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Improving environmental odor measurements: comparison of lab-based standard method and portable odor measurement technology

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Abstract: Current standard odor measurement methods are lab-based and require substantial investment in hardware, sample collection, training, and maintenance. Odor samples must be collected in the field using bags and brought to the lab to test. This can be a time-consuming process, with the possibility of the sample loss. The actual odor measurements are based on dilution olfactometry, embodied in the AC'SCENT® International Olfactometer, following the ASTM E679-04 standard. In recent years a portable olfactometer, the Scentroid SM100i, has been developed for odor measurements. The portable olfactometer has many advantages over lab-based standard method, especially the lower cost-per-sample. However, very little is known about the performance and reliability of portable olfactometer where the dilutions are controlled with orifices in metallic plates. It is important to evaluate the Scentroid SM100i accuracy to determine the usefulness of using it as a comparable technology for odor measurements. The main objective of this research is to compare the performance of the lab-based ASTM E679-04 method with portable odor measurement technology. Specific objectives include: (1) determining the accuracy of the dilution ratios specified by the manufacturer of both the AC'SCENT International Olfactometer and the Scentroid SM100i; (2) comparing results between olfactometers using *n*-butanol, a commonly used standard gas in the olfactometry field, and (3) determining the accuracy of odor measurement using real odor samples collected from livestock farms in Iowa. The AC'SCENT olfactometer had an average percent error between the factory specifications and measured dilution ratios of 5.23% compared with 14.1% for Scentroid SM100i (using plate i-2 with dilution range most comparable to the AC'SCENT olfactometer). The use of other dilution plates resulted in average percent errors ranging from 9.68% to 25.31%. The Scentroid SM100i deviated from the manufacturer specifications for flowrates and dilution ratios, but these flowrates were generally consistent with each dilution setting. Overall, the Scentroid SM100i overestimated the odor concentrations with the mean difference of 22.9% (ranging from 0.95% to 93.34%). When the post-measurement adjustment using dilution correction was made, the mean percent average difference was 11.8%.

Introduction

Current odor measurement methods are lab-based and require substantial investment in hardware, sample collection, training, and maintenance. Odor samples must be collected in the field using bags and brought to the lab for testing. This can be a time-consuming process, with the possibility of the sample air undergoing chemical reactions and physical losses, resulting in possible changes to odor strength and character, and challenges to sample recoveries. The actual odor measurements are based on dilution olfactometry, embodied in the AC'SCENT® International Olfactometer, following the ASTM E679-04 standard. Large amounts of filtered air are mixed with a small amount of the odorous air sample to create a diluted mix that is presented to a trained panelists. In recent years a portable olfactometer, the Scentroid SM100i, has been developed for odor measurements which use compressed air tanks for the odorless air and calibrated orifices in thin metallic plates for dilutions control. The portable olfactometer has many advantages over lab-based standard method, especially the lower cost-per-sample. However, very little is known about the performance and reliability of portable olfactometer. It is important to evaluate the accuracy of Scentroid SM100i to determine the usefulness of using it as a comparable technology for odor measurements.

Odor measurements: purpose and regulatory aspects

Odor concentration measurements are one of the tools to evaluate mitigation technologies. Odor concentration measurements are also used for compliance with regulations. Both the United States and Canada have no federal regulations on odor. In both countries, odor regulation are handled by local and state authorities (provinces and territories in Canada). In

Canada, the odor regulations specifically refer to the use of the European odor units per cubic meter (OU_E m^{-3}). The limit of the odor units in selected use areas (e.g., residential, industrial) is different between the provinces and territories. In the United States, there are approximately ten states that regulate direct odor concentrations. In these states, odor regulations are measured in dilution to threshold (D/T), the standard field measurement units for American Standard ASTM E679-040. Other odor-related regulations in the United States include regulations for concentrations of specific odorous compounds (e.g., H_2S) in ~9 states, and a separation distance used for regulation for livestock in ~9 states. Some states and provinces use Nuisance Law principles. A nuisance complaint or lawsuit filed can trigger solution on a case by case basis (Redwine and Lacey 2000). In Canada and most EU countries, the European standard EN 13725:2003 is used for odor measurements. The EN 13725:2003 and ASTM E679-04 have some similarities, e.g., laboratories following the EN 13725:2003 standard with a triangular forced-choice method are typically compliant with the ASTM E679-04 standard. However, when operating under the ASTM E679-04 standard, the EN 13725:2003 standard is not always met (Brancher et al. 2017).

Odor measurement technology

Currently, the selected larger manufacturers of odor measurement equipment include St Croix Sensory Inc. (the manufacturer of the AC'SCENT olfactometer and the Nasal Ranger); Olfasense (the manufacturer of the TO Olfactometer series); and Scentroid (manufacturer of the Scentroid SM100i and other portable and lab olfactometers). Olfasense tends to follow meeting the European standard while St. Croix Sensory Inc., and Scentroid meet the European standards (EN) and the ASTM standard. One common approach used in odor measurement is a choice between yes/no selection. This requires a panelist evaluating a sample to choose "*yes*" when the odor is perceived and "*no*" if no odor is detected. This method is used in the TO8, TO8s, and TO8-8 olfactometer series (from Olfasense), and the lab & field olfactometer from Scentroid. Another common approach is a 'forced-choice.' A panelist is presented with two to three choices where one is the diluted air sample and the others are blank (odor-free) samples with only the filtered air. The panelist is then 'forced' to choose which one is the diluted odor sample. This method is used in the AC'SCENT olfactometer and certain models of olfactometers from Scentroid.

Previous studies comparisons of portable odor measurement technologies

To date, only a few and limited evaluations have been completed for field olfactometers made by IDES Canada Inc. (Scentroid SM100 and Scentroid SM110) specifically comparing them to other odor measurements equipment (Bokowa 2013, Benzo et al. 2012). Bokowa (2013) tested the Scentroid SM100 and the Nasal Ranger with comparisons to ORTECH's eight-member panel dynamic olfactometry. Bokowa (2013) reported that the Scentroid SM100's results had a "good correlation" with the results by the lab olfactometer in the range of 2 to 100 odor units. Post--publication assessment of the data given in the report by Bokowa (2013) yields a moderate to strong correlation between data with a larger range of dilutions (R^2 = 0.779 and 0.855). Interestingly, one lab-based trial resulted in lower odor concentrations measured by the Scentroid when compared to the ORTECH olfactometer yet still had a moderate to a strong correlation. Also for the trials with a smaller range of dilutions, the correlation was weak to moderate (R^2 = 0.470 and 0.558), while the majority of measured concentrations by the Scentroid SM100 were again lower.

Benzo et al. (2012), tested the Scentroid SM110 and the Nasal Ranger with comparisons to chemical analysis using the marker compound *p*-cymene and reported that the Scentroid SM110 is reliable for field measurements with a greater quality of measurements in comparison to the Nasal Ranger. Also reported was the caution statement that comparisons using single markers like *p*-cymene should not be over-interpreted since the typical field measurements include many different chemical compounds and odorants. It is therefore recommended to compare field olfactometers with lab-based standard-following dynamic olfactometry as a benchmark (Table 1).

Both Bokowa (2013) and Benzo et al. (2012) used the dilution ratios provided by the manufacturer. Neither study verified the actual dilutions presented to a panelist. Thus, considering some apparent discrepancies and trends reported, it is warranted to test for actual dilutions as they affect odor concentrations. Manufacturer specifications for dilutions are presented in Table 2 for AC'SCENT olfactometer, Nasal Ranger, and Scentroid SM110. The same information is also presented in a graphical form in Figure 1.

Table 1. Mini literature review of comparisons of Scentroid with other olfactometers

Reference	Scentroid Compared to:	Samples Tested	Result
Bokowa (2013)	Dynamic Olfactometry	Field	Odor detection threshold is under estimated
Benzo et al., (2012)	Nasal Ranger	Field	11% difference
Walgraeve et al., (2015)	Nasal Ranger/SIFT-MS	Standards	Higher dilution ratios observed compared to factory set points
Szydlowski (2014)	Nasal Ranger	Standards/Field	Higher dilution to threshold ratios observed compared to Nasal Ranger
Szydlowski (2016)	Nasal Ranger	Field	Not significantly different
Bokowa & Bokowa (2017)	Dynamic Olfactometry/Nasal Ranger	Field	Varied by 24–38% (mostly higher odor detection threshold values)
This Study	Dynamic Olfactometry (AC'SCENT)	Standards/Field	Flow rates vary from factory specs, Odor detection threshold is over estimated.

Table 2. Manufacturer Specifications: Basic comparisons of the different components of the AC'SCENT® International Olfactometer, Scentroid SM 100i Intelligent Personal Olfactometer, and the Nasal Ranger

	AC'SCENT® International Olfactometer	Scentroid SM100i Intelligent Personal Olfactometer	Nasal Ranger®
Dilution Ratio Range	8–64,000	2–11,00	2–60
Number of Dilution Steps	14	15	6
Accuracy		± 5% of target value based on a confidence ≥95%[1]	± 10% of Dilution to Threshold Ratios
Total Presentation Flow Rate	20 L/min	20 L/min	Inhalation of 16–20 L/min
Test Method	Triangular Forced-Choice	Yes/No detection	Yes/No detection
Size	61 cm × 61cm × 138 cm (24 in × 24 in × 54 in)	≈16 in × 6 in × 6 in	35.5 cm × 19 cm × 10 cm (14 in × 7.5 in × 4 in)
Weight	160 kg (350 lbs.)	3.5 kg (8 lbs.)	0.91 kg (2.0 lbs.)
Portability	Not portable	Backpack portable	Handheld portable
Sniffing Device/ Port	Plastic nose piece (Similar to Nasal Ranger)	Face mask (In Field) Cone shaped sniffing port (In Lab)	Plastic nose piece (Similar to AC'SCENT)
Power	Electricity (5 amps or 60 Hz)	Rechargeable lithium ion battery (36 Hours)	9-Volt alkaline battery
Clean Air Source	Dried and carbon filtered dilution air	Odorless diluting air from compressed air tanks with an active-carbon odor filter	Odor-filter cartridge Carbon filter
Standards Met	EN13725:2003 ASTM E679-04 AS/NZS 4323.3:2001	EN13725:2003 ASTM E679-04	EN 61326: 1997, Class B EN 61326:1997
Recommended Calibration	Checked on a regular time interval and calibrated when required (not in allowed ranges)	Annual calibration: does not require frequent re-calibration	Annual Calibration Verification
Other		Can collect a diluted sample from the Scentroid	

Note: [1] Defined as "Uncertainty of Measurement."

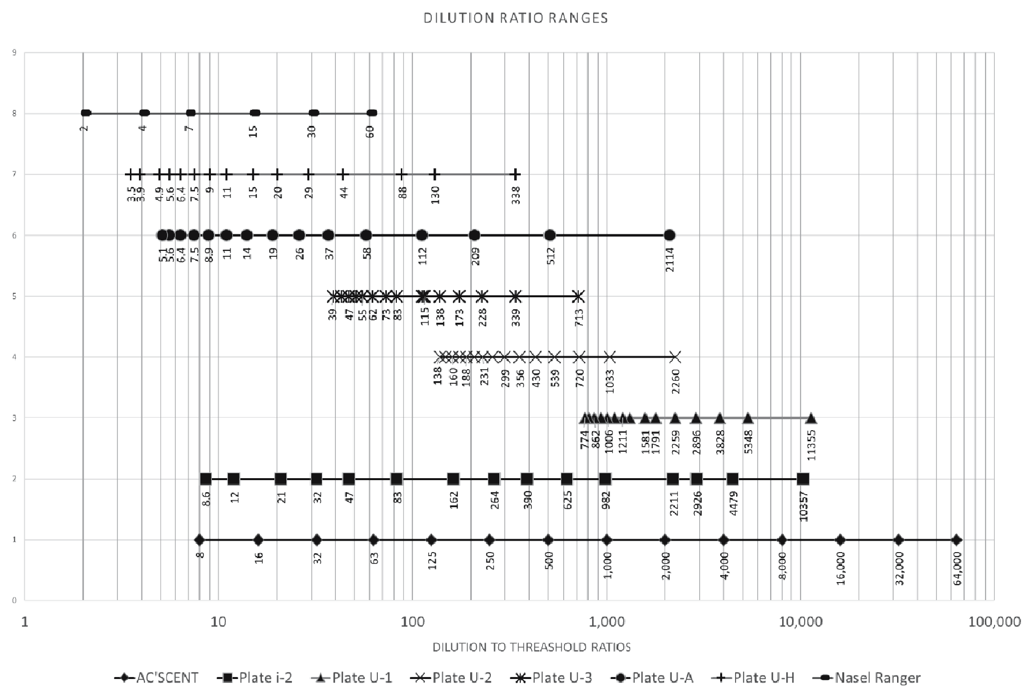

Fig. 1. Graphical representation of the range of the dilution ratios used by the AC'SCENT® International Olfactometer, the Nasal Ranger, and the different plates used by the Scentroid SM 100i Intelligent Personal Olfactometer. The x-axis, representing the dilution to threshold ratios, uses a logarithmic scale to display the data for a better visual comparison. This graph includes the values for each dilution ratio available (except the tightly packed data points for plates U-1, U-2, and U-3)

Other factors can also affect odor concentration measurements. Longer storage time (most cases maximum of 30 h recommended) can amplify sample losses due to adsorption to walls, permeation, and chemical reactions (Koziel et al. 2005, Parker et al. 2010). Some materials used for odor bag manufacturing release compounds used in the manufacturing (Koziel et al. 2006). New materials used for odor bag manufacturing can mitigate some of the losses (Zhu et al. 2015). There is a possibility of contamination in field environments during sampling if good sampling practices are not taken. There can be background odor in the bags from reuse even after cleaning and sanitation. (Laor et al. 2014). Portable (field) devices usually are based on detection and not a choice. This can present a challenge in a field environment where conditions can affect assessment as testers could become fatigued from a direct contract with the odor (Laor et al. 2014).

The main objective of this research is to compare the performance of the lab-based ASTM E679-04 method with portable odor measurement technology. Specific objectives include:

1) Determining the accuracy of the dilution ratios specified by the manufacturer of both the AC'SCENT International Olfactometer and the Scentroid SM100i.
2) Comparing odor concentration measurements between olfactometers using *n*-butanol.
3) Determining the accuracy of odor measurement using real odor samples collected from livestock farms in Iowa.

Materials and methods

AC'SCENT and Scentroid SM100i Flow Rate Measurements

The AC'SCENT flow rate measurements were conducted as described in its standard operating manual, using a Mini-Buck M-30 air flow calibrator (A.P. Buck Inc., Orlando, FL, USA) to measure the total flow, a Alltech Digital Flow Check-HR (Alltech, Deerfield, IL, USA) to measure sample flow rates between 0.2 and 200 mL min^{-1}, and a Mini-Buck M-5 air flow calibrator to measure sample flow rates greater than 300 mL min^{-1}. This same method and equipment were used to measure total and sample flow rates of the Scentroid SM100i.

Mitigation of Scentroid SM100i Background Odor

An investigation of apparent impurities from the Scentroid nose cone (motivated by a noticeable 'plastic'-like smell) was conducted. Volatiles collection was completed using SPME (2 cm 50/30 µm DVB/Carboxen/PDMS fiber, 57348-U, Supelco, Bellefonte, PA, USA) before and after 113 h at 50 °C bake out in a laboratory oven. Then, SPME ambient temperature extraction was conducted for 1 h from the headspace of a nose cone sealed in a background-free glass jar after an equilibration time of the nose cone in the jar of 4 h. Impurities were analyzed on a GC–MS-Olfactometry (GC-MS-O) system (Microanalytics, Volatile Analysis Corp., Round Rock, TX, USA) used for analysis and equipped with two columns connected in series. The non-polar pre-column was 30 m × 0.53 mm i.d.; film thickness, 0.50 µm with 5% phenyl polysilphenylene siloxane stationary phase (SGE BPX-5) and operated with constant pressure mode at 13.5 psi (0.92 atm). The polar analytical column was 30 m × 0.53 mm bonded polyethylene glycol (PEG) embedded in a synthetic glass (SGE SolGel-Wax) at a film thickness of 0.50 µm. System automation and data acquisition software were MultiTraxTM V. 10.1 (Microanalytics, Volatile Analysis Corporation, Round Rock, TX, USA) and ChemStation™ (Agilent Technologies, Santa Clara, CA, USA). The GC run parameters were as follows: injector, 250°C; column, 40°C initial, 3 min hold, 7°C min-1 ramp to 240°C final, 8.43 min hold; carrier gas, UHP-grade helium (99.999%). The GC was operated in a constant pressure mode where the mid-point pressure, i.e., the pressure between pre-column and analytical column, was always 5.7 psi (0.39 atm) and the heart-cut sweep pressure was 5.0 psi. The MS full scan range was 34 to 150 m z^{-1}. Spectra were collected at two scans s^{-1} using full scan. The quadrupole MS was set to electron ionization (EI) mode with ionization energy of 70 eV. MS tuning was performed using the default autotune setting by means of perfluorotributylamine (PFTBA) daily.

Odor Sample Collection and Measurements

Standard samples of *n*-butanol (40.3 ppm, balance gas nitrogen) were collected in 10 L Tedlar® bags directly from the standard gas cylinder (Praxair, Danbury, CT, USA) or were diluted via an Environics Series 4040 gas dilution system (Environics, Tolland, CT, USA) with zero air generated by a Teledyne zero air module, model 701 (Teledyne API, San Diego, CA, USA). Field samples were collected in 10 L Tedlar® bags using an SKC Vac-U-Chamber and a pump (SKC Inc, Eighty Four, PA, USA). Odor panel evaluations were conducted in accordance with manufacturer specifications within 24 h of samples collection and involved four panelists with two replications for each panelist. The AC'SCENT olfactometer panels were conducted in triangular forced-choice test mode, and the Scentroid olfactometer panels were conducted in automatic test mode. Each day the same four panelists measured each sample with both the AC'SCENT and Scentroid olfactometers twice, for a total of eight samplings on each instrument. The same four panelists were not necessarily used on different days. The odor dilution thresholds were calculated according to ASTM method.

Results

Comparison of AC'SCENT and Scentroid SM100i Flow Rate Measurements

The AC'SCENT olfactometer had an average percent error between the factory specifications and measured dilution ratios of 5.23% (ranging from 0.35% to 34.3%) over the span dilution settings and 2.98% average error (ranging from 0.61% to 8.44%) between dilution ratios over the course of weekly measurements. Flow rate measurements completed on the Scentroid SM100i olfactometer resulted in an average percent error between the factory specifications and measured dilution ratios of 14.06% (ranging from 0.50% to 57.1%) over the span dilution settings and 4.59% average error (ranging from 2.36% to 7.64%) between dilution ratios over the course of weekly measurements of the i-2 plate. The i-2 Scentroid plate has the dilution range most comparable to the AC'SCENT olfactometer. The use of other Scentroid plates resulted in similar average percent errors ranging from 9.68% to 25.31% between the factory specifications and measured dilution ratios and average errors ranging from 2.25% to 7.02% between dilution ratios over the course of weekly measurements over the span dilution settings (Table 3).

Table 3. Factory specified and measured dilution ratios of AC'SCENT and Scentroid SM100i olfactometers

	Dilution Ratio setting	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ac'scent	Factory Spec	64516	31746	16000	8000	4000	2000	1000	500	250	125	63	32	16	8	NA
	Avg. Measured	42378	31493	16398	9018	4268	2097	1003	493	254	124	60	31	16	8	NA
	Measured Avg. % Error	8.44	4.85	2.77	2.85	0.88	0.61	0.68	0.82	0.77	7.85	4.81	2.43	2.42	1.60	NA
	Measured vs Factory % Error	34.31	0.80	2.49	12.72	6.70	4.83	0.35	1.33	1.56	0.80	4.15	0.95	0.55	1.65	NA
Scentroid (plate i-2)	Factory Spec	10357	4479	2926	2211	982	625	390	264	162	83	47	32	21	12	8.6
	Avg. Measured	4380	2750	2321	2003	891	755	433	242	149	78	47	31	20	11	7.9
	Measured Avg. % Error	5.62	4.78	5.60	6.51	6.92	7.64	5.19	4.28	4.38	3.91	3.38	2.89	2.94	2.53	2.36
	Measured vs Factory % Error	57.71	38.59	20.69	9.39	9.24	20.74	11.06	8.22	8.19	5.82	0.50	2.67	3.73	6.07	8.23
Scentroid (plate U-1)	Factory Spec	11355	5348	3828	2896	2259	1791	1581	1315	1211	1097	1006	932	862	808	774
	Avg. Measured	9113	4895	3098	2275	1856	1314	1154	991	903	767	710	630	595	544	512
	Measured Avg. % Error	4.21	9.21	5.40	3.86	14.50	10.96	9.43	7.68	7.10	6.59	6.27	5.15	5.44	5.07	4.48
	Measured vs Factory % Error	19.75	8.47	19.08	21.45	17.82	26.63	27.01	24.65	25.41	30.09	29.41	32.38	30.96	32.72	33.84
Scentroid (plate U-2)	Factory Spec	2260	1033	720	539	430	356	299	259	231	208	188	174	160	147	138
	Avg. Measured	1492	771	525	410	334	287	247	217	196	177	165	149	136	126	119
	Measured Avg. % Error	1.04	2.66	2.66	1.29	2.25	2.88	3.15	2.58	2.63	2.69	2.13	2.44	1.93	1.80	1.57
	Measured vs Factory % Error	33.98	25.38	27.09	24.02	22.26	19.42	17.26	16.17	15.12	14.98	12.46	14.60	15.00	13.98	13.69
Scentroid (plate U-3)	Factory Spec	713	339	228	173	138	115	112	83	73	62	55	51	47	43	39
	Avg. Measured	577	287	191	150	117	103	88	74	67	60	54	49	46	43	40
	Measured Avg. % Error	6.57	4.44	4.00	3.60	2.83	6.93	5.62	3.34	3.15	3.03	2.92	2.77	3.09	3.08	3.12
	Measured vs Factory % Error	19.13	15.38	16.02	13.29	14.96	10.42	21.06	11.40	8.81	3.86	1.63	3.46	2.76	0.39	2.57
Scentroid (plate U-A)	Factory Spec	2114	512	209	112	58	37	26	19	14	11	8.9	7.5	6.4	5.6	5.1
	Avg. Measured	1510	433	178	95	56	35	24	17	13	10	7.5	6.0	4.9	4.1	3.6
	Measured Avg. % Error	3.67	4.05	0.76	1.86	2.69	2.11	2.19	1.83	1.61	1.68	1.86	1.68	1.56	1.50	5.78
	Measured vs Factory % Error	28.56	15.34	14.60	14.81	3.86	4.37	6.82	10.74	10.18	13.12	15.36	20.02	22.94	26.48	28.99
Scentroid (plate U-H)	Factory Spec	338	130	88	44	29	20	15	11	9	7.5	6.4	5.6	4.9	3.9	3.5
	Avg. Measured	354	126	67	40	26	18	13	10	8	6.2	5.1	4.2	3.5	2.1	1.7
	Measured Avg. % Error	11.96	5.94	5.52	3.90	3.16	2.34	1.97	1.78	1.21	1.45	1.40	1.39	0.95	3.58	2.24
	Measured vs Factory % Error	4.80	3.30	23.38	9.84	9.68	8.33	10.46	9.06	12.77	16.79	20.32	24.87	28.47	45.75	51.12

Note: Measured average % error is the % error of the measured reps. Measured vs. Factory % error is the % error between the average measured and the factory specs.

Scentroid SM100i Background Odor Mitigation

During preliminary odor panel testing panelists described difficulties in distinguishing if an odor was present at low concentrations with the Scentroid due to the background 'plastic'-like smell emitting from the plastic nose cone. The background emittance was explored using GC-MS before and after baking the nose cone to minimize background odor of the new plastic (Figure 2). Baking the nose cone resulted in a 72% reduction in impurities peak area of compounds emitted.

Odor Sample Measurements

Odor samples of standard *n*-butanol and field samples from swine barns were accessed by a panel using a Scentroid SM100i, and the resulting OD values that were obtained by the Scentroid automatically were then compared to the OD values calculated manually using measured flow rates (Table 4). The factory preset dilution ratios (cannot be adjusted to recalibrate to actual flow rates as it is possible with the AC'SCENT) were typically associated with higher OD values compared to the OD values manually calculated using measured flow rates of the system. The percent differences between OD values automatically calculated (with factory preset values) and OD values manually calculated (flow-corrected) ranged from 0.22–32.16%.

Odor samples of standard *n*-butanol and field air samples from swine barns were accessed by a panel using both the Scentroid SM100i and the AC'SCENT olfactometer. The OD values resulting from both olfactometers are presented in Figure 3 and Table 4. OD values resulting from the Scentroid SM100i was re-calculated (corrected) manually using measured flow rates.

Overall, the Scentroid overestimated the OD values of the odor samples. The percent difference calculated between the OD values of same air samples measured by both olfactometers ranged from 0.95–93.34%, with the mean difference of 22.9% (Table 5). When the post-measurement adjustment to OD values was made, the mean percent average difference was 11.8%.

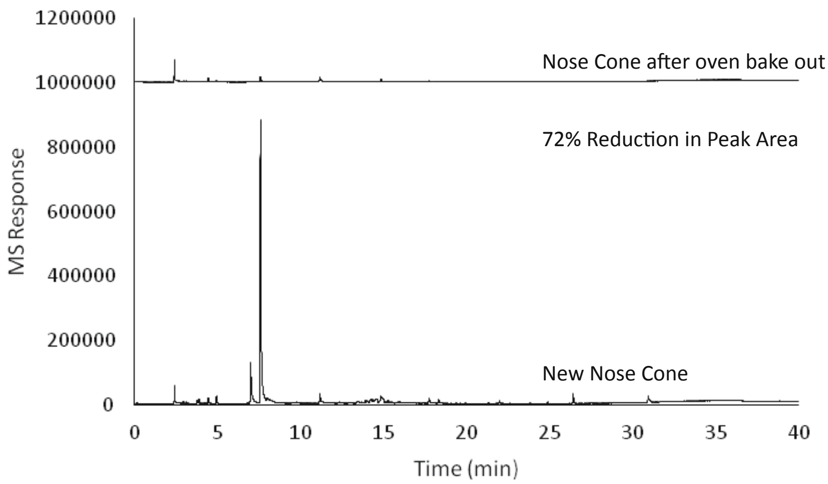

Fig. 2. Effects of heat treatment of the original Scentroid nose cone

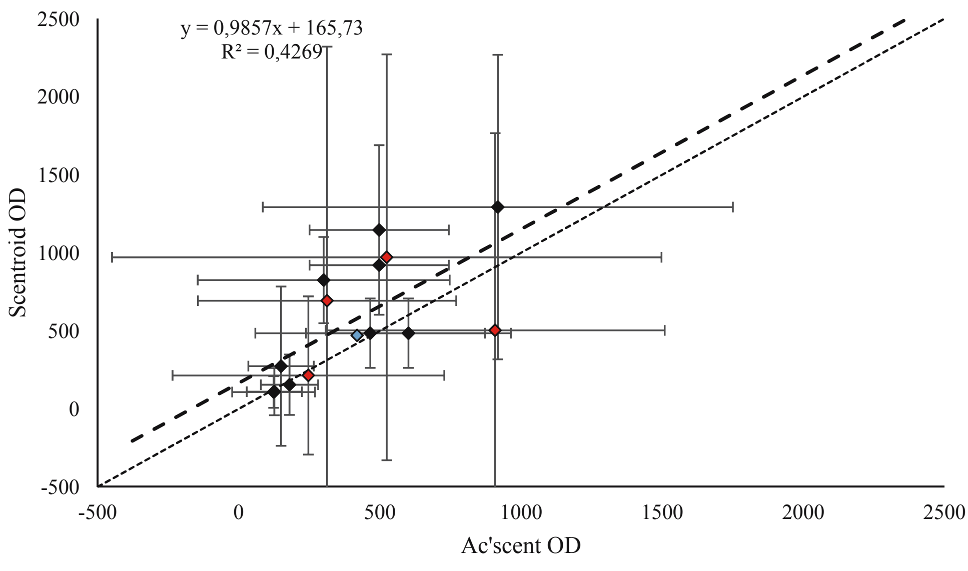

Fig. 3. Adjusted (for dilution errors) Scentroid measured ODs vs. AC'SCENT measured ODs. Black: field samples. Red: standard n-butanol. Blue: overall average

Table 4. OD values estimated with measured air flow values vs. calculated with factory specs airflow values of Scentroid SM100i

Sample	Flow-Corrected OD Values Used	St. Dev.	Factory-setting OD Values Used	St. Dev.	% Diff
1 Swine barn air	1293	976	1789	1517	**32.16**
2 Swine barn air	108	102	122	113	**12.27**
3 Swine barn air	274	511	315	587	**13.78**
4 Swine barn air	826	276	917	345	**10.54**
5 Swine barn air	110	151	125	152	**12.49**
6 Swine barn air	155	194	170	195	**9.35**
7 Swine barn air	485	223	447	202	**8.22**
8 Swine barn air	485	223	447	202	**8.22**
n-butanol	514	791	515	1174	**0.17**
n-butanol	503	1264	559	2431	**10.53**
n-butanol	542	669	530	820	**2.39**
n-butanol	484	529	483	611	**0.22**

Note: Scentroid plate i-2 was used.

Table 5. Comparison of Scentroid measured ODs vs. AC'SCENT measured ODs

Sample	AC'SCENT	St. Dev.	Scentroid	St. Dev.	% Difference
1 Swine barn air	**601**	363	**485**	223	**21.28**
2 Swine barn air	**465**	407	**485**	223	**4.20**
3 Swine barn air	**917**	833	**1293**	976	**34.04**
4 Swine barn air	**123**	147	**108**	102	**12.72**
5 Swine barn air	**149**	116	**274**	511	**59.07**
6 Swine barn air	**300**	446	**826**	276	**93.34**
7 Swine barn air	**125**	98	**110**	151	**12.74**
8 Swine barn air	**179**	101	**155**	194	**14.55**
n-butanol	**508**[a]	601	**503**	1264	**0.95**
Average	**374**		**471**		**22.93**

Note: [a] value calculated with outliers included.

Reflecting on these results, it is important to discuss potential sources of discrepancies of the measured values by both olfactometers. Typically, portability feature results in some tradeoffs compared with a stationary lab-based instrumentation for many practical reasons of limited size, weight, cost, materials, power supply, resistance to variations in air temperature, pressure and relative humidity. One potential source of error is the airflow controlling devices (thin metal plates), i.e., simple flow restrictors for dilutions control. The AS'SCENT olfactometer uses mass flow controller for the same purpose, i.e., a device that is less prone to environmental parameters change. The second possible source of added variation associated with the Scentroid is the odor sample presentation. Odor sample is almost continuously presented to the panelist, i.e., from one dilution level to another, without periodic and consistent presentation of fresh (odorless) air. This feature could potentially lead to sensory fatigue in a panelist. The AC'SCENT has a consistent and periodic presentation of odorless air to the panelist as a part of triangular-forced-choice olfactometry. Background odors associated with materials used to manufacture the Scentroid SM100i are also of concern.

It is possible to lower the discrepancy of apparent ODs obtained with the use of Scentroid SM100i by correcting for actual measured flowrates. However, this is not simple and requires additional flowrate measurement, checks and development of correction factors. Based on this research, it is not possible to determine if these correction factors are specific to individual Scentroid SM100i on the market (i.e., this study used a Scentroid purchased directly from the manufacturer in the fall of 2016. Caution is advised when using Scentroid SM100i for odor measurements.

Conclusions

The Scentroid SM100i deviated from the manufacturer specifications for flowrates and dilution ratios, but these flowrates were generally consistent with each dilution setting. The use of the Scentroid and AC'SCENT resulted in similar measured odor levels of the same samples, but only after the values were adjusted to match the actual flow rates and dilution ratios. Furthermore, the Scentroid SM100i had a tendency to slightly overestimate odor concentrations compared with AC'SCENT.

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