INTERIM REPORT ON THE

PRELIMINARY ASSESSMENT OF ARSENIC, CADMIUM, MERCURY, NICKEL AND POLYCYCLIC AROMATIC HYDROCARBONS IN AMBIENT AIR IN MALTA

Malta Environment and Planning Authority
Pollution Prevention and Control Unit

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Summary

As required by the 4th Daughter Directive on Ambient Air Quality (2004/107/EC), a study has been initiated in order to determine the overall distribution of ambient air concentrations of Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air in Malta.

Systematic measurements started in November 2006 and are still ongoing. However, due to some lack of resources and instrumentation at that time, only a limited number of daily PM_{10} samples are available at this stage. So far it can be concluded that none of the daily samples contained levels of arsenic, cadmium and polycyclic aromatic hydrocarbons above the detection limits of 4.5 ng/m^3, 0.9 ng/m^3 and 1.8 ng/m^3, respectively. Nickel was detected in almost all samples. The highest daily concentration of about 18 ng/m^3 occurred at a traffic site, while the average of the 11 samples from this station was 10.7 ng/m^3. About eight months of real-time measurements of gaseous mercury revealed daily averages between 1.9 ng/m^3 during the summer 2006 and 0.6 ng/m^3 in the beginning of 2007. Mercury concentrations observed so far in Malta therefore seem to be lower than what was found during other measuring campaigns carried out in the Mediterranean.

In order to obtain a conclusive picture about the concentration levels and spatial distribution of the air pollutants treated by this Directive, further measurements are absolutely necessary comprising a better time coverage and better analytical accuracy.

1. Introduction

The Directive 2004/107/EC of the European Parliament and of the Council, commonly known as the 4th Daughter Directive on Air Quality, deals with the regulation of ambient air concentration levels of arsenic (As), cadmium (Cd), mercury (Hg) and nickel (Ni) as well as polycyclic aromatic hydrocarbons (PAH) in order to minimise their harmful effects to human health and the environment. Polycyclic aromatic hydrocarbons form a group of approximately 100 organic compounds consisting of at least two fused benzene rings. Benzo[a]pyrene (B[a]P) should be used as a proxy for the polycyclic aromatic hydrocarbons family.

The substances in question show various acute health effects on humans, usually when exposed to higher doses. These range from mild symptoms such as discomfort and allergic reactions to more severe forms such as disruption of the nervous system, respiratory failure or of other organs (*WHO, 2000*). Scientific evidence revealed the need of regulating and monitoring these substances in particular due to the fact that they are also genotoxic carcinogens. This means that even low concentrations are considered to be harmful to humans and the environment and there is, in principle, no identifiable threshold below which these substances do not pose a risk. Some of them, such as arsenic and mercury, are also bio-accumulative.

Arsenic, cadmium and nickel are mainly emitted into the atmosphere through anthropogenic activities, such as mining, various industrial metal processing activities or the combustion of fossil fuels and waste and they are found in the atmosphere mainly as trace elements in suspended particulate matter. On the contrary to this, mercury also has strong natural sources, such as volcanism and is emitted from surface waters and from top soil. Besides being attached to particulate matter, mercury is also highly volatile and occurs in the atmosphere in gaseous form as elemental mercury, as well as oxidised mercury (reactive gaseous mercury). The latter is easily dissolved in water and in this manner, enters the food chain. Polycyclic aromatic hydrocarbons are only significantly emitted through incomplete combustion processes of solid and liquid fossil fuels as well as other organic matter. They are mainly found in the atmosphere as part of suspended particulate matter, but may become volatile with increasing temperatures.

One of the Directive's objectives is that Member States have to determine the ambient air concentration levels of the pollutants in question and to define zones and agglomerations, in which these concentrations are above or below the respective target values. In areas, where the respective lower assessment thresholds were exceeded, monitoring should become mandatory.

The following chapter gives an overview of the principal anthropogenic emission sources of some other elements in addition to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons on the Maltese Islands.

2. Estimation of Malta's Emissions of Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons Emissions

Table 1 gives an overview about the estimated annual emissions of arsenic, cadmium, nickel and mercury into air for the year 2005, for the major anthropogenic emission sources in the Maltese Islands. The emission factors were taken from the *EMEP/CORINAIR Emission Inventory Guidebook – 2006*, while the activity data is equivalent to that reported in relation to the emissions inventory for the National Emissions Ceilings Directive (2001/81/EC).

Emission Source Sector	**As**	**Cd**	**Ni**	**Hg**
	kg	***kg***	***kg***	***kg***
Power generation	293.4	586.8	20538	586.8
Transport	[1]	1.5	11	[1]
Other mobile sources & machinery	[1]	0.4	3	[1]
Waste incineration [2]	[1]	37.5	[1]	30.9
Industrial	17.2	17.2	601	3.4
total	**311**	**643**	**21153**	**621**

Table 1: Estimated emissions of arsenic, cadmium, nickel and mercury in Malta in 2005.
[1] Not estimated; [2] Hospital waste only

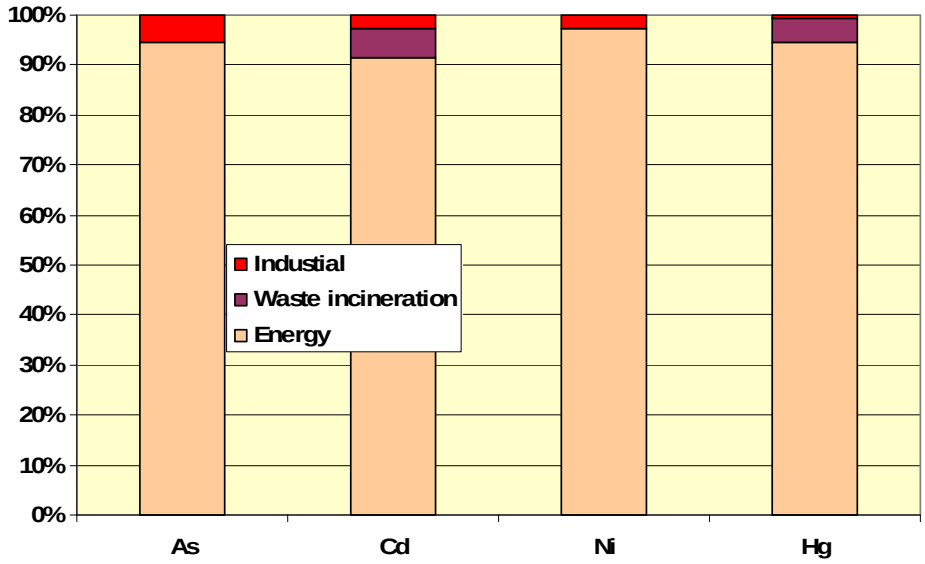

Figure 1: Relative contribution of power generation, waste incineration and industrial combustion to emissions of arsenic, cadmium, nickel and mercury.

Table 1 and Figure 1 clearly show that by far the strongest emission source of the elements in question in Malta is the energy sector, to be precise the combustion of heavy fuel oil in the Marsa and Delimara power plants. Only about 5 to 6 % of arsenic, 3 % of cadmium and about 3 % of the remaining nickel emissions are due to heavy fuel oil use in the industrial sector, while about 6 % of the cadmium and 5 % of the mercury emissions can be attributed to the incineration of hospital waste. One of the reasons for the dominance of the energy production sector is basically the absence of any metal production industry in Malta. Also, waste

incineration is only resorted to for hospital waste and not on a large scale such as for municipal waste.

Keeping this in mind, it can be expected that the total emissions of the elements in question strongly depends on the country's heavy fuel oil consumption. Figure 2 depicts the temporal development of emissions of arsenic, cadmium, mercury and nickel as well as the ones of copper, zinc, lead, chromium and vanadium also emitted by the power generation sector, from 2000 to 2005. The increase in emissions can be related to an increase in heavy fuel oil consumption in Malta's power plants, which is equivalent to 22 % from the year 2000 to the year 2005. It should be noted that Malta's nickel emissions from the power generation sector in 2003 seem to be approximately one ninth of the combined emissions of Belgium, Finland, France, Hungary, the Netherlands, Slovakia, Spain, Sweden and the United Kingdom from the same sector and the same reporting year (*Afinogenova et al., 2006*). This anomaly may be explained by the high emission factor for heavy fuel oil given by the EMEP/CORINAIR guidelines which have been used in this present study. It should be also noted that nickel emissions of the Marsa power plant are surely lower than estimated here due to the fact that a certain amount of particulate matter is retained by the plant's precipitators. Unfortunately, no specific emission factor for nickel from Malta's power plants is available as yet.

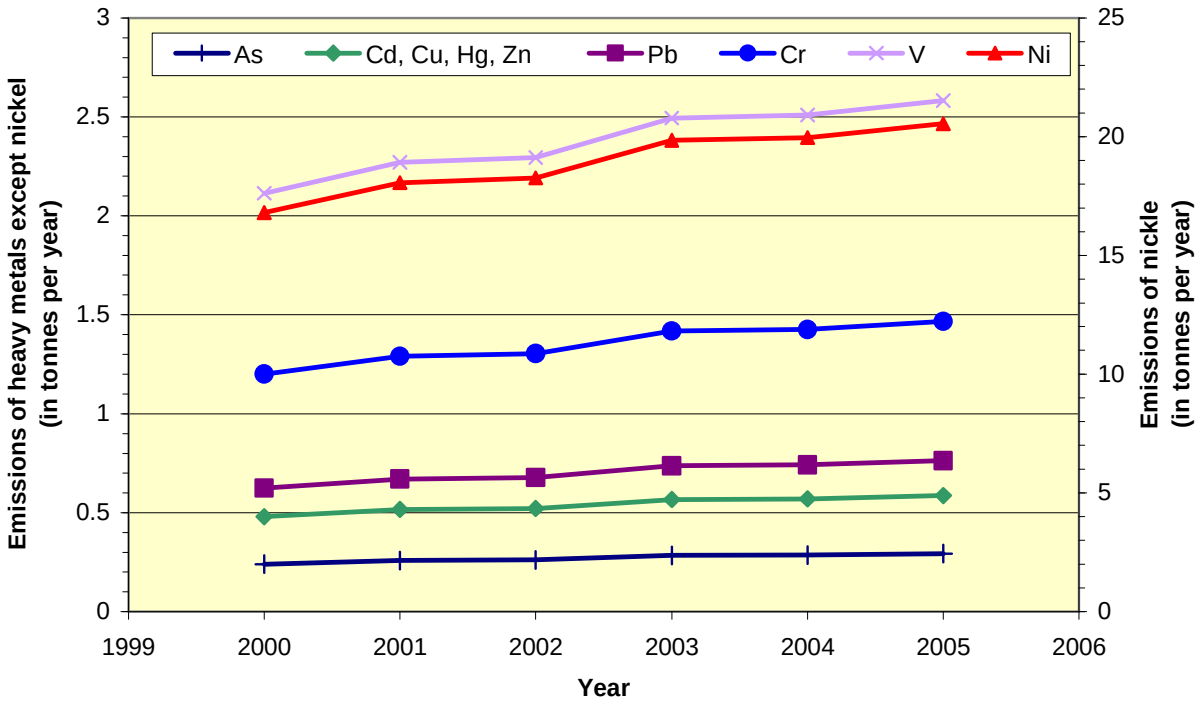

Figure 2: Temporal development of heavy metal emissions from the power generation sector in Malta. Due to the fact that the emission factors of cadmium, copper, mercury and zinc are the same their trend is depicted as one line, only.

Table 2 and Figure 2 give an overview of the contributions of various sectors to Malta's total emissions of polycyclic aromatic hydrocarbons in 2005. Other sources such as waste incineration or biomass burning were not estimated due to the lack of appropriate emission factors or activity data, respectively. The compounds considered for this inventory are

benzo[a]pyrene (B[a]P), benzo[b]fluoranthene (B[b]F), benzo[k]fluoranthene (B[k]F), benzo[ghi]perylene (B[ghi]P), indeno[1,2,3-cd]pyrene (IndP) and fluoranthene (Fluor). All but fluoranthene are considered to be carcinogenic. Most of the emission factors were taken from *Tsibulksi et al. (2001)*. In order to distinguish better between the emissions from different vehicle categories (petrol / diesel, passenger car / heavy duty vehicle), emission factors of the transport sector were proportionally adapted according to the documentation of the COPERT III model. Two very strong emission sources found in most other counties are the domestic combustion of firewood and the production of aluminium. The latter is absent on the Maltese Islands, while firewood has to be imported and is only used occasionally, (but still at the level of a few days per year) in recent years. No activity data could be obtained for wood burning in Malta for domestic heating. However, it is safe to assume much lower emissions from firewood burning as compared to other European countries due to the relatively high cost of the wood and the mild winters in Malta.

Emission Source Sector	**B[a]P**	**B[b]F**	**B[k]F**	**B[ghi]P**	**IndP**	**Fluor**
	kg	***kg***	***kg***	***kg***	***Kg***	***kg***
Energy	2.5	5.0	2.3	7.6	2.1	76.3
Transport	9.9	20.8	12.1	11.8	9.3	110.6
Other Sources & Machinery	1.1	8.0	4.4	0.9	1.9	27.0
Industrial	0.1	0.3	0.1	0.4	0.1	4.2
total	**13.5**	**33.9**	**18.8**	**20.4**	**13.3**	**213.9**

Table 2: Estimated annual emissions of benzo[a]pyrene (B[a]P), benzo[b]fluoranthene (B[b]F), benzo[k]fluoranthene (B[k]F), benzo[ghi]perylene (B[ghi]P), indeno[1,2,3-cd]pyrene (IndP) and fluoranthene (Fluor) in Malta in 2005.

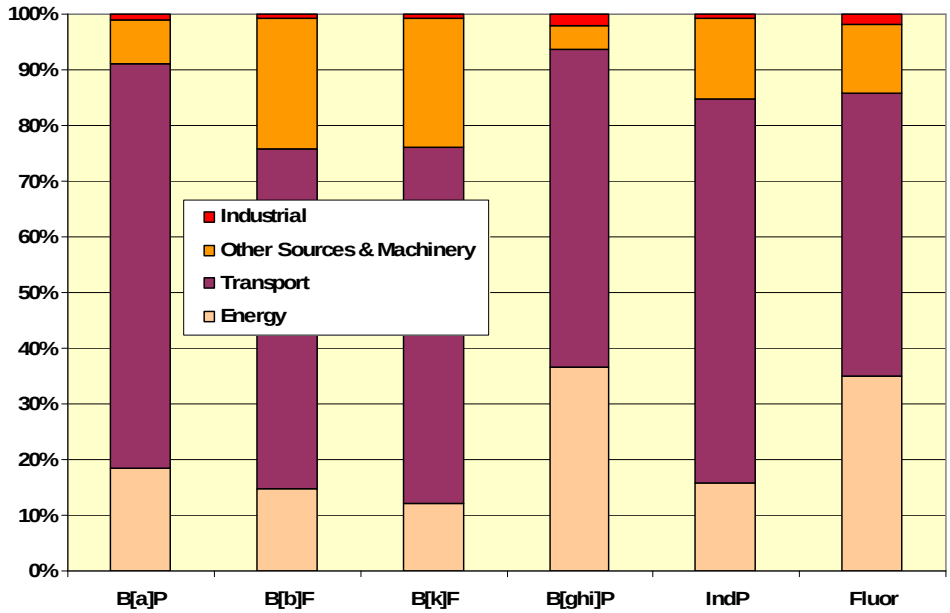

Figure 3: Relative contribution of the energy sector, transport, other machinery and the combustion in industry respectively, to emissions of different polycyclic aromatic hydrocarbons.

Table 2 shows that the annual emissions of polycyclic aromatic hydrocarbons are in the range of several kilograms of which the transport sector, in particular petrol vehicles, contributes a major fraction. However, it can be seen from Figure 3 that some polycyclic aromatic hydrocarbons, such as benzo[ghi]perylene, are also emitted in a greater amount by Malta's power plants.

3. Sampling Sites and Method

In order to assess the ambient air concentrations of various inorganic elements and polycyclic aromatic hydrocarbons in particulate matter in relation to the influence of different primary sources in Malta, sampling was carried out at three locations with different characteristics.

MEPA also operates air monitoring stations at these sites, which are equipped with automatic analysers for all classical air pollutants, namely ozone, carbon monoxide, sulphur dioxide, nitrogen oxides and PM_{10}. Two of the stations, located in Msida and Zejtun respectively, are also equipped with automatic $PM_{2.5}$ analysers, while at the Zejtun station gaseous mercury is also measured. Figure 4 depicts the outline of the Maltese main island and the position of the sampling sites in relation to the agglomeration.

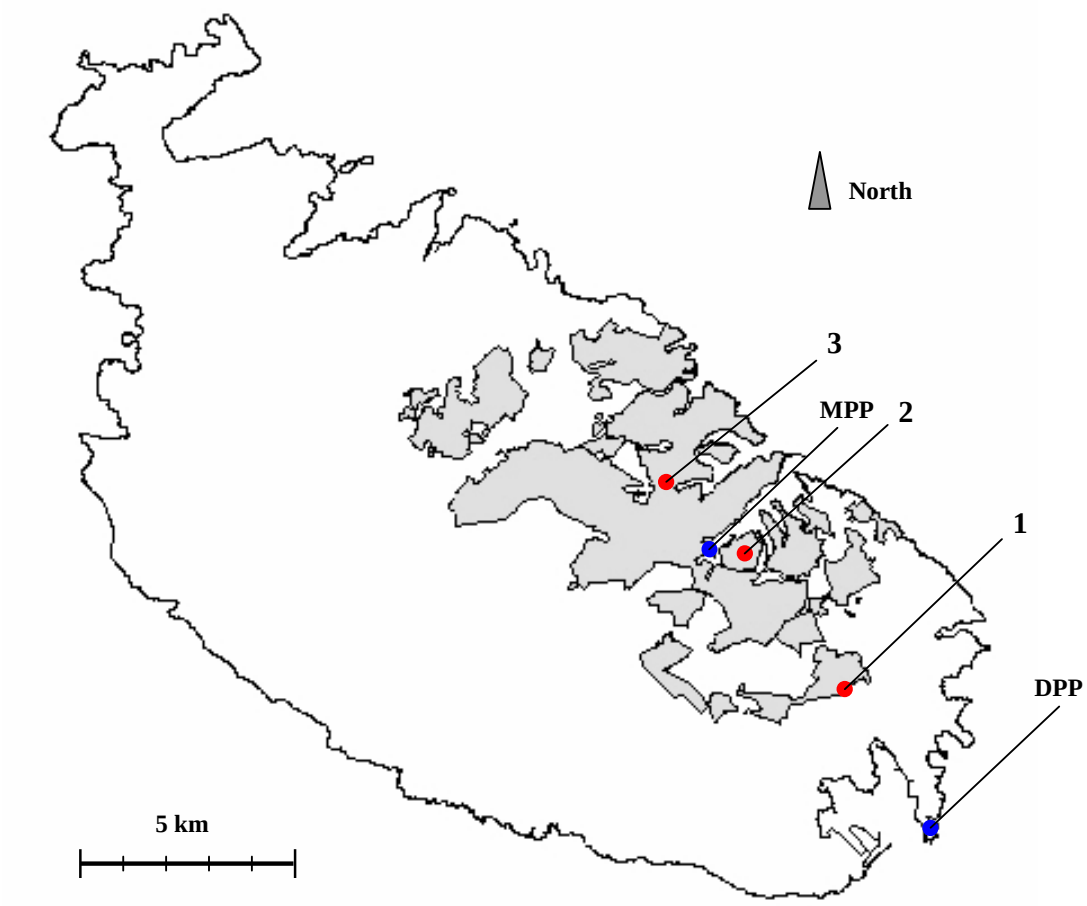

Figure 4: The Maltese main island with the agglomeration (grey) and the positions of the sampling sites as well as of Malta's power plants (MPP: Marsa, DPP: Delimara).
1: Zejtun, suburban site; 2: Kordin / Paola, industrial site and 3: Msida, traffic site.

The air monitoring site in Zejtun (1) is situated on the south-easterly edge of the agglomeration being mostly affected by anthropogenic air pollution sources with north-westerly winds, which is the prevailing wind direction on the Maltese Islands. This site is of suburban character and the air quality there should not be determined by a particular single source. Kordin station (2) is meant to monitor possible ground level pollution plumes coming from the Marsa power plant. Since this station is also situated within an industrial estate it can be characterised as an industrial site. The air monitoring site in Msida (3) is a typical traffic influenced site with approximately 40,000 cars passing by the station every day. The station is situated in an area where several traffic arteries merge, with the closest road passing in the East of it, in about four metre distance.

The sampling of particular matter was performed using a low volume reference sampler (Derenda, Model LVS3.1) equipped with a standard PM_{10} inlet head and in combination with a sequential filter changer (model PNS15), which in principle allows unsupervised sampling over fifteen days. Samples of particulate matter considered for this preliminary assessment were taken from the beginning of November 2006 until the end of December 2006. However, since only one sampler was available for this study it had to be moved from site to site, where it remained for approximately two weeks. In Zejtun and Msida, sampling took place from the roofs of the stations in about four metre height above ground level, while in case of Kordin the sampler was place on the roof of the MEPA offices about 20 metre above ground. The sampling flow rate of the low volume sampler was set to be in accordance with *MSA EN12341:2000*. It was also programmed to sample on each filter for a period of nearly 24 hours, in most cases from midnight to midnight. However, in some cases it appeared to be more practical to start the sampling from 9a.m. until 9a.m. of the next day. Filters, which were intended to be analysed for polycyclic aromatic hydrocarbons, were removed from the filter cartridge in the morning of the following day and were stored in a fridge until conditioning and weighing took place. Quartz fibre filters (Munktell, MK 330) were used for all the sampling. However, due to the lack of an equilibration chamber in the beginning of the sampling period, the unloaded filters being used for sampling in Zejtun and Msida were not weight under defined humidity conditions. Hence, the total weights of particulates sampled at these sites contain an additional uncertainty. However, all dust-loaded filters were conditioned and weighed according to standard.

All dust-loaded filters were sent to CE.F.I.T S.r.l (Avola, Italy) for analysis. Filters, which were intended for the determination of the concentration levels of arsenic, cadmium and nickel (27 filters in total) were additionally analysed for the following elements:

Calcium (Ca),	lead (Pb),	tin (Sn),
total chromium (Cr),	copper (Cu),	vanadium (V) and
iron (Fe),	silicon (Si),	zinc (Zn).
manganese (Mn),	sodium (Na),	

This was done in order to be able to extract additional information about the contribution of different emission sources to the particulate matter composition and, with respect to lead, to satisfy the requirements of Directive 1999/30/EC. Most of these elements were analysed by

Inductive Coupled Plasma – Atomic Emission Spectroscopy (according to *NIOSH 7300*), whereas silicon was analysed by Visible Absorption Spectrophotometry (according to *NIOSH 7601*).

Until now, total gaseous mercury (mainly in for of elemental mercury) was measured only at Zejtun station using a UT-3000 Mercury Ultra Tracer automatic analyser (Mercury Instruments, USA). The measurements started in the beginning of July 2006 and data up to the end of February 2007 is discussed in this assessment. The instrument was programmed to sample in 15-minute intervals, of which daily averages were calculated.

Table 3 lists the lower detection limits for each of the elements using the above described analytical methods.

In addition, sixteen daily PM_{10} samples were separately analysed for the following polycyclic aromatic hydrocarbons via gas chromatography with a (fluorescence detector):

Acenaphthene,	benzo[b]fluoranthene,	fluorine,
Acenphthylene,	benzo[k]fluoranthene,	indeno[1,2,3,-cd]pyrene,
Anthracene,	benzo[g,h,i]perylene,	naphthalene,
benzo[a]anthracene,	chrysene,	phenanthrene and
benzo[a]fluoranthene,	dibenzo[a,h]anthracene,	pyrene.
benzo[a]pyrene,	fluoranthene,	

Thus, in total 17 polycyclic aromatic hydrocarbons were tested for, including most of those recommended by the 4th Daughter Directive.

For the given sampling conditions the lower detection limit was about 1.8 ng/m^3 for each of the polycyclic aromatic hydrocarbons. This is somewhat higher than the target value defined by the Directive, which is 1 ng/m^3 for benzo[a]pyrene. However, the emission inventory of Chapter 2 (see Table 2) suggests that other polycyclic aromatic hydrocarbons, such as benzo[ghi]perylene and fluoranthene, are emitted in much higher quantities compared to benzo[a]pyrene and should therefore be present in relative higher concentrations. One should therefore still be in the position to get a rough idea regarding the general situation about the burden of this class of air pollutants in Malta.

4. Results and Discussion

4.1 Elemental Inorganic Compounds – General Aspects of Sources and Characteristics at the Various Sampling Sites

In this study, 27 filters were analysed for inorganic elements in the PM_{10} fraction. Tables 4a to 4c list the results of the laboratory analysis from the different sites. Since Table 4a shows the results from Zejtun, the corresponding daily averages of mercury obtained from the real-time measurements are also included. Since the exposure to air pollution is in particular dependent on the prevailing wind direction at the Zejtun and Kordin stations, wind was also analysed for the days of sampling and is noted in the respective tables. No further meteorological factors were considered in this study, such as precipitation, which may have a significant influence on the outcome of the sampling.

Generally, in case of the sampling site in Zejtun (Table 4a) one could expect elevated concentrations of air pollutants, when the wind is blowing from the agglomeration. In fact pollution roses from other air pollutants such as nitrogen dioxide or carbon monoxide clearly show this behaviour. However, Table 4a shows that neither the concentration of arsenic nor the one of cadmium exceeded the lower detection limit at any day of sampling. The concentrations of nickel, together with other elements such as chromium, copper and lead, which are often emitted by the same anthropogenic processes, were on some occasions significantly higher on only one of such days with winds mainly coming from the agglomeration (e.g. 9th November 2006). However, mercury or vanadium do not follow this behaviour as one might expect..

From the five samples colleted at the industrial site in Kordin and considered for the metal analyses the wind was mainly from easterly directions and not coming from the direction of the Marsa power plant for a significant period of time. Nevertheless, from all the 27 samples considered in this study, the highest concentration of vanadium (an element often emitted by the power generation sector) was still recorded at this site (24th December 2006). However, in disagreement to this observation is the corresponding value of nickel was actually the lowest compared to the other days of sampling at this site.

The greatest variation in nickel concentration was found to occur at the traffic site in Msida. Some of the samples obtained from this site also revealed higher concentrations of copper as compared to the other two sites. Although the closest road passes to the East of the station one can consider the entire area to be heavily affected by emissions from road transport. This site should therefore be less dependent on the wind direction. A previous study carried out at a different traffic site (Msida) using the filters of a real time particulate matter analyser (Tapered Element Oscillating Balance - TEOM), which were loaded with PM_{10} for approximately fourteen days each between mid-September 2004 and April 2005, also revealed a high variability in the nickel concentration in air (*MEPA, 2005*). However, Table 1 and Figure 1 reveal that road transport should contribute only to a small part to the national nickel emissions. It should also be mentioned that the site of the previous study (Floriana) might also be affected by emissions from the Marsa power plant under certain weather conditions. This previous study also revealed low concentrations of arsenic and cadmium, when they were detected on only one out of seven filters.

	As	Cd	Ni	Hg	Cr	Fe	Mn	Pb	Cu	Sn	V	Zn	Ca	Si	Na
	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³
lower detec. limit	4.5	0.9	1.8	0.25	0.5	1.8	0.2	9.1	0.9	27.2	1.4	0.9	4.5	9.1	4.5

Table 3: Lower detection limit of metals and other substances analysed by CE.FI.T / Italy (with respect to the sampling conditions in this campaign) and real-time mercury measurements.

exposure date	As	Cd	Ni	Hg[2)]	Cr	Fe	Mn	Pb	Cu	Sn	V	Zn	Ca	Si	Na	total mass	wind direction
	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	µg/m³	µg/m³	µg/m³	µg/m³	
08.11.06	1)	1)	9.1	1.04	5.4	90.6	1)	12.7	9.1	1)	1)	95.1	3.89	0.40	0.34	41.1	
09.11.06	1)	1)	14.5	0.83	27.2	144.9	1)	16.3	19.9	1)	1)	95.1	2.99	0.49	0.50	36.2	3)
10.11.06	1)	1)	5.4	0.91	1)	108.7	1)	7.2	9.1	1)	1)	67.9	2.26	0.56	0.66	31.0	3)
11.11.06	1)	1)	7.2	0.85	2.7	144.9	1)	7.2	9.1	1)	1)	40.8	2.08	0.58	0.68	25.9	
12.11.06	1)	1)	5.4	0.95	7.2	90.6	1)	7.2	9.1	1)	1)	58.9	1.54	0.69	0.91	25.4	
13.11.06	1)	1)	9.1	0.90	2.7	163.0	1)	16.3	18.1	1)	9.1	22.6	3.17	0.72	1.31	33.3	3)
14.11.06	1)	1)	1)	0.88	1)	1)	1)	1)	1.8	1)	1)	77.0	1.90	0.91	1.38	14.9	
16.11.06	1)	1)	7.2	0.93	2.7	90.6	1)	7.2	9.1	1)	1)	40.8	1.72	0.49	0.41	20.3	
17.11.06	1)	1)	9.1	0.80	4.6	304.0	1)	12.2	18.2	1)	1)	38.0	0.76	0.64	0.56	14.6	
22.11.06	1)	1)	7.2	n/a	4.5	163.0	54.3	9.1	10.9	1)	1)	13.6	0.45	0.72	1.07	21.7	
24.11.06	1)	1)	7.2	0.95	5.4	144.9	36.2	9.1	10.9	1)	1)	77.0	2.45	0.54	0.66	47.8	3)

Table 4a: Results of laboratory analyses and total mass of PM_{10} collected at Zejtun.

[1)] Concentration levels were below detection limit
[2)] Daily averages of real-time measurements
[3)] Prevailing wind direction was from the agglomeration

exposure date	As	Cd	Ni	Hg	Cr	Fe	Mn	Pb	Cu	Sn	V	Zn	Ca	Si	Na	total mass
	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	µg/m³	µg/m³	µg/m³	µg/m³
29.11.06	1)	1)	14.5	n/a	7.2	217.4	1)	9.1	27.2	1)	1)	99.6	4.17	0.36	0.47	48.4
30.11.06	1)	1)	9.1	n/a	6.3	452.9	90.6	9.1	10.9	1)	1)	126.8	3.99	1.09	1.60	43.3
01.12.06	1)	1)	7.2	n/a	3.6	181.2	1)	9.1	10.9	1)	1)	45.3	2.17	0.76	1.02	44.9
02.12.06	1)	1)	9.1	n/a	5.4	235.5	1)	14.5	16.3	1)	1)	54.4	4.35	0.54	0.73	49.1
03.12.06	1)	1)	16.3	n/a	8.2	126.8	1)	18.1	16.3	1)	9.1	135.9	3.80	0.65	1.00	57.6
05.12.06	1)	1)	7.2	n/a	6.3	108.7	1)	10.9	12.7	1)	1)	108.7	2.54	0.63	0.84	64.3
07.12.06	1)	1)	18.1	n/a	6.3	1014.5	1)	16.3	45.3	1)	1)	99.6	9.96	0.53	0.67	107.8
08.12.06	1)	1)	9.1	n/a	5.4	905.8	54.3	27.2	27.2	1)	10.9	117.8	6.34	0.74	1.00	78.4
09.12.06	1)	1)	10.9	n/a	2.7	543.5	163.1	18.1	30.8	1)	1)	72.5	8.15	0.58	0.72	79.9
11.12.06	1)	1)	9.1	n/a	6.3	362.3	1)	10.9	14.5	1)	1)	126.8	4.35	0.33	0.27	50.9
12.12.06	1)	1)	7.2	n/a	2.7	108.7	1)	9.1	10.9	1)	1)	108.7	2.90	0.60	0.94	26.6

Table 4b: Results of laboratory analyses and total mass of PM_{10} collected at Msida.
Footnotes: See legend of Table 4a.

exposure date	As	Cd	Ni	Hg	Cr	Fe	Mn	Pb	Cu	Sn	V	Zn	Ca	Si	Na	total mass
	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³	µg/m³	µg/m³	µg/m³	µg/m³
21.12.06	1)	1)	9.1	n/a	6.3	163.0	1)	12.7	12.7	1)	1)	72.5	2.36	0.65	0.64	37.0
22.12.06	1)	1)	9.1	n/a	6.3	90.6	54.3	7.2	14.5	1)	1)	126.8	3.26	0.54	0.60	19.6
23.12.06	1)	1)	9.1	n/a	6.3	543.5	1)	10.9	9.1	1)	1)	54.3	2.54	0.74	0.96	22.6
24.12.06	1)	1)	7.2	n/a	2.7	90.6	72.5	18.1	30.8	1)	16.3	36.2	3.26	0.72	0.87	15.6
25.12.06	1)	1)	9.1	n/a	3.6	1087.0	108.7	14.5	16.3	1)	3.6	181.2	1.99	0.91	1.21	16.5

Table 4c: Results of laboratory analyses and total mass of PM_{10} collected at Kordin.
Footnotes: See legend of Table 4a.

4.2. Assessment of Air Quality

4.2.1. Arsenic, Cadmium and Nickel

The Tables 4a to 4c show, that for all of the samples, independent of the location, the ambient air concentration of arsenic and cadmium was always below the lower detection limit of 4.5 ng/m^3 and 0.9 ng/m^3, respectively.

For arsenic, the Directive defines an annual target value of 6 ng/m^3 and an upper and lower assessment threshold of 3.6 ng/m^3 and 2.4 ng/m^3, respectively. Typical concentration levels of arsenic in urban areas including traffic sites are in the rage of 0.5 - 3 ng/m^3 (*EC, 2001a*). For cadmium, the Directive sets an upper and lower assessment threshold of 3 ng/m^3 and 2 ng/m^3, respectively. Annual averages of cadmium in European cities show concentrations typically between 0.2 - 2.5 ng/m^3 (*EC, 2001a*).

However, no firm conclusion can be drawn for these two pollutants, due to the fact that only a limited number of samples was available for this interim assessment (in particular at Kordin) and.

The nickel concentration in European urban areas and traffic sites is usually in the range of 1.4 - 13 ng/m^3 (EC, 2001a). In Malta, nickel was detected in almost all the samples but the daily concentration levels never reached the annual target value of 20 ng/m^3 and averages were 8.2 ng/m^3 in Zejtun, 8.7 ng/m^3 in Kordin and 10.7 ng/m^3 in Msida. Considering that the upper and lower assessment thresholds are defined to 14 ng/m^3 and 10 ng/m^3, respectively, this would mean that monitoring may become mandatory in areas heavily affected by traffic.

However, although it is a positive indication that the concentrations of arsenic, cadmium and nickel in daily PM_{10} samples seem to be very low, it is nevertheless not possible to positively determine zones and agglomerations within which monitoring should become mandatory, since sampling was carried out within a very limited time period. Further measurements are therefore needed in order to come to an accurate and comprehensive conclusion about these air pollutants.

4.2.2. Mercury

The gaseous mercury measurements considered in this study were carried out at the station in Zejtun and cover a period of about 8 months. Figure 5 depicts the daily averages, which were computed from 15-minute averages. The figure shows that highest concentrations of up to 1.9 ng/m^3 were observed in the beginning of the measuring campaign in July 2006. The values dropped during the late summer and reached a minimum of about 0.6 ng/m^3 at the end of January 2007. The average over the entire period is 1.0 ng/m^3, which seems to be somewhat lower as compared to what was found during some other measuring campaigns carried out in the Mediterranean in the years 1998 to 2000 (*EC, 2002; Sprovieri et al., 2003; Wängberg et al., 2001*). Further measurements are necessary to confirm the behaviour depicted in Figure 5.

As mentioned in Chapter 4.1., concentration levels of mercury do not seem to be particularly elevated when the wind was blowing from the agglomeration. This can be interpreted that the mercury levels found on the Maltese islands are in fact of regional background character,

mainly affected by transboundary and /or diffuse natural sources (e.g. the Mediterranean Sea) and not by local anthropogenic sources. However, since at the time of writing this report, the mercury data has not been integrated into the general database, the prevailing wind direction was only analysed for those days, when PM_{10} sampling for the determination of inorganic elements was performed. Thus, further data treatment is necessary in order to produce a proper pollution rose for mercury. It may be suggested to perform future measurements of gaseous mercury at the Kordin station in order to monitor the most likely strongest anthropogenic source of mercury in Malta, the Marsa power plant.

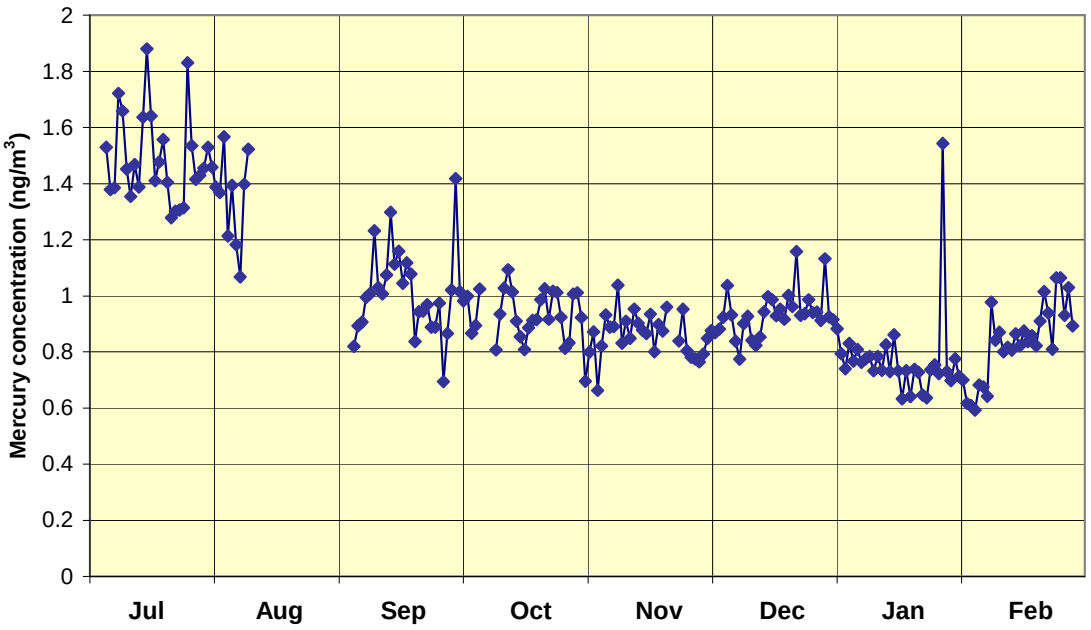

Figure 5: Daily averages of elemental mercury in Zejtun.

4.2.3. Polycyclic Aromatic Hydrocarbons

Five filters from each of the three sampling sites were individually analysed for the presence of polycyclic aromatic hydrocarbons, as described in Chapter 3. The results showed that the concentrations on all of the 15 filters, independent of the sampling location, were below the laboratory's detection limit of 1.8 ng/m^3. Although the Directive defines an annual target value of 1 ng/m^3 for benzo[a]pyrene these measurements still give a good first indication as to whether there may be substantial reason for concern in particular at the traffic site in Msida. One can expect the concentration levels of this group of air pollutants to be significantly higher than the detection limit at this site in particular on days, which favour the accumulation of air pollutants. In the 90's, annual averages of polycyclic aromatic hydrocarbons levels in urban areas were between 0.5 and 3 ng/m^3 including traffic sites (*EC, 2001b*).

When sampling took place at the Zejtun station, the wind came predominantly from the agglomeration on only one out of five days. This might explain the relatively low values at this site. Unfortunately, no wind data is available from the Kordin station itself, while sampling took place there. However, when applying the wind conditions at Zejtun to the Kordin station then this site might have been affected by the Marsa power plant on three days.

It is also a positive indication that no detectable levels of polycyclic aromatic hydrocarbons have been found at the traffic site in Msida.

Earlier studies of benzo[a]pyrene and benzo[k]fluoranthene on total suspended particulate matter and cistern water in Malta were also carried out by *Said Pullicino (1999)*. In this study, sampling was carried out at different locations throughout Malta, of which the location in Msida is basically identical to the site utilised in this study. Samples were taken on three different days for eight hours. Benzo[a]pyrene concentrations of 2.5 ng/m^3, 2.9 ng/m^3 and 6.1 ng/m^3 and benzo[k]fluoranthene concentrations of 3.5 ng/m^3, 3.2 ng/m^3 and 5.8 ng/m^3, were found respectively. Sampling was also carried out at another traffic site (Floriana) for two days, where concentrations of 6.0 ng/m^3 and 5.2 ng/m^3 of benzo[a]pyrene and 7.1 ng/m^3 and 6.0 ng/m^3 of benzo[k]fluoranthene were measured. Benzo[a]pyrene concentrations were mostly well below 1 ng/m^3 on other less polluted sampling sites.

In this regards it may be plausible that ambient air concentrations of polycyclic aromatic hydrocarbons in the PM_{10} fraction may have been really much below or close to the target value as outlined in the Directive. However, further monitoring and analysis is still required in order to reach a comprehensive conclusion about this group of air pollutants.

5. Concluding Remarks

In general, it is a positive result that ambient air concentrations of arsenic, cadmium and nickel on these indicative measurements were below their respective target values and in case of polycyclic aromatic hydrocarbons below the laboratory's detection limit. However, these measurements are too sparse and do not cover a sufficient period of time. It would therefore be inappropriate to define zones and agglomeration for these air pollutants at the present stage.

Sampling is currently ongoing in order to confirm these findings. Also, a different laboratory with better lower detection limits has been chosen to carry out future analysis. With respect to polycyclic aromatic hydrocarbons, it is also suggested that the individual filters of several days should be analysed as a composite sample (as allowed by the 4th Daughter Directive) in order to ensure that detectable levels of these pollutants are collected using a low volume sampler.

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