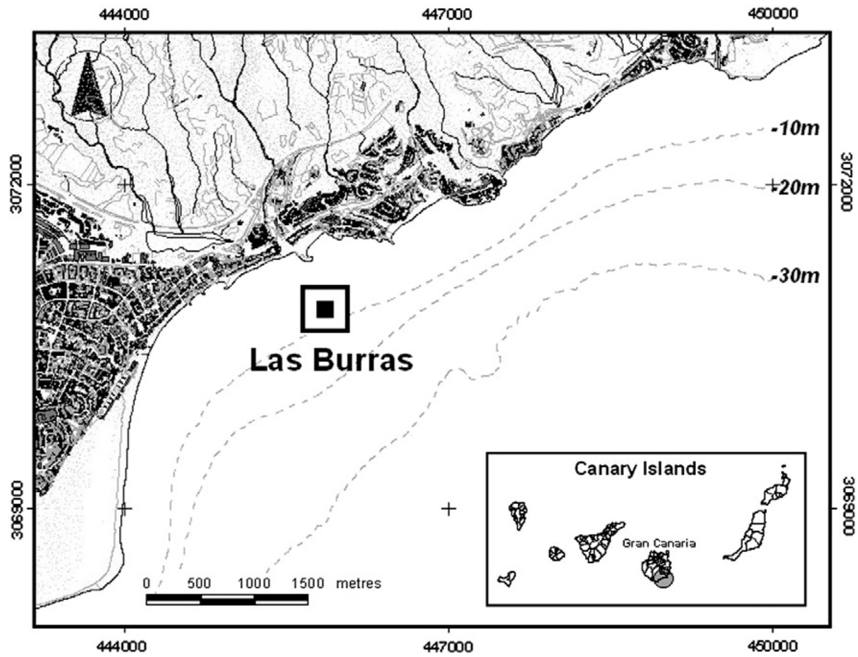

Fig. 1. Map of the study area, showing the location of the brine discharge point.

point, salinity ranged at natural values, i.e. between 36.6 and 36.8 PSU (Table 1). Indeed, a dilution from 75 to 38 PSU within 20 m from a brine outlet has been registered in a zone adjacent to the study area [38], and so samples at 30 m away from the outfall can be considered as controls.

Table 1
Mean (±SE) values of abiotic variables located at different distances (0, 15 and 30 m) from the brine discharge point.

	May 2008		
	0 m	15 m	30 m
Pore water salinity	45.6 ± 1.2	38.7 ± 0.7	36.6 ± 0.2
Water column salinity	48.9 ± 2.7	40.1 ± 1.2	36.7 ± 0.2
Water column temperature (°C)	20.64 ± 0.3	20.61 ± 0.04	20.61 ± 0.04
Water column pH	8.17 ± 0.02	8.17 ± 0.02	8.17 ± 0.02
Chlorophyll-a (μg/l)	0.3 ± 0.2	0.2 ± 0.2	0.2 ± 0.2
Sediment: total nitrogen (mg/kg)	<1	<1	<1
Sediment: total phosphorus (mg/kg)	7.80 ± 2.33	3.93 ± 0.55	3.13 ± 0.77
Sediment: organic matter (%)	0.39 ± 0.06	0.25 ± 0.01	0.21 ± 0.06
Sediment: gravels (%)	1.28 ± 0.61	0.34 ± 0.17	0
Sediment: very coarse sands (%)	8.28 ± 2.05	0.99 ± 0.85	0
Sediment: coarse sands (%)	46.67 ± 5.15	4.99 ± 3.80	0
Sediment: medium sands (%)	16.84 ± 4.13	4.56 ± 2.78	0.26 ± 0.13
Sediment: fine sands (%)	6.67 ± 0.96	28.10 ± 2.19	21.07 ± 5.03
Sediment: very fine sands (%)	14.26 ± 3.82	48.33 ± 6.63	61.08 ± 4.12
Sediment: silt/clay (%)	6.01 ± 1.47	12.68 ± 1.29	17.61 ± 1.16
	January 2009		
	0 m	15 m	30 m
Pore water salinity	45.1 ± 1.4	38.5 ± 0.6	36.4 ± 0.3
Water column salinity	48.4 ± 2.5	40.1 ± 1.3	36.8 ± 0.3
Water column temperature (°C)	19.54 ± 0.4	19.12 ± 0.2	19.11 ± 0.3
Water column pH	8.15 ± 0.03	8.16 ± 0.02	8.17 ± 0.03
Chlorophyll-a (μg/l)	0.2 ± 0.1	0.2 ± 0.2	0.2 ± 0.1
Sediment: total nitrogen (mg/kg)	1 ± 0.1	1.2 ± 0.2	1.2 ± 0.3
Sediment: total phosphorus (mg/kg)	6.17 ± 1.83	4.33 ± 0.55	9.30 ± 4.26
Sediment: organic matter (%)	0.48 ± 0.02	0.63 ± 0.10	0.46 ± 0.07
Sediment: gravels (%)	2.33 ± 1.18	36.98 ± 17.72	5.11 ± 3.51
Sediment: very coarse sands (%)	9.98 ± 1.78	9.78 ± 2.34	17.71 ± 2.72
Sediment: coarse sands (%)	50.97 ± 3.14	31.43 ± 14.46	55.49 ± 3.59
Sediment: medium sands (%)	14.94 ± 3.32	14.22 ± 3.93	17.50 ± 1.23
Sediment: fine sands (%)	8.79 ± 2.92	3.98 ± 2.33	2.30 ± 1.05
Sediment: very fine sands (%)	12.47 ± 5.68	2.97 ± 2.06	1.33 ± 1.01
Sediment: silt/clay (%)	0.51 ± 0.11	0.63 ± 0.2	0.56 ± 0.18

Collection of samples took place at a distance of 0, 15 and 30 m away from the brine discharge point. Collections at 0 m were as close to the brine discharge point as possible; a slight underestimation of the real distance was then assumed, though in terms of sampling design we will refer this level as “0 m” throughout the entire manuscript. Sediment cores (20 cm inner diameter) were pushed into the sediment, with the help of a hammer, to a depth of 30 cm. Nine replicates ($n = 9$) were collected randomly for faunistic determinations at each distance, while three cores at each distance were additionally collected for analysis of abiotic variables. Since sediment features, such as size and the content of organic matter, influence soft-bottom macrofaunal assemblages [23,32], we proceeded to quantify these two attributes as a way to estimate their effects over the patterns of abundance and assemblage structure of macrofauna located at different distances from the brine discharge point. The sediment characteristics might co-vary with salinity, since they could be indirectly affected by either the brine plume or directly by the physical presence of the outfall. The level of replication was based on a previous study [36]. Sampling was repeated twice: at May 2008 and January 2009, to determine whether patterns were consistent when measured at different times.

2.2. Analysis of abiotic factors

To assess the particle size distribution of the sediment, ca. 100 g of sediment from each sample was oven dried at 105 °C, passed through a graded series (mesh size of 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm and 0.063 mm) of sieves, and then dry weighed [8]. The method of [41] was used to determine the organic matter content of the sediment through dichromate oxidation. Total nitrogen was determined following the Kjeldahl method [6], by digestion with sulphuric acid, and total phosphorus concentration was calculated using a spectrum-photometric method [31]. Water column parameters (salinity, temperature, pH and Chlorophyll concentration: Chl-a) were determined by means of a SBE9plus CTD along a vertical profile from the seabed to the sea surface; we took measurements on the bottom and at the surface as the most representatives (Table 1). Water samples