Marine sediment quality in Mar del Plata city sewage discharge area -period 1999-2007

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Abstract
The city of Mar del Plata, located on the coast of the Atlantic Ocean is the main seaside resort of Argentina and has a stable population of about 615,000 inhabitants, however, during the summer receives the main tourist flow of the country. At present, the wastewater is pre-treated by filtration with milliscreens (0.5 mm apertures) and discharged at a unique point to the coastal marine waters. The submarine outfall for the city is actually under construction. Mar del Plata Public Sanitation Works (OSSE) has been evaluating the impact produced by the sewage discharge to the receiving marine environment through the last two decades and the Quality Management Division implemented in 1999 a monitoring sediment programme in order to have a baseline before the submarine outfall construction, that provides a fundamental tool to evaluate the environmental situation achieved after the outfall. Marine sediments were sampled in a surface around 36 km2 near the wastewater discharge. The sampling designs considered the geographical and the seasonal variability and the variability caused by episodic storms. The parameters analyzed were grain-size distribution, organic matter and heavy metals in total fraction and in fraction less than 63 micrometers. The general results obtained, shows the stability in the natural conditions but within a broad range of natural variability. The levels of metals did not exceed the Provisory Binational Reference Values (VRBPs, 2006) based on the Canadian sediment quality guidelines for the protection of aquatic life (2002). Organic matter data shows a strong sedimentary dynamics in the area. This monitoring programme provides baseline chemical data and the comparison tools to evaluate the influence of the Mar del Plata's sewage outfall, in order to achieve and maintain the quality objectives by the implementation of future improvements if necessary.

Keywords
Wastewater discharge, metals levels, sediment, ocean outfall, integrated coastal management

INTRODUCTION

The city of Mar del Plata (38º S, 57º W), located on the coast of the Atlantic Ocean is the main seaside resort of Argentina and has a stable population of about 615,000 inhabitants, however, during the summer receives the main tourist flow of the country.

At present, the wastewater that generates a flow average of 2.8 m3. seg-1 in winter increasing to 3.5 m3. seg-1 in summer, is pre-treated by filtration with milliscreens (0.5 mm apertures) and discharged at a unique point to the coastal marine waters. Different studies that OSSE requested to several institutions[1,2,3,4,5] recommended the construction of marine outfall as an alternative to meet local health problems with regard to the recreational quality of the coast. In 2001 there was a failed attempt to construct the outfall that has served to evaluate the impact due to the dredging works. The submarine outfall for the city is actually under construction.

Taking into account other studies in the area[6,7,8], Mar del Plata Public Sanitation Works (OSSE) has been evaluating the impact produced by the sewage discharge to the receiving marine environment through the last two decades and the Quality Management Division implemented in 1999 a monitoring sediment programme in order to have a baseline before the submarine outfall construction, that provides a fundamental tool to evaluate the future environmental situation.

The aim of this communication is to present the baseline data for trace metals in sediments near the wastewater discharge, compare results with reference values and evaluate variability due to seasonal and climate changes and the impact of dredging during the 5 m deep outfall trench construction.

MATERIALS AND METHODS

Sampling and processing

Since 1999 marine sediments were sampled in a surface around 36 km2 near the wastewater discharge (Fig. 1, Fig.2, Fig. 3 and Fig 4). The sampling designs considered the geographical and the seasonal variability and the variability caused by episodic storms. Table 1 summarize the sampling campaigns since 1999. In order to evaluate seasonal changes 18 samples have been taken quarterly in the period 2001-2002 (Fig. 3). These evaluations match dredging during the 5 m deep outfall trench construction. Two campaigns were performed in 2003 to evaluate the effects of the storms (Fig. 2). In 2007 seven sampling sites, located in the transect of 3800 m in the outfall trench made in 2001, have been sampled (Fig 4).

Table 1- Summary of sampling campaigns 1999-2007

Year	Nº of locations	Sampling frecuency	Nº of sampling campaigns	Objective
1999	49	1	8	Baseline study (Fig 1)
2001-2002	18	4	10	Seasonal variability– evaluation of impact due to outfall trench construction (Fig 3)
2003	12	2	2	Climate influence variability (Fig 2)
2007	8	1	1	Baseline update (Fig 4)

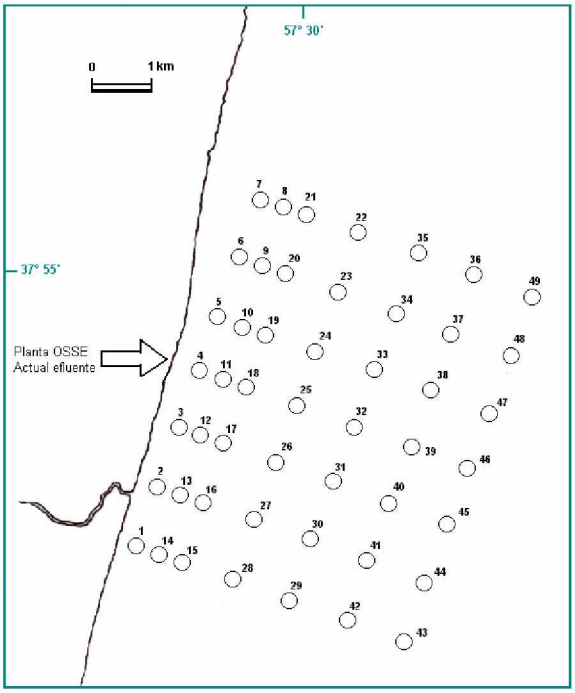

Figure 1 – Area sampled in 1999

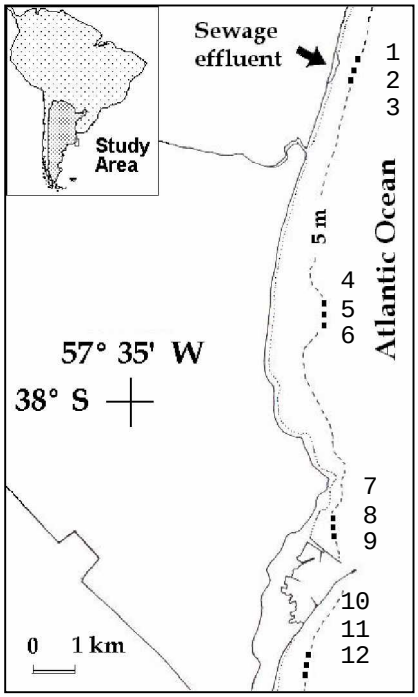

Figure 2 – Area sampled in 2003

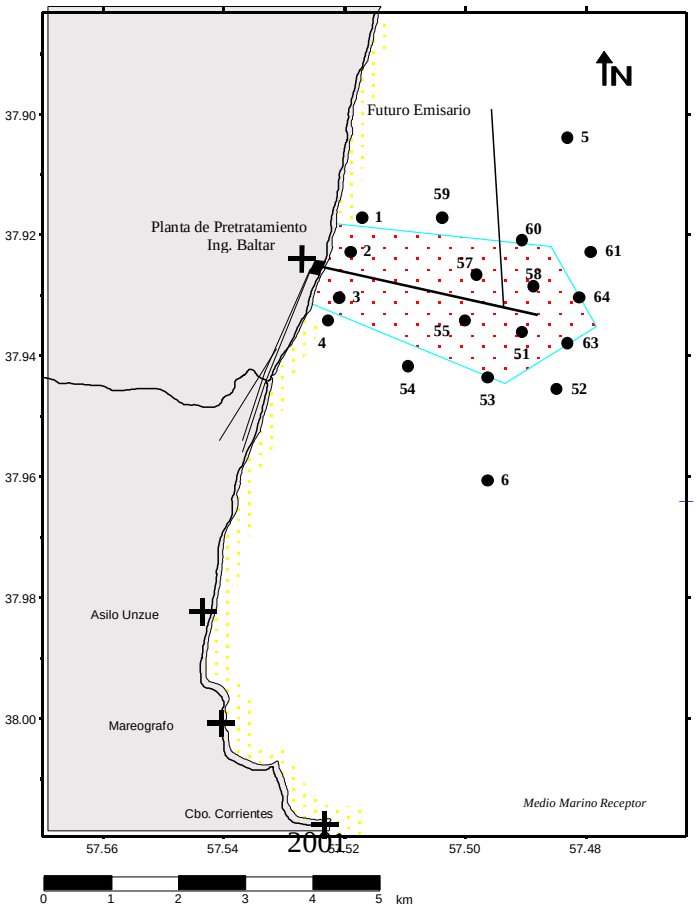

Figure 3 - Area sampled in 2001-2002

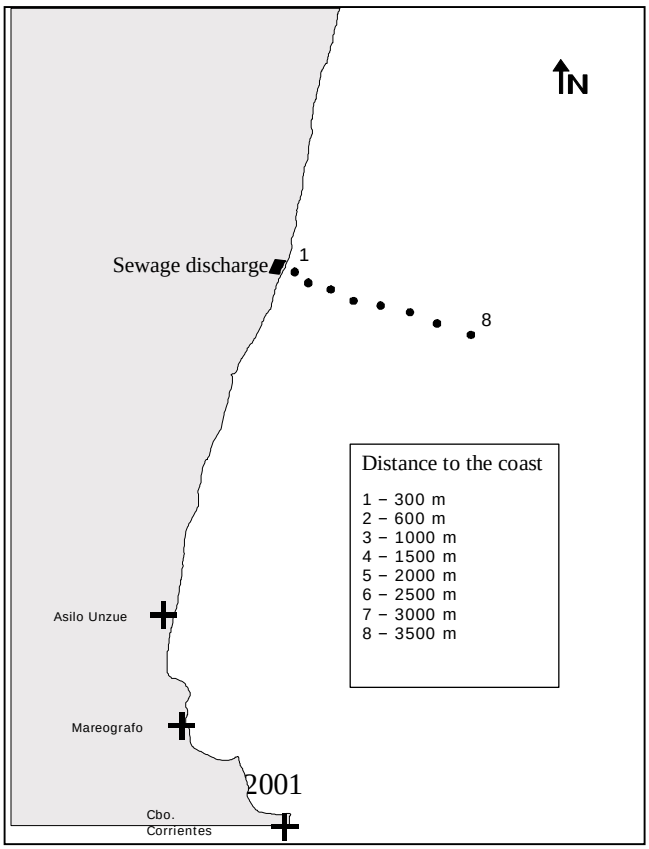

Figure 4 - Area sampled in 2007

Sediments were collected using a stainless-steel Van Veen grab, and stored deep freeze (-18ºC) in a plastic bag in the laboratory until analyses. The samples were dried (T<60ºC), lightly ground in a mortar and pestle to break up aggregates[9].

Sediment analyses. Grain size distribution was determined using the classical sieving methods (4.75, 1, 0.5, 0.25, 0.125, 0.063 mm sieves). The fine sediment fraction (<63 µm) was microwave acid digested with concentrated nitric acid. Metal concentrations (Cu, Zn, Pb, Cd, Ni, Cr) in sediment digests were determined using flame atomic absorption spectrometry[10] and Hg in the silt clay fraction was analyzed using cold vapour atomic absorption spectrometry (AAnalyst 300 Perkin Elmer).[11] Organic matter was determined using ignition at 550 ºC until constant weight. [10]

Quality control procedures. Blanks were included in each batch of analyses. The Quality Assurance Programme for Waters Laboratory (OSSE) included the participation in the Laboratory Performance Studies developed for the EU Quasimeme Programme (Quality Assurance of Information for Marine Environmental Monitoring). The test materials corresponding to the rounds 46, 48, 50 y 52 (MS1- Trace metals in sediments, 2006-2008) were analysed with satisfactory results for Cu, Zn, Cd, Pb, Ni, Cr and Hg.[12]

Sediment data analyses: to evaluate the differences between sample sites, seasonal changes and temporal trends, analyses of variance were performed with SPSS software with a 0.05 significance level (ANOVA test)[13].

RESULTS AND DISCUSSION

The general results obtained, shows the stability in the natural conditions but within a broad range of natural variability. The sediments in the area near to the shore shows a predominance of fine sand, while the deepest areas (>10 m) shows coarse sand with shells.

Even when the total and the fine (<63 µm) sediment fraction were analysed, in order to evaluate the level of metal concentrations in the area the comparison was made with the data corresponding to the fine fraction.

No statistical significant differences (P<0.05) were observed in the heavy metal levels found in sediments from locations near shore, under direct anthropogenic influence, and those sampled in blank zones. Also there were no seasonal significant differences in the data.

During the campaigns in 2001-2002, organic matter data shows differences related with the occurrence of storms. This effect was evaluated in 2003 when 12 sites (Fig. 2) were sampled before and after a storm. Organic matter data shows significant differences among same sample sites, due to processes related with the transportation of sediments in the area as a result of currents and climate conditions (Fig. 5).

Sediments provide habitat for benthic organisms and also act as a sink where contaminants can be stored, acting then as a source of these contaminants to the overlying water and biota. In high-energy environments with high energy of the overlying flow, the sorptive capacity of the sediments for contaminants is small with consequent low depositional rates.[14]. The studied area is very hydrodynamic, with high energy and a strong sedimentary dynamic associated to the action of winds, currents and waves, favourable for dilution and dispersion of waste water. This effect has been seen in 2001 when the bathyimetry after 75 days of the trench dredging during the failed attempt of the outfall construction shows a range of sand accumulation from 3 to 4 m.

As mentioned before, during the sample campaigns performed in 2001 some of the works related to construction of the outfall were developed. Particular importance has the dredging of the trench, with a high volume of mobilized sediment. In broad terms, between 80m and 500m from the shore, the trench is 12 meters wide at the base; between 500m and 3300m, it is 5 meters wide at the base and has almost vertical slopes and finally, the remainder line until 3800m has gradually smoother slopes. The depth of the digging ranges from 3 to 4 meters[15]

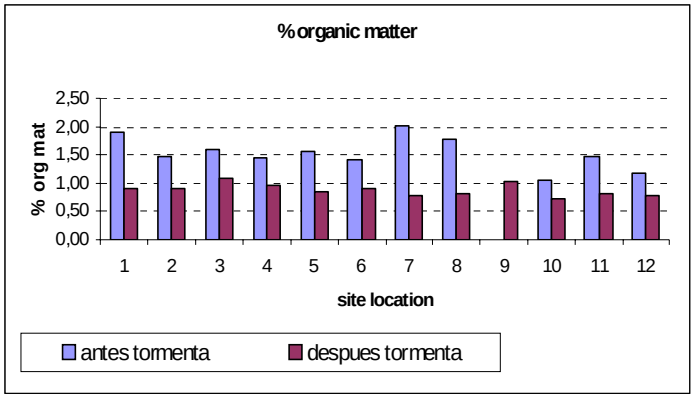

Fig 5. Organic matter obtained in samples before and after a storm (2003)**.** Sites location in Fig. 2

The littoral current flows from south to north[16], so the dredged sediment was carried out north of the area to avoid the refilling of the trench. The data evaluation (campaigns 2001-2002) shows no significant differences ($P<0.05$) among metals concentration in the north and south area.

For cadmium all values fell below the analytical detection limit (Cd < 0.03 mg/kg), and for mercury, several results fell below the analytical detection limit (Hg < 0.1 mg/kg) with a maximum value detected of 0.15 mg/kg.

Based in the Canadian sediment quality guidelines for the protection of aquatic life (2002),[17] Argentina and Uruguay set in 2006 the VRBP (Valores de Referencia Binacionales Provisorios)[18] as quality guidelines. In general, the levels of metals found in sediment samples taken during the sampling campaigns since 1999 did not exceed VRBP (Figure 6). This is consistent with the predominance of food industry in the city of Mar del Plata. Only in a few cases, some values were slightly higher than the VRBP, but were always below the probable effect level (PEL) so no incidence of adverse biological effects can be expected [17, 19, 20].

The evaluations of data since 1999 to 2007 do not indicate a temporal trend in the level of trace metal concentrations in the fine sediment fraction.

CONCLUSIONS

The concentration ranges of metals found in sediment samples taken since 1999 are below the VRBP, do not present high levels of contaminants and no adverse biological effects are expected.

The evaluation of trace metals data in the fine sediment fraction shows no geographical, seasonal or temporal trends.

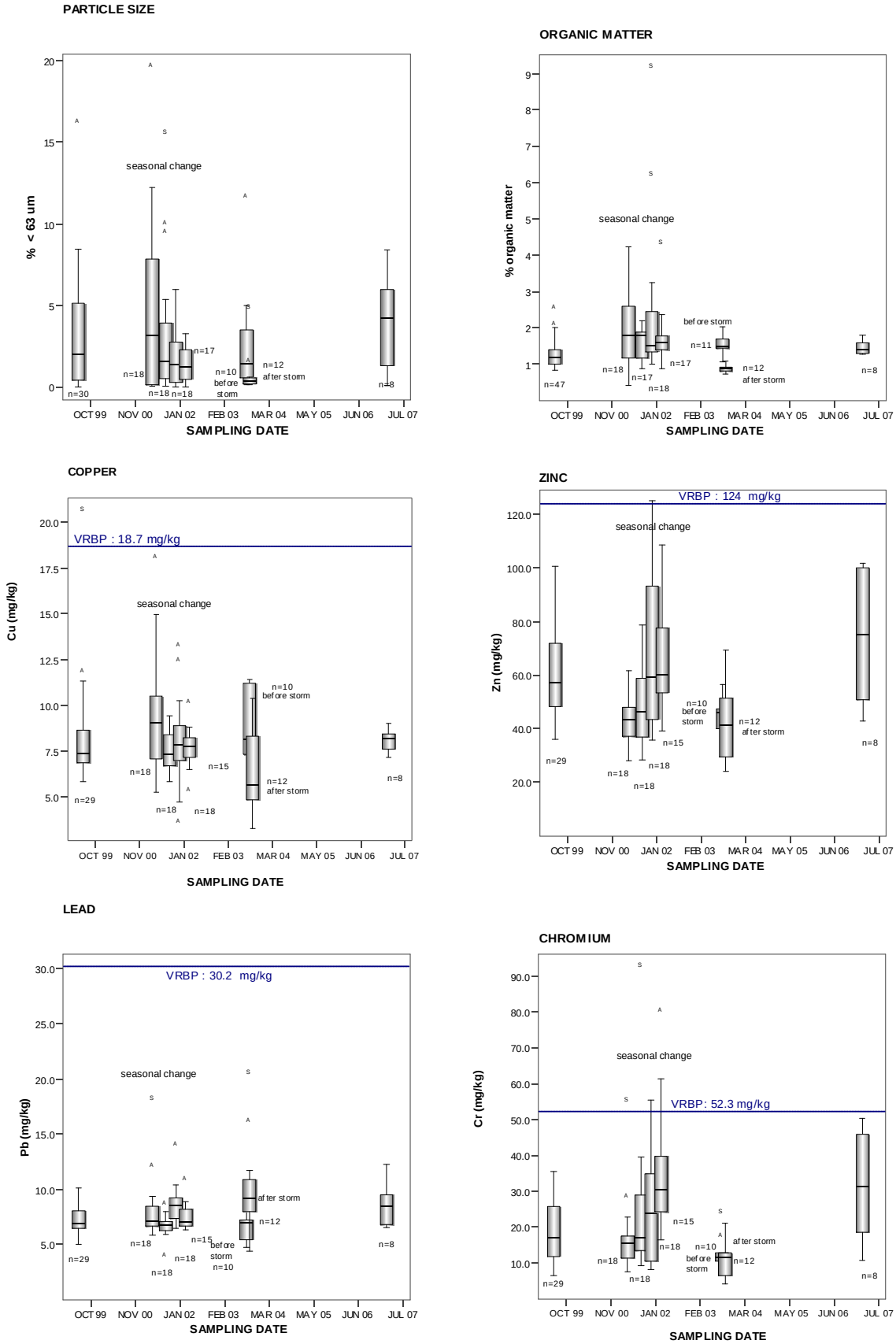

Fig. 6- Box plot presentation for particle size, organic matter and metal concentrations in sediment fraction < 63 µm.

The dredging of a trench around four kilometers long, perpendicular to the coast , during the failed attempt to build the outfall in 2001, would be the anthropogenic actions of greater impact on the coastal ecosystem but showed no effect on the quality of marine sediments. That evidences the strong drift of sediments in a south-north direction which led to the partial filling of the trench.

This monitoring programme provides baseline chemical data and the comparison tools to evaluate the influence of the Mar del Plata's sewage outfall, in order to achieve and maintain the quality objectives by the implementation of future improvements if necessary

REFERENCES

[1] Instituto Nacional de Ciencia y Técnica Hídricas (INCyTH): "Estudio de la factibilidad de la disposición en el mar de los efluentes cloacales de la ciudad de Mar del Plata". (1984).

[2] Isla,F.: "Estudio del sector de plataforma receptor de la descarga cloacal de Camet, Mar del Plata". Facultad de Ciencias Exactas y Naturales de la Universidad Nacional de Mar del Plata, 1997

[3] ENOHSA – "Convenio de asistencia técnica a Obras Sanitarias de Mar del Plata (OSSE). Tratamiento y disposición final de los efluentes cloacales en Camet". Informe Final. 1997

[4] Marti, José,A. Manejo de los efluentes de la Planta Camet de Mar del Plata, Argentina. Informe Final. 1997

[5] Facultad de Ciencias Exactas y Naturales. Universidad Nacional de Mar del Plata (FCEyN-UNMDP) "Evaluación de Impacto Ambiental. Segunda etapa de la Estación Depuradora de Aguas Residuales de la ciudad de Mar del Plata". Tomo 1 y 2. (1998).

[6] Scagliola,M.: "Metales pesados en sedimentos, material particulado y organismos bentónicos del medio marino receptor del efluente cloacal de Mar del Plata" Facultad de Ciencias Exactas y Naturales de la Universidad Nacional de Mar del Plata. Unpublished Thesis (1993).

[7] Prefectura Naval Argentina (PNA). Informe Final. Análisis físico bacteriológico del Río de la Plata y su frente marítimo. FREPLATA A7.1- 2003

[8] Carsen, A.E, Perdomo, A., Arriola, M. -Río de la Plata y su frente marítimo. Contaminación de aguas, sedimentos y biota.Proyecto FREPLATA. Mayo 2004.

[9] U.S. Environmental Protection Agency: Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological analyses: Technical Manual. EPA-823-B-01-002. October 2001

[10] APHA, AWWA, WEF (eds.) (1998) - Standard Methods for the Determination of Water and Wastewater, 20th edition

[11] Lobring, L.; Potter, B. Determination of Mercury in Sediments by Cold Vapor Atomic Absorption Spectrometry, Method 245.5.Environmental Monitoring Systems Laboratory Office of Research and Development. U.S. Environmental Protection Agency. Cincinnati, Ohio. Pp 267-280. (1991)

[12] ICES. 2004. Chemical measurements in the Baltic Sea: Guidelines on quality assurance. Ed. by E. Lysiak-Pastuszak and M. Krysell. ICES Techniques in Marine Environmental Sciences, No. 35. 149 pp.

[13] Walpole,R.E.; Myers, R.H.; Myers, S.L. "Probabilidad y estadística para ingenieros", 6ta ed. Edit. Prentice-Hall. 739 pp 1998

[14] Santos, C., Paulo-Martins,C., Barreiros, A., Pestana, P., Cardoso, A., Freire, A."Quality assessment of water and sediments of eight submarine outfalls – west coast of Portugal" Proceedings of the 4th International Conference on Marine Waste Water Disposal and Marine Environment. – P 1-16. Antalya, nov. 6-10, 2006

[15] Scagliola, M., Furchi,P. "Sewage outfall project of Mar del Plata city (Argentina): An effective intervention to achieve quality objectives on the marine environment" Proceedings of the 4th International Conference on Marine Waste Water Disposal and Marine Environment - Antalya, nov. 6-10, 2006

[16] Scagliola,M-Reta,R-Ferrante,A.: "Medición de corrientes superficiales en un sector del litoral costero de Mar del Plata durante el período estival 1997/98". OSSE – UNMdP, Unpublished work (1998).

[17] Canadian Council of Ministres of the Environment. 2002. Canadian sediment quality guidelines for the protection of aquatic life: Summary tables. Updated. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministres of the Environment, Winnipeg

[18] Valores de referencia binacionales provisorios de Calidad de agua y sedimentos para la protección de la biota acuática (VRBPBs), ANEXO 1. En "Objetivos de Calidad de Agua y sedimentos para el área común del Río de la Plata y su frente marítimo". FREPLATA Proyecto PNUD/GEF RLA/99/G31.Octubre 2006

[19] The development of a common set of water and sediment quality guidelines for the coastal zone of the BCLME. Project BEHP/LBMP/03/04 .CSIR, Natural Resources and the Environment, South Africa, enero 2006

[20] Buchman,M.F,. 1999. NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages