ODOROUS COMPOUNDS EMISSIONS IN AN URBAN AND INDUSTRIALIZED AREA

EMISIONES DE COMPUESTOS OLOROSOS EN ÁREAS URBANAS E INDUSTRIALIZADAS

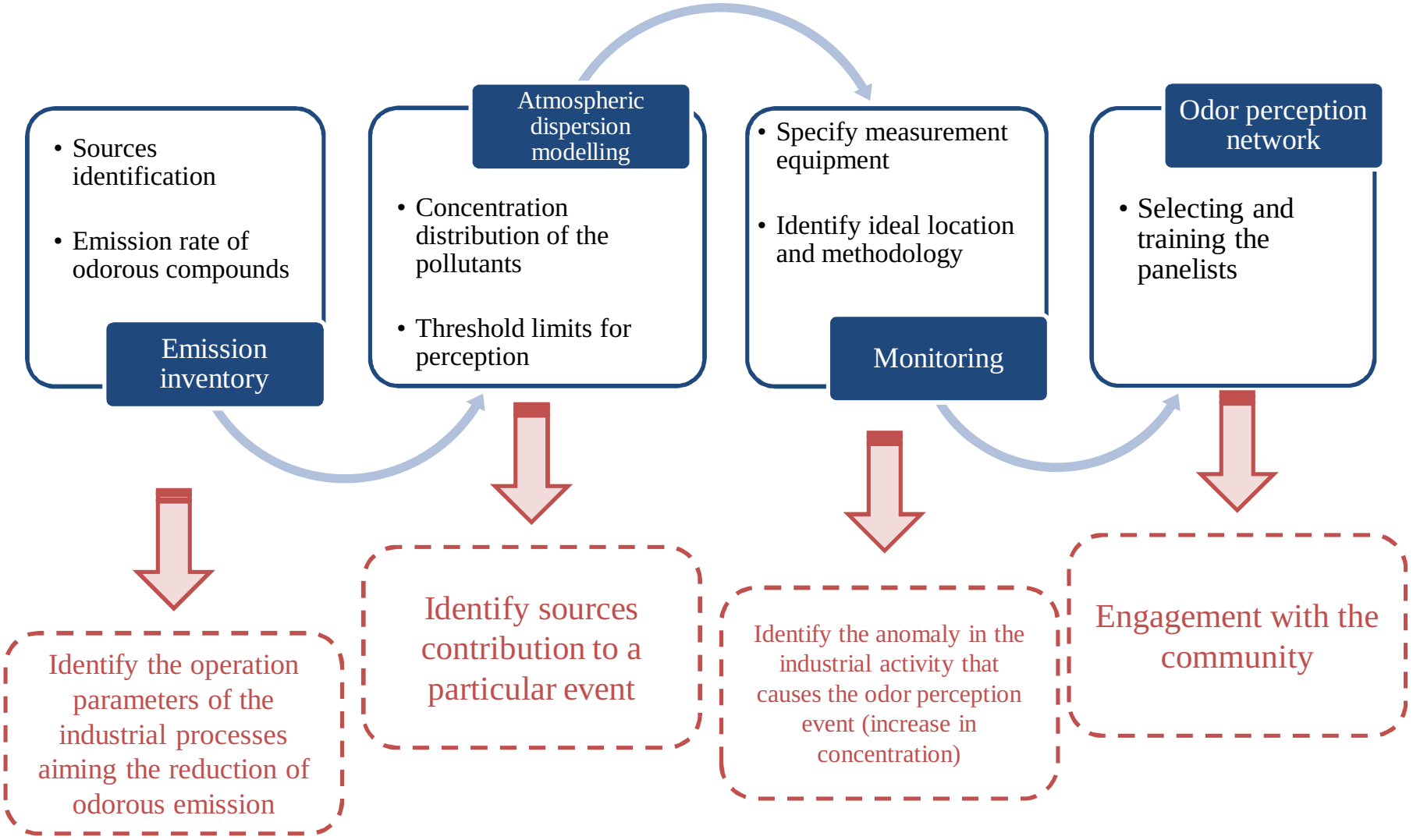
OLORES·19
LA CONFERENCIA HISPANA DE OLORES

Authors
Davi de Ferreyro Monticelli,
Bruno Furieri,
Vitor Ferreira Lavor,
Elisa Valentim Goulart,
Jane Meri Santos,
Neyval Costa Reis Jr,
Elson Silva Galvão,
Erick Lopes
Milena Machado Melo

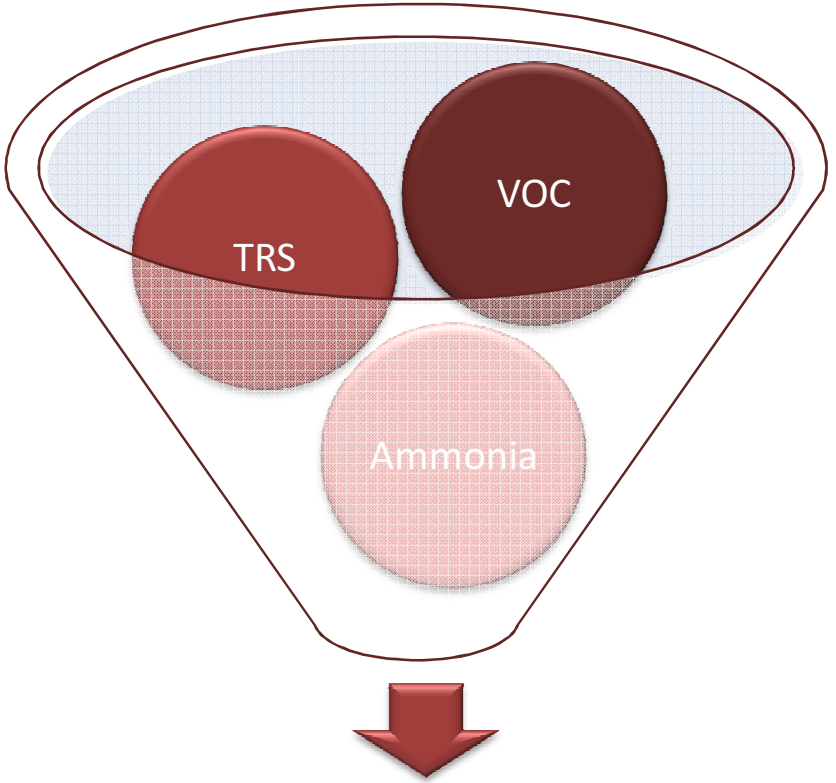
NQUALIAR
NÚCLEO DE ESTUDOS DA QUALIDADE DO AR

UFES
FEDERAL UNIVERSITY OF ESPÍRITO SANTO

CONTEXT

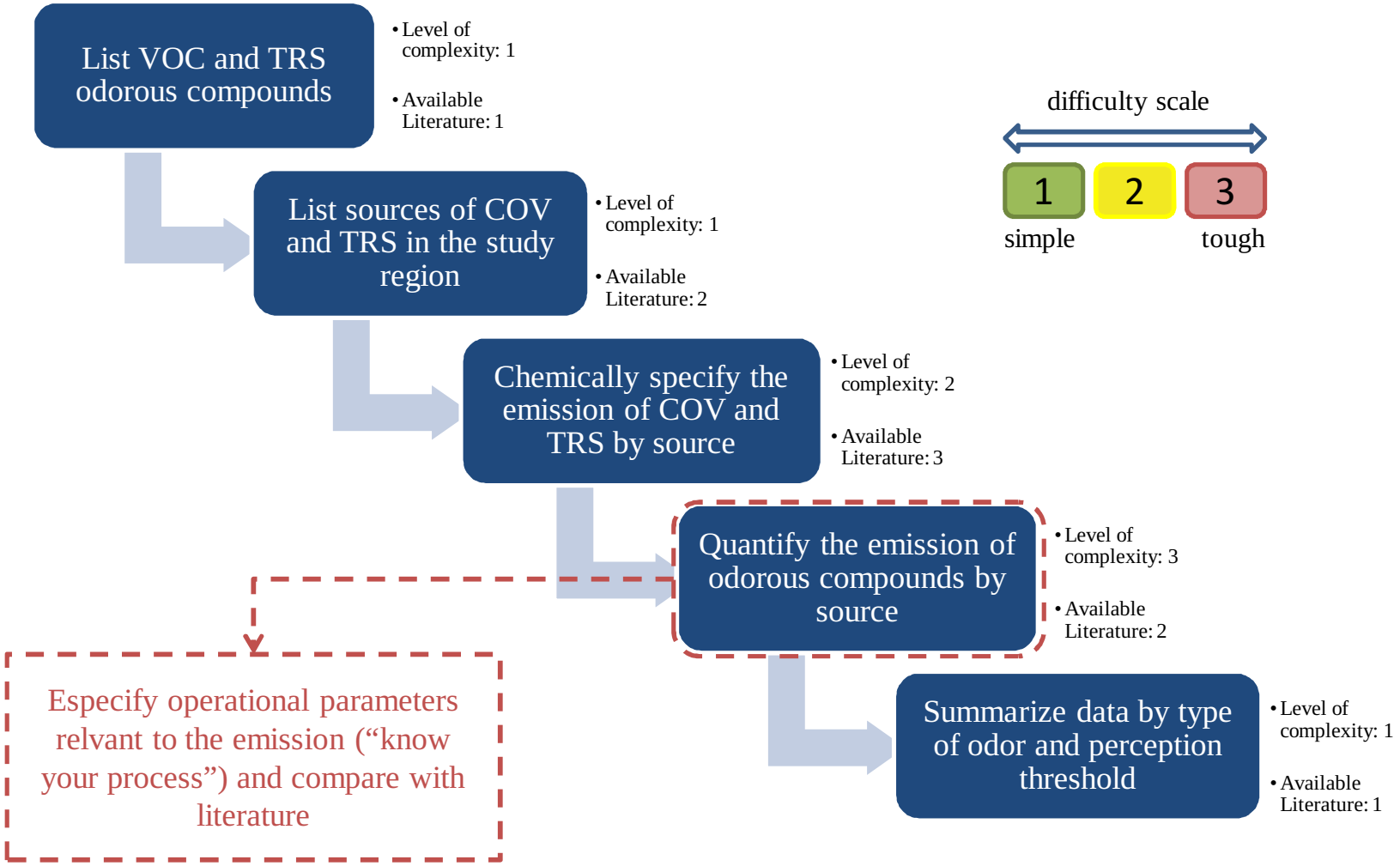

Emission inventory
• Sources identification
• Emission rate of odorous compounds
Atmospheric dispersion modelling
• Concentration distribution of the pollutants
• Threshold limits for perception
Monitoring
• Specify measurement equipment
• Identify ideal location and methodology
Odor perception network
• Selecting and training the panelists
Identify the operation parameters of the industrial processes aiming the reduction of odorous emission
Identify sources contribution to a particular event
Identify the anomaly in the industrial activity that causes the odor perception event (increase in concentration)
Engagement with the community

CONTEXT

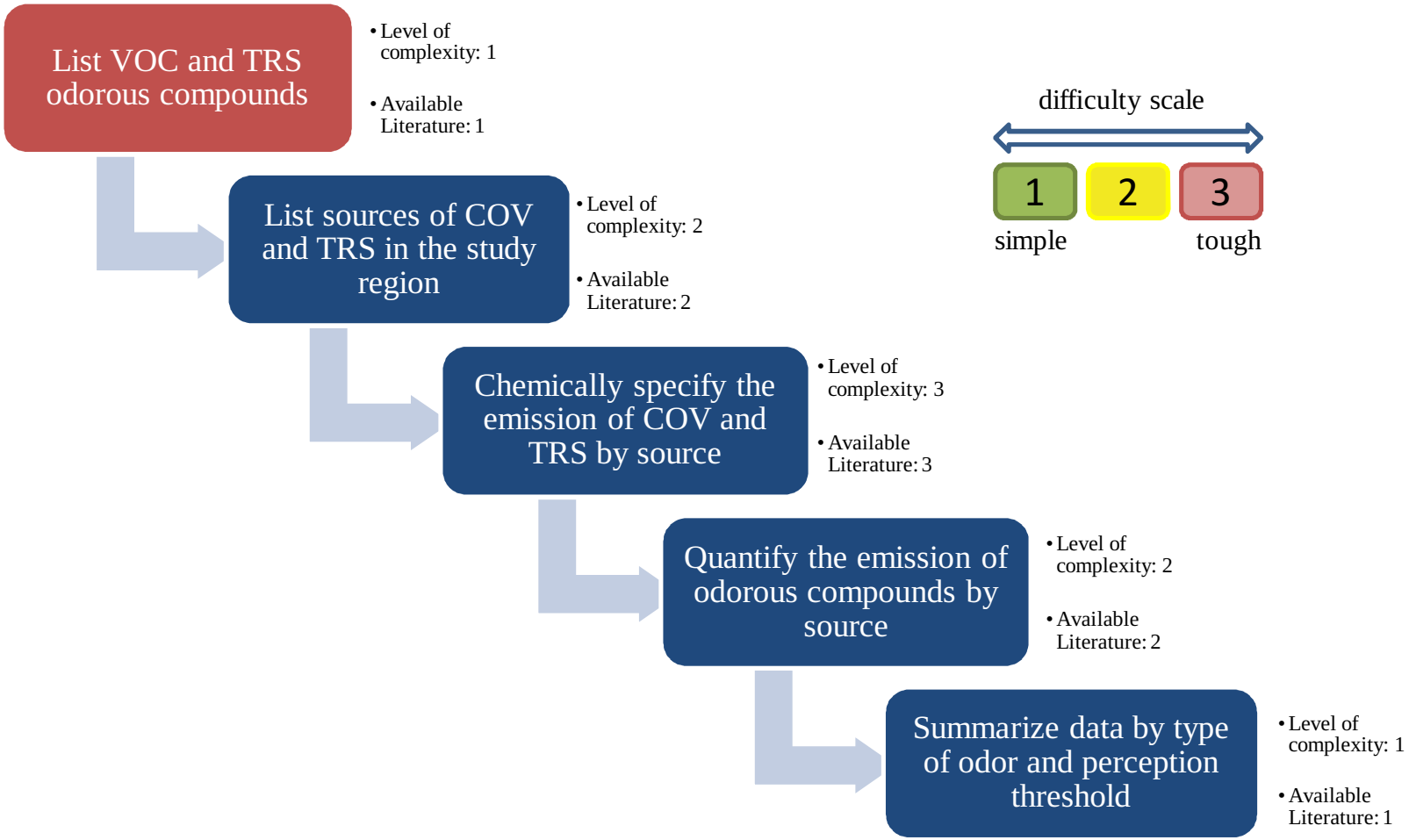


Annoyance caused by odorous compounds

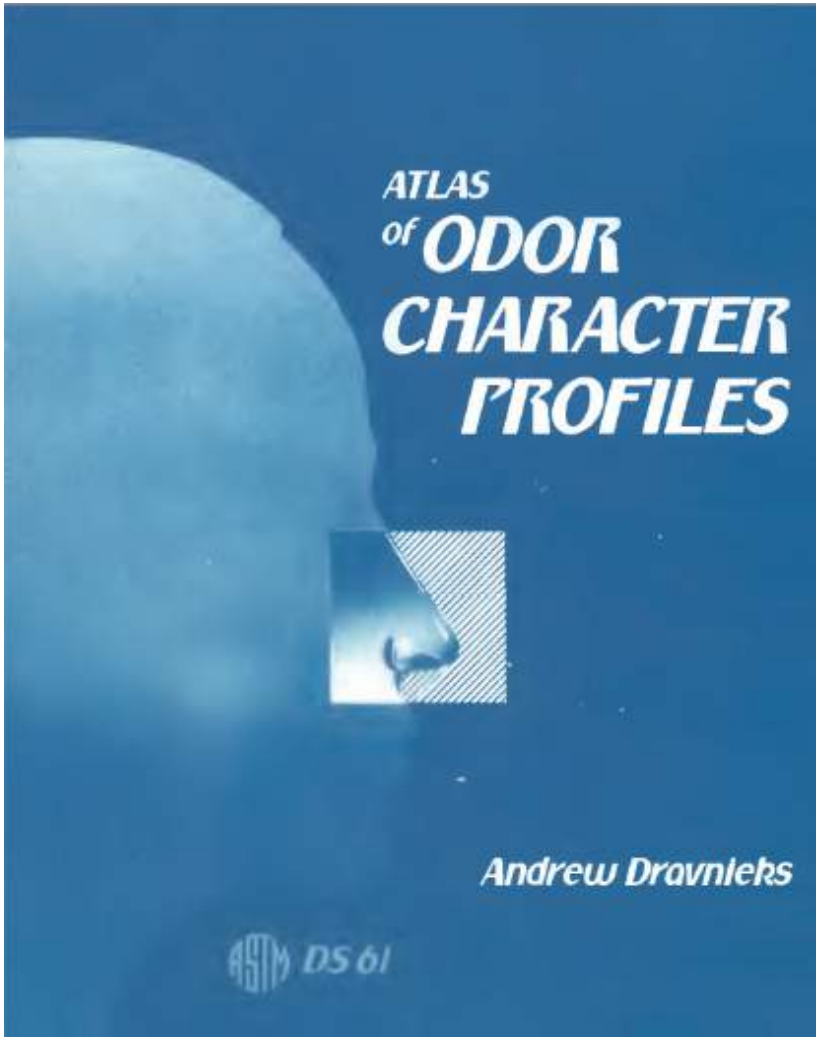
METHODOLOGY



METHODOLOGY



IDENTIFYING ODOROUS COMPOUNDS



Taylor & Francis

Critical Reviews in Environmental Science and Technology

ISSN: 1064-3389 (Print) 1547-6537 (Online) Journal homepage: http://www.tandfonline.com/loi/best20

Odor Emissions from Domestic Wastewater: A Review

Guangming Jiang, Denham Melder, Jurg Keller & Zhiguo Yuan

ELSEVIER

Available online at www.sciencedirect.com

SCIENCE DIRECT®

wasteWmanagement

Waste Management 25 (2005) 887–907

www.elsevier.com/locate/wasman

Odor compounds in waste gas emissions from agricultural operations and food industries

S. Rappert, R. Müller *

Biotechnology II, Technical University Hamburg-Harburg, Denickestrasse 15, 21071 Hamburg, Germany

Accepted 18 July 2005
Available online 29 August 2005

Journal of Environmental Management 170 (2016) 186–206

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

ELSEVIER

Review

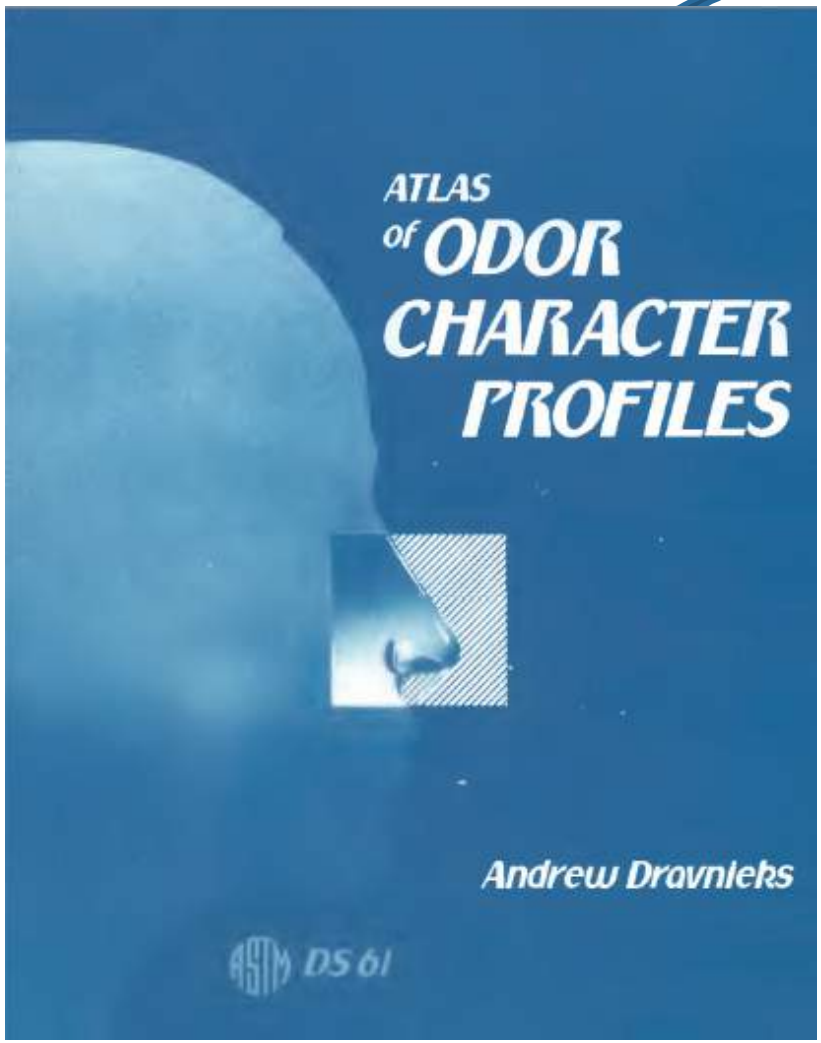
An overview of principles of odor production, emission, and control methods in wastewater collection and treatment systems

CrossMark

Amirreza Talaiekhozani [a, *], Marzieh Bagheri [b], Amin Goli [c], Mohammad Reza Talaei Khoozani [d]

[a] Jami Institute of Technology, Civil Engineering Department, Isfahan, Iran
[b] Jami Institute of Technology, Chemical Engineering Department, Isfahan, Iran
[c] Jami Institute of Technology, Mechanical Engineering Department, Isfahan, Iran
[d] University of Isfahan, Faculty of Engineering, Chemical Engineering Department, Isfahan, Iran

IDENTIFYING ODOROUS COMPOUNDS

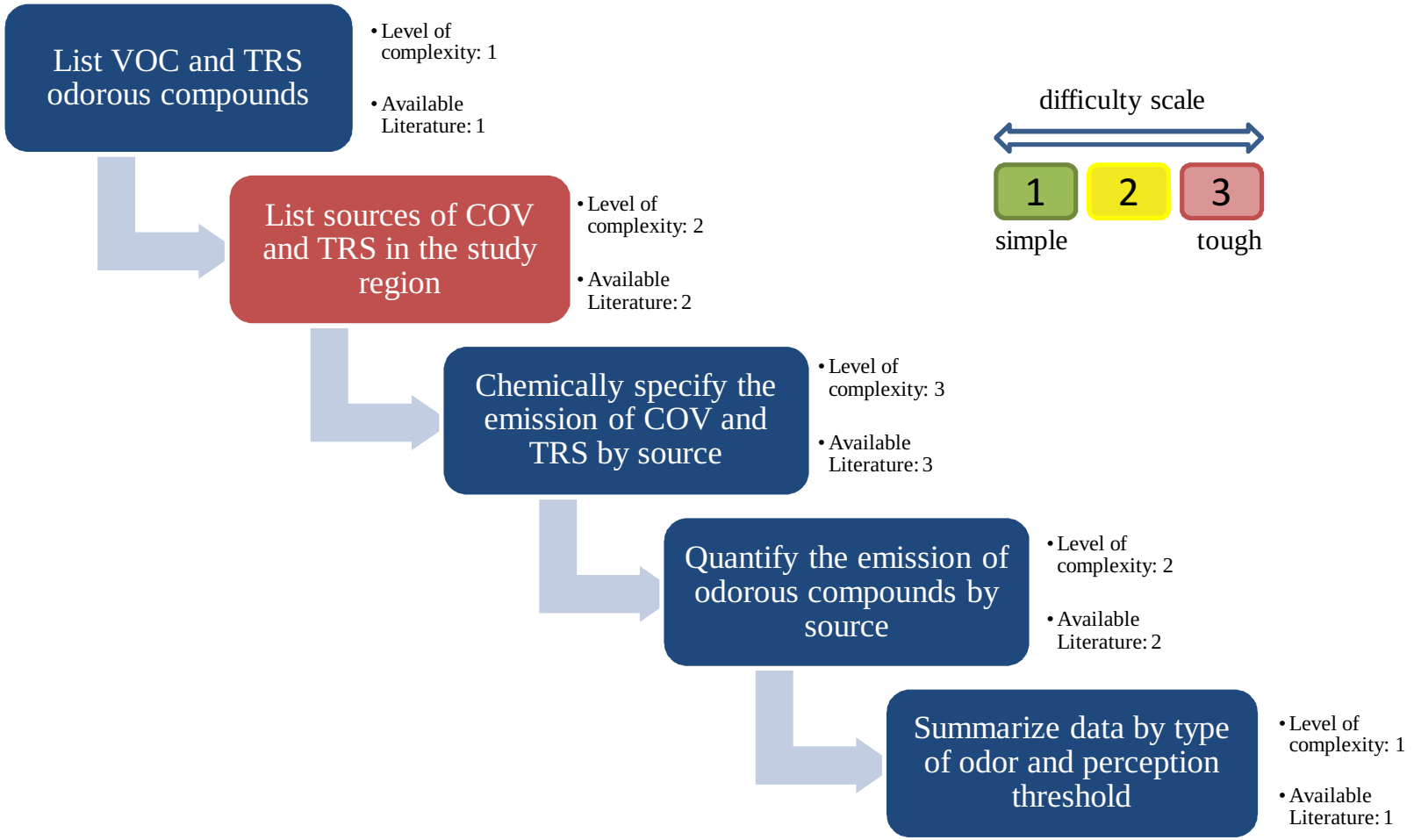


Compound (IUPAC Name*)	Chemical Formula (Yesple)
2-propene-1 thiol	C3H6S
1-thiol-pentane	C5H9S
Benzyl mercaptan	C7H8S
2-butene-1-thiol	C4H8S
Dimethyl sulfide	C2H6S
Ethyl mercaptan	C2H6S
Hydrogen sulfide	H2S
Methyl mercaptan	CH4S
Propyl mercaptan	C3H8S
Sulfur dioxide	SO2
tert-Butylthiol	C4H10S
Thiocresol	C7H8S
Ammonia	NH4
Thiophenol	C6H6S
Geosmin	C12H22O
Methylisoborneol	C11H20O

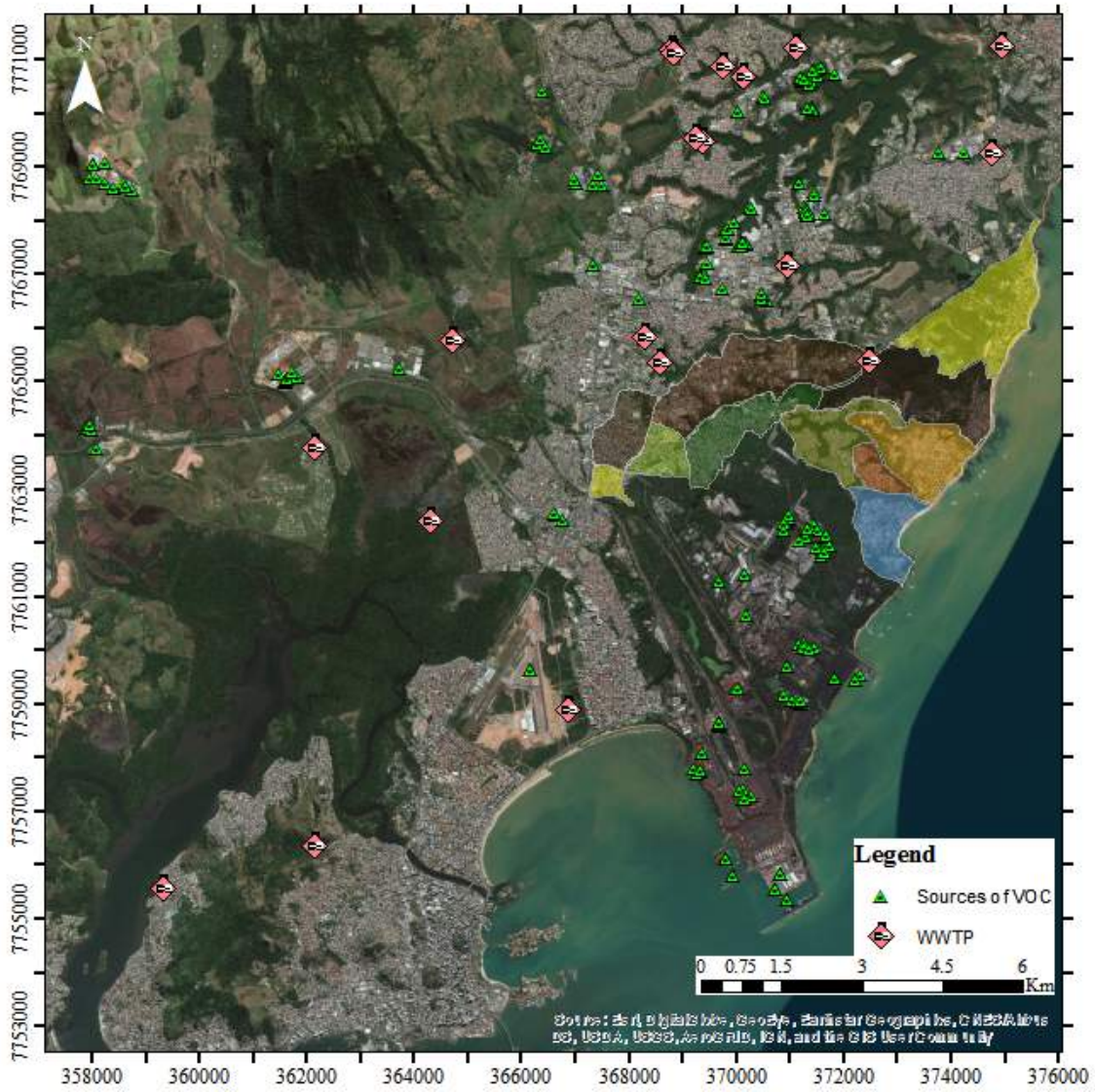
(...)

For this research: 468 compounds listed

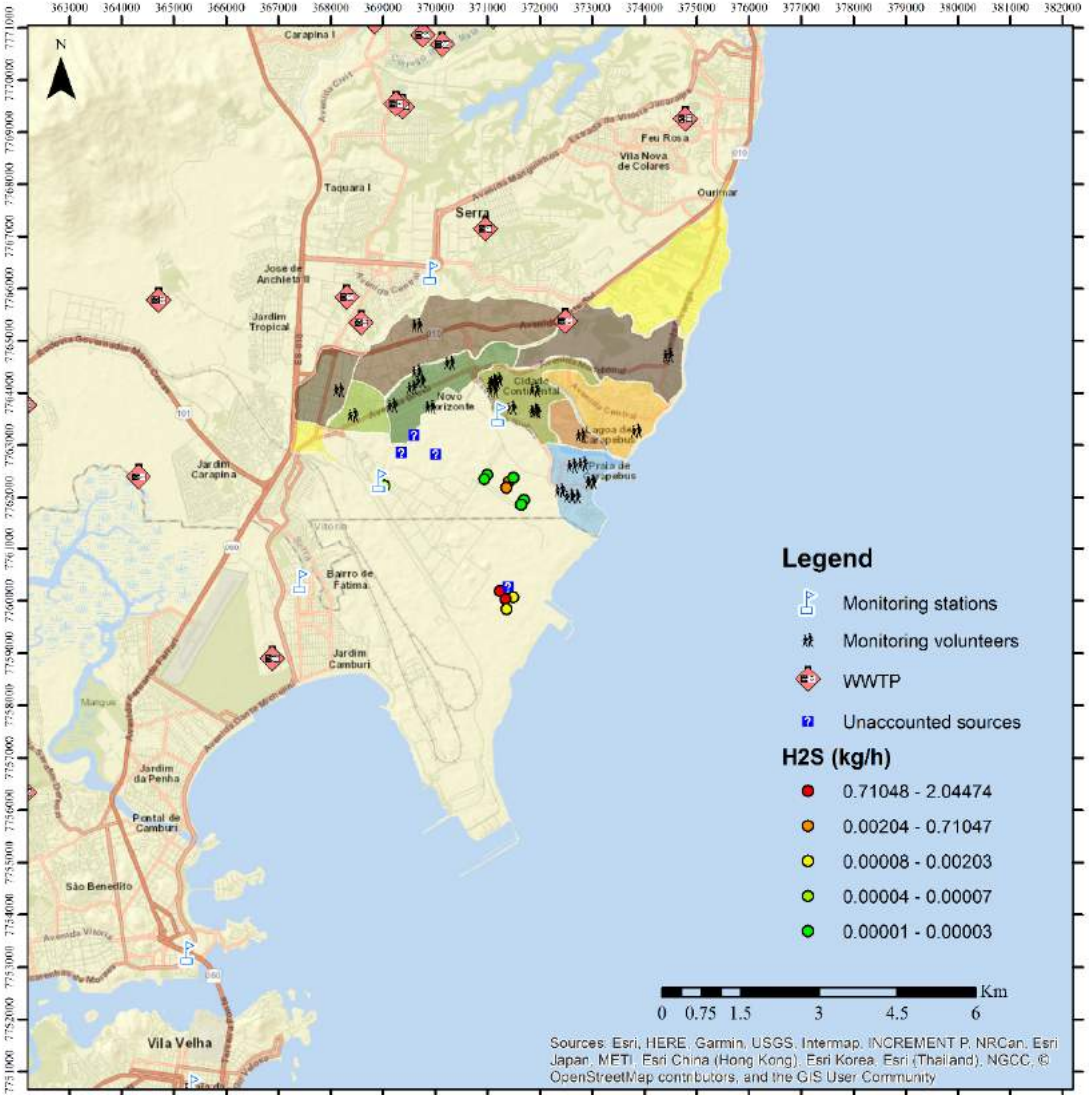
METHODOLOGY



IDENTIFYING SOURCES OF VOC IN THE STUDY REGION



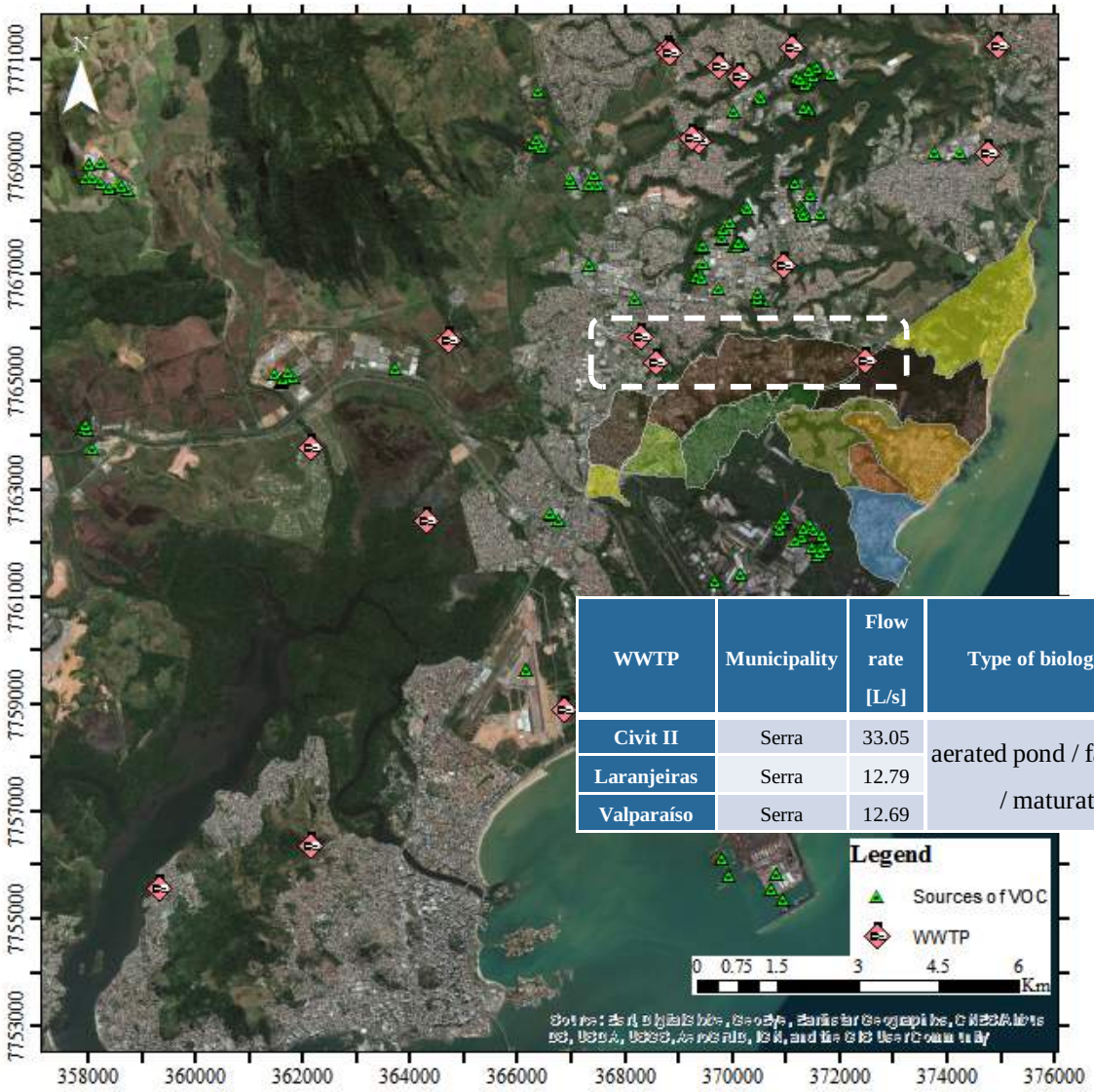
IDENTIFYING SOURCES OF H_2S IN THE STUDY REGION



Compounds Emitted:

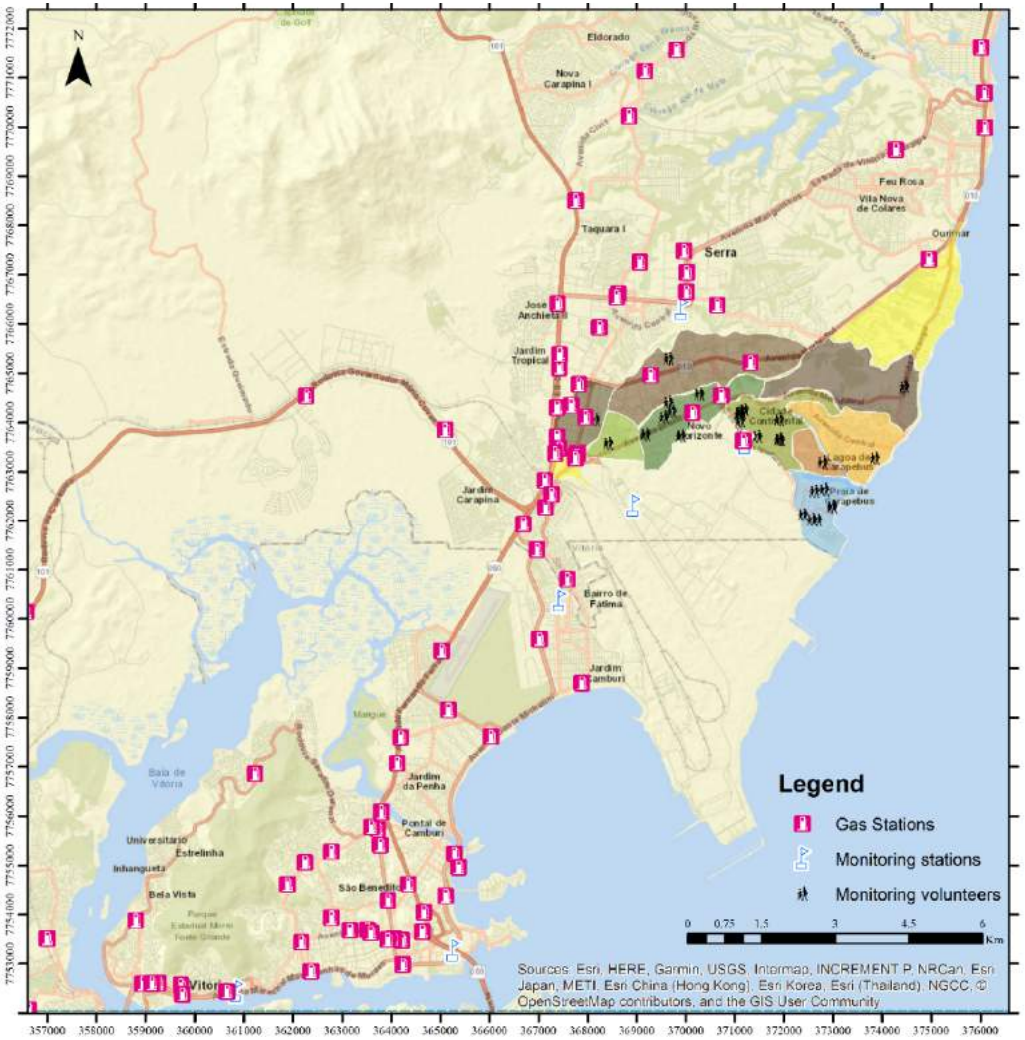
Hydrogen sulfide (H_2S)
Carbon disulfide (CS_2)
Carbonyl sulfide (OCS)

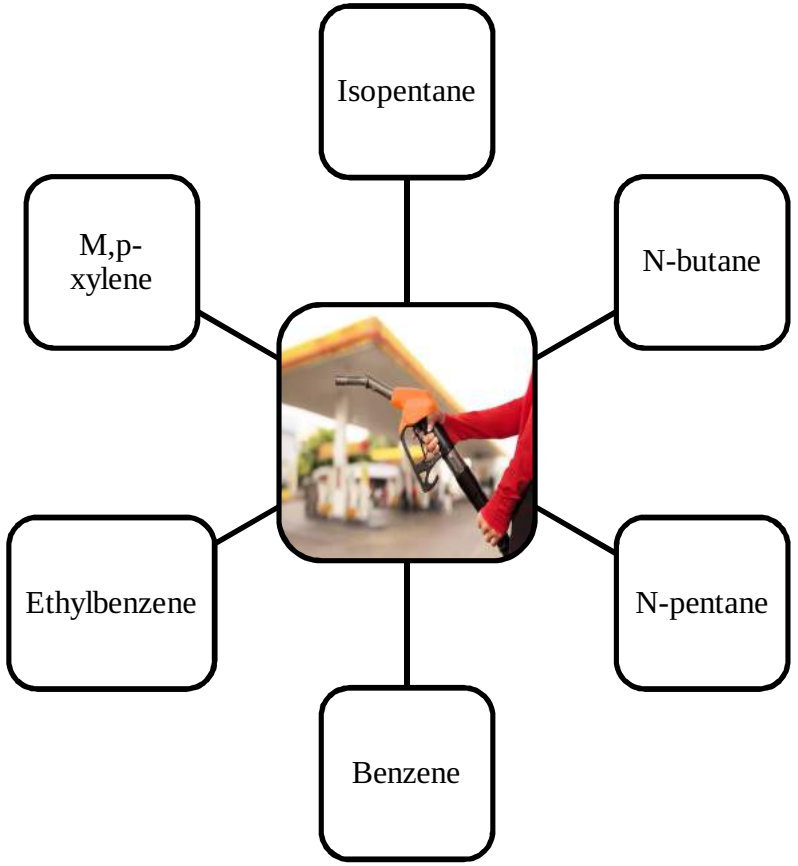
IDENTIFYING SOURCES OF H_2S IN THE STUDY REGION



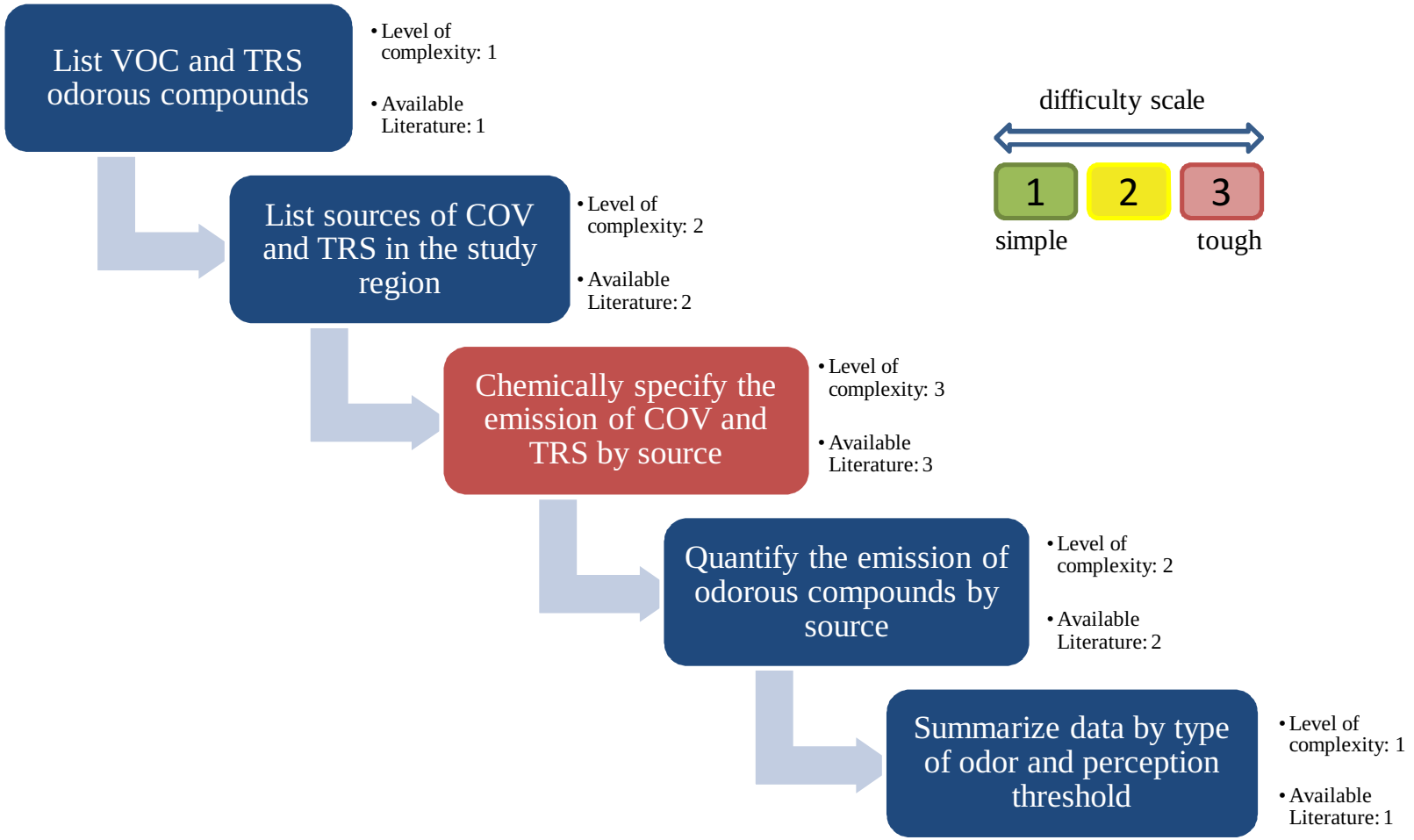
WWTP	Municipality	Flow rate [L/s]	Type of biological treatment	Population	BDO Efficiency removal (%)	Coordinates UTM [m]	
Civit II	Serra	33.05	aerated pond / facultative pond / maturation pond	25129	96	370959	7767150
Laranjeiras	Serra	12.79		9725	82	368584	7765350
Valparaíso	Serra	12.69		9649	93	368311	7765840

IDENTIFYING OTHER SOURCES OF ODOROUS COMPOUNDS





METHODOLOGY



CHEMICALLY SPECIFY VOC EMISSIONS

Industrial

Sintering Stack emission - Jiun-Horng et al. (2008)

Name	Emission Weight (%)	Simple Formula	Possible Odor? (by Formula)	Possible Odor? (by Name)
n-Butane	0.03	C4H10	Yes	Yes
Isopentane	0.08	C5H12	Yes	Yes
n-Pentane	0.04	C5H12	Yes	Yes
2,2-Dimethylbutane	0.01	C6H14	Yes	Yes
Cyclopentane	0.01	C5H10	Yes	#N/D
2,3-Dimethylbutane	0.01	C6H14	Yes	Yes
2-Methylpentane	0.02	C6H14	Yes	Yes
3-Methylpentane	0.02	C6H14	Yes	Yes
n-Hexane	0.01	C6H14	Yes	Yes
Methylcyclopentane	0.00	C6H12	Yes	Yes
2,4-Dimethylpentane	0.00	C7H16	Yes	Yes
Cyclohexane	0.00	C6H12	Yes	Yes
2-Methylhexane	0.01	C7H16	Yes	Yes
2,3-Dimethylpentane	0.00	C7H16	Yes	Yes
3-Methylhexane	0.01	C7H16	Yes	Yes
2,2,4-Trimethylpentane	0.00	C8H18	Yes	Yes
n-Heptane	0.01	C7H16	Yes	Yes
Methylcyclohexane	0.01	C7H14	Yes	Yes

(...)

Non-Industrial

Refueling Profile - SPECIATE 2561

Name	Emission Weight (%)	Simple Formula	Possible Odor? (by Formula)	Possible Odor? (by Name)
2,3-dimethylpentane	3.2	C7H16	Yes	Yes
2,4-dimethylpentane	0.51	C7H16	Yes	Yes
3-methylpentane	2	C6H14	Yes	Yes
Benzene	0.77	C6H6	Yes	Yes
Ethane	0.01	C2H6	#N/D	#N/D
Ethylbenzene	0.13	C8H10	Yes	Yes
Isobutane	6.17	C4H10	Yes	#N/D
Isopentane	30.56	C5H12	Yes	Yes
M,p-xylene	0.37	C24H30	Yes	Yes
N-butane	24.58	C4H10	Yes	Yes

(...)

AP-42: Compilation of Air Emissions Factors

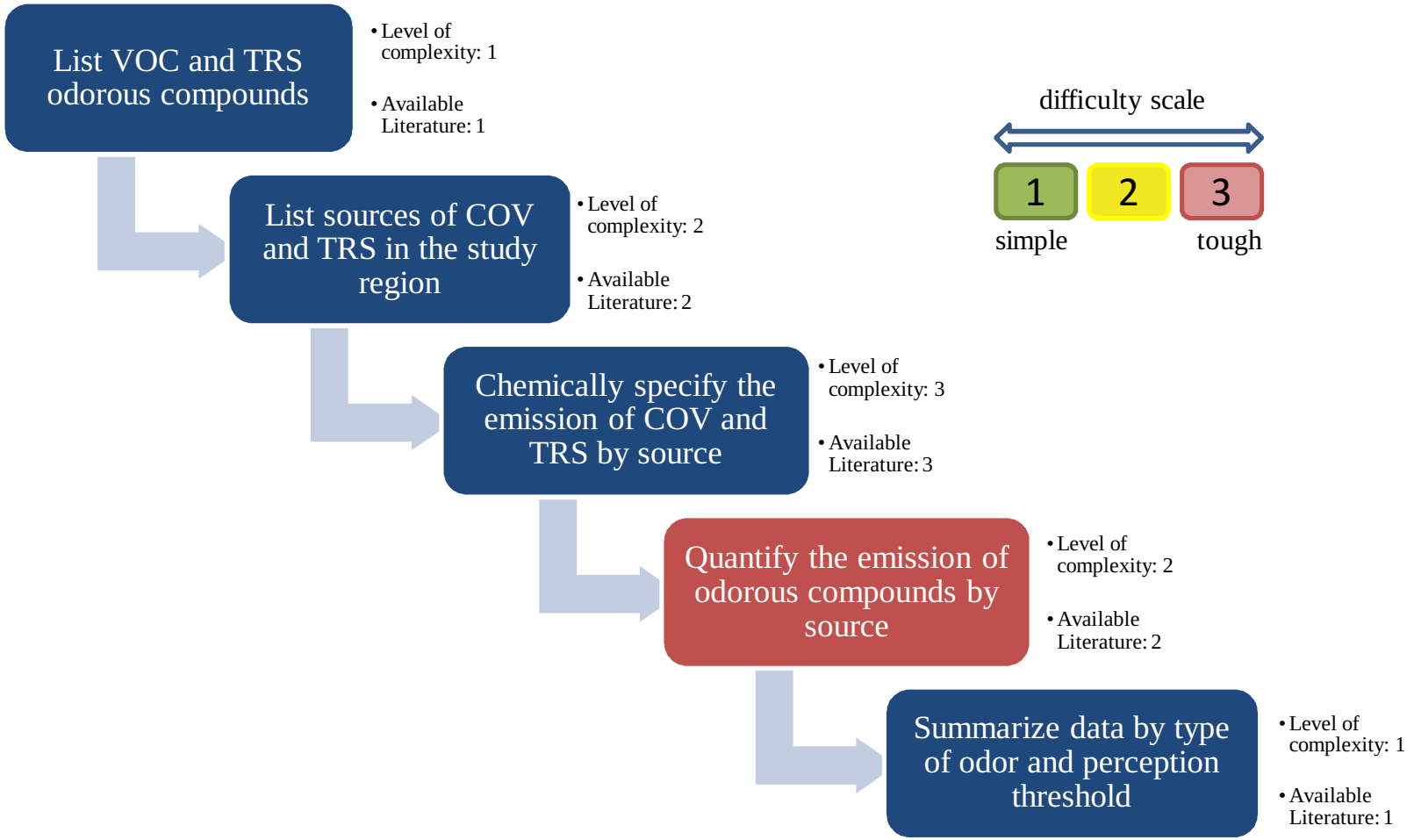
EPA United States Environmental Protection Agency

SPECIATE

CHEMICALLY SPECIFY VOC EMISSIONS

Source group	Major references
Steel industry	SPECIATE 2569, 0217, 0013; Ciaparra et al. (2009); Li et al. (2018); USEPA (2008); Jiun-horng et al. (2008); Lin et al. (2012); USEPA, (2008a, 1979)
Landfill	SPECIATE 0202
Airport	SPECIATE 2571
Wastewater Treatment	SPECIATE 3003, Jiang et al. (2017); Talaiekhozani et al. (2016); Mihelcic et al. (2012)
Vessels and Harbours	Huang et al. (2018); Milazzo et al. (2017); Xiao et al. (2018)
Natural Gas Distribution	SPECIATE 7197
Natural Gas Combustion	USEPA (2008b)
Food industry	Yeretzian et al. (2002); Nagorny and Francke (2005); Rappert and Müller (2005)
Refuelling/Vehicles	SPECIATE 2561; Chin and Batterman (2012); Wang et al. (2018); (USEPA, 2008c);
Thermal power	Shi et al. (2015); Garcia et al. (1992); Li et al. (2017);
Electronic manufacturing	Shen et al. (2018)

METHODOLOGY



QUANTIFYING ODOROUS EMISSION IN THE REGION

Industrial

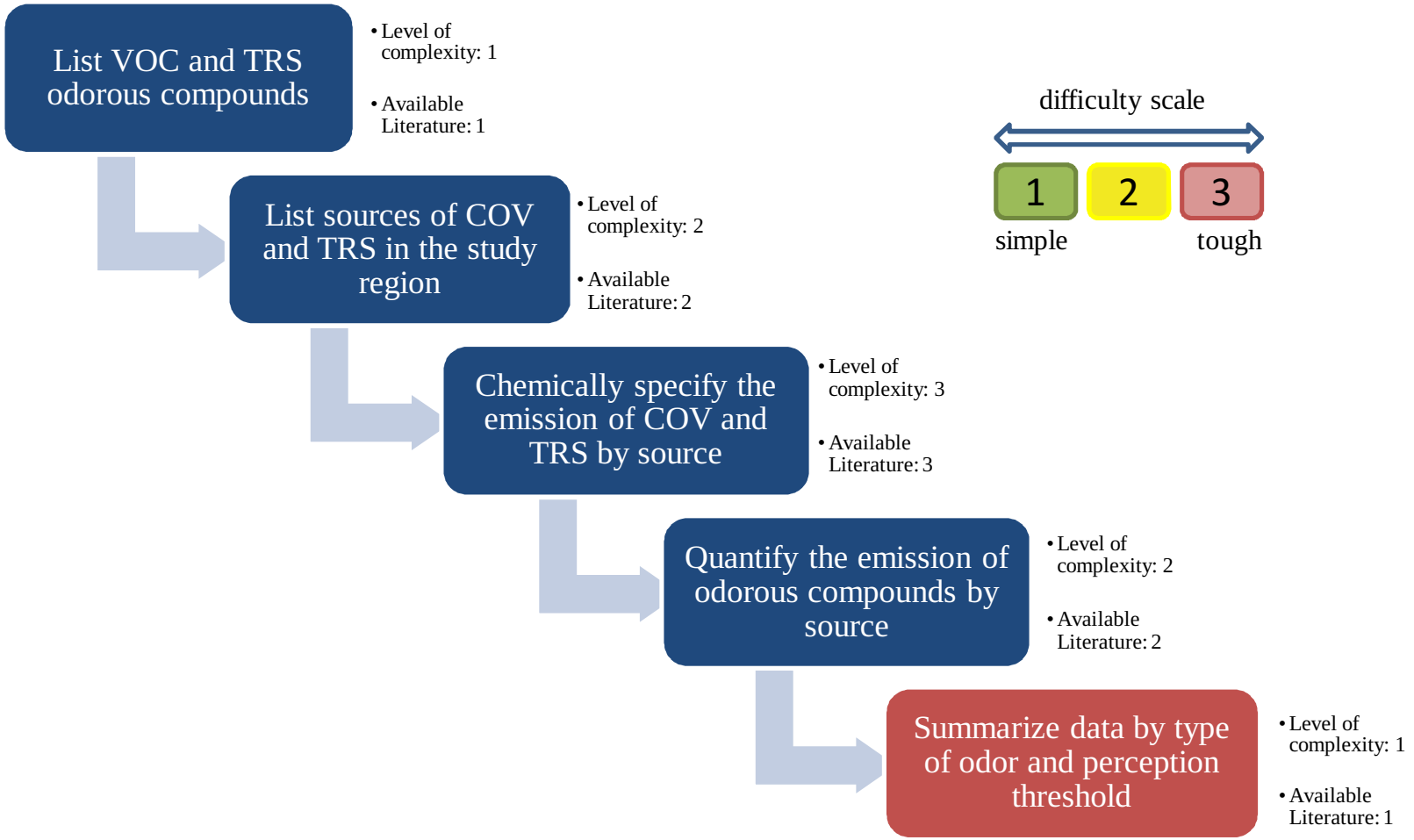
+

Non-Industrial

Major VOCs emitted in the study region[1]	Total Emission (kg/h)	Odour threshold (mg/m³)	Scent/Smell	Reference
Benzene	168.17	1.5	Sweet, Solvent	Jiang et al. (2017)
Toluene	71.66	0.4	Rubber, Tar, Naphthalene	Jiang et al. (2017)
Dodecane	29.91	11.8	Petrol, Alkane	Jiang et al. (2017)
Pentane	29.80	350.0	Petrol	Jiang et al. (2017)
Butane	24.07	1.0	Light petrol smell	Jiang et al. (2017)
Propane	19.11	22000.0	Light petrol smell	Jiang et al. (2017)
p-Xylene	8.80	0.052	Rubber	Jiang et al. (2017)
Isopentane	5.58	3.92	Gasoline, Pleasant	Nagata (2003)
Ethylbenzene	3.91	0.01	Sweet, Solvent	Jiang et al. (2017)
N-butane	3.62	2916.51	Light petrol smell	Nagata (2003)
Formaldehyde	3.30	0.06	Pungent and irritating	Jiang et al. (2017)
O-xylene	2.61	0.77	Rubber	Jiang et al. (2017)
N-pentane	2.44	4.22	Light petrol smell	Nagata (2003)
N-decane	2.13	3.69	Weak, Petrol, Bituminous	Nagata (2003)
Methyl cyclohexane	2.02	0.62	Petrol	Nagata (2003)
n-Undecane	2.01	5.69	Gasoline to inexistent	Nagata (2003)
Acetone	1.95	0.94	Pungent, Fruity, Sweet, Minty	Jiang et al. (2017)
Styrene	1.86	0.15	Sweet, Balsamic, Floral	Nagata (2003)
N-octane	1.78	71.00	Gasoline	Jiang et al. (2017)
Nonane	1.76	60.00	Gasoline	Jiang et al. (2017)

(...)

METHODOLOGY

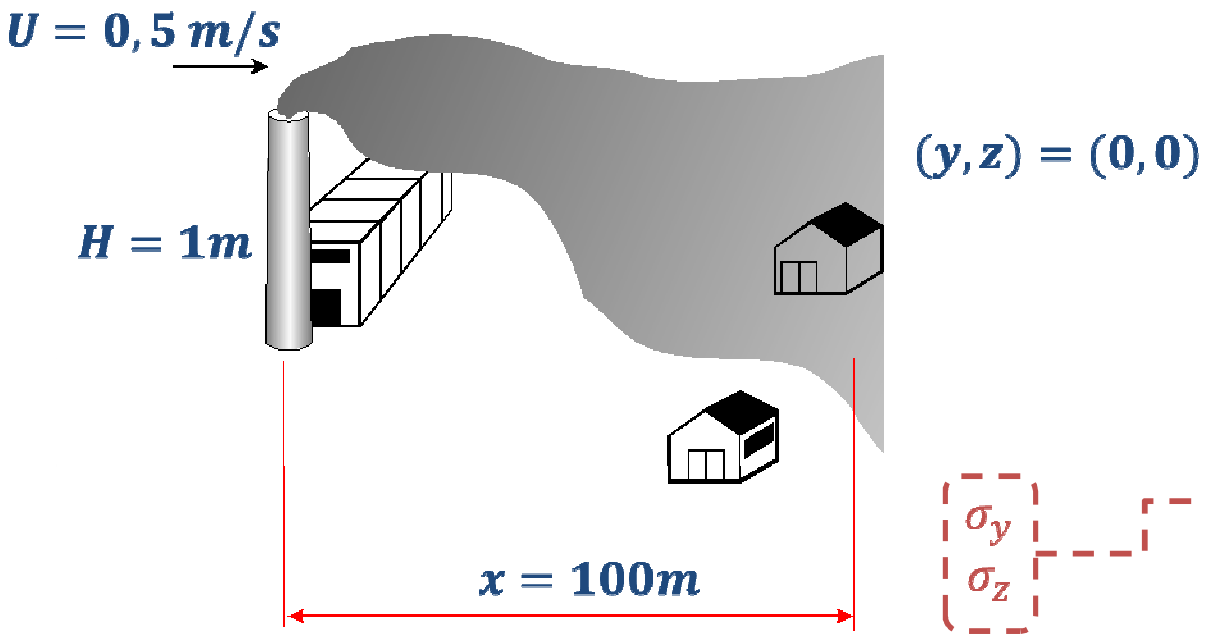


RANKING COMPOUNDS

Total emission rate for every odorous compound

$$C_m(x,y,z) = \frac{Q}{2\pi U \sigma_y \sigma_z} exp\left(-\frac{y^2}{2\sigma_y^2}\right).\left[exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right) + exp\left(-\frac{(z+H)^2}{2\sigma_z^2}\right)\right]$$

$$\frac{C_p}{C_m} = \left(\frac{t_p}{t_m}\right)^n$$



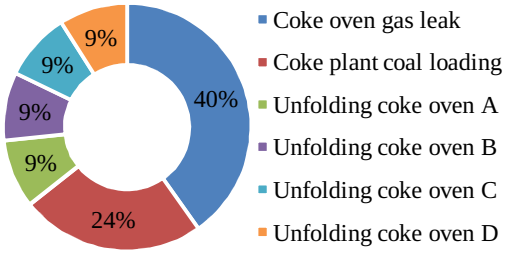
σ_y
σ_z

Stable atmosphere

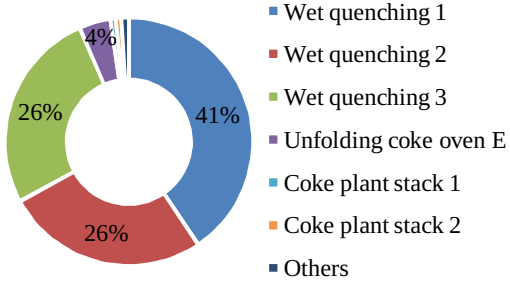
RANKING COMPOUNDS

Compound	Total emission [kg/h]	Odor threshold [mg/m³]	Estimated concentration [mg/m³]	Odor/Smell
Benzene	169.3400	1.50000	5.4585	Sweet, solventy
Toluene	71.9000	0.40000	2.3175	Rubber, Tarry, Naphthalene
Ammonia	3.2400	0.03000	0.1045	Pungent, Disturbing
Ethylbenzene	3.9901	0.01000	0.1286	Sweet, solventy
Hydrogen sulfide	3.4600	0.00006	0.1114	Rotten eggs

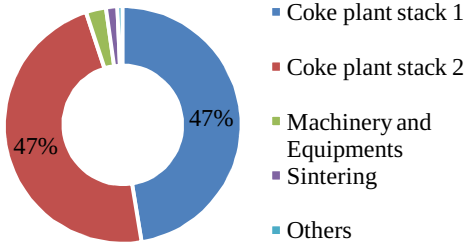
Ammonia (3.24 kg/h)



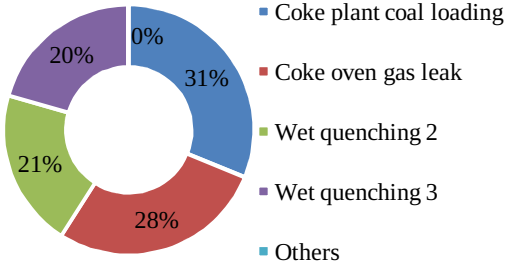
Benzene (169.34 kg/h)



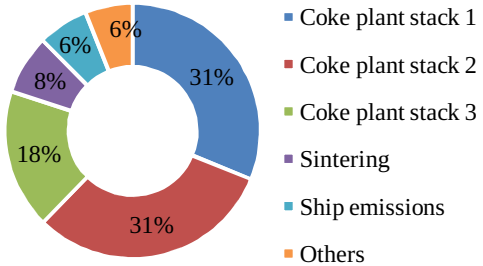
Ethylbenzene (3.24 kg/h)



Hydrogen sulfide (3.46 kg/h)



Toluene (71.90 kg/h)



FUTURE RESEARCH – AMPLIFY DATABASE

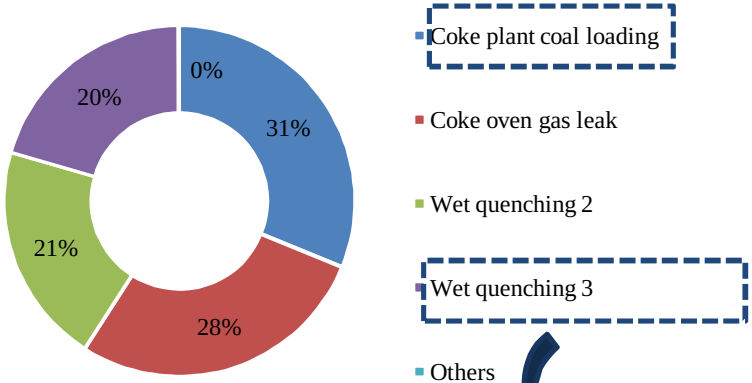
What other sources are lefting a VOC/TRS profile for a complete inventory

?

FUTURE RESEARCH – MANAGEMENT PRACTICES

What operational parameters are relevant to the emission of odorous compounds

?



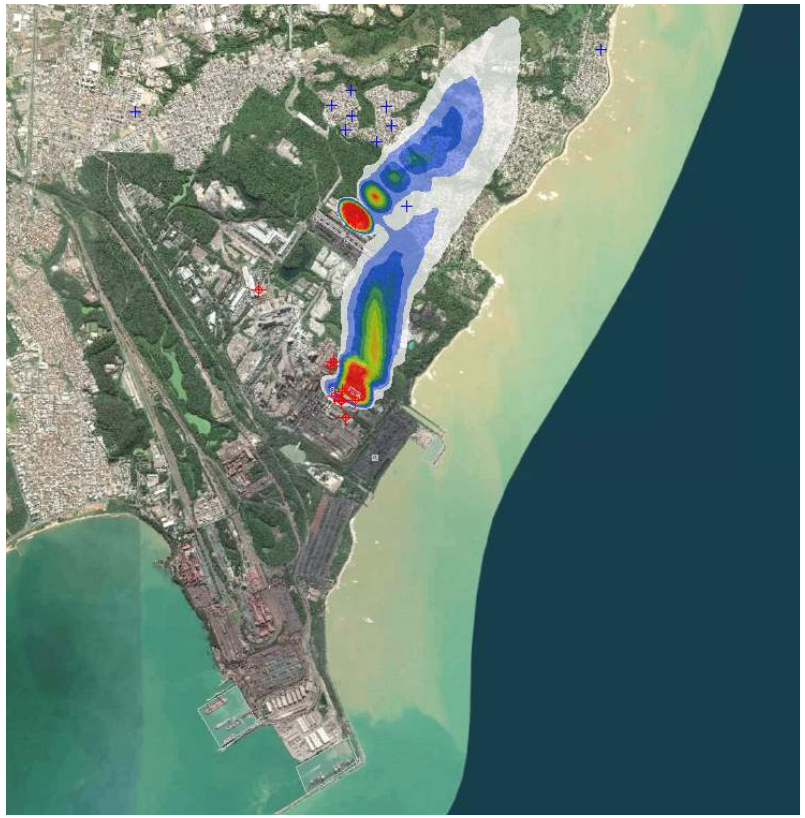
How to lower emissions during such operation?

Is it possible to use a different process (e.g Dry quenching)?

FUTURE RESERACH – DISPERSION MODELLING

What are the worst case scenarios of emission

?



REFERENCES*

*for the complete list please refer to the paper

ABDUL-WAHAB, S. et al. A study to investigate the key sources of odors in Al-Multaqa Village, Sultanate of Oman. **Environmental Forensics**, v. 18, n. 1, p. 15–35, 2017. Disponível em: <http://dx.doi.org/10.1080/15275922.2016.1230911>.

ABRAHAM, M. H. et al. An algorithm for 353 odor detection thresholds in humans. **Chemical Senses**, v. 37, n. 3, p. 207–218, 2012.

BADACH, J. et al. A case study of odour nuisance evaluation in the context of integrated urban planning. **Journal of Environmental Management**, v. 213, p. 417–424, 2018.

BORREGO, C., MONTEIRO, A., FERREIRA, J., MORAES M.R., CARVALHO, A., RIBEIRO, I. Modelling the photochemical pollution over the metropolitan area of Porto Alegre, Brazil. **Atmospheric Environment**, v. 44, p. 370–380, 2010.

BRANCHER, M. et al. A review of odour impact criteria in selected countries around the world. **Chemosphere**, v. 168, p. 1531–1570, 2017.

CAPELLI, L. et al. Measuring odours in the environment vs.Dispersion modelling: a review. **Atmos Environ**, v. 79, p. 731–743, 2013.

CAPELLI, L.; SIRONI, S.; DEL ROSSO, R. Electronic Noses for Environmental Monitoring Applications. **Sensors**, v. 14, n. 11, p. 19979–20007, 2014. Disponível em: <http://www.mdpi.com/1424-8220/14/11/19979/>.

DRAVNIEKS, A.; FOREST, P. Atlas of Odor Character Profiles. **Atlas of Odor Character Profiles**, 2015.

IEMA. **Inventário de emissões atmosféricas da Região da Grande Vitória - ano base 2015**. . [S.l: s.n.], 2019.

JIANG, G. et al. Odor emissions from domestic wastewater: A review. **Critical Reviews in Environmental Science and Technology**, v. 47, n. 17, p. 1581–1611, 2017.

LAOR, Y.; PARKER, D.; PAGÉ, T. Measurement, prediction, and monitoring of odors in the environment: A critical review. **Reviews in Chemical Engineering**, v. 30, n. 2, p. 139–166, 2014.

LEONARDOS, G.; KENDALL, D.; BARNARD, N. Odor threshold determinations of 53 odorant chemicals. **Journal of the Air Pollution Control Association**, v. 19, n. 2, p. 91–95, 1969.

LUCIANO, A. et al. The modelling of odour dispersion as a support tool for the improvements of high odours impact plants. **Environmental Technology (United Kingdom)**, v. 38, n. 5, p. 588–597, 2017.

NICELL, J. A. Assessment and regulation of odour impacts Jim. **Atmospheric Environment**, v. 43, n. 2, p. 195–206, 2009. Disponível em: <http://dx.doi.org/10.1016/j.atmosenv.2008.09.033>.

RAPPERT, S.; MÜLLER, R. Odor compounds in waste gas emissions from agricultural operations and food industries. **Waste Management**, v. 25, n. 9, p. 887–907, 2005.

RUTH, J. H. Odor Thresholds and Irritation Levels of Several Chemical Substances: A Review. **American Industrial Hygiene Association Journal**, v. 47, n. 3, p. A-142-A-151, 1986.

SCHIFFMAN, S. S.; WILLIAMS, C. M. Science of odor as a potential health issue. **Journal of environmental quality**, v. 34, n. 1, p. 129–38, 2005. Disponível em: <http://www.ncbi.nlm.nih.gov/pubmed/15647542>.

SEINFELD, J. H.; PANDIS, S. N. **Atmospheric Chemistry and Physics: from Air Pollution to Climate Change**. Second ed. [S.l.]: John Wiley & Sons, Inc., 2006. v. 51.

SIRONI, S. et al. Development of a system for the continuous monitoring of odours from a composting plant: Focus on training, data processing and results validation methods. **Sensors and Actuators, B: Chemical**, v. 124, n. 2, p. 336–346, 2007.

_____. Odour impact assessment by means of dynamic olfactometry, dispersion modelling and social participation. **Atmospheric Environment**, v. 44, n. 3, p. 354–360, 2010.

TALAIEKHOZANI, A. et al. An overview of principles of odor production, emission, and control methods in wastewater collection and treatment systems. **Journal of Environmental Management**, v. 170, p. 186–206, 2016. Disponível em: <http://dx.doi.org/10.1016/j.jenvman.2016.01.021>.

THURSTON, G. D. Outdoor Air Pollution: Sources, Atmospheric Transport, and Human Health Effects. **Int. Encycl. Public Heal.** [S.l.]: Reference Module in Biomedical Sciences, 2017. p. 367–377.

U.S. EPA. Clarification of regulatory status of CALPUFF for near-field applications. p. 1–7, 2008.

THANK YOU!

MUCHAS GRACIAS!

OBRIGADO!

OLORES·19
LA CONFERENCIA HISPANA DE OLORES

Authors
Davi de Ferreyro Monticelli,
Bruno Furieri,
Vitor Ferreira Lavor,
Elisa Valentim Goulart,
Jane Meri Santos,
Neyval Costa Reis Jr,
Elson Silva Galvão,
Erick Lopes
Milena Machado Melo

NQUALIAR
NÚCLEO DE ESTUDOS DA QUALIDADE DO AR

UFES
FEDERAL UNIVERSITY OF ESPÍRITO SANTO