Integrated Coastal Management Strategy of Mar del Plata city and the Sewage outfall project

Marcelo Scagliola *, Ana Paula Comino ** Gabriela von Haeften ** Roberto Gonzalez**

* Quality division, Mar del Plata Public Sanitation Works (Obras Sanitarias Mar del Plata-Batán Sociedad de Estado - OSSE). Brandsen 6650, CP 7600, Mar del Plata. Municipality of General Pueyrredón County, Argentina (email: scagliola@osmgp.gov.ar; laborat@osmgp.gov.ar)
** Waters Laboratory, Quality division, Mar del Plata Public Sanitation Works (Obras Sanitarias Mar del Plata-Batán Sociedad de Estado - OSSE). Brandsen 6650, CP 7600, Mar del Plata. Municipality of General Pueyrredón County, Argentina (email: laboratorio@osmgp.gov.ar; lab.aguas@osmgp.gov.ar)

Abstract
The city of Mar del Plata is the fifth largest urban area of Argentina. In summertime it receives the main tourist flow of the country which involves the main recreational use of the sea shore. The city sewage is discharged on the coast line, after a previous pretreatment. At present, the submarine outfall for the city is under construction. Mar del Plata Public Sanitation Works (OSSE), has considered that the treatment plant and outfall technologies are only two of many pieces that together make up an Integrated coastal wastewater management strategy and has been implemented different monitoring and control programs taking into account other, less visible components of a management strategy that include source control efforts to discourage the production of undesirable wastes and prevent their introduction into wastewater and stormwater drainage systems, monitoring to assure compliance and ascertain the effectiveness of management strategies and environmental studies to improve understanding of the impact of wastewater managements strategies and point toward opportunities for improvement. OSSE has been evaluating the impact produced by the sewage discharge into the receiving marine environment. The results have shown that the urban sewage is characterized for a high content of organic matter, due to fishery industries, restaurants and food shops activities and low concentration of toxic substances. The marine environment, which receives the sewage discharge, is a zone of high energy, with an important sedimentary dynamics influenced by strong winds and storm events and therefore with a high "autodepuration" capacity. Regarding preservation of beaches water quality mitigation action has been implemented during the last summers meanwhile the submarine outfall is been constructed. This paper presents the actions and the results of the Integrated Coastal Management Strategy implementation, providing a base line condition previous to the outfall installation.

Keywords
Sewage, ocean outfall, integrated coastal management, recreational quality, and ecosystem.

INTRODUCTION

The city of Mar del Plata (38º S, 57º W) is the seventh bigger urban area of Argentina (614.350 inhabitants), located on the coast of the Atlantic Ocean. This seaside resort receives the main tourist flow of the country during the summer months, December to March, and the beaches, around 39 Km length, are used extensively by local and tourist population for recreational activities. Mar del Plata generates a flow average of 2.8 m^3. seg^{-1} in winter and 3.5 m^3.seg^{-1} in summer of wastewater, which is discharged at a unique point to the coastal marine waters after a pre-treatment with milli-screens with apertures of 0.5 mm.

Mar del Plata Public Sanitation Works (OSSE) has been evaluating over the last two decades the impact on the marine environment produced by the sewage discharge, through the implementation of an integrated coastal management strategy [1] that includes monitoring and control programmes as well as mitigating strategies. These research projects [2,3,4,5,6,7,8,9,10,11] involves the characterization of the physicochemical quality of the urban sewage (mixture of domestic and industrial) discharged into the sea and the industrial wastewaters discharged into the sewer system, and also the response of the marine environment, through the analysis of physical, chemical, biological and

bacteriological parameters. The aim of the implemented methodology is the permanent evaluation of the environmental area in order to implement the correspondent mitigation strategies, on the basis of the achievement of environmental quality objectives rather than the application of technologies.

The present work shows some of the obtained results in the projects, with particular emphasis in the most relevant aspects that characterize the sewage - receiving marine environment Mar del Plata system. This results leads to the construction of the submarine outfall for the discharge of the urban sewage, as an effective sanitation alternative, which is also suggested and supported by different studies that OSSE requested to several institutions [12,13,14,15] .The results obtained constitute the baseline before the submarine outfall construction, and provide the fundamental tool to evaluate the environmental situation achieved after the outfall.

METHODOLOGY AND RESULTS

Monitoring and control of industrial sewage

Mar del Plata is the most important commercial fishing harbour of the country. Fishery, tourism and textile industries are the main industrial activity of the city, and affect the urban sewage quality introducing grease that produces serious operative troubles. The low levels of heavy metals and organic contaminants found in the sewage are expected according to the sort of activities developed at the industrial area of the city. In order to preserve facilities and to control the discharges to the sewer system, OSSE has categorized the Industries, according to their principal activities, mantaining a monitoring and control program through sampling of the industrial effluent.

Based on fifteen years of industrial control data, the average grease concentration for each kind of industry was obtained. [8] The figure 2 shows the results obtained during the first ten years period and clearly indicates that the value for the fish flour factories is higher than any other category in the city. During the last five years a strong control program, especially focused on reduce the grease industrial discharge contribution have been implemented by OSSE[16,17] This is evidenced in the figure 3 that show the decrease of grease of 24 hs composed samples since 2004 to 2010, from "Escollera Sur" pumping station which pumped all the industrial effluents generated by the industrial fishing harbour activities. The average grease concentration for each kind of industry was recalculated including the five last years industrial control data and the results are showed in figure 4.

Figure 2: Oil and grease individual industry contribution till 2006

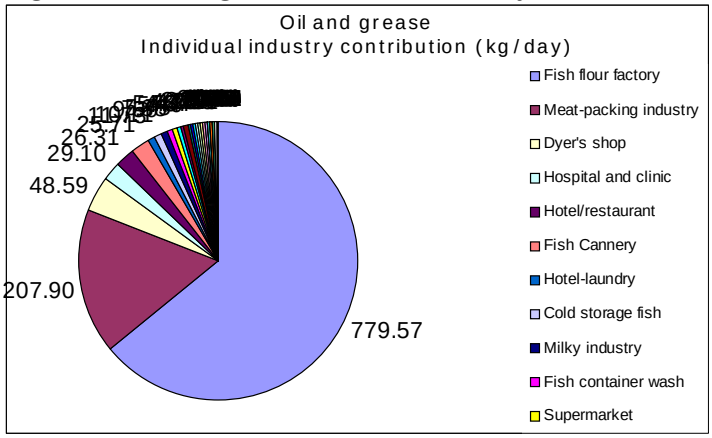


Figure 3: Oil and grease of 24 hs composed samples (2004 to 2010)

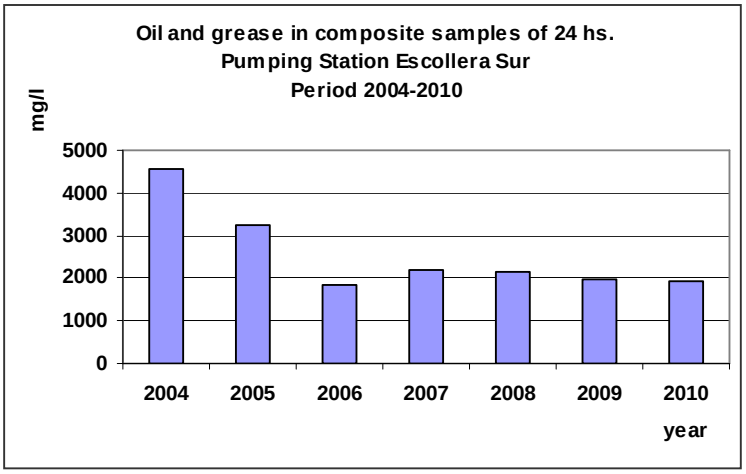
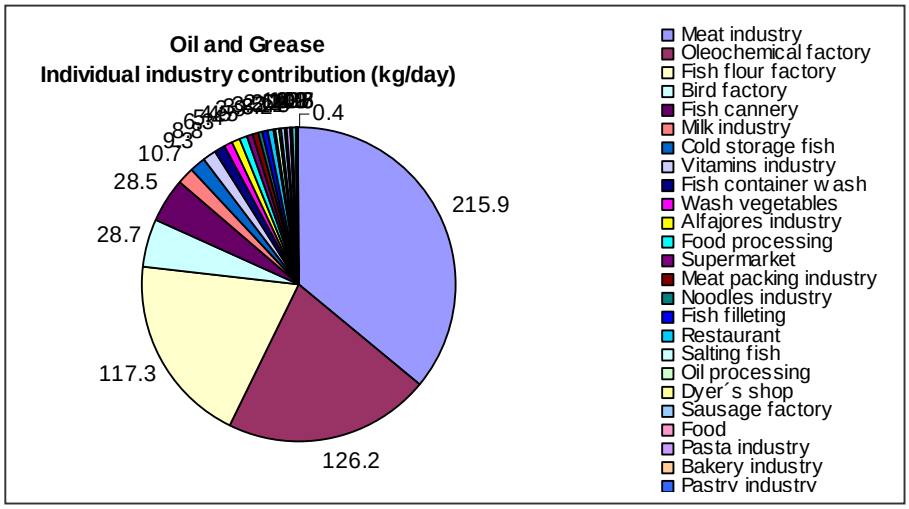


Figure 4: Oil and grease individual industry contribution till 2010



Characterization of the city waste water (15 years control)

Characterization and monitoring of liquid effluent

The urban wastewater monitoring program is developed since 1996, with monthly sampling of the effluent released to the sea after pretreatment. The sampling is performed with an automatic sampling device and involves 24 daily aliquots, 1 each hour, during a complete day, where the sample volume is proportional to the effluent flow (24-hour compensate sample). The average annual concentrations of several parameters are summarized in table 1. It can be observed the evolution in levels of the annual average concentration (12 monthly samples) for general constituents and heavy metals from 1999 to 2010.

Characterization and monitoring of solid effluent

The solids retained by the effluent pretreatment (20–25 daily tons-wet weight) are transported about 40 km distant in containers to a local nursery and stabilized in order to obtain a final compost product [9] to reuse as organic matter amendment in ornamental plants. The program implemented involves quarterly sampling of the solid and leaches tests, as well as quality controls over the

obtained product after the treatment. The solid test samples (24-hour composite sample) is obtained with the mixture of 24 aliquots, one each hour during a complete day. The table 2 summarized the basic statistics for the different analytical parameters obtained from the raw sludge during 1999–2010 period. The results show a high content in organic matter and a low levels of heavy metals (below the values required in national and international normative), allowing the reuse of the solid product obtained after the organic matter stabilization and pathogen minimization. The stabilized solid effluent (after 40% organic matter reduction show organic matter amendment characteristic (Sum of N, P y K below 5%) and low heavy metals levels (according to the kind of Mar del Plata industrial activity) would allow the agricultural use of the product.

Table 1: Monitoring of liquid effluent, average annual concentrations

General constituents	**year**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
pH	UpH	7.92	7.88	7.96	7.92	7.93	7.93	8.06	7.83	7.65	7.99	8.00
Solids, total	mg/l	1584	1588	1582	1534	1631	1571	1580	1510	1591	1578	1548
Fixed	mg/l	1192	1168	1194	1165	1219	1204	1209	1148	1181	1179	1164
Volatile	mg/l	390	420	388	369	412	367	371	362	410	399	384
Suspended Solids	mg/l	279	295	218	207	193	205	190	193	208	243	242
Fixed	mg/l	63	57	39	41	28	58	42	40	35	44	44
Volatile	mg/l	215	239	180	159	164	178	149	153	173	199	198
Setteable solids (2 hs)	ml/l	3.35	3.84	3.38	3.45	3.51	2.86	2.64	2.72	2.71	2.98	3.19
Setteable solids (2 hs)	mg/l	99	100	89	87	100	201	84	92	90	102	104
Fixed	mg/l	34	29	25	26	26	73	29	32	27	35	33
Volatile	mg/l	66	71	63	60	74	128	56	60	63	67	142
Disolved, Total	mg/l	1246	1293	1352	1311	1367	1332	1360	1280	1344	1324	1310
Fixed	mg/l	1054	1090	1164	1034	1152	1137	1160	1108	1131	1148	1114
Volatile	mg/l	192	203	188	187	215	195	200	172	213	160	197
Nitrogen, total (NTK)	mg/l	62.5	67.5	61.1	64.7	65.2	65.0	63.1	61.9	68.7	53.91	60.84
Organic	mg/l	32.5	38.7	34.9	33.7	37.0	37.5	33.3	37.0	34.5	25.46	34.84
Ammonia (NH_3-N)	mg/l	30.0	28.8	26.2	28.0	28.2	27.5	29.8	24.9	26.2	28.45	27.52
Phosphorus, total	mg/l	11.6	14.3	7.8	6.6	5.8	4.8	5.21	5.23	4.76	5.19	4.46
Disolved, ($o\text{-}PO_4^{-3}$)	mg/l	4.4	4.8	4.2	3.7	3.9	4.0	4.01	3.30	3.45	3.34	3.25
$B.O.D._5$	mg/l	341	336	314	253	296	279	275	262	366	286	282
C.O.D.	mg/l	612.7	639.2	518.3	497.5	571.9	534.5	532	532	592	617	563
Oil and grease	mg/l	72.4	79.4	55.4	50.5	58.3	53.9	59.3	70.3	83.2	78.2	77.4
Metals												
Zinc	mg/l	0.081	0.095	0.080	0.082	0.075	0.081	0.092	0.091	0.072	0.098	
Copper	mg/l	0.041	0.041	0.036	0.033	0.033	0.032	0.037	0.030	0.029	0.031	
Cadmium	mg/l	0.0018	0.0022	0.0007	0.0006	0.0008	0.0038	0.002	0.0012	0.0013	0.0023	
Lead	mg/l	0.006	0.015	0.012	0.009	0.011	0.013	0.01	0.014	0.006	0.012	
Nickel	mg/l	0.012	0.007	0.004	0.005	0.004	0.008	0.004	0.003	0.001	0.001	
Chromium	mg/l	0.021	0.033	0.006	0.005	0.006	0.007	0.004	0.005	0.005	0.003	

Table 2: Solid effluent characteristics. 2000 – 2010

General constituents	**Unit**	**n**	**Average**	**Max**	**Min**	**S D**
Moisture	%	90	76.95	87.00	63.76	5.00
Solids, Total	%	34	20.38	28.87	14.68	3.64
Fixed	%	27	3.41	8.23	1.65	1.44
Volatile	%	27	16.90	21.65	12.54	2.68
Organic mater	%	35	85.56	89.88	77.05	2.94
Total Organic Carbon (TOC)	%	35	42.78	44.94	38.53	1.47
Phosphorus, total	gP/Kg	36	6.24	15.13	1.83	2.83
Nitrogen, Total (N.T.K.)	gN/Kg	36	24.29	33.28	17.37	3.76
Proteins	%	36	15.25	20.90	10.91	2.36
Oil and grease	g/Kg	30	180.25	275.00	64.77	49.60
Hidrocarbon, Total	g/Kg	15	5.78	10.40	2.51	2.59
Heavy metals						
Zinc (Zn)	mg/Kg	25	317.15	417.05	248.52	59.04
Copper (Cu)	mg/Kg	25	537.18	813.69	302.13	197.17
Cadmium (Cd)	mg/Kg	24	1.24	2.82	0.68	0.73
Lead (Pb)	mg/Kg	25	60.21	83.11	44.19	14.43
Nickel (Ni)	mg/Kg	22	14.47	36.00	7.89	9.88
Chromium (Cr)	mg/Kg	25	25.47	60.58	12.75	17.76
Mercury (Hg)	mg/Kg	14	0.61	1.65	0.21	0.47

Recreational quality

Since the eighties, OSSE maintains a microbial marine water quality assessment, carrying out a sampling programme aimed at obtaining the microbial sewage indicators density in recreational

bathing area of the city. After 1995 the count of *enterococci* as a better faecal pollution indicator was incorporated (close relationship with health hazards associated with bathing in marine waters), [18,19,20,21,22,23,24 ,25]. The fluctuations in *enterococci* along the sea shore of the city till 2006 are presented in figure 5. This Box plot were obtained for each sampling location after a numerous sampling events (n) performed during the last years. The figure represents the data in a box showing the distance between quartiles and the median inside. The figure clearly shows the incidence of the wastewater discharge in a wide section of the coast affecting the recreational quality of the waters. In February 2006 the first local reference value was established for recreational waters[25] .The criterion was the same adopting by the USEPA in 1986 for marine recreational waters: 35 *enterococci* geometric mean per 100 ml. The figure indicates this reference value as a logarithmic mean (1.5). The results found in this evaluation shows that winds are responsible for the variability of faecal bacteria levels in each sampling location. In 2007 OSSE had worked in collaboration with "Virtual Beach Empirical Model software" authors from the U.S. EPA Office of Research and Development in developing site-specific predictive models for Mar del Plata beaches using multiple linear regression techniques and a data base of ten years and the obtained regression equations were validated during summer 2008 [26,27] .Since summer 2009, the validated regression models are being used to predict (through forecasted variables) bacterial levels in order to decide when chlorination of wastewater becomes necessary, as a mitigation action, to assure beach water quality. Figure 6 shows that the calculated enterococci geometric mean obtained from empirical values during summer 2010 compared to historical levels achieves the local compliance criteria for Buenos Aires province for the most popular beaches. Finally, organochlorine compound were analyzed in chlorinated effluent and no were detected at levels higher than regulated in any of the samples.

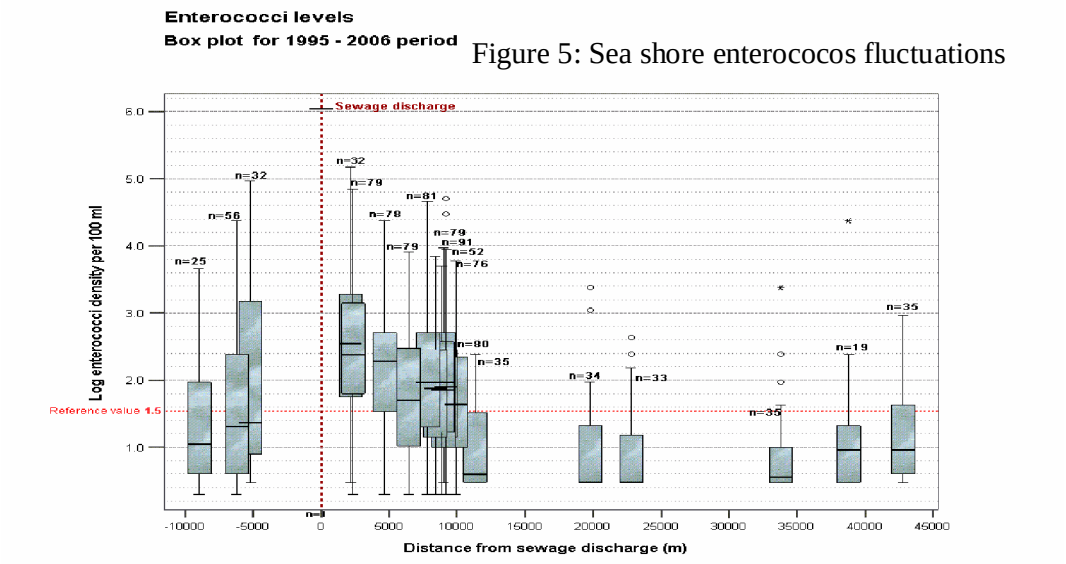


Figure 5: Sea shore enterococos fluctuations

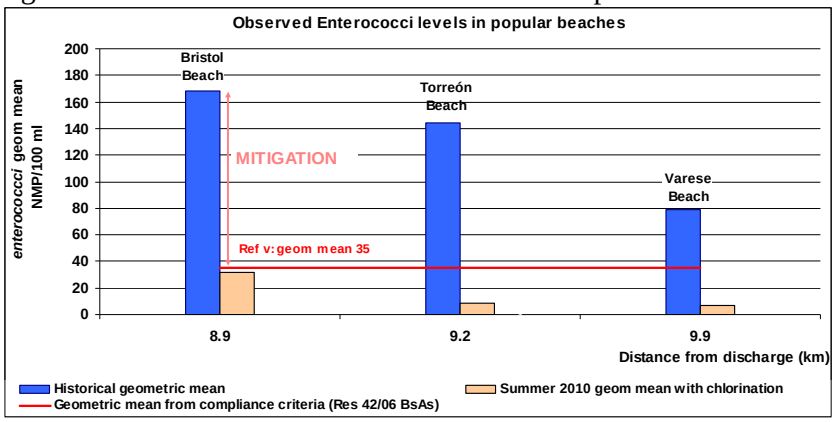


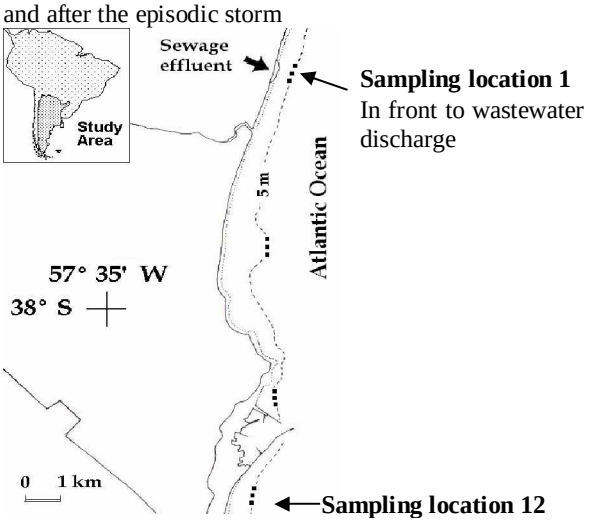
Figure 6: Geometric mean of *enterococci* vs. compliance criteria

Ecosystem quality

Since 1999 marine sediments were sampled, in a surface around 36 km^2 near the wastewater discharge, according to three sample schemes designed with defined objectives which considered geographical and seasonal variability (summer, autumn, spring, winter) and the variability caused by episodic storms, analyzing grain-size distribution, organic matter, nitrogen (NTK), total phosphorous, heavy metals in total fraction and in fine fraction (< 63 µm) and polinuclear aromatic hydrocarbons (PAH). The general results obtained, shows the stability in the natural conditions but within a broad range of natural variability. The temporally differences observed, in all the analyzed parameters, before and after episodic storms, in the same sampling location were bigger that difference between each sampling locations. In summary, sewage discharge incidence in sediment quality is not observed. The study area and some of these results are shown in figure 6 and 7.

Figure 6: Study area

Sample schemes 2: Twelve samples before and after the episodic storm



Sample schemes 1

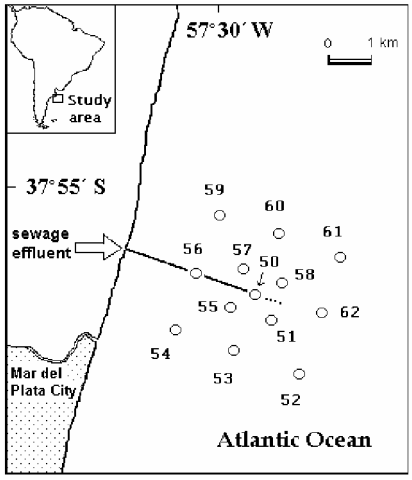
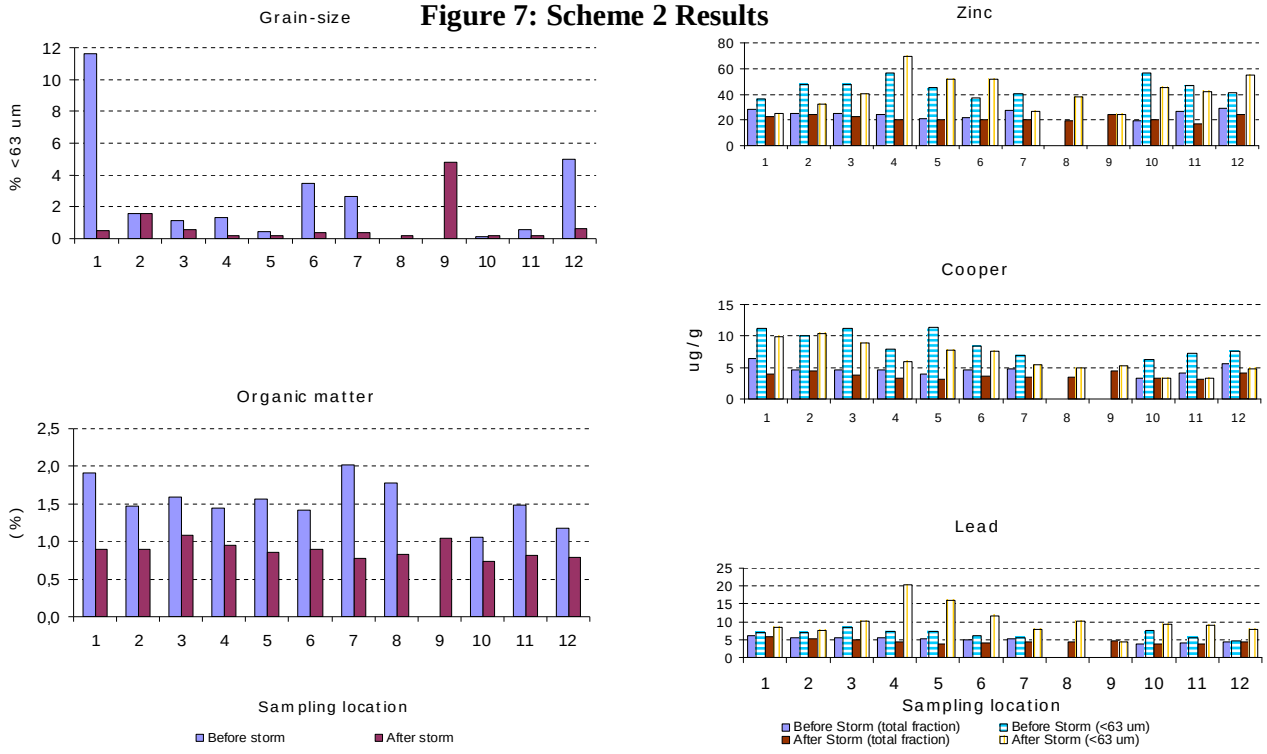


Figure 7: Scheme 2 Results



Conclusions

- Mar del Plata urban wastewater presents a high content in grease due to the incidence of food industries, principally fishery industries, causing operational troubles. Therefore, during the last five years a strong control program, especially focused on reduce the grease industrial discharge contribution have been implemented by OSSE.
- There is no contribution of toxic substances (heavy metals, hydrocarbons) from industrial effluents that constraint (a) the sewage discharge to marine environment, or (b) solid reuse.
- To assure beach water quality, until the submarine outfall, actually in construction, is operational, OSSE has implemented mitigation actions, which consist in use site-specific predictive models for Mar del Plata beaches to predict bacterial levels in order to decide when chlorination of wastewater becomes necessary. There were not detected any organochloride compounds, in the chlorinated effluent, at levels higher than regulated values in any of the analyzed samples.
- The receiving marine environment presents a great nature's self cleaning ability to assimilate the organic matter amount discharged from the sewage.
- The monitoring programmes show that ecosystem remain stable.
- The episodic storms have strong incidence in such stability.
- There is neither heavy metals enrichment processes nor hydrocarbons contamination in sediments.
- A great bottom settlement dynamic along the proposed pipeline route of the submarine outfall, including the future discharge area was observed. Consequently, actuality ecosystem not needs more depuration of organic matter discharged. Therefore, the construction of the submarine outfall with a well design diffuser system will be the better solution to improve the recreational quality. Furthermore, intertidal ecosystem preservation will be achieved and a nature's self cleaning ability for the subtidal ecosystem will be expected.

Recommendations

- To continue with the Integrated Coastal Management programme.
- To continue working to improve the industrial control in the origin to preserve the observed marine environment's self cleaning ability.

The results and conclusions exposed in this work agree with those from previous studies that proposed the construction of a marine outfall for the Mar del Plata city as a solution for the currently situation and are part of the ongoing monitoring programme performed to obtain the baseline data in the period previous the outfall construction.

REFERENCES:

[1] Committee on Wastewater Management for Coastal Urban Areas: "Managing Wastewater in Coastal Urban Areas" (1993)

[2] 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).

[3] Scagliola,M.-Costagliola,M.-Jeckel,W.-Marcovecchio,J.: "Evaluación de la eficiencia del proceso de cloración en la Planta de Pretratamiento de Efluentes Cloacales de Mar del Plata" (OSSE - INIDEP Unpublished study) (1993)

[4] Scagliola,M- Caldararo,A.M.-Casakin,N: "Sobre la calidad recreativa del litoral marítimo de Mar del Plata" Gerencia de Laboratorio y Control de Calidad, Obras Sanitarias Mar del Plata SE, Unpublished work.(1995)

[5] Scagliola,M-Caldararo,A.M.-Vergara,S-Levequi,A. : "Sobre la calidad recreativa del litoral marítimo de Mar del Plata - Período estival 1995/96" Departamento de Control de Calidad, Obras Sanitarias Mar del Plata SE. Unpublished work (1996)

[6] 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).
[7] Scagliola,M.: "Revisión de la aplicación de un sistema de desinfección por cloración para el efluente cloacal de Mar del Plata: Evaluación Ambiental y Técnica".- OSSE. Unpublished work (2002).
[8] Scagliola, M–Gonzalez, R–Gayoso G,-Genga, G.: "Efluentes industriales de Mar del Plata". Laboratorio de Aguas. Gerencia de Calidad. OSSE Unpublished work. (2002)
[9]] Peralta, E - Scagliola,M – González,R - von Haeften,G – Comino,A – Gayoso,G – Vergara,S - Genga,G: "Experiencia Piloto de Compostaje de Barros Primarios Cloacales de Mar del Plata" Revista de Ingeniería Sanitaria y Ambiental - Asociación Argentina de Ingeniería Sanitaria y Ciencias del Ambiente (AIDIS Argentina)- ISSN: 0328-2937 Nº 64, 65, 66. 2002.
[10] Scagliola , M-von Haeften G, Comino A,- Gonzalez R- Cerdá G.- Pontaut, S. : "Estrategia de Manejo Costero Integrado para la gestión del efluente urbano de la ciudad de Mar del Plata" . Proyecto: Protección Ambiental para el Río de la Plata y su Frente Marítimo: Prevención y Control de la Contaminación y Restauración de Habitats. FREPLATA. PNUD/GEF/RLA99/G31. (2005)
[11] Comino, Ana Paula – Scagliola Marcelo: "Calidad recreativa del litoral marítimo de Mar del Plata: 10 años de control". Gerencia de Calidad, Obras Sanitarias Mar del Plata SE. Unpublished work (2006)
[12] 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).
[13] 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)
[14] Ente Nacional de Obras Hídricas de Saneamiento "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)
[15] 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).
[16] Ordenanza Municipal Nº 19062 (Incremento en el valor del metro cúbico desaguado para los vuelcos de efluentes industriales que presenten excesos de Demanda Química de Oxígeno (DQO)). 2010
[17] Resolución OSSE Nº 132/10, Registro de Generadores de Efluentes Industriales Transportados por Camiones Atmosféricos. 2010
[18] Cabelli,V.J.-Dufour,A.P.-McCabe,L.J.-Levin;M.A.: "A marine recreational water quality criterion consistent with indicator concepts and risk analysis". Journal of Water Pollution Control Federation, Vol. 55 Nº10:1306-1314. 1983
[19] Salas, ,H.. : "Historia y aplicación de normas microbiológicas de calidad de aguas en el medio marino". Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente(CEPIS), 21 pp. 1994.
[20] Health-Based Monitoring Of Recreational Waters: The Feasibility of a New Approach (The "Annapolis Protocol"). Outcome of Expert Consultation, Annapolis, Usa Co-Sponsored By Usepa. (1999)
[21] Salas, H – Bartram, J.: "Borrador De Las Guias Para Ambientes Seguros En Aguas Recreativas". Organización Mundial de la Salud, Volumen 1: Aguas Costeras Y Dulces. Resumen (Parte 1). (2002)
[22] Guidelines For Safe Recreational Water Environments. Volume 1: Coastal And Fresh Waters. World Health Organization. (2003)
[23] Marco Conceptual Para El Establecimiento De Niveles Guia Nacionales De Calidad De Agua Ambiente. Subsecretaría De Recursos Hídricos De La Nación. Diciembre 2003
[24] Desarrollos De Niveles Guías Nacionales De Calidad De Agua Ambiente Correspondientes A Escherichia Coli/Enterococos (2003)
[25] Resolución nº 42/06 Directorio de la Autoridad del Agua. Pcia de Bs.As. (boletin oficial 25353). (2006)
[26] Frick, Walter E., Zhongfu Ge, and Richard G. Zepp. 2008. "Nowcasting and Forecasting Concentrations of Biological Contaminants at Beaches: A Feasibility and Case Study." Environmental Science and Technology, Volume 42, Number 13. Pages: 4818-4824
[27] Comino Ana Paula, Frick Walter, Ge Zhongfu, Scagliola Marcelo, Patat Laura, **"**Beach Water Quality of Mar del Plata (Argentina) previous to outfall construction: ten years of bacterial control and Virtual Beach model prediction testing" 5th International Conference on Marine Waste Water Disposal and Marine Environment. MWWD 2008. Croatia