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Indoor Air Quality Guidelines Connection to IAQ Certification and Labelling Process

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***Abstract* – The world's leading indoor air quality guidelines provide for the identification of certain parameters with a specific limit value based on the latest empirical measurements, however, most of them do not have legal coverage and are voluntary. This leads to unequal assessment of indoor air quality, because there is an identifiable difference between the limit values set out in the various guidelines. And these values would be related to the results obtained during the experimental activities of the application of the specific parameters and the interpretation of their effects on human health. The aim of this IAQ guideline and IAQ certification review was to develop IAQ label for Nordic countries and to find gaps the legislation established by the Latvian government. The development of indoor air quality labels provides an opportunity to maintain and promote the optimal functionality of human physiological processes and the sustainability of the building.**

***Keywords* – Actions; indoor air criteria; indoor environment; health; pollution prevention; quality labels**

1. INTRODUCTION

Indoor air quality (IAQ) is a common term used by public health professionals and occupational safety specialists and has become a more frequently heard term for the last two years in connection with the global pandemic. It describes the quality of air within a building environment [1]. It is an immense discussion in public, governmental and legislative institutions, as well as the worldwide leading influential organisations because of its prodigious impact on human health [2]. Human exposure to air pollutants in the indoor environment has a negative outcome on the welfare, comfort and health of occupants. Even one missed indoor air quality criteria, if left unchecked, can reduce IAQ in a building and that could weaken the efficiency of the building in terms of air quality [3]. Therefore, many countries` governmental organisations and worldwide influential institutions have set out standards and guidelines that are compatible with desired IAQ control [4], [5]. These IAQ guidelines include limit values for air pollutants to reduce exposure to humans [3].

Commonly found air pollutants in indoor environment are carbon dioxide (CO_2), formaldehyde (HCHO), total volatile organic compounds (TVOCs), ozone (O_3), some outdoor pollutants, like, nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2) and particulate matter (PM2.5 and PM10), they all contribute to diminish IAQ. Nevertheless, IAQ criteria, such as, air temperature, air flow rate and humidity levels, which are also associated with thermal comfort, contribute to the indoor environment and the

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efficiency of the building [1]. As a result, disregarding IAQ guidelines and standards may cause sick building syndrome (SBS) [6]. SBS term describes an indoor environment with a poor IAQ and can result in acute health or comfort related effects (no specific illness or cause can be identified other than being in the building) [6], [7]. The inauspicious side effects of SBS on health might be nausea, dizziness, headaches, eye, nose or throat irritation, dry cough and sometimes personality changes [8].

Generally, IAQ standards and guidelines set up recommended air pollutant limit values for facilities during design and construction process. If the values are not achieved by the handover date of the building and IAQ guidelines are legally binding. Never the less, in some countries, such as Japan or South Korea, it can result in the penalty or punishment for facilities owner. In other countries IAQ guidelines are only recommendations, and do not have a legal aspect to them, for example, UK and US, that use industry technical guides [4], [9]. It should be noted that there are countries without IAQ standards or guidelines, for example, India [4]. For detail information on criteria requirements for standards or guidelines, refer to the cited documents for additional information. Because of these legal differences in IAQ standards and guidelines, there is also a volunteering IAQ certification process. This certification process helps to deal with the same problem – minimise health effects and reduce the probability of Sick Building Syndrome. Besides the IAQ guidelines and IAQ certification process, there is also a Green Building certification scheme that only assesses indoor environment quality in buildings undergoing energy renovation [5], [10], [11].

The present work, initiated within the Student Research and Innovation Grant project, was consequently performed to review IAQ guidelines and certification labels, as well systematise criteria for IAQ in process to develop an indoor air quality label for Nordic countries.

2. Selection Principles of IAQ Guidelines and IAQ Certification

Nine IAQ guidelines and eleven IAQ certification labels were reviewed to identify and outline the parameters that are currently used to evaluate IAQ in buildings and grant quality labels with a focus on non-residential premises. The search for government guidelines and legislation was conducted on the official government websites, and all laws and standards in English, Russian, German, and Latvian related to indoor air quality were included and analysed. Moreover, commercial labels and certification were surveyed by browsing the Internet. Within each IAQ guideline air quality criteria were identified and determined in prescribed ranges. For better comparison several pollutants were converted to equal dimensions (from $\mu g/m^3$ to ppm). For IAQ labels, only information included on the official website of IAQ label (brand) was used. Some IAQ labels that focus on emissions of material not indoor air itself also were included, because of their connection to IAQ. However, Green building certification programs were excluded, because even if IAQ is considered in the building certification scheme, the main focus of the certification process is energy saving.

The peer-review literature search amplifying the overview of IAQ guidelines was accomplished to identify articles providing additional data on specific IAQ criteria to the overall rating of IAQ in buildings and limit value connection to health problems of building occupants. Search for publications was performed in English, Russian and German using online databases – Wiley Online Library, ProQuest, ScienceDirect and EBSCO using terms and combinations of them. Terms were searched in title, abstract and keywords, the following terms were used: 'indoor air', 'guideline', 'public building' (or 'school', 'shop', 'hospital', 'concert hall'), 'measurement', 'concentration', 'indoor pollutant', 'certification', 'indoor air quality' plural form of terms was also searched as well as combination of terms.

3. OVERVIEW AND DISCUSSION

3.1. Indoor Air Quality Guideline Limits

The reference to the leading indoor air quality guidelines sets the regulatory values for the essential air quality markers. International established air quality guidelines and standards are listed in Table 1.

The Environmental Protection Agency (EPA) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) bring forward similar regulatory values. It is important to note that these guidelines do not contain microclimate limits. However, this aspect would be related to the effect of temperature, relative humidity and air speed on emission levels and human health as well [12]. Moreover, it should be mentioned that ASHRAE and EPA aim to provide carefully designed standards to help professionals assess and improve the ventilation of private and commercial buildings [13].

Au contraire, the Occupational Safety and Health Administration (OSHA) has developed sound standards for ventilation, with particular emphasis on the education and medical sectors, but lacks information on IAQ of public buildings. At the same time, the National Institute for Occupational Safety and Health (NIOSH) highlights air quality factors that affect human health in the workplace, also underlining strategic goals to improve the work environment [14]. Additionally, one important factor in the guidelines is the concentration of carbon dioxide over a 10-hour interval within a 40-hour working week. The indicator limits are 5000 ppm for 8-hour work day, which is five times higher than the limit recommended in other guidelines.

Additionally, the guidelines of the World Health Organization (WHO) state that an exposure limit value of 8-hour or 24-hour should be established for important IAQ criteria that have a considerable impact on health. In particular, the presence of formaldehyde as a toxic compound, the exposure limit for a 30-minute interval, limit values compared to other guidelines are on average 5 units lower, which indicates a special emphasis on human health. Although, WHO does not limit the carbon dioxide concentration in indoor environment due to a potential correlation between suspended particles and CO_2 molecules, which would make it doubtful to determine a specific CO_2 limit value in order to judge air quality [2]. Consequently, studies have shown that the particulate matter may be increased at normal levels of carbon dioxide [15].

Furthermore, the review of the legislative framework of the Republic of Latvia shows a clear goal to achieve good indoor air quality in relation to the places for the pursuit of intellectual work, namely schools. These are spaces where air quality is particularly important for high quality mental activity and cognitive function [15]–[18].

The IAQ limit values are complex in terms of exposure to building materials, ventilation efficiency, biological contamination and occupants’ activities. The assessment of indoor air quality should distinguish between complex structures, for example investigate the sources of exposure to gain a deeper understanding of their potential impact on residents.

3.2. Indoor Air Quality Criteria

3.2.1. Indoor Air Chemical Pollution

The recommended value ranges of these criteria that stipulate conditions for the health and well-being of building occupants. Indoor air chemical pollutants assessed in IAQ guidelines and standards were carbon dioxide, carbon monoxide, nitrogen dioxide, aldehydes, ozone, radon, total volatile organic compounds, particulate matter (PM2.5 and PM10), total particle count.

Carbon dioxide (CO_2) is a colourless, tasteless, odourless, and non-flammable gas that is heavier than air. The main source of CO_2 in the non-industrial indoor environment is human metabolism [19]. Office workers exposed to indoor CO_2 concentrations higher than 800 ppm reported a significant increase in eye irritation and upper respiratory symptoms [19], [20], but a short-term CO_2 exposure beginning at 1000 ppm was associated with an increase in heart rate and in number of symptoms: skin problems, headaches and reduction in cognitive performances including decision making and problem resolution [21]. Respiratory symptoms have been indicated in children exposed to indoor CO_2 concentrations higher than 1000 ppm and it showed significantly higher risk for dry cough and rhinitis [19], however the symptoms of asthma and allergy have been reported already from CO_2 concentration of 900 ppm [5]. Although, groups exposed for a couple of hours to levels higher than 1500 ppm CO_2 showed an increase in their blood pressure and heart rate compared to the 600 ppm exposure group [19].

Particulate matter (also referred to as PM or particle pollution) is a complex mixture of solid and liquid particles suspended in the air. These particles can vary in size, shape and composition [22], [23]. In many studies were reported PM harmful effects to human health.

PM10 is especially associated with cardiovascular and respiratory mortality, hospitalizations, and emergency room visits for acute respiratory infections [23]. However, PM2.5 is more dangerous as it can penetrate deeper into the human respiratory tract and the toxic compounds that are part of the particles can have severe health impacts [24]. PM2.5 was also associated with total and cardiovascular (but not respiratory) mortality [25] and the mortality attributable to PM2.5 was about 7.1 % of global mortality in the year 2010. In the Global Burden of Disease (GBD) study, it was indicated that PM2.5 was responsible for 4.09 million premature deaths in 2016 [26].

Ozone is one of the most critical inorganic pollutants due to its high reactivity and many adverse health effects. Human exposure to ozone is primarily by inhalation, but reactions on the skin are also reported [27]. The indoor ozone can affect human health and can also react with gaseous chemicals and building materials, resulting in by-products. The indoor ozone concentration depends on the outdoor concentration as an ambient ozone enter buildings through doors, windows and ventilation system and, the indoor air change rate and indoor ozone emission sources such as photocopiers, laser printers, disinfectors, air purifiers, ozone generators, and other household appliances [28]. Epidemiological studies in public office buildings indicated associations between late afternoon outdoor ozone and upper respiratory and eye symptoms [29]. More recent studies have shown that daily exposure to high levels of ozone may cause DNA damage, as previously reported for operators in photocopier centres [27].

Carbon monoxide (CO) is considered to be a very dangerous indoor environment compound, because of its odourless, colourless, tasteless and lethal qualities. CO is emitted during the incomplete combustion of carbonaceous fuels such as wood, petrol, coal or natural gas. High concentrations in the indoor environment indicate incorrectly installed, or poorly maintained gas heaters, cookers, leaking chimneys or automobile exhaust from attached garages [14], [22], [23]. Exposure to higher concentrations can cause unconsciousness and death but short time exposure or lower concentrations can cause damage to the central nervous system, psychiatric changes and affect the cardiovascular system [30].

In the absence of indoor carbon monoxide sources, the indoor air concentration is the same as the concentration of ventilated outdoor air, which is well below the level of existing air quality guidelines and standards [31]. Therefore, to assess whether CO monitoring is necessary, a building survey should be carried out in the building concerned.

TABLE 1. INTERNATIONAL INDOOR AIR GUIDELINES AND REPRESENTED AIR QUALITY PARAMETERS FOR 8 HOUR EXPOSURE

	LV	**ASHRAE**	**CA**	**EPA**	**FI**	**PHE**	**NIOSH**	**OSHA**	**WHO**
CO_2	1000 ppm (2021)		100 ppm (24 h) (2021)		700 ppm (S1); 900ppm (S2); 1200 ppm (S3) (2001)	5000 ppm (2005)	5000 ppm (10 h) (2019)	5000 ppm (2020)	
CO		25 ppm (2004)	10 ppm (24 h) (2021)	25 ppm (2009)	2 ppm (S1); 3 ppm(S2); 8 ppm (S3) (2001)	10 ppm (2021)	35 ppm (2019)	50 ppm (2019)	4 ppm (2021)
HCHO		0.081 ppm (30min) (2004)	0.05 ppm (2021)	0.1 ppm (2021)	0.03 ppm (S1); 0.05 ppm(S2); 0.1 ppm (S3) (2001)	0.1 ppm (30 min) (2019)	0.016 ppm (2019)	0.75 ppm (15 min) (2019)	0.1 ppm (30 min) (2010)
Acetaldehyde			0.28 ppm (2021)	0.14 ppm (2020)		1.42 ppm (2019)		180 mg/m^3 (1989)	
TVOC			0.00044 ppm (2021)					0.44 ppm (24 h)	0.0001 ppm (2002)
NO_2		0.2 ppm (2004)	0.2 ppm (2013)	0.2 ppm (2020)	0.2 ppm (S1); 0.3 ppm (S2); 0.6 ppm(S3) (2001)	0.3 ppm (2020)			0.3 ppm (2010)
O_3		0.1 ppm (2020)	0.002 ppm (2021)	0.188 ppm (2020)		0.04 ppm (2020)	1 ppm (2019)	5 ppm (2021)	0.025 ppm (24 h) (2021)
PM2.5		0.1 ppm (2004)	0.04 ppm (2021)	0.065 ppm (2020)	0.02 ppm (S1); 0.05 ppm (S2); 0.08 ppm (S3) (2013)	0.1 ppm (2021)	0.1 ppm (TWA) 2019	0.1 ppm (1 h) (1978)	0.1 ppm (2021)
PM10		0.025 ppm (24 h) (2020)		0.025 ppm (24 h) (2020)		0.025 ppm (24 h) (2010)		5 ppm (2004)	0.015 ppm (24 h) (2021)
Temperature summer/ winter	20.0–28.0 °C/ 19.0–25.0 °C (2009)	22.5–26.0 °C/ 20.0–23.5 °C (2013)			23–24 °C*;23–26 °C**;22–27 °C***/ 21–22 °C*; 20–22 °C*; 20–23 °C*** (2001)	In winter 20–25 °C (2005)			
Relative humidity	3–70 % (2009)	40–60 % / 30–60% (2013)	30–80% / 30–55% (1989)		25–45%* (2001)				
Air flow rate	0.05–0.15 m/s (2009)				0.13 m/s*; 0.16 m/s**; 0.19 m/s*** (2001)				0.25 m/s (2013)
MC			<500 CFU/m^3 (1995)					<1000 CFU/m^3 (1992)	<500 CFU/m^3 (1988)

Note: limit value (last year of approval); a – 30 min exposure limit; b – 15 min exposure limit; c – 24 h exposure limit; d – 1 h exposure limit; WHO – world health organization [2], [31]; OSHA – Occupational Safety and Health Administration, US [32]; EPA – Office of Environmental Health, US [22]; ASHRAE – American Society of Heating, Refrigerating and Air Conditioning Engineers, US [33]; PHE – Public Health England, UK [34], [35]; CA – Health Canada, Canada [23], [36]; FI – Finnish Society of Indoor air Quality and Climate, Category for IAQ *(S1 – The best IAQ), ** (S2 – Good IAQ), ***(S3 – Satisfactory IAQ) [37]; LV – Republic of Latvia [38], [39]; NIOSH – The National Institute for Occupational Safety and Health, US [14].

However, the source of NO_2 emissions is various types of combustion of fuels, such as gas and diesel, power stations or forming in the atmosphere from nitric oxide (NO) which is also initially produced during the combustion process. Gas appliances, space heating boilers, cookers and tobacco smoke are the main indoor sources of NO_2 [40]. World Health Organization report shows that in the absence of indoor NO_2 sources, emission levels indoors are lower than outdoor levels [40]. Long- and short-time exposure to NO_2 can intensify allergic responses, causing inflammation of the airways in the lungs. Short term exposure may be associated with risk of cardiovascular disease and premature mortality.

Aldehydes are a common constituent of building materials used in floor boards, carpeting and furniture. Formaldehyde is considered a carcinogen and can cause cancer of the nasal cavity [41]. Aldehyde levels were based on individual concentrations affecting health of each aldehyde – formaldehyde 50–100 μg/m^3, acetaldehyde 280–1420 μg/m^3, acrolein 0.44–38 μg/m^3 [42].

Volatile organic compounds (VOCs) are one of the major pollutants commonly found in indoor environments. Various organic compounds can be detected in the indoor environment including: aromatic hydrocarbons, aliphatic alcohols, saturated aliphatic hydrocarbons (n, -iso, cyclo-), aldehydes, aromatic alcohols, glycols, glycol ethers and terpenes [35].

Considering there are over 500 types of VOCs detectable in the indoor environment, it's complicated to continuously monitor all of them incessantly, therefore it`s more applicable to measure total volatile organic compounds (TVOC). TVOC refers to the sum of identified and unidentified VOC concentrations on the premises [43].

As TVOC covers a wide range of organic gases that may be chemically similar but difficult to distinguish and differ in their toxicological properties it must be taken in account that TVOC measurements provide restrictive information on the possible toxicity and concentrations of individual compounds present. Typical health impacts of VOCs range from sensory irritation of the respiratory tract, eyes, allergies, headaches to cancer risks even at low and medium levels of exposure [44].

3.2.2. Microbiology Contaminates (MC)

The concentration of microbiological contamination indoors is determined by factors such as an untidy environment and increased humidity. Microbiological contamination appears as an IAQ problem in built-up basements and bathrooms, in rooms with air conditioning and humidifiers, without regular maintenance, and in rooms with soft floors. Moulds are characterised by the production of toxins and mycotoxins. Exposure to microbiological toxins at clinically low doses can cause fever, vasodilation, increased antibody synthesis, inflammation, but at high doses - shock and intravascular coagulation. The most dangerous aflatoxins (a type of mycotoxin that can cause cancer) are produced by the fungi *Aspergillus*, *Fusarium*, *Cladosporium* and *Penicillium* [45].

Many bacteria are characterised by airborne transmission. Pseudomonas aeruginosa can spread through the air during certain procedures, such as removing bandages from a leg ulcer or piercing an abscess [45]. However, staying in a mould-saturated room or building causes irritation, allergies and respiratory diseases. Mould growth is also a problem in hospitals and kindergartens and can have a negative impact on the health if moisture damage remains unresolved [46], [47].

3.2.3. Indoor Air Thermal Criteria

Temperature is a parameter that characterises the degree of ambient heat and the most appropriate value is the one that corresponds with a person’s subjective well-being. In a relatively calm state the most suitable temperature is from 18 to 20 °C [48]. Temperature is also influenced by the seasons and individual human characteristics (biological thermal insulation).

However, the body’s heat exchange and productivity are affected by temperatures above 25 °C and below 15 °C. The heat indifferent zone is between these temperatures, based on the fact that it has the lowest metabolic rate and heat production is almost constant [4], [49].

Relative humidity is the concentration of water vapour in the air [12]. Excessive humidity adversely affects the body's thermoregulation at both elevated and low temperatures. As the humidity level increases, the evaporation of sweat becomes more difficult and the body's heat output decreases. The most significant of the hygrometric indicators are the relative humidity and the humidity deficit [37].

Third factor of thermal comfort is air flow rate. The difference in temperature and pressure ensures the air masses movement. A person does not feel the air movement at a speed of 0.03 m/s, but the skin receptors perceive these fluctuations. A person senses the air movement when its speed is 0.1 m/s. If the air speed exceeds 0.3 m/s, it is drafted [49].

3.3. IAQ Certification Labels

The available indoor air quality certificates provide an assessment of a wide range of air parameters to meet the customer's needs. The study covered 11 different certificates that ensure optimal indoor air quality. Reviews of each IAQ certification label are summarized in Table 2.

TABLE 2. INDOOR AIR QUALITY CERTIFICATIONS

Name (Country)	**Review**	**IAQ parameters***
AirScore (UK)	AirScore is an AirRated certification based on leading medical and scientific research as well as industry best practice guidelines. Ratings are divided into several levels, starting with ‘AirScore Certified’, ‘Silver’, ‘Gold’ and the highest level ‘Platinum’	Humidity, Temperature, PM2.5, VOCs, CO_2
The Inside Advantage (US)	Inside Advantage ™ is a customised certification program that allows institutions such as schools, hospitals, senior living centres and office complexes to continuously manage their IAQ to achieve greater productivity.	Humidity, Temperature, PM2.5 (<12 μg/m^3), VOCs (<400 μg/m^3), CO_2 (<600 ppm)
RESET Air (China)	The RESET Air standard specifies requirements for the collection of IAQ data with continuous indoor monitoring to obtain indoor air quality data that is reliable and usable. RESET focuses on human health as a key objective, taking care of indicators that have a direct impact on human health.	Humidity, Temperature, PM2.5 (<35 μg/m^3, <12 μg/m^3), VOCs (<500 μg/m^3, <400 μg/m^3) CO_2 (<1000 ppm, <600 ppm)
TIEQMA (Thailand)	Taiwan's IAQ certification systems are innovative indoor air quality labels for various public buildings, so that improving indoor air quality can better meet the needs of different building occupants and be more targeted. The label has three levels.	CO_2 (800 ppm), CO (2 ppm), Formaldehyde (0.03 ppm), TVOC, Bacteria (800 CFU/m^3), Fungi, PM10 (50 μg/m^3), PM2.5, O_3

INDOOR AIR QUALITY AWARDS (US)	The Air Quality Awards program recognizes visionary facility leadership in creating spaces that either meet or exceed these critical indoor air quality standards. These awards also provide a visible means for the public to understand how each space protects them and purifies the air they breathe. Recognizing and publicising these air quality benefits and achievements also further encourages indoor air quality stewardship in even more shared spaces.	Platinum standard: Temperature (In summer 20–24 ºC, In winter 24–27 ºC), Humidity (40–50 %), CO_2 (<1090 ppm), PM2.5 (<15 µg/m^3), PM10 (<50 µg/m^3), CO (<9 ppm), TVOC (<500 µg/m^3), Air quality monitoring
IAQ Certification Scheme (China)	To improve IAQ and promote public awareness of the importance of IAQ, the Government has implemented an IAQ Management Programme. A core element of the Programme is to launch a voluntary IAQ Certification Scheme for Offices and Public Places. The IAQ Certification Scheme aims to recognise good IAQ management practices and provide incentives for owners of premises/buildings or property management companies to pursue the best level of IAQ.	Excellent Class: Temperature (20–<25.5 ºC), Humidity (40–<70 %), Air Movement (<0.2 m/s), CO_2 (<800 ppm), CO (<1.7 ppm), PM10 (<20 µg/m^3), NO_2 (<40 µg/m^3), O_3 (<50 µg/m^3), Formaldehyde (<30 µg/m^3), TVOC (<200 µg/m^3), Rn (<150 Bq/m^3), Bacteria (<500 CFU/m^3)
Indoor airPLUS homes (US)	Indoor airPLUS is a voluntary partnership and labelling program that helps new home builders improve indoor air quality by requiring construction practices and product specifications that reduce exposure to air pollutants.	Humidity, Radon, Pest control, combustion ventilation, building materials
WELL (US globally)	WELL Building Standard ™ Version 2 (WELL v2 ™) is a tool for buildings and organisations to provide smarter and more focused spaces that improve people's health and well-being. WELL includes a set of strategies supported by the latest research to improve human health through planning interventions and operational protocols and policies, and to promote a culture of health and well-being.	PM2.5 (<15 µg/m^3), PM10 (<50 µg/m^3), TVOC: Formaldehyde (<50 µg/m^3), Acetaldehyde (<500 µg/m^3); CO (<9 ppm), NO_2, O_3 (<51 µg/m^3), Radon (<0.15 Bq/L); Bacteria and fungi; Ventilation
Danish Indoor Climate Labelling (Denmark)	The DICL differs from EU Ecolabel and The Blue Label in setting standards for emitted chemical compounds and their effects on the indoor climate and health, rather than compounds and their effects on the environment and allergies.	Emission class 3: TVOC (<1000 µg/m^3)
Eurofins (Europe)	Eurofin's Indoor Air Comfort (IAC) product certification is a well-established means of demonstrating that a product meets the European low VOC emission criteria.	Emission of TVOC (1000 µg/m^3 after 3 days)
Eurovent HAHU (France)	This certification program applies to air filter elements that have been assessed and sold in accordance with EN ISO 16890-1: 2016.	VOC; Energy efficiency class limits for filter class according to EN ISO 16890

Note: * Indoor air parameters and exposure levels for granting IAQ label or certification if mentioned.

IAQ certification labels Airscore, The Inside Advantage, RESET Air, TIEQMA, WELL Building Standard, Indoor airPLUS Homes, INDOOR AIR QUALITY AWARDS (IAQA), IAQ Certification Scheme are aimed to assess and improve the IAQ of private and public buildings. Central object of certification is a human and human-friendly environment.

The WELL Building Standard specifically emphasises the fact that it works according to the latest scientific studies, operational protocols and policies aimed at improving human health. On the other hand, Indoor airPLUS Homes highlights the education and assessment of new building owners by requiring building practices and product specifications that reduce exposure to air pollutants. On the contrary INDOOR AIR QUALITY AWARDS identify buildings that either meet or exceed IAQ standards. But the IAQ Certification Scheme is a part of the People's Republic of China management program, to improve and raise public awareness of IAQ; it is a government-run, but voluntary process.

The indoor air quality of Eurovent HAHU, Eurofins and Danish Indoor Climate Labelling is viewed from the technical side and certifies building materials. The Eurovent HAHU certification programme covers the air filter elements evaluated by the International Organization for Standardization (ISO). However, the Eurofin 'Indoor Air Comfort' (IAC) has established means to demonstrate the low-VOC emission criteria at two levels: firstly, the standard level that shows the product compliance with the legal specification criteria issued by the European Union. Secondly, the higher level that shows the product emission compliance with voluntary specifications relevant to sustainable construction. The Danish Indoor Climate Labelling (DICL) certifies products that have been extensively and thoroughly tested and show low chemical emissions into indoor air. DICL sets standards for chemical emissions and their effects on indoor environment and health.

The most of IAQ certifications are based on IAQ guidelines, however AirScore, The Inside Advantage, RESET Air does not indicate which guidelines they are based on, this can lead to distrust of the label. The RESET certification is characterised by continuous monitoring to ensure that air quality is maintained after certification has been obtained. Eurovent HAHU French certification is based on ISO and CEN (European Committee for Standardisation) recommendations. On the other hand, the Eurofin specification includes an evaluation of emissions of VOC, based on recommendations from ECHA (European Chemicals Agency). In this case, the total exposure of the individual parameters from the indoor manufacture is assessed.

This review indicates that the end-consumer of IAQ label could be in the public and private sector, however maintaining the label requires a homogenous environment. This aspect would be relatively difficult for the private sector [8]. The decision of private building owners to purchase technical equipment to ensure homogeneity and maintain air quality is voluntary, therefore IAQ certification labels suggest that each private household should be assessed separately, which is not related to public buildings, where the whole building is valued and certified.

3.4. Latvian Indoor Air Quality Label

All IAQ criteria were studied in order to address overall indoor environment quality and were used in creation of indoor air quality label for Latvia, shown in Table 3. The assessment procedure, suitable for Latvian conditions, includes 13 IAQ parameters, set at three grades: Green, Amber and Red. Green level indicates that indoor air is very low in all measured pollutants, Amber grade represents good indoor air and Red grade has poorer indoor air, but it is still admissible. When assigning one of the 3 categories to a building, it is evaluated whether the building's ventilation system is properly maintained and whether HEPA or carbon filters are used. CO_2, temperature and relative humidity sensor set up in the ventilation system is also valued as a bonus. The assessment procedure also includes parameter thresholds that require immediate action on building or ventilation system maintenance. This evaluation procedure is suitable for the evaluation of public buildings, as it is possible to ensure a homogeneous environment in them thanks to the existing technical support. This evaluation procedure was developed based on researched literature in this study work group.

TABLE 3. INDOOR AIR QUALITY LABEL FOR LATVIA

	IAQ parameters	Green	Amber	Red	Not acceptable
	Parameters to be monitored				
1	CO_2, ppm	<800	<1000	<1000	>5000
2	Temperature, °C				
	Summertime	20–25	20–25*	20–25**	∓ 4 °C
	Wintertime	18–22	18–22*	18–22**	∓ 4 °C
3	Relative humidity, %	40–60	30–70	30–70***	<20 or >80
4	TVOC, μg/m^3	<100	100–300	>300	>1000
5	PM2.5, μg/m^3	<25	25–50	50–100	>150
	Parameters measured in the first evaluation process				
6	Air flow rate, m/s	0.05–0.15			>0.3
7	CO, mg/m^3	0	0	0	>10
8	Ozone, μg/m^3	<40	40–70	70–100	>100
9	Formaldehyde, μg/m^3	<50	50–70	70–100	>100
10	Acetaldehyde, μg/m^3	<280	280–500	500–1420	>1420
11	Acrolein, μg/m^3	<0.44	0.44–15	15–38	>38
12	NO_2, μg/m^3	<20	20–100	100–170	>170
13	Microorganisms, CFU/m^3	Common microorganisms <500 CFU Fungi and moulds <50 CFU staphylococci < 36 CFU pseudomonas 0 CFU			

Notes: * Allowed to exceed the specified interval 3 times at monthly intervals; ** Allowed to exceed the specified interval 6 times at monthly intervals; *** Allowed to exceed the specified interval 15 times at monthly intervals.

4. CONCLUSION

The present review summarises the IAQ guidelines, their connection to IAQ certification process and labelling. The limiting values and health effects for main air pollutants and variables for thermal comfort are summarised. This work facilitates the selection of parameters when assessing indoor air quality and helps to find the most appropriate quality brand for indoor air certification. This study indicates that each indoor air quality guideline focuses on evaluating specific parameters based on the potential benefits of identifying air risks and assessing them. All examined air pollutants are experienced similarly by the countries within one continent, however some contaminates vary between guidelines such as carbon dioxide and formaldehyde. None of the IAQ guidelines looked at all indoor air quality criteria. Latvian legislation does not specify most indoor air pollutants, only carbon dioxide. Latvian legislation looks into thermal comfort, but not into chemical pollutants in indoor air environment for public sector. Corresponding laws in connection to indoor air quality for the public sector lack adequate information or international standards related to legislation are no longer valid.

Nevertheless, it is particularly clear that the parameter limits between the guidelines and air quality certifications differ, due to the non-selectivity of the partition between the public and private buildings. Maintaining a homogeneous environment during the evaluation process in the public sector can help to adjust the threshold limits for the private sector as well.

Developed indoor air quality assessment procedure nationwide would improve public health in general and this study can assist in building a national IAQ certification program.

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