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**REPORT ON THE ANALYTICAL TESTS PERFORMED ON  
SAMPLES OF FILTERS DERIVING FROM URBAN AIR  
TREATMENT SYSTEMS**

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## 1. INTRODUCTION

This report indicates the results of the laboratory analyses performed on the samples of filters supplied by System(life) s.r.l., a company based in Camposampiero, Padova, to the Environmental Health Engineering Laboratory of the Department of Hydraulic, Maritime, Environmental and Geotechnics Engineering at the University of Padova. These filters derive from the Città model of Filtering Stations which treat urban air.

The analyses, the results of which are indicated in this report, were performed both on the filter material of the filters of the Città model of Filtering Stations, and on a sample of particulate trapped in the filters. These analyses provide initial indications on how to dispose of these filters and the material deriving from the filter cleaning procedures performed during operation of the filtering station.

Laboratory analyses were performed on the following types of materials:

- 1 sample of used filter supplied by System(life), called "Used filter material".
- 1 sample of unused filter material supplied by System(life), for use as the reference standard, called "New filter material".
- 1 sample of particulate trapped by the filter material and extracted from it according to the methods indicated in Section 2 of this Report.

The analyses performed on the above materials were:

- Leach test in distilled water, as indicated in Ministerial Decree of 3rd August 2005. This test was performed on the "Used filter material" and "New filter material" samples.
- Analysis of the composition of the particulate captured by the filter material.

The parameters analysed on the eluates produced in the leach tests are: Dissolved Organic Carbon (DOC), Chlorides (Cl), Fluorides (F), Sulphates ( $\text{SO}_4^{2-}$ ), Arsenic (As), Barium (Ba), Cadmium (Cd), Total chrome (Cr), Copper (Cu), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Zinc (Zn), Cyanides (CN).

The parameters analysed on the particulate trapped by the filter material are: Total Solids (ST), Volatile Solids (SV), Total Organic Carbon (TOC), Arsenic (As), Barium (Ba), Cadmium (Cd), Total chrome (Cr), Copper (Cu), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Zinc (Zn).

The following sections illustrate the methods used to perform the analyses and the relative results.

## 2. ANALYTICAL METHODS

### 2. 1. Leach tests performed according to Ministerial Decree of 3rd August 2005

Ministerial Decree of 3rd August 2005 establishes the admissibility criteria and procedures of waste into dumps. Waste is allowed to be disposed of in dumps if it complies with the admissibility criteria of the corresponding dump category of (dumps for inert waste, dumps for non-hazardous waste and dumps for hazardous waste).

In order to determine which dump category waste belongs to, M.D. of 3rd August 2005 requires tests to be performed according to the analytical methods established in UNI EN 12457. These analytical methods envisage a leach test in distilled water of a quantity of waste amounting to 90g of Total Solids with a leaching liquid and solid waste ratio of 10. 90 grams of Total Solids deriving from the filters and 900 ml of distilled water were therefore placed into a plastic (PE) test bottle. The bottle was then agitated for 24 hours in a tumble agitator at a speed of 10 rpm. After the 24 hours of shaking required by the leach test, the eluate was filtered with a 0.45 µm porous membrane in order to obtain just the dissolved fraction of the total solids in the eluate.

The analyses indicated in Section 1 were performed on the filtered eluate according to the standard methods indicated in CNR IRSA Quaderno 100 "Analytical methods for waters".

### 2.2. Preparing the filter samples for the leach test

Two samples called "Used filter material" and "New filter material" were handled as described below in order to obtain a material suitable for leach test requirements.

The filter material in the "Used filter material" and the "New filter material" samples was removed from the metal frame and from the metal mesh support. The filter material obtained in this way was cut with a pair of scissors in order to obtain a sample size satisfying the requirements of the method. While handling the "Used filter material", care was taken not to lose the particulate trapped in the filter material. Figure 1 shows the cutting phase of the "Used filter material" sample while Figure 2 shows the cutting phase of the "New filter material" sample.



Figure 1. Cutting the "Used filter material" sample.



Figure 2. Cutting the "New filter material" sample.

### 2.3. Preparing the particulate sample for composition analysis

To obtain a representative sample of particulate for performing the analyses Described in Section 1, the films supplied by Systemlife were handled as follows. The filters identified with the staff of Systemlife for removing the particulate to analyse were dismantled from the metal frame supporting the filter material. The metal mesh was not dismantled when taking the particulate sample from the filters because it was useful for removing the particulate. The particulate held by the filter material of the supplied filters was then removed with a brush and collected on a sheet of paper to prevent it from scattering. This operation is shown in Figure 3. After removing all the particulate from all the supplied filter samples, it was screened using a 4 mm mesh screen mainly in order to eliminate the filter material fibres that have been removed by the mechanical action of the brush and which could have interfered with particulate analysis. Figure 4 shows the screening operation. The analyses indicated in Section 1 were performed on the screened particulate according to the standard methods indicated in CNR IRSA Quaderno 24 "Analytical methods for sludge".



Figure 3. Removing the particulate.

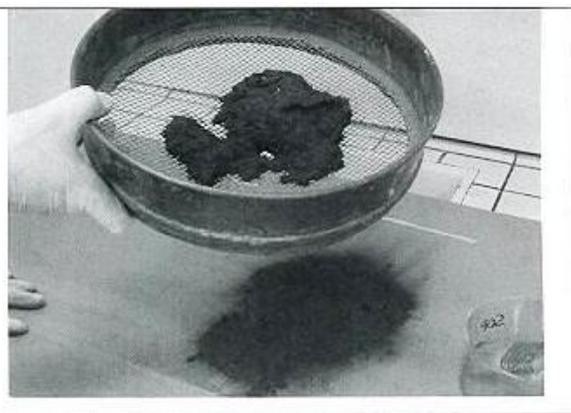


Figure 4. Screening the particulate

## RESULTS

### 3.1 Leach tests according to M.D. of 3rd August 2008

The results of the leach tests on the "Used filter material" and "New filter material" samples are shown in Table 3. The limits for the admission into inert, non-hazardous and hazardous waste dump, concerning the parameters analysed indicated by the Decree, are shown in the same table. Analysis of leach test concentrations in the "Used filter material" sample shows that the concentrations of Dissolved Organic Carbon (DOC), Zinc (Zn) and Arsenic (As) exceed the hazardous waste limit. The concentration of Antimony (Sb) exceeds the limit value for non-hazardous waste but not that for hazardous waste. The concentration of Fluorides (F), Sulphates ( $\text{SO}_4^{2-}$ ), Chlorides (Cl), Cadmium (Cd), Copper (Cu), Molybdenum (Mo), Nickel (Ni) and Lead (Pb) exceeds concentrations for inert waste but not for non-hazardous waste. The concentrations of Total chrome ( $\text{Cr}_{\text{tot}}$ ), Barium (Ba), Selenium (Se) and Mercury (Hg) do not exceed limit concentrations for inert waste. For the "new filter material" sample, the concentration of DOC exceeds the limit value for hazardous waste while concentrations of Zinc (Zn) and Antimony (Sb) exceed the limit concentrations for non-hazardous waste but do not exceed the limit concentrations for hazardous waste. All the other leach test parameters analysed on the "New filter material" sample are below the limit value for inert waste.

Table 3.1. Results of the leach test eluate analyses and limit values for the various categories of dump

Parameter	U.M.	"New filter material"	"Used filter material"	Inert	Non-hazardous	Hazardous
Parametro	U.d.M.	"Materiale filtrante nuovo"	"Materiale filtrante usato"	Inerti	Non pericolosi	Pericolosi
Fluoruri, F <sup>-</sup>	[mg F <sup>-</sup> /l]	0.09	14.39	1	15	50
Solfati, $\text{SO}_4^{2-}$	[mg $\text{SO}_4^{2-}$ /l]	26	635	100	2000	5000
Cloruri, Cl <sup>-</sup>	[mg Cl <sup>-</sup> /l]	78	674	80	1500	2500
Cianuri, CN <sup>-</sup>	[mg CN <sup>-</sup> /l]	< 0.03	< 0.03	-	0.5	5
Carbonio Organico Disciolto, DOC	[mgC/l]	163	482	50	80	100
Arsenico, As	[mgAs/l]	0.47	4.06	0.05	0.2	2.5
Cadmio, Cd	[mgCd/l]	< 0.01	0.02	0.004	0.02	0.2
Cromo totale, Cr	[mgCr/l]	< 0.01	0.05	0.05	1	7
Rame, Cu	[mgCu/l]	0.06	3.53	0.2	5	10
Bario, Ba	[mgBa/l]	0.04	0.75	2	10	30
Molibdeno, Mo	[mgMo/l]	< 0.01	0.16	0.05	1	3
Nickel, Ni	[mgNi/l]	< 0.02	0.17	0.04	1	4
Piombo, Pb	[mgPb/l]	0.04	0.08	0.05	1	5
Selenio, Se	[mgSe/l]	< 0.005	< 0.005	0.01	0.05	0.7
Zinco, Zn	[mgZn/l]	6.26	76.5	0.4	5	20
Mercurio, Hg	[mgHg/l]	< 0.0001	< 0.0001	0.001	0.005	0.05
Antimonio, Sb	[mgSb/l]	0.19	0.47	0.006	0.07	0.5

### 3.2. Analysis of particulate composition

The results of the analysis of the composition of the particulate taken from the used filters according to the methods indicated in Section 2.2 are shown in Table 3.2.

The analyses indicate a concentration of Total Solids of this particulate of 95% compared with the weight as is. This means that it has a low water content corresponding to a Humidity H of 5% with respect to the weight as is. Concentrations of Volatile Solids amounted to 41% with respect to the Total Solids of the particulate. The Total Organic Carbon (TOC) content amounted to 20.7% with respect to the total solids of the particulate. This means that approximately 20% of the Total Solids of the particulate comprises Organic Carbon.

Analysis of the heavy metals shows that the compounds with the greatest concentrations are Zinc, with a concentration of 10871 mgZn/Kg<sub>ST</sub>, and Copper, with a concentration of 1704 mgCu./Kg<sub>ST</sub>. Barium has a concentration of 340 mgBa/Kg<sub>ST</sub>, Lead a concentration of 309 mgPb/Kg<sub>ST</sub>, Total chrome has a concentration of 223 mgCr/Kg<sub>ST</sub>, Antimony a concentration of 207 mgSb/Kg<sub>ST</sub>, Molybdenum a concentration of 121 mgMo/Kg<sub>ST</sub>. Nickel has a concentration of 53.3 mgNi/Kg<sub>ST</sub>, Cadmium a concentration of 3.4 mgCd/Kg<sub>ST</sub>, Mercury a concentration of 2.9 mgHg/Kg<sub>ST</sub> and Selenium a concentration of 0.3 mgSe/Kg<sub>ST</sub>.

Table 3.2. Results of particulate composition analysis

Parametro	U.d.M.	Concentrazione nelle polveri
Solidi Totali, ST	[% sul tal quale]	95
Umidità, U	[% sul tal quale]	5
Solidi Volatili, SV	[% sui Solidi Totali]	41
Carbonio Organico Totale, TOC	[% sui Solidi Totali]	20.7
Arsenico, As	[mgAs/Kg <sub>ST</sub> ]	1.7
Mercurio, Hg	[mgHg/Kg <sub>ST</sub> ]	2.9
Cromo totale, Cr tot	[mgCr/Kg <sub>ST</sub> ]	223
Rame, Cu	[mgCu/Kg <sub>ST</sub> ]	1704
Nickel, Ni	[mgNi/Kg <sub>ST</sub> ]	53.3
Piombo, Pb	[mgPb/Kg <sub>ST</sub> ]	309
Selenio, Se	[mgSe/Kg <sub>ST</sub> ]	<0.3
Zinco, Zn	[mgZn/Kg <sub>ST</sub> ]	10871
Cadmio, Cd	[mgCd/Kg <sub>ST</sub> ]	3.4
Bario, Ba	[mgBa/Kg <sub>ST</sub> ]	340
Molibdeno, Mo	[mgMo/Kg <sub>ST</sub> ]	121
Antimonio, Sb	[mgSb/Kg <sub>ST</sub> ]	207

#### 4. CONCLUSIONS

Concerning the structure of the filters, the metal frame and the metal mesh supporting the filter material can be sent for metal recycling while the filter material it contains must be sent to a dump.

Given that hazardous waste concentrations were by Dissolved Organic Carbon (DOC), Zinc (Zn) and Arsenic (As) in the "Used filter material" sample, this material should be pre-treated in order to reduce the leachability of these compounds and respect the limits established in Ministerial Decree of 3rd August 2005. However, it should also be considered that these filters are periodically washed during operation of the filtering station. This operation can release the substances trapped in the filters and therefore decrease the concentrations of DOC, Zinc and Arsenic in a leach test.

The analyses performed on the particulate trapped by the filter material can give indications concerning the composition of the "washing sludge" generated during the filter cleaning phase. This gives useful initial indications on the chemical-physical composition of the sludge that will be generated.

The CER Codes for the analysed materials remain to be defined. For the filter material, the following CER Codes can be used:

15 02 02\* : Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances.

15 02 03 : Absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02

The hazardous (15 02 02\*) or non-hazardous material (15 02 03) classification of the used filters must be confirmed according to a more in-depth analysis of the organic part of the Total Solids trapped in the filter material of the filters. This analysis is not envisaged in this report. The concentrations of heavy metals measured in the particulate are not sufficient to classify the filters as hazardous waste, according to Article 2 of European Commission Decision 2000/532/EC, as amended by 2001/118/EC 2001/119/EC, 2001/573/EC. This non-hazardousness only refers to the analyses of the heavy metals.

Seeing that the limit value of Dissolved Organic Carbon (DOC), Zinc (Zn) and Arsenic (As) were exceeded in the leach test, thus requiring the filters to be pre-treated and seeing that the limit value for non-hazardous waste was exceeded for Antimony (Sb), this waste should be classified as hazardous as a precautionary measure.

As regards the "washing sludge", the CER code definition depends on its chemical and physical characterisation once it is produced. Its classification into non-hazardous or hazardous waste will be defined according to the concentration of heavy metals measured in this report and to a more in-depth analysis of the organic fraction of Total Solids, which constitutes a significant part of them. This analysis is not envisaged in this report.