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Report

Assessment of the odour filter function of Ecobreeze air filtration system

Client: Ecobreeze
6B Park Way, Porterswood,
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Report number: ECOB17A_05
Project code: ECOB17A

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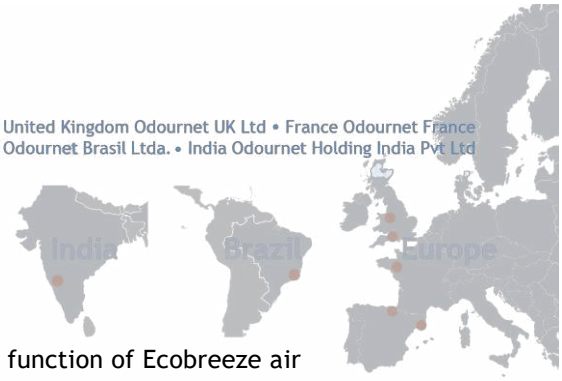

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1 Introduction and scope

1.1 Introduction

Ecobreeze manufacture air quality control systems designed for interior room use, typically washrooms. The system incorporates an activated carbon filter designed to adsorb volatile organic compounds and associated odours. Ecobreeze commissioned Odournet UK Ltd to assess the effectiveness of the carbon filtration element of the system in reducing odour levels from a sensory perspective.

The specific objective of the study was to assess odour levels within a public washroom-type environment under both air quality control system operational and non-operational conditions to examine any odour reduction levels achieved by the system. The study utilised a stale urine based malodour at the request of Ecobreeze.

The Ecobreeze system also incorporates a wick based fragrance system. For this study, the fragrance system of the units was disengaged to investigate the odour reducing performance of the carbon filter in isolation.

1.2 Structure of report

The report is structured as follows:

- The methodology applied in the study is described in Section 2.
- Section 3 presents results of the study.
- A results are summarised in Section 4.

Supporting information is provided in the Annex.

2 Description of approach

2.1 Sample preparation

The test design utilised test chambers of identical size (3 m^3 chambers) to allow a comparison of treated and untreated odours. The chamber for the treated odour test condition housed an Ecobreeze unit with a carbon filter in place. The chamber for the untreated test condition housed another Ecobreeze unit, however the carbon filter had been removed; both chambers had the fan set to run continuously on the medium setting. In addition, both test chambers housed identical malodour sources.

The odour source was located at a height of approximately 0.6 m, with the Ecobreeze unit 1.1 m above this.

Samples of urine were collected from four males and were stored for a minimum of two days to generate a stale urine based odour source. A 1 litre volume of the aged urine/water mixture[1] was placed in a container within each chamber, with a 15 x 24 cm surface area.

The chambers were then left for a period of 1 hour to allow odour levels within the chambers to stabilise prior to sensory analysis.

For odour concentration analysis (see Section 2.2.1 below), samples were extracted into Nalophan sample bags for subsequent analysis. Triplicate odour samples were collected and analysed. The overall performance was calculated from the geometric mean of replicate samples.

Odour intensity and hedonic tone analyses (2.2.2 and 2.2.3) were undertaken from a sniff port within the chamber wall. For odour intensity assessments, replicate tests were completed on two separate days. The overall performance was calculated from an average of the two test runs.

2.2 Sensory analysis

Sensory analysis techniques were applied to assess the human perception of the odours within the chambers under the two test conditions. Analysis was undertaken using odour concentration, perceived odour intensity and hedonic tone assessment.

2.2.1 Odour concentration: Dynamic olfactometry according to EN 13725:2003

As no instrumental methods exist at present that simulate and predict the responses of the human sense of smell satisfactorily, the human nose is the most suitable 'sensor'. Objective methods have been developed to establish odour concentration using human assessors. A European standard, EN 13725:2003[2], details the method of odour concentration measurements through dynamic olfactometry.

The odour concentration of a gaseous sample of odorants is determined by presenting the sample to a panel of human subjects in varying dilutions with neutral gas using an olfactometer (dilution system). A minimum of 4 panel members participate in each test, which is a computer controlled process. Panel members are selected for suitability by testing their ability to detect a standard reference odour (n-butanol).

EN 13725:2003 imposes strict statistical criteria for accuracy and repeatability, which are checked regularly using reference odorant mixtures. Panel members are checked frequently and excluded from

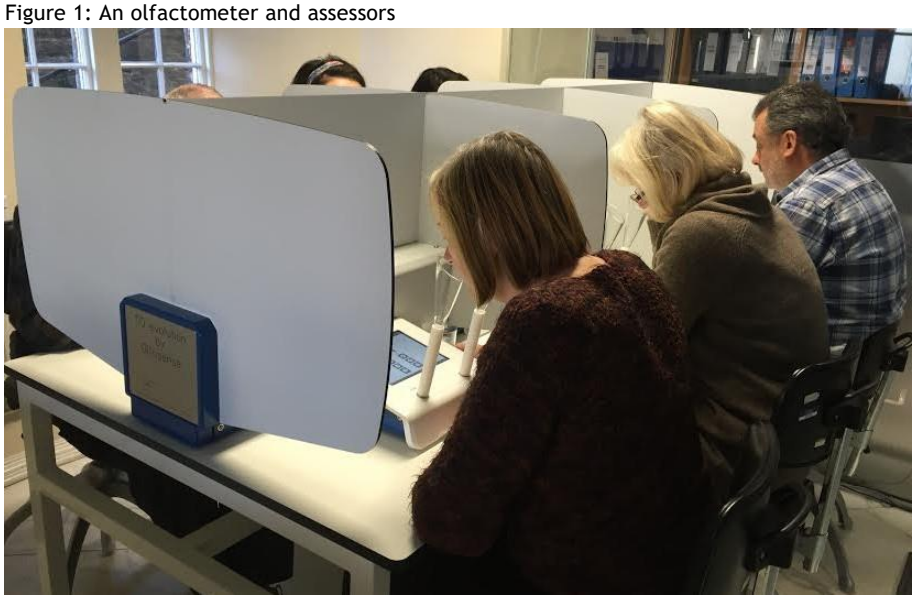
[1] Pre-testing identified a dilution level to be applied to the urine to achieve a suitable odour strength within the chamber for the testing.

[2] BSEN 13725:2003, Air quality - Determination of odour concentration by dynamic olfactometry.

the test if their ability to detect odours falls outside of the fixed selection criteria. Quality control and assurance of the Odournet UK olfactometry laboratory is accredited under ISO 17025:2005[3].

The odour concentration assessment is by definition an assessment of diluted samples. The perceived odour of an undiluted sample can vary between product types at the same odour concentration.

Figure 1: An olfactometer and assessors



2.2.2 Perceived odour intensity

Odour intensity assessments involve a subjective assessment of odour strength, against a standardised reference scale. Odour intensity assessments are an evaluation of perceived intensity of odours as collected/assessed directly from the test design, whereas odour concentration assesses odours at diluted levels to achieve the detection threshold. This assessment allows a direct assessment of odour levels as they would be perceived during normal use.

For the evaluation of the intensity a scale with 7 levels based on VDI 3882[4] was used. A minimum of 20 individual assessments were included in the study. All panellists were previously screened for acuity to odour and had been trained in the use of the assessment scale. For the evaluation process the panellist correlates the intensity description to the odour impression.

Table 1: Category scale of odour intensity

Description		Intensity level
Extremely strong	Extremely strong odour	6
Very strong	Very strong odour	5
Strong	Easily recognisable, strong odour.	4
Distinct	Easily detectable odour, which may be just recognisable.	3
Weak	Noticeable. Odour is present, but cannot be described in precise words or terms.	2
Very weak	Possible odour, barely noticeable.	1
Not detectable	No odour	0

[3] ISO 17025:2005, General requirements for the competence of testing and calibration laboratories

[4] VDI 3882 Part 1, Olfactometry – Determination of Odour Intensity

The arithmetic mean was calculated from the individual results. A statistical analysis of results determined for each of the products was undertaken to demonstrate if a difference is observed between the two test conditions.

2.2.3 Hedonic tone assessment

The determination of hedonic tone of an odour sample gives a subjective assessment into the how pleasant or unpleasant an odour is perceived. The panel members were asked to rank their perception of the pleasantness of the air against a standard reference scale[5].

Table 2: Category scale of hedonic tone

Hedonic tone ranking								
-4	-3	-2	-1	0	+1	+2	+3	+4
Extremely unpleasant		←		Neutral Neither pleasant nor unpleasant		→		Extremely pleasant

The arithmetic mean was calculated from the individual results. A statistical analysis of results determined for each of the products was undertaken to demonstrate if a difference is observed between the two test conditions.

[5] VDI 3882 Part 2, Olfactometry – Determination of Hedonic Odour Tone

3 Results

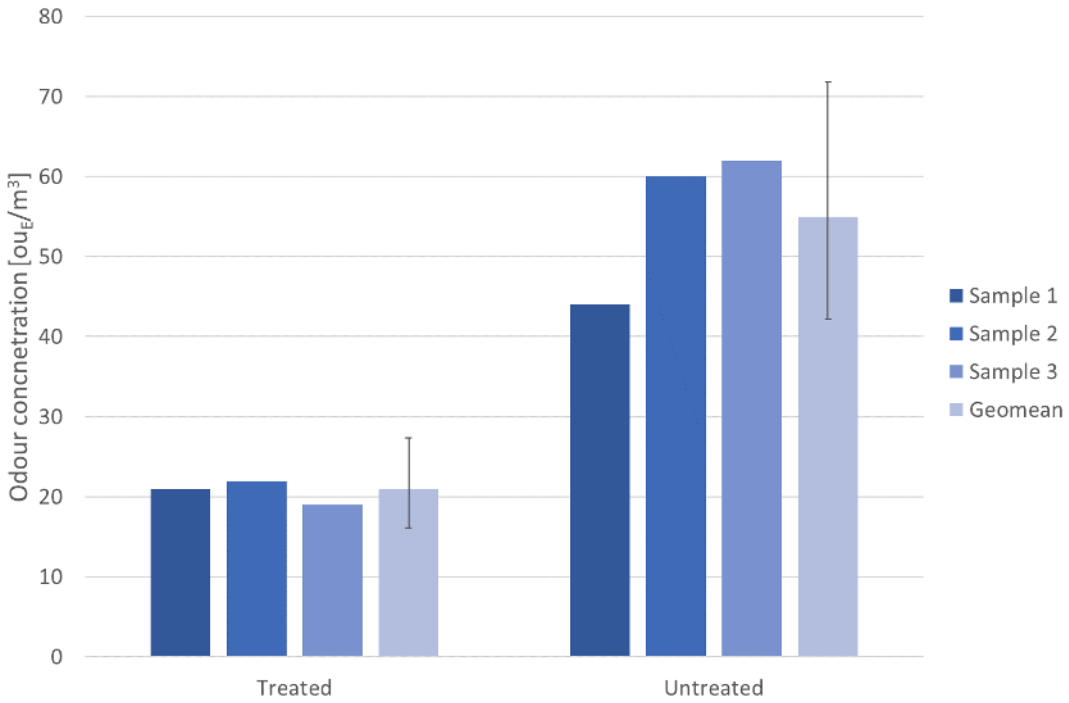
3.1 Odour concentration analysis

The results of the odour concentration analysis are presented in Table 1 below. The upper and lower limits of the analysis result based on the 95% confidence interval of the Odournet UK laboratory are presented in grey. Figure 2 presents the results of the analysis graphically, with 95th% confidence limits presented for the overall result. Where results were below the limit of detection (LOD, formally 30 ou_E/m^3), the results are presented as less than an estimated value.

Table 1: Results of odour concentration analysis

Sample	Odour concentration [ou_E/m^3]					
	Lower limit	**Treated**[6]	Upper limit	Lower limit	**Untreated**	Upper limit
1	<14	**<21 (<LOD)**	<34	27	**44**	70
2	<14	**<23 (<LOD)**	<35	37	**60**	96
3	<12	**<19 (<LOD)**	<30	39	**62**	99
Geomean	<16	**<21 (<LOD)**	<28	42	**55**	78

Figure 2: Odour concentration assessment results



Due to the low odour levels, the true concentration of the treated test condition could not be determined and will be lower than those presented in the figure.

The results indicate that the untreated chamber generated a higher odour concentration than the treated chamber, but that the odour concentration from the treated chamber was too weak to generate a valid result according to the requirements of BSEN 13725. Insufficient assessors could correctly detect the odour during the analysis, which is indicative of a weak odour. It is expected for the acuity to odour

[6] The odour of the sample was below the limit of detection (LOD) and too weak to generate a valid result. The values presented are an indication of odour concentration based on review of individual analysis data.

to vary between assessors, which is why mutilple assessors are required. The fact that some panellists can detect an odour and some cannot is therefore completely expected for samples whose concentration is near the limit of detection.

From review of individual responses in the analyses matrices, an estimate of the odour concentration in the treated chamber has been calculated. The true value of the analyses will be lower than this number, but it cannot be quantified as to what degree. The results do however indicate a statistically valid difference between the two test conditions, and show that the carbon filter within the Ecobreeze unit is reducing the odour levels within the test chamber. This assessment was undertaken on the effect of the carbon filter in isolation, with no consideration to the effect of the fragrance system on the perception of odour within the room.

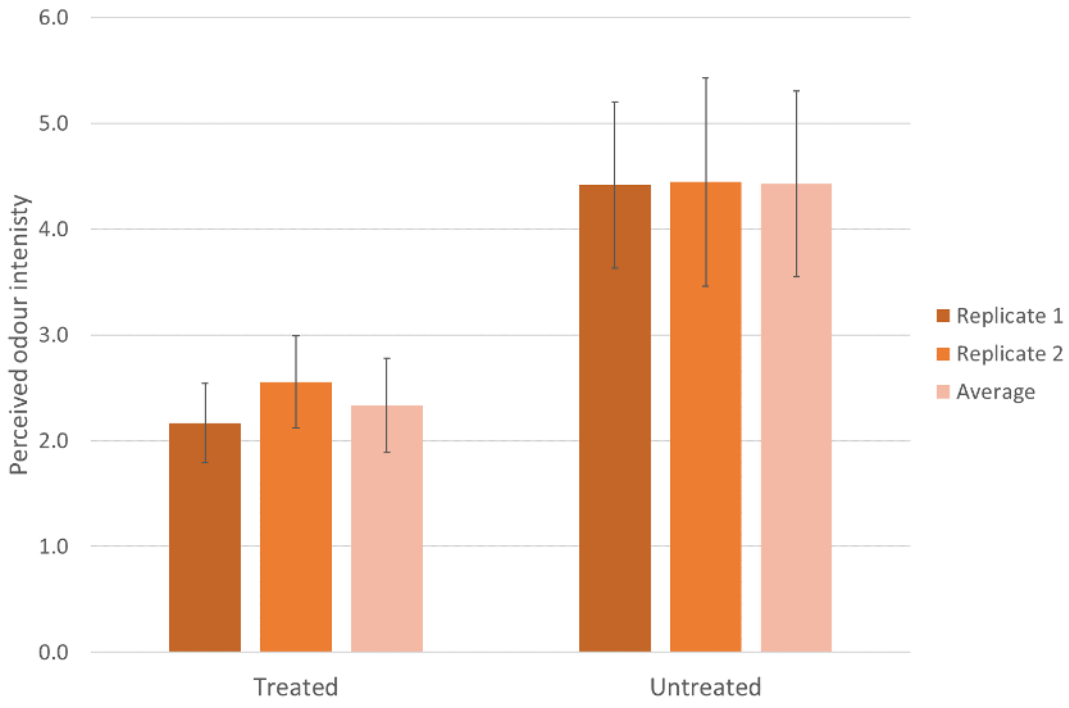
3.2 Perceived odour intensity analysis

Results of the perceived odour intensity analysis are presented in Table 2 below. The results are presented graphically in Figure 3, which displays the standard deviation of individual results as error bars.

Table 2: Perceived odour intensity results

Result	Replicate	Test condition	
		Treated	Untreated
Mean of results	1	2.2	4.4
	2	2.6	4.4
	Overall	2.3	4.4
Standard deviation	1	0.37	0.79
	2	0.59	0.98
	Overall	0.45	0.88

Figure 3: Odour intensity assessment results



The results show that the odour in the untreated test condition was ranked at 4.4, or a strong to very strong odour, and the odour in the treated test condition was ranked at 2.3, or a weak to distinct odour. This assessment is of the carbon filter in isolation, with no consideration to the effect of the fragrance system on the perception of odour within the room.

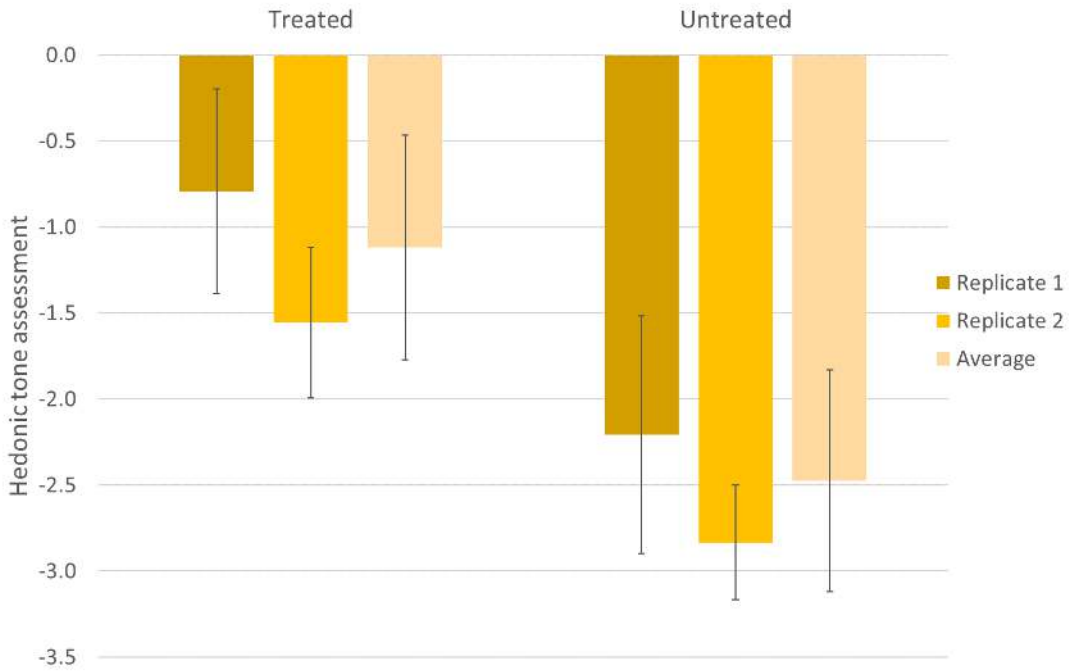
3.3 Hedonic tone analysis results

Table 3 and Figure 4 present the results of the hedonic tone assessment. The standard deviation of the individual results are presented as error bars in Figure 4.

Table 3: Hedonic Tone Assessment Results

Result	Replicate	Test condition	
		Treated	Untreated
Mean of results	1	-0.8	-2.2
	2	-1.6	-2.8
	Overall	-1.1	-2.5
Standard deviation	1	0.59	0.69
	2	0.44	0.33
	Overall	0.65	0.65

Figure 4: Hedonic tone assessment results



The results show that the odour in the untreated test condition was ranked at -2.5, or an unpleasant to very unpleasant odour, and the odour in the treated test condition was ranked at -1.1, or a slightly unpleasant odour. This assessment is of the carbon filter in isolation, with no consideration to the effect of the fragrance system on the perception of odour within the room. The fragrance system is anticipated to influence the perception of hedonic tone when in use.

3.4 Statistical evaluation of results

3.4.1 Wilcoxon signed-rank test

Statistical significance of malodour intensity and hedonic tone in treated and untreated samples is summarized in Table 4. The non-parametric Wilcoxon signed-rank test (two tailed) was used for this purpose at a significance level of $p < 0.05$, which indicates whether any statistically valid differences exist between two mean values at the confidence interval of 95%.

Table 4: Statistical evaluation of results (Wilcoxon signed-rank test)

	Intensity	Hedonic tone
p-value	<0.0001	0.0001

The results marked in orange are significantly different for the confidence intervals of 95% (with $p < 0.05$).

The table indicates that for both perceived intensity and hedonic tone analyses, the results from the treated and untreated are statistically different beyond the 95% confidence limit and that the treated test condition resulted in lower odour intensity levels and a less offensive environment.

4 Summary of results

The results of the study can be summarised as follows:

- Odour concentration analysis results show a clear reduction in odour levels in the treated test condition when compared to the untreated test condition.
- The perceived odour intensity assessment demonstrated that the odour in the test chamber reduced from 4.4 to 2.3 using a 0 (no odour) to 6 (extremely strong odour) scale based on VDI 3882. This equated to a reduction from a strong/very strong odour to a weak/distinct odour. The difference in odour levels is statistically valid beyond the 95% confidence limit.
- The hedonic tone analysis indicated that the environment in the treated test condition was considered less offensive than the untreated test condition, with the results between the two datasets demonstrating a statistically valid difference beyond the 95% confidence limit. Results from the assessment using the VDI 3882 assessment scale show that the odour in the untreated test condition was ranked at -2.5 (an unpleasant to very unpleasant odour) and the odour in the treated test condition was ranked at -1.1 (a slightly unpleasant odour).
- All analyses were undertaken on the effect of the carbon filter of the Ecobreeze treatment system. The fragrance system was disengaged and therefore no consideration to the effect of the fragrance system on the perception of odour within the room was considered in the study. In real use conditions, the fragrancing system will influence the perception of odours when the system is in use. The study demonstrates that the carbon filter in isolation is capable of reducing both the strength and offensiveness of odour perceivable within the test design.

Annex A: Individual analysis results

A.1 Perceived intensity results

Table 5: Individual perceived odour assessment results

Panellist	Date	Round	Intensity ranking (VDI 3882 scale)	
			Treated	Untreated
1	22/11/2017	1	2.0	5.0
2			2.0	3.5
3			3.0	4.5
4			2.0	5.0
5			2.0	4.0
6			2.0	5.0
7			2.0	5.0
8			2.0	4.0
9			2.0	3.0
10			2.0	6.0
11			2.0	4.0
12			3.0	4.0
1	24/11/2017	2	3.0	6.0
2			3.0	4.0
3			2.5	6.0
4			3.0	5.0
5			2.0	3.0
6			3.0	4.0
7			2.0	4.5
8			2.5	3.5
9			2.0	4.0
Average result			2.3	4.4
Standard deviation			0.45	0.88

A.2 Hedonic tone results

Table 6: Individual hedonic tone results

Panellist	Date	Round	Intensity ranking (VDI 3882 scale)	
			Treated	Untreated
1	22/11/2017	1	0.0	-1.0
2			-0.5	-2.0
3			-0.5	-2.5
4			0.0	-3.0
5			-1.0	-3.0

Panellist	Date	Round	Intensity ranking (VDI 3882 scale)	
			Treated	Untreated
6			0.0	-3.0
7			-1.5	-3.0
8			-1.0	-2.0
9			-1.0	-2.0
10			-2.0	-1.0
11			-1.0	-2.0
12			-1.0	-2.0
1	24/11/2017	2	-2.0	-3.0
2			-1.0	-2.0
3			-1.5	-3.0
4			-1.5	-2.5
5			-1.0	-3.0
6			-2.0	-3.0
7			-2.0	-3.0
8			-2.0	-3.0
9			-1.0	-3.0
Average result			-1.1	-2.5
Standard deviation			0.65	0.65

Annex B: Photograph of Ecobreeze unit

Figure 5: Photograph of opened Ecobreeze unit with and without carbon filter fitting (unit was closed for testing)