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Air quality classification using Electronic nose and other methods: A Review

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Abstract: - Air is the main aspects of life on earth or for whole world. Now days, air quality is degraded due to vehicles, industries and many more things in developing countries. Polluted air directly affects the human health. This paper reviewed the air quality classification using different techniques. Electronic noses capable of mimicking the human olfactory system have been developed to classify the measured data of odors using neural networks. In most sensing instruments and e-noses as well, data processing is essential element.

Keywords: - *Air quality index , classification , Electronic nose, carbon monoxide , Sensor array,*

I. INTRODUCTION

An Electronic nose is a device which is a combination of sensor array and artificial intelligence algorithm. The response of sensor array is known as Fingerprint. It has been introduced to many field of applications such as food-engineering [1-3], explosive detection [4-6], disease diagnosis [7-10], environmental control [11, 12], spaceflight application[13], and odour analysis problems[14-16].

Air Pollution becomes more critical in urban areas due to industries development, solid waste management, solid waste disposal, and release of toxic materials. So, it is important for us to monitor air quality index which is a numerical value used by agencies to assess the concentration of various pollutant present in Air [17]. A survey on these indices was shown in [17]. Using single numerical value it is very easy to represent the air quality. Similarly indoor air may be polluted due to cleaning products, perfumes, cigarette smoke, construction activity, water damaged building materials and other pollutant present in the form of gases [22]. These pollutant or mixed gases could be hazardous if their amount exceeded from particular threshold limits of exposures and this will affect human health also. To regulate indoor air quality, ventilation is used to improve it. Pleasant or unpleasant odours present in the air dominate the perception of occupant [24].

Section II contain the related work of air quality monitoring and its classification using e-nose and other method , Section III contain tabular analysis of environmental, air quality analysis, Section IV concludes review of the paper with future perspective.

II. RELATED WORK

U. Kizil ei al. (2017) developed Metal oxide Figaro based electronic nose system for air quality monitoring near Livestocks barns. The developed e-nose system consists of data acquisition software unit and temperature sensor as well. Kriging method was applied to monitor spatial distribution of response of e-nose sensors. This system was used to detect air quality condition within poultry operations where there were mixtures of odours. 10 gas sensors were used but only 6 gas sensors that were TGS 813, TGS 822, TGS 825, TGS 826, TGS 2600, and TGS 2602 were responded to sampled air. Each sensor response of three different locations were compared and showed linear relationship between responses of sensor. It was clear from result that e-nose readings could be used for air quality monitoring. Mean, root mean square, average standard, mean standardized, and root mean square standardized were calculated for each sensor. Response of AM-1-2600 was used as reference value in non-odorous and clean environment. Above this reference value, the response of sensor was considered as odorous air while, below this reference non-odorous air. In future, e-nose system will be integrated with GPS sensor with software and hardware components.

S. Munawar et al. (2017) presented prediction of air quality of Lahore city, Pakistan using Neuro-fuzzy inference system. Ambient air sample data were recorded from April 2007 to May 2015 by Environmental Protection Department, Punjab. Fuzzy rules were generated according to air quality. The main pollutant carbon mono oxide (CO), sulphur dioxide(SO2), particulate matter(PM 2.5), O3, and Nitrogen Dioxide(NO2) were used as Neuro- fuzzy inference model. There was three types of AQI prediction classification as unhealthy air, moderate, and good air. Result showed that Neuro fuzzy model performed best as compared to Interpolation method.

A. Saxena et al. (2017) developed a mathematical model Grey wolf optimized based SVM for classification of ambient air quality. Cumulative index were calculated for four major pollutants SO2, NO2, PM2.5 and PM10. Supervised learning approaches were used for classification of air as good air and harmful air. The efficiency of proposed classifier was tested on data collected from three different locations Bhopal, Delhi, and Kolkata. Result showed that proposed classifier performance was good.

S. Mad Saad et al. (2017) proposed a Electronic nose for indoor air quality monitoring which was able to recognize pollutants. MLP, LDA, and KNN were used for detection of pollutants. The source of pollutants present in air was chemicals, fragrances', presence of food and beverages, and combustion activity. Results showed that three algorithm MLP, LDA, KNN were successfully classify the five air pollutant sources with 100% success rate. The proposed system was able to classify single or mixed sources of pollutant present in the air. For mixed pollutant, it classify as unknown pollutant using MLP algorithm with model structure of 9-3-5.

X. Jiang et al. (2017) used e-nose to distinguish indoor pollutant gases. EQBC-RBFNN was proposed and applied for pollutant analysis present in indoor air. Labelled sample and unlabeled samples were compared. Results showed that e-nose able to detect and distinguish three pollutant gases toluene, formaldehyde, and benzene. LDA, BPNN, KNN, SVM, and RBFNN were used as classifier. RBFNN showed best classification accuracy rate as compared to other classifier. Classification accuracy of the e-nose improved when unlabeled samples in application process are used to refine the e-nose.

J. Michel Guillot (2016) studied limitation of electronic nose in terms of calibration procedure, sampling location, external condition, and its instability related to environmental odour analysis. Electronic nose cannot be efficient in all environmental conditions. This is still in development phase if consider their limitation than it would be more sensitive and selective for environmental analysis. Sensor used in these e-noses, were made up with olfactory epithelium for the detection of compounds.

S. Sironi et al. (2014) designed an electronic nose EOS 101 for indoor applications. Laboratory and indoor field test was conducted to measure CO_2 concentration and other pollutant present in the air. The indoor air quality data was collected for three months in a university room of different timings, and cafeteria. Results showed that both odour and CO_2 concentration increased to peak level at lunch time. The cafeteria was more populated at lunch time and also due to use of microwave oven to heat the food it also increased the CO_2 concentration level.

M. Pascal et al. (2013) reviewed the epidemiological methods which were used to investigate the affects of air pollution on human health around industrial area. Major health problem due to air pollution were cancer, morbidity, mortality, birth outcome, and mental diseases found in countries like United Kingdom, Italy, and Spain.

J. Srinnonchat (2013) developed electronic nose for monitoring air pollutions and fire alarming for industries. There were four sensors TGS2620, TGS 2620, TGS2442, and TGS832 used for detection of pollution in air. These sensors were sensitive to Methanol, n-Propanol, Hexane, and Dichloro-methane gases. When these gases were leaked, an alarming system was also attached to it. PCA was used as classifier.

L. Zhang et al. (2012) studied six types of indoor air contaminates using e-nose. These contaminates were formaldehyde, toluene, benzene, ammonia, carbon monoxide, and nitrogen dioxide. Sensors TGS2602, TGS2620, TGS2201A, and B (Figaro company) were used detection of contamination in indoor air. SFAM, EDC, MLP based back propagation learning rule FLDA, single SVM, and hybrid SVM were used for detection and classification of contaminates present in indoor air. Result showed that hybrid SVM outperforms as compared to other classifier and achieved classification rates for training and testing sample were 93.74% and 92.62% respectively.

L. Dentoni et al. (2012) compared the characteristics of two e-noses EOS 507 and EOS 835 for continuous monitoring of environmental odours. Result showed that e-nose EOS 835 monitors air quality more accurate as compared to e-nose EOS 507.

I. Morsi (2008) collected six months data to examine urban air quality using electronic nose. Basically, CO2 and CO gas were monitored in Alexandrea-Egypt and traffic roads as well. Environmental data were collected using these sensors TGS 822, TGS 2442, TGS 813, TGS 4160, TGS 2600, wind speed measurement sensor, humidity sensor and temperature sensor. Quadratic surface regression model were used to find correlation between pollutants present in the air. Weather condition, local situations, and topography were also considered to improve the regression model. MSE and ANOVA were calculated in proposed model to detect the significant pollutant present in air.

M.A. Ryan et al. (1997) developed 32 polymer sensor based e-nose at JPL Caltech for environmental monitoring in the International Space Station. The data were collected for 49 days. E-nose sensor observed the CO2 spiking and 12 contaminates in an enclosed space. Result showed that proposed e-nose was able to observe the CO2 level in a JPL.

C. Arnold et al. (2002) showed the KAMINA micro array based e-nose to monitor indoor air quality and also able to detect the fire development conditions. Data were collected over longer period of time in

various situations and sizes of rooms such as different building room materials, different furniture, and different room sizes. LDA was applied for classification but it's not sufficient. Further KNN applied to extended datasets and it gave successful classification of air quality for proposed KAMINA System.

M. Amy Ryan et al. (2004) designed an e-nose at Jet Propulsion Laboratory Pasadena CA. The developed e-nose was able to identify, detect, and quantify reactive humidity change and contaminants. Total 32 polymer carbon black composite based sensor array were used. These sensors were C71, A,Q,C38,C7,C58,C90,E15,C,D,E,F,C88,C22,and C20. Levenberg- Marquart non-linear least square method was used to identify and quantify air quality. E-nose was operated for six days and data were collected daily and analyzed after flight. Result showed that the overall success rate of 85% for single gas and 65% for mixed gas identification in air quality monitoring in Space shuttle. It was also concluded from the result that the proposed device was microgravity insensitive.

Misselbrok et al. (1997) studied two different electronic noses named Odourmapper and Aromascan PLC. These noses used to quantify the odours. Result showed that variance of Aromascan and odourmappers were 59% and 62% respectively.

S. Sironi et al. (2007) used electronic nose to analyze and classify odorous air. E-nose exposed to the odor emission from a composting plant. Six MOS Sensors based two e-noses were used to monitor composting plant. One e-nose was installed near the plant, while second e-nose was installed in the surroundings. At every twelve min. these e-nose analyzed air quality continuously. KNN was used to classify the air quality and achieved classification rate was72%.

A.C. Romain et al. (2002) analyzed air data in a 4 year period to evaluate the performance of electronic nose. Result showed that accuracy of classification rate decreased with respect to time and accuracy decreased from 98% to 20% at the end of the experiment. Sensor drift automatically due to repeated training over time it automatically compensate sensor drift over time.

III. TABULAR ANALYSIS OF AIR QUALITY DATA USING E-NOSE AND OTHER DIFFERENT TECHNIQUES

Sl. No.	Author Name	Ref. No.	Type of Sensor Used	Proposed Technique	Remarks
01.	U. Kizil et al. (2017)	[18]	TGS 813, TGS 822, TGS 825, TGS 826, TGS 2600, TGS 2602	Kriging method	Mean, root mean square, Average standard, Mean Standardized, root mean square standardized were calculated for each sensor and response of AM-1-2600 was used as reference value. The response of sensor above this value treated as odors air and below this non-odors condition.
02.	S. Munawar et al. (2017)	[19]	Not specified	Nuero Fuzzy Inference System	Nuero Fuzzy Model gave best result and Air quality index were classified as Unhealthy air, Moderate, and Good Air.
03.	A.Saxena et al. (2017)	[22]	Not specified	Grey wolf Optimized based SVM	Data were collected from three different locations Bhopal, Delhi, and Kolkata. Four major pollutants SO_2, NO_2, $PM_{2.5}$ and PM_{10} were detected and classified using Grey wolf optimized based SVM.
04.	S. Mad Saad et al. (2017)	[26]	Not specified	MLP, LDA, KNN	MLP, LDA, and KNN were applied for indoor air quality monitoring. These three algorithms were successfully classifying five air pollutant sources and classification rate was 100%. Proposed e-nose system was able to classify single or mixed sources of pollutants.
05.	X. Jiang et al. (2017)	[31]	Not specified	LDA, BPNN, KNN, SVM, RBFNN, and EQBC-	EQBC-RBFNN showed best classification rate as compared to other classifier.

				RBFNN	
06.	J. Michel Guillot (2016)	[20]	Olfactory receptors, odorant binding proteins, olfactory epithelium		Presents the limitation of e-nose related to environmental odor analysis. Sensor used in proposed e-nose, were made up with olfactory receptors, odorant binding proteins, and olfactory epithelium for the detection of compounds.
07.	S. Sironi et al. (2014)	[24]	Not specified	Not specified	Laboratory and indoor field test were conducted to measure CO_2 concentration level using proposed e-nose EOS 101.
08.	M. Pascal et al. (2013)	[21]	Not specified	Not specified	Reviewed the Epidemiological methods which investigate the affects of air pollution on human health. Major health problem occurred due air pollution were cancer, morbidity, mortality, birth outcome, and mental health in United Kingdom, Italy, and Spain.
09.	J. Srinnonchat (2013)	[23]	TGS 2620, TGS 2620, TGS 2442, and TGS 832.	PCA	Methanol, n-Propanol, Hexane, and Dichloro methane pollutant were detected using developed e-nose with alarming system attached to it.
10.	L. Zhang et al. (2012)	[29]	TGS 2620, TGS 2620, TGS 2201A, and B(Figaro company)	SFAM, EDC, MLP-BPNN, SVM, and Hybrid SVM	Six types of contaminates formaldehyde, toluene, benzene, ammonia, carbon monoxide and nitrogen dioxide were detected in indoor air quality and classified it. Hybrid SVM outperforms as compared to other classifier.
11.	L. Dentoni et al. (2012)	[30]	Not specified	EOS 507, EOS 835	Characteristics of two e-nose EOS 507and EOS 835 were used for continuous monitoring of environmental odors. Result showed that EOS 835have more features and gives more accurate result as compared to EOS 507.
12.	I. Morsi (2008)	[17]	TGS 822, TGS 2442, TGS 813, TGS 813, TGS 4160, TGS 2600	Quadratic surface regression model	MSE and ANOVA were Calculated in proposed model to detect the significant pollutant present in the air.
13.	M.A. Ryan et al. (1997)	[25]	Polymer Sensor- 32 No.	Not Specified	Developed e-nose used for environmental monitoring in International Space Station. E-nose sensor observed the CO_2 spiking in space station for 49 days.
14.	C. Arnold et al. (2002)	[27]	KAMINA micro array	LDA, KNN	KNN showed best classification result of air quality for proposed KAMINA system.
15.	M. Amy Ryan et al. (2004)	[28]	C71, A, Q, C38, C7, C58, C90, E15, C, D, E, F, C88, C80, C22, C20	Levenberg-Marquart non linear square method.	E-nose was operated for six days and data were collected daily and analyzed after the flight. Levenberg-Marquart non-linear least square method used to identify and quantify air quality.
16.	T.H. Misselbrook et al. (1997)	[33]	Not specified	Aromascan, Odoumappers	Perfomnce of two different e-noses Aromascan and odourmappers were copared and their variance were 59%

					and 62% respectively.
17.	S. Sironi et al. (2007)	[34]	MOS Sensor	KNN	Six MOS sensor based e-nose were used to monitor composting plant and surroundings as well. KNN applied for air quality classification and achieved classification rate was 72%.
18.	A.C. Romain et al. (2002)	[35]	SnO_2 Sensor	PCA, DFA	The classification of field measurement and lab instrument measurement were compared. Result showed that DFA did not give better result when cluster overlaps, while PCA showed better result for monitoring of malodorous in environment.

IV. DISCUSSION

The authors have studied paper related to Air Quality analysis and its classification. The authors have given analysis of these many papers in tabular form to get the correct description of this paper. The previous authors have worked on LDA, BPNN, KNN, SVM, Hybrid SVM, RBFNN, EQBC-RBFNN, and Nuero Fuzzy technique for air quality classification and pollutant odorant detection. The author has found that Adaptive Nuero Fuzzy Inference System gives best result as compared to previous methods.

V. CONCLUSION AND FUTURE PERSPECTIVE

This paper presents the review of air quality monitoring using e-nose and other methods. Above study proved that electronic nose is able to monitor indoor air quality and outdoor air quality as well. A micro sensor array based electronic nose can be integrated with temperature control system and alarming system to be built with high performance accuracy in future. The developed microelectronic nose can be expected to meet the requirement of consumer in terms of price, size, and less energy consumption. If micro e-nose could be integrated with in air monitoring system it controls the CO_2 concentration and other pollutant level present in the air.

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REFERENCES

[1] A. Loutfi, S. Coradeschi, G.K. Mani, P. Shankar, J.B.B. Rayappan, "*Electronicnoses for food quality: a review"*, J. Food Eng. 144 (2015) 103–111.

[2] E. Gobbi, M. Falasconi, G. Zambotti, V. Sberveglieri, A. Pulvirenti, G.Sberveglieri, "Rapid *diagnosis of Enterobacteriaceae in vegetable soups by ametal oxide sensor based electronic nose*", Sens. Actuators B: Chem. 207(2015) 1104–1113.

[3] Y. Dai, R. Zhi, L. Zhao, H. Gao, B. Shi, H. Wang, " *Longjing tea qualityclassification by fusion of features collected from E-nose*", Chemom. Intell. Lab.Syst. 144 (2015) 63–70.

[4] A. Norman, F. Stam, A. Morrissey, M. Hirschfelder, D. Enderlein, " *Packaging effects of a novel explosion-proof gas sensor*", Sens. Actuators B: Chem. 95(2003) 287–290.

[5] L. Wang, Y.H. Gui, S.P. Zhang, " *Research on explosives detection by electronicnose*", Chin. J. Sens. Actuat. 20 (2007) 42–45.

[6] K. Brudzewski, S. Osowski, W. Pawlowski, "*Metal oxide sensor arrays fordetection of explosives at sub-parts-per million concentration levels by thedifferential electronic nose*", Sens. Actuators B: Chem. 161 (2012) 528–533

[7] P. Jia, T. Huang, L. Wang, S. Duan, J. Yan, L. Wang, "*A novel pre-processingtechnique for original feature matrix of electronic nose based on supervisedlocality preserving projections*", Sensors 16 (2016) 1019.

[8] E.A. Chapman, P.S. Thomas, E. Stone, C. Lewis, D.H. Yates, " *A breath test formalignant mesothelioma using an electronic nose*", Eur. Respir. J. 40 (2012) 448–454.

[9] P. Jia, F. Tian, Q. He, S. Fan, J. Liu, S.X. Yang, "*Feature extraction of woundinfection data for electronic nose based on a novel weighted KPCA*", Sens.Actuators B: Chem. 201 (2014) 555–566.

[10] G.C. Green, A.D.C. Chan, H. Dan, M. Lin, "*Using a metal oxide sensor(MOS)-based electronic nose for discrimination of bacteria based onindividual colonies in suspension*", Sens. Actuators B: Chem. 152 (2011)21–28.

[11] A.C. Romain, J. Nicolas, "*Long term stability of metal oxide-based gas sensorsfor E-nose environmental applications: an overview*", Olfaction Electron. Nose(2009) 502–506.

[12] F.D. Cesare, S. Pantalei, E. Zampetti, A. Macagnano, "*Electronic nose and SPME techniques to monitor phenanthrene biodegradation in soil*", Sens. ActuatorsB: Chem. 131 (2008) 63–70.

[13] P. Ciosek, W. Wróblewski, "*The analysis of sensor array data with variouspattern recognition techniques*", Sens. Actuators B: Chem. 114 (2006) 85–93.

[14] Q. Liu, H. Wang, H. Li, J. Zhang, S. Zhang, F. Zhang, K.J. Hsia, P. Wang, "*Impedance sensing and molecular modeling of an olfactory biosensor basedon chemosensory proteins of honeybee*", Biosens. Bioelectron. 40 (2013)174–179.

[15] J.H. Sohn, N. Hudson, E. Gallagher, M. Dunlop, L. Zeller, M. Atzeni, "*Implementation of an electronic nose for continuous odour monitoring in apoultry shed*", Sens. Actuators B: Chem. 133 (2008) 60–69.

[16] A. Kanchan, K. Gorai, and P. Goyal, "A review on air quality indexing system," *Asian Journal of Atmospheric Environment*,vol. 9, no. 2, pp. 101–113, 2015.

[17] I.Morsi, "*Electronic noses for monitoring environmental pollution and building regression model*",Conference: Industrial Electronics, 2008,IECON 2008,Vol.**34,** pp.**1730-1735-**, **2008**.

[18] U.Kizil, L. Genc, and S.A. Ksu, "*Air Quality mapping using an e-nose system in Northwestern Turkey*", Agronomy Research 15(1), pp. **205-217, 2017.**

[19] S. Munawar, MD. Hamid, Md Saleen Khan, A. Ahmed, and N. Hameed, " *Health Monitoring Considering Air Quality Index Prediction using Neuro Fuzzy Inference Model: A case study of Lahore, Pakistan"* Journal of Basic and ApplliedSciences, Vol. 13,pp. 122-132, 2017.

[20] J. Michel Guillot, " E-*noses: Actual Liitation andperspectives for Environmental Odour Analysis"* Chemical Engineering Transactions , Vol.54,pp. 223-228, 2016.

[21] M. Pascal, Laurence Pascal, Marie- Laure Bidondo, Amandine Cochet, Helene Sarter, Morgane Stempfelet, and Verene Wagner, "*A review of the Epidemiological methods used to investigate the health impacts of air pollution arround major industrial areas*" ,Journal of Environmental and Public Health, Hindawi, Vol.2013, pp. 1-17, 2013.

[22] A. Saxena and Shalini Shekhawat, " *Ambient Air Quality Classification by Grey Wolf Optimizer based Support Vector Machine*", Journal of Environmental and public Health, Hindawi, Vol.2017, pp.1-12, 2017.

[23] J. Srinonchat, " *Development of Electronic nose and Program for Monitoring Air Pollutions and Alarm in Industrial Area*" , International Journal of Computer and Electrical Engineering, Vol. 5, No.1pp. 61-64,2013.

[24] S. Sironi, Lidia Eusebio, Laura Capelli, Marco Remondini, Renato Del Rosso, "*Use of Electronic nose for indoor air quality monitoring*" , Chemical Engineering Transactions, Vol.40, pp. 73-78, 2014.

[25] M. A. Ryan, M.L. Homer, M.G. Buchler, K.S.Manatt, and J.Graf, "*Monitoring the air quality in a closed chamber using an Electronic nose*" , 1997.

[26] S. Mad Saad, Allan Melvin Andrew, Ali Yeon Mdd Shakaff, Mohd AzuwanMat Dhahir, Mohamed Hussein, Maziah Mohamad, and Zair Assar Ahmad, "*Pollutant Recognition Based on Supervised Machine Learning for Indoor Air Quality Monitoring Systems"* , MDPI, Applied Sciences, Vol.7,823,pp.2-21, 2017.

[27] C. Arnold, Michael Harms, and Jaochim Goschinick, " *Air Quality Monitoring and Fire Detection with the Karlsruhe Electronic Micronose KAMINA*", IEEE SENSORSJournal,Vol. 2, No.3, pp.179-188,2002.

[28] M. Amy Ryan, Hanying Zhou, Martin G. Buehler, Kenneth S. Manatt, Victoria S. Mowrey, Shannon P. Jackson, Adam K. Kisor, Abhijit V. Shevade, and Margie L.Homer, "*Monitoring Space Shuttle Air QualityUsingthe Jet PropulsionnLaboratoryElectronic Nose*", IEEE SENSORS Journal, Vol. 4,No.3, pp 337-347,2004

[29] L. Zhang, Fengehun Tian, Hong Nie, Lijun Dang, Guorui Li, Qi Ye, Chaibou Kadri, "*Classification of Multiple indoor air contaminates by an electronic nose and a hybrid support vector machine*" , Elsevier,Sensor and Actuators B: Chemical 174,pp. 114-125, 2012.

[30] L. Dentoni, L. Capelli, S. Sironi, M. Remondini, M. Della Torre, I. Ricco, F. Dematte, S. Zonetti, M. II Grande, " *Electronic noses for the qualitative and Quantitative Determination of Environmental Odours*" , Chemical Engineering Transactions, Vol. 30,pp. 211-216, 2012.

[31] X. Jiang, pengfei Jia, Rudan Luo, Vin Deng, Shukai Duan, Jia Yan, " *A Novel electronic nose learning technique based oin active learning: EQBC-RBFNN*", Elsevier, Sensor and Actuators B 249, pp.533-541, 2017.

[32] E. Martinelli, E. Zampetti, S. Pantalei, F.Lo. Castro, M. Santonico, G. pennazza, R. Paolesse, G. Mascetti, V. Contronei, F. Giannini, C. Di Natale, and A. D'Amico, "*Design and test of an electronic nose for monitoring the air quality in the International Space Station*" , Microgravity Science Technology, XIX-5/6, pp.60-64, 2007.

[33] T.H.Misselbrook, P.J. Hobbs, K.C.Persaud, " *Use of an electronic nose to measure odour concentration following application of cattle slurry to grassland*". *J. Agric. Eng. Res. 66*,213–220, 1997.

[34] S. Sironi, L. Capelli,P. Centola, P.; R. del Rosso, M.Il Grande, "*Continuous monitoring of odours from a composting plant using electronic noses*". *Waste Manag. 27*, 389–397, 2007.

[35] A.C.Romain,P Andre,J Nicolas, " *Three years experiment with the same tin oxide sensor arrays for the identification of malodorous sources in the environment*". *Sens. Actuators B Chem. 84*, 271–277,2002.

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