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PRESENT STATE OF THE ROMANIAN BLACK SEA BATHING WATERS QUALITY

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ABSTRACT

The paper analyses the present state of the bathing waters quality along the Romanian Black Sea sector in comparison with the previously period (1970-2000), using the microbiological and physico-chemical parameters provided by the national and European water quality standards. The monitoring data obtained between 1970-2000 showed frequently an unacceptable situation of the bathing waters quality along the important Romanian coastal areas mainly as a consequence of the wastewater discharges from four treatment plants (Constantza North, Constantza South, Eforie South and Mangalia) situated near the most important seaside resorts. Beginning with 2001, a real improvement of the bathing waters quality was observed, particularly in most popular beaches of the Romanian Black Sea coast, due to reconstruction and rehabilitation of the sewerage and wastewater treatment system and by provision of the modern beaches facilities in the recreational zone.

KEY WORDS: bathing waters quality, microbiological, physico-chemical parameters, Romanian coast, Black Sea

INTRODUCTION

Recreational coastal waters are often subject to important changes in their quality due to microbiological and chemical pollution (BARTRAM *et al.*, 2001).

Most of the large cities located in the coastal area of the world prefer to discharge their sewage into the sea through marine outfall systems for convenient and economic reason (YANG and CHANG, 1998). However, such discharges constitute a threat to public health and in some cases pose a barrier to the development of sustainable tourism and aquaculture. Sewage effluents contain a wide variety of pathogenic microorganisms and a high level of chemical contaminants such as pesticides, heavy metals, nitrates and phosphates that may pose a health hazard to the human population when the are discharged into recreational waters (PIPES, 1982; CRANE and MOORE, 1986; PHILIPP, 1991; DAVIES *et al.,* 1995; BURKHARDT et al., 2000).

The Romanian Black Sea coast (245 km length) is a main touristic area. Like many other coastal areas of the Black Sea, the Romanian seashore is subject to some intense morphological changes and to pollution pressures (AUBREY *et al.,* 1996). Especially its southern part is a coastal area with a high average population density and multiple social and economic activities: tourism, industry, harbours, agriculture and fishery. Rapid industrialization and urbanization in this part of the Romanian coast have produced many serious water pollution problems since the ‘70s (MIHNEA and SERBANESCU, 1978; MIHNEA and PECHEANU, 1986). As a result of many heavy industry factories, maritime harbours and shipping activities, development of touristic facilities and explosive population increases (from 260,331 inhabitants in Constanta city in 1977 to 425,000 inhabitants in 2003), a large amount of untreated or insufficiently treated sewage was discharged into Romanian coastal waters. This situation has resulted in a high level of coastal zone pollution (LUPU and STOICA, 2002; MIHNEA and SERBANESCU, 1978; MIHNEA *et al.,* 1994*).*

The long-term evolution of the bathing water quality (1977-2003) is analyzed in order to identify the present status and the trends of pollutants levels along the Romanian Black Sea shore. The paper presents the quality of seawaters from the vicinity of municipal and industrial sewage outfalls alongthe southern Romanian Black Sea coast, using the main indicators of seawater pollution. The southern part of the coast was selected for attention as it includes highly popular tourist beaches.

MATERIAL AND METHODS

The quality of bathing waters is assessed in the entire world by using of quality standards within the framework of different monitoring programs (WHO, 1995; FIGUERAS *et al.*, 2000).

Concerns about chemical and microbiological pollution of Romanian Black Sea coastal waters are not new. The microbiological observations in these waters started between 1940-1950, when different pathogens were identified both in seawater and marine organisms, due to seawater pollution (MIHNEA and PECHEANU, 1986; BARTRAM *et al*,. 2001).

In the early 70's the Romanian Marine Research Institute (present National Institute for Marine Research and Development "Grigore Antipa") conducted a bacteriological survey in Romanian coastal waters. This survey involved tests for the presence of total and faecal coliform bacteria and faecal streptococci as indicators of microbiological pollution. Tests on water samples detected that levels of faecal coliform bacteria at several locations were not in compliance with national and international standards (e.g. World Health Organization). Since 1972, the Romanian coastal waters have been and continue to be monitored for the conventional microbiological and chemical water quality parameters (BARTRAM *et al*., 2001; STOICA, 2002).

The methods and standards used in the Romanian coastal waters monitoring system until May, 2002 were in compliance with the national legislation (STAS 3001-83, STAS 1258-87 and STAS 3001-91) (MANESCU, 1989; LUPU and STOICA, 2002). In order to align with European water legislation, new *Natural Resource Bathing Water Quality Norms* have been adopted recently in Romania. They have been in use ever since June, 2002 on the basis of a collaboration protocol between Ministry of Health and Family, Ministry of Water and Environment Protection as well as Ministry of Tourism (*Monitorul Oficial al Romaniei no. 350/2002*) and are in compliance with *Bathing Water Directive 76/160/EEC* and *European Union Directive 2000/60/EEC* (Table 1).

The coastal water quality monitoring activity focused on areas with known sources of pollution: harbours and urban coastal areas where the frequency of industrial pollution and discharge of sewage are highest (Constantza North, Constantza South, Eforie South, Mangalia).

Other areas of specific interest are areas with a high number of recreational facilities (Cazino-Mamaia, Costinesti, Vama Veche).

The network of sampling stations in the monitoring system is presented in Figure 1.

Table 1

The recent Romanian bathing water quality standards in comparison to European water legislation (*Bathing Water Directive 76/160/EEC* and *European Union Directive 2000/60/EEC*

Romanian standard (Official Journal of Romania, PartI, No 350 / 16 mai 2002)				**European standard (Directive 76/160/CEE)**			
Parameters	**G**	**I**	**Method of analysis and inspection**	Parameters	**G**	**I**	**Method of analysis and inspection**
MICROBIOLOGICAL PARAMETERS**				**MICROBIOLOGICAL PARAMETERS****			
Total coliforms /100 ml	500	10 000	MPN or membrane filtration methods	Total coliforms /100 ml	500	10 000	MPN or embrane filtration methods
Faecal coliforms /100 ml	100	2000	Identical	Faecal coliforms /100 ml	100	2000	Identical
Faecal treptococci/100 ml	100	-	Identical	Faecal streptococci/100 ml	100	-	Identical
PHYSICO-CHEMICAL PARAMETERS**				**PHYSICO-CHEMICAL PARAMETERS****			
pH	-	6-9 (0)	colorimetric method	pH	-	6-9 (0)	colorimetric method
Transparency	2	1 (0)	Secchi disc	Transparency	2	1 (0)	Secchi disc
Dissolved oxygen % saturation O2	80 to 120	-	Winkler method	Dissolved oxygen % saturation O2	80 to 120	-	Winkler method
Ammonia (mg/litre NH4)	-	*	SA or Nessler meth.	Ammonia (mg/litre NH4)	-	-	SA or Nessler meth.
Nitrogen Kjeldahl mg/litre N	-	*	Kjeldahl method	Nitrogen Kjeldahl mg/litre N	-	-	Kjeldahl method
Pesticides (mg/litre parathion, HCH, dieldrin)	-	*	GC	Pesticides (mg/litre parathion, HCH, dieldrin)	-	-	GC
Heavy metals(mg/litre As, Cd, Cr, Pb, Hg)	-	*	SAA	Heavy metals (mg/litre As, Cd, Cr, Pb, Hg)	-	-	SAA
Nitrates and phosphates (mg/litre NO_3 and PO_4)	-	*	colorimetric methods	Nitrates and phosphates (mg/litre NO_3 and PO_4)	-	-	colorimetric methods
BOD_5 (mg/l O_2)	5	*	Winkler method	BOD_5 (mg/l O_2)	5		Winkler method

* A I. category – surface water (STAS 4706-88 and *Norms for surface waters classification* / 2002)

**Selection according to parameters analysed in this paper

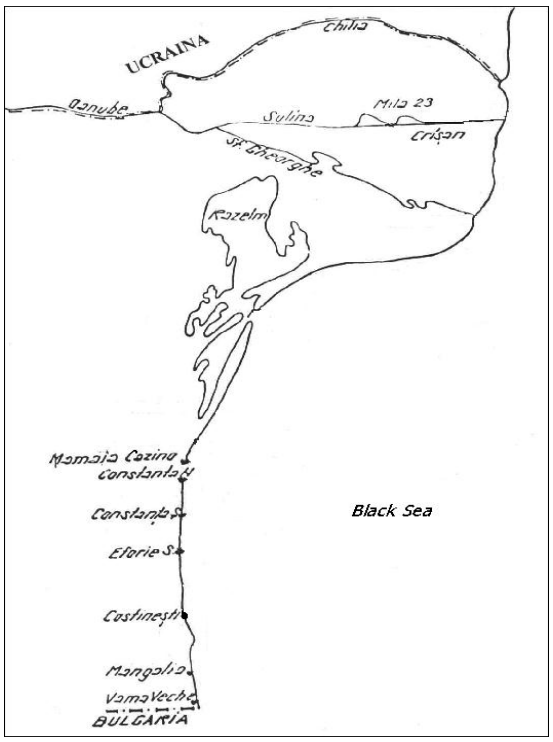

Fig.1 – Location of the sampling stations along
the southern part of the Romanian Black Sea coast

The results are based on processing of seawater samples collected seasonaly between 1977 and 2003 in described monitoring system (VELESCU and PECHEANU, 1984; PECHEANU and VELESCU, 1986; BADEA, 1992; COCIASU, 1994; OROS and PECHEANU, 2001; STOICA, 2001, 2002; STOICA *et al., 2*003).

RESULTS AND DISCUSSION

The monitoring data obtained between 1977-2000 showed frequently an unacceptable situation of the bathing waters quality along the important Romanian coastal areas (Tables 2 and 3).

These studies identified four major wastewater treatment plants (WWTP) Constantza North, Constantza South, Eforie South, Mangalia situated along the southern part of the Romanian coast and near the most important seaside resorts; none of them was classified as functioning

TABLE 2

Multiyearly means of major chemical parameters (BOD_5 mg/l O_2, ammonia mg/l, pesticides mg/l, heavy metals mg/l, nitrates mg/l and phosphates mg/l) in Romanian coastal waters (recreational and nearly WWTP zone)

STATIONS	**1990 – 1995**						**1996 - 2000**					
	BOD_5	NH_4	pesticides	Heavy metals	NO_3	PO_4	BOD_5	NH_4	pesticides	Heavy metals	NO_3	PO_4
Mamaia	3.48	2.93	nd*	na*	3.44	11.5	0.56	0.04	0	0.007 (Cu) 0.053 (Cd) 0.005 (Pb)	0.45	0.001
Constantza North	4.87	7.57	nd*	na*	7.33	15.2	1.22	0.05	0	0.005 (Cu) 0.004 (Cd) 0.006 (Pb)	0.37	0.009
Constantza South	5.44	17.6	nd*	na*	11.4	22.4	nd	nd	0	0.012 (Cu) 0.001 (Cd) 0.006 (Pb)	nd	nd
Eforie South	3.18	3.25	nd*	na*	4.30	7.88	nd	0.17	0	0.012 (Cu) 0.005 (Cd) 0.011 (Pb)	nd	nd
Costinesti	3.45	2.14	nd*	na*	4.47	1.49	2.3	0.07	0	0.007 (Cu) 0.004 (Cd) 0.008 (Pb)	0.40	0.031
Mangalia	6.04	26.3	nd*	na*	5.54	86.7	nd	1.99	2.1 (dieldrin)	0.011 (Cu) 0.005 (Cd) 0.010 (Pb)	0.336	1.57
Vama Veche	3.83	1.62	nd*	na*	7.16	2.34	3.07	0.13	0	0.004 (Cu) 0.007 (Cd) 0.009 (Pb)	0.669	0.0009

nd* – not determined

na** – not available

TABLE 3

Multiyearly means of microbiological parameters
(Total coliforms - TC/100 ml, Faecal coliforms - FC/100 ml, Faecal streptococci – FS/100 ml)
in Romanian coastal waters (recreational and nearly WWTP zone)

STATIONS	**1977 - 1980**			**1980-1990**			**1990- 2000**		
	TC	FC	FS	TC	FC	FS	TC	FC	FS
Mamaia	0.53×10^4	0.29×10^4	0.12×10^4	0.47×10^4	0.27×10^4	0.67×10^3	0.24×10^4	0.11×10^4	0.59×10^3
Constantza North	0.58×10^6	0.71×10^6	0.42×10^5	0.83×10^5	0.48×10^5	0.19×10^4	0.1×10^5	0.88×10^4	0.61×10^4
Constantza South	0.27×10^9	0.17×10^9	0.33×10^8	0.88×10^6	0.25×10^6	0.1×10^6	0.22×10^5	0.19×10^5	0.23×10^5
Eforie South	0.76×10^6	0.79×10^5	0.10×10^5	0.64×10^3	0.3×10^3	0.89×10^2	0.38×10^4	0.15×10^4	0.15×10^4
Costinesti	0.14×10^4	0.57×10^3	0.86×10^2	nd*	nd*	nd*	0.54×10^3	0.1×10^3	0.1×10^{43}
Mangalia	0.38×10^4	0.3×10^4	0.55×10^3	0.16×10^7	0.27×10^6	0.86×10^6	0.13×10^5	0.11×10^4	0.59×10^3
Vama Veche	0.33×10^4	0.13×10^4	0.22×10^3	0.26×10^3	0.8×10^2	0.12×10^3	0.54×10^4	0.37×10^4	0.14×10^4

nd* - not determined

has resulted in a high level of coastal zone pollution, the studies made until 2000 giving a clear indication that sewage effluent is having significant impacts upon the coastal water quality:

- **Constantza North**: maximum admissible values for all the parameters were constantly exceeded with few exceptions such as for instance in 1990, 1991 and 2000 (Tables 2 and 3).

-**Constantza South**: high levels of microbiological contamination are being recorded from 1977 to 2000 (e.g. 10^9 TC and FC / 100 ml, 10^8 FS/ 100 ml between 1977-1980 and 10^5 faecal bacteria / 100 ml during 1990 -2000); as for chemical parameters high levels of nitrates and phosphates and presence of heavy metals (Cd, Pb) were also recorded;

- **Eforie South:** all indicators were exceeded between 1977 and 1980, 1990 and 2000.

- **Mangalia:** maximum admissible values for all microbial indicators (TC, FC, and FS) were constantly exceeded from 1977 to 2000; same situation was evidenced for chemical parameters between 1990-1995 and 1996-2000 (Tables 2 3).

For the recreational areas, the level of chemical and faecal pollution indicators (Total coliforms, Faecal coliforms, Faecal streptococci) is shown in Tables 2 and 3. The data are based on monthly sampling frequency in the near shore bathing area from May to September between 1977 and 2003. The values of faecal microbiological indicators - the major parameters of bathing water quality assessment - have frequently exceeded admissible limits (10,000 TC / 100 ml, 2,000 FC / 100 ml and 100 FS / 100 ml).

The bathing water quality presented the following characteristics:

- **Cazino-Mamaia**: at Mamaia, the biggest marine summer resort in Romania (also called "the Black Sea's Pearl"), the maximum levels of Faecal streptococci were exceeded between 1977 and 2000, as well as all chemical indicators between 1990-1995 (e.g. 3.44 mg/l NO_3 and 11.5 mg/l PO_4). The major pollution sources are the wastewater discharges from the Constantza North WWTP (situated in the southern part of this resort) and the infringement of hygiene norms by bathers during the summer season.

- **Costinesti:** even if this resort is not under the direct influence of wastewater discharges, the admissible values were temporarily exceeded for microbiological indicators (especially for FC and FS) between 1997 and 2000 (Table 3). Obviously, the main sources of pollution of the bathing waters in this summer resort were until 2000 the increase of tourist number during summer and the lack of the modern beach facilities.

- **Vama Veche**: a similar quantitative level of the main microbiological indicators was found by comparison to Costinesti. Between 1977 and 1980 and 1990 and 2002 the limits were temporarily exceeded for microbiological

indicators also due to seawater use for recreational purpose by tourists as well as to polluted water transport originated from the stations located in the northern part of Vama Veche (Tables 3 and 4).

Between 1970 and 2000 Constanta county had serious sewage disposal problems, sewage pollution acting as a major factor in the degradation of the Romanian coastal waters quality.

The initially planned capacity of the WWTPs on the Romanian coast represented only half of current loading capacity, the stations being endowed only with primary or secondary treatment technology. Significant pollution issues related to entire sewage treatment system in the southern part of the Romanian coast have imposed immediate decision making strategies for its rehabilitation. Various research and management programs have been developed by national and by international organizations to upgrading of existing and poorly functioning sewage treatment systems at both the domestic and industrial levels (LUPU and STOICA, 2002):

- the rehabilitation of Constantza North WWTP (closed down in 1998) by E.C. finnancial assistance, planing to became operative in 2004;

- modernisation of Constantza South WWTP with European Bank for Reconstruction and Development (EBRD) assistance, bilateral support provided by Danish government as well as own sources of the Authonomous County Water Authority Constantza (RAJA); its rehabilitation started in 1999 and was finished in 2001;

- investment for Eforie WWTP aimed at treatment station rehabilitation, construction of a new pumping station, all of them being planned to become operative in 2004;

- Mangalia WWTP Rehabilitation Project with European Bank for Reconstruction and Development assistance started in 1999 and was finished in 2001.

The observations made after improving the sewage treatment systems (between 2001 and 2003) shown a visible change in the seawater quality, particularly in bathing beaches (Table 4). Seasonal analysis of the chemical and microbiological seawater quality on the whole coastal area investigated between 2001 and 2003, has evinced a reduced level of chemical and microbiological indicators, in compliance with national and international standards (Table 4). These data have shown the improving of the Romanian bathing seawaters beginning 2001 compared with previous decades.

TABLE 4

The mean of chemical and microbiological parameters determined both in recreational and coastal waters (nearly WWTP) after the improving the sewage treatment systems (2001-2003)

Stations	Chemical parameters						Microbiological parameters		
	BOD_5 mg/l O_2	NH_4 mg/l	pesticides mg/l	Heavy metals mg/l	NO_3 mg/l	PO_4 mg/l	TC / 100 ml	FC / 100 ml	FS / 100 ml
Mamaia	3.06	0.18	0.0000016 (HCH) dieldrin - absent	0.0058 (Cu) 0.0014 (Cd) 0.0043 (Pb)	1.62	0.015	2.9×10^2	1.8×10^2	0.6×10^2
Constantza North	3.29	0.21	0.000073 (HCH) 0.000057 (dieldrin)	0.0063 (Cu) 0.0012 (Cd) 0.0080 (Pb)	0.37	0.028	6.2×10^3	6.3×10^3	0.2×10^3
Constantza Suouth	2.24	2.23	0.00021 (HCH) 0.000045 (dieldrin)	0.0109 (Cu) 0.0017 (Cd) 0.0050 (Pb)	1.50	1.463	1.6×10^4	1.6×10^4	3.9×10^3
Eforie South	3.78	0.23	0.000028 (HCH) dieldrin - absent	0.0037 (Cu) 0.0017 (Cd) 0.0021 (Pb)	0.32	0.034	1.2×10^3	1.2×10^3	6.6×10^2
Costinesti	4.11	0.08	0.000185 (HCH) 0.000035 (dieldrin)	0.0081 (Cu) 0.0011 (Cd) 0.0035 (Pb)	0.43	0.028	4.5×10^3	8.7×10^2	0.4×10^2
Mangalia	5.04	0.06	0.000066 (HCH) 0.00006 (dieldrin)	0.0068 (Cu) 0.0020 (Cd) 0.0052 (Pb)	0.35	0.030	1.3×10^3	2.2×10^2	1.3×10^2
Vama Veche	4.07	0.10	0.000091 (HCH) 0.000032 (dieldrin)	0.0016 (Cu) 0.0016 (Cd) 0.0094 (Pb)	0.26	0.031	5.5×10^3	2.2×10^2	0.2×10^2

CONCLUSIONS

- High levels of contaminants, exceeding the European and Romanian standards, have been recorded frequently in the Romanian Black Sea coastal area during a 30 years period (1970 - 2000).

- The major sources of pollution of the bathing waters identified along the Romanian coast were: the increase of tourist number during summer and of local population in the main localities of Constantza county and more particularly the waste water discharges from four treatment plants (Constantza North, Constantza South, Eforie, Mangalia) situated near the most important seaside resorts.

- The quality of Romanian coastal waters changed depending on fluctuation in the inflow pollution load. Reduction in the inflow load is well reflected in the water quality.

- Beginning with 2001, the Romanian coastal waters were better protected from pollution by provision of modern sewerage and wastewater treatment systems. Correcting the problems of sewage pollution is not an easy task but not impossible; it requires significant input of human and financial resources.

- Due to the improving of the sewage treatment systems (between 2001 and 2003) a visible change in the seawater quality was observed, particularly in most popular beaches of the Romanian Black Sea coast.

- A real improvement of the water quality in the entire Romanian coastal area may be observed after the complete reconstruction of the entire sewage system and treatment facilities with European financial assistance. Once the rehabilitation project is completed, a significant decrease (100%) in pollutant discharges by all four wastewater treatment plants will be expected. Other benefic effects include decreases in contamination risk as regards population's health.

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