Original scientific article

Analysis of sanitary--technical and hygienic conditions of Slovenian kindergartens and proposed measures

Katarina **KACJAN ŽGAJNAR**[1], An **GALIČIČ**, Urška **ZORAN**, Luka **PAJEK**, Mateja **DOVJAK**[2*]

ABSTRACT

Most children in early childhood spend approximately one third of the day in kindergartens. Therefore, it is essential that their stay in an educational institution is comfortable and without adverse health effects. Statistical data over the last decade show that the amount of enrolled children in kindergartens has increased. The problem of overcrowded kindergartens is usually solved by changing the existing norms for class sizes, or with alternative spaces that do not serve the original purpose. According to EU Directives, kindergartens are among building facilities that have to be renovated. The purpose of the paper was to analyse sanitary-technical and hygienic conditions of the selected playrooms of kindergartens and to define measures. Real-state conditions were evaluated in 35 playrooms of 16 kindergartens in the Central Slovenian region. The main emphasis was on the used materials, their cleaning capability, room acoustics, natural daylight, safety and comfort issues, as well on their possible adverse health effects. The combination of observation, measurements and calculations of reverberation time, and comparison with regulation demands was carried out. In many playrooms sanitary-technical and hygienic conditions did not fulfil regulation demands. Irregularities are mainly related to improper installation of final coverings, to low parapet heights and total opening area of windows, poor hygienic conditions, and selection of materials that may present health risks. Calculated and measured reverberation times deviated from optimal values.

Key words: playrooms, sanitary-technical conditions, hygiene, noise, measures

Received: 11. 11. 2013
Accepted: 17. 12. 2013

[1] Senior Lecturer, MSc. Katarina Kacjan Žgajnar, dipl. san. inž.
University of Ljubljana
Faculty of Health Sciences
Zdravstvena pot 5, 1000 Ljubljana
katarina.kacjan@zf.uni-lj.si

[*] *Corresponding author*
Assistant, PhD. Mateja Dovjak, dipl. san. inž.
University of Ljubljana
Faculty of Civil and Geodetic Engineering
Chair for Buildings and Constructional Complexes, Jamova cesta 2
1000 Ljubljana, Slovenia
mdovjak@fgg.uni-lj.si

INTRODUCTION

In Slovenia, children are included in the system of pre-primary education (i.e. kindergartens, day-care centres, preschool) from the end of the maternity leave (i.e. 11 month old) till starting compulsory education [1]. According to preschool legislation, learning standards and guidelines [2-5], the maximum kindergarten class sizes are from 14 to 24 children, depending on the child age, special needs and disabilities. Kindergartens present biological, physical and social environment where a child usually spends approximately one-third of the day. The environment of kindergarten has a strong interactive influence on a child [6], so it is very important to assure a high level of safety without any health risks.

Children represent a specific population group, mainly due to their lower body weight, higher activity levels and age-related behavioural characteristics. In the childhood, the immune system is not fully developed, so children are more susceptible to environmental influences [7,8] than adults. Moreover, entering kindergarten also presents a physiological health risk for a child (i.e. stress). Epidemiological data indicate an increased morbidity among children in the first months of visiting kindergartens [9].

Statistical data of the Republic of Slovenia showed that in the school year 2012/13 almost 77 % of all children of proper age were enrolled in kindergartens. The number of enrolled children in kindergartens increased from 70 % in school year 2008/2009 to 77 % in school year 2012/13 [10]. The EU benchmark on pre-school participation stipulates that by 2020 at least 95 % of children between the age of 4 and the starting age of compulsory education should participate in early childhood education [10-12]. Despite large amount of children enrolled in early childhood education system, many existing buildings do not fulfil pre-school standards and guidelines. Moreover, the problem of overcrowded kindergartens is usually solved by changing existing norms for class sizes, or with alternative spaces that usually do not serve the original purpose (i.e. containers, mobile houses). For example, the average age of the selected kindergarten buildings in the Central Slovenian region is 1978. According to EU Directives [13-15], kindergartens are among the building facilities, which have to be renovated.

Current studies on kindergartens and health issues are mainly focused on chemical risks, i.e. chemical pollutants in indoor air [16,17], metal contamination [18,19], radon emission sources [20]; biological risks, i.e. transmission of biological agents [21-23], microbiological quality and safety of food [24] as well on physical risks, i.e. noise [25-28]. The review by Le Cann et al. [29] was taking a broad approach to the indoor environment and including chemical, microbial, physical and social aspects.

Noise as a physical health risk in kindergartens presents well researched topic [25-27]. McAllister et al. [25] studied children's exposure to background noise at the ears during a normal day in three day-care centres in Linköping, Sweden. Chatzakis et al. [26] performed measurements of noise levels in occupied and unoccupied classrooms

Kindergartens present biological, physical and social environment where a child usually spends approximately one-third of the day. The environment of kindergarten has a strong interactive influence on a child, so it is very important to assure a high level of safety without any health risks.

Epidemiological data indicate an increased morbidity among children in the first months of visiting kindergartens.

For example, the average age of the selected kindergarten buildings in the Central Slovenian region is 1978. According to EU Directives, kindergartens are among the building facilities, which have to be renovated.

in overall ten kindergartens in the city of Heraklion, Crete, Greece. Sjödin et al. [27] carried out an investigation on 101 employees at 17 preschools in Umeå county, Sweden. Voss [28] investigated the correlation between the reverberation time (that is the time that would be required for the sound pressure level in the enclosure to decrease by 60 decibels after the source has been stopped) and the resulting room noise level, as well as the correlation between the one-hour room noise levels and the number of children present in day-care centres, Denmark. Kovačič and Kacjan Žgajnar [30] and Kacjan Žgajnar et al. [31,32] measured equivalent and impulse levels of noise in kindergartens in Ljubljana, Slovenia. The results from the above studies often exceeded the permissible noise levels for working and living environments [33-35]. Based on the results by Voss [28], three main factors for effective reduction of noise levels in day-care centres were defined, i.e. physical surroundings (buildings, rooms, etc.), the number of children, and social behaviour. Other guidances in schools also include acoustic [36] as well as educational measures [37]. The effectiveness of measures for the reduction of noise levels was evaluated in a few studies. Gerhardsson and Nilsson [38] studied noise-related problems in personnel at Swedish day-care centres before and after acoustical treatment. L'Espérance et al. [39] performed measures of noise levels, reverberation time and the surface radiation factor at 40 locations in 20 day-care centres in Quebec. Installing an acoustic ceiling and adding a band of acoustic panels at the top of the walls reduced noise levels on average by 6 to 7 dBA [39] and 2 to 6 dB [38]. There even exist defined recommendations for the reduction of noise levels in kindergartens, but there is still a large gap between recommended implementation and execution. Studies dealing with overall sanitary-technical and hygienic issues of kindergarten playrooms are rare. However, there are no defined measures important for building design and renovation.

Studies dealing with overall sanitary-technical and hygienic issues of kindergarten playrooms are rare. However, there are no defined measures important for building design and renovation.

The purpose of our paper is to analyse sanitary-technical and hygienic conditions of selective playrooms of kindergartens in the Central Slovenian region. The main emphasis was on the used materials, their cleaning capability, room acoustics, natural daylight, safety and comfort issues, as well on their possible adverse health effects. The main findings will be compared with current regulations and guidelines. Based on the comparison, measures important for building design stage, construction and renovation will be prepared.

STATISTICAL BACKGROUND: SLOVENIA, EU

In Slovenia, in the school year 2012/13, almost 77 % of all children of the proper age are enrolled in kindergartens [10]. In the school year 2012/13, 938 kindergartens and their units were providing pre-school education; this is 16 more than in the previous school year [10]. The majority (95 %) of kindergartens are public; only 50 or 5 % are private. In the school year 2012/13 the number of children enrolled in kindergartens increased by 2.3 % over the previous school year, but the growth is not as high as in the school years 2008/09 to 2011/12, when the annual growth rate was around 7 %. Slightly more than 83,000 children were enrolled in kindergartens and in child-minders' families, which is 76.7 % of all children of the proper age. Compared to the previous school year, the number of children particularly increased in the second age period (children from the age of 3 up to entering basic school), which represented a 3.3 % increase in enrolment, so that the share now stands at almost 90 %. In the first age period (children up to 3 years) the number of children increased only slightly. Kindergartens now include more than half of the children in this age group. Slightly more than 38,500 4- and 5-year-olds are enrolled in pre-school education, which is 93.3 % of all children of that age [10]. In the school year 2012/13 pre-school care and education in kindergartens is provided by about 10,453 professional staff, of whom 4,986 are educators and 5,467 assistant educators. There are 2 % men – mostly assistant educators – among professional staff. There are on average 8.1 children per educator and assistant educator; in the first age period 6.2 children and in the second age period 9.4 children [10].

According to EU statistics [11,12], there was a significant rise in children attending pre-primary education, from 85.6 % in 2000 to 92.5 % in 2009 (between the age of 4 and the start of compulsory primary education). In Belgium, Spain, France, Italy and the Netherlands, all children are enrolled at the age of 4 until the start of (compulsory) primary education, while Germany, Cyprus, Latvia, Lithuania, Austria, Poland, Portugal, Romania, Slovenia, Finland and Sweden have seen significant increases in participation over the period. In general, in the EU Member states, high levels of children attending pre-primary education correspond with high employment rates of women [11,12].

According to EU statistics, there was a significant rise in children attending pre-primary education, from 85.6 % in 2000 to 92.5 % in 2009 (between the age of 4 and the start of compulsory primary education).

METHODS

Analysis of sanitary-technical and hygienic conditions was performed from March to May 2013 in 35 playrooms (for children age from 3 to 6 years) of 16 kindergartens in the Central Slovenian region. General characteristics of playrooms and population group are described in Table 1. According to the required demands [3] the main observed groups of sanitary-technical and hygienic parameters were: material type (floor, wall, ceiling covering), cleaning capability (installation of cove fillet, washable wall covering), safety (parapet height, protection of radiator surfaces), natural daylight (window-to-floor ratio), comfort (installation of wall covering up to 1.2 m high, thermal properties-warm/cool feeling to touch), basic hygienic conditions (dust, curtains), room acoustics (reverberation time). Real-state conditions were evaluated according to EU and SI legislation. Possible adverse health effects were defined according to reviewed studies.

Room acoustics were evaluated with calculated and measured reverberation times. Reverberation time was calculated with Sabine formula Eq. (1) [40-42], Eyring formula Eq. (2) [41-43] and Millington-Sette formula Eq. (3) [44-46].

$$T_s = \frac{0.163\ V}{A+4\ mV} \tag{1}$$

where T_S is calculated reverberation time with Sabine formula [s], V is the volume of the room [m^3], A is the sum of the surface areas of the room multiplied by their respective absorption coefficients at a given frequency and m is the absorption coefficient as a function of air absorption and frequency [m^{-1}]. Sabine formula (Eq. 1) should be used for rooms with volumes less than 200 m^3 and a reasonable distribution of sound and lower sound absorption (absorption coefficient less than 0.2) [41,42].

$$T_{Ey} = \frac{0.163\ V}{-S\ln(1-\bar{\alpha})+4mV} \tag{2}$$

where T_{Ey} is calculated reverberation time with Eyring formula [s], where V is the volume of the room [m^3], S is the total surface area of the room in [m^2], $\bar{\alpha}$ is average absorption coefficient [-] and m is the absorption coefficient as a function of air absorption and frequency [m^{-1}]. Eyring formula (Eq. 2) should be used for rooms with higher sound absorption (absorption coefficient more than 0.2) [41,42].

$$T_{M-S} = \frac{0,16\ V}{-\sum_i S_i ln(1-\alpha_1)} \tag{3}$$

where T_{M-S} is calculated reverberation time with Millington-Sette formula [s], V is the volume of the room [m^3], α_1 is the sound absorption coefficient as sub-area S_i. Millington-Sette formula [44-46] should be used when the materials of a room have a wide variety of absorption coefficients [46]. Absorption coefficients at 500 Hz (relevant for child voice, baby cry, unoccupied room [47]) were selected from the relevant literature [48]. For the calculation it was assumed that the rooms were unoccupied.

Measurements of reverberation time were performed in two typical playrooms (playroom No. 28, located in kindergarten M; playroom No. 33 located in kindergarten O). Measurements were conducted according to the standards [49,50]. Reverberation time was measured with calibrated modular precision sound analyser type 2260 Investigator, manufacturer Brüel and Kjaer.

The observed sanitary-technical and hygienic conditions were evaluated according to the Rules on the criteria and the minimum technical requirements for space and equipment of kindergartens [3], Rules on the acoustic insulation in buildings [41], TSG-1-005:2012 [42], Rules on the protection of workers from the risks related to exposure to noise at work [33], Rules on the ventilation and air-conditioning of buildings [51], Regulation (EU) No 305/2011 [15] of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC.

Calculated and measured reverberation times were compared to optimal levels for classrooms according to [42].

$$T_{opt} = 0,32\ log\ V - 0,17 \qquad (4)$$

where T_{opt} is calculated optimal reverberation time [s] and V is the volume of the room [m^3].

RESULTS AND DISCUSSION

Design of active spaces

According to regulation demands [3], all active spaces in kindergarten have to be functionally designed according to child age. The position of active spaces must be transparent and directly connected to the central area. The plan of the playroom should be dynamic with minimum surface area 40 m^2.

The examined 35 playrooms were functionally designed according to child age group 3-6 years with transparent and direct connection to the central area. All plans were dynamic, but the surface areas of 13 playrooms (No. 1, No. 3, No. 7-9, No. 16, No. 22, No. 25, No. 26, No. 28 and No. 30-32) were less than 40 m^2; surface areas of the following 4 playrooms were less than 35 m^2 (No. 1, No. 3, No. 7, No. 9).

Table 1: Analysed 35 playrooms of 16 kindergartens (A-P) in the Central Slovenian region and population group.

Kindergarten	Playroom No.	Construction year [yr]	No. of children [ ]	No. of professional staff [ ]
A	1	1952	21	2
	2		23	3
B	3	1982	24	2
C	4	1973	19	2
	5		24	2
	6		23	2
D	7	1976	21	2
	8		20	2
	9		20	2
	10		21	3
	11		23	2
E	12	1976	21	3
F	13	1979	19	2
	14		20	3
G	15	2005	22	2
H	16	2013	24	2
I	17	1971	19	2
	18		24	2
J	19	1972	19	2
	20		23	2
	21		21	2
	22		18	2
	23		19	2
K	24	1963	21	2
	25		19	3
	26		21	2
L	27	1906	20	3
M	28	1979	22	4
N	29	1976	20	2
	30		21	2
	31		22	2
	32		21	2
O	33	1976	19	2
P	34	2012	24	2
	35		23	2

The majority of materials used in playrooms were wood (particle boards, plywood), parquet, linoleum, paint, glass, washable upholstery cushions, foam, cork, paper, fabric, and PVC (window frames). Most of used materials are harmless, but according to epidemiological studies some of them may present health risks.

Sanitary-technical conditions

Results of the evaluation of sanitary-technical conditions of the 35 playrooms in 16 kindergartens in the Central Slovenian region are presented in Table 2. Fulfilment of regulated demands is marked with + (evaluated real-state condition fulfilled regulation demand) or – (evaluated real-state condition did not fulfil regulation demand).

Used materials in playrooms and their health issues

Regulation (EU) No. 305/2011 [15] of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC define basic requirements for construction works and construction products (materials) that have to be fulfilled throughout the whole life cycle of a building. The construction works as a whole and their separate parts must be fit for their intended use, taking into account in particular the health and safety of persons involved throughout the life cycle of the works. Some of the main issues of the Regulation are hygiene, health and environment; safety and accessibility in use; protection against noise explicitly defined in basic requirements No. 3, No. 4 and No. 5. The Regulation [15] shall be binding in its entirety and directly applicable in all Member States, as well as harmonized with their horizontal and vertical legal framework.

Basic requirement No. 3 – Hygiene, health and the environment [15], relevant for used materials, demands that construction works must be designed and built in such way that throughout their life cycle they will not be a threat to the hygiene or health and safety of workers, occupants or neighbours, nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition. This basic requirement is harmonized with the Rules on the criteria and the minimum technical requirements for space and equipment of kindergartens [3] which defines that all constructional and installation products must be environmentally friendly without health risks.

The majority of materials used in playrooms were wood (particle boards, plywood), parquet, linoleum, paint, glass, washable upholstery cushions, foam, cork, paper, fabric, and PVC (window frames). Most of used materials are harmless, but according to epidemiological studies some of them may present health risks [52-59]. The literature review [53,54] showed that wooden construction products and furniture as well as paints, adhesives, varnishes, floor finishes, disinfectants, cleaning agents and other household products present the main indoor sources of formaldehyde. Paints, varnishes and cleaning agents may be the source of volatile organic compounds (VOCs) [55-57]. Linoleum has been shown to emit a series of aldehydes and fatty acids as major VOCs [60]. Various studies [55,56,58,59] have indicated that numerous indoor sources and insufficient ventilation often result in higher formaldehyde and VOCs levels and may cause adverse health effects. Wieslander et al. [56] indicated that exposure to chemical emissions from

Table 2:
Evaluation of sanitary-technical conditions in 35 playrooms of 16 kindergartens, Central Slovenian region.

Playroom/ Observed parameter	Material			Cleaning capability		Safety issues		Natural daylight	Comfort	Basic hygienic conditions	
	Floor	Wall	Ceiling	Cove fillet	Washable wall covering	Parapet height [m]	Protection of radiator surfaces	Window-to-floor area ratio [%]	Installation of wall covering up to 1.2 m high. Thermal properties- warm/cool feeling to touch	Dusty shelves	Curtain
1*	parquet	paint, wood	paint	-	+	0.65	+	22.39	+	+	+
2*	laminate	paint	paint	-	-	1.00**	+	36.77	-	+	+
3	parquet	paint, wood	paint	-	-	0.61	+	34.92	-	-	+
4	linoleum	paint	wood	+	+	0.54	+	35.01	-	-	-
5	linoleum	paint	wood	+	+	0.54	+	19.48	-	-	+
6	linoleum	paint	wood	-	+	0.60	+	18.74	+	-	+
7	linoleum	paint	Armstrong gypsum board	-	+	0.80**	-	33.12	-	+	+
8	linoleum	paint	Armstrong gypsum board	-	+	0.80**	-	28.15	-	+	+
9	linoleum	paint	Armstrong gypsum board	-	+	0.80**	-	36.08	-	+	+
10	linoleum	paint	Armstrong gypsum board	+	+	0.90	-	23.46	-	+	+
11	linoleum	paint	Armstrong gypsum board	+	+	0.90	-	25.27	-	+	+
12	linoleum	paint, wood	paint	-	+	0.50	+	36.29	+	+	+
13	linoleum	paint, wood	paint	+	+	0.40	+	21.80	+	+	-
14	linoleum	paint, wood	paint	+	+	0.52	+	21.02	+	+	-
15	laminate	paint	paint	-	+	0.55	+	18.49	-	-	+
16	linoleum	paint	paint	-	-	0.00	-	44.43	-	+	+
17	parquet	paint	Armstrong gypsum board	-	+	0.60	-	25.09	-	-	+
18	parquet	paint	paint	-	+	0.60	-	31.74	-	+	+
19	parquet	paint	paint	-	+	0.89**	+	25.96	-	+	+
20	parquet	paint	paint	-	+	0.89**	+	25.01	-	+	+
21	parquet	paint	paint	-	+	0.89**	+	26.40	-	+	+
22	parquet	paint	paint	-	+	0.85**	-	35.39	-	+	+
23	parquet	paint	paint	-	+	0.85**	-	21.21	-	+	+
24	linoleum	paint, wood	paint	+	+	0.74**	-	31.62	+	-	+
25	linoleum	paint, wood	paint	+	+	0.73**	-	41.63	+	-	+
26	linoleum	paint, wood	paint	+	+	0.75**	+	22.77	+	-	-
27*	parquet	paint, wood	paint	-	+	0.60	+	9.09	+	+	+
28	linoleum	paint, wood	paint	-	+	0.55	+	27.44	+	+	-
29	linoleum	paint, wood	paint	+	+	0.90**	-	39.92	+	-	-
30	linoleum	paint, wood	wood	-	+	0.90**	-	38.42	+	-	-
31	linoleum	paint, wood	wood, steel (I beam)	-	+	0.90**	-	46.24	+	-	-
32	linoleum	paint, wood,	wood, steel (I beam)	+	+	0.86**	-	39.19	+	-	-
33	linoleum	Wood, paint	Armstrong gypsum board	+	-	0.60	-	37.38	-	+	+
34	rubber	paint, rubber	paint	-	+	0.00	-	35.67	+	+	+
35	rubber	paint, rubber	paint	+	+	0.00	-	26.24	+	+	+

*Building was not intended for educational purposes; **Playroom is located in the first floor.

indoor paint is related to asthma, and that some VOCs may cause inflammatory reactions in the airways. Results by Norback et al. [55] suggested that indoor VOCs and formaldehyde may cause asthma-like symptoms. Used PVC materials for window frames (installed in playrooms No. 1-2, No. 4-11, No. 15, No. 17-23, No. 29-32; representing 62.9 % of total playrooms) also may present an important cause of health concerns. The literature review on health concerns associated with PVC building materials concluded that PVC building material presents an important emission source of phthalates that may have adverse health effects [61-64]. Most exposed population is young children and certain groups of adults during occupational exposure. Various studies [63,64] have indicated that these chemicals may be endocrine disruptors and may lead to the development of asthma, allergies, or related respiratory effects. Additionally, PVC window frames are usually wider than wooden ones, and provide less amount of daylight [65]. All building materials, where there exist scientific facts for adverse health effects, should be fully eliminated, especially in buildings occupied with sensitive population group.

The literature review on health concerns associated with PVC building materials concluded that PVC building material presents an important emission source of phthalates that may have adverse health effects.

All building materials, where there exist scientific facts for adverse health effects, should be fully eliminated, especially in buildings occupied with sensitive population group.

Hygienic and comfort issues

Rules on the criteria and the minimum technical requirements for space and equipment of kindergartens [3] define that all floor coverings must be solid, non-slip and should allow effective wet cleaning. Additionally, the floor-wall junctions (cove fillets) must be installed to assure easy and effective wet cleaning [3]. Floor coverings in all playrooms met the criteria, except floor coverings in playrooms No. 1-3, No. 15, No. 17-23 and No. 27 that were covered with laminate or parquet. Laminate and parquet do not allow effective wet cleaning, disinfection and they may absorb water. Floor-wall junctions were properly installed in 13 playrooms; among them there were 12 playrooms covered with linoleum and 1 playroom with rubber. Floor-wall junctions were not properly installed in playrooms where floors were mainly covered with parquet and laminate.

Wall coverings up to 1.2 m high must be washable and made from materials that are pleasant to touch and feel warm, and with proper abrasion resistance [3]. Wall coverings were washable in 31 playrooms where wall coverings were made from waterproof paint or wooden panels. Wall coverings in 4 playrooms (No. 2, No. 3, No. 16 and No. 33) did not fulfil the regulated demands, because they were made from non-waterproof paint. Wall coverings in 16 playrooms were made from materials that are pleasant to touch and feel warm (wood). Wall coverings in 19 playrooms did not fulfil the regulated demands; they were covered with wall paint.

Effective and regular cleaning contributes significantly to the prevention and control of infectious diseases. Dust deposition on playroom surfaces may lead to bacterial growth [66]. Study [67] found a correlation between the content of organic dust in carpets and the appearance of symptoms of sick building syndrome (SBS). Additionaly, Gyntelberg et al. [68] found a significant correlation between the prevalence of Gramnegative bacteria in the indoor dust and symptoms such as fatigue, heavy-headedness, headache, dizziness and lack of ability to concentrate, and symptoms from the mucus membrane of the upper respiratory tract. Dust mites and their residue found in beds, pillows, carpets, and furniture surfaces cause allergies [69]. Basic hygienic conditions in many playrooms were poor. 13 playrooms from overall 35 had dust deposited on the top of shelves, 9 playrooms from overall 35 had window curtains.

Safety issues

In all playrooms high level of safety must be provided. Basic requirement No. 4 – Safety and accessibility in use [15], requests that the construction works must be designed and built in such a way that they do not present unacceptable risks of accidents or damage in service or in operation, such as slipping, falling, collision, burns, electrocution, injury from explosion and burglaries. In particular, construction works must be designed and built taking into consideration accessibility and use for disabled persons. Therefore, Rules on the criteria and the minimum technical requirements for space and equipment of kindergartens [3] define that all floor coverings must be solid and non-slip. All wall corners up to 1.2 m must be secured with rounded corner profiles. All the furniture corners and edges must be smooth and free of sharp edges. Heavy and high furniture must be screwed to the floor and to the wall [3]. All playrooms fulfilled the safety demands.

Dust deposition on playroom surfaces may lead to bacterial growth. Study found a correlation between the content of organic dust in carpets and the appearance of symptoms of sick building syndrome (SBS).

The required maximum height of window parapets in playrooms that are located at the ground floor is 0.60 m above the ground, and minimum 0.90 m for playroom located in the first floor. All windows have to assure high level of safety and prevent falling out of windows [3]. Parapets in 4 out of 18 playrooms located at the ground floor did not meet the criteria; parapets in 13 out of 17 playrooms located in the first (or higher) floor did not meet the criteria. Overall 48.6 % of playrooms did not comply with conditions.

Natural daylight

External environment has stimulative effect on the human body and mind. Daylight provides quality lighting, stimulates sense of sight and is an important communication between the internal and external space [65]. Several researches showed connection between natural daylight and improved learning outcomes in schools. Other positive effects of natural daylight are: better illumination, visual stimulation, improved concentration and responsiveness, faster learning, less illnesses, less dental decay (cavities), improved eyesight, increased body growth and improved immune system [65,70-72].

Natural daylight has to be provided in all playrooms. The depth of the playroom should not be more than 2.5 times height level (from the ground to the upper edge of the window); otherwise the playroom must be illuminated from two room sides. The total opening area of windows must not be less than 1/5th the floor area of the room [3]. 25 playrooms fulfilled the criteria for the depth of the playrooms. 10 playrooms did not meet the criteria and had room depths more than 2.5 times the height level, only 4 of them were illuminated from two room sides. Playroom No. 16 was illuminated from two room sides and had ratio 3.76. Playroom No. 34 had the worst ratio 2.80 and was not illuminated from two room sides. 31 playrooms had the total opening area over 1/5 of the floor area of the room, 14 of them had the total opening area over 1/3th of the floor area of the room (No. 2-4, No. 9, No. 12, No. 16, No. 22, No. 25 and No. 29-34). Playrooms No. 5, No. 6, No. 15 and No. 27 did not meet the criteria for the total opening area of windows. Playroom No. 27 had the total opening area of windows 9.09 % (less than 1/11th of the floor area).

Clean, double glazed windows transmit about 70 % of daylight. On the other hand, triple glazed windows, in an effort to improve thermal insulation, transmit barely about 50 % of daylight [65]. After observing several playrooms, we found out that 24 % of them had triple glazed windows. This type of glazing was noticed in playrooms with replaced windows, in an attempt to reduce energy losses, and in playrooms of the newly build kindergartens. As we know, triple glazed windows transmit less natural daylight than double glazed windows [65]. Additionally, in evaluated playrooms daylight penetration was often distracted by inappropriate use of shading system or even by various items attached to the window (shaped paper, drawings etc.).

Analyses of reverberation time

Basic requirement No. 5 – Protection against noise, requests that construction works must be designed and built in such a way that noise perceived by the occupants or people nearby is kept to a level that will not threaten their health and will allow them to sleep, rest and work in satisfactory conditions. Rules on the criteria and the minimum technical requirements for space and equipment of kindergartens [3] state that floor, wall and ceiling coverings must be made of materials that reduce noise. Rules on the acoustic insulation in buildings [41] and Technical guidelines for protection against noise in buildings [42] define that protection against noise in buildings must provide actions against noise produced outside and/or in a building, actions against direct sound transmission (through air and structures), actions against equipment noise and actions against reverberation sound. Protection against reverberation noise has to be ensured by proper installation of sound absorptive surface elements, taking into account the size and shape of the space.

The reverberation time was measured in two playrooms, No. 28 and 33, and compared to calculated and optimal values (Figure 1).

Most playrooms had calculated reverberation time more than two times higher than optimal time. Connection (trend) between all the calculated values is very similar, with lowest values calculated with Millington-Sette formula, middle values calculated with Eyring and higher values with Sabine formula. For most of the playrooms (except playrooms No. 4 and No. 17) reverberation times that were calculated with the Sabine formula are more accurate (absorption coefficients less than 0.2). It can be observed that the reverberation time values calculated using the Sabine, Eyring and Millington-Sette formulae significantly deviate from the measured values. Similar conclusions were found in the study by Neubauer and Kostek [46]. To compare the measured and calculated reverberation times additional analysis is needed.

Measurements of reverberation time were made in the frequency range from 100 to 8000 Hz (Figure 2). Playroom No. 28 had better sound absorption at high frequencies and worse at low frequencies, and vice versa in playroom No. 33. The main reason for this is in sound absorption of materials that depend on the frequency level. Some materials are better sound absorbers at low frequencies and some at high. That is why we have to be careful with the selection of materials for kindergartens. The data [47] showed that baby cries have a basic frequency of around 500 Hz. Child speech ranges from 250-400 Hz, adult females tend to speak at around 200 Hz on average, and adult males around 125 Hz. The average measured reverberation times for typical frequencies for child voice in playrooms (250 to 500 Hz) were 0.62 s for playroom No. 28 and 0.63 s for playroom No. 33 (optimal value 0.50 s).

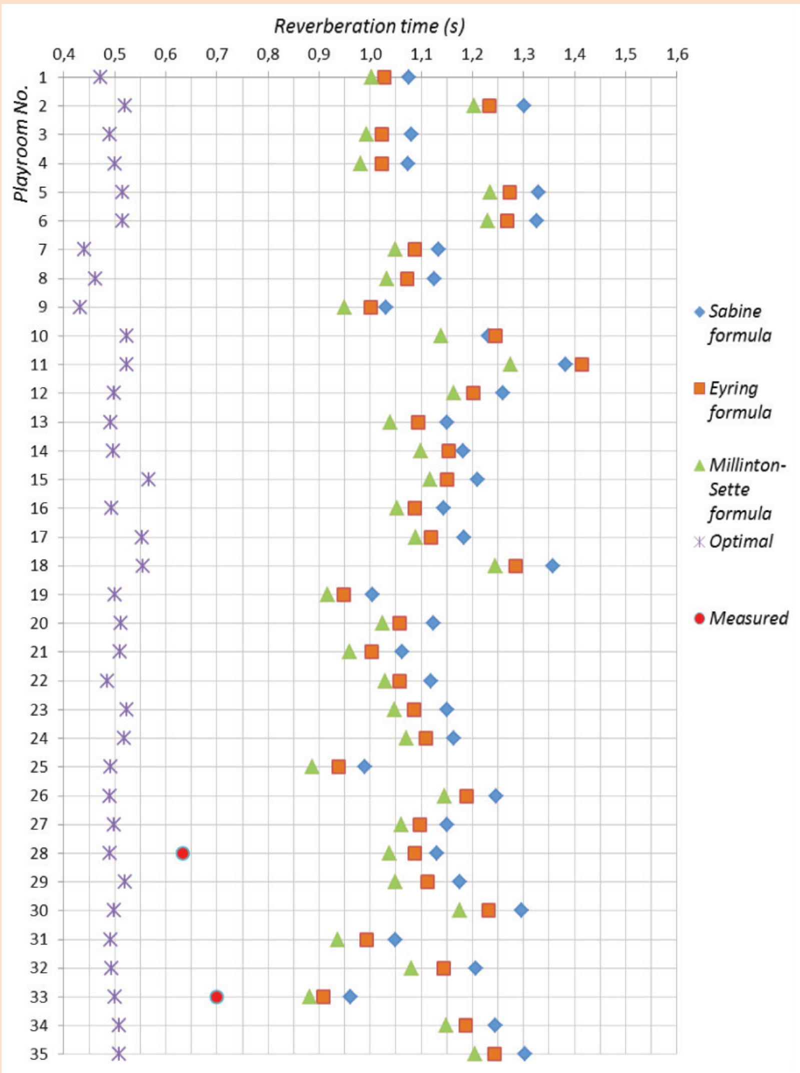

Figure 1:
Calculated, measured and optimal reverberation times [s] in 35 playrooms of 16 kindergartens.

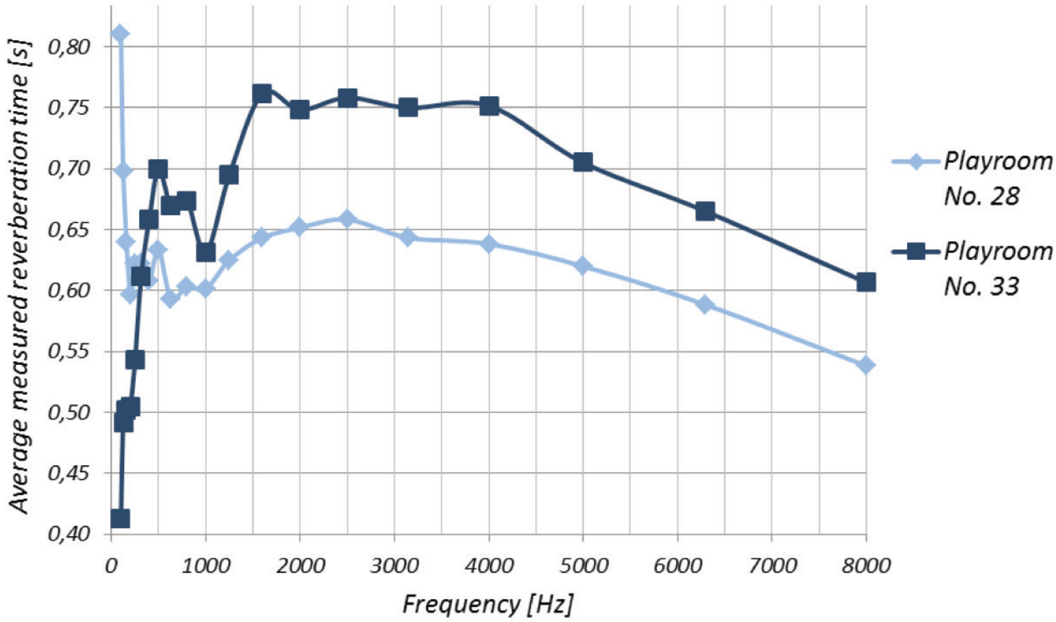

Figure 2:
Average measured reverberation time [s] in the frequency range from 100 to 8000 Hz in playroom No. 28 and playroom No. 33.

MEASURES ON THE LEVEL OF SANITARY-TECHNICAL AND HYGIENIC ISSUES WITH NOISE PREVENTION

Analysis of 35 playrooms in 16 kindergartens in Central Slovenian region showed that in many playrooms sanitary-technical and hygienic conditions did not fulfil the regulation demands. Based on the evaluation of real-time conditions, measures were prepared. They include actions on the level of sanitary-technical and hygienic improvements, implication of health and environment friendly building materials as well as measures for effective noise prevention.

Sanitary-technical improvements of analysed playrooms:

- removal of all materials where there exists scientific proof of adverse health concerns (i.e. PVC materials), replacement with health and environment friendly alternatives (i.e. PVC window frames for wooden window frames),
- installation of washable wall coverings that are zero VOC and non-toxic,
- wall coverings have to be made from materials that are pleasant to touch and feel warm,
- installation of wall-floor cove fillets and safety covers for room radiators in all playrooms where they were missing,
- repair of parapet heights or installation of safety window fences, safety windows,
- providing natural daylight with proper size of total opening area of windows (not less than 1/5th the floor area of the room),
- regular effective cleaning and maintenance.

Noise prevention and control in analysed playrooms:

- assuring optimal room acoustics with technical measures, including installation of sound acoustic elements that are hygienically adequate.

For complete noise protection it is necessary to implement technical measures defined by TSG-1-005:2012 [42] that include protection against outside noise, direct sound transmission through structures, equipment noise and reverberation sound. In kindergartens it is very difficult to meet the requirement for optimum reverberation time and at the same time avoid materials that are hygienically questionable (i.e. fabric curtain). Therefore, the selection of materials with good sound absorption and hygienically appropriate needs special attention. Organizational measures include implementation of legislation on the level of noise protection of all users (children, staff), introduction of permanent health education of teachers, parents and children, use of less noisy toys, raising the awareness in general public, state and local authorities. Alternative measures include introduction of more quiet activities in regular work day, relaxation.

Holistic approach is necessary for solving problems in the first stages of design.

All listed measures are not important only for the evaluated kindergartens, but also for the design, construction and renovation of buildings. At the level of the design, all basic bioclimatic principles presented in Krainer et al. [73] have to be implemented. Building envelope and constructional complexes have to allow optimal regulation of thermal and daylight fluxes as well as assure proper sound insulation. Holistic approach is necessary for solving problems in the first stages of design. In particular, buildings must be designed and built taking into consideration accessibility and use for disabled persons (physical, visual, hearing, mental and cognitive disability) [15, 74-76]. Sanitary-technical conditions of playrooms will be further on analysed in relation to the whole building concept. Our research areas will include thermal comfort, noise, and indoor air quality issues. All the above stated is necessary to assure comfort and healthy indoor environment for children and staff.

ACKNOWLEDGEMENTS

Research project Municipality of Ljubljana: "Noise at kindergarten – information for children, teachers and parents", Agreement No.: 169-19/2012-7.

REFERENCES

[1] Marjanovič Umek L, Fekolja Peklaj U. Sodoben vrtec: možnosti za otrokov razvoj in zgodnje učenje. Ljubljana: Filozofska fakulteta, 2008: 22.

[2] Kindergarten Act, O.J. RS, No. 12/1996; 44/2000, 78/2003, 113/2003, 72/2005, 100/2005, 25/2008, 98/2009, 36/2010, 62/2010, 94/2010, 40/2012.

[3] Rules on the criteria and the minimum technical requirements for space and equipment of kindergartens (O.J. RS, No. 73/2000, 75/2005, 33/2008, 126/2008, 47/2010, 47/2013).

[4] Hoke RJ, Ramsey CG. Architectural Graphic Standards, Tenth Edition. Canada: John Wiley Sons, Inc., 2000: 1072.Charles George Ramsey (Author)

[5] Neufert P. Projektiranje v stavbarstvu. Ljubljana: Tehniška založba Slovenije, 2002.

[6] Strah B. Zdravstveno-higienski režim v vrtcu. Vrtec pod Gradom: http://vrtec-podgradom.org/zdravstveno-higienski-rezim-v-vrtcu/ (17. 10. 2013)

[7] Vračko P. Otroci so na dejavnike okolja še posebej občutljivi. Vpliv okolja na zdravje otrok. V: Priročnik za izvajalce vzgoje za zdravje ob sistematskih pregledih predšolskih otrok. Ljubljana: Inštitut za varovanje zdravja Republike Slovenije, 2012: 2.

[8] Yassi A, et al. Basic Environmental Health. Oxford: Oxford University Press, 2001: 456.
[9] Skaza B. Vstop otroka v vrtec. Maribor: Pedagoška fakulteta, 2010.
[10] Stat SI 2013. Kindergartens, Slovenia, school year 2012/13 – final data, Statistical Office of the Republic of Slovenia: http://www.stat.si/eng/novica_prikazi.aspx?ID=5386 (21. 10. 2013).
[11] COM(2011) 66. European Commission Brussels, Commission Communication COM(2011) 66 of 17 February 2011: Early Childhood Education and Care: Providing all our children with the best start for the world of tomorrow:http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0066:FIN:EN:PDF (9. 7. 2013)
[12] Eurostat. 2011. Education statistics 2011: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Education_statistics#Pre-primary_education (9. 7. 2013)
[13] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF (9. 10. 2013).
[14] EPBD-r 2010/31/EU. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast): http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF (9. 10. 2013).
[15] Regulation (EU) no 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:088:0005:0043:EN:PDF (9. 7. 2013)
[16] Roda C, et al. Assessment of indoor environment in Paris child day care centers. Environ Res 2011; 111(8):1010-7.
[17] St-Jean M et al. Indoor air quality in Montréal area day-care centres, Canada. Environ Res 2012, 118: 1-7.
[18] Tong STY, Lam KC. Are nursery schools and kindergartens safe for our kids? The Hong Kong study. Sci Total Environ1998; 216, 3: 217-225.
[19] Zhu Z, et al. Identification of trace metal pollution in urban dust from kindergartens using magnetic, geochemical and lead isotopic analyses. Atmos Environ 2013; 77:9-15.
[20] Vaupotič J, Kobal I. Radon exposure in Slovenian kindergartens and schools. International Congress Series 2005; 1276:375-376.
[21] Yang SC, et al. Knowledge about and attitude toward enterovirus 71 infections: a survey of parents and teachers at kindergartens in Taiwan. Am J Infect Control 2010; 38, 4: 21-24.
[22] Ho P-L et al. Molecular epidemiology and nasal carriage of Staphylococcus aureus and methicillin-resistant S. aureus among young children attending day care centers and kindergartens in Hong Kong. J Infect 2012; 64 (5):500-506.
[23] Engelhart et al. House dust mite allergen levels in German day-care centers. Int J Hyg Environ Health 2002; 205 (6): 453-457
[24] Marzano MA, Balzaretti CM. Protecting child health by preventing school-related foodborne illnesses: microbiological risk assessment of hygiene practices, drinking water and ready-to-eat foods in Italian kindergartens and schools. Food Contr 2013; 34, 2:560–567.
[25] McAllister AM et al. Child Voice and Noise: A Pilot Study of Noise in Day Cares and the Effects on 10 Children's Voice Quality According to Perceptual Evaluation. J Voice 2009; 23, 5:587–593.
[26] Chatzakis NS, et al. Excessive noise levels are noted in kindergarten classrooms in the island of Crete. Eur Arch Otorhinolaryngol 2013; Mar 21, in press.
[27] Sjödin et al. Noise and stress effects on preschool personnel. Noise Health 2012;14:166-78
[28] Voss, P. Noise in children's daycare centres. In: magazine 8. Noise at Work. European Agency for Safety and Health at Work 2005; 23-25: http://osha.eu.int/publications/magazine/8/en/magazine8_en.pdf (9. 10. 2013).

[29] Le Cann P, et al. Indoor environment and children's health: Recent developments in chemical, biological, physical and social aspects. Int J Hyg Envir Heal 2011; 215, 1:1-18.
[30] Kovačič D, Kacjan Žgajnar K (2004). Hrup kot premalo upoštevan dejavnik tveganja v vrtcih. In: Zbornik referatov (VI. mednarodna konferenca Globalna varnost v Evropi), Varnost v prometu, varnost in zdravje pri delu 2004, Portorož. Ljubljana: Svet za preventivo in vzgojo v cestnem prometu Republike Slovenije, 2004, 8.
[31] Kacjan Žgajnar K et al. Problematika hrupa v vrtcih - možnosti ukrepanja. In: Varstvo pri delu, varstvo pred požari in medicina dela : dvodnevni posvet z mednarodno udeležbo, Portorož 2009, 12.-13. 5. 2009. Ljubljana: Fakulteta za kemijo in kemijsko tehnologijo, Oddelek za tehniško varnost, 2009: 10.
[32] Kacjan Žgajnar K et al. Hrup v vrtcih in izpostavljenost pri predšolskih otrocih. In: Rugelj D, Sevšek F, eds. Raziskovalni dan Zdravstvene fakultete, 4. december 2009. Zbornik predavanj. Ljubljana: Zdravstvena fakulteta, 2009c: 111-118.
[33] Rules on the protection of workers from the risks related to exposure to noise at work (O.J. RS, No. 17/2006, 18/2006, 43/2011).
[34] WHO 2001.Occupational and community noise, Fact Sheet 258 (rev. Feb. 2001). Fact sheets: http://www.who.int/mediacentre/factsheets/fs258/en/ (9. 10. 2013).
[35] OSHA 2005. Noise in figures. Belgium: European Agency for Safety and Health at Work, 122 pp: https://osha.europa.eu/en/publications/reports/6905723 (9. 7. 2013).
[36] Classroom Acoustics. Technical Committee on Architectural Acoustics of the Acoustical Society of America, 2000: http://asa.aip.org/classroom/booklet.htm (9. 10. 2013).
[37] Larm in Bildungseinrichtungen – ein Lern- und Gesundheitsproblem (Noise in educational establishments — a learning and health problem). Thema des Monats Juni 2005. Landesunfallkasse Nordrhein-Westfalen: http://www.luk-nrw.de/praev/thema/thema_05_06.asp (9. 10. 2013).
[38] Gerhardsson L, Nilsson E. Noise disturbances in daycare centers before and after acoustical treatment. J Environ Health 2013; 75(7):36-40.
[39] L'Espérance A et al., Noise reduction in day-care centres by reducing reverberation time. Analyses and case studies. Québec: IRSST, 2006, 69: http://www.irsst.qc.ca/media/documents/pubirsst/r-463.pdf (18.10.2013)
[40] Sabine WC. Collected Papers on Acoustics. New York: Dover Publications, 1964.
[41] Rules on the acoustic insulation in buildings (O.J. RS, No. 14/1999, 10/2012).
[42] TSG-1-005: 2012. Technical guidelines for protection against sound in buildings. 1st edition. Ljubljana, Ministry of the Environment and Spatial Planning, 2012: 42.
[43] Eyring CF. Revereberation Time in "Dead" Rooms. J Acoust Soc Amer 1930; 1:217-241.
[44] Millington G. A Modified Formula for Reverberation. J Acoust Soc Amer 1932; 4:69-82.
[45] Sette WH. A New Reverberation Time Formula, J Acoust Soc Amer 1933; 4:193-210.
[46] Neubauer R, Kostek, B. Prediction of the Reverberation Time in Rectangular Rooms with Non-Uniformly Distributed Sound Absroption. Ingolstdt: Consulting Bureau, 2004: str.
[47] NCVS, 2013. National Center for Voice and Speech, University of Iowa: http://www.ncvs.org/ncvs/tutorials/voiceprod/tutorial/influence.html (28. 10. 2013).
[48] Long M. Architectural acoustics. Amsterdam: Elsevier Academic Press, 2006: 844.
[49] ISO 9612:2009. Acoustics – Determination of occupational noise exposure - Engineering method, 2009.
[50] ISO 3382: 1999. Acoustics – Measurement of room acoustic parameters, 1999.
[51] Rules on the ventilation and air-conditioning of buildings (O.J.RS, No., 42/2002, 105/2002).

[52] Missia DA, et al. Indoor exposure from building materials: a field study. Atmos Environ 2010; 44, 35:4388–4395.

[53] EPA, 1997. Environmental Protection Agency, An Introduction to Indoor Air Quality (IAQ) Formaldehyde: http://www.epa.gov/iaq/formaldehyde.html (9.10.2013).

[54] Šestan P, Kristl Ž, Dovjak M. Formaldehyde in the built environment and its potential impact on human health, Gradb vestn 2013; 62:191–203.

[55] Norback D, et al. Asthmatic symptoms and volatile organic compounds, formaldehyde, and carbon dioxide in dwellings. Occup Environ Med 1995; 52:388–395.

[56] Wieslander G, et al. Asthma and the indoor environment: the significance of emission of formaldehyde and volatile organic compounds from newly painted indoor surfaces. Int Arch Occup Environ Health 1997; 69:115–124.

[57] McCoach JS, et al. Floor cleaning materials as a cause of occupational asthma. Indoor Air 1999; 99, 5:459–464.

[58] NIOSH, 2010. NIOSH Pocket Guide to Chemical Hazards. Atlanta: CDC, 2010.

[59] OSHA, 2011. Occupational Safety and Health Administration, Formaldehyde: http://www.osha.gov/dts/chemicalsampling/data/CH_242600.html (8.7.2013)

[60] Jensen B, et al. Characterization of linoleum, Part 1: Measurement of volatile organic compounds by use of the field and laboratory emission cell "FLEC". Indoor Air 1995; 5: 38–45.

[61] Dovjak M, Kristl Ž. Health concerns of PVC materials in the built environment. Int J San Eng Res 2011; 5, 1:4–26.

[62] Peijnenburg WJGM. Phthalates. Encyclopedia of Ecology. Bilthoven: Laboratory for Ecological Risk Assessment, 2008:2733–2783.

[63] Heudorf U, et al. Phthalates: Toxicology and exposure. Int J Hyg Envir Heal 2007; 210, 5:623–634.

[64] Jaakkola JJK, et al. Surface materials in the home and development of bronchial obstruction in young children in Oslo, Norway. Am J Public Health 1999; 84(2): 188–192.

[65] Krainer A et al. Passive house versus bioclimatic house. Gradb vestn 2008; 57, (3): 58–68.

[66] Bauer, M. Higiensko tehnične zahteve za ravnanje z odpadki. In: Ferfila N, Jevšnik M, eds. Obvladovanje higienskih procesov v vrtcih in domovih za starejše. Ljubljana: Inštitut za sanitarno inženirstvo, 2004: 28.

[67] Valbjorn O, Skov P. Influence of indoor climate on the sick building syndrome prevalence. In: Indoor air '87, Proceedings of the 4 th Intern.-Conf. on Indoor Air Quality and Climate, Berlin (West) 17-21 Aug. 1987. Berlin: Inst. fur Wasser-, Boden- und Lufthygiene, 1987, 2: 593–597.

[68] Gyntelberg, F. et al. Dust and the sick building syndrome. Indoor Air 1994; 4: 223–238.

[69] Carrer P, et al. Allergens in indoor air: environmental assessment and health effects. Sci Total Environ 2001, 1-3: 33–42.

[70] Rosenberg L. Health benefits of Green buildings. Washington DC: US Environmental Protection Agency, 2003.

[71] Peyton C. Sunlight could perk up kids' grades, store profits. California: Sacramento Bee News, 1999.

[72] Edwards L, Torcellini P. A Literature Review of the Effects of Natural Light on Building Occupants. Colorado: National Renewable Energy Laboratory, 2002: 54.

[73] Krainer A et al. Vernacular buildings in Slovenia: genesis of bioclimatic growth of vernacular buildings in Slovenia. London: European Commission TEMPUS Programme, 1993: 102.

[74] Construction act, ZGO-1 (OJ. RS, No. 110/02, 102/04, 126/07, 108/09, 57/12)

[75] Rules on the requirements for the design of barrier-free built environments (OJ RS, No. 92/1999, 97/2003)

[76] Dovjak M, Kristl Ž. Development of the Leonardo da Vinci Accessible World for all Respecting Differences – AWARD project. Int J San Eng Res 2009; 2, 3: 35–49.