CHAPTER 16

Assessment of the Maltese Environmental Matrix to Define the Future Monitoring Strategy

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Introduction

As a member of the EU and of the international community, Malta has important obligations to report on the state of the environment and the effectiveness of policy measures addressing particular concerns, such as pollution (Regional Environmental Center, 2008). Failure to collect reliable and up-to-date environmental data would make Malta exposed to various environmental pressures due to poorly informed policy decisions, which could eventually also lead to economic implications (European Commission, 2014a). Under this context Malta is in the process of implementing the EU legislative framework regarding the environmental themes of air, water, radiation and soil. Prior to the implementation of the project "Development of environmental monitoring strategy and environmental monitoring baseline surveys", air and water data from the Maltese environmental network were already available, though data coverage presented some lacunas, whereas radiation and soil network system was not in place, hence minimum baseline data was available. Therefore, the long term monitoring strategic proposal discussed in this article has been designed as a primary tool to improve the state of the environment as well as to be in compliance with the EU Directives related with nature conservation.

Theoretical Issues

The following section introduces the main EU environmental legislation which establishes the regulatory framework for the long-term monitoring strategy.

Water: Inland waters and Coastal

The Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishes a framework for community action in the field of water policy. The latter is better known as the Water Framework Directive (WFD) which creates an innovative approach for water management based on river basins, the natural geographical and hydrological units, and sets specific deadlines for member states to achieve ambitious environmental objectives for aquatic ecosystems. The purpose of the WFD is to establish a legal framework to protect and restore water quality across Europe and ensure its long term and sustainable use. It also establishes a new concept – that water resources should not be protectes solely for human consumption and use but inherently have a value and are important for ecosystems (Official Journal of the European Communities, 2000a).

Air

The two European Directives of greatest relevance to this air quality assessment are: 2008/50/EC and 2004/107/EC (European Commision, 2014b).

Directive 2008/50/EC incorporates, in a single directive, the previous existing legislation acts issued between 1996 and 2002:

- Air quality Framework directive (Directive 96/62/EC).
- First Daughter Directive (1999/30/EC).
- Second Daughter Directive (200/69/EC)
- Third Daughter Directive (2002/3/EC) except for the Directive 2004/107/EC relating the Arsenic, Cadmium. Mercury, Nickel and Benzo(a)pyrene that remains in force.

The main aim of this Directive is to maintain, and whenever possible, improve the air quality to protect the health of humans, vegetation and ecosystems. It sets up air quality objectives, plans, monitoring requirements and methods as well as the pollutants' target and limit values to assess the state of the air quality in each member state (European Commision, 2014b).

Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in ambient air (the Fourth Daughter Directive) is the final stage in the process launched by framework Directive 96/62/EC of recasting the European legislation on the presence of pollutants posing a risk to human health. Given that the substances involved are human carcinogens, and that there is no identifiable threshold below which they do not pose a risk to human health, the Directive applies the principle of lowest possible exposure to them (European Commision, 2014b).

Radiation

Under Article 35 of the EURATOM Treaty, each member state of European Union is required to establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in the environment. An independent assessment is conducted periodically by the European Commission to verify the operation and efficiency of member states' facilities (European Commission, 2000).

In addition, Article 36 of the EURATOM Treaty requires that data gathered from this monitoring be communicated periodically to the European Commission (European Commission, 2000).

Commission Recommendation 2000/473/EURATOM (European Commission, 2000) on the application of Article 36 of the EURATOM treaty gives specific guidance on the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole (Official Journal of the European Communities, 2000b). This recommendation gives specific guidance as to the structure of monitoring networks, the media that should be sampled, the types of measurements, the radionuclides to be monitored and the sampling frequencies.

Soil

On September 22nd 2006, the European Commission adopted a Soil Thematic Strategy which consists of: communication from the Commission to the other European Institutions, a proposal for a framework Directive (a European law), and an impact assessment (European Comission, 2014c).

The overall objective of the EU Strategy is protection and sustainable use of soil, based on the following guiding principles:

1) Preventing further soil degradation and preserving its functions.

2) Restoring degraded soils to a level of functionality consistent at least with current and intended use, thus also considering the cost implications of the restoration of soil.

This recognises that certain threats, such as erosion, organic matter decline, compaction, salinisation and landslides, occur in specific risk areas which must be identified.

Methodology

The methodology followed to design the long term monitoring involved the following steps in the different elements of the environmental matrix:

Water: Coastal and Inland waters

1) Analysis of existing legislation and regulatory framework:

The WFD has been transposed into Maltese legislation under the Environment Protection Act (Chapter 435) and the Malta Resources Authority Act (Chapter 423) through the Water Policy Framework Regulations (LN 194 of 2004), which entered into force on April 23rd 2004. LN 194 of 2004 defines the Malta Resources Authority (MRA) as the competent authority for groundwater and inland surface waters, with the exception of inland surface waters protected under the Development Planning Act (1992 as amended) or the Environment Protection Act (2001). Such inland surface waters are placed under the competency of the Malta Environment and Planning Authority (MEPA), which is also responsible for coastal waters.

2) Analysis and assessment of the current status of environmental monitoring networks

After reviewing and analysing the existing legislation and directives related to the monitoring of inland surface, transitional and coastal waters, it was concluded that to date there is no comprehensive and integrated water monitoring program for surface waters in Malta. The only monitoring program that exists is for bathing waters which is coordinated by the Department of Environmental Health.

3) Performing a baseline survey.

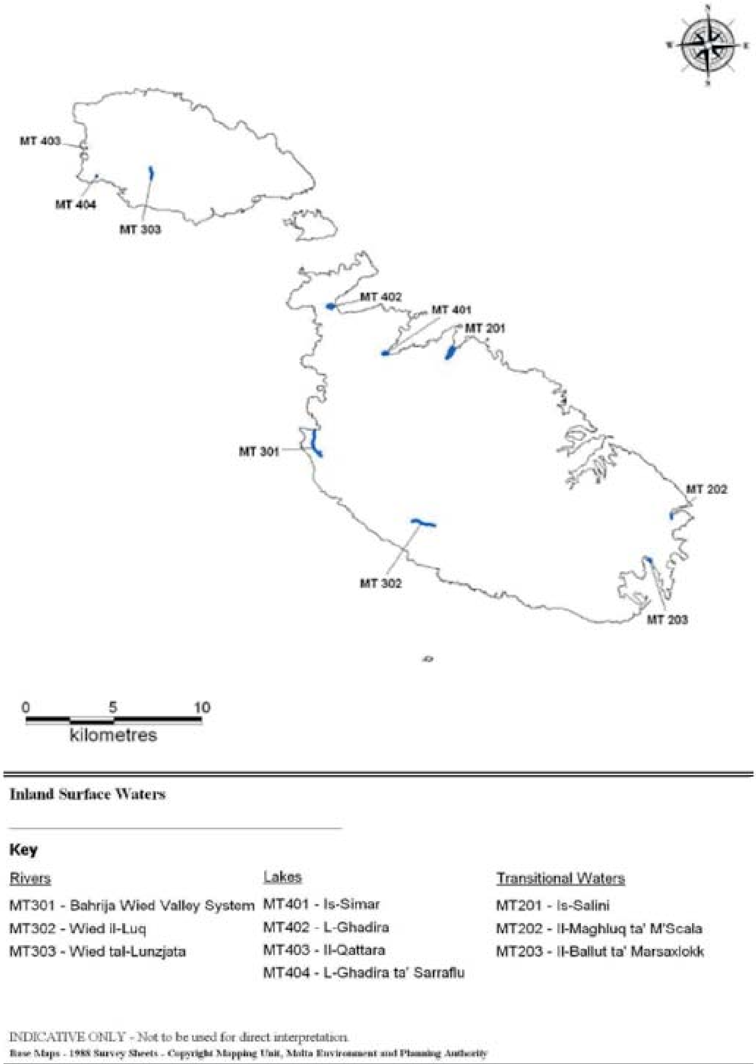
Due to the lack of baseline data the results obtained from the baseline surveys and monitoring programs carried out for inland surface, transitional and coastal waters between 2012/2013 were critical for this long term monitoring strategy.

Figure 1 and Table 1 describe the 10 inland surface water bodies where the baseline surveys were carried out.

Table 1: Inland and Transitional Water Bodies of the Maltese Islands

Reference Code	Name	Latitude	Longitude	Length in km /Area in km2	Water body Type
MT201	Is-Salini	5 56.50 N	14 25.21 E	0.8	Transitional
MT202	Il-Magħluq ta' Marsascala	35 51.46 N	14 33.46 E	0.3	Transitional
MT203	Il-Ballut ta' Marsaxlokk	35 50.24 N	14 32.59 E	0.1	Transitional
MT301	Baħrija Valley System	35 53.75 N	14 20.20 E	1.794	Watercourse
MT302	Wied il-Luq	35 51.31 N	14 24.21 E	1.395	Watercourse
MT303	Wied il-Lunzjata	36 2.21 N	14 14.3 E	0.654	Watercourse
MT401	Is-Simar	35 56.48 N	14 22.56 E	0.032	Standing
MT402	L-Għadira	35 58.15 N	14 20.52 E	0.044	Standing
MT403	Il-Qattara	36 3.7 N	14 11.35 E	0.001	Standing
MT404	L-Għadira ta' Sarraflu	36 2.16 N	14 11.59 E	0.002	

Figure 1: The Inland and Transitional Water Bodies of the Maltese Islands



Source: MEPA (2011a)

Sampling

Figure 2 and Figure 3 represent the water bodies and the specific points in which the sampling was performed. Table 2 provides additional information of the specific locations.

Figure 2: Coastal Maltese water bodies [9]

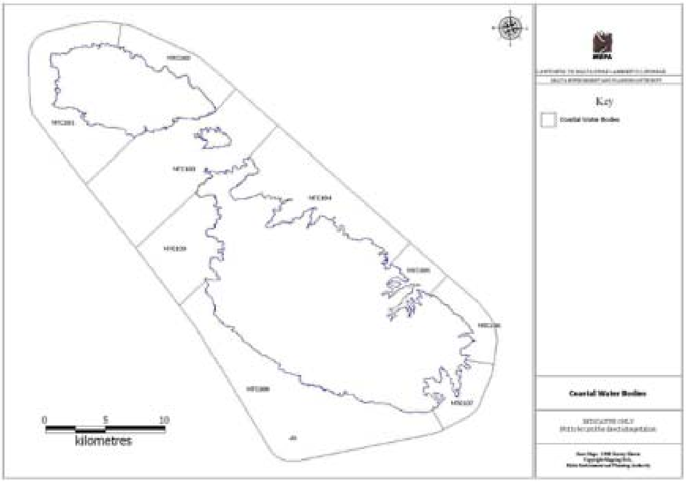


Figure 3: Sampling points for chemical and physicochemical elements and biological monitoring at Coastal Waters

Table 2: Sampling points for chemical and physicochemical elements and Biological Monitoring at Coastal Waters

WFD Water Body	Sites	lat (°N)	long (°E)
MTC101	CN01-2	36 01.814	14 12.989
MTC101	CS01	36 04.350	14 10.546
MTC101	CN01-1	36 03.181	14 11.171
MTC102	CN02-1	36 04.506	14 15.610
MTC102	CS02	36 04.269	14 17.060
MTC103	CN03-1	36 01.027	14 16.999
MTC103	CN03-2	36 01.664	14 18.073
MTC103	CN03-3	35.98. 917	14.33. 866
MTC103	CN03-4	36.03.550	14.23.506
MTC103	CN03-5	36.01.321	14.34.265
MTC103	CN03-6	36.00.605	14.35.076
MTC103	CS03	36 00.334	14 21.710
MTC104	CN04-1	35 58.503	14 21.787
MTC104	CN04-2	35.97.764	14.33.317
MTC104	CN04-3	35.90.697	14.45.111
MTC104	CN04-4	35 57.028	14. 23.357
MTC104	CN04-5	35.93.557	14.48.830
MTC104	CN04-6	35 55.183	14 29.759
MTC104	CN04-7	35.89.384	14.44.717
MTC104	CP04-1	35 56.635	14 29.236
MTC104	CP04-2	35 57.738	14 26.073
MTC105	CN05-1	35 54.041	14 30.181
MTC105	CN05-2	35.89.611	14.51.579
MTC105	CP05	35 54.164	14 31.512
MTC106	CN06-1	35 51.978	14 33.958
MTC106	CN06-2	35.87.434	14.51.431
MTC106	CP06-1	35 53.222	14 34.116
MTC106	CP06-2	35.87.434	14.51.431
MTC107	CN07-1	35.83.735	14.57.189
MTC107	CN07-2	35 50.035	14 33.028
MTC107	CN07-3	35 49.741	14 32.163
MTC107	CN07-4	35.87.434	14.51.431

WFD Water Body	Sites	lat (°N)	long (°E)
MTC107	CP07	35 49.227	14 33.270
MTC108	CN08-1	35.83.185	14.41.734
MTC108	CS08	35 48.491	14 29.221
MTC109	CN09-1	35 57.549	14 20.143
MTC109	CS09	35 55.665	14 19.882

In order to fulfil the requirements of Directive 2013/39/EU, the baseline surveys collected robust scientific data on the physicochemical, hydro-morphological and biological quality elements of the coastal, inland surface and transitional waters designated in 2005.

The biological parameters sampled included of phytoplankton, macroalgae, angiosperms, and benthic invertebrates.

The measured physico-chemical quality elements for seawaters have been aggregated in three main groups:

- Group A: Physicochemical parameters supporting biological quality elements; these are required to be measured at most monitoring sites (Refer to Directive 2000/60/EC);
- Group B: Priority substances to be measured in water. These are split in oils (Group B1) and miscellaneous (Group B2) (Refer to Directive 2008/105/EC, Annex I);
- Group C: Substances to be measured in sediments (Refer to Directive 2008/105/EC, Annex I).

The schedule of the sampling was performed according to the information given in Table 3.

Table 3: Sampling schedule

Sampling Dates	Water	Sediment	Biota
Coastal	Monthly basis from May 2012 to July 2013.	1st August to mid August 2012	End of June/ early August 2012.
Inland	Monthly basis from February 2012 to January 2013		August 2012 November 2012 December 2012 February 2013

Assessment of the baseline survey results

For data assessment the criteria indicated in Table 4 and Table 5 were applied:

Table 4: Evaluation criteria for biological parameters

Water	Parameter	Index	Variables
Coastal	Chlorophyll a concentration		
	Angiosperms	Rapid Easy Index	
	Macroalgae:	The CARLIT index	
	Benthic		Number of species (S) Richness (Margalef, D) Abundance (N: ind/m2) Diversity (Shannon Wiener, H') Equitability (Pielou, J).
	Macroinvertebrate species	AZTI Marine Biotic Index (AMBI)	
Inland	Benthic macro invertebrates	SWI: Shannon-Weiner Index, EBI: Extended Biotic Index, CBS: Chandler Biotic Score.	

Table 5: Evaluation criteria for chemical parameters

Parameters	Matrix	Reference	Classification	Criteria
Priority substances and other pollutants	Water	Annual average EQS, (Directive 2008/105/EC)	Moderate/Poor	1 parameters > EQS
			Good high	All parameters < EQS
	Sediments	Italian EQS	Moderate/Poor	1 parameters > EQS
			Good high	All parameters < EQS

Air

Analysis of existing legislation and regulatory framework:

- The Maltese Legal Notice 478/2010 (Ambient Air Quality Regulations) transposes two main European Directives on the ambient air quality: Directive 2004/107/EC (Government of Malta, 2011) relating to arsenic, cadmium, mercury and nickel and polycyclic aromatic hydrocarbons in ambient air and Directive 2008/50/EC on ambient air quality and cleaner air for Europe.
- Analysis and assessment of the current status of environmental monitoring networks

The air quality monitoring network in Malta comprises two different monitoring systems (Stacey and Bush, 2002): automated monitoring system providing near real-time data for many pollutants (5 monitoring stations and passive sampling tubes (131 monitoring sites).

The five real-time monitoring stations (refer to Table 6) are located in different zones, with different territorial characteristics (e.g. land use, morphology, etc.), demography and emission sources (traffic, industrial, etc.).

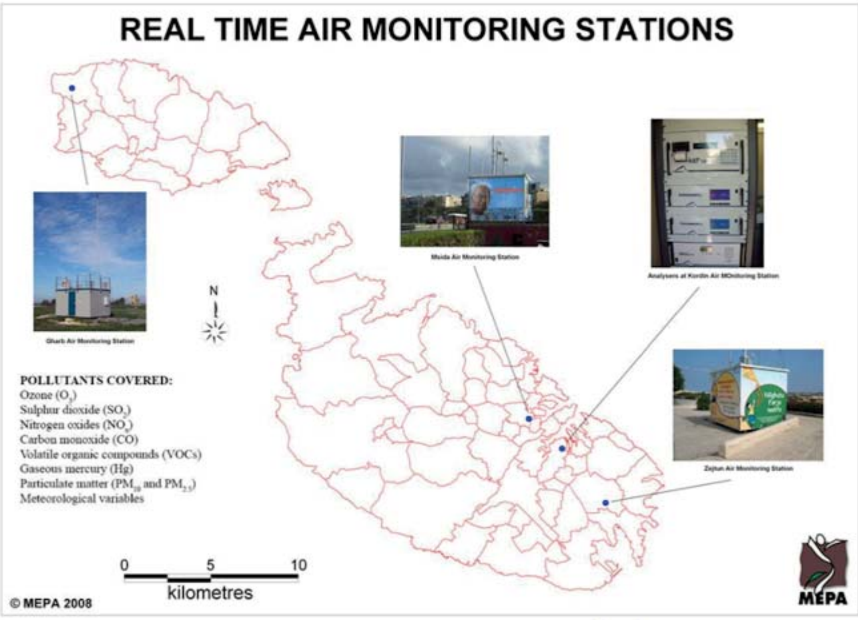
The local fixed station network is in compliance with the monitoring requirements of the Directive 2008/50/EC with regards to the sampling sites, pollutants monitored, sampling locations, zoning and air assessment of the zones or agglomerations.

The following table reports the classification of each station (Government of Malta, 2011):

Table 6: Classification of the real-time monitoring stations in Malta

	Name of the station	Classification of stations
Valletta/Sliema Agglomeration	Msida	Traffic location
	Żejtun	Suburban background
	Attard	Urban background
	Kordin	Urban industrial: (Point of max ground level concentration for plume from Marsa power station)
Malta Zone	Għarb	Rural background

Figure 4: Map of the monitoring sites



Source: Stacey and Bush, 2002

Performing a baseline survey

The objective of this survey was to determine the PM10 concentration in Malta for one year (minimum requested time interval by the L.N. 478/2010 in order to assess the air quality in Malta), using the reference sampling and measurement method stated in the L.N. 478/2010 (Ambient Air Quality Regulations) in order to have a more accurate assessment of the air quality during the time interval considered and also, to evaluate any possible relationship between pollutant concentrations, pollutant sources, location and time of the year.

The monitoring sites were located in the same place as those for the four fixed air monitoring stations in Malta (refer to Figure 4).

The general description of these stations is given in the next paragraphs. Table 7 summarises the station characteristics:

Table 7: Site locations, classification and monitoring dates.

Site name	Location	Site classification	Monitoring dates
Għarb	36°4’4.9” N 14°12’11”E 114m ASL	Rural	From 01/03/2012 to 28/02/2013
Msida	35°53’51.4” N 14°29’28” E 2m ASL	Urban - Traffic	From 01/03/2012 to 28/02/2013
Kordin	35°52’55.1” N 14°30’40.4” E 40m ASL	Industrial	From 01/03/2012 to 28/02/2013
Żejtun	35°51’13.5” N 14°32’24” E 56m ASL	Suburban background	From 01/03/2012 to 28/02/2013

Assessment of the baseline survey results

In order to evaluate the PM10 average concentrations during the monitoring time, the values were confronted with the relative limit values imposed by the Maltese national legislation

Table 8 summarizes the requirements laid down in the L.N. 478/2010 for the specific pollutants considered in this analysis.

Table 8: Limit values for the protection of human health – L.N. 478/2010

Pollutant	Averaging period	Limit value	Minimum Data capture
PM10	One day	50 µg/m3 not to be exceeded more than 35 times a calendar year	90%
	Calendar year	40 µg/m3	90%

Radiation

1) Analysis of existing legislation and regulatory framework

Due to ts small size, Maltese authorities consider Malta as a single region for the purpose of assessing radiological exposure in line with the Recommendation 200/473/Euratom. In order to meet the requirements of the Euratom Treaty's Articles 35 and 36, the National Surveillance Plan (NSP) was performed and approved by the l Radiation Protection Board (RPB), which is appointed by the Prime Minister under the provisions of the Nuclear Safety and Radiation Protection Regulations (LN44/03).

The NSP was designed to be in-line with the practices set out in Commission Recommendation 2000/473/Euratom on the application of article 36 of the Euratom Treaty which seeks to observe the minimum level of these practices and the implementation of the measurement systems and procedures is not yet mature, and some elements of the plan are still partially incomplete.

Table 9: Summary of current Radioactivity Surveillance Plan for Malta managed by MEPA

	Sampling Stations	Sampling Frequency	Measurement frequency (Nr. samples)	Radion-uclide	
	Number	Location			
Air – continuous dose rate	1 (fixed)	Malta- Kordin	Continuous		Dose rate
Air particulates	1 (fixed)	Malta- Kordin	Continuous	Weekly	7Be, 137Cs
Coastal waters	3	North, Centre and South	Quarterly	Quarterly	40K, 137Cs
Soil	5	Malta	Annually	Annually	40K, 137Cs, 60Co

2) Analysis and assessment of the current status of environmental monitoring networks:

MEPA's remit in "The National Environment Radioactivity Surveillance Plan for Malta" (European Commission, 2008) was partitioned in four separate actions: monitoring external ambient gamma dose rate; monitoring of airborne radioactivity, marine monitoring and monitoring of soil.

The principal characteristics of radiological monitoring plan of Malta, i.e. sampling stations, sampling frequency, measurement frequency and radionuclides, are summarized in Table 9 for each investigated medium.

3) Performing a baseline survey

Ionising radiation survey of coastal waters, coastal sediments and soils was carried

Ionisation radiation surveys were carried out along the Maltese coastline during which samples of coastal waters and sediments were collected and analysed. Soil samples from all over the three islands were also collected to enable the establishing of a baseline survey of artificial radionuclides.

Coastal waters: during the pilot survey carried out in June 2012, 9 water samples were collected from the coastal water bodies showed in Figure 5. MTC 101, MTC 104 and MTC 108 were then the three points which were consequently sampled on a quarterly basis.

Figure 5: Coastal water bodies

Sediments

Sediments: 12 samples of sediments were collected between the 1 August and the 22 August 2012 from the points indicated in Figure 6. These points were only sampled once during this assessment.

Soil sampling: 60 soil samples were collected across the Maltese Islands as represented in the map below. This sampling exercise was carried out between the 30 May and the 6 June 2012 (refer to Figure 6).

Figure 6: Marine sediments: sampling sites

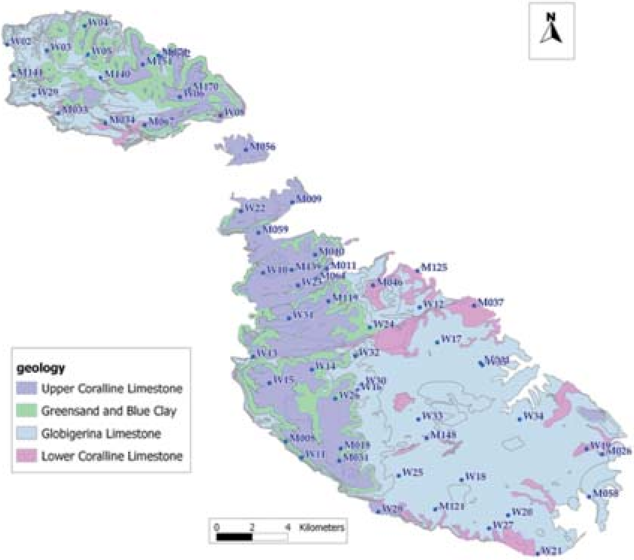
4) Assessment of the baseline survey results

Gamma spectrometry was used to calculate radionuclides concentration of:

- Cs-137, Co-60 and other radionuclides detectable by gamma spectrometry (artificial radionuclides).

Data results of survey were treated with advanced statistical software in order to estimate the radiation level from made-man sources, as well as to compile a database for radioactivity levels on the Maltese Islands, in compliance with the requirements of the European Union (Art. 35 Euratom Treaty).

Figure 7: Location of sampling points in Maltese Islands.



Soil

1) Analysis of existing legislation and regulatory framework

In Malta, soil protection and management are traditionally divided between two different fields of law: land-use (spatial) planning and environment protection. Actually, a third field of law is taking shape: agricultural and rural affairs in view of the multitude of obligations emerging from certain Directives on related themes and the Common Agricultural Policy. Consequently, Maltese legislation is mostly concentrated in procedures associated with agricultural production (code of Good Agricultural Practice, GAEC measures, Cross-compliance) and on transportation of soils. The latter activity is regulated by Act XXIX of 1973 (LN104/1973): Fertile Soil (Preservation) Regulations – Subsidiary legislation Chapter 236 of the Laws of Malta (and as amended) which specifically prevents site owners from construction development over soil profiles.

Additionally, in March 2010, Government launched a process to develop Malta's National Environment Policy (NEP) (Government of Malta, 2014). The NEP is a comprehensive environmental policy covering all sectors and natural resources.

The soil is one of the fundamental Malta's Environmental objectives concerning with using resources efficiently and sustainably of the NEP.

The NEP highlights Malta's high rate of urbanisation, together with the intensification of agricultural practices in certain sites, as the main pressures on soil.

2) Analysis and assessment of the current status of environmental monitoring networks.

Malta's process towards EU accession led to the first systematic soil survey of the Maltese Islands initiated by the then National Soil Unit.

The development of a Soil Information System for the Maltese Islands: MALSIS LIFE 00 TCY/M/036 Vella, 2001), proved to be a major turning point in establishing a wealth of soil information and equipping Malta's public sector with the technical expertise to describe, assess, monitor and manage soils in a sustainable way.

This project was launched in March 2002 by the then Ministry for Agriculture and Fisheries and was completed in February 2004. The MALSIS consisted of a national grid-based inventory of the soil resources at 1km intervals, totalling approximately 280 sites in Malta, Gozo and Comino.

Data collected in the MALSIS database covered soil features of Maltese Islands based on :

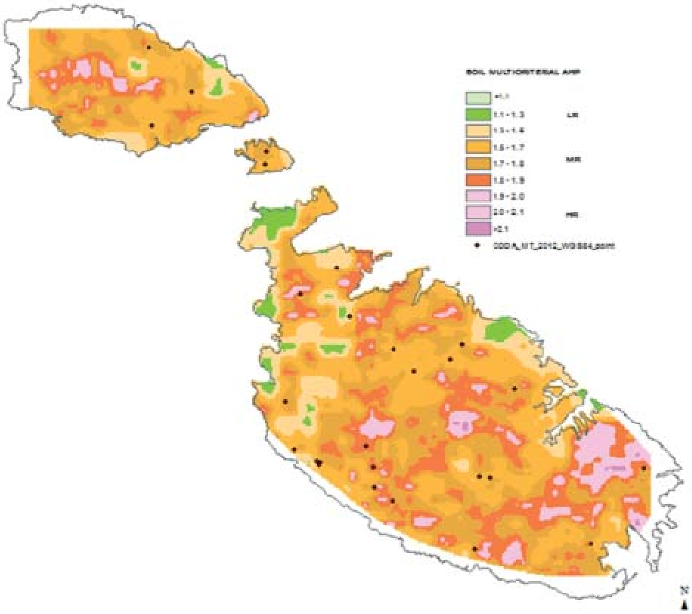
- Soil type;
- Bulk Density in gcm-3;
- Texture (Clay, Sand, Silt %);
- CEC in cmol+kg-1 ;
- CaCO3 ingkg-1;
- Electrical conductivity in μScm-1;
- Organic Carbon in kg;
- Soil Contamination;
- Land Use

3) Performing a baseline survey

In order to optimise the results derived from this investigation, a multi-criteria strategy was applied. The different soil threats were determined individually by the available data on the output of 2004 Malta Soil Information System (MALSIS).

This analysis provided a final returning output, which allows the identification of the high, medium and low risk areas.

Figure 8: Soil Multicriteria Map



The final sampled monitoring points (refer to Figure 6 and Figure 7), investigated in the survey were divided in 24 basic points, in which the following indicators are assessed:

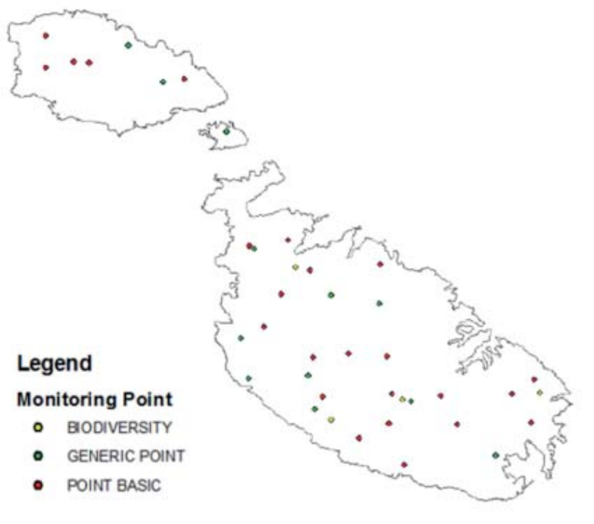
- Bulk density
- Rock
- Soil Depth
- Soil Electrical Conductivity
- Soil Texture
- Soil Typological Unit
- Heavy metal contaminants
- Hydrocarbon
- Pesticides
- Soil Organic Carbon

4 biodiversity points where the following indicators are examined:

- Earthworms
- Micro-arthropods

- Microbial Respiration
- Soil Analysis (*p*H, Moisture, Soil texture, Soil Organic Carbon, Nitrogen content, Ratio C:N, Bulk, Density, Calcium, Potassium, Phosphorous)
- 12 point basic in which the following parameters are investigated:
- Soil Analysis (*p*H, Moisture, Soil texture, Soil Organic Carbon, Nitrogen content, Ratio C:N, Bulk Density, Calcium, Potassium, Phosphorus).

Figure 9: Soil sampling points



Results

Inland Waters

The baseline survey, which covered one year, provided a short-term representation of the environmental condition of ten inland water bodies in the Maltese Islands. Based on the assessment of benthic macro invertebrates, the baseline report concluded the water quality status for the ten water bodies (refer to Table 10). The results showed that all the ten sites have been subject to some form of alteration and deviations from natural, undisturbed conditions. Only two stations in two separate sites (Magħluq ta' Marsascala inner basin and Ballut ta' Marsaxlokk) attained good water status temporarily using Shannon-Weiner Index and one site (Qattara) attained Class II status temporarily using Chandler Biotic Score.

Table 10: Water quality status for the ten water bodies as concluded from the baseline study carried out in 2012 from the assessment of benthic macro invertebrates

Water body	Station	Water quality status/ class	Assessment method (SWI: Shannon-Weiner Index, EBI: Extended Biotic Index, CBS: Chandler Biotic Score)
Salini	Eastern canal	Poor/ Bad	SWI
	Western canal	Poor/ Bad	SWI
Maghluq ta' Marsascala	Inner basin	Good/ Moderate	SWI
	Outer basin	Poor	SWI
Ballut ta' Marsaxlokk	Good/ Moderate/ Bad	SWI	
Wied il-Bahrija	Upstream	Class IV/ V	EBI
	Midstream	Class III/ IV	EBI
	Downstream	Class IV/ V	EBI
Wied il-Luq	Upstream	Class III/ IV	EBI
	Midstream	Class IV/ V	EBI
	Downstream	Class IV	EBI
Wied il-Lunzjata	Upstream	Class III/ IV	EBI
	Midstream	Class IV	EBI
	Downstream	Class IV	EBI
Simar	Inner basin	Class III/ IV	CBS
	Outer basin	Class III/ IV	CBS
Ghadira	Inner basin	Class III/ IV/ V	CBS
	Outer basin	Class III/ IV	CBS
Qattara		Class II/ III	CBS
		Class III/ IV	EBI
Ghadira ta' Sarraflu		Class V	CBS
		Class V	EBI

Coastal waters

Biological parameters

The results of the survey (refer to Table 11)show that the nine coastal water bodies were found to be of good quality with rare exceptions. Most of the monitoring stations under investigation recorded "high status" for the large majority of the analysed biological quality elements, only few monitoring stations were classified "moderate status".

Table 11: Biological Quality Element results. Empty cells refer to no scheduled sample collection

Sampling site	Macroalgae	P. oceanica	Benthic invertebrates	Phytoplankton
CN01-1	High	High	High	High
CN01-2	High	High	High	Good
CS01	High		High	High
CS02	High	High	High	High
CN02 - 1		High	High	Good
CN03-1	Good	Good	High	High
CN03-2	Good		High	Moderate
CN03-3	High	High		
CN03-4	Good	High		
CN03-5	High			
CN03-6	High	High		
CS03	High	High	High	High
CN04-1	Good	High	High	Good
CN04 - 3		High		
CN04-4	Good	Good	Good	Good
CN04 - 5		Good	High	
CN04-6	High	Good		Good
CN04-7			High	
CP04-1	High	High	High	Good
CP04-2	Good	High	Good	Good
CN05-1	Good		High	Poor
CP05	Moderate		Good	Moderate
CN06-1	High	Good		Moderate
CN06-2			Good	
CP06-1	Good	Good	High	Moderate
CP06-2	Good	Good	High	
CN071	Good	High		
CN07-2	Moderate	Moderate		Moderate

Sampling site	Macroalgae	P. oceanica	Benthic invertebrates	Phytoplankton
CN07-3	Poor	Moderate	Good	Good
CP07	High	Good	High	Good
CN08-1	High	High		
CS08	High		High	Good
CN09-1	Moderate	Good	High	Good
CS09	High	High	High	High

Figure 10: Levels of ecological status along the Maltese coasts

Based on these results, three different levels of ecological status along the Maltese coasts were identified (refer to Figure 10):

1. Pristine areas, where no signs of disturbance have been detected;
2. Intermediate areas, where only small signs of disturbance have been detected in one or more biological indicator;
3. Impacted areas, where all biological indicators have shown signs of disturbance.

As expected, the south-eastern coast of Malta was found to be in the most negative water quality condition (impacted areas). Such results were noted in the vicinity of the Marsaxlokk and Marsascala harbours, where several marine activities take place.

Chemical parameters

A classification of the sites based on the results from the water and sediment monitoring is reported in Table 12.

Table 12: Chemical Quality Element results. Empty cells refer to no scheduled sample collection

Sampling site	EQS water	EQS sediment
CN01-1		
CN01-2		
CS01		
CS02	Moderate/poor	Good/high
CN02-1		Good/high
CN03-1		
CN03-2	Moderate/poor	Good/high
CS03	Moderate/poor	Good/high
CN04-1	Good/high	Good/high
CN04-2		
CN04-3		
CN04-4		Good/high
CN04-5		
CN04-6		
CP04-1	Moderate/poor	Moderate/poor
CP04-2		
CN05-1	Moderate/poor	Moderate/poor
CP05	Moderate/poor	Moderate/poor
CN06-1		
CP06-1	Moderate/poor	Moderate/poor
CP06-2		Moderate/poor
CN07-1	Good/high	Good/high
CN07-2		Moderate/poor
CN07-3		Good/high
CP07	Moderate/poor	Good/high
CS08		
CN09-1		
CS09	Moderate/poor	Good/high

Air

The daily limit value of 50 μg/m3 for PM10 were exceeded in all four monitoring points (refer Figure 11). Several peak values were also noted in different months. No significant trends could be identified as the average PM10 concentrations assumed high values in different time intervals. Table 13 summarises the main statistical parameters computed over the entire dataset.

Figure 11: PM10 histogram plot for the entire duration of the monitoring campaign without the extreme monitoring day (i.e. 2012/03/10).

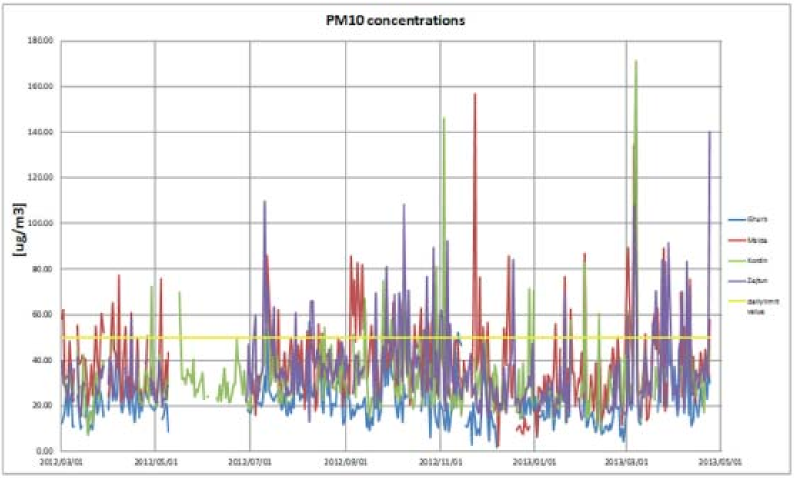


Table 13: Summary table for PM10 data for the total monitoring period

	Għarb	Msida	Kordin	Żejtun
Average [μg/m3]	23.26	38.96	32.88	35.67
Exceedance LV [50 μg/m3]	13	70	36	42
Median [μg/m3]	20.54	36.03	29.19	30.80
Standard Deviation [μg/m3]	13.05	18.44	17.32	17.73
Minimum [μg/m3]	1.83	2.56	7.15	12.65
Maximum [μg/m3]	141.86	156.89	171.30	140.26
valid data [#]	337	341	336	334
data capture [%]	80%	81%	80%	80%

As expected, both the highest PM10 average concentration and number of exceedances were found in Msida while, conversely, the lowest are in Għarb followed by Kordin and Żejtun. This means that Msida is generally influenced by quite high concentrations due to traffic emissions (that also lead to many limit exceedances) but seems less influenced by high isolated PM10 concentrations probably due to natural sources.

Radiation

The results from the baseline survey are shown below.

Soil

The statistical approach utilised in the study allowed the identification of 3 populations for each radionuclide investigated and the observation of geological map indicated that the lithology is the major factor controlling the behaviour of each population (refer Table 14). Each population was characterised by a Normal or Lognormal distribution, respectively. Concentration of Cs-137 in sediments is generally low (refer Figure 12), in fact the highest concentration value detected is 0.41 Bq/kg.

Table 14: Main statistical parameters of mass-based concentrations of 137Cs in Malta topsoil samples.

Pop.	N	%	Median	Mean	95% perc.	99% perc.	Std. Dev.
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
A	8	13.8	4.8	4.8	5.4	5.6	0.34
B	41	70.7	1.3	1.5	2.9	4.1	0.76
C	9	15.5	0.13	0.16	0.34	0.51	0.10

Water

Cs-137 results(refer Figure 13) in coastal water are aligned with concentration data measured in Mediterranean Sea (Marine Pollution Bulletin, 2008).

In MTC104 and MTC108 sampling points, the concentration values of Cs-137 in marine water were comprised between 1.7 and 2.4 Bq/m3. The maximum concentration value was measured in MTC108, at a depth of 5 mt.

Figure 12: Simplified geological map of Malta Islands, showing the geographical distribution of the three individual populations of 137Cs separated through the partitioning approach of Sinclair.

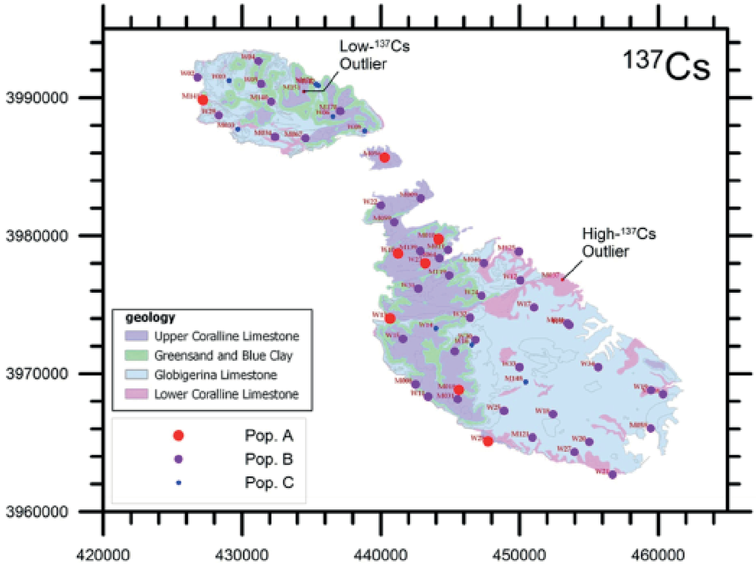
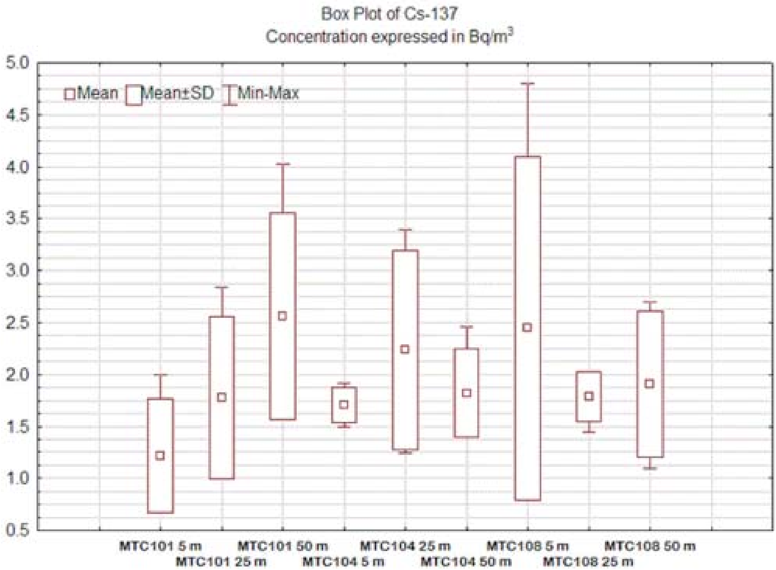


Figure 13: Box Plot of Cs-137 concentration value



Soil

The picture that emerges from this study suggested that for the majority of the soil sampled, the level of the Potential Toxic Elements (PTE) is within the National Background Volumes (NBV) established for European soil (European Soil Bureau, 2014). Due to a small number of samples it was not possible to determine the PTEs NBV for Maltese soil. It was recommended that for the purpose of establishing the NBVs for PTEs, the country should be divided in two domains, an urban domain that comprises mainly the inner harbour, outer harbour and the south east sectors, and a principal domain comprising the rest of the country, thus representing the rural areas. In order to establish the NBV at least a minimum number of 30 spatially distributed sample points, are required. The criteria for the determination of the NBVs should be based on ISO 19258:2011.

With regards to organic matter, salinity and bulk density, these results showed that the level of organic matter in these soils was rather low and that there was no change from that recorded in 2006. This was somehow an expected outcome considering the climatic conditions of the region and the fact that the majority of the sites were agricultural sites; cultivated soils in general have lower organic matter content than non-agricultural soil. Salinity was on the high side, but again this is another characteristic of soils from arid or semi-arid regions. The fact that in some areas irrigation is carried out with water of relatively high conductivity further aggravates the situation. Compaction was surprisingly high and differed substantially from what was reported in 2006. One should consider comparison of the methods used here and method used during the MALSIS survey before drawing conclusions in this respect.

Recommendations

Inland waters

Due to the short-term nature of the 2012 baseline data and the lack of previous baseline information prior to the implementation of the project, another baseline study is recommended to be carried out for the following parameters:

- Parameters indicative of all biological quality elements;
- Parameters indicative of all hydro-morphological quality elements;
- Parameters indicative of all general physico-chemical quality elements;
- Priority list pollutants and other pollutants discharged in significant quantities in the river basin or sub-basin.

A three-year gap has been recommended to carry out the next baseline study, which coincides with the year 2015 when the target for 'good ecological status' and 'favourable conservation status' under the WFD and the Habitats Directive respectively need to be achieved. The 2015 baseline study should follow the requirements of surveillance monitoring in line with the WFD. Accordingly the monitoring frequency for parameters indicative of physico-chemical and hydro morphological quality elements should be monthly for the duration of one year. In the case of biological quality elements, monitoring should be carried out at least quarterly during the same year.

Table 15: Proposed future monitoring point for Inland waters

Water Body	Physico-chemical parameters	Priority substances	Biological Phyto-plankton	Quality Macro invertebrates	Elements Fish	Amphibians
Salini	√	√	√	√	√	N/A
Maghluq ta' Marsascala	√	√	√	√	√	N/A
Ballut ta' Marsaxlokk	√	√	√	√	N/A	N/A
Simar	√	√	√	√	√	N/A
Ghadira	√	√	√	√	√	N/A
Wied il-Bahrija	√	√	N/A	√	N/A	√
Wied il-Luq	√	√	N/A	√	N/A	√
Wied ix-Xlendi/	√	√	N/A	√	N/A	√
Wied il-Lunzjata/	√	√	N/A	√	N/A	√
Wied tal-Ghancija	√	√	N/A	√	N/A	√
Qattara	√	√	√	√	√	√
Ghadira ta' Sarraflu	√	√	√	√	√	√

The monitoring schedule following the 2015 baseline study would depend on the outcome of the respective results, which should be also interpreted in light of the results obtained in the 2012 baseline data. Should the 2015 baseline studies be considered to provide sufficient information, a monitoring programme consistent with the WFD guidelines was recommended to be undertaken envisaging a surveillance monitoring on a six-year cycle followed by five years of operational monitoring (Table 15).

Table 16: Proposed future monitoring point for Biological elements in coastal waters

WFD Water body	Monitoring point	Phytoplankton	Macroalgae	Angiosperms	Benthic Invertebrate fauna	Hydromorphological
	Pristine (PR)					
MTC 101	CN 01 1	x	x	x	x	x
MTC 102	CS 02	x	x	x	x	x
MTC 103	CS 03	x	x	x	x	x
MTC 108	CS 08	x	x		x	x
MTC 109	CS 09	x	x	x	x	x
	Intermediate (IN)					
MTC 103	CN 03 2	x	x	x	x	x
MTC 104	CN 04 1	x	x	x	x	x
MTC 104	CP 04 2	x	x	x	x	
MTC 104	CN 04 6	x	x	x	x	
MTC 105	CP 05	x	x		x	x
	Impacted (IM)					
MTC 109	CN 09 1	x	x		x	x
MTC 107	CN 07 2	x	x		x	x
MTC 105	CN 05 1	x	x		x	x
MTC 106	CP 06 1	x	x	x	x	x
MTC 106	CN 06 1	x	x		x	

The baseline study on priority substances and other pollutants of national concern in the water phase recommended that the ten water bodies should be monitored as follows:

- Annually (in December or January) for the whole list of forty-seven chemicals analysed in the same study;
- Bi-monthly (every 2 months) for the dichloromethane, di(2-ethylhexyl)phthalate, fluoranthene, lead, mercury, nickel, trichloromethane and perchlorates.

Coastal waters

Based on the results the future monitoring strategy was designed (refer Table 16). It was agreed that a reduction in the number of monitoring stations was required, especially in the coastal zones, where anthropogenic pressures were found to be low and the water quality status was classified as “high”.

With regards to the frequency it was agreed that the first year should establish a strong and extensive baseline data which up till now is limited in the Maltese Islands. It is also necessary to perform hydrological monitoring of the coastal waters in the future, specifically where anthropogenic pressures have been recorded or can be expected to occur, as such anthropogenic pressures have a strong influence on the BQE status.

The monitoring stations proposed for chemical water monitoring were identified as those classified moderate/poor for water quality or sediment status(refer Table 17).

With regards to the frequency the following has been proposed: for group A, a monthly monitoring survey should be carried out at least for the first year, afterwards and depending on the results obtained, a quarterly monitoring survey might be enough. For group B1 and B2 a monthly monitoring survey is being suggested. For group C, sampling for the analysis of sediments should be held once a year, which is thought to be sufficient.

Table 17: Proposed future monitoring point for Chemical elements in coastal waters

WFD Water Body	Mon. Site Ref. Code	Chemical Quality Elements				
		A	B1	B2	C1	C2
MTC101	CN01-2	x				
MTC101	CS01	x				
MTC101	CN01-1	x				
MTC102	CN02-1	x			x	x
MTC102	CS02	x	x	x	x	x
MTC103	CN03-1	x				
MTC103	CN03-2	x	x	x	x	x
MTC103	CN03-3					
MTC103	CN03-4					
MTC103	CN03-5					
MTC103	CN03-6					
MTC103	CS03	x	x	x	x	x
MTC104	CN04-1	x	x		x	
MTC104	CN04-2	x				
MTC104	CN04-3					
MTC104	CN04-4	x	x		x	
MTC104	CN04-5	x				

WFD Water Body	Mon. Site Ref. Code	Chemical Quality Elements				
		A	B1	B2	C1	C2
MTC104	CN04-6	x				
MTC104	CN04-7					
MTC104	CP04-1	x	x	x	x	x
MTC104	CP04-2	x				
MTC105	CN05-1	x	x	x	x	x
MTC105	CN05-2				x	x
MTC105	CP05	x	x	x	x	x
MTC106	CN06-1	x				
MTC106	CN06-2					
MTC106	CP06-1	x	x	x	x	x
MTC106	CP06-2				x	x
MTC107	CN07-1	x	x		x	
MTC107	CN07-2	x			x	x
MTC107	CN07-3	x			x	x
MTC107	CN07-4					
MTC107	CP07	x	x	x	x	x
MTC108	CN08-1					
MTC108	CS08	x				
MTC109	CN09-1	x				
MTC109	CS09	x	x	x	x	x

Air

MEPA fixed stations network resulted to be compliant with the requirements of the Directive as the minimum number of sampling sites and the parameters monitored fully respect the EC and national monitoring requirements.

PM measurements should be maintained in all the locations due to the high concentration levels registered. MEPA is implementing a plan to reduce these concentrations (MEPA, 2010) and the maintenance of the fixed stations would be indeed useful to detect a potential decrease of PM levels.

MEPA carries out accurate and periodic maintenance procedures in accordance with the Legislation and based on their actual technical –organizational capabilities which is encouraged to be maintained in order to assure the minimum data quality requirements established by the Directive.

Radiation

Table 18 summarizes the monitoring details for each environmental medium specifying the radionuclide's that should be identified; the sampling periodicity, the number and the location of the sampling points in which measurements should be carried out.

Table 18: Proposed monitoring plan for radioactivity

Media	Radionuclides	Sampling frequency	Location
Particulate matter	Artificial Alpha and Beta. Radon and Thoron		
Cs-137, and other selectable nuclides, up to a maximum of 8	Continuously.	Benghisa, Attard, Gozo	
Fall out (precipitation and deposition)	Cs-137, Beta residual	Monthly	MEPA
Gamma dose rate	Gamma dose absorbed	Continuously	Benghisa, Attard, Gozo and Kordin.
Coastal water bodies	Cs-137, beta residual	Six monthly	MTC101, MTC104, MTC108
Coastal sediments	Cs-137, Th-232, U-238, K-40	Six monthly	MTC101, MTC104, MTC108 (*)
Marine biota (bivalves)	Cs-137	Six monthly	MTC101, MTC104, MTC108
Soil	Cs-137, Th-232, U-238, K-40, Beta residual	Yearly	(*)

(*) The n.15 points are suggested in par. 3.7.2.1 of the document "Technical Report on Activity 3 – Design of the Programmes (Radiation – Lot 1)" (February 2013)

Soil

Following the baseline survey and the evaluation of the results retrieved, a set of recommendations for further studies were presented. These are required to ensure that the conclusions are made with more confidence, reliability and representativeness.

A greater number of sampling points have to be investigated to have a more robust baseline assessment. The points should not be limited to single fields in specific areas but extended over larger stretches to cover the whole territory. A number of variables have to be taken into consideration in the choice of the sampling points as these determine the quality of the results emanating from the study. Soil type, slope steepness and size of fields are among such variables. Representativeness also needs to be taken into consideration, hence the sampling points should encompass the various land characteristics such as soil samples from coastal areas, from steeper slopes, from areas more prone to erosion amongst others. This would lead to a thorough analysis upon which a clearer strategic monitoring plan on this thematic area can be based.

Conclusion

Malta, as part of the European Union, needs to comply with several obligations regarding the protection, conservation and restoration of its natural environment. By the implementation of this project and its outputs, Malta has taken an important step forward towards this goal. The knowledge and conclusions acquired during the implementation of this project represents an important basis for the implementation of long term strategies in accordance with the specific context and targets of each environmental component. It will allow Maltese authorities to use its resources efficiently when aiming to achieve their environmental goals. Nevertheless, additional steps will be needed to be carried out in the short term before establishing definitive long term strategies, such as performing additional base line surveys in the case of soil and inland waters or analysing future monitoring outputs in the rest of the environmental matrix. After doing so, Malta will be able to establish the final characteristics of its environmental monitoring network.

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