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Do treatments of sewage plants really work? The intertidal mussels' community of the southwestern Atlantic shore (38ºS, 57ºW) as a case study

¿Funcionan realmente las plantas de tratamiento de aguas residuales? La comunidad de bivalvos intermareales del Atlántico sudoccidental como caso de estudio

**Rodolfo Elías[1], María S. Rivero[1], María A. Sanchez[1],
Lourdes Jaubet[1] and Eduardo A. Vallarino[1]**

*[1]Departamento de Ciencias Marinas -Bioindicadores Bentónicos. Universidad Nacional de Mar del Plata
Deán Funes 3350 B 7602 AYL, Mar del Plata, Argentina
roelias@mdp.edu.ar*

Resumen.- Para evaluar el efecto de la planta de tratamiento de efluentes domésticos de Mar del Plata, se realizó una serie de muestreos en los alrededores de la salida de dicho efluente. La hipótesis es que la planta produce un significativo mejoramiento de la salud ambiental, y que los métodos de cobertura y los cuantitativos producen resultados similares siendo ambos efectivos para determinar impacto por efluentes cloacales en comunidades de bivalvos intermareales. Los muestreos fueron efectuados en cuatro localidades (Impactada, Norte, Sur y Control), con tres estaciones ubicadas en cada localidad. Se obtuvieron muestras replicadas de cobertura (diez marcos de 0,5 m^2) y de datos cuantitativos (cuatro cilindros de 78 cm^2) en cada estación, cuatro veces a lo largo del 2004, antes y después de cada una de las dos paradas de mantenimiento de la planta. Los análisis incluyeron métodos no paramétricos y paramétricos para los datos de cobertura y los cuantitativos. Los resultados mostraron diferencias significativas para ambos tipos de datos para localidades y para Antes-Después, tanto en los análisis paramétricos como en los no paramétricos. El funcionamiento de la planta de tratamiento tiene un efecto significativo en la salud del medio, como muestra la estructura de la comunidad bentónica intermareal.

Palabras clave: Bancos de bivalvos, impacto por cloacas, costa rocosa del Atlántico sudoccidental

Abstract.- To test the effect of the treatment plant of the Mar del Plata city, a series of samplings were carried out in the mussel beds around the sewage effluent. The hypothesis is that this treatment plant produces an effective mitigation process in the health of the environment, and cover and quantitative methods produce similar results being both useful for assessing sewage impact in intertidal mussels' community. Samplings were performed in four locations (Impacted, North, South and Control) and three stations were placed into each location. Replicated cover (ten 0.5 m^2 squares) and quantitative (four 78 cm^2 corers) data were obtained in each station four times during 2004, before and after each of the two stops of the treatment plant for maintenance. Analyses included non-parametric and parametric methods for both cover and quantitative data. Results showed significant differences in both cover and quantitative data for Before-After and among locations, in both parametric and non-parametric analyses. The functioning of the treatment plant has a significant effect on the health of the environment, as shown by the structure of the intertidal benthic community.

Key words: Mussel beds, sewage impact, SW Atlantic rocky shores

Introduction

Today, approximately 3 billion people - about half of the world's population - live within 200 km of a coastline. By 2025, that figure is likely to double. Most coastal countries discharge domestic wastes into the sea, because ocean disposal is still considered a cost-effective method for urban wastes due to the dilution effect. In the United States of America the wastes generated by the population are collected in sewer systems and carried along by some 14 billion gallons of water a day. Of this enormous volume, some 10% is allowed to pass untreated into rivers, streams, and the ocean[1]. In Latin America this proportion could reach almost 100% in some areas.

The simplest and least effective method of treatment is to allow the undissolved solids in raw sewage to settle out of suspension forming sludge. Such primary treatment removes only one-third of the Biochemical Oxygen

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[1] http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/S/SewageTreatment.html

Demand (BOD) and virtually none of the dissolved minerals. However, many treatment plants in Northern Hemisphere then pass the effluent from primary treatment to secondary treatment. Here the effluent is brought in contact with oxygen and aerobic microorganisms. They break down much of the organic matter to harmless substances such as carbon dioxide. The combination of primary and secondary treatment removes most of the organic matter in sewage and thus lowers up to 90% of the BOD. However, most of the nitrogen and phosphorus in sewage remains in the effluent from secondary treatment.

Nutrients are washed out from rivers and fall from the atmosphere to over-fertilize coastal waters. These inorganic nutrients can cause euthrophication of surface water receiving the effluent causing blooms of algae. This happens primarily as a result of fertilizer runoff from agricultural fields, wastes from livestock operations, discharges from sewage treatment plants, automobile and power plant emissions, and seepage from septic tanks. Stimulated by this rapid influx, microalgae bloom in densities far exceeding the grazing potential of planktonic animals; when the excess algae die they are decomposed by bacteria. However, these bacteria have a very high oxygen demand, so as they multiply, oxygen in the water column and in sediments is depleted. The result is large anoxic (no oxygen) or hypoxic (low-oxygen) areas where fish, invertebrates, seagrasses and other organisms cannot live.

Treatment plants are useful in habitats with seagrass and algae dominance, but do they really work in other environments? In the Southern Hemisphere the intertidal zone is often dominated by mussel beds of the small mytilid genus *Brachidontes* Swainson. The populational parameters of this mussel, as well as the response of the associated flora and fauna, have been successfully used in assessing sewage impact in Argentine (López Gappa *et al.* 1990, 1993, Vallarino 2002, Vallarino *et al.* 2002, Elías *et al*. 2003, 2006), and Australia (Hindell & Quinn 2000). In Argentine, one of the greatest seaside resorts is the Mar del Plata city (38ºS, 57ºW). The city has a permanent population of about 600,000 people, but receives almost 3,000,000 tourists during summer (December-March). The sewer system (with a mean rate of 2.8 $m^3 s^{-1}$ in winter, and 3.5 $m^3 s^{-1}$ in summer) has only a treatment plant with milli-screens with apertures of 0.5 mm (Scagliola *et al.* 2006), but must be stopped twice a year for maintenance (Scagliola pers. com. 2004). Maintenance demands approximately 30 days and the wastes were by-passed directly to the sea. How effective is this plant, or is it effective at all?

To test the effect of the sewage treatment plant of the Mar del Plata city, a series of samplings were carried out in the mussel beds of *Brachidontes rodriguezii* D'Orbigny, with two different methods, a quantitative and a cover one. The hypothesis to be tested is that this treatment plant produces an effective mitigation of the impact over the health of the environment, and both methods are effectives.

Material and methods

The study site

The coast of the Buenos Aires Province in the zone of Mar del Plata city is dominated by sandy beaches only interrupted by quartzite outcrops and abrasion platforms of consolidated loess formed by sandstones of silica cement (Teruggi 1959, Amor *et al.* 1991). The present study was carried out on one of these platforms, which surrounds the sewage effluent of Mar del Plata city. These substrates are azoic up to several kilometers to the north (except for a few opportunistic algae), while to the south they are covered with a well-established community of *B. rodriguezii*. The area has been sampled since 1997, and several papers have been published (Vallarino 2002, Vallarino *et al.* 2002, Elías *et al.* 2003, 2006, and Vallarino & Elías 2006).

The tidal regime is regular and semidiurnal, ranging between 0.90 m in extraordinary tides and 0.60 m in normal tides, but subjected to weather conditions. The climate is typically marine-temperate with regular rains (850 mm $year^{-1}$). Dominant winds are from the west and southwest in winter, and from the north in summer. A strong littoral current (15 cm s^{-1}) from south to north (Isla & Ferrante 1997[2]), and also frequent storms from the southeast constantly affect the coast (Manolidis & Alvarez 1994). Oceanographically, the area is characterized by residual waters of the continental shelf with temperatures between 8 and 21ºC, and salinities between 33.3 and 33.8 psu (Lucas *et al.* 2005, Guerrero & Piola 1997). Biogeographically, the region comprises warm-temperate and transition waters between the Subantartic region (Patagonia) and the Subtropical region (south of Brazil) (Boschi 2000).

Methodology

Four locations (Fig. 1) named Impacted (between 50 to 150 m from the effluent), South (between 700 to 850 m south from the effluent), North (3 km north from the

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[2] Isla FI & A Ferrante. 1997. Corrientes. In: Isla FI (ed). Estudio del sector de plataforma receptor de la descarga cloacal de Camet, Mar del Plata. Unpublished report to Obras Sanitarias Sociedad del Estado (OSSE), Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, pp. 209.

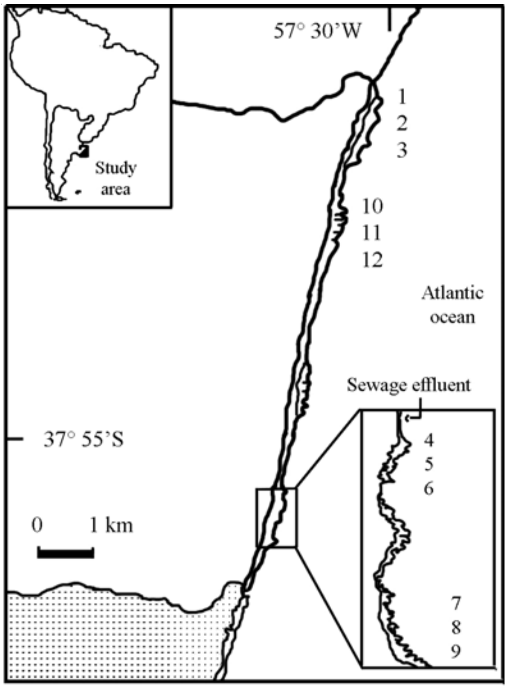


Figure 1

Sampling design in the Mar del Plata sewage discharge area. Stations 1, 2 and 3 = Control location; 4, 5 and 6 = North location; 7, 8 and 9 = Impacted location; 10, 11 and 12 = South location. Samplings were performed Before (March and October 2004) and After (June and December 2004) sewage treatment plant stop

Diseño del muestreo en la descarga de aguas residuales de Mar del Plata. Estaciones 1, 2 y 3 = localidad Control; 4, 5 y 6 = Norte; 7, 8 y 9 = Impactada; 10, 11 y 12 = Sur. Los muestreos fueron realizados Antes (marzo y octubre 2004) y Después (junio y diciembre 2004) de las paradas de la planta de tratamiento de efluentes

effluent), and Control (9 km north from the effluent) were sampled during March (autumn), June (winter), and October and December (spring) of 2004. During the sampling period the plant had to stop twice for maintenance in the ends of March and November, so March and October were considered Before, and June and December were considered After.

In each location, three independent stations were selected in a 150 m section. Biological samples were taken by two methods, a semi-quantitative sampling based on the percent cover, and a quantitative sampling by mean of corers. In each station ten squares of 0.5 m^2 were randomly selected on the intertidal, and the percent cover of bare space and major macrobenthos organisms (bivalves, algae, limpets, patches of polychaete turfs, and other biological features that could be identified) were recorded. Quantitative samplings were performed by four sampling units (SU) that were randomly taken by corers, which were coincident with the existence of a developed community of *B. rodriguezii*. The SU were obtained by means of a 78 cm^2 and 20 cm long corer, which was buried in the matrix until its contact with the solid substrate. Each SU (organisms, and sediments retained in the matrix and between the matrix and the substrate) was fixed in the field with a buffered formaldehyde solution (5%). In the laboratory each SU was sieved through a 1 mm screen mesh and the organisms retained were preserved in 70% alcohol.

Mean macrobenthic richness (S), abundance (A), Shannon diversity (H´, Shannon & Weaver 1963) and evenness index (J´, Pielou 1969) were calculated for each SU. Differences in these parameters were tested by a two-way ANOVA between locations (Impacted-Control) and Before/After plant stops. In each station environmental variables were also measured (pH, turbidity and salinity from the water column, and Total Organic Carbon, TOC, from retained sediments using the titration method). These data were analyzed using a two-way ANOVA (locations and Before/After as factors). Although the homogeneity of variances could not be achieved by any transformation, data were analyzed by ANOVA, since analysis of variance is robust for departure from this assumption when there are many independent replicates and sizes of samples are equal (Underwood 1997). Results were, however, interpreted with caution by a more conservative significance level (α=0.01). Whenever a difference was established in the ANOVA, multiple comparisons were done by Student-Newman-Keuls (SNK) method at the appropriate alpha level to determine differences between means.

A Bray-Curtis coefficient was adopted for community analyses because it is strong enough for marine data and is not affected by the lack of values (Field *et al.* 1982). Thereafter a similarity matrix was used to generate two-dimentional plots with the non-metric multi-dimensional scaling (MDS) technique. Abundances in cover method were not transformed since the objective of the work was to see the general picture of common species. On the other hand, abundances of quantitative data were double square root transformed to down-weighting the importance of the highly abundant species, so that the similarities depend not only on their values but also on those less common 'mid-range' species. The two-way crossed ANOSIM test (analysis of similarities) was used to examine the differences between pre-defined groups of sample sites (locations and Before/After plant stops) in the multidimensional analysis (Clarke 1993), applied to the (rank) similarity matrix calculated by the Bray-Curtis similarity index. The null hypothesis was that there is no difference Before and After the sewage treatment plant stops and among locations. The Similarity Percentage procedure (SIMPER) (Clarke 1993) was used to determine the contributions of individual species to the Bray-Curtis dissimilarities between locations and Before/After, for both cover and abundance date. These subroutines were performed using PRIMER package, while Statistica was used for ANOVA.

Results

Environmental data (Fig. 2) showed highly significant differences among locations, and also between Before/After. Since there are significant interaction effects for all environmental parameters except for pH, data must be graphically interpreted (Table 1).

There were an increase in turbidity and a reduction in salinity in impacted location and South location after the stops of the treatment plant, suggesting the increases of sewage loading during summer. TOC increased only in impacted and north locations after the stops, and pH increased in all locations after the treatment plant stops (Fig. 2).

The cover data of the intertidal macrobenthic community

The ordination in the MDS (Fig. 3) showed Impacted and Control sites in opposite sides, and locations South and North between them. Station 7 from Impacted location was azoic due to close proximity to sewage outfall, as well as a very impacted station form South location resulting both in an out-layer position in the left bottom.

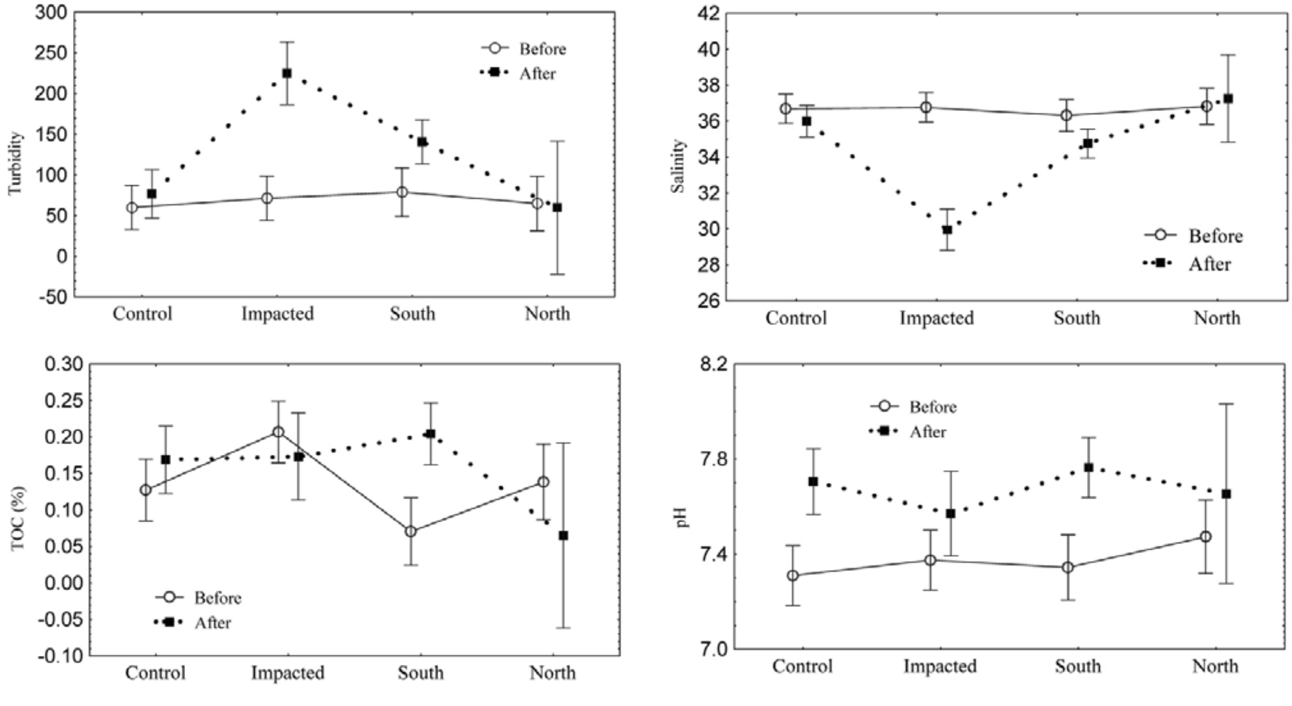


Figure 2

Turbidity, salinity, total organic carbon (TOC in %) and pH in the four locations and Before/After treatment plant stops around Mar del Plata sewage discharge

Turbidez, salinidad, carbono orgánico total (TOC en %) y pH en las cuatro localidades y Antes/Después de las paradas de la planta de tratamiento alrededor de la descarga de aguas servidas de Mar del Plata

Table 1

Summary of all effects for environmental variables in the four locations and Before/After sewage treatment plant functioning. **: Highly significant differences ($P < 0.01$); ns: no significant differences

Resumen de todos los efectos en las variables ambientales en las cuatro localidades y Antes/Después de las paradas de planta de tratamiento de efluentes domésticos. **: Diferencias altamente significativas ($P < 0{,}01$); ns: Diferencias no significativas

	df Effect	MS Effect	df Error	MS Error	F	*P*-level
pH						
Location	3	0.08	158	0.06	1.28	0.28ns
Before-After	1	4.54			71.00	0.00**
Interaction	3	0.09			1.35	0.25ns
Turbidity						
Location	3	58580.3	158	3718.39	15.75	0.00**
Before-After	1	132778.8			35.70	0.00**
Interaction	3	40527.8			10.90	0.00**
Salinity						
Location	3	204.83	158	8.49	24.13	0.00**
Before-After	1	235.98			27.80	0.00**
Interaction	3	154.12			18.15	0.00**
TOC						
Location	3	0.03	106	0.01	3.59	0.01**
Before-After	1	0.01			1.66	0.19ns
Interaction	3	0.05			6.53	0.00**

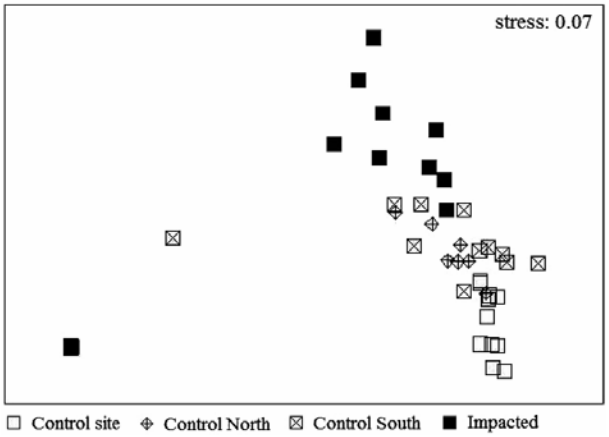


Figure 3

MDS with cover data (not transformed) for locations

Diagrama MDS de datos de cobertura (no transformados) para localidades

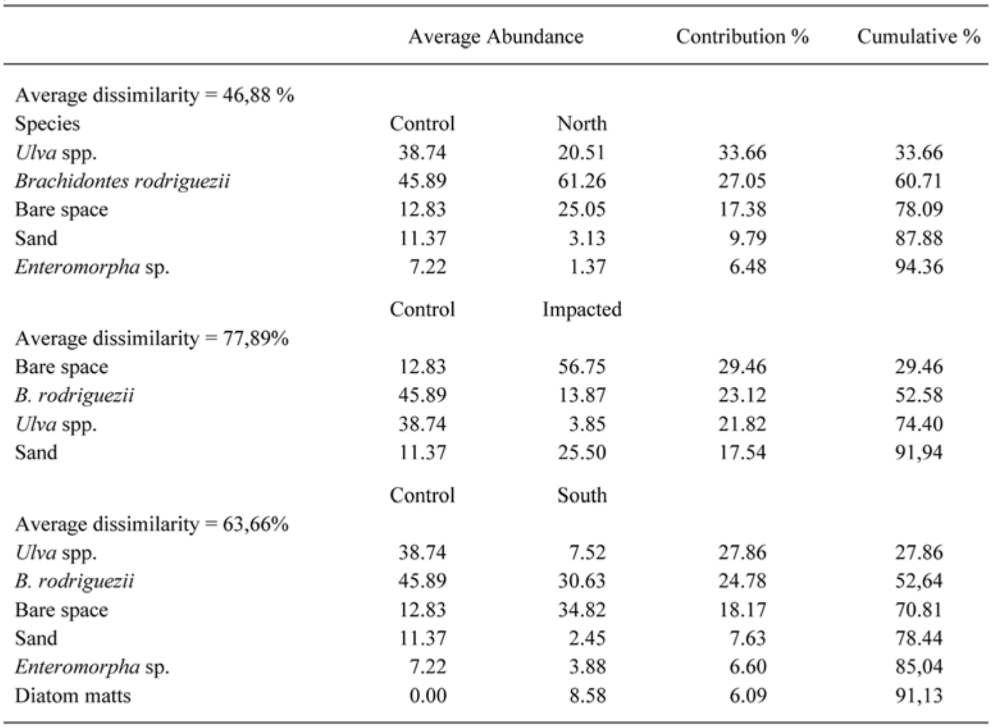
Analysis of cover data (not transformed) showed significant differences both among locations (Global R=0.421; *P*=0.001) and between Before and After sewage plant stops (R=0.215; *P*=0.01). Pairwise comparisons showed significant differences between all locations (Control *vs.* North: R=0.53, *P*=0.1; Control *vs.* Impacted: R= 0.7, *P*=0.1; Control *vs.* South: R= 0.53, *P*=0.1; North *vs.* Impacted: R= 0.33, *P*=2.7; South *vs.* Impacted: R= 0.41, *P*=0.3), but for North *vs.* South (R= -0.093, 0.3).

SIMPER among locations and between Before and After the effluent plant stops showed the species that most contributed to the dissimilarity (Tables 2 and 3). Control site was characterized by high cover of *B. rodriguezii* and *Ulva* spp., while impacted location was characterized by more than 80% of bare space and sand, and the lowest values of *B. rodriguezii* and *Ulva* spp. cover. The average dissimilarity was the greatest (77.89%). South location had also high values of bare space. After plant stops, sand cover increased three times.

Table 2

Results of SIMPER cover data in four localities in 2004. Test shows variables contributing most to dissimilarity in paired comparisons between localities ranked by decreasing discriminating power (%)

Resultados del análisis SIMPER en datos de cobertura en las cuatro localidades analizadas en 2004. El análisis muestra las variables que más contribuyen a la disimilaridad, comparadas de a pares entre localidades y colocadas en porcentaje de dismilaridad decreciente

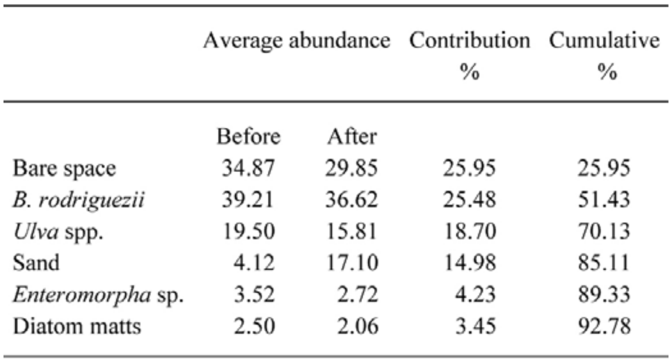


	Average Abundance		Contribution %	Cumulative %
Average dissimilarity = 46,88 %				
Species	Control	North		
Ulva spp.	38.74	20.51	33.66	33.66
Brachidontes rodriguezii	45.89	61.26	27.05	60.71
Bare space	12.83	25.05	17.38	78.09
Sand	11.37	3.13	9.79	87.88
Enteromorpha sp.	7.22	1.37	6.48	94.36
	Control	Impacted		
Average dissimilarity = 77,89%				
Bare space	12.83	56.75	29.46	29.46
B. rodriguezii	45.89	13.87	23.12	52.58
Ulva spp.	38.74	3.85	21.82	74.40
Sand	11.37	25.50	17.54	91,94
	Control	South		
Average dissimilarity = 63,66%				
Ulva spp.	38.74	7.52	27.86	27.86
B. rodriguezii	45.89	30.63	24.78	52,64
Bare space	12.83	34.82	18.17	70.81
Sand	11.37	2.45	7.63	78.44
Enteromorpha sp.	7.22	3.88	6.60	85,04
Diatom matts	0.00	8.58	6.09	91,13

Table 3

Results of SIMPER cover data Before/After the stops of the sewage treatment plant. The analysis shows the variables that most contributed to dissimilarity in Before/After situation ranked by decreasing discriminating power (%). Average dissimilarity = 58.65 %

Resultado del análisis SIMPER en datos de cobertura Antes/Después de las paradas de planta de tratamiento de efluentes domésticos. El análisis muestra las variables que más contribuyen a la disimilaridad en Antes/Después y colocadas en porcentaje de disimilaridad decreciente. Disimilaridad promedio = 58,65 %



	Average abundance		Contribution %	Cumulative %
	Before	After		
Bare space	34.87	29.85	25.95	25.95
B. rodriguezii	39.21	36.62	25.48	51.43
Ulva spp.	19.50	15.81	18.70	70.13
Sand	4.12	17.10	14.98	85.11
Enteromorpha sp.	3.52	2.72	4.23	89.33
Diatom matts	2.50	2.06	3.45	92.78

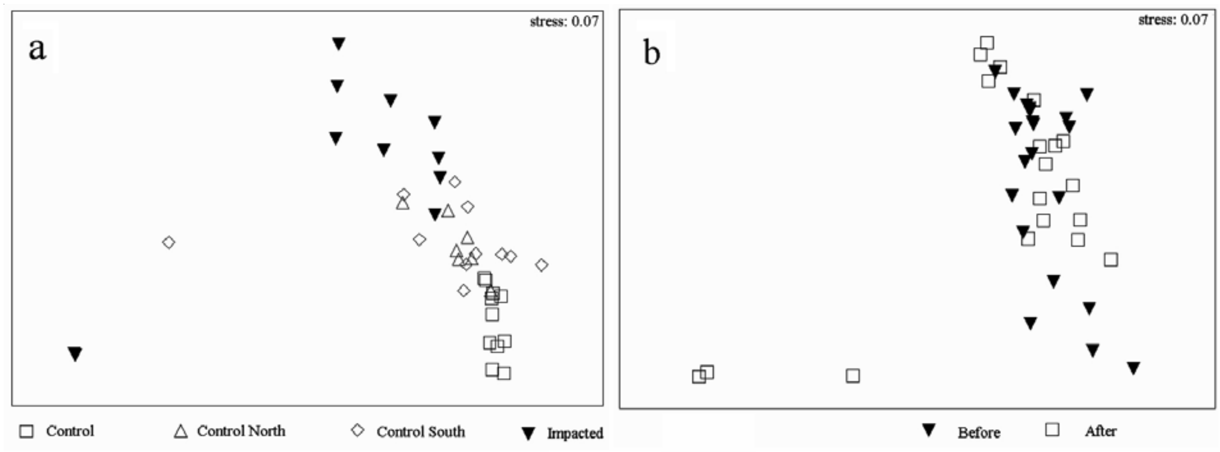


Figure 4

MDS with quantitative data among locations (a) and between Before and After sewage treatment plant stops (b). Data were double square root transformed

MDS con datos cuantitativos entre localidades (a) y entre Antes y Después de las paradas de la planta de tratamiento de efluentes (b). Datos transformados con doble raíz cuadrada

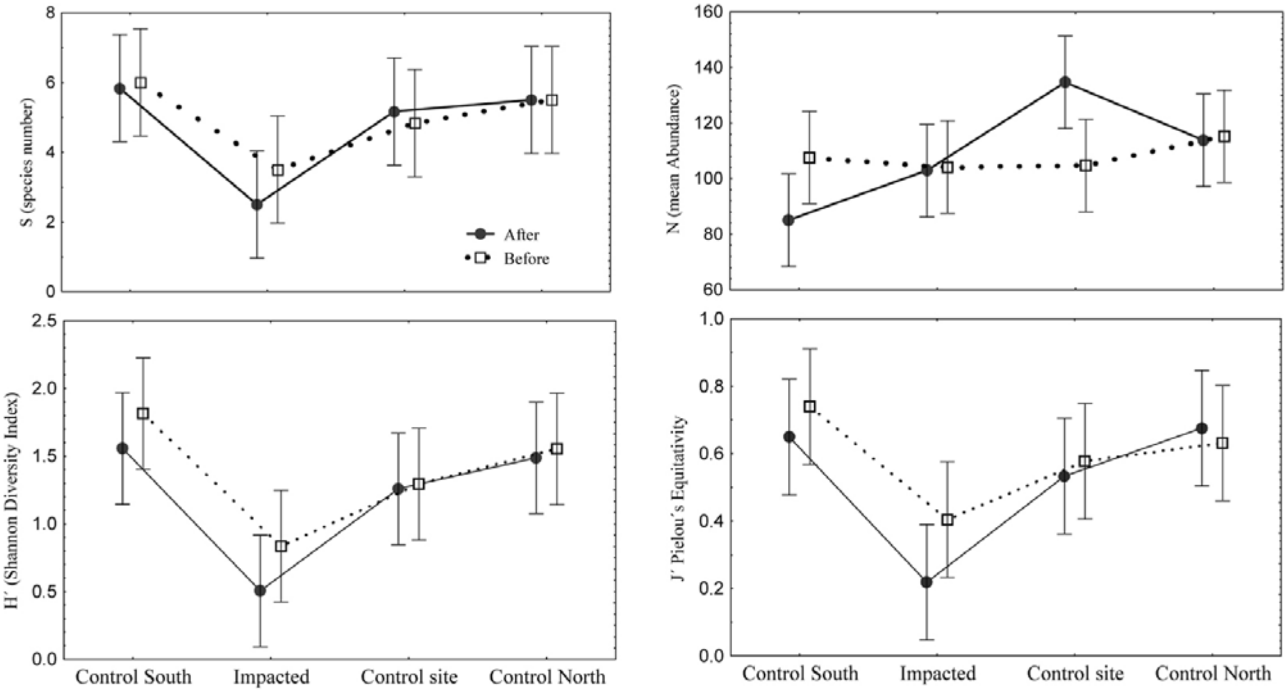


Figure 5

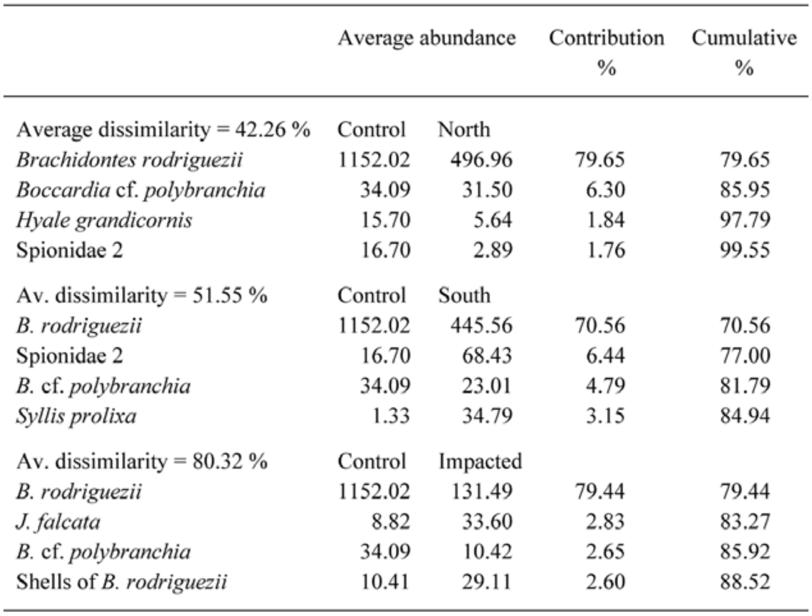
Species number (S), mean abundance (N), Shannon Diversity index (H´) and Pielou´s Equitativity (J´) in the four locations and Before/After sewage treatment plant stops

Número de especies (S), abundancia media (N), índice de diversidad de Shannon (H’) y uniformidad de Pielou (J’) en las cuatro localidades y Antes/Después de las paradas de la planta de tratamiento

Table 4

Results of SIMPER showing species that most contributed to differences among pairs of locations on quantitative data, ranked by decreasing discriminating power (%)

Análisis SIMPER mostrando las especies que más contribuyen a las diferencias entre pares de localidades con datos cuantitativos, ordenadas por el poder discriminante en orden decreciente

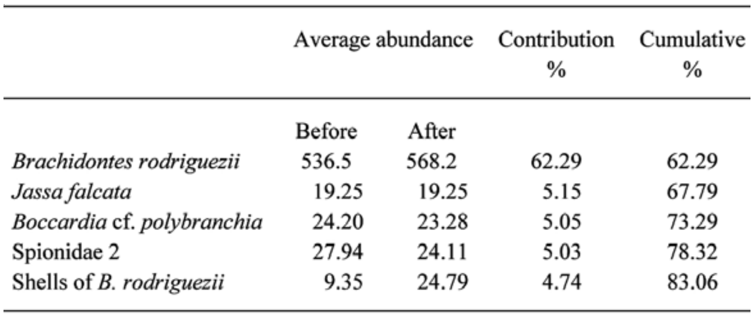


	Average abundance		Contribution %	Cumulative %
Average dissimilarity = 42.26 %	Control	North		
Brachidontes rodriguezii	1152.02	496.96	79.65	79.65
Boccardia cf. *polybranchia*	34.09	31.50	6.30	85.95
Hyale grandicornis	15.70	5.64	1.84	97.79
Spionidae 2	16.70	2.89	1.76	99.55
Av. dissimilarity = 51.55 %	Control	South		
B. rodriguezii	1152.02	445.56	70.56	70.56
Spionidae 2	16.70	68.43	6.44	77.00
B. cf. *polybranchia*	34.09	23.01	4.79	81.79
Syllis prolixa	1.33	34.79	3.15	84.94
Av. dissimilarity = 80.32 %	Control	Impacted		
B. rodriguezii	1152.02	131.49	79.44	79.44
J. falcata	8.82	33.60	2.83	83.27
B. cf. *polybranchia*	34.09	10.42	2.65	85.92
Shells of *B. rodriguezii*	10.41	29.11	2.60	88.52

Table 5

SIMPER analysis showing the species that most contributed to differences between Before and After the sewage treatment plant stops, with quantitative data

Análisis SIMPER mostrando las especies que más contribuyen a las diferencias entre Antes y Después de las paradas de la planta de tratamiento de efluentes domésticos, con datos cuantitativos



	Average abundance		Contribution %	Cumulative %
	Before	After		
Brachidontes rodriguezii	536.5	568.2	62.29	62.29
Jassa falcata	19.25	19.25	5.15	67.79
Boccardia cf. *polybranchia*	24.20	23.28	5.05	73.29
Spionidae 2	27.94	24.11	5.03	78.32
Shells of *B. rodriguezii*	9.35	24.79	4.74	83.06

The quantitative analyses

The nMDS with quantitative data showed also Impacted and Control sites in opposite sides, and locations South and North between them. A single station (7), the closer most to the sewage discharge, resulted azoic as well as a very impacted station form South location resulting both in the left-bottom as out-layers (Fig. 4a). In the Before/After analysis there was also a gradient, but the stations after treatment plant stops were clustered in the bottom while before stations were on the top (Fig. 4b).

The quantitative analysis (rooth-transformed data) showed highly significant differences both among locations (R=0.417; *P*=0.001) and between Before and After treatment plant stops (R=0.374; *P*=0.001). The pairwise comparison showed highly significative differences (<0.01) between Impacted and the other locations, and between Control and South locations.

The ANOVA showed highly significant differences between locations in S ($F_{3, 40}$= 5.78, *P*<0.01), in N ($F_{3, 40}$= 3.29, *P*<0.01 and also interactions), H´ ($F_{3, 40}$= 9.53, *P*<0.01) and J´ ($F_{3, 40}$= 8.19, *P*<0.01). Mean diversity, Evenness and species number decreased in Impacted location, and also during the treatment plant stops. Mean abundance showed a great reduction in the North location after the stops, but increased in the control site (Fig. 5).

SIMPER undertaken with abundance data showed the species that most contributed to both the differences among locations (Table 4) and between Before and After (Table 5). Control location was characterized by high quantities of *B. rodriguezii*, while Impacted location was characterized by the lowest value in all organisms but the highest values of *Jassa falcata*, *Corophium* sp. and empty shells of *B. rodriguezii*. Average dissimilarity was also greater between Control and Impacted locations. After the plant stops high differences were observed in the increased number of *B. rodriguezii*, and also in the lesser number of both *Syllis prolixa* and empty shells of *B. rodriguezii* (three time less).

Discussion

Brachidontes rodriguezii is the structuring organism of this community reaching dominance between 70 to 90%, and almost a 100% cover. As ecosystem engineering, it gives shelter to several accompanying organisms (Vallarino *et al.* 2002). Previous results showed significant reduction in both mussels and associated fauna due to sewage discharge, even in the short-term (Vallarino *et al.* 2005[3], 2007[4], Elías *et al.* 2006). The density variations of this mussel affect the possibility of secondary space in this community, and the disponibility of bare space (Vallarino 2002).

Cover data showed the lowest value for *B. rodriguezii* in the Impacted location, as well as the highest values for bare space and sand covering the stones. Average dissimilarity was greatest between Impacted and Control, and minimum between Control North and Control site. After the sewage treatment plant stops all items decreased (including *B. rodriguezii* and bare space), except sand cover, which increased four times. Beaches and littoral fringe in the area have high hydrodynamics due to storms, producing great sand movements (Isla *et al.* 2001). Nevertheless the method is useful to assess sewage impact in this community.

Abundance data showed the lowest value for *B. rodriguezii* in Impacted location, and the greatest in Control location. No differences were observed in mean *B. rodriguezii* abundances between Before and After the stops of the sewage treatment plant. One station of Impacted and other from South locations were denuded of macrofauna due to the severity of the impact. In the first case, it was due to the proximity to sewage outfall and, in the second, due to the plant stops, which increased the impacted area. In the same way, although with low contribution almost three times more empty shells of the mussel were observed after the stop, suggesting a high mortality of mussel population due to sewage pollution, and also a decrease in the polychaete *S. prolixa*, indicator of clean habitats (Elías *et al.* 2003, 2006). In China the intertidal rocky shore community also shows great mortality of bivalves (oysters) due to sewage effect (Klein & Zhai 2002).

Vallarino (2002) and Vallarino *et al.* (2002) found that location South behaved as a control most part of the year. This is due to the prevalent longshore current from south to north that pushes the flume to the north, allowing the south to remain relatively clean of organic pollution. However, during summer months, prevalent winds from

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[3] Vallarino EA, MS Rivero & R Elías. 2005. Efecto de corto plazo en comunidades de mitílidos intermareales sometidas a contaminación orgánica. Tres años de estudio. Expanded Abstracts of the X Congreso Latinoamericano de Ciencias del Mar. Viña del Mar, Chile, pp. 88-91.

[4] Vallarino EA, R Elias, N Manolidis & MS Rivero. 2007. Relación entre la dirección del viento y el efecto del efluente doméstico de Mar del Plata (Argentina). Efecto sobre la comunidad bentónica intermareal. Expanded Abstracts of the XII Congreso Latinoamericano de Ciencias del Mar. Florianópolis, Brasil, pp. 105-108.

north attach the flume to south shore, and this area results moderately polluted. When sewage treatment plant stops the area polluted increases, so the South stations are also affected by organic pollution. Moreover, an increase in TOC was detected in the South location in response to the existence of greater impact due to the treatment plant stops. Other environmental variables also showed significant variations respect sewage plant stops, like high values of turbidity and lower values of salinity (see Fig. 2). The intertidal community presented all the characteristics proper of increasing sewage impact, like low *Brachidontes* cover and abundance, lower diversity and richness, and increased numbers of the polychaete *Boccardia* cf. *polybranchia*, indicator of organic enrichment (Pearson & Rosenberg 1978, Elías *et al.* 2003, 2006).

There is a lot of literature about reduction of pollution after reduction or cessation of sewage discharge and the consequent response of subtidal macrobenthic communities (Swartz *et al.* 1986, Ferraro *et al.* 1991, Stull 1995, Smith & Shackley 2006). The recovery of benthos was also evident when the sludge dumping sites were changed (Moore & Rodger 1991, Reid *et al.* 1995, Valente *et al.* 1997, Whomersley *et al.* 2007). Similar results were found in experiments of recolonization and succession of transplanted organic-enriched sediments by fish farms (Lu & Wu 1998). However, there is less literature on biological response to sewage treatment plants. Recently, Douxfils *et al.* (2007) showed that a sewage treatment plant do not substantially impair fish reproduction in a polluted river, although caution is required because some signs of reproductive impairment and endocrine disruption was observed downstream in females of the stoneloach *Babatula barbatula* Linne. In the Nervión estuary (southern Bay of Biscay) the commencement of sewage and industrial treatment produces a progressive increasing of oxygen saturation and also an improvement of benthic communities. Bottom oxygen saturation explains 81% of the variance of the AMBI values (Borja *et al.* 2006).

Some works have been done in the recovery of algal communities due to sewage treatment plants. In the Mediterranean Sea, intertidal macroalgal communities were studied 8 years after the setting up of a sewage treatment plant in the vicinity of Marseille (France). The improvement of the richness and other changes were related to the decrease in pollutant load and the ferric chlorates used in the treatment process (Soltan *et al.* 2001). Similar results were found in Bilbao (NE Spain) by Gorostiaga & Diez (1996), and in Norway by Bokn *et al.* (1996) in relation to sewage treatment plants.

Cover methods are useful because the time needed for sampling and analyzing data is quite short respect to other methodologies. The taxonomic sufficiency is also less (although in this work has not been tested) because it is enough to determine the major components of macrobenthos rather than specific determinations. As Ellis (2003) says identification of the local species is superfluous. This means that the time/cost is lower than for other methods, although results not always are accurate in order to assess the environmental impact in an area. However, in this case the results are good enough to assess the sewage impact in intertidal mussel beds.

Not identifying to species, and not counting the numbers of each, substantially reduces the time needed (and costs) for the surveys, or alternatively allows extension of their scale at any one time. This monitoring procedure could only be developed for shoreline biodiversity assessment because of the well established documentation of a global pattern of intertidal biological zonation. In modern terms the zonation pattern represents the equilibrium state for a rocky shore ecosystem anywhere in the world (Ellis 2003).

This work is the first referred to the sewage treatment plant effect on intertidal macrobenthic community of the southwestern Atlantic shore. The two methods used with cover and quantitative data showed very similar results, being both useful in assessing environmental impact due to sewage discharges rates. This is good news for managers because a rapid, quick and cheaper cover method can be used to assess impact in intertidal areas dominated by mytilids of the Southwestern Atlantic rocky shores.

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