VULNERABILTY ASSESSMENT – POLAND

Based on local, regional, national and international studies, surveys and field campaigns

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Abstract

Indoor air quality in schools is a very important issue in the field of public health. Primary school students in Poland (approximately 2 481 800 students), who are a vulnerable population, spend approximately 6 – 9 h daily in school buildings, thus, monitoring and supervision of indoor air quality in primary school buildings is necessary to ensure children's health and well-being.

In Poland the state of primary school buildings (n=13 563) does not vary significantly throughout the whole country. However, currently an educational reform that covers primary schools is taking place. Some junior high school buildings after closing down will be transformed into primary schools. Due to the fact that in the last decades many of them were newly build, after the reform primary school buildings may vary more considerably. In the last 5 years performance of renovation works started including replacement of windows and/or insulation, modernization of heating, lighting and sanitary installations. However, there are still several more factors (e.g., ambient air pollution, consumer/building/furniture products, etc.) that might affect indoor air quality.

Recently, there is no consensus on how to regulate indoor air quality worldwide. What is more, in Poland there are no legal regulations on the indoor air quality (except for the reference values for harmful biological agents). Moreover, there is no published, reliable data from measurements of the indoor air quality, particularly in Polish schools.

Therefore, in Poland there is an urgent need to perform scientific studies on ambient pollutants in a school environment and to trigger establishing indoor air quality guidelines/regulations at a national level

1. Primary school education and the state of school buildings in Poland

Educational system in Poland is centrally managed by a combination of centralized educational policy and governance (the Minister of National Education and the Minister of Science and Higher Education) and decentralized administration of educational institutions (local government authorities). MEN, along with regional schools superintendents are in chargé of pedagogic supervision of schools. Education is guaranteed for all the citizens by public authorities. Education in public schools is free of charge but parents are free to choose schools other than the public ones. Non-public schools comprise civic schools, church-administered schools and private schools, which can be financed from tuition fees paid by pupils' parents, and from other sources such as private business or foundations. In the case of public primary schools administrative and organizational matters as well as public funding allocation remain in the hands of schools and school governing bodies – communes. The greater part of financial support for education comes from the public budget. Amount of the general subvention for all local government units is defined annually in the budgetary act.

The school year lasts from September to June, and is divided into two semesters. The standard limit of the number of pupils in a class in the case of grades I-III of primary school – does not exceed 25.

According to the Education Information System, the percentage of classes, where the number of pupils exceeds 30, in general in primary schools amounts to 7%, and in I-III grades it is only 1.45%.

Currently, in Poland an educational reform that covers primary schools is taking place. Till the year 2015/2016 primary school lasted 6 years, and from the year 2016/2017 it has been extended by 2 years and now it lasts 8 years. Similar changes concern children who just start school. Over the years 2014/2015 and 2015/2016 children aged 6 years old started school; but now, after the reform has been introduced, beginning from the current school year, the age of 7 as the age of starting school has been brought back. Primary school pupils, in accordance with the new system (starting from the school year 2016/2017) are children aged 7-15. Primary school is divided into two parts. From the school year 2016/2017 in a Polish primary school there are two stages: the first stage

(grades 1-4) and the second stage (grades 5-8). Previously primary school was divided into 1-3 grades (the first stage) and 4-6 grades (the second stage).

The latest statistical data on public education can be found in the "Oświata i wychowanie w roku szkolnym 2015/2016" [Education and upbringing in the school year 2015/2016] published by the Central Statistical Office on their website. This publication covers elementary, overall data on education in Poland. Detailed data are presented in Tables 1-3. Generally, in Poland public school sector dominates over the private one.

In the school year 2015/2016, approximately 2 480 800 pupils attended primary public and non-public schools with public status. Of this number, 2 388 890 pupils attended public schools, and about 91 900 non-public schools with public status.

Table 1. Primary schools, teachers and students in 2015/2016 school year.

Specification	The number of:		
	schools	teachers	pupils
Grand total Poland	13 563	190 510	2 480 793
Primary public schools Poland	12 365	180 426	2 388 890
Primary non-public schools with public status Poland	1 198	10085	91903
Region of Lodz (incl. Lodz city)	845	11 617	151 776

Source: Oświata i wychowanie w roku szkolnym 2015/2016, Główny Urząd Statystyczny, 2016; [Education and upbringing in the school year 2015/2016, Central Statistical Office of Poland, 2016]

Table 2. Pupils in primary schools by place of residence in 2015/2016 school year.

Specification	Urban areas		Rural areas
	less than 5 thous. inhabitants	more than 5 thous. inhabitants	
Grand total Poland	77 610	1 319 703	1 083 482
Region of Lodz (incl. Lodz city)	3 910	84 504	63 362

Source: Oświata i wychowanie w roku szkolnym 2015/2016, Główny Urząd Statystyczny, 2016 [Education and upbringing in the school year 2015/2016, Central Statistical Office of Poland, 2016]

Table 3. Students/teacher ratio in 2015/2016 school year.

Specification	Student/teacher ratio
Grand total Poland	13.0
Primary public schools Poland	13.2
Primary non-public schools with public status Poland	9.1
Region of Lodz (incl. Lodz city)	13.1

Calcualted based on: Oświata i wychowanie w roku szkolnym 2015/2016, Główny Urząd Statystyczny, 2016[Education and upbringing in the school year 2015/2016, Central Statistical Office of Poland, 2016]

Approximately 190 500 teachers were working full- or part-time in primary schools in the school year 2015/2016. Majority of them were employed in public schools (94.7%) and the remaining ones taught in primary non-public schools with public status (5,3%). In the school year 2015/2016, in Poland the students/teacher ratio was approximately 13.0.

The main issue and challenge that Polish education is currently facing are demographic changes. In the recent two decades the number of births has dramatically dropped, which results in less and less numerous cohorts of pupils at the individuals levels of education. The increase in the number of first grade goers in primary schools, which as a result of the previous reform of the schooling age considerably increased (especially in the year 2015/2016) is a short-term change. Constantly decreasing number of students enforces organizational changes of schools due to economic reasons. Also the number of educational units and their average size are dropping, and primary schools are more and more frequently transformed into complexes of schools. The number of teachers in schools in recent years has also decreased, though, this drop is considerably smaller when compared to the dynamics of changes in the numbers of pupils. One of the main causes of changes in local school networks is demographic decline. Over the years 2007-2012 the number of primary school pupils decreased by 9.1%. The number of pupils decreases fastest in the rural and peripheral areas, whereas in some cities and suburbs it starts to grow.

Primary schools in Poland are run mainly by districts authorities. However, a slow process of an increasing part of schools run by other organs is being observed. In the school year 2007/08 districts authorities run 94.1% of primary schools, and in the year 2012/13 – already only 89.8%. Those changes stem from closing primary schools by districts authorities and passing them to other organs (mainly societies). The mean number of pupils in a primary school in the school year 2012/13 amounted to 167.6 and was lower

than the mean from the school year 2007/08 by 6 pupils. The mean size of a school significantly depends on the type of organ which is running it. The mean size of a school run by district authorities in the analyzed period has hardly changed and amounts to about 180 pupils. This means that districts authorities closed mainly small schools. Over the years 2007-2012 954 primary schools were closed down. These were mainly decisions of districts authorities (90% of closed down schools). Over the years 2007-2012 new primary schools were opened mainly by commercial bodies. Societies hardly ever opened new schools, but the number of primary schools run by them doubled, mainly because of taking them over from the districts authorities.

In the school years 2007/08 – 2012/13 the number of pupils in primary schools dropped by more than 9%, while the number of schools in the same period dropped almost by 6% (Table 4). While in school year 2015/2016, there was an increase in the number of students over 16%, with an increase in the number of schools by almost 7% (compared to 2012/2013).

Table 4. The number of primary schools and the number of pupils over the years 2007/08-2015/16.

	2007/08	2012/13	Change	2015/2016	Change compared to:	
					2007/2008	2012/2013
Number of students	2 341 316	2 127 891	-9.1%	2 480 793	+6.0	+16.6
Number of schools	13 483	12 696	-5.8%	13 563	+0.6	+6.8

Sources:
Herczyński J., Sobotka A. Diagnoza zmian w sieci szkół podstawowych i gimnazjów 2007-2012.[Diagnosis of changes in the network of primary schools and junior high schools 2007-2012] Warszawa, 2014.
Oświata i wychowanie w roku szkolnym 2015/2016, Główny Urząd Statystyczny, 2016; [Education and upbringing in the school year 2015/2016, Central Statistical Office of Poland, 2016]

Table 5. Primary schools and their pupils by the running organ (2007/08, 2012/13).

	2007/08		2012/13		% change	
	Schools	Pupils	Schools	Pupils	Schools	Pupils
Districts authorities	12 691	2 287 724	11 398	2 041 756	-10.2%	-10.8%
Societies	544	32 258	949	52 854	74.4%	63.8%
Commercial bodies	183	11 460	275	20 741	50.3%	81.0%
Religious organizations	60	9 466	71	12 207	18.3%	29.0%

	2007/08		2012/13		% change	
	Schools	Pupils	Schools	Pupils	Schools	Pupils
Other	5	408	3	333	-40.0%	-18.4%
In total	13 483	2 341 316	12 696	2 127 891	-5.8%	-9.1%

Source: Herczyński J., Sobotka A. Diagnoza zmian w sieci szkół podstawowych i gimnazjów 2007-2012. [Diagnosis of changes in the network of primary schools and junior high schools 2007-2012] Warszawa, 2014

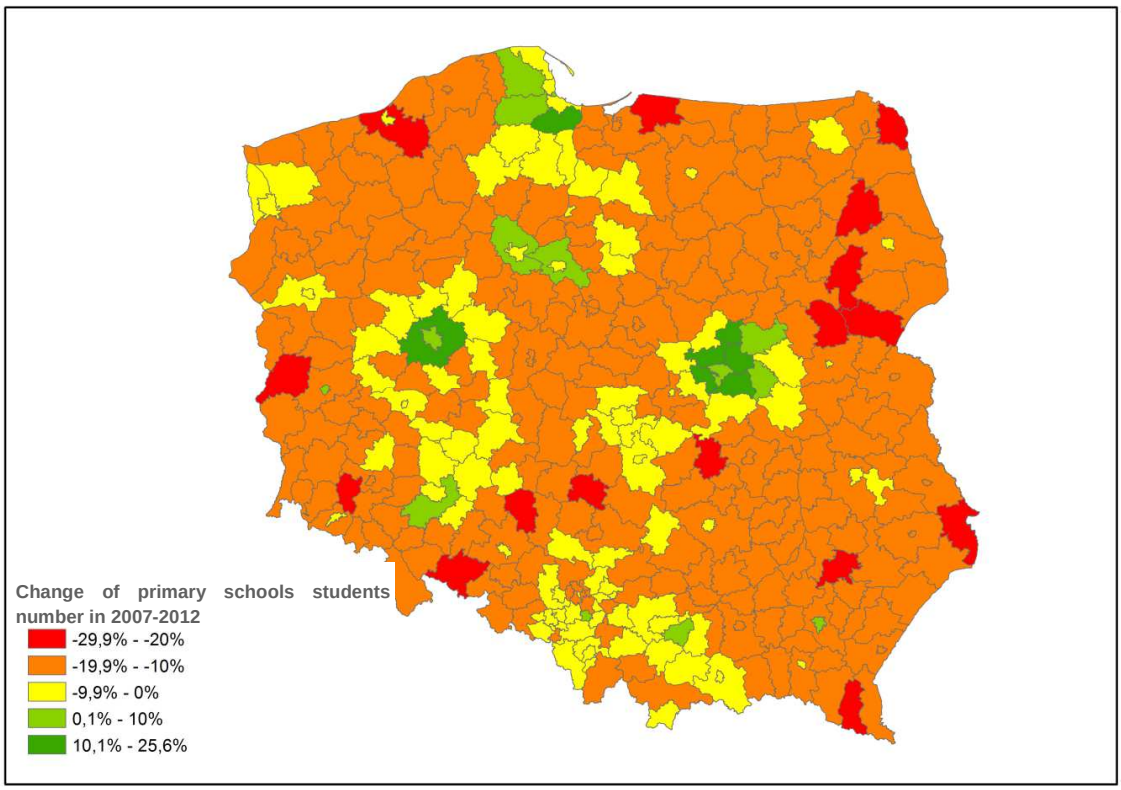
During the discussed 5 years both the number of schools run by districts authorities as well as the number of pupils in those schools have dropped by 10%. The number of schools run by societies and commercial organizations as well as pupils attending those schools have increased considerably. Among primary schools, schools run by districts authorities are the most numerous ones, but in the study period the structure of primary schools by the type of the running organ has changed. This structure in the school year 2007/08 as well as in 2012/13 is presented on table 6.

Table 6. The structure of primary schools by the running organ (2007/08, 2012/13).

Running organ	2007/08 year		2012/13 year	
	Schools	Pupils	Schools	Pupils
Districts authorities	94.1%	97.7%	89.8%	96.0%
Societies	4.0%	1.4%	7.5%	2.5%
Commercial bodies	1.4%	0.5%	2.2%	1.0%
Religious organizations	0.4%	0.4%	0.6%	0.6%

Source: Herczyński J., Sobotka A. Diagnoza zmian w sieci szkół podstawowych i gimnazjów 2007-2012. [Diagnosis of changes in the network of primary schools and junior high schools 2007-2012] Warszawa, 2014

Figure 1 shows the change in the number of pupils in primary schools over the years 2007-2012. The number of students increased only in few big cities (inter alia Warsaw). The number of students also increased in counties neighboring with the big cities (urbanization process). Lodz is an exception from this rule, no increase in the number of pupils in the suburbs of the city has been reported. The second characteristic which is visible when looking at the map is the division into central and peripheral areas – the further from the city, the bigger the drop in the number of pupils.



Source: Herczyński J., Sobotka A. Diagnoza zmian w sieci szkół podstawowych i gimnazjów 2007-2012. [Diagnosis of changes in the network of primary schools and junior high schools 2007-2012] Warszawa, 2014

Figure 1. Change in the number of pupils over the years 2007-2012

To the best of our knowledge, there is no statistical data on the state of primary schools buildings in Poland. However, thanks to the courtesy and a great contribution of the Department of Education, The City of Lodz Office we have obtained overall data that characterize buildings of primary schools in the city of Lodz. This data has been presented in the Table presented below. In the last decade in the whole country, school buildings were gradually subjected to renovations, that most frequently included processes of thermomodernization. This process is associated with legal regulations that apply in the European Union (reduction of CO_2 emission) as well as actual renovation needs (among others poor state of window joinery). In general, non-public school buildings are in better condition that those of the public schools.

The state provided financial support allotted mainly for the improvement of educational tools (e.g., new computers and boards), less financial support remained for the renovation works. To the best of our knowledge, in Poland there is no actual data on the state of school buildings. Nevertheless, thanks to the courtesy of the Unit of Projects and Investments, Department of Education, The City of Lodz Office, the employees of which

contacted all the schools via phone and gathered very detailed information, it became possible to prepare a report on the state of public school buildings in Lodz. As there is no basis to conclude that the schools in Lodz differ considerably from the schools in the rest of the country, this report may be considered as representative for the whole Poland. Table 7 and Figure 2 present institutions that run primary schools in Lodz.

Table 7. Primary schools in Lodz by the funding institution in the school year 2016/2017 (before the reform getting rid of junior high schools).

Schools	Funding institution	Number of schools
Public (n=86)	City of Lodz Office	83
	Society	3
Non-public (n=22)	Foundation	3
	Church/ religious organizations and societies	2
	Private schools (companies)	9
	Other (societies)	8

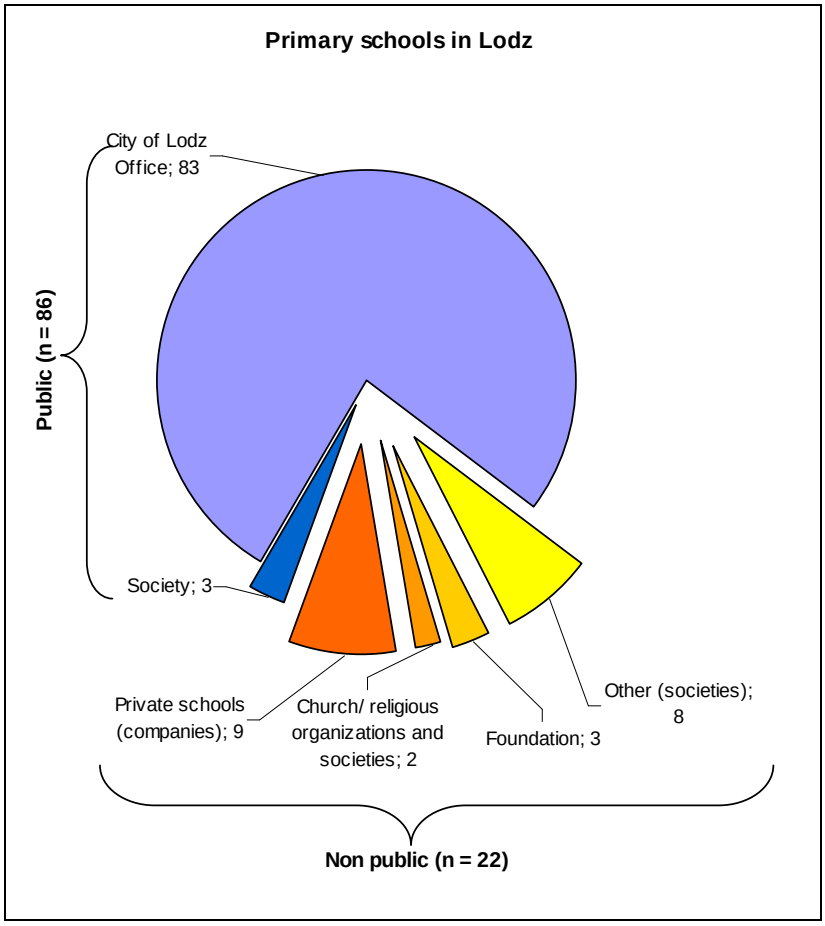


Figure 2. Percentage of primary schools in Lodz by the funding institution in the school year 2016/2017 (before the reform getting rid of junior high schools).

A detailed list of numbers of selected features of buildings of public schools in Lodz is presented in Table 8. The list includes buildings according to the state as of January 2017, i.e. before the educational reform that closed down junior high schools, the part of which in the coming years will be transformed into primary schools. However, buildings of junior high schools in Lodz do not differ from the buildings of primary schools because of the fact that in the period during which they were created, in vast majority, they were created from the buildings of the closed down primary schools.

Table 8. The state of public primary school buildings in Lodz in the school year 2016/2017 (before the reform closing down junior high schools).

Specification		Number of schools
Age of the building or the date of the building construction:	1900 - 1945	10
	1946 - 1979	65
	1980 - 1989	7
	After 1990	1
Type of construction materials:	concrete slab	20
	hollow brick	1
	brick	51
	mixed	11
Floors number:	ground-floor	0
	1-storey	9
	2-storey	52
	3-storey (and more)	22
Shape of the building:	Regular	32
	Irregular	7
	L shaped	27
	U shaped	10
	T shaped	3
	C shaped	2
	H shaped	1
	E shaped	1
Schools without thermomodernization		57
Schools after thermomodernization		26
Schools that require thermomodernization:	Thermomodernization planned in 2017	9
	Thermomodernization planned in 2018	9
	Thermomodernization planned in 2019	6

Specification		Number of schools
Renovation needs*:	Thermoinsulation of walls	59
	Replacement of windows	46
	Fixing the roof	57
	Repair of facades	57
	Replacement of sanitary installation	42
	Replacement of electric installation	69
	Replacement of lighting	54
	Interiors renovation	69
	Replacement of furniture	68
	Ventilation cleaning/repair	44
	Chimneys	3
	Foundation insulation	1
	Lightning protection	1
	Dehumidifying of basements	1
Heating type:	Municipal	71
	Gas	8
	Gas and oil	1
	Oil	3
Ventilation type**:	Gravity	83
	Mechanical	20
	Air Conditioning	1
Location:	High intensity of traffic	27
	Medium intensity of traffic	33
	Low intensity of traffic	23

* more than one answer could be chosen
** more than one answer: mechanical ventilation in the kitchen or sports part, and air conditioning in the sports part

The report on the state of primary schools buildings in Lodz indicates a bad technical state of the buildings; more than a half of the buildings require a thorough renovation including thermoinsulation of walls, replacement of windows, roof and facades fixing, replacement of sanitary, electric installations, replacement of lighting, renovation of interiors and replacement of furniture. Detailed needs are showed on Figure 3. The need for ventilation cleaning or repairing reported by 50% of schools included in the report is particularly alarming. Not properly working ventilation results in the increase of harmful agents concentration present in the indoor air, including mainly CO_2 that the pupils themselves are a source of. Exposure to a high concentration of CO_2 in humans induces problems with

concentration and negatively affects well-being. It has also negative health effects (among others: headache or mucosal irritation). Therefore, one should pay particular attention to raising awareness of schools management and institutions that run and manage schools of the problem of an inappropriately working or clogged ventilation.

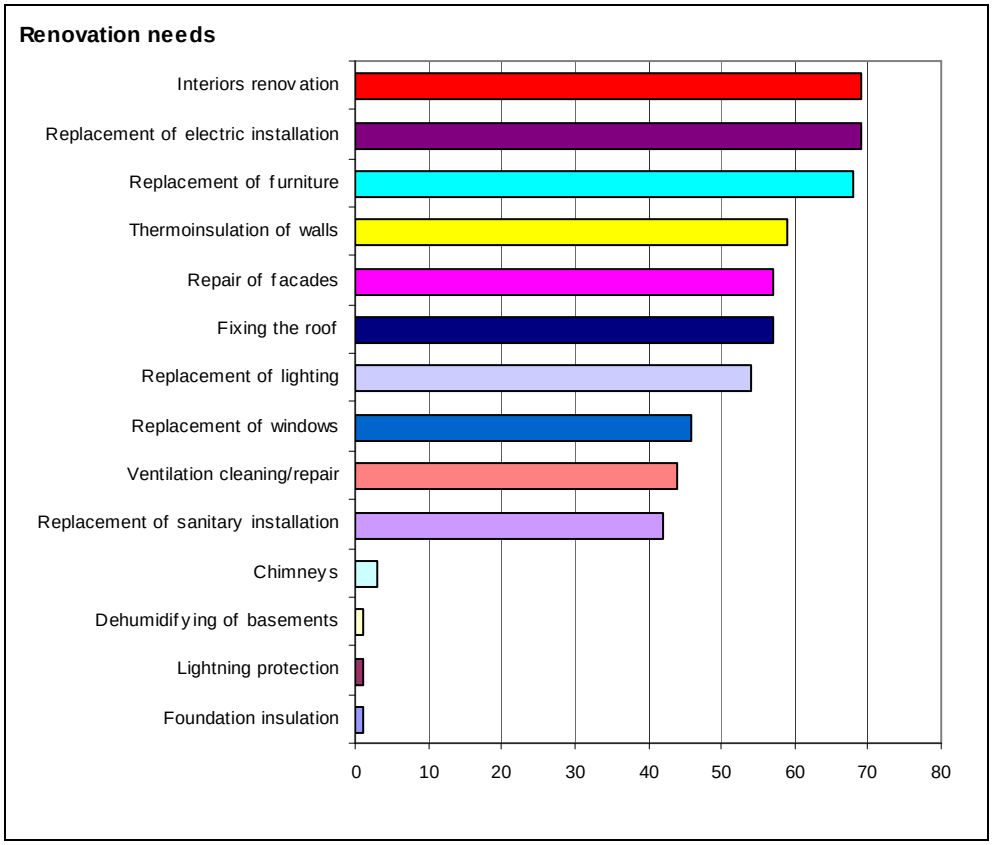


Figure 3. Renovation needs in public schools in Lodz in school year 2016/2017 according to schools directors.

Situation concerning the need for replacement of windows is similarly alarming. Old, damaged windows are often impossible to open and make proper airing of the classrooms impossible, which when combined with the previously discussed inappropriately working air ducts increases the problem of long-term exposure of children to elevated levels of CO_2 in schools.

According to the information provided by the public primary schools in Lodz nearly all school buildings are asbestos free. One school is an exception – according to the information provided by the school, it has some asbestos in the part of the roof. Exposure to asbestos fibers is associated with respiratory diseases including mesothelioma.

The surveyed schools did not have any information if plumbing installations in their buildings contained lead. Lead can leak from the pipe into the drinking water and might

cause adverse health effects even at low concentration levels. Lead is considered a highly toxic metal that may induce serious health hazards, especially in children, such as; elevated blood pressure, hearing problems. Lead is particularly dangerous to children because their growing bodies absorb more lead than adults' bodies do and their brains and nervous systems are more prone to the damaging effects of lead. In accordance with the applying legislation, the use of lead containing pipes in Poland is forbidden, therefore, one may assume that even in old school buildings lead pipes were replaced by safe ones many years ago. Majority of the schools reported the need for interiors renovation and replacement of furniture. Selection of new flooring material and furniture has to be done with care. Several consumer/building products emit volatile organic compounds, which might cause sensory irritation in the eyes and airways and deterioration of performance. Recently, replacement of old windows by airtight ones in the primary schools could lead to the reduction of energy used for heating; however, the concentration of indoor air pollutants (e.g., volatile organic compounds, carbon dioxide) might be higher due to the lower air exchange rates.

The primary schools in Lodz, which were described by us, are located in various parts of the city with various intensity of road traffic and resulting from it diverse levels of air pollutants and noise in the direct neighborhood of the school.

Taking into consideration all the described varieties one should conclude that in the schools of Lodz that represent primary schools in the region of Lodz and in Poland, actions aiming at improvement of indoor air quality should be definitely taken.

2. Policies on the indoor environment in school buildings

In Poland legal regulations on the quality of indoor environment in school buildings are formulated in a very general way. The main legal act is the Directive of the Minister of National Education and Sport of December 31, 2002 on the health and safety in public and non-public schools and educational units. However, this regulation does not specify detailed technical or organizational requirements that should be used to ensure good quality indoor air in schools. Content of the regulation includes only a general statement that head masters of schools and other educational units are responsible for providing safe and healthy conditions in the schools as well as safe and healthy conditions of participation in the classes organized by the school but taking place outside the premises of the schools.

There is also lack of any formal regulations with regard to supervision of the indoor air quality in schools. A headmaster is obliged to ensure healthy conditions; however, there is lack of reference values for pollutants concentration in the air, as well as there are no institutions that would control fulfilling this obligation. In general, in Poland there is lack of institution that would supervise indoor air quality in almost all types of environment. Environment of work is the only exception – for this particular environment there are a number of legal regulations and two national inspections that supervise practical fulfillment of such obligations. In theory, these regulations also apply in schools, which in fact are workplaces. However, in practice, based on this regulations, measurements of harmful agents present in the indoor air of school classes are hardly ever taken.

One of the main purposes of the vulnerability assessment was to review the existing policies, i.e. officially adopted documents on the indoor environment. Based on the type of policy, legally binding standards or regulations, the legally non-binding recommendations or guidelines as well as action plans or programmes are distinguished. Furthermore, policies exist at different levels such as international, national or sub-national (regional) levels. International bodies have developed several regulations and guidelines on selected air pollutants outdoors; however, there are still no regulations covering concentration of air pollutants indoors. In 2010, the World Health Organization (WHO) published a book ("WHO guidelines for indoor air quality: selected pollutants") in which some common indoor air pollutants are reviewed and guidelines are recommended.

Besides these international bodies, big effort is made to establish indoor air quality guidelines at national or at sub-national levels in several countries all over the world. WHO collected relevant information by the "Environment and health policy action questionnaire" from the member states and the results of the work were published in 2014 as "School environment. Policy and current standards".

It is well-known that the temperature and relative humidity in the classrooms are a matter of human comfort. Inappropriate air parameters have negative influence on well-being of teachers and pupils that spend their time there. Too low relative humidity of air, especially during the heating season, results in dryness in the nose and throat and leads to eyes irritation. Whereas, a too high air temperature (especially when combined with an increased concentration of CO_2) may induce breathlessness and tiredness.

Legal regulations oblige to maintain the following temperatures in a school building, in the heating season:

- rooms for learning: at least +18°C (*Directive of the MEiS of December 31, 2002 on the safety and health in public and non-public schools and educational units*),
- cloakrooms, corridors, staircases, gyms: +16°C,
- undressing rooms, showers: +24°C.

In case of not meeting the criterion of minimal temperature, the headmaster suspends classes for an unspecified period of time.

There are national regulations related to ventilation in schools but general formulated as 'In school premises ensures appropriate lighting, ventilation and heating' (Directive of the Minister of Education and Sport of December 31, 2002 on the safety and health in public and non-public schools and educational units). In Poland in 2008 was implemented European Standard EN 13779:2007 Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems (Polish Standards PN-EN 13779:2008).

To protect non-smokers from tobacco smoke, strict regulations are in force in Poland.

The Act of November 9, 1995 on the health protection against consequences of tobacco and tobacco products smoking strictly bans smoking tobacco products, including novelty tobacco products and e-cigarettes, on the premises of organizational units of educational system, and also outside those premises.

There are in Poland the reference values related to harmful biological agents present in the indoor air proposed by Górny RL. In practice the concentrations of biological agents in schools very rarely (even never) are measured and only experts in the field of exposure to biological agents know about it.

Currently applying legal regulations on the technical state of school buildings:

1. Ordinance of the Minister of Education and Sport of December 31, 2002 on the safety and health in public and non-public schools and educational units (Journal of Acts. No 6, 2003 r., Item 69 as later amended.).
2. Ordinance of the Minister of Health and Social Welfare of March 12, 1996 on acceptable concentrations and intensity of adverse to health agents, secreted by construction materials, equipment and fittings in rooms designed to accommodate people. Polish Monitor No. 19 of 1996. Item. 231.
3. Ordinance of the Minister of Labour and Social Policy of September 26, 1997 on general safety and health (consolidated text Journal of acts No. 169 of 2003., Item. 1650).
4. The Act of June 7, 2001 on public water supply and public wastewater removal (Journal of Acts No. 72 of 2001., Item 747, as amended later)
5. Ordinance of the Minister of Infrastructure of April 12, 2002 on the technical conditions to be met by buildings and their location (Journal of Acts No. 75 of 2002., Item 690 with subsequent amendments).

6. Ordinance of the Minister of the Environment of June 14, 2007 on acceptable noise levels in the environment (Journal of Acts No 120 of 2007., Item 826 with subsequent amendments).
7. PN-EN 13779:2008 Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems
8. The Act of November 9, 1995 on health protection against consequences of tobacco and tobacco products use (Journal of Acts 1996 No. 10, Item. 55 with subsequent amendments).
9. DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE EUROPEAN COUNCIL 2010/31/EU of May 19, 2010. on the energy characteristics of buildings
10. DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE EUROPEAN COUNCIL 2012/27/UE of October 25, 2012 on energy efficiency, amending Directives 2009/125/ EC and 2010/30 /EU and repealing Directives 2004/8/EC and 2006/32/EC.

3. Review of indoor air quality data

To the best of our knowledge, SINPHONIE was the only international project related to the indoor air in schools that was conducted in Poland. According to the information published by WHO („School environment. Policy and current standards", 2014) one of the highest in Europe levels of concentration of benzene and formaldehyde was indicated in the indoor air of school buildings that were examined within the SINPHONIE project in Poland.Median of the average weekly levels of formaldehyde was 12 $\mu g/m^3$ (range from 1 to 66 $\mu g/m^3$). The maximum concentration and the highest country-level median value were detected in Romania, the second highest levels were reported in Poland. The WHO guideline for formaldehyde (100 $\mu g/m^3$) was not exceeded in any of the schools. The median level of benzene was 2 $\mu g/m^3$ (ranging from below the method detection limit to 38 $\mu g/m^3$). The maximum value and the highest country-level median were reported in Poland. Benzene is a carcinogen with no safe level.

A national project conducted three years ago in NIOM could be another possible source of such results; however, now the results are not yet published and due to the Copyrights we cannot use them in the InAirQ project (authors are not in the project team). The problem will be solved after publication of the results.

In the literature there are only few reports on the results of measurements of harmful agents in the air of primary schools in Poland. The list of publications that were found in the PubMed database is presented in the Table 10.

Table 9. Results of national studies concerning the indoor air quality in educational institutions in Poland based on PubMed database.

No	References	Type of educational institutions, localisation	Harmful agents
1	Połednik B. Particulate matter and student exposure in school classrooms in Lublin, Poland. Environ Res. 2013 Jan;120:134-9. doi: 10.1016/j.envres.2012.09.006. Połednik B. Aerosol particle concentrations and indoor air parameters in school classrooms. Management of Indoor Air Quality.2011, 31-38. Połednik B. Variations in particle concentrations and indoor air parameters in classrooms in the heating and summer season. Archives of Environmental Protection. 2013, 39(4),15-28. Połednik B., Dudzińska M.R., Ventilation Control Based on the CO_2 and Aerosol Concentration and the perceived Air Quality Measurements – a Case Study. Archives Environ. Prot. 2010. 36(4), 67-80. Połednik B., Dudzińska M.R., The impact of the room occupation and the indoor air parameters on the aerosol particle concentration in classrooms. Indoor Air 2011, Austin TX. Połednik B., M. Dudzińska, A. Raczkowski: The influence of occupation on aerosol and CO_2 concentration in classroom, [in:] Indoor Air 2008, The 11th International Conference on Indoor Air Quality and Climate, Conference Proceedings, Paper ID: 546, Copenhagen 2008. Połednik B. Zanieczyszczenia a jakość powietrza wewnętrznego w wybranych pomieszczeniach. Monografie - Polska Akademia Nauk. Komitet Inżynierii Środowiska. 2013 [Pollution and indoor air quality in selected areas. Monographs - Polish Academy of Sciences. Committee of Environmental Engineering].	junior high schools, Lublin	The highest concentration in [$\mu g/m^3$] was shown in classrooms during the heating season: * in the presence of students ** without presence of students Benzene 1.4 – 6.5* Chlorobenzene 0.4 – 29.8** 1,4-dichlorobenzene 2.7 – 18.5** Ethylobenzene 2.7 – 18.5** Formaldehyde 9.0 – 28.4** Xsylene m+p+o 8.7 – 77.9** Styrene 0 – 9.9** Toluene 231.5 – 46.8** Trichloroethene 0.6 – 27.0** PM (TSP) 280.3±57.0* PN (9.1±2.7) x $10^3 cm^3$ PM_1 86 – 166* *(selected classroom, the highest results)* $PM_{2.5}$ 88 – 167* *(selected classroom, the highest results)* PM10 163 – 538* *(selected classroom, the highest results)* *TSP - Total Suspended Particle* *PN - Particle Number* *PM - Particle Matter*

No	References	Type of educational institutions, localisation	Harmful agents
2	Mainka A., Zajusz-Zubek E., Kaczmarek K. PM2.5 in Urban and Rural Nursery Schools in Upper Silesia, Poland: Trace Elements Analysis. Int. J. Environ. Res. Public Health 2015, 12, 7990-8008; doi:10.3390/ijerph120707990	nursery schools, Gliwice	$PM_{2.5}$ 53.09 to 96.6 [$\mu g/m^3$] *(winter and spring)* In $PM_{2.5}$ samples were analyzed: As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Sb, Se and Zn. An anthropogenic origin revealed most trace elements; however, the most enriched elements in indoor $PM_{2.5}$ were Cd, Se, Sb, Zn and—additionally—Cr in spring.
3	Műllerová M, Kozak K, Kovács T, Smetanová I, Csordás A, Grzadziel D, Holý K, Mazur J, Moravcsík A, Neznal M, Neznal M. Indoor radon survey in Visegrad countries. Appl Radiat Isot. 2016 Apr;110:124-8. doi: 10.1016/j.apradiso.2016.01.010.	schools and kindergartens, Lodz, Lublin, Krakow	Radon: - kindergartens: 611 - 673 [Bq/m^3] - schools: > 300 [Bq/m^3]

The above shown data suggests low quality of indoor air in Polish schools. One should pay particular attention to the fact that there is an urgent need for measurement of harmful agents that are present in the indoor air in schools in Poland.

4. Outdoor air pollution in Poland

The quality of indoor air is closely related to the quality of atmospheric/outdoor air in the direct surrounding of a building. Buildings with installed system of central air conditioning constitute an exception; however the performed local visions indicate that the school buildings in Poland do not use such modern technological solutions. Atmospheric air, and along with it all the pollutants present in it (chemical and biological) get into the school buildings through windows, doors and air ducts. Moreover, according to MEN, based on the declarations of schools headmasters it seems that in 90% of the schools PE classes at least once a week take place in school gyms and school playing fields. Therefore, atmospheric air quality in the surroundings of the schools constitutes one of the most important factors that pose hazard to the health of children who attend the schools. In Poland monitoring of outdoor air is carried out by the Chief Inspectorate of Environmental Protection. The Chief Inspectorate of Environmental Protection publishes, on its website, detailed results of measurements taken in the existing network of measurement points and the current state of air pollution (levels exceeding normative values) for Poland. Analogical data in terms of

individual 16 voivodeships is made public on the websites of 16 Regional Inspectorates of Environmental Protection.

Figures 4-6 presented below show printscreens from the websites of the two institutions. The websites provide historical and current data.

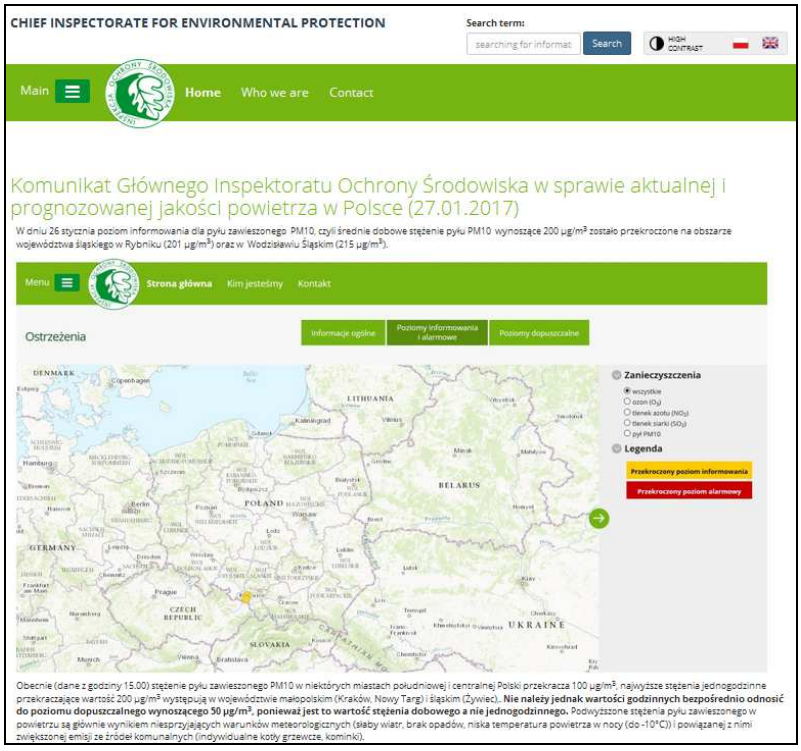


Figure 4. Website of the Chief Inspectorate of Environmental Protection with information on the current and anticipated air quality in Poland (information level and alarm level).

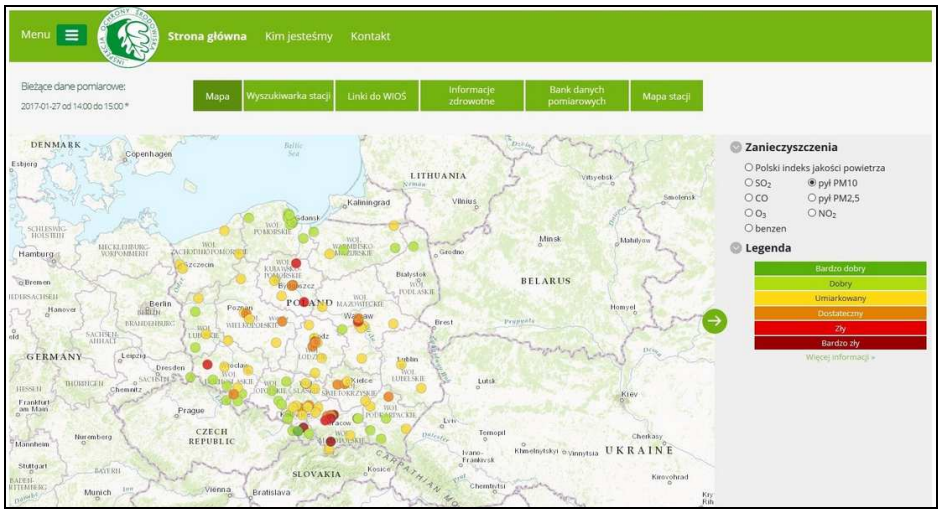


Figure 5. Website of the Chief Inspectorate of Environmental Protection with information on the current and anticipated air quality in Poland (levels explained in table 10).

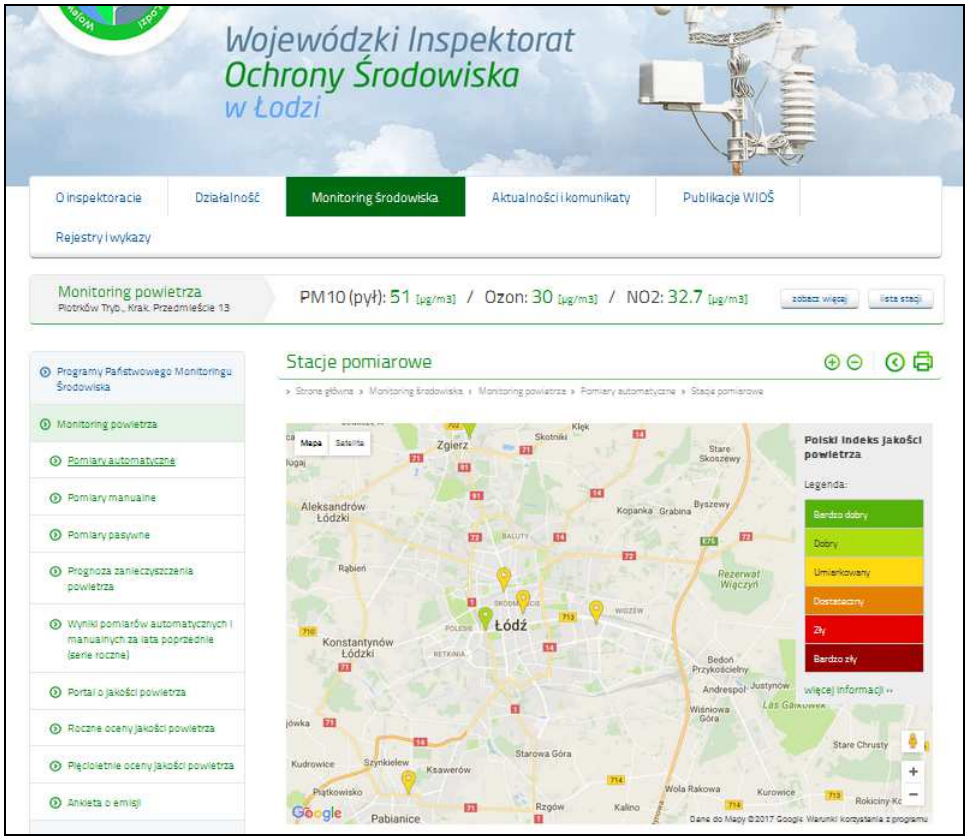


Figure 6. Website of the Regional Inspectorate of Environmental Protection with the map of measurement points and results of the measurements taken in Lodz and the region (levels explained in table 10).

According to the Regional Inspectorate of Environmental Protection in Lodz, within monitoring system of air quality currently automatic, manual and passive measurements are taken. Due to the quality of measurements, the biggest value is represented by continuous measurements. Over the years 2016-2020 the continuous measurements system consists of:

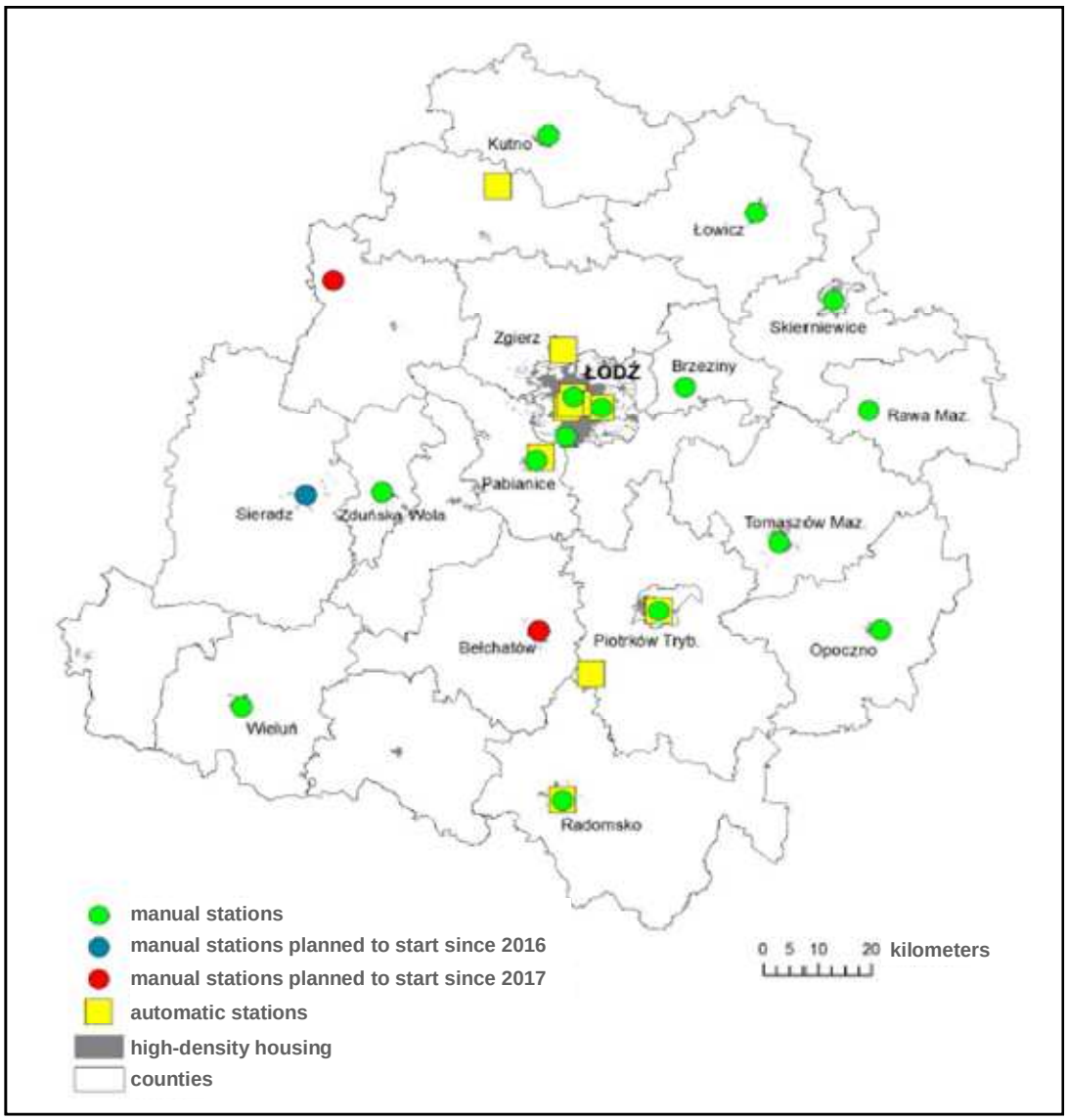
1) 10 automatic stations (benzene, NO, NO_2, NO_X, O_3, PM_{10}, $PM_{2.5}$, SO_2), including:
   a) 6 stations that measure air pollution and 1 meteorological station in the assessment zone of Lodz Agglomeration;
   b) 4 stations in the region of Lodz (Lodz Region);
2) 21 manual points in the region of Lodz, including:
   a) 6 manual points for measurement of PM_{10} concentration and contents of Pb, As, Cd, Ni in PM_{10}
   b) 15 points for measurement of concentration of PM_{10} and B(a)P in PM_{10} dust.

Measurements with passive sampling constitute supplementation of manual and automatic measurements. A major disadvantage of this method is the possibility to determine only long-term characteristics of air quality (estimation of the mean annual concentration value). Maps with location of the stations and measurement points are presented on Figures 7 and 8. Reference values for harmful agents are listed in the Directive of the Minister of Environment of January 26, 2010 on the reference values for some substances in the air (Journal of Acts 2010 No 16, Item 87).

Monitoring stations are located in urban (traffic, industrial or background), suburban (traffic, industrial or background) and rural (background or industrial) areas. The collected data is classified according to the reference values presented in Table 10.

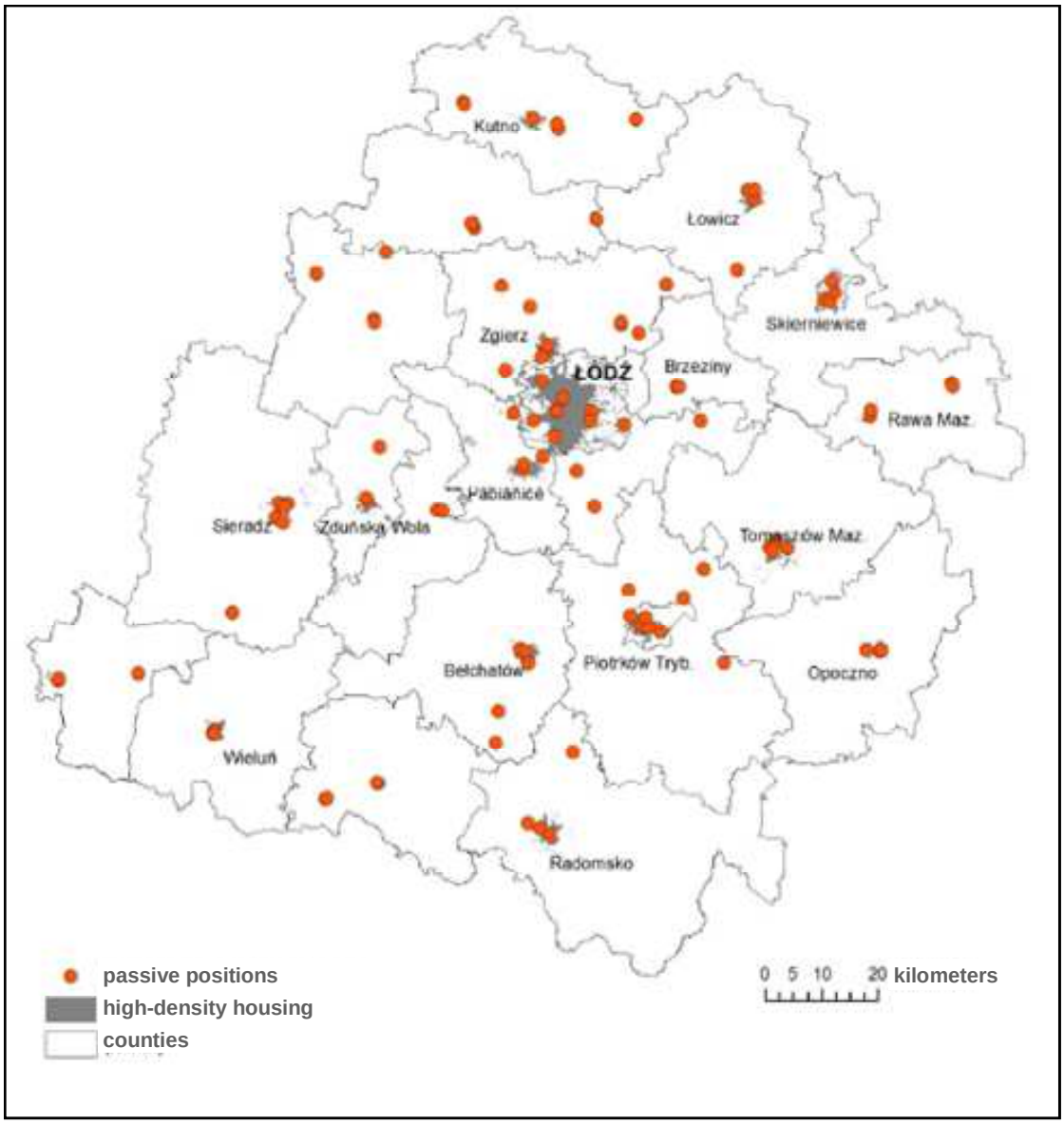
Table 10. Classification of outdoor air quality and reference values for harmful agents that apply in Poland (according to the Chief Inspectorate of Environmental Protection).

Category	Health Information	PM_{10} [µg/m^3]	$PM_{2,5}$ [µg/m^3]	O_3 [µg/m^3]	NO_2 [µg/m^3]	SO_2 [µg/m^3]	C_6H_6 [µg/m^3]	CO [mg/m^3]
Very good	Air quality is very good, Air pollution does not constitute a health hazard, conditions favorable for outdoor activities, with no limitations	0 - 20	0 - 12	0 - 30	0 - 40	0 - 50	0 - 5	0 - 2
Good	Air quality is satisfactory, air pollution constitutes no or a low hazard for human health. One may stay outdoors and perform any activities with no limitations	21 - 60	13 - 36	31 - 70	41 - 100	51 - 100	6 - 10	3 - 6
Moderate	Air quality is acceptable. Air pollution may constitute a health hazard, in special cases (ill persons, elderly people, pregnant women and small children). Moderate conditions for outdoor activities.	61 - 100	37 - 60	71 - 120	101 - 150	101 - 200	11 - 15	7 - 10
Not bad	Air quality is not bad. Air pollution constitutes a health threat (especially for ill and elderly people, pregnant women and small children) and it may have negative health effects. It is worth to consider limiting (shortening or dividing in time) outdoor activities, especially when those activities require long or intensive physical effort.	101 - 140	61 - 84	121 - 160	151 - 200	201 - 350	16 - 20	11 - 14
Bad	Air quality is bad. Ill persons, elderly people, pregnant women and small children should avoid staying outdoors. The remaining population should reduce all outdoor physical activities to minimum – especially physical activities that require long and intensive physical effort	141 - 200	85 - 120	161 - 240	201 - 400	351 - 500	21 - 50	15 - 20
Very bad	Air quality is very bad and has negative influence on health. People who are ill, elderly people, pregnant women and small children must avoid staying outdoors. The remaining population should reduce spending time outdoors to the necessary minimum. Physical activity outdoors is not advised. Long exposure to the substances present in the air increases the risk of changes in, among others, respiratory system, cardiovascular and immune systems.	> 200	> 120	> 240	> 400	> 500	> 50	> 20



Source: The website of the Regional Inspectorate of Environmental Protection in Lodz .

Figure 7. Location of air quality monitoring stations in the lodzkie voivodeship as part of The Programme of Environment Monitoring over the years 2016-2020 (automatic and manual measurements).



Source: The website of the Regional Inspectorate of Environmental Protection in Lodz .

Figure 8. Location of air quality monitoring stations in the Lodzkie Region that operate as part of the Subsystem of Environment Monitoring over the years 2016-2020 (passive-supportive measurements).

Based on the location of the schools selected within the InAirQ project, the monthly mean concentration values of some regularly measured air pollutants are listed in Tables 11 - 12 for 2016 for the areas of interest (Region of Lodz and Lodz city, Poland). When comparing these two areas it needs to be emphasized that the biggest differences between the mean values, both monthly as well as annual, concern nitric oxide. Both NO_2 as well as NOX present in the atmospheric air in the city of Lodz are in higher concentrations than in the rest of the region. It is caused by high intensity of traffic in the city agglomeration.

Table 11. Monthly mean concentration values of some regularly measured air pollutants for 2016 in Lodz.

Year 2016	SO_2	NO_2	CO	O_3	NOX	PM_{10}	$PM_{2.5}$
January	14.42	29.39	731.69	26.42	55.01	59.58	58.65
February	7.53	23.31	534.82	39.84	36.19	32.94	35.10
March	6.96	26.92	584.38	40.94	46.24	38.68	36.61
April	4.94	26.99	477.21	61.36	43.82	33.82	22.96
May	2.97	24.35	437.42	77.11	35.52	26.30	15.02
June	2.33	23.04	397.64	74.39	34.42	21.04	13.01
July	2.68	19.68	429.69	61.25	29.52	19.36	16.37
August	3.24	20.48	418.17	58.60	29.76	21.09	12.94
September	2.75	30.48	508.85	57.90	49.40	31.10	18.25
October	4.86	22.95	538.85	24.66	45.37	28.68	23.24
November	6.84	28.28	611.79	22.21	53.40	38.96	38.97
December	6.74	29.23	609.79	24.74	47.63	37.94	41.35
Annual mean	***5.52***	***25.42***	***523.36***	***47.45***	***42.19***	***32.46***	***27.70***

Table 12. Monthly mean concentration values of some regularly measured air pollutants for 2016 in the region of Lodz.

Year 2016	SO_2	NO_2	CO	O_3	NOX	PM_{10}	$PM_{2.5}$
January	14.37	23.28	834.82	30.24	36.42	68.31	52.85
February	7.86	16.76	574.16	43.53	23.00	40.12	28.73
March	8.22	18.72	691.05	42.34	27.20	47.90	33.40
April	5.88	17.75	525.04	57.31	24.09	36.01	21.85
May	3.33	15.21	407.11	68.89	19.47	24.38	13.70
June	2.87	13.34	384.74	68.94	17.98	20.51	10.71
July	2.69	12.75	374.74	57.92	17.11	18.85	10.14

Year 2016	SO_2	NO_2	CO	O_3	NOX	PM_{10}	$PM_{2.5}$
August	3.03	14.80	372.08	55.27	19.74	20.76	10.33
September	3.97	20.91	512.79	54.16	31.61	32.56	17.73
October	6.28	16.60	534.73	25.08	27.13	32.35	21.12
November	9.41	20.71	598.72	24.99	33.27	43.44	31.40
December	9.62	20.61	656.45	30.80	31.56	37.70	28.31
Annual mean	6.46	17.62	538.87	46.62	25.72	35.24	23.36

Poland lies in a moderate zone with mixed continental and oceanic climates influences, with cold winter and warm summer. Accordingly, concentration of several air pollutants (e.g., PM_{10} mass concentration, O_3, CO) shows seasonal variation. During the winter period, levels of almost all measured agents often exceeded the 24-h limit values, simultaneously exceeding alarming values. The annual mean values for $PM_{2.5}$ measured in 2016 in Lodz exceeded the year limit value set by the European Commission.

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