

## Analysis of Acoustic Environment on Premises of Nursery Schools in Wrocław

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The aim of this project was to create a ranking of the nursery schools in Wrocław with regard to the quality of the acoustic environment on their premises, using a specially developed evaluation methodology. Each nursery school was rated according to an adopted grading scale on the basis of the noise level distribution on the playground and on the nursery school building facades. Using the grading scale one can classify nursery school premises into twelve categories characterized by different acoustic environment quality, from exceptionally good ( $< 45$  dB) to exceptionally bad ( $> 70$  dB).

The appropriately rescaled data from the acoustic map of Wrocław and the authors' own measurements and simulation analyses were used. The developed methodology was verified by comparing the ratings yielded by it with those determined on the basis of field measurements and simulation studies, carried out for several selected nursery schools. The paper presents the results of an acoustic environment quality assessment carried out, using the developed investigative methodology, for 118 nursery schools located in Wrocław.

**Keywords:** nursery schools, noise exposure, noise rating.

### 1. Introduction

Children playing on nursery school playgrounds located close to congested streets are a common sight in Polish cities, despite the fact that numerous studies have shown that staying in a noisy environment has an adverse effect on children (BERGLUND *et al.*, 1999; BISTRUP, 2001; Common Traffic Noise..., 2001; Future noise policy..., 1996; EVANS, LEPORE, 1993; How pollutants and noise affect..., 2007; KAWADA, 2004; MAXWELL, EVANS, 2009; SHIELD, DOCKRELL, 2005; STANSFELD, MATHENSON, 2003) and that the premises of nursery schools are legally protected against noise. Children are a group particularly sensitive

to the effects of noise, since at lower equivalent noise levels produce in children similar effects as in adults (BISTRUP, 1999). Studies show that children in schools and nursery schools exposed to high noise levels are less motivated than children in quiet institutions of this kind (EVANS, LEPORE, 1993). Children exposed to constant noise show less enthusiasm for problem solving, taking on challenges and concentrating on a started activity. Studies confirm the numerous reports of teachers suggesting that children staying in nursery schools exposed to excessive noise generally show less willingness to play, are less engaged in playing and often find it difficult to keep on playing a started game to its end. Constant exposure to a high level of noise may increase in the youngest the sense of helplessness and generate many negative emotions, such as anger, disappointment, dissatisfaction, withdrawal, sadness, anxiety, agitation and exhaustion.

According to the Polish law, the daytime noise limit value (expressed by noise indicator  $L_{AeqD}$ ) for nursery premises amounts to 55 dB. By comparing the measured or computed  $L_{AeqD}$  with the limit value one can determine whether the acoustic environment quality standards are met. However, this often does not show the actual exposure to noise of the children staying in a given institution. To a large extent, the noise exposure depends on the layout of the nursery premises, the location of the playground on which the children stay and the location of the nursery building relative to the street being the source of noise.

The above considerations provided a stimulus for this study aimed at assessing the noise exposure of the nursery schools in Wrocław, taking into account two factors: the noise level on the playground and the noise level on the nursery school building facades (CZAJKOWSKA, 2009).

## 2. Investigative methodology

In the assessment of the acoustic climate on nursery school premises, the daytime noise coming from the main roads and the other roads was considered. The approximate method of assessing the road noise level range was used. The noise level for the main roads was determined from the acoustic map of Wrocław, taking into account a typical relation between indicators  $L_{DWN}$  and  $L_{AeqD}$ :  $L_{AeqD} = L_{DWN} - 5$  dB. The noise level for the other roads was determined on the basis of noise and traffic conditions measurements and computer simulations, carried out for representative types of streets.

The road noise level on the playground and the road noise level on the school building facades were used as the basis for assessing the acoustic climate of a given nursery school. Car parks, access paths to the building, decorative lawns and places which clearly were not meant for children to stay in, were excluded from the analyzed nursery school premises (Fig. 1). A database, containing general and detailed data on land development, neighbourhood and noise sources as well as photographic documentation and survey maps, was created (CZAJKOWSKA, 2009).

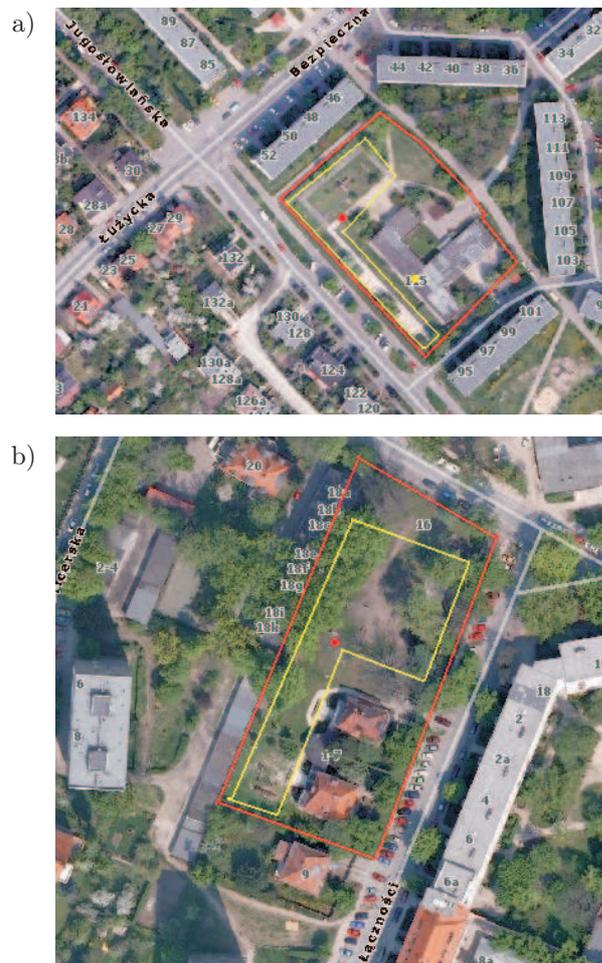


Fig. 1. The view of the tested nursery school No. 1 (a) and No. 3 (b); the red line – the border of the nursery school premises, the yellow line – the playground, red point – the measuring point.

It was assumed that noise exposure grades could be given to playgrounds and nursery school buildings on the basis of the approximately determined road noise level ranges occurring on nursery school premises. The grades were used to rate the nursery schools from exceptionally bad to exceptionally good. A 12-grade scale, based on (BERGLUND *et al.*, 1999; Future noise policy..., 1996), was adopted for nursery school noise exposure rating (Table 1). A possibly simple and repeatable scheme of determining the average grade according to the above scale was devised according to the schema described below.

1. For each nursery school, the following partial grades were determined:
  - the average grade for the noise on the playground, coming from: a) the main roads, b) the other roads;

- the average grade for the noise on the building facades, coming from:
  - a) the main roads, b) the other roads;
- 2. For every  $j$ -th type of road, the average grade  $\bar{K}_j$  was calculated as a weighted average from the Relation (1):

$$\bar{K}_j = \frac{\sum_{i=1}^n K_{ji} \cdot S_{ji}}{100\%}, \quad (1)$$

where  $K_{ji}$  – the grade according to the Table 1 for each  $i$ -th 5 dB road noise level range on the playground or near the building facades,  $S_{ji}$  – percentage of the area within the reach of the  $i$ -th 5 dB road noise level range against the total playground area or  $S_{ji}$  – the percentage of the perimeter length of the building facades within the reach of the  $i$ -th 5 dB range. The resultant grade  $\bar{K}_j$  was rounded off to the nearest value on the adopted 12-grade scale.

3. The maximum ( $L_{AeqD,max}$ ) and minimum ( $L_{AeqD,min}$ ) value of the resultant road-noise level were calculated according to the dependences:

$$\begin{aligned} L_{AeqD,max} &= 10 \log (10^{0.1L_{AeqD,up,1}} + 10^{0.1L_{AeqD,up,2}}), \\ L_{AeqD,min} &= 10 \log (10^{0.1L_{AeqD,lo,1}} + 10^{0.1L_{AeqD,lo,2}}), \end{aligned} \quad (2)$$

where  $L_{AeqD,up,j}$  and  $L_{AeqD,lo,j}$  – respectively the upper and lower limit of the  $L_{AeqD}$  range according to the Table 1, complied with the calculated value of  $\bar{K}_j$ , 1 – main road, 2 – other road.

4. As the resultant grade  $K_{tot}$ , the nearest grade according to the Table 1 following from the newly received range of the noise level was accepted.

**Table 1.** Nursery school noise exposure grading scale.

No.	$L_{AeqD}$ [dB]	Points	Noise
1	< 45	0	exceptionally good
2	45–50	1	good
3	48–53	1.5	respectable
4	50–55	2	ordinary
5	53–58	2.5	nearing to the limit value
6	55–60	3	bad
7	58–63	3.5	bad
8	60–65	4	very bad
9	63–68	4.5	very bad
10	65–70	5	exceptionally bad
11	68–73	5.5	exceptionally bad
12	70–75	6	exceptionally bad

The adopted investigative methodology was verified by comparing its results with those of field noise measurements and simulation studies, carried out for a few selected objects. Both the road noise levels determined from the acoustic map, and nursery school acoustic climate assessments, were verified in this way. In order to check whether the data obtained from the acoustic map were accurate enough for the purposes of this work, noise measurements were carried out for seven selected nursery schools. The measurements were performed using sampling method in one measuring point located in the centre of the playground at height  $h_o = 1.5$  m. The verification showed the data to be accurate enough (Table 2). In six cases the measured value of  $L_{AeqD}$  was within the noise levels range estimated according to the adopted methodology. The measured values tended to be close to the lower limit of the noise interval.

**Table 2.** The comparison of results of analyses and noise measurements on the playgrounds for chosen nursery schools.

No.	Grade			$L_{AeqD}$ [dB]		Verification
	Mian Road $\bar{K}_1$	Other road $\bar{K}_2$	Total $K_{tot}$	Calculated acc. (2a-2b)	Measured	
1	1.5	3	3	55.8–60.8	55.9	positively
2	2.5	1	2.5	53.6–58.6	56.6	positively
3	2	1.5	2.5	52.1–57.1	53.7	positively
4	3	2	3	56.2–61.2	56.3	positively
5	2.5	1	2.5	53.6–58.6	54.4	positively
6	2	1	2	51.2–56.2	52.1	positively
7	2	1	2	51.2–56.2	48.2	negatively

In the second stage of verification, noise exposure grades determined on the basis of simulation studies were compared with those based on approximate data. The comparison was carried out for five selected nursery schools with different land development. The SoundPLAN software and the NMPB computing method were used for the simulations. The simulation models were calibrated using the results of measurements performed near the boundary of the premises of the investigated nursery schools. The verification proved the noise exposure grading for noise coming from the main roads and from the other roads to be correct. The estimated average noise level for the playgrounds differs from the estimated one by no more than 2.5 dB for four of the nursery schools, while for one of them the difference amounted to 4.5 dB. An on-site visit showed that the difference in the latter case could be due to the roadworks being carried out on the nearest road and the consequent changes in traffic organization.

### 3. Results

The survey covered 118 nursery schools located in Wrocław. An analysis of the assessments of noise on nursery school premises showed that:

- 64 % of the nursery school buildings and 55% of the area of the nursery school playgrounds in Wrocław is exposed to excessive noise, i.e. exceeding the limit value of 55 dB. The fact that the number of buildings exposed to noise is larger than the number of playgrounds exposed to noise can be explained by the frequent nursery school premises configuration in which the school building is located closer to the main street than the playground.
- Noise whose level exceeds 55 dB occurs on both the building facade and the playground in 57 nursery schools, which amounts to 48% of all the investigated nursery schools.
- The acoustic climate quality assessment made according to the adopted scale (Table 1) shows that only in 9 nursery schools in Wrocław the acoustic climate is good. The average indicator  $L_{AeqD}$  is below 50 dB on both the playground and the building elevation.
- The acoustic climate in 9 nursery schools should be rated as exceptionally bad. The average indicator  $L_{AeqD}$  exceeds 65 dB on both the playground and the building facade. The nursery schools are located near the busy major roads or between several streets without being screened from them in any way.

Tables 3 and 4 show the grades received by the nursery schools in Wrocław according to the grading scale proposed by WHO and according to the acoustic comfort grading scale, assuming many hours long noise action.

**Table 3.** Rating of nursery schools in Wrocław according to WHO scale (Future noise policy..., 1996).

$L_{AeqD}$ [dB]	Noise annoyance	Playgrounds		Nursery buildings	
		<i>N</i>	%	<i>N</i>	%
< 55	low or average annoying noise	53	45	42	36
(55; 60)	annoying noise, causing serious nervousness	31	26	42	36
(60; 65)	seriously annoying noise, unacceptable	25	21	25	21
> 65	constrained behaviour patterns, symptomatic of serious damage caused by noise arise	9	8	9	8

According to the WHO scale, the road noise nuisance on the premises of less than half of the nursery schools in Wrocław can be rated as low or medium, while on the premises of as many as 9 nursery schools it is rated as producing changes

**Table 4.** Rating of nursery schools in Wrocław according to acoustic comfort scale.

$L_{AeqD}$ [dB]	Acoustic comfort	Playgrounds		Nursery buildings	
		$N$	%	$N$	%
< 50	complete acoustic comfort	9	8	10	8
(50; 60)	average acoustic conditions	75	64	74	63
(60; 70)	average danger of noise	33	28	34	29
> 70	high danger of noise	1	1	–	–

in behaviour and other serious effects. Only less than 10% of the nursery schools in Wrocław have an acoustic climate which could be described as comfortable (Table 4).

#### 4. Conclusion

The results of this study indicate that a high percentage of the nursery schools in Wrocław are exposed to excessive noise, which is alarming. Such a situation is unacceptable in the 21st century.

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