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Investigation of Air Quality beside a Municipal Landfill: The Fate of Malodour Compounds as a Model VOC

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Abstract: This paper presents the results of an investigation on ambient air odour quality in the vicinity of a municipal landfill. The investigations were carried out during the spring–winter and the spring seasons using two types of the electronic nose instrument. The field olfactometers were employed to determine the mean odour concentration, which was from 2.1 to 32.2 ou/m^3 depending on the measurement site and season of the year. In the case of the investigation performed with two types of the electronic nose, a classification of the ambient air samples with respect to the collection site was carried out using the k-nearest neighbours (kNN) algorithm supported with the cross-validation method. Correct classification of the ambient air samples collected during the spring–winter season was at the level from 71.9% to 87.5% and from 84.4% to 94.8% for the samples collected during the spring season depending on the electronic nose type utilized in the studies. It was also revealed that the kNN algorithm applied for classification of the samples exhibited better discrimination abilities than the algorithms of the linear discriminant analysis (LDA) and quadratic discriminant function (QDA) type. Performed seasonal investigations proved the ability of the electronic nose to discriminate the ambient air samples differing in odorants' concentration and collection site.

Keywords: electronic nose; field olfactometry; landfill; odour; VOC (Volatile Organic Compound); Principle Component Analysis (PCA); k-Nearest Neighbours (kNN)

1. Introduction

Volatile organic compounds, due to their physical properties such as ease of conversion into gas state and low solubility in water, often constitute by-products in numerous industrial processes and they are sources of outdoor and indoor air pollution [1]. Moreover, many compounds are characterized by unpleasant odour, which is a cause of citizens' complaints about environment quality. The progress in urbanization and municipal infrastructure in many countries contributes to a negative phenomenon connected with the fact that residential areas are too close to such municipal objects as sewage treatment plants or municipal landfills [2–5]. The volatile organic compounds emitted from these sources and characterized by unpleasant odour include mercaptanes, sulphides (disulphides), amines, carboxylic acids, aldehydes, ketones, aliphatic and aromatic hydrocarbons [6–8]. Information on the threshold levels of odour perception for selected volatile organic pollutants emitted from sewage treatment plants or municipal landfills are gathered in Table 1 [9].

Table 1. Examples of the threshold levels of odour identification of selected odorous pollutants.

Pollutants	Threshold Level of Odour Identification (ppm)	Pollutants	Threshold Level of Odour Identification (ppm)
methanol	100	butane	1200
methylamine	4.7	octane	1.7
dimethylamine	0.34	chlorobenzene	0.68
methyl ethyl ketone	10	benzene	2.7
styrene	0.047	ethyl acetate	0.87
toluene	0.33	acetaldehyde	0.0015
methanethiol	0.00007	ethylbenzene	0.17
ethanethiol	0.0000087	α-pinene	0.018
dimethyl sulphide	0.003	limonene	0.038
acetone	42	hexane	1.5

These compounds irritate nerve cells in the human nose and they are naturally associated with danger, create a feeling of discomfort and can be a reason for negative psychosomatic symptoms. This problem could be aggravated in the future with the progress in economic and industrial development. Hence, there is a need to search for suitable tools enabling the reduction of odorous compounds emission in order to decrease odour nuisance over a particular area. The attempts to reduce the emissions of the volatile organic compounds characterized by unpleasant odour become a priority for these fields of industry, which are responsible for the emissions. Correction measures include the implementation of deodorization systems in already existing plants as well as the appropriate design and location of new-built facilities [10–12].

The acquisition of the information about the concentration levels of particular odorants in ambient air is indispensable for the complex evaluation of the condition of the natural environment [13,14]. This goal is reached by the utilization of suitable tools for the measurement and control of the level of air pollutants as well as for the identification of the presence of odorous compounds. The following devices for VOCs analysis in outdoor and indoor air can be distinguished:

- indicator tubes, in which an analyte reacts with an indicator chemical of the tube packing; the reaction results in the appearance of a colour or change of a colour of some of the tube packing. The extent (length) of the coloured zone in the tube is directly proportional to the analyte concentration and sampling period.
- stationary measurement devices such as gas chromatographs, ultraviolet (UV) and infrared (IR) spectrometers (including the ones with Fourier transformation), mass spectrometers, as well as electron capture detectors, flame ionization detectors, photo-ionization detectors and thermal conductivity detectors.
- on-line analysers (portable), which include gas chromatographs, electrochemical analysers, photo-ionization analysers, IR or UV absorption analysers, colorimeters and photometers with prepared paper tape, which changes colour upon contact with the analyte [15,16].

Two basic approaches—analytical and sensory—can be identified regarding the general classification of the techniques used for the evaluation of malodorous VOCs. The sensory techniques include the most frequently applied dynamic and field olfactometry, whereas the analytical techniques engulf gas chromatography with olfactometric detection, gas chromatography coupled with a mass spectrometer and chemical sensors matrixes (often termed electronic nose instruments).

Particular odorous substances, when present in a gas mixture, can mutually attenuate or amplify odour intensity and change the hedonic quality of odour. That is why odour impact evaluation calls for holistic analysis without quantitative identification of particular components of the odorous mixture. The analytical techniques, which fulfil this condition include [17–22]:

- olfactometric techniques,
- electronic nose technique.

The first technique consists of the utilization of the human nose as a sensor for air quality evaluation with respect to odour. Appropriately a selected group of assessors, characterized by defined odour perception, describes the odour concentration of the odorous mixtures via the determination of the dilution degree of the odorous mixture with pure air (or inert gas). This concentration is expressed in ou/m^3 units. The olfactometric techniques (dynamic olfactometry, field olfactometry) are the most frequently used ones for air evaluation with respect to odour in the countries, which possess legal regulations defining the admissible levels of odour concentration over a particular area.

The second technique relies on the detection of the odorous compounds using a set of selective/partially selective/non-selective chemical sensors. Abilities of the electronic nose are significantly limited as compared to its "biological counterpart", just to mention a necessity of suitable training and application of frequently complicated mathematical-statistical algorithms responsible for the correct interpretation of results. There are three main commercial approaches to the structure of the electronic nose:

(a) the first type, where the measurement system is comprised of the chemical sensors of one type only,
(b) the second type, where the measurement system consists of the chemical sensors of different types,
(c) the third type, where the measurement system employs chromatographic detectors and appropriately selected chromatographic columns differing in polarity of a stationary phase.

The chromatographic columns separate volatile components, which are then identified by standard chromatographic detectors. In the case of the electronic nose technique, these are short columns for ultra-fast gas chromatography that are employed, which results in a short time of analysis equal to 1–2 min [23–25]. Obtained chromatograms are analysed using data analysis methods; in this case, the chromatographic peaks play the role of the sensors.

Due to their discrimination abilities, the electronic nose instruments can be employed to discriminate the gas samples differing in quality and odour. They have found many practical applications in such fields as safety, environmental pollution, medicine, work safety regulations, the food industry, the chemical industry and other [26–47].

The authors of this paper want to compare the discrimination abilities of the electronic nose instruments built according to the second and the third concept as far as the discrimination and classification of the ambient air samples collected in the vicinity of the municipal landfill are concerned. A prototype of the electronic nose—comprised of four commercial semiconductor sensors by FIGARO Engineering Inc. (Osaka, Japan) (TGS 832, TGS 2600, TGS 2602, TGS 2603), one photoionization sensor by Ion Science Ltd (Cambridge, UK) (PPB MiniPID) and two electrochemical sensors by FIGARO Engineering Inc. (Osaka, Japan) (FECS44, FECS50)—was compared with a commercial electronic nose based on the fast gas chromatography (Fast GC)—HERACLES II. Additionally, the Nasal Ranger field olfactometers were used to assess odour concentration in ambient air at the sampling sites where the samples for electronic nose measurements had been collected.

2. Experimental

2.1. Measurement Set-Up

The electronic nose prototype was designed and involved a set of four commercial semiconductor sensors by FIGARO Engineering Inc. (TGS 832, TGS 2600, TGS 2602, TGS 2603), one photoionization sensor of PID-type (PPB MiniPID by Ion Science Ltd) and two electrochemical sensors by FIGARO Engineering Inc. (FECS44, FECS50). The measurement set-up utilized in the investigation consisted of a Tedlar bag (SKC Inc., Valley, California, CA, USA) of 5 L volume, a Tecfluid flow meter, the prototype

of the electronic nose (Figure 1), a suction pump and a personal class computer. The volumetric flow rate of the air sucked from the Tedlar bag was constant and equalled 1 L/min. An analogue-to-digital converter was used to process the output signal from the sensor set of the prototype. The output signal was converted into digital form in the range from 0 to 16 bits. Measurement data were collected and archived. The values of a particular sensor signal taken for data analysis originated from the range where the sensor signal attained a steady value. The operation mode of the electronic nose was as follows: 30 s—suction of a sample, measurement; 5 min—washing of the sensors chamber with clean air.

Figure 1. Prototype of the electronic nose.

The commercial electronic nose of Fast GC-type—HERACLES II (Figure 2) was built from two independent chromatographic-detection systems. The main components of these systems were two chromatographic columns characterized by different polarity of a stationary phase and two detectors of Flame Ionization Detector (FID-type). The measurement set-up consisted of the HERACLES II device, the Tedlar bag of 5 dm^3 volume and a 5 cm^3 syringe. The measurement procedure consisted of sampling the air directly from the Tedlar bag using the syringe. Then, a 5 cm^3 air sample was supplied to a proportioner. Sorption of the sample occurred behind the proportioner, inside a sorption trap of Tenax. The analytes were released from the trap after it had been heated to 270 °C and the stream was directed to two independent chromatographic-detection systems. A single analysis lasted about 100 s. The surface area of the chromatographic peaks was utilized in the analysis. In the case of the electronic nose of Fast GC-type, its operation mode followed the pattern 100 s—injection of a sample, analysis; 500 s—cleaning of the chromatographic columns with hydrogen + air at the volume ratio 1:5, respectively.

Figure 2. Electronic nose of Fast Gas Chromatography (Fast GC-type)—HERACLES II.

The principle of the operation of the device and method of testing is also described in the article [48]. Figure 2 presents the electronic nose of Fast GC-type.

Table 2 presents a comparison of both types of electronic nose instrument with respect to the operation parameters such as mass, dimensions, price, portability, gases utilized for correct operation and time of correct operation.

Table 2. Examples of the threshold levels of odour identification of selected odorous pollutants.

Parameters	Electronic Nose Prototype	Fast GC
mass (kg)	20	35
dimensions (cm × cm × cm)	30 × 20 × 50	100 × 50 × 50
portability	possible	no
operation gases utilized	clean air	hydrogen + clean air
price (euro)	ca. 8000	ca. 160,000
time of correct operation (years)	2–3	10

Four persons took part in the investigation carried out with the field olfactometers Nasal Ranger (St. Croix Sensory, Stillwater, MN, USA). These persons (a team of panellists) were selected from a larger group and trained following a standard procedure elaborated by the St. Croix Sensory, Inc. (St. Croix Sensory 2006). Moreover, the panelists were trained with respect to sensory measurements using the Nasal Ranger field olfactometers. Assessment of odorants' concentration in ambient air involved the determination of D/T values (dilution to sensing threshold), at which the odour was sensed. In order to compare the correct operation of the electronic nose prototype, Fast GG and Nasal Ranger instruments, they were tested in laboratory conditions using a reference mixture of n-butanol + air, where the concentration of n-butanol in air was 0.8 ppm v/v, which corresponded to the odour concentration at the level of 20 ou/m^3. Figure 3 schematically presents the experimental procedure of the measurement techniques—electronic nose prototype, commercial electronic nose of Fast GC-type and Nasal Ranger field olfactometer—applied for the determination of air quality beside the municipal landfill.

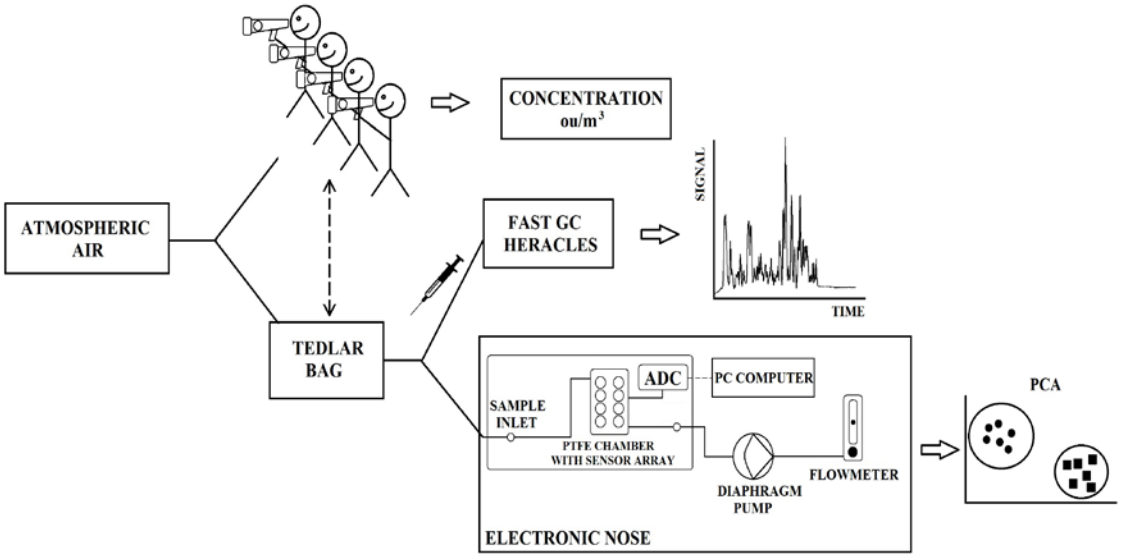

Figure 3. Schematic plan of investigation of ambient air beside the municipal landfill.

2.2. Methodology of Investigation

Investigation of air quality with respect to odorants' concentration, carried out with the electronic noses, was performed for the air samples collected around the municipal landfill in the vicinity of the

Tricity Agglomeration. The samples were collected at four control points located within 1-kilometre distance from the landfill. Localization and distribution of the air sampling points around the landfill is illustrated in Figure 4. The samples were collected during two seasons of the year: spring–winter (January–March) and spring (April–June). There was no atmospheric precipitation during the sampling operation. The samples were collected into the Tedlar bags (SKC Inc., Valley, California, CA, USA) of 5 dm^3 volume using a self-designed device called a Lung sampler. A total of 96 ambient air samples were collected around the landfill and analyzed. Analysis of the data obtained with the electronic nose prototype was performed employing free R software, part of Free Software Foundation (Free Software Foundation, Boston, MA, USA). A method of classification of the collected samples with respect to localization of the collection point involved the k-nearest neighbours algorithm (where k equaled 3); discrimination of the samples utilized the principle component analysis (PCA). Air quality investigation with respect to odorants' concentration performed with the field olfactometers was carried out at the same time and at the same control points, where the air was sampled into the Tedlar bags. A total of 384 measurements were performed with the Nasal Ranger field olfactometers.

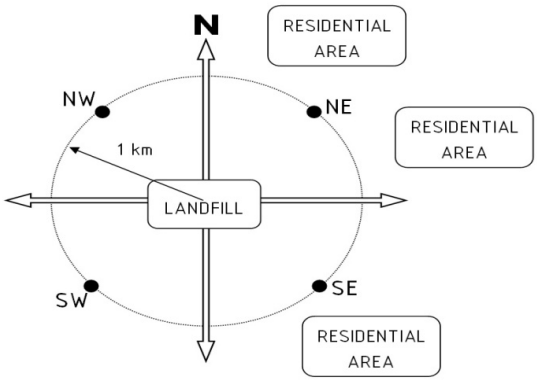

Figure 4. Map of the municipal landfill with the points of atmospheric air samples collection.

3. Results and Discussion

Figure 5 presents the PCA results for the ambient air samples collected in the vicinity of the municipal landfill when the measurements were performed with the electronic nose prototype during the spring–winter season. This time, the two-dimensional plane reveals three characteristic clusters of points, which correspond to the air samples' collection sites. One cluster is associated with the samples collected along the NE direction, the second cluster corresponds to the SE direction and the third one describes the remaining two directions, namely NW and SW. Table 3 shows an error matrix with the results of kNN (where k = 3) classification supported with the cross-validation method for the ambient air samples collected around the municipal landfill during the spring–winter season. The results of the performed classification originated from the investigation carried out with the electronic nose prototype. A total of 71.9% of the samples collected from the selected directions was correctly classified. The biggest number of correctly classified samples was 24 and they originated from the SE direction. In the remaining cases, the number of correctly classified samples was as follows: 23 for the NE direction, 13 for the NW direction and nine for the SW direction. Correctness of classification was at the level of 95.8% for the NE direction, 100% for the SE direction, 54.2% for the NW direction and 37.5% for the SW direction.

Figure 6 presents the PCA results for the ambient air samples collected in the vicinity of the municipal landfill when the measurements were performed with the commercial electronic nose of Fast GC-type during the spring–winter season. Also, in this case, there are three characteristic clusters of points on the two-dimensional plane. However, as compared to Figure 4, the clusters NE and SE are clearly resolved from the remaining points. Table 4 shows an error matrix with the results of the kNN (where k = 3) classification supported with the cross-validation method for the ambient air samples

collected around the municipal landfill during the spring–winter season. The results of the performed classification originated from the investigation carried out with the commercial electronic nose of Fast GC-type. A total of 87.5% of the samples collected from the selected directions was correctly classified. The biggest number of correctly classified samples was 24 and they originated from the NE direction. In the remaining cases, the number of correctly classified samples was as follows: 23 for the SE direction, 21 for the NW direction and 16 for the SW direction. Correctness of classification was at the level of 100% for the NE direction, 95.8% for the SE direction, 87.5% for the NW direction and 66.7% for the SW direction.

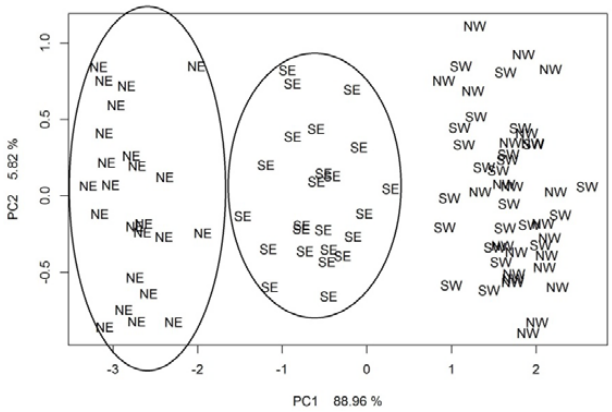

Figure 5. PCA result for the ambient air samples collected from four directions localized in the vicinity of the municipal landfill. Measurements were carried out with the electronic nose prototype during the spring–winter season.

Table 3. Cross-validation supported the k-nearest neighbours (k = 3) classification of the ambient air samples collected in the vicinity of the municipal landfill. Measurement data for classification were obtained with the electronic nose prototype during the spring–winter season.

Direction	NE	SE	SW	NW
NE	23	0	0	0
SE	1	24	1	0
SW	0	0	9	11
NW	0	0	14	13

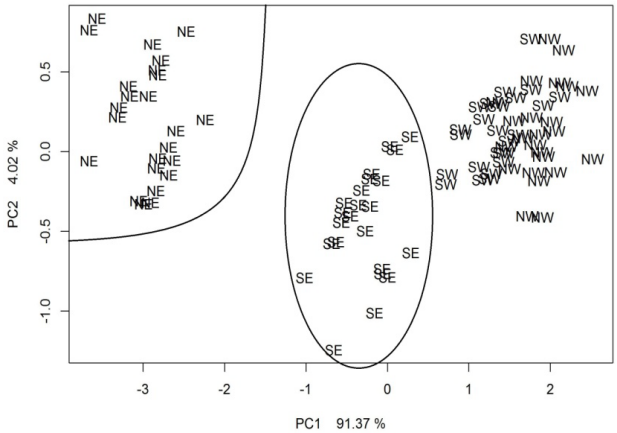

Figure 6. PCA result for the ambient air samples collected from four directions localized in the vicinity of the municipal landfill. Measurements were carried out with the commercial electronic nose of Fast GC-type during the spring–winter season.

Table 4. Cross-validation supported the kNN (k = 3) classification of the ambient air samples collected in the vicinity of the municipal landfill. Measurement data for classification were obtained with the commercial electronic nose of Fast GC-type during the spring–winter season.

Direction	NE	SE	SW	NW
NE	24	0	0	0
SE	0	23	1	0
SW	0	1	16	3
NW	0	0	7	21

Table 5 gathers the values of odour concentration C_{od} (ou/m^3) calculated as a geometric mean of the n-element set of all individual odour concentrations for a given measurement point. It can be observed that the highest values of odour concentration were estimated along the NE and SE directions. These values were 22.4 and 14.5 (ou/m^3), respectively. Concentration values determined for the remaining measurement points were similar and amounted to 2.4 (NW) and 2.1 (SW). High odour concentrations in the measurement points located along the NE and SE directions could result from many factors, including wind direction. During the investigation, predominant wind directions were north-east and south-east, which moved air masses from the area of the landfill towards the NE and SE directions where higher odorants concentrations were noticed as compared to the other measurement points.

Table 5. Values of odour concentration C_{od} (ou/m^3) calculated as a geometric mean of the n-element set of all individual odour concentrations for a particular measurement point during the spring–winter season.

Direction	NE	SE	SW	NW
concentration (ou/m^3)	22.4	14.5	2.1	2.4

Figure 7 presents the PCA results for the ambient air samples collected in the vicinity of the municipal landfill when the measurements were performed with the electronic nose prototype during the spring season. Similar to Figure 5, there are three characteristic clusters of points corresponding to the air sampling sites. One cluster represents the samples collected along the NE direction, the second cluster corresponds to the SE direction and the third cluster is associated with the remaining two directions, which are NW and SW.

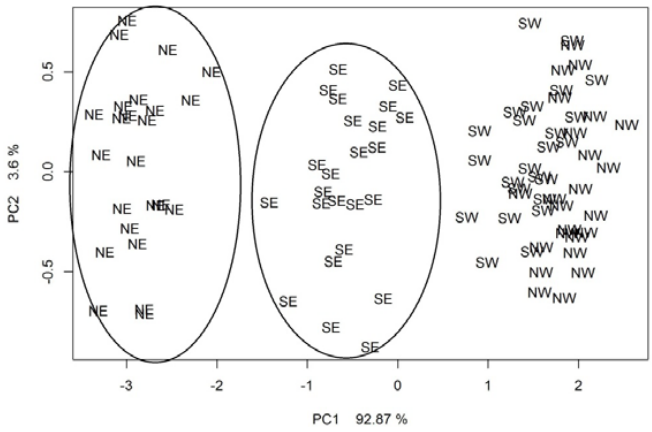

Figure 7. PCA result for the ambient air samples collected from four directions localized in the vicinity of the municipal landfill. Measurements were carried out with the electronic nose prototype during the spring season.

Table 6 shows an error matrix with the results of the kNN (where k = 3) classification supported with the cross-validation method for the ambient air samples collected around the municipal landfill during the spring season. The results of the performed classification originated from the investigation carried out with the electronic nose prototype. A total of 84.4% of the samples collected from the selected directions was correctly classified. The biggest number of correctly classified samples was 24 and they originated from the NE direction. In the remaining cases, the number of correctly classified samples was as follows: 24 for the SE direction, 18 for the NW direction and 15 for the SW direction. Correctness of classification was at the level of 100% for the NE direction, 100% for the SE direction, 75.0% for the NW direction and 62.5% for the SW direction.

Table 6. Cross-validation supported the kNN (k = 3) classification of the ambient air samples collected in the vicinity of the municipal landfill. Measurement data for classification were obtained with the electronic nose prototype during the spring season.

Direction	NE	SE	SW	NW
NE	24	0	0	0
SE	0	24	1	0
SW	0	0	15	6
NW	0	0	8	18

Figure 8 presents the PCA results for the ambient air samples collected in the vicinity of the municipal landfill when the measurements were performed with the commercial electronic nose of Fast GC-type during the spring season. However, as compared to Figure 5, the clusters NE and SE are clearly resolved from the remaining points. Table 7 shows an error matrix with the results of the kNN (where k = 3) classification supported with the cross-validation method for the ambient air samples collected around the municipal landfill during the spring season. The results of the performed classification originated from the investigation carried out with the commercial electronic nose of Fast GC-type. A total of 94.8% of the samples collected from the selected directions was correctly classified. The biggest number of correctly classified samples was 24 and they originated from the NE and SE direction. In the remaining cases, the number of correctly classified samples was as follows: 22 for the SW direction, 21 for the NW direction. Correctness of classification was at the level of 100% for the NE and SE direction, 91.7% for the SW direction, 87.5% for the NW direction.

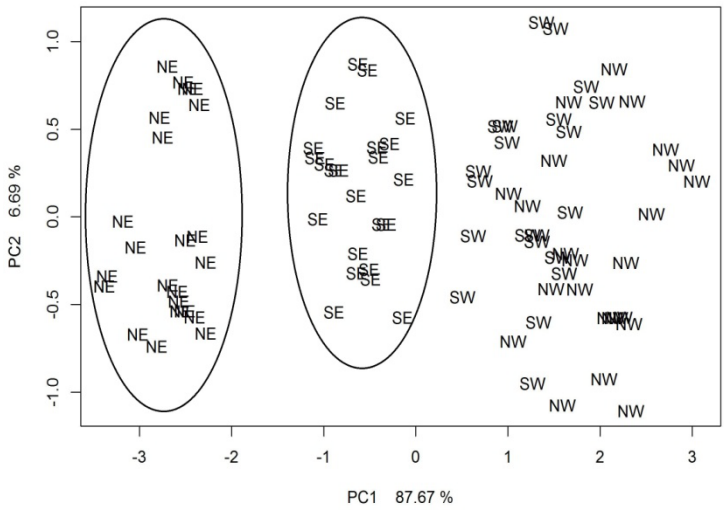

Figure 8. PCA result for the ambient air samples collected from four directions localized in the vicinity of the municipal landfill. Measurements were carried out with the commercial electronic nose of Fast GC-type during the spring season.

Table 7. Cross-validation supported the kNN (k = 3) classification of the ambient air samples collected in the vicinity of the municipal landfill. Measurement data for classification were obtained with the commercial electronic nose of Fast GC-type during the spring season.

Direction	NE	SE	SW	NW
NE	24	0	0	0
SE	0	24	0	0
SW	0	0	22	3
NW	0	0	2	21

A comparison of Tables 3, 4, 6, 7 shows that the correctness of classification of the ambient air samples collected from different control points around the municipal landfill depends on the season of the year and the measurement device enabling discrimination of the samples. The dependence between the season of the year and the correctness of classification of the ambient air samples polluted with odours has already been observed in the paper [49] where the measurements had been conducted with a commercial electronic nose of Fast GC type. It was noticed that the correctness of classification of the samples collected from various control points during the summer season was higher than in the case of the samples collected at the same points but during the winter season. Higher temperature and humidity during the summer season allows the emission of the compounds produced in anaerobic conditions inside waste dumps of municipal landfills. Table 8 gathers the values of odour concentration C_{od} (ou/m^3) calculated as a geometric mean of the n-element set of all individual odour concentrations for a given measurement point during the spring season. It can be observed that the highest values of odour concentration were estimated along the NE and SE directions. These values were 32.2 and 17.3 (ou/m^3), respectively. Concentration values determined for the remaining measurement points were similar and amounted to 2.3 (NW) and 2.2 (SW). High values of odour concentration in the control points during the spring season as compared to the spring–winter season confirm that the dominant factors causing the emission of unpleasant odorous compounds are temperature and air humidity, contributing to enhanced anaerobic processes occurring in waste dumps of municipal landfills. Earlier investigations, performed with gas chromatography allowing the identification of the compounds responsible for elevated odour concentrations, revealed the presence of the following groups of compounds: sulphides, aldehydes, ketones, amines, aliphatic and aromatic hydrocarbons, organic acids, terpenes [49]. All these compounds at the concentration levels above the odour identification threshold can undergo different phenomena of odour interaction, for instance synergism—odour intensification. Higher concentrations of odorous compounds during the spring season may arise not only from the aforementioned anaerobic or climatic processes (air temperature, relative humidity) but also due to additional compounds generated by enhanced sun radiation during this season of the year, which are characterized by high volatility and susceptibility to chemical conversions. These factors and predominant north-east and south-east winds (ca. 60% during a year) result in a higher concentration of odorous compounds along the NE and SE directions beside the municipal landfill as compared to SW and NW directions.

Table 8. Values of odour concentration C_{od} (ou/m^3) calculated as a geometric mean of the n-element set of all individual odour concentrations for a particular measurement point during the spring season.

Direction	NE	SE	SW	NW
concentration (ou/m^3)	32.2	17.3	2.2	2.3

In order to compare the discrimination abilities of the kNN algorithm (where k = 3) applied in the investigations performed with both types of the electronic nose, the obtained results of the correct classification were compared with the classification results for the kNN algorithm (where k = 5 and k = 7), the LDA (linear discriminant analysis) algorithm and the QDA (quadratic discriminant function)

algorithm. The results are presented in Table 9. It can be noticed that the highest level of correct classification is exhibited by the kNN algorithm (where k = 3). The k-nearest neighbours algorithm classifies an investigated object into a particular group based on k-nearest located observations from a training set. A number of the nearest located observations (k) taken into account is pre-assumed and is an odd number. This algorithm belongs to the so-called *lazy learning algorithms* due to the fact that it investigates only a small part of the training set. It is one of the simplest classification algorithms because an unknown object is assigned to a particular group by the majority of its neighbours, the object is identified as a member of the group, which is the most popular among the object's k-nearest neighbours.

Table 9. Comparison of the discrimination abilities of the algorithms: kNN (where k = 3, k = 5, k = 7), linear discriminant analysis (LDA) and quadratic discriminant function (QDA).

Direction	Electronic Nose Prototype		Fast GC	
algorithms	spring–winter	spring	spring–winter	spring
kNN (k = 3)	71.9	84.4	87.5	94.8
kNN (k = 5)	68.7	78.5	81.2	92.0
kNN (k = 7)	66.8	76.7	80.4	90.2
LDA	70.2	81.2	85.2	93.2
QDA	71.1	82.5	86.2	93.6

4. Conclusions

Classification of the ambient air samples collected in the vicinity of the municipal landfill performed with the kNN algorithm (where k = 3) revealed that the biggest number of correctly classified samples originated from the NE and SE control points both during the spring–winter and the spring season. Correct classification of the ambient air samples for these control points was at the level of 71.9% and 84.4%, respectively, for the electronic nose prototype and at the level of 87.5% and 94.8%, respectively, for the electronic nose of Fast GC-type. Field olfactometry measurements also indicated that these control points exhibited higher odour concentration than the other measurement points. The measured values were equal to 22.4 (ou/m^3) for the NE direction and 14.5 (ou/m^3) for the SE direction during the spring–winter season and 32.2 (ou/m^3) for the NE direction and 17.3 (ou/m^3) for the SE direction during the spring season.

High values of odour concentration and higher values of the correct classification of the ambient air samples collected at different control points during the spring season as compared to the spring–winter season confirm that the main factor responsible for such a situation is climatic conditions. They include ambient air temperature, air humidity, wind direction, wind velocity and sun irradiation. A higher level of the correct classification of the air samples with the commercial electronic nose of Fast GC-type resulted from the fact that more information had been taken for analysis (data were collected from the first 18 chromatographic peaks from both columns). If each chromatographic peak (surface area) is treated as a signal from a single sensor, then the advantage of the electronic nose comprised of chromatographic columns will be obvious as far as detection abilities are concerned. However, a comparison of the operation parameters of both types of electronic nose instrument shows that the electronic nose prototype exhibits a satisfactory level of correct results in relation to its unit price. The application of the semiconductor, electrochemical and PID-type sensors improved its detection abilities and the prototype became competitive to the Fast GC-type device.

The information obtained from these season investigations will be used by the authors during further research within the frame of the project aimed at on-line monitoring of ambient air in the vicinity of the odorous compounds' emitters.

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Conflicts of Interest: The authors declare no conflict of interest.

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