Bathing Water Quality Monitoring Programme

2005

Report on monitoring of physico-chemical parameters

Malta Environment and Planning Authority

April 2006

Executive Summary

As a Member State of the European Union and as a Contracting Party to the Barcelona Convention, Malta is required to monitor and report on the quality of its bathing waters. The legal instrument to this effect is the Bathing Water Regulations (LN380/2003) which transposes the European Bathing Water Directive CD76/160/EEC.

The Bathing Water Regulations (LN380/2003 under the Public Health Act) identify the Department of Public Health as the Competent Authority for the implementation of these regulations.

These regulations require that identified bathing waters are regularly monitored during the designated bathing season; which, in Malta, runs from approximately mid-May to mid-October. The monitoring required by these regulations is of two types:

- Microbiological monitoring
- Physico-chemical monitoring

The monitoring effort under the Bathing Water Regulations is shared between the Department of Public Health and the Pollution Prevention and Control Unit within the Environment Protection Directorate of MEPA. The former carries out monitoring of all microbiological parameters while the latter carries out monitoring of physico-chemical parameters at 43 selected monitoring points which coincide with monitoring points used for microbiological monitoring.

The present report details the results of the analyses for physico-chemical parameters carried out by MEPA during the 2005 bathing season.

1. Introduction

As an EU Member State and a Contracting Party to the Barcelona Convention, Malta is legally bound to carry out monitoring of its bathing waters according to laid-down procedures and protocols.

The European legal instrument for this purpose, the Bathing Water Directive (CD76/160/EEC) has been transposed as LN380/2003 under the Public Health Act, which identifies the Department of Public Health (DPH) within the Ministry of Health, the Elderly and Community Care.

Bathing water monitoring takes place during the designated bathing season, with microbiological monitoring carried out by the DPH and physico-chemical monitoring carried out by MEPA.

Physico-chemical monitoring of bathing waters involves both on-site visual and olfactory inspection as well as sample collection for later laboratory analysis. All samples collected by MEPA during the bathing water season were analyzed at the Malta National Laboratory in San Gwann. While a number of parameters are analyzed in all collected samples, a few parameters are analyzed in only a sub-set of the samples collected.

2. Methodology

2.1 Logistics

Sample collection took place early in the morning, generally on Mondays and Wednesdays early mornings. The DPH grouped samples into 4 geographically-close groups for practical purposes. These are Malta South (Zone A), Sliema area (Zone B), Malta North (Zone C) and Gozo (Zone D). The four zones were sampled over a two week period as follows:
Week 1 Monday – Zone A
Week 1 Wednesday – Zone B
Week 2 Monday – Zone C
Week 2 Wednesday- Zone D
Week 3 Monday – Zone A etc.

Thus the full complement of 43 samples was collected in fortnightly cycles. Within each coastal zone, the following number of samples was collected:

- 11 samples from Malta South
- 9 samples from Sliema area
- 15 samples from Malta North
- 8 samples from Gozo

2.2 Sampling and on-site inspection

Samples were collected from the shoreline, at a depth of approximately 0.3m, labeled and placed in glass sample bottles. Samples were kept in a picnic cooler and transported to the laboratory immediately after all samples for the day had been collected.

While on site, MEPA staff carried out the following observations:

- The bathing area was noted for any odour, oily film, lasting foam, tarry residues, abnormal water colour or any floating material.
- Portable equipment was used to measure pH, temperature, and dissolved oxygen.

2.3 Analyses

Samples were delivered to the Malta National Laboratory on the same day of collection, as soon as all sampling for the day had been completed. Details of the analytical techniques and limits of detection are summarized in the table below.

Table 1. Summary of the analytical methods and limits of detection for each parameter analyzed.

Parameter	***Analytical method***	***Limit of detection***
Ammonia N	Spectrometric method ISO 7150/101984)	0.75mg/L
Anionic surfactants	Spectrophotometric method with methylene blue	0.1 mg/L
Arsenic	Inductive coupled plasma	0.23 mg/L
Cadmium	Inductive coupled plasma	0.01 mg/L
Chromium	Inductive coupled plasma	0.04 mg/L
Cyanides	According to ASTM D 2036-98	0.03 mg/L
Kjeldahl N	According to ISO 5663-1984)	1 mg/L
Lead	Inductive coupled plasma	0.21 mg/L
Mercury	Inductive coupled plasma	0.8 mg/L
Nitrate N	According to ISO 7890/2-1986)	1 mg/L
Phenols	(BS 6068: Section 2.12.1990) 4-aminoantipyrine spectrometric method	0.05 mg/L
Phosphate P	According to ISO 6878: 1998)	0.01 mg/L

All samples were tested for ammonia N, Kjeldahl N, nitrate N and phosphate P.

Further to this, oil and grease, anionic surfactants, phenols, metals (arsenic, cadmium, chromium, lead, and mercury) and cyanides were analyzed in 10 specific samples collected from the following sites:

- Malta South: A05, A09, A11
- Sliema area: B01a
- Malta North: C19, C28, C30
- Gozo: D13, D20

2.4 Statistics and other general information

(a) On-site inspection of bathing waters was carried out between May 2nd and October 31st 2005.
(b) Sampling of bathing waters for laboratory analyses was carried out between July 11th and October 31st 2005.
(c) Each monitoring point was inspected 13-14 times, and was sampled for laboratory analysis 8-9 times throughout the duration of the bathing season.
(d) A total of 355 samples from around Malta and Gozo were collected for laboratory analysis.
(e) The total cost of the laboratory analyses amounted to approximately Lm17, 800.

3. Results

The importance of physico-chemical monitoring under the Bathing Water Regulations is two-fold; it allows assessment of compliance with the quality requirements annexed to the regulations and, on a more general level, provides for trend monitoring over time. This trend monitoring cannot be said to be indicative of the state of the marine environment in general since naturally sampling is biased in favour of specific (bathing) areas. However, within these areas, it allows monitoring of water quality conditions subject to specific pressures linked to the summer tourist season.

3.1 Results by parameter

Following is an overview of the results obtained for each parameter and how these compare with the requirements of the Bathing Water Regulations. The quality requirements are deemed to have been achieved when the results achieved comply with the mandatory requirements.

Table 2. Summary table for the monitored parameters

Parameter	*Mandatory value in LN380/2003*	*Guideline value in LN380/2003*	*Results*	*Exceedance*		
				Site	*Date*	*Value*
pH	6 to 9	-	12 results were outside the mandatory range. 97.8% compliance for this parameter over the whole bathing season was achieved.	B01a B04 D06 D09 D13 D15 D20 A03 A05 A07 C01 D20	1.6.05 1.6.05 8.6.05 8.6.05 8.6.05 8.6.05 8.6.05 13.6.05 13.6.05 13.6.05 20.6.05 22.6.05	9.21 9.06 9.15 9.03 9.23 9.39 9.27 9.34 9.33 5.54 5.94 9.71
Colour	No abnormal change in colour	-	1sample was of abnormal colour due to rainfall causing land run-off. Thus, 99.5% compliance for this parameter over the whole bathing season was achieved.	D07	26.10.05	Abnormal colour
Mineral oils	No film visible on the surface of the water and no odour	≤0.3mg/L	An oil film on the surface of the water was noted on two occasions. Thus, 99.5% compliance for this parameter over the whole bathing season was achieved.	A03 D07	5.9.05 3.8.05	Visible film Visible film
Surface active substances	No lasting foam	≤0.3mg/L	Lasting foam was noted on 9 occasions. Thus, 98.4% compliance for this parameter over the whole bathing season was achieved.	A03 B05 B03 B11 B13 B13 D07 D07	13.6.05 13.7.05 15.6.05 1.6.05 27.7.05 7.9.05 8.6.05 26.10.05	Lasting foam present
Phenols	No specific odour ≤0.05mg/L	≤0.005mg/L	100%compliance with mandatory quality requirements was achieved in that no specific odour was detected in any sample. All samples analyzed for phenols were below the 0.05mg/L detection limit			

			value.			
Transparency	2m	1m	No specific measurement for this parameter was carried out. However the sea bottom was nearly always visible in all most sampling locations.			
Dissolved oxygen - %saturation O_2	-	80-120	Only a 5.4% compliance was achieved for this parameter, with the absolute majority of sites exhibiting DO values averaging 52%.	*Numerous.*		
Tarry residues and floating material	-	Absence	There is no mandatory quality standard for this parameter; however 96.7% compliance with the guideline parameter was achieved over the duration of the bathing season.	B11 A08 A12 A16 B01a B05 C01 C06 B04 B05 B04 B05 B04 C06 A05 B13 C01 D10 D20	1.6.05 13.6.05 13.6.05 13.6.05 15.6.05 15.6.05 20.6.05 20.6.05 28.6.05 13.7.05 27.7.05 27.7.05 24.8.05 29.8.05 5.9.05 7.9.05 10.10.05 12.10.05 12.10.05	Floating waste and debris mainly composed of plastic articles and aluminum cans.
Ammonia mg/L NH_4	-	-	No quality requirements for this parameter. However all samples analyzed resulted below the detection limit of 0.75mg/L.			
Nitrogen Kjeldahl mg/L N	-	-	No quality requirements for this parameter. The average Kjeldahl N concentration was <1.31mg/L. It was assumed that all results that were below the 1mg/L detection limit are equal to 1.			
Arsenic	-	-	No quality requirements for this parameter. However all samples			

			analyzed resulted below the detection limit of 0.23mg/L.			
Cadmium	-	-	No quality requirements for this parameter. However all but one of samples analyzed resulted below the detection limit of 0.01mg/L. One sample (A09 on October 31st) had a concentration of 0.02mg/L.			
Chromium	-	-	No quality requirements for this parameter. However all samples analyzed resulted below the detection limit of 0.04mg/L.			
Lead	-	-	No quality requirements for this parameter. However all samples analyzed resulted below the detection limit of 0.21mg/L.			
Mercury	-	-	No quality requirements for this parameter. However all samples analyzed resulted below the detection limit of 0.8mg/L.			
Cyanides	-	-	No quality requirements for this parameter. However all samples analyzed resulted below the detection limit of 0.03mg/L.			
Nitrates in mg/L	-	-	No quality requirements for this parameter. 67% of samples analyzed resulted below the detection limit of 1 mg/L. The average nitrate value for all analyzed samples is 2.06mg/L if samples collected after heavy rain periods are excluded. If the nitrate values obtained for samples collected after heavy rain periods are included, then			

			the average nitrate value is 4.78mg/L.			
Phosphates in mg/L	-	-	No quality requirements for this parameter. 26.56% of samples analyzed resulted below the detection limit of 0.01 mg/L. The mean concentration of phosphates in analyzed samples is <0.02mg/L			

The following graphs illustrate the average changes in concentrations of certain parameters over the duration of the monitoring period. These graphical representations have been produced only for those parameters which have exhibited notable changes in concentration over the duration of the sampling period. The following parameters: ammonia N, all metals, arsenic, cyanides, phenols and anionic surfactants showed no or minimal variation during the monitoring period and so are not graphically presented.

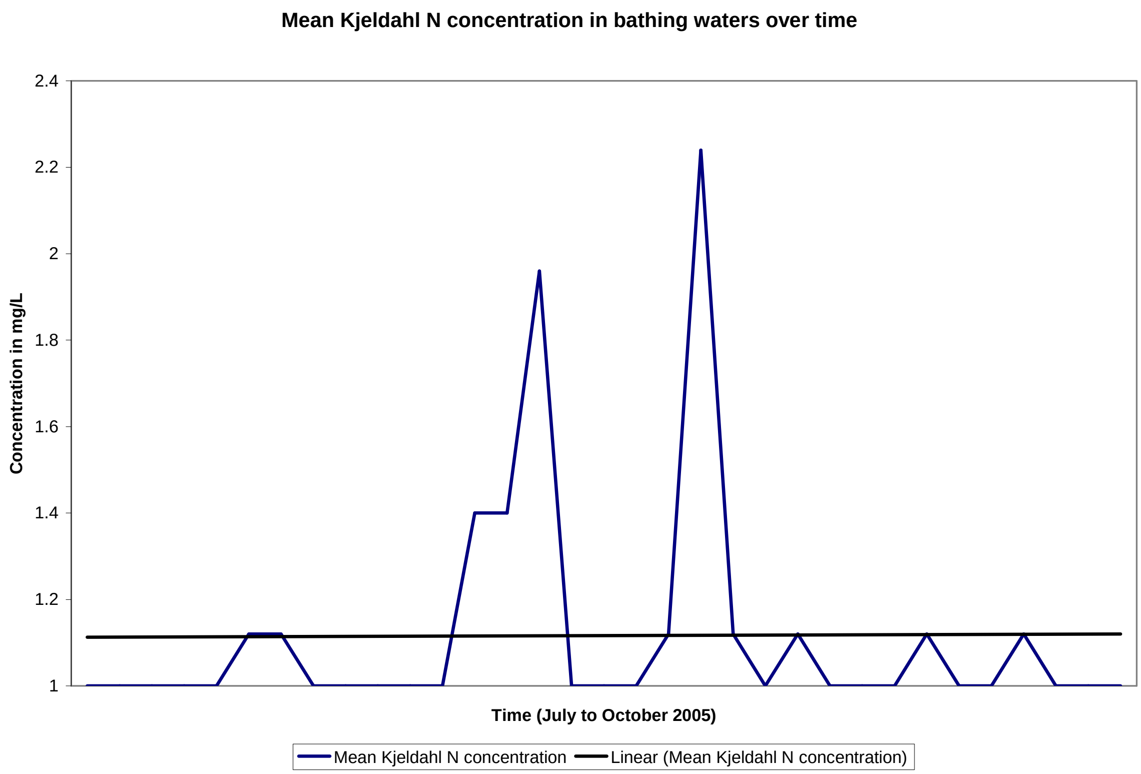

Figure 1. Variation in average Kjeldahl N concentration over the monitoring period July to October 2005

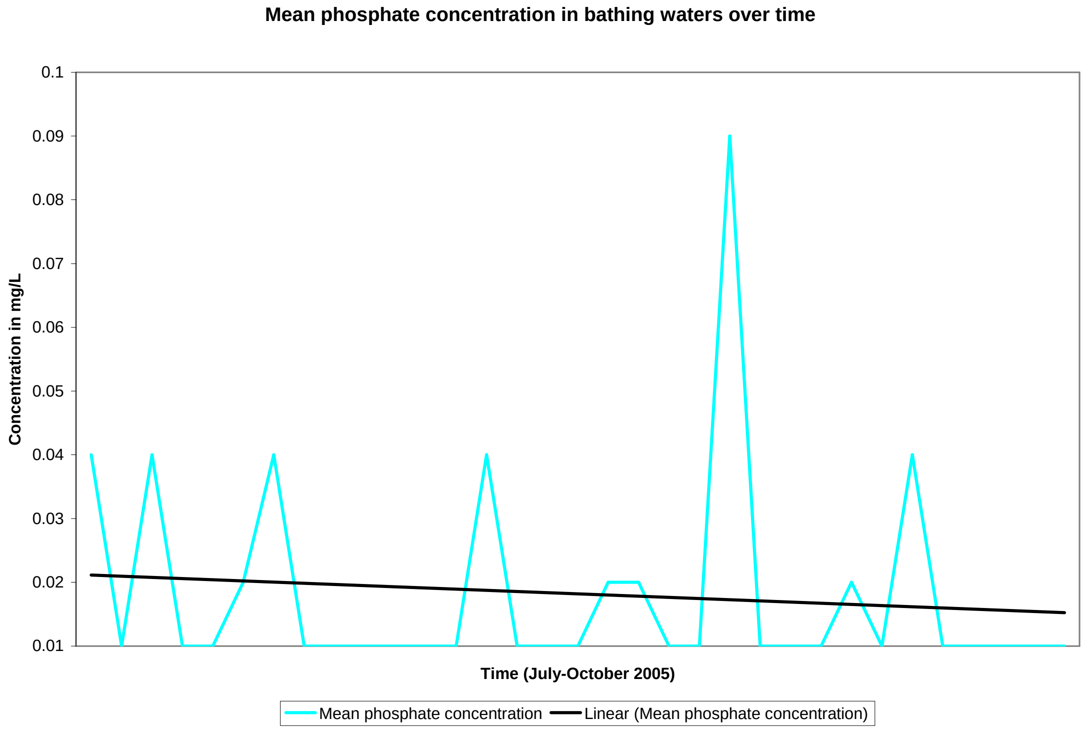

Figure 2. Variation in average phosphate concentration over the monitoring period July to October 2005

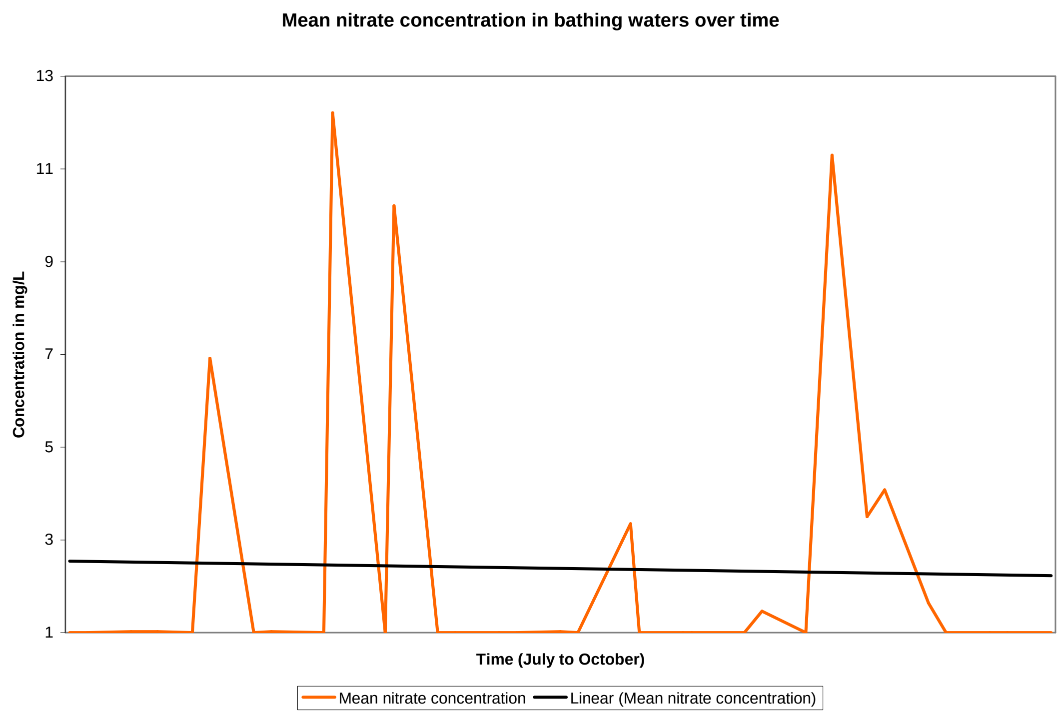

Figure 3. Variation in average nitrate concentration over the monitoring period July to October 2005

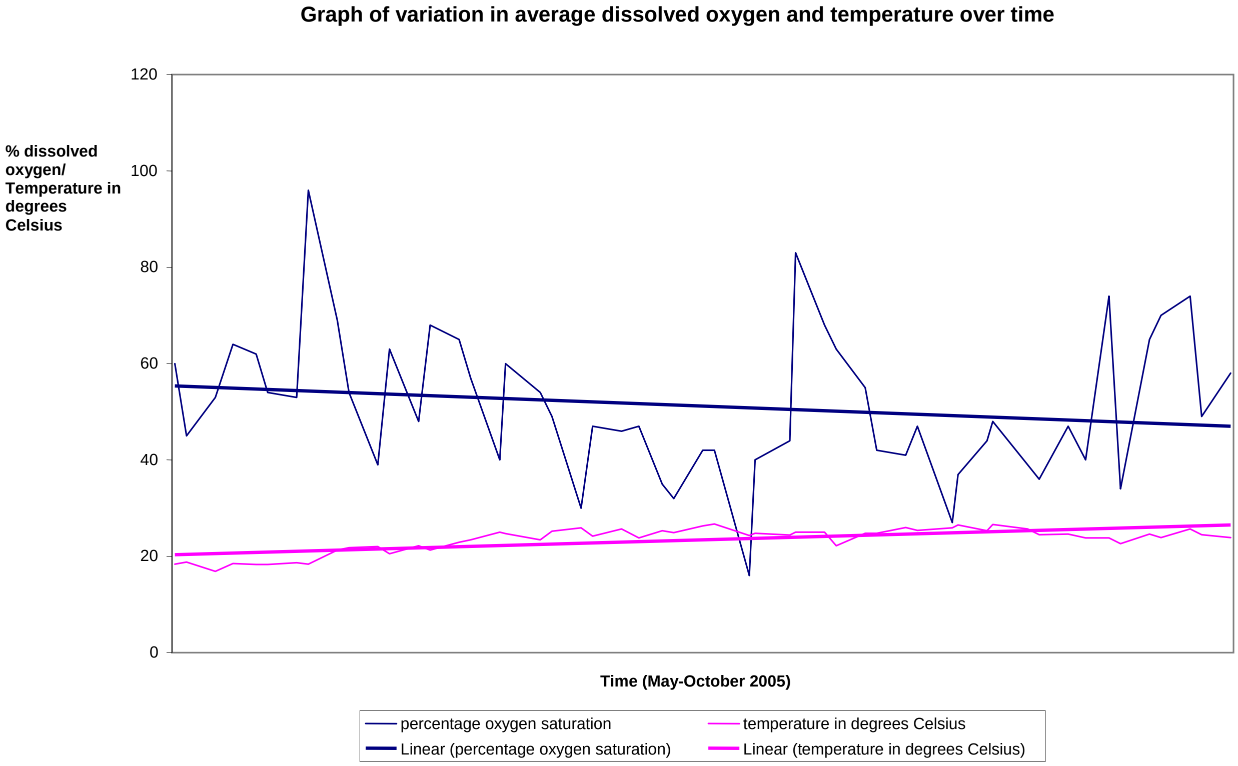

Figure 4. Variation in average dissolved oxygen concentration and temperature over the monitoring period May to October 2005

3.2 Results by sampling site

The following tables summarize the results obtained for parameter analyzed in each site.

Table 3. Average values of nutrients and dissolved oxygen in bathing waters in mg/L

	Average values of parameters indicating nutrient content, pH and dissolved oxygen in bathing waters					
Site code	*Ammonia N in mg/L*	*Kjeldahl N in mg/L*	*Nitrates in mg/L*	*Phosphates in mg/L*	*pH*	*% oxygen saturation*
A03	<0.75	<1.01	<1.21 (24.70)	<0.02	8.05	50
A05	<0.75	<1.32	<2.08 (14.00)	<0.017	8.13	53
A07	<0.75	<1.16	<1.18 (11.72)	<0.02	7.87	54
A08	<0.75	<1.38	<1.23 (9.12)	<0.03	7.97	46
A09	<0.75	<1.51	<2.11	<0.03	8.02	57
A11	<0.75	<1.58	<1.96 (21.58)	<0.02	8.06	56
A12	<0.75	<1.24	<3.15 (11.18)	<0.02	8.06	53
A13	<0.75	<1.26	<1.90 (9.84)	<0.02	8.11	57
A15	<0.75	<1.57	<2.68 (10.44)	<0.03	8.11	59
A16	<0.75	<1.25	<2.14	<0.03	8.09	59
A17	<0.75	<1.25	<1.90	<0.02	8.07	50
B01a	<0.75	<1.08	<5.27 (14.18)	<0.02		54
B03	<0.75	<1.37	<2.84	<0.03	8.11	50
B04	<0.75	<1.12	<2.39	<0.02	8.05	39
B05	<0.75	<1.11	<1.11	<0.02	8.10	40
B06	<0.75	<1.29	<1.77	<0.01	8.15	60
B09	<0.75	<1.24	<2.09	<0.01	8.14	54
B11	<0.75	<1.34	<1.84	<0.02	8.16	60
B12	<0.75	<1.22	<1.37	<0.01	8.15	58
B13	<0.75	<1.05	<2.74	<0.01	8.19	48
C01	<0.75	<1.18	<0.75	<0.02	7.97	52
C03	<0.75	<1.34	<0.47	<0.02	8.14	56
C05	<0.75	<1.23	<0.42	<0.01	8.17	51
C06	<0.75	<1.78	<0.80	<0.02	8.15	52
C07	<0.75	<1.20	<0.55	<0.02	8.12	63
C09	<0.75	<1.26	<3.20	<0.03	8.12	53
C13	<0.75	<1.19	<1.00	<0.02	7.35	57

C17	<0.75	<1.72	<1.06	<0.02	8.08	42
C19	<0.75	<1.38	<3.49	<0.02	8.01	52
C20a	<0.75	<1.45	< 1.11	<0.02	8.09	45
C23	<0.75	<1.90	<1.26	<0.02	7.45	47
C26	<0.75	<1.36	<1.19	<0.03	7.69	56
C28	<0.75	<1.32	<1.02	<0.02	7.83	63
C30	<0.75	<1.13	<1.44	<0.02	7.81	63
C32	<0.75	<1.65	<2.60	<0.02	7.87	51
D02	<0.75	<1.16	<2.42	<0.02	8.08	55
D06	<0.75	<1.2	<3.05	<0.04	8.09	54
D07	<0.75	<1.17	<2.03	<0.02	8.03	54
D09	<0.75	<1.45	<1.57	<0.02	7.97	50
D10	<0.75	<1.31	<1.93	<0.03	7.91	58
D13	<0.75	<1.17	<2.21	<0.02	8.10	57
D15	<0.75	<1.17	<2.21	<0.01	8.05	53
D20	<0.75	<1.32	<1.79	<0.01	8.22	54

Note: In the above table, values shown in brackets indicate the average values if the results obtained for samples collected soon after heavy rain are included.

Table 4. Average values of metals and semi-metals in bathing waters in mg/L

	Average values of metals and semi-metals in bathing waters in mg/L				
Site code	*Arsenic*	*Cadmium*	*Chromium*	*Lead*	*Mercury*
A05	<0.23	<0.01	<0.04	<0.21	<0.8
A09	<0.23	<0.01	<0.04	<0.21	<0.8
A11	<0.23	<0.01	<0.04	<0.21	<0.8
B01a	<0.23	<0.01	<0.04	<0.21	<0.8
C19	<0.23	<0.01	<0.04	<0.21	<0.8
C28	<0.23	<0.01	<0.04	<0.21	<0.8
C30	<0.23	<0.01	<0.04	<0.21	<0.8
D13	<0.23	<0.01	<0.04	<0.21	<0.8
D20	<0.23	<0.01	<0.04	<0.21	<0.8

Table 5. Average values of anionic surfactants, cyanides and phenols in bathing waters in mg/L

	Average values of anionic surfactants, cyanides and phenols in bathing waters in mg/L		
Site code	*Anionic surfactants*	*Cyanides*	*Phenols*
A05	<0.10	<0.03	<0.05
A09	<0.10	<0.03	<0.05
A11	<0.10	<0.03	<0.05
B01a	<0.10	<0.03	<0.05
C19	<0.10	<0.03	<0.05
C28	<0.10	<0.03	<0.05
C30	<0.10	<0.03	<0.05
D13	<0.10	<0.03	<0.05
D20	<0.13	<0.03	<0.05

4. Analysis of results and concluding remarks

4.1 Analysis of results

While physico-chemical monitoring is not usually the determining factor in determining the suitability of a bathing site for use as such, it gives insight to the pressures to which bathing waters are subjected.

4.1.1 Nutrients - Kjeldahl N, ammonia N, nitrates and phosphates

At the right concentrations, nutrients are a normal component of coastal waters and are a necessary component of aquatic life. It is when the levels of these parameters increases significantly due to anthropogenic influences that environmental harm may result.

Ammonia nitrogen (NH_3-N) is an inorganic, dissolved form of nitrogen found in water and is the preferred form for algae and plant growth. Ammonia is found in water where dissolved oxygen is lacking. High ammonia concentrations can stimulate excessive aquatic production and indicate pollution. Sewage is an important source of ammonia N to coastal waters. Throughout the 2005 bathing season, ammonia N was never detected above the 0.75mg/L analytical limit.

Kjeldahl nitrogen is the sum of organic nitrogen and ammonia nitrogen and, at high levels may be indicative of sewage pollution. The highest average value of Kjeldahl N recorded was approximately 2.2mg/L. As shown in the linear trend line in figure 1, Kjeldahl appears to have remained on average unchanged for the whole duration of the bathing season.

Nitrates and phosphates are also parameters indicative of water quality, since in excess amounts they can accelerate eutrophication, causing an increases in aquatic plant growth, a reduction in oxygen levels (hypoxia) and changes in the types of plants and animals that live in the affected area. The Mediterranean is naturally oligotrophic, with nutrients (nitrates, phosphates) being scarce in the illuminated surface layers. However anthropogenic inputs and run-off may cause an increase in nutrient levels in inshore waters. Over the duration of the bathing season, nitrates and phosphates both decreased. This may partly be explained by the lack of mixing of waters in the summer months resulting in a severe depletion of nutrients from the surface water layers, and the lack of inputs through run-off waters.

Although during the 2005 bathing season there have been isolated incidences of temporary ‘closure’ of bathing sites due to sewage pollution, it is not possible to correlate these to the nutrient data obtained since the sampling dates and times for microbiological and nutrient analysis may not necessarily have been the same.

4.1.2 Arsenic, cadmium, lead, chromium and mercury

These substances are a natural component of seawater, however when in excess they are indicative of pollution usually due to industrial discharges. No quality requirements (guideline/ mandatory limit values) are set in the legislation for these parameters. All metals were found to be below the analytical detection limits.

4.1.3 Anionic surfactants, phenols and cyanides

Anionic surfactants are substances which form lasting foam on the surface of the water and can arise from both point and diffuse pollution sources. Phenol has a limited solubility in water and at high enough concentrations may be detected through its ‘sweet, tarry odour’. Cyanides may be discharged from industrial processes. No quality requirements (guideline/ mandatory limit values) are set in the legislation for these parameters. However all analyses for these parameters resulted below the limit of detection.

4.1.4 Dissolved oxygen, pH, temperature and transparency

The typical pH of seawater in the Mediterranean is slightly alkaline, on average pH 7.5-8. However localized changes in pH may result due to discharge of effluents and large volumes of run-off over short periods. The mandatory value range for pH is 6-9. A few exceedances were recorded which were slightly above pH 9 and are not considered particularly abnormal or problematic. A few exceedances below pH 6 were recorded, and it is not excluded that the latter are due to instrumental or human errors.

Temperatures measured were typical of the summer months, although in some instances they were somewhat higher than average temperatures due to being measured in very shallow waters with little or no wave action.

Dissolved oxygen is the parameter for which there are most exceedances. The legislation gives no mandatory value but indicates a guideline value for dissolved oxygen of 80-120%. The average value of percentage dissolved oxygen recorded was 52%. The reason for low dissolved oxygen concentration is in part explained through the inverse relation between dissolved oxygen and temperature. As time progresses from May to October seawater temperature gradually increases. Over the same period it is noted that dissolved oxygen concentration gradually decreases due to the fact that oxygen dissolved less at higher water temperatures.

Transparency is visual measure of water clarity; this is the depth at which the pattern on a Secchi disk containing black-and-white markings can no longer be distinguished under water. Transparency can serve as an indicator of the amount of phytoplankton: More plankton causes increased turbidity and reduced transparency. Eutrophication thus contributes to reduced transparency (secchi depth). During the 2005 bathing season, turbidity measurements (in Nephelometric Turbidity Units) for bathing waters were taken; turbidity and transparency being inversely proportional. However these readings cannot be classified against the guideline and mandatory values for transparency under the bathing water regulations, which involves the use of the secchi disc. The Secchi disk has the advantages of integrating turbidity over depth (where variable turbidity layers are present).

4.2 Concluding remarks

The physico-chemical component of bathing water quality is a useful but limited tool for the monitoring of water quality. The sampling is naturally biased towards clean sites and monitoring of waters alone is not sufficient, especially for monitoring of heavy metals, as these tend to absorb to suspended matter and sediment.

Thus, while useful, physico-chemical monitoring of bathing waters needs to be integrated into a general, more holistic monitoring regime covering areas exposed to greater anthropogenic pressure, areas classified as non–bathing and possibly also reference areas. In fact since May 2005, MEPA has embarked on a holistic monitoring program for coastal waters, covering the monitoring requirements under the various water quality Directives under the EU *Acquis*. It is aimed to use this program as a platform for designing chemical monitoring of coastal waters under the Water Framework Directive (CD2000/60/EC).

4.2.1 Improvements

Within the framework of the legal monitoring requirements under the bathing water regulations, in 2005 bathing sites were insufficiently monitored for a number of physico-chemical parameters. It is anticipated that the monitoring locations will be increased to cover all bathing sites identified by the Public Health Department while the actual monitoring and sampling protocol will be adjusted to fit the Bathing Water regulation’s requirements.

It is anticipated to improve the analytical aspect of the monitoring program. Certain parameters are analyzed using methodologies for which detection limits are too high, to the point of making the data unusable for compliance and trend monitoring of bathing waters.

The use of the secchi disc method as the means of measuring water transparency is also anticipated, in addition to monitoring of turbidity.

4.2.2 Future legal developments

Council Directive 76/160/EEC on Bathing Water Quality was one of the first pieces of European environmental legislation. It set binding standards for bathing waters throughout the European Union. However, it clearly reflects the state of knowledge and experience of the early 1970s, both technically as socially. Since 1976, epidemiological knowledge has progressed and managerial methods have improved.

In October 2002, the Commission adopted the proposal for a revised Directive of the European Parliament and of the Council concerning the Quality of Bathing Water COM (2002)581. The proposed Directive makes use of only two bacteriological indicator parameters, but sets a higher health standard than the 1976/160 Directive. Based on international epidemiological research and on the experience with implementing the current Bathing Water and Water Framework Directives, the revised Directive provides long-term quality assessment and management methods in order to reduce both monitoring frequency and monitoring costs.

5. References

The following were consulted in the preparation of this report:

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