Report

Empirical study: “The current situation and management of indoor air pollution (IAQ) in European collections”

for **Fraunhofer-Institut für Silicatforschung**
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2011-12-06

1. Situation / Objective

One serious problem for museums is the damage of art and cultural objects by environmental influences. Parameters such as light (HV), temperature (T), relative humidity (RH) play a significant role in this context but also construction materials used for display and storage can have a great impact on the surrounding atmosphere. This damage should be contained through preventative measures.

The empirical study "Emissions in the museum environment" [Spiegel 2009] examined the current situation of pollutants that occur in museums throughout Germany as well as the management of materials used in them. Up to now, no such data exists for museums in Austria, Belgium, Denmark, France, Ireland, Italy, Lithuania, Norway, United Kingdom, Romania, Spain, Poland and Turkey. In order to fill this gap, a survey was carried out amongst these MEMORI participating countries including also the countries that are the end-users.

Against this background the research questions of the study are:

- To what extent have measures been taken to minimize the effects of foreign substances and pollutants emitted by exhibition materials? (As a follow-up: Have measurements of pollutants been made, and if so, what type? Have exhibition materials been tested prior to their use in the museum?)
- What role do standard and routine operations play in the selection of exhibition materials and are they already in use?

Objectives of the study are:

- Identification/ evaluation of the current situation of indoor air quality (IAQ) in collections of Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Lithuania, Norway, UK, Romania, Spain, Poland and Turkey (see chapter 3.1; page 8 ff.).
- Identification/ evaluation of the management (e.g. mitigation strategies, measuring methods) of IAQ in museums, libraries and archives (see chapter 3.2; page 10 ff).

The survey is part of the European FP7 project MEMORI (Grant agreement no: 265132):

> *"Task 11.4 Consultation with end-users via a web based survey. A larger selection of end-users will be contacted and asked about their priority regarding environmental measurements and survey in their collections, and interest in using an instrument such as the MEMEORI dosimeter. The consultation will be analyzed with a web tool as well as with traditional analysis methods for validation. The results will be included on the web site and are part of the business plan as well. The web based survey is due until the first end-user symposium."*

And is part of the following deliverable:

> *"D11.4) Web based survey and report from the mid-term end-user symposium: [month 20]".*

2. Notes on the study design

2.1. Experimental method and background information

The interviews were organized by an online questionnaire and an automatically readable pdf-questionnaire. The development of the hypotheses and the questionnaire for the MEMORI survey was done by Elise Spiegel (CARE FOR ART) in close cooperation with the MEMORI partners. The technical implementation and support of the survey was carried out by the Bamberger Center for Empirical Studies (BACES), a department of the Otto-Friedrich-University of Bamberg, Germany.

The online questionnaire was programmed with *EFS Survey 7.1* (Globalpark GmbH) and hosted on the BACES server.

The paper-based questionnaire was implemented by *Cardiff Teleform V10.4.1* (Cardiff). This automatically readable pdf document was hosted on the survey homepage and on the official home page of the MEMORI project (www.memori-project.eu). The data of all completed questionnaires have been analysed with SPSS V20 (IBM) by BACES. The transforming and cleaning of the basic data was done by using SPSS V20 (IBM) and Excel V14.0.0 (Microsoft).

2.2. Target group

The target group of the survey were conservation specialists and scientists with research focus on IAQ working in museums, libraries and archives located in the 14 MEMORI participating countries (Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Lithuania, Norway, Poland, Romania, Spain, Turkey, United Kingdom).

Museums

Since the identification and selection of the defined target group is difficult to achieve, the following hypothesis was applied: Conservation specialists and scientists with research focus on IAQ can usually be found in museums with more than 5.000 visitors per year, since only large institutions will be in the position to provide exclusive resources for IAQ. Since the number of visitors correlates with the size of an institution, “visitors per year” is an appropriate indicator to select the right museums. According to the institutions for museum research [IFM (2007) p. 16], 10 size ranges of museums can be distinguished:

Table 1: Size ranges of Museums due to the number of visitors [IFM (2007) p. 16].

Size Range	Visitors
1	less than 5.000
2	5.001 – 10.000
3	10.001 – 15.000
4	15.001 – 20.000
5	20.001 – 25.000
6	25.001 – 50.000
7	50.001 – 100.000
8	100.001 – 500.000
9	500.000 - 1 Mio.
10	more than 1 Mio.

Most of the countries participating in the MEMORI project do not run databases as the IFM nor are they allowed to forward data on their members to third parties. Thus the total number of museums per size range is not known. During the survey 6.177 museums with more than 5.000 visitors per year could be identified (see Table 2):

Table 2: Number of museums in the participating countries.

	Country	Year	Total	Museums with more than 5.000 visits/ year
1	Austria	2008	493	216
2	Belgium	2004	162	100
3	Denmark	2010	425	308
4	France	2003	1.173	680
5	Germany	2006	6.175	2.126
6	Ireland	2005	258	129*
7	Italy	2008	435	277
8	Lithuania		–	40**
9	Norway	2010	137	122
10	Poland	2009	774	387*
11	Romania	2007	748	31
12	Spain	2008	1.450	778
13	Turkey	2012	–	58***
14	United Kingdom	1999	1.850	925*
Total				**6.177**

Comments:

* Missing value; max. 50% of Total Number of Museums

** Estimated Number

*** Museums > 20.000 visits/year (Written Massage of the General Directorate of Cultural Assetts and Museums Turkey)

Libraries and Archives

Similar to museums there is no exact number of libraries and archives in the 14 participating countries available. Based on input of the MEMORI project only selected libraries and archives with major national and international importance have been selected (see Tab. 3).

Table 3: Number of archives and libraries in the participating countries.

	Country	Number of selected Libraries and Archives
1	Austria	4
2	Belgium	2
3	Denmark	2
4	France	2
5	Germany	2
6	Ireland	2
7	Italy	3
8	Lithuania	2
9	Norway	3
10	Poland	2
11	Romania	2
12	Spain	5
13	Turkey	2
14	United Kingdom	2
Total		**35**

As the data for a systematic selection process of museums, archives and libraries was not available in most of the countries, a nonprobability sampling was used. The contact of the target group was organized as follows:

a) Promotion of the MEMORI survey by different museum associations of the participating countries as the International Council of Museum – EUROPE, International Council of Museum ICOM-CC and the European Confederation of Conservator-Restorers Organisations.
b) Direct contact via email send by CARE FOR ART (about 3.000 contacts) and by the members of the MEMORI project.

The MEMORI survey was open for five weeks from January 30, 2012 at 12:00 (noon) CET (Central European Time) until March 04, 2012 at 0:00 a.m. CET. The online survey was available in eight different languages: French, English, German, Italian, Lithuanian, Polish, Spanish and Turkish. The MEMORI partners and end-users of the different countries supported the translation.

2.3. Response Rate/ Sample

Due to the nonprobability sampling technique it is not possible to infer the results of the sample to the general populations of all museums, archives and libraries of the participating countries. The following table (see Table 4) and image (see **Image 1**) shows the response rate of the survey.

1.544 accesses to the online survey were measured during the field time. Since it is not possible to identify the accesses per museum a reference to the 6177 identified museums (with > 5.000 visitors per year) can not be made. 1441 of the 1544 accesses (92,5%) did not continue the survey.[1] The high rate of discontinuations can be explained by the nature of the distribution technique [Birnbaum 2004: p. 817]. As different museum associations promoted the survey invitation, there was no control over the single recipients of the number of invitations [Kay/Johnson 1999 p. 326].

In total there were 117 returned questionnaires (7,5% of all accesses) during the field time. From this 14 (0,9%) were unusable samples[2] so finally 103 (6,6%) were valid participants[3]. Only these valid participants have been used for the evaluation.

Table 4: Response rate oft he MEMORI survey.

	Number of Accesses to Survey	Discontinuations	Adjusted Sample (Number of valid Participants)	Unusable Sample
Number of Institutions	1544	1441	103	14
Percentage of Accesses	**100%**	**92,5%**	**6,6%**	**0,9%**

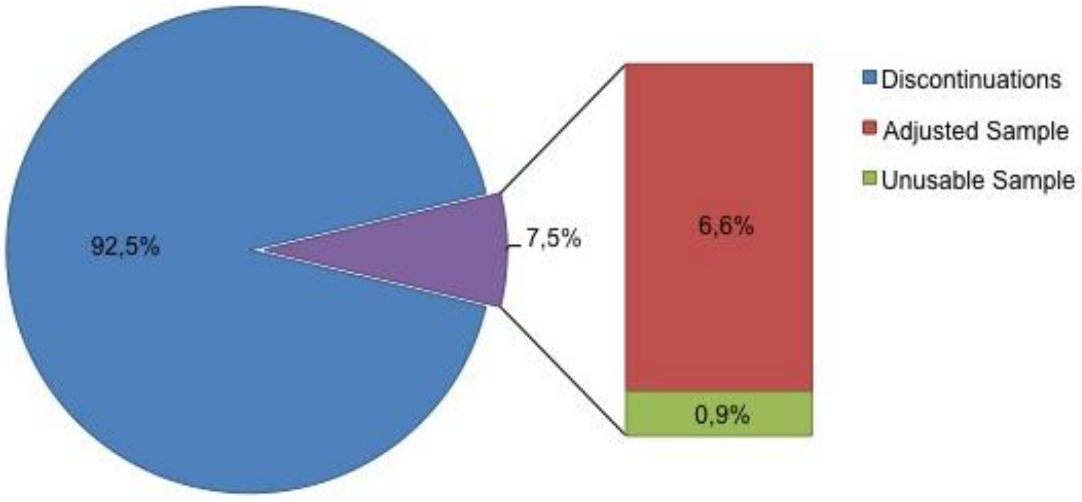

Image 1: Response rate of the MEMORI survey (N= 1544).

[1] The discontinuations respectively drop-out was mainly on the front page of the online survey and therefor has no influence on the composition of the data itself. A high drop-out is only considered a problem if the termination occurs selectively [Thielsch/Weltzin 2009 p. 77].

[2] The returned questionnaires were adjusted so that the sample contains only museums, archives and libraries. Additional duplicates and other institutions have been neglected.

[3] The adjusted sample contains museums of all group sizes (1-10).

The distribution of the sample within the participating countries is as follows: Germany (17,5%) and United Kingdom (16,5%) are the most strongly represented countries. Austria (8,7%) as well as Spain, Norway, Lithuania and Denmark (each 7,8%) followed by Turkey and Poland (each 6,8%) as well as Romania (5,8%) shows a lower participation with similar distribution. Less represented are Belgium (3,9%) and France (2,9%). Italy and Ireland are not represented in the sample at all even they were also invited.

Country	n	Distribution In sample
Germany	18	17,5%
United Kingdom	17	16,5%
Austria	9	8,7%
Spain	8	7,8%
Norway	8	7,8%
Lithuania	8	7,8%
Denmark	8	7,8%
Turkey	7	6,8%
Poland	7	6,8%
Romania	6	5,8%
Belgium	4	3,9%
France	3	2,9%
Italy	0	0,0%
Ireland	0	0,0%
TOTAL	**103**	**100%**

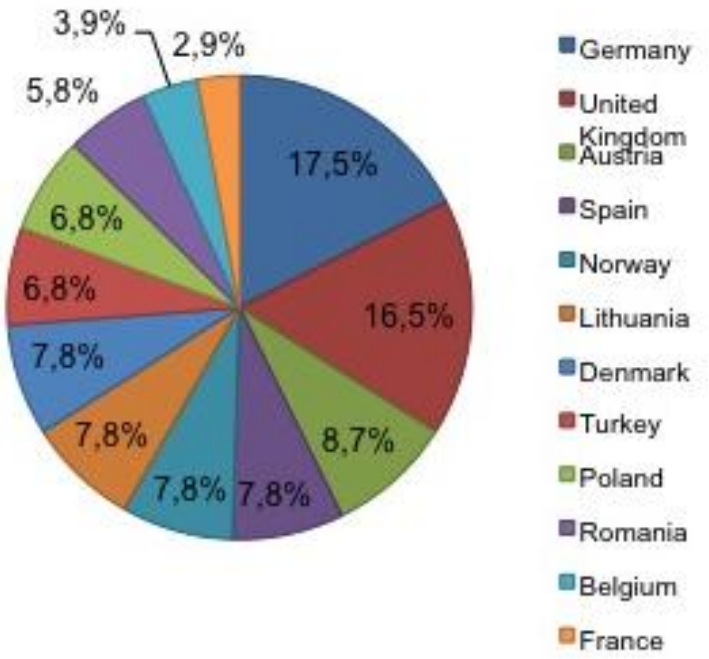

Image 2: Distribution of participating countries in the sample (N = 103).

2.4. Methodology

In this study the current pollution situation and management of perhaps materials emitting unsuitable or corrosive gases were explored. In addition, correlations between the expenses for collection care (preventive conservation; monitoring of the environmental conditions (T/RH/HV)); pollutant measurement (airborne pollutants and dust/particles/soiling) and the possible influencing factors were analysed. For this propose univariate and bivariate frequency distributions were used.

The evaluation of the pollution situation and the dealing with pollution was initially carried out using the univariate method. To analyse the relationship between the cost of preventive conservation and their possible causes and influencing factors, bivariate methods such as the correlations and mean comparisons have been used.
Due to the low random samples which is accompanied with limited statistical power it should be noted that small to moderate correlations (in case of correlations and mean

comparisons) often do not mean statistically significant results. The absence of a statistically significant correlation does not imply the absence of a correlation per se, but simply that the sample size is not sufficient for a proper evidence of a correlation.

2.5. Frequency Distributions

The data was prepared in tabular (frequency tables) as well as in graphical form. The main data analysis makes use of further characteristic metrics. To simplify the analysis, averaging, grouping variables summarized some variables. Absolute frequencies provide information about how many cases of the present data set show a particular characteristic. Relative frequencies indicate the proportion of these cases in the total population, expressed in percentage.
The shape of the graph depends on the scale level of the considered feature. As the present study contains mainly nominal scale characteristics, circular and bar charts have been used.

2.5.1. Univariate Frequency Distributions

In addition to tabular or graphical representations statistical measures were used to characterize a distribution. The following statistical measures were used for an indication of the central tendency of a distribution (arithmetic mean, median). For secondly for specifying the width or dispersion of the variables (2nd and 3rd quartile of the median) were used.
Box plots were used for a clear graphical representation of numerical data. The box plot provides a five-point summary where the median is presented in addition to the two quartiles and the extreme values. Furthermore, outliers are shown.[4]

2.5.2. Bivariate Frequency Distributions

Bivariate relationships are graphically illustrated by bar charts. Scatter plots were not used in the present study because there are ordinal or rank-scaled features.

3. Results of the Study

3.1. The current situation of IAQ in collections of participating countries

The study shows that only 36,8% of the surveyed institutions observed damages in their collection that are related to pollutants. In comparison to other environmental influences such as excessive light (HV), inappropriate temperature (T) and relative humidity (RH), this is the least common reason for observed damages (see ***Image 3***).

[4] Outliers are between 1,5 times and three times the interquartile range and extreme values more than three times the interquartile range away from the median. The interquartile range is derived from the distance between the lower and upper quartile.

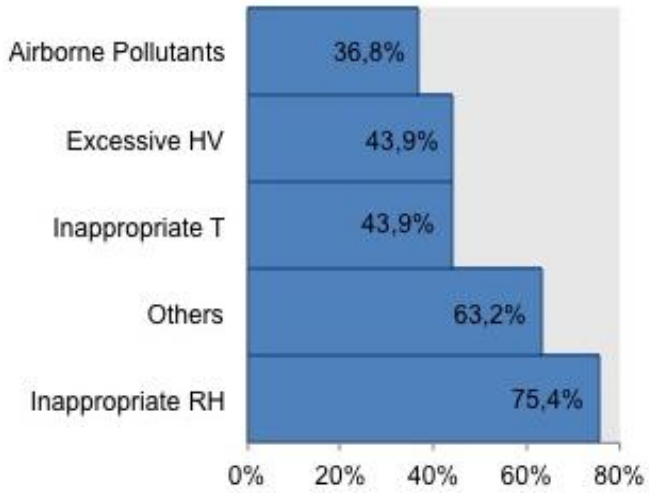

Image 3: Institutions observed damages due to environmental conditions (N= 57).

Of course inappropriate RH and T in collections are well known as major factors affecting the maintenance of objects, but the low percentage shown here might be misleading: The data demonstrates that 72,2 % of the Institutions that have not observed damages related to pollutants have also not measured airborne pollutants (see ***Image 4***). Taking this into account it may be the case that the total number is higher – as you can only find what you are looking for. Another reason for the relative low number of pollutant-induced damages might be that there are multiple damage symptoms (e.g. colour changes, effloresces, degradation) that complicate the assignment of cause and effect.

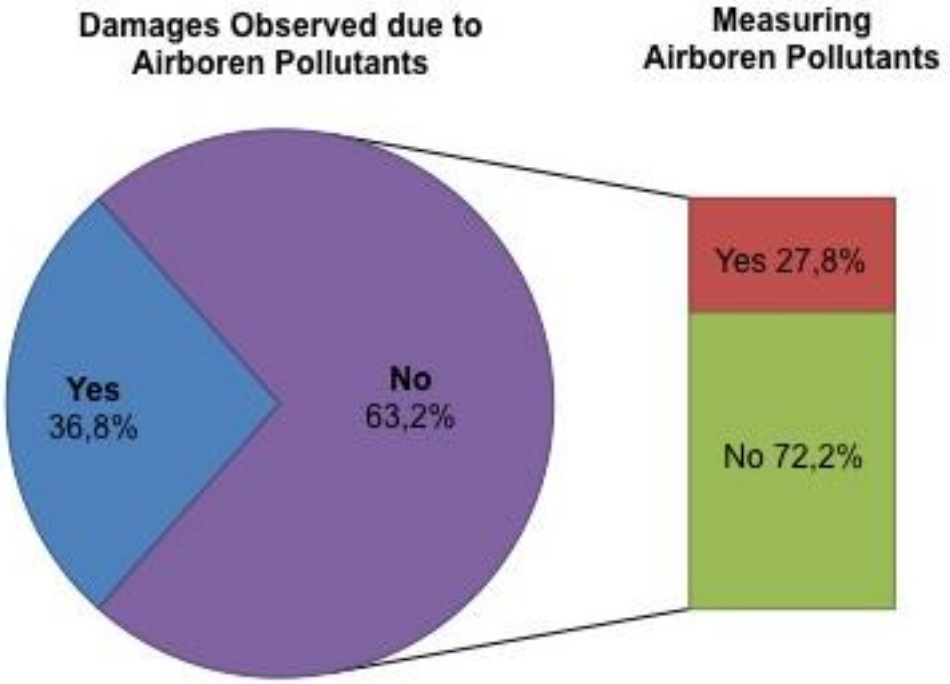

Image 4: Institutions that have no damages observed due to pollutants: measuring pollutants versus not measuring pollutants (N = 57; N = 84).

3.2. The management of IAQ in participating museums, libraries and archives

The research results of the management part of IAQ can be divided into three sections:

1) Development and determination of guidelines/standards for the assessment of the IAQ situation (target levels for airborne pollutants; satisfy external requirements (e.g. terms of bidding, lenders, commercial constraints) for display and storage materials that require the use of low emitting materials)
2) Monitoring of airborne pollutants to comply the guidelines (target levels)
3) Active mitigation strategies to reduce the new entry of pollutants (check display/storage materials)

Guidelines/ standards for the assessment of the IAQ situation

The study shows that only a very small percentage of the participants do recommend target levels for gaseous pollutants (12,6%) as well as for display and storage materials (11,2%).

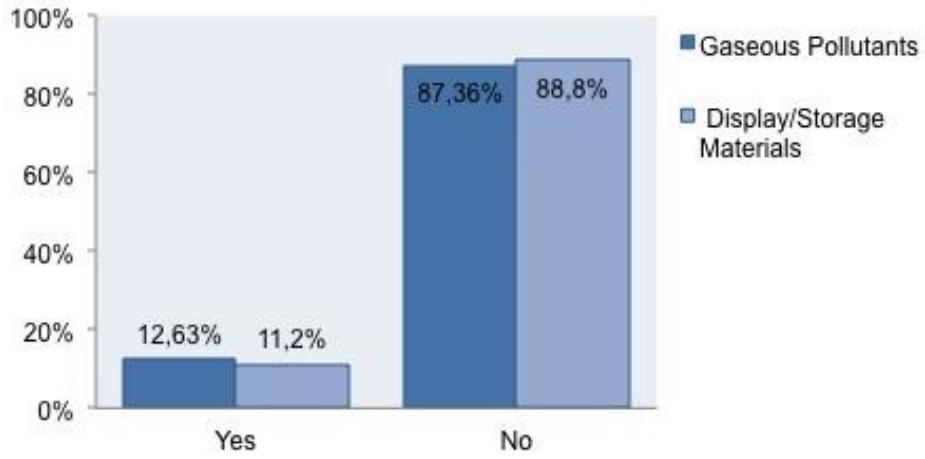

Image 5: Percentage of institutions with recommended target levels (N=96).

Mostly mentioned substances restricted in case of **gaseous pollutants** are acetic acid, nitrogen dioxide, ozone, and sulphur dioxide (59,6%). Frequently cited are also formaldehyde (44,4%), acidic nitrogen gases and formic acid (33,3%). Less frequently named are acetaldehyde and hydrogen sulphide as well as the group of Total Volatile Organic Compouns (TVOCs 11,1%). In addition 22,2 % of institutions that require target levels restrict other chemical compounds.

In case of **display and storage materials** half of the institutions (50%) have target levels to restrict acetic acid as well as “other compounds” that have not been listed for multiple choice. Frequently named are formic acid (37,5%) and formaldehyde (25,0%). With 12,5% less frequently named are acetaldehyde and the group of TVOCs.

In both cases acetic acid is the mostly restricted pollutant. One possible reason might be that for acetic acid there are easy and inexpensive methods available to measure

(e.g. A-D strip). Another point might be that the compound is well known in the museum environment for its corrosive effects.
Also remarkable is the low number of institutions that have a target level for TVOCs regarding gaseous pollutants as well as for display and/or storage materials. One reason for this could be that TVOC is the most expensive of the gases cited to measure. In addition very few VOCs are known to be corrosive, hence TVOC can be very high whilst no damage occurs to the objects.

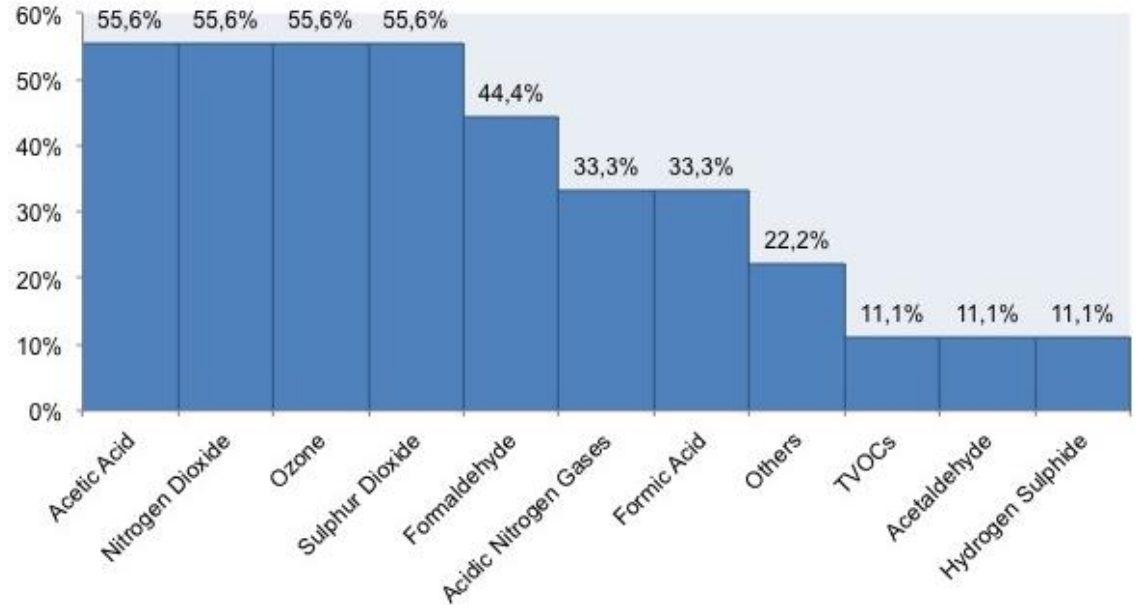

Image 6: Allocation of restricted compounds for institutions that have target levels for gaseous pollutants (N= 12).

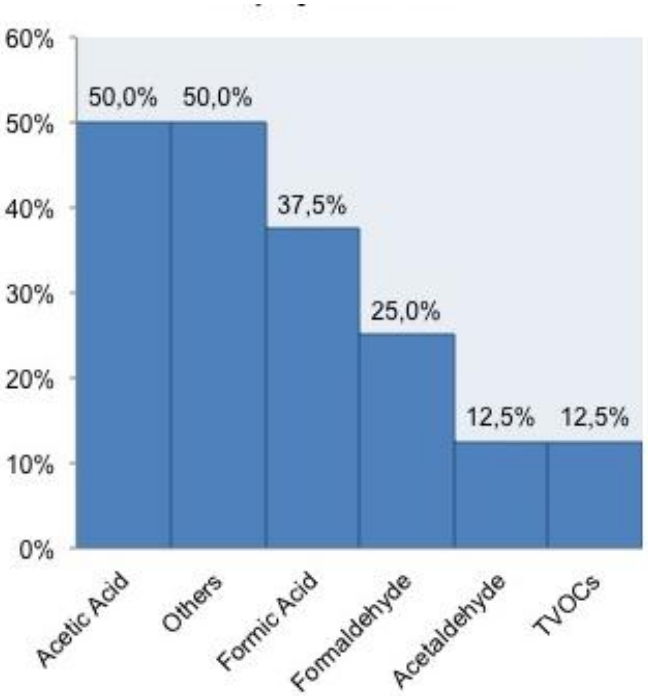

Image 7: Allocation of restricted compounds for institutions that have target levels for display and storage materials (N=11).

Participants that do not have target levels for gaseous pollutants (87,4%) do name the lack of knowledge as most common cause (59,7%), while 39,0% of cases indicate the lack of human resource as reason and 20,8% of cases quote that it is not supported by the person in charge. In addition 26% of cases name other reasons.
Further more appreciable is the small number of participants that do not see any need to advise pollution limits for there collections (7,8%). Conversely that means that more than 92,2% of institutions sees the necessity pollution limits for their collections.

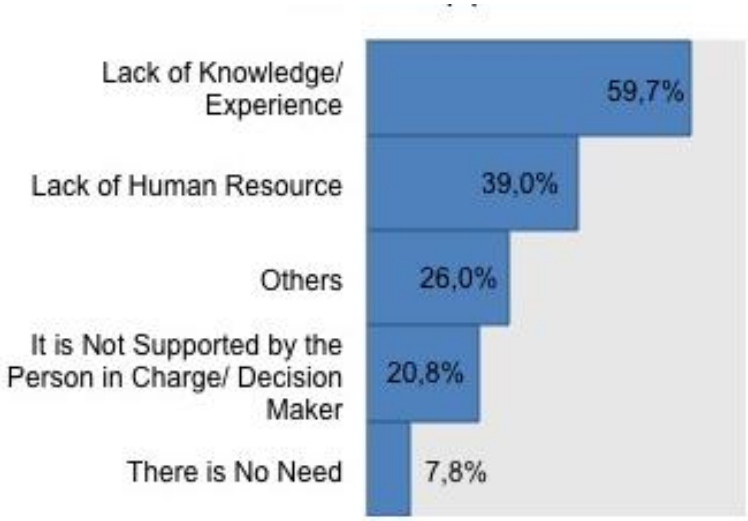

Image 8: Reasons for not advising pollution limits for collections (N = 37).

Monitoring of airborne pollutants to comply with guidelines

While guidelines and standards for gaseous pollutants and low emitting materials are the requirements of good indoor air quality, the monitoring of airborne pollutants is a sine qua non to comply with guidelines. The study shows that more than half of the institutions (56%) do measure pollutants in their collections, whereby it is most common to measure on demand (36,9%). Only 1,2% do measure airborne pollutants daily and 4,8 % do measure once a month. Furthermore 13,1 % indicate that they measure less frequently than once a month (see ***Image 10***).
In comparison to the monitoring of other environmental conditions as RH (98%) T (99%) and HV (92,2%) the number of Institutions that monitor pollutants is much smaller. Taking to account that more than three-quarter of institutions even daily measure RH (75%) and T (73,5%) one can assume that monitoring pollutant is not common at all.

The main reason why institutions do not measure airborne pollutants is with 56,8% a lack of knowledge. Also high frequently named is a lack of financial resource; this result is supported by the analyses of the funding for pollutant measurement that has been queried. Requested was the annual average value (€) based on the last three years. The data analyses shows that at least 50% (2nd and 3rd quartile of the median) of institutions have not spent any money for pollutant measurement. A closer

look into the data shows also, that only big museums with more than 100.000 visitors per year (group size 8-10) have invested in pollutant monitoring in their collections (see Appendix A.2.). The median as central value differs between 0 €, 500 € and 2.750 € depending on the size of the museum (group size 8, 9 and 10).
Of additional interest is that the expenses for the monitoring of other environmental conditions (RH/T/HV) are much higher in comparison to the expenses for pollution monitoring. The median as central value is 200 € and shows no significant differences across all categories of group size (p = 0,058); while the 2nd and 3rd quartile of the median show that 50% of the institutions spend between 0 € and 3.000 € for this purpose (see Appendix A.1.).

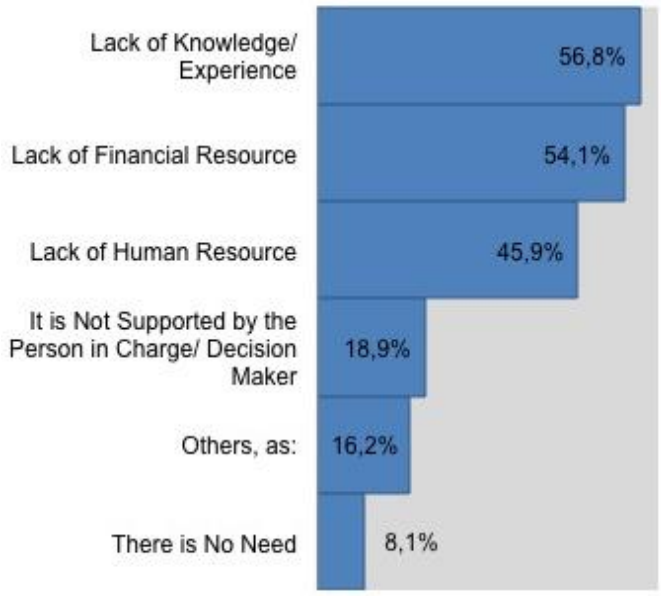

Image 9: Reasons why institutions do not measure airborne pollutants in there collections (N = 37).

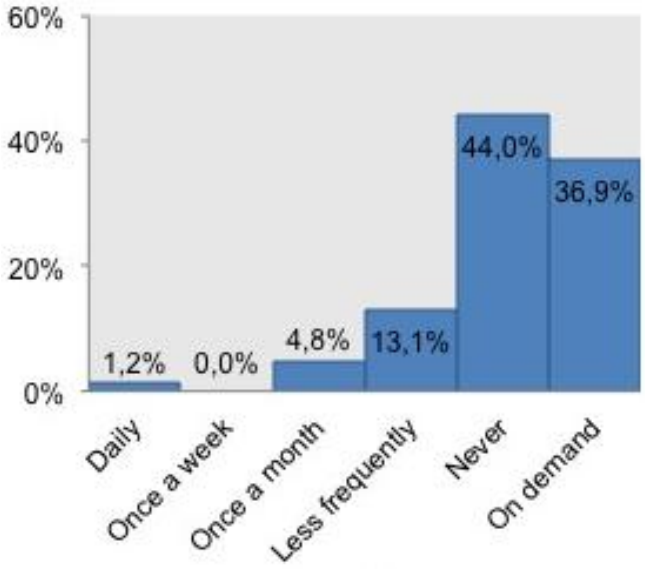

Image 10: Frequency of monitoring airborne pollutants (N = 84).

An additional decisive factor regarding the monitoring of airborne pollutants is where the measurements take place; as pollutants do accumulate in rooms and enclosures with low air exchange rates like showcases, microclimate frames and tight boxes. The following graph (see ***Image 11***) shows that only 14,6% of institutions do measure pollutants in showcases, 3,1% in storage boxes and only 1% in microclimate frames. Furthermore transport boxes were not mentioned at all. In partial terms this means that the places where pollutant can accumulate, enclosures are little observed.

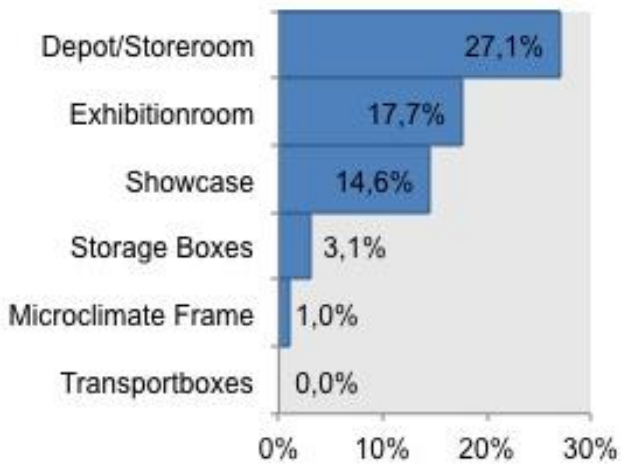

Image 11: Rooms and enclousures for measuring airborne pollutants (N = 96).

Of interest also are the methods used for detecting pollutants and the compounds measured. In general environmental measurement methods (77,8%) are used more often than effect measurement methods (55,6%). Taking a closer look at institutions that use effect measurement methods to analyse the impact of pollutants on an indicator material the use of A-D strips (32,1%) and metal coupons (21,4%) are most frequently named. The Fraunhofer Glass Slide (GSD) Dosimeter and the Early Warning Dosimeter for Organic Materials (EWO) that are of high interest for the MEMORI project are only mentioned by 14,3% respectively 10,7% of measuring institutions (see ***Image 12***).

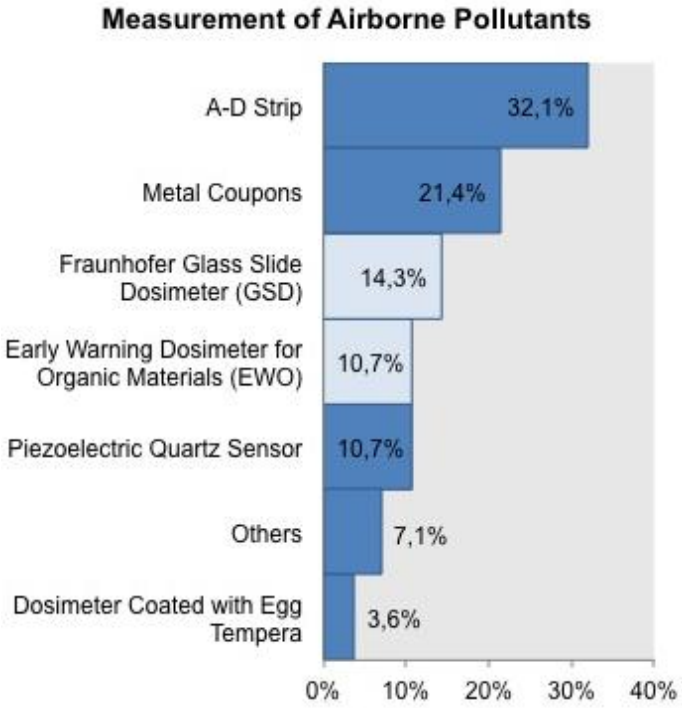

Image 12: Percentage of institutions that use specific effect measurement methods (N = 16).

Looking at the measured pollutants, acetic acid (66,7%) is the most frequently compound mentioned. This tallies with the results for guidelines and standards that show a high frequency of institutions that named target levels (gaseous pollutants/ materials) for acetic acid.

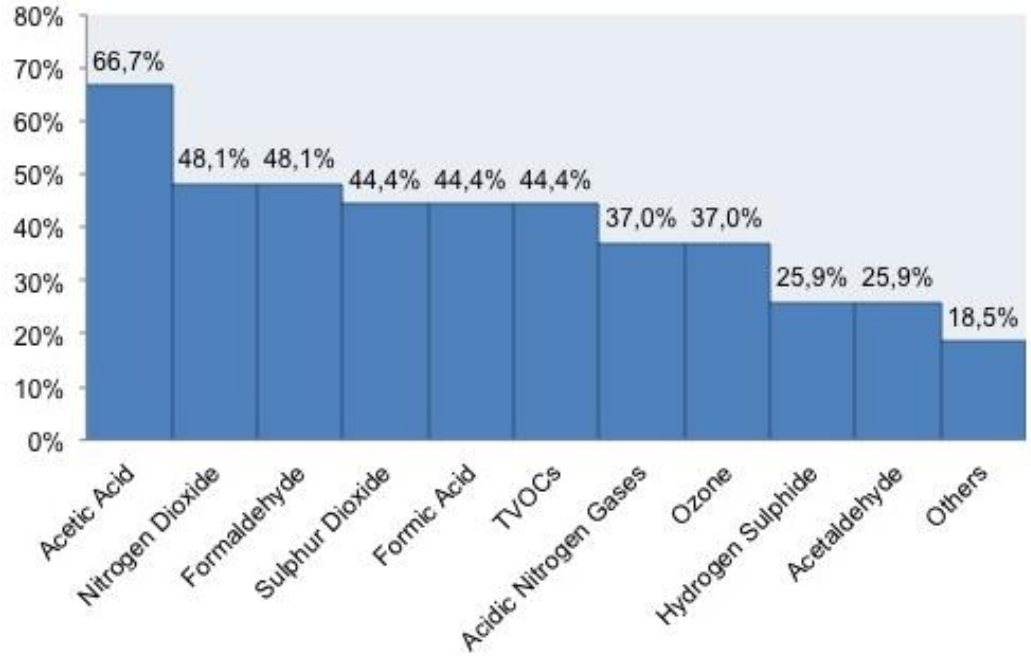

Image 13: Percentage of institutions that measure selected compounds in rooms and enclosures (N = 27).

Quite often measured are also nitrogen dioxide, formaldehyde (48,1%), sulphur dioxide, formic acid and TVOCs (44,4%). Less frequently named are acidic nitrogen

gases and ozone (37%) as well as hydrogen sulphide and acetaldehyde (25,9%). Additional to the key pollutants available for selection, 18,5% of institutions measure other compounds.
Of particular note in case of the TVOCs is, that a relatively high proportion of participants do indicate that they measure this group of compounds (44,4%), but only a small amount of institutions have determined target levels for this purpose (11,1% for gaseous pollutants/ 12,5% for display and storage materials). This gap shows that there are no guidelines and/or standard processes developed in terms of the interpretation of measuring results and the subsequent implementation of measures. Target levels are assessment values and therefor indispensable for a consequent decision-making and process tracing.

Active mitigation strategies to reduce the new entry of pollutants

To reduce the new entry of pollutants into collections due to display and storage materials it is essential to use low emitting substances. Therefor it has to be checked if these materials emit foreign and/or harmful substances. The data analysis shows that more than half of the institutions (65,3%) do require low emitting materials e.g. in case of bidding but only 46,9% do also check display and storage materials before use in collections. The most common cause requested is – in both cases – the lack of knowledge/experience (60,0% respectively 70,6%) (see ***Image 14*** and ***Image 15***).

In addition 31,4% of institutions indicate that it is not supported by the person in charge and/or decision maker to have external demands and only 14,3% do think that there is no need. Furthermore 20,0% of cases name other reasons.

In case of emission analyses for materials almost half of the institutions that do not check before use, name a lack of human (49,0%) and/or financial (45,1%) resource as the reason. Furthermore 19,6% mentioned that the person in charge and/or decision maker does not support it. It must be pointed out that only a very small amount of cases (7,8%) do indicate that there is no need for this purpose. As a consequence 92,2% of institutions do think that it is necessary to check if display and storage materials emit foreign and/or of harmful substances before use (but only 46,9% do so).

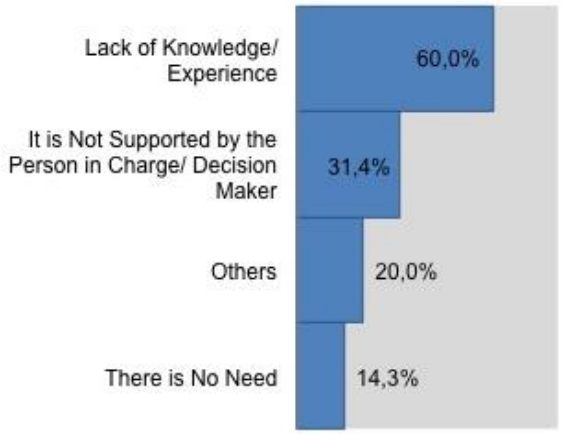

Image 14: Reasons for no external demands that require the use of low emitting materials (N = 37).

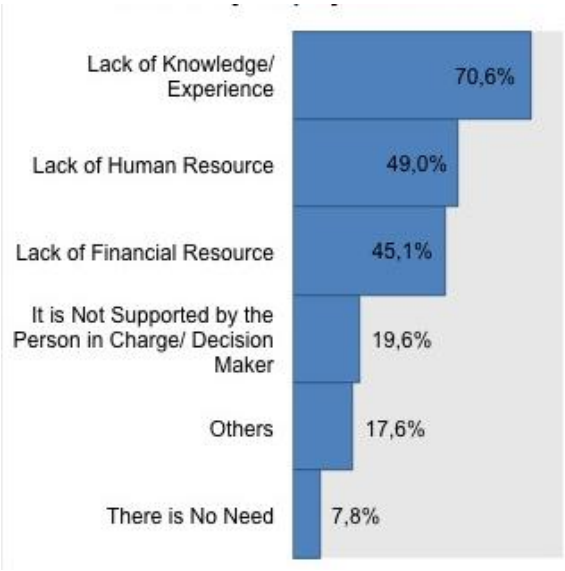

Image 15: Reasons for „Not Checking" if display and storage materials do emit foreign and/or harmfull substances before use in museum/ collections (N = 37).

3.3. Conclusion

In the time period from January 30 until March 04, 2012 the survey "The current situation and management of indoor air quality (IAQ) in European collections" was conducted as part of the European funded MEMORI project. The objective of the study was the identification/ evaluation of the current situation of IAQ in collections, as well as the management (e.g. mitigation strategies, measuring methods) of IAQ in museums, libraries and archives.

In summary the study shows that the topic of dealing with pollutants is commonplace in museums, libraries and archives. This emphasizes the fact that more than half of the institutions (56%) have done pollutant measurements and 36,8% of institutions have observed pollutant-induced damages in their collections. In this connection it has been shown that the number of institutions affected by this issue may continue to be revised upward, as 72,2% of institutions that have not observed damages related to pollutants also not measured pollutants.

Taking a look on the assessment of the IAQ situations of museums, libraries and archives it has been shown that most of the questioned institutions do not have target levels for gaseous pollutants (87,4%) and display materials (88,8%). According to the participants the most reasonable cause for the omission is a lack of knowledge. Remarkable in this connection is the low number of institutions that do not see any need to advise pollution limits for there collections (7,8%) and external demands that require low emitting materials (14,3%). Conversely that means that more than 85% of institutions see the necessity of emission control in terms of preventive conservation.

Nevertheless only 64,1% of requested institutions do measure pollutants in their collections, even though the monitoring of airborne pollutants is a sine qua non to

comply standard values for pollutants. The analyses show that the number of institutions that periodically monitor pollutants is very small (up to 10,7%). This demonstrates that – in comparison to other environmental influences (RH/T/HV) – the monitoring of pollutants is not common at all. The main reason why museums, libraries and archives do not monitor airborne pollutants is – again – a lack of knowledge and/or experience. Furthermore half of the institutions do name a lack of financial resource as a reason for the failure. In this connection it has been shown that only big museums with more than 100.000 visitors per year have invested to do pollutant monitoring in their collections (with reference to the last three years).
An additional interesting aspect relating to the monitoring of airborne pollutants is that enclosures with a high risk of pollutant accumulation (showcases 14,6%, storage boxes 3,1%, microclimate frames 1%) are infrequently monitored by museums, libraries and archives.

In terms of active mitigation strategies to reduce the new entry of pollutants it has been shown that more than half of institutions (65,3%) do use low emitting materials do satisfy external requirements (e.g. terms of bidding, lenders), while only 46,9% do check if display and storage materials are suitable (in terms of pollutants) before use.
Once again the most frequently named reason for this omission is a lack of knowledge and/or experience.

The study demonstrates that there is additional help need to assist the museums in terms of evaluation and management of IAQ. It has been shown that a lack of knowledge and experience is the most frequently mentioned reason for various abuses in terms of IAQ evaluation and management. To support the management of IAQ in museums, libraries and archives the knowledge and experience of IAQ professionals needs a larger audience in the community. Therefore efficient ways of knowledge transfer would be desirable. Furthermore easy to use measurement methods are essential for the use in the museum environment.

4. List of Literature

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Appendix A

A.1. Expenses for Collection Care

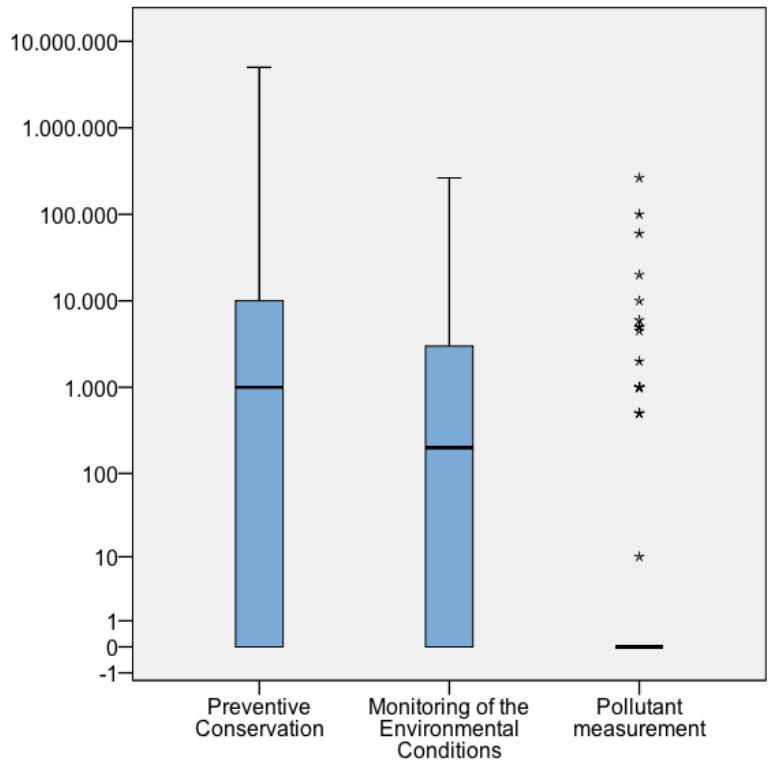

Image 16: : Boxplot to compare the expenses preventive conservation, environmental monitoring and pollution measurement (N = 103).

Table 5: Expenses for preventive conservation, environmental monitoring and pollution measurement.

Group Size		Preventive Conservation €	Monitoring Environment €	Pollutant Measurment €
N	Valid	103	103	103
Missing		0	0	0
Mean		112.043	9.770	4.748
Median		1.000	200	0
Minimum		0	0	0
Maximum		5.000.000	264.000	264.000
Sum		11.540.390	1.006.293	489.009
Percentiles	25	0	0	0
	75	10.000	3.000	0

A.2. Expenses for Pollution Measurement

Summary
Acceptance:
The expenses for pollutant measurement increase with increasing group size due to increasing budget of bigger sized Institutions

Null Hypothesis:
The expenses for pollutant measurement is the same across the categories of group size

Statistic Test:
Kruskal-Wallis Test: p = 0,000

Distribution of Sample:
The sample is significantly different from the normal distribution (Test of Normality)

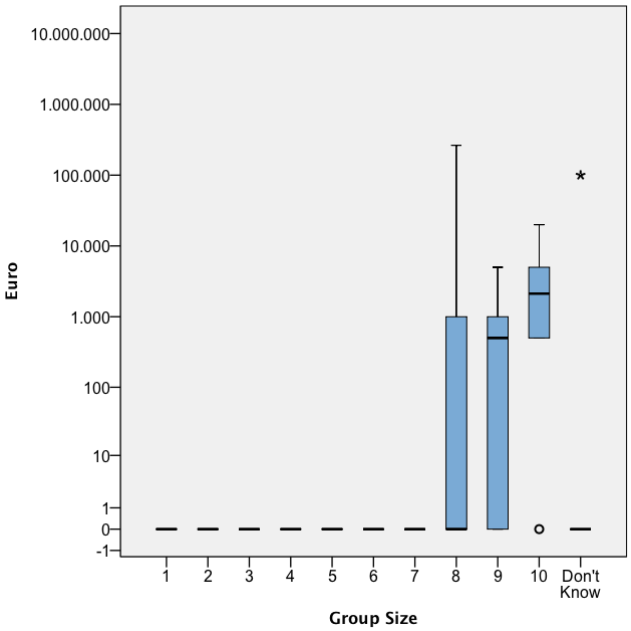

Image 17: Boxplot to compare the expenses for pollution measurement (airborne pollutants and dust/particles/soiling) by group size (N = 103).

Table 6: Expenses for pollution measurement (airborne pollutants and dust/particles/soiling) by group size

Group Size		1	2	3	4	5	6	7	8	9	10	Don't Know
N	Valid	14	9	4	5	6	6	14	21	5	10	9
Missing		0	0	0	0	0	0	0	0	0	0	0
Mean		0	0	0	0	0	0	0	16.143*	1300	4350	11.111
Median		0	0	0	0	0	0	0	0	500	2750	0
Minimum		0	0	0	0	0	0	0	0	0	0	0
Maximum		0	0	0	0	0	0	0	264.000	5.000	20.000	99.999
Sum		0	0	0	0	0	0	0	339.000	6.500	43.500	99.999
Percentiles	25	0	0	0	0	0	0	0	0	0	500	0
	75	0	0	0	0	0	0	0	1000	3000	5250	0

Comment:
* The high mean in group size eight can be explained due to outliners (that are not shown in the graph).