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Review article

Analysis of benzene air quality standards, monitoring methods and concentrations in indoor and outdoor environment

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ABSTRACT

Benzene is a proven carcinogen. Its synergistic action with other pollutants can damage different components of the biosphere. Literature comparing the air quality standards of benzene, its monitoring methods and global concentrations are sparse. This study compiles the worldwide available air quality standards for benzene and highlights the importance of strict and uniform standards all over the world. It was found that out of the 193 United Nation member states, only 53 countries, including the European Union member states, have ambient air quality standard for benzene. Even where standards were available, in most cases, they were not protective of public health. An extensive literature review was conducted to compile the available monitoring and analysis methods for benzene, and found that the most preferred method, i.e, analyzing by Gas Chromatography and Mass spectroscopy is not cost effective and not suitable for real-time continuous monitoring. The study compared the concentrations of benzene in the indoor and outdoor air reported from different countries. Though the higher concentrations of benzene noticed in the survey were mostly from Asian countries, both in the case of indoor and outdoor air, the concentrations were not statistically different across the various continents. Based on the analyzed data, the average benzene level in the ambient air of Asian countries (371 $\mu g/m^3$) was approximately 3.5 times higher than the indoor benzene levels (111 $\mu g/m^3$). Similarly, the outdoor to the indoor ratio of benzene level in European and North American Countries were found to be 1.2 and 7.7, respectively. This compilation will help the policymakers to include/revise the standards for benzene in future air quality guideline amendments.

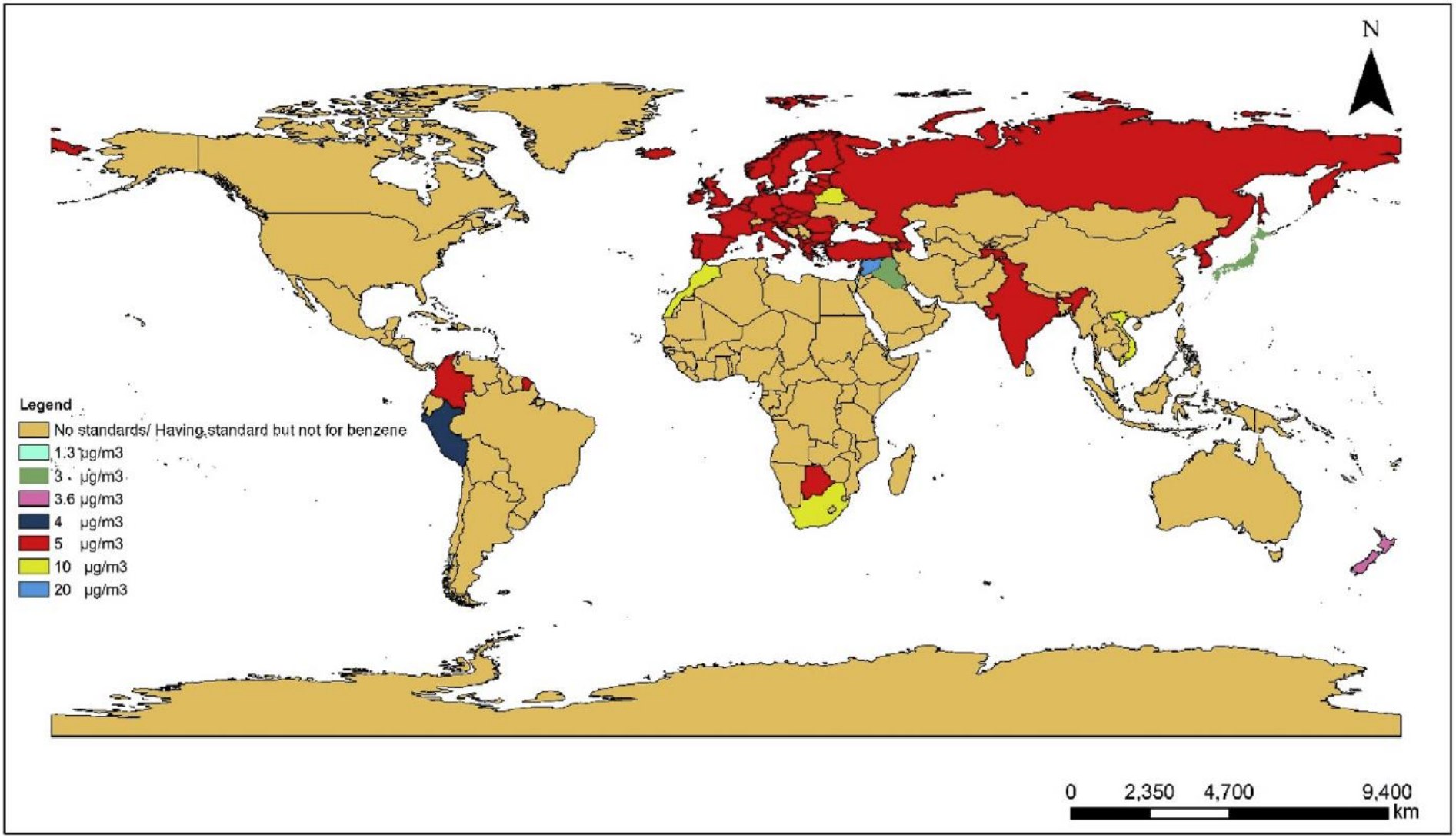

Figure 1. Map representing worldwide standards for benzene.

Table 2. Worldwide ambient air quality standards for benzene.

Continent	Country	Limit (μg/m^3)	Averaging interval	Standard/Definitions	Reference
Asia	India	5	Annual	Air quality standards	(Central Pollution Control Board, 2009)
Asia	Iraq	3	Annual	Air quality standards	(Ministry of Oil, 2018)
Asia	Japan	3	Annual	Air quality standards	(Ministry of Environment, 2009)
Asia	Lebanon	5	Annual	Limit value	(European Union, 2016)
Asia	Russia	100 300 5	24 h 20 min Annual	Maximum Allowable Concentration GN 2.1.6.1338–03 for sanitary protection zone	(ENVIRON, 2014)
Asia	South Korea	5	Annual	Air quality standard	(Ministry for the Environment South Korea, 2010)
Asia	Syria	20	Annual'	Air quality standard	(Offical Gazetta, 2003)
Asia	Vietnam	22 10	1 h Annual	National Technical Regulation on Hazardous Substances in Ambient Air (QCVN 06:2009/BTNMT)	(Clean Air Initiative for Asian Cities (CAI-Asia) Center, 2010)
Asia	Israel	3.9 1.3	24 h Annual	Air quality standards	(Department of Environmental health, 2017)
Australia	New Zealand	5 (2002) 3.6 (2010)	Annual	Air quality standards	(Ministry for the Environment and the Ministry of Health, 2002)
Africa	Botswana	5	Annual	Air quality standards	(Modupe O. Akinola, 2017)
Africa	Morocco	10	Annual	Air quality standards	(Chirmata et al., 2017)
Africa	South Africa	10	Annual	Air quality standards	(Department of Environmental Affairs South Africa, 2009)
Europe	European Union	5	Annual	The limit value for human health protection	(European Union, 2008)
Europe	France	2	Annual	Long-term objective	(Air quality observatory in the Paris region, 2018)
Europe	Albania	5	8 h	Primary and secondary standards	(Environmental center for Administration and Technology, 2008)
Europe	Belarus	40 10	24 h Annual	Maximum allowable concentration	(European Union, 2012)
Europe	Sweden	Upper threshold: 3.5 Lower threshold: 2	Annual	Environmental quality standards	(Swedish Code of Statutes, 2010)
Europe	Malta	Upper threshold: 3.5 Lower threshold: 2	Annual	Ambient air quality regulations	(Ambient air quality Standards Malta, 2010)
Europe	Scotland	3.25	Annual	Objective value	(Air Pollution Information System, 2016)
Europe	Northern Ireland	3.25	Annual	Objective value	(Air Pollution Information System, 2016)
S. America	Colombia	5	Annual	Maximum allowable concentration	(Airlex worldwide Air quality legislation, 2013)
S. America	Peru	4	Annual	Air quality standards	(Decreto Supremo N 074, 2001-Pcm, 2007)
N. America	Cuba	1000	20 min	Maximum allowable concentration	(Airlex worldwide Air quality legislation, 2013)