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Noise from refuse collection and disposal in residential developments in the context of Polish legal and formal conditions

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Abstract

The generation of waste is one of the main global environmental problems. Waste segregation, storage in containers and disposal are issues requiring adequate solutions. It is the architect who is responsible for designing the correct place for the collection of solid waste within the area of residential development, and this task is a complicated issue. A place for solid waste collection and its disposal is particularly important in the context of a friendly acoustic climate and a healthy residential environment. The author analysed the amounts of solid waste generated in the residential development area and the requirements related to refuse segregation. A significant element of the performed analysis is to study formal requirements and design guidelines for solid waste collection points in the area of multi-family residential developments. The author describes the impact of the individual elements of the refuse collection and disposal process on the acoustic climate prevailing in the nearest residential locations.

Keywords: solid waste, noise annoyances, acoustic climate, multi-unit residential development, a healthy living environment

1. Introduction

The urbanised housing environment is a complicated technical and social structure. It is composed of physical elements that are either created or transformed by men – such as built structures and elements of nature – and is also composed of occupants within various groups and with individual needs.

Our perception of the housing environment should be based on the recognition of the dynamic co-dependencies between the physical and social environment and the individual needs of each person. It should take into account the complex dependencies of biogenetic, psychological, behavioural, environmental (including geographic and architectural), technological and socio-cultural "landscapes", and the efforts aimed at designing healthy housing environment should be directed both towards individuals and populations and should be coordinated on multiple levels (Schneider-Skalska, 2011).

The urban structure of the housing environment can have a positive or negative effect on living conditions and a sense of comfort; this has been defined within the housing environment by Helga Santos da Silva (Santos, 2018).

The overall feeling of comfort relies on the ease of use of local infrastructure which is dependent upon appropriate functional programmes, the accessibility of services and their parameters, spatial comfort dependent on the scale of buildings and proportions of interiors, the clear hierarchisation of space, aesthetics and contact with nature, and acoustic comfort, which is rarely taken into consideration when assessing environmental quality. Spatial and aesthetic considerations concerning the housing environment have been broadly discussed in literature on the subject. The problem of acoustic comfort and the acoustic climate has been investigated by the author of this paper (Walicka--Góral, 2018). These studies show that an acoustically friendly space, in which noise is limited or eliminated, is one of the major factors that shape a healthy housing environment.

Noise, as the fundamental negative component of the acoustic climate, is most often associated with traffic or with the significant impact of annoying manufacturing processes. Small elements of the required features of a housing environment, such as public waste collection sites, can have an equally negative impact on the acoustic climate.

2. Location and form of collecting waste in housing areas

The placement of waste collection areas largely depends on the zone of the city in which a given housing complex or building is located. In city centre areas, most often built up in the form of urban blocks, waste bins, containers or enclosed waste collection sites that are most often placed inside urban blocks, in their courtyards.

In newly built infill buildings, interior waste collection spaces are placed on the ground floors. In housing areas in which the basic spatial structure is composed of housing complexes grouped around an urban interior, the waste collection site is most often a freestanding element, often with a roof and is located a certain distance away from a building's windows while remaining within the legally prescribed range of staircases. The constantly developing waste segregation system creates more and more elaborated groups of waste containers, causing them to become a significant spatial element affecting the aesthetics of the surroundings within the housing environment. In low-rise single or multi-unit low-density residential developments, small waste bins made of artificial materials are often sufficient (Fig. 1). Complexes of high-density multi-unit buildings require the placement of a greater number of larger containers, appropriate for the number of units. Containers can be made out of plastics or metal. In both cases, they must be resistant to atmospheric conditions (Fig. 2).

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Fig. 1. Small waste containers in a Dutch low-density housing estate, located adjacent to a building, although from a windowless side (photo by G. Schneider-Skalska)

Fig. 2. A similar principle of placing much larger waste containers in the Solar-City housing estate, in a fenced-off area planted with greenery, close to a gable wall with an emergency staircase (photo by G. Schneider-Skalska)

The convenience of using waste containers is ensured by placing them close to buildings, always in accordance with local regulations. It should be a visible place and one that is easily accessed. The aesthetic level is also important. A series of examples, both from abroad and from Poland, demonstrates that designers strive to introduce an appropriate approach to isolating them by using attractive greenery (Fig. 3) or propose various forms of enveloping them, often in accordance with the aesthetic of the residential architecture, such as in the Warzelnia housing estate in Poznań (Fig. 4). Structures in which waste containers are placed can and should follow the principles of sustainable design, an example of which is a structure with a green roof located in a housing estate in Innsbruck (Fig. 5).

Fig. 3. 4, 5. Various ways of locating waste bins close to residential buildings (photo by G. Schneider-Skalska)

In each of the presented examples, the material from which the containers are made, their distance from apartment windows and the way in which they are isolated from their surroundings are all key factors. In each case, the necessity to empty them, which is associated with the appropriate transport vehicle arriving at properly set time intervals (weekly, bi-weekly) and at a certain hour, is also apparent, often even visible.

Each of the above-mentioned elements or activities affects the noise intensity that is produced by the opening, closing and emptying of waste containers. The problem of depositing public waste in Poland and the legal conditions of this process both in Poland and in the EU are discussed later in the article, followed by the presentation of a study that demonstrates how the inappropriate placement of waste collection sites, the material out of which the containers are made, and the mode of transport can worsen acoustic conditions within a housing environment. The study was carried out in a housing estate in Rzeszów.

3. Analysis of design guidelines for solid waste collection points

3.1. The amount of solid waste in the area of residential development

The preparation of methods for the determination of the number and type of containers for municipal waste collection – including containers for selective collection – and the frequency of emptying is an important part of the policy of healthy residential environment, including noise reduction. In compliance with the Act on Waste (Dz.U. 2013 poz. 21)., waste management should be performed in a way ensuring the protection of human life, health and the environment, in particular, it should not be a source of nuisance noise.

The determination of the amount of solid waste and the collection method is a basis for the appropriate design of solid waste collection and refuse disposal points, a so-called municipal waste. The weight of a given type of waste generated by one resident per day can be calculated by multiplying the waste content by the value of weight accumulation factor according to the equation (Opęchowski, 2006).:

$$Mi = Zi \times Wm \tag{1}$$

where:

- Mi – weight in kg of a constituent of waste generated daily by one resident,
- Zi – content of an ith constituent in a stream of municipal waste,
- Wm – weight factor of waste accumulation in kg per resident per day.

Volume corresponding to the weight of accumulated refuse is calculated from the equation:

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$$Vi = Mi / di \quad (2)$$

where:

Vi – a volume in dm³ of an ith constituent of waste generated daily by one inhabitant,
di – bulk density in kg/dm³.

To determine the size and type of equipment for the collection of municipal waste and the frequency of disposal of the collected waste, the municipalities are obliged to specify important information in the regulations, including those related to the type of equipment intended for municipal waste collection and the frequency of disposal of the collected waste (Dz.U. 1996 nr 132 poz. 622). The basis for the implementation of this obligation by the municipality is information concerning the amount and type of generated municipal waste, including the collection system and the number of people using this equipment. Based on the information collected by the municipalities in Poland, it can be assumed that the average amount of waste generated by a typical resident in the cities varies from 5 dm3 to 75 dm3 per week. Whereas, according to the recommendations, the minimum size of containers for solid waste collection for single-family housing is 110 dm³ or 120 dm³, while in multi-family development, it is required to use bigger containers (Opęchowski, 2006). Requirements for solid waste containers are specified in the Polish standards, which do not include requirements concerning the required acoustic parameters.

The planned frequency of collection is an important factor in designing the location for municipal waste storage. The frequency of collection of mixed waste for single-family housing in Polish municipalities varies from, on average, twice a week to once a month, while for multi-family developments, it is once a week.

A basic principle to determine the number and type of containers for municipal waste collection is the requirement to provide the development with containers of combined capacity sufficient for the collection of the total amount of municipal waste generated by the residents or people temporarily staying on its premises, with a specified frequency of refuse disposal. The number of required containers is calculated for the individual housing units in accordance with the following equation (Opęchowski, 2006).:

$$n = Wv \times M \times t / V \quad (3)$$

where:

n – the number of containers with V capacity,
Wv – a volumetric indicator of waste accumulation in dm³/inhabitant/day,
M – the number of residents,
t – the number of days (collection frequency),
V – container capacity in dm³.

The number of containers varies depending on the type of development. In the case of the collection of mixed waste containing biodegradable food waste, as well as in case of the separate collection of such waste, the collection frequency should not be less frequent than seven days during summer and ten days outside of this period.

3.2. Waste sorting

The need for waste sorting forces designers to choose the necessary areas on a plot lot intended for the collection of solid waste. In accordance with the provisions of Polish law (Dz.U. 2013 poz. 21), the waste is stored on-site owned by the owner of the waste. In the case of Poland, in accordance with the EU guidelines, waste recovery should reach approx. 60%. The requirement for waste sorting generates the necessity to find a suitable place on a plot. While adapting the surroundings of the building for these purposes, one should assume the appropriate number and size of the containers. Classic rolling containers have a capacity of 1000 l and a width of approx. 1.3 m. In accordance with the rules of sorting, there should be five such containers and

at least one for each type of waste. To meet these requirements, the necessary area for containers and methods of their operation should be 13 m^2 without taking into consideration the space required for access to the bins and the manoeuvring area. Larger residential developments should include provisions for an additional waste container intended for non-sortable waste. A good solution is to use an underground system of containers that do not spoil the appearance of the surroundings and at the same time, take up relatively little space. The fermentation and decomposition process is slower during summer months due to the constant temperature of the ground ranging from 10 to 15°C. The underground system also reduces the noise associated with collection.

3.3. Formal and legal conditions for solid waste collection points

Solid waste collection points near multi-family buildings should be accessible to disabled people. While designing solid waste collection points, one should keep specific distances from rubbish bins and containers from windows and doors. Solid waste collection points should be located at least 10 m from the windows and doors of buildings with rooms intended for people to stay.

For playgrounds, playing fields for children and young people and recreational places, this distance is 10 m, and from a border or building plot, it is appropriate to keep a distance of 3 m. Keeping the required distance from the plot boundary is not required if these places have contact with similar places on the adjacent plot. The above requirements are not mandatory for single-family housing, farmsteads or individual recreational developments. According to the guidelines of the Polish legislation in Regulation (Dz.U. 2002 nr 75 poz. 690). it is important to maintain the permissible maximum length of access to the places where solid waste is collected from the building. The farthest entrances to a multi-unit residential building, collective residence or public utility building to a solid waste collection site should not be located further than 80 m. This distance is already sufficient to prevent the residents from experiencing noise nuisance related to the collection and disposal of waste.

4. Noise from collection and gathering of solid waste

Many noise annoyances are related to the collection and disposal of solid waste.

For multi-family building areas, allowable noise levels in the external environment are specified in compliance with Regulation (Dz.U. 2014 poz. 112). According to the mentioned regulation for noises generated by the individual groups of noise sources, they should not exceed 55 dB during the day and 45 dB during the night. That requirement excludes noise generated by the take-off, landing and flying of aircraft and electricity power lines.

A solid waste collection system forces the segregation of solid waste. Throwing cullet to a container for glass generates noise when the glass is crushed. Such noise, due to its physical properties and unpredictable nature, is particularly burdensome for the residents. Other operations related to the collection of solid waste, such as the raising and lowering of metal or plastic containers flaps, cause impetuous noises of high intensity. Due to sanitary and performance requirements, containers intended for solid waste often are made of metal. When occupants throw their waste into the containers, they raise and lower the flap causing a noise of high intensity, often reaching 100 dB.

There are numerous complaints made by residents related to the noise of refuse disposal. The city council in one of the UK towns received a complaint from the residents on such noise generated in the early morning hours during the collection of waste from the nearby supermarket. The residents suffered from the squeaky noises generated by refuse collection vehicles, reversing alarms, the movement of hydraulic arms lifting large containers, the striking of empty containers on the ground (EPA, 2013).

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Waste disposal is accompanied by the noise generated by the collection vehicle. This begins with the approach of such a vehicle to as close to the collection point as possible, then moving to successive collection points and ending with the departure from the residential area. Also, during this process, the vehicle's engine is turned on to operate the containers. The noise level generated by a waste collection vehicle is very high. According to the standard, it should not exceed 85 dB, while it is a maximum value for normal operation, which is the movement of such vehicle on the streets (PN-EN ISO 3746:2011). The noise level of a working collection vehicle, excluding the additional noise generated by crashing containers, is considerably high, and it depends on the type of vehicle and its size. The Scania P82MD6X2V refuse collection vehicle is one of the quietest, and it generates a noise of 94.5 dB, while the Scania PM6X2ZL65165V generating noise of 102.2 dB is one of the loudest (SCANIA, 2017). An additional noise is produced during the emptying of garbage containers, and it includes the noises of: reversing alarm, hydraulic arms for lifting the containers, the slamming flaps of the containers, the rubbish landing in the vehicle container and finally, the noise of the empty container hitting the ground.

The maximum noise value for working waste collection vehicles during the emptying of solid waste containers is not given in Polish legislation. Noise created during the collection and disposal of solid waste within residential development areas can be problematic for the residents because it often occurs in the morning.

5. Acoustic measurements and extant state acoustic climate simulation

Information relating to noise levels generated as a result of the collection and disposal of solid waste is limited. The noise level generated during the operation of the refuse collection vehicle and the emptying of metal waste containers was tested during the author's work (Walicka-Góral, 2018). The area that was studied was located in south-eastern Poland in the city of Rzeszów and its immediate vicinity. Areas of multi-unit residential buildings selected for the investigation of the acoustic climate represent typical urban layout distinctive of contemporary Polish development (Fig. 6). Noise sources were located inside the urban interior. On the south-western side, inside the

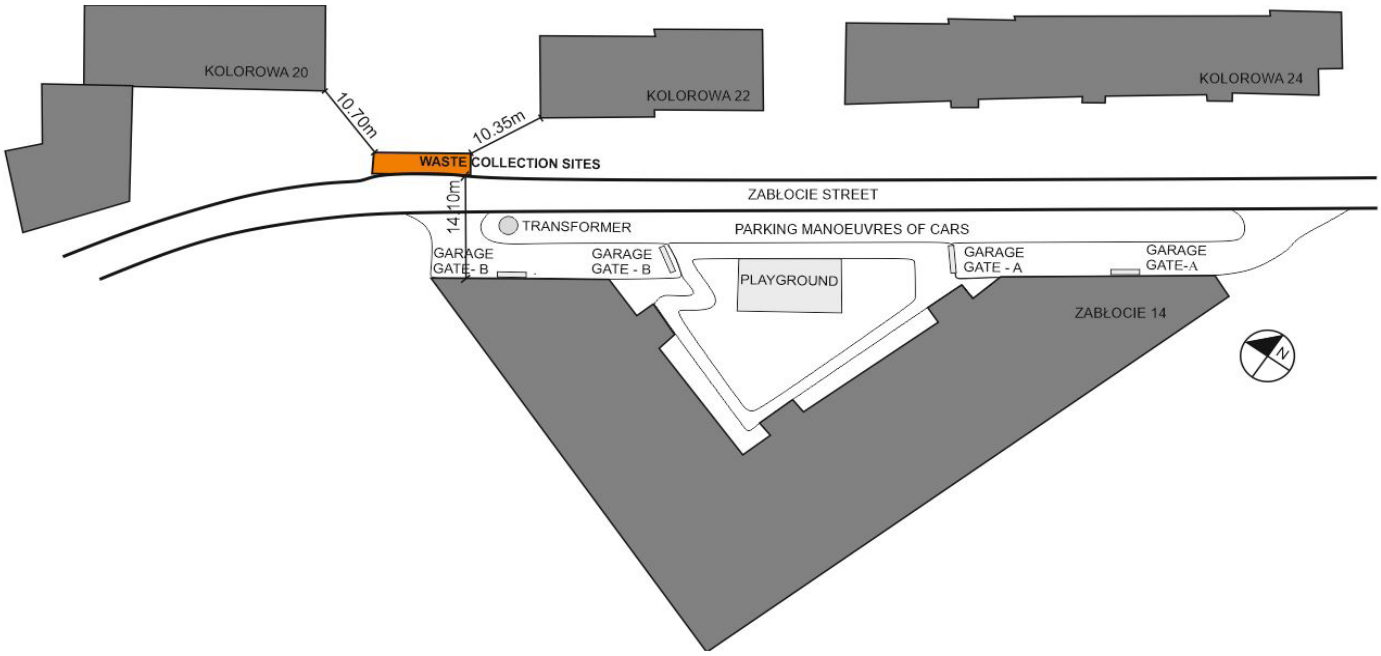

Fig. 6. Site map (prepared by B. Walicka-Góral)

interior, is a waste collection site (Fig. 7). Figure 8 shows the author's test of the sound level during refuse collection.

The sound level results for the noise generated during the operation of the waste collection vehicles were determined using the SvanPC ++ program based on data obtained from field tests, the analysis of these data and observations and notes from the field performed during noise measurements. The maximum sound level LAmax was 102 dB for the vehicle operation, and during these tests, the peak sound level for hitting metal flaps against the vehicle was also measured at LApeak 120 dB (Walicka-Góral, 2018).

The author also performed simulation studies, the purpose of which was to visually illustrate how noise was generated, including as a result of the operations of the garbage truck and of emptying metal containers, in the examined residential urban areas and how it affects the acoustic comfort of occupants.

Fig. 7. Place of waste collection site in the investigated urban interior (photo by B. Walicka-Góral)

Fig. 8. Garbage disposal from solid waste collection points in the Kolorowa residential development, Zabłocie street in Rzeszów (source: own noise measurements performed by B. Walicka- Góral)

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For the construction of simulation models, geometric data were used for the studied urban interiors and their surroundings, which were developed for the purposes of the dissertation of B. Walicka-Góral (Walicka-Góral, 2018). Figure 9 presents a noise map of the examined urban housing interior. The pink point is the location of the source of noise resulting from the collection and export of solid waste.

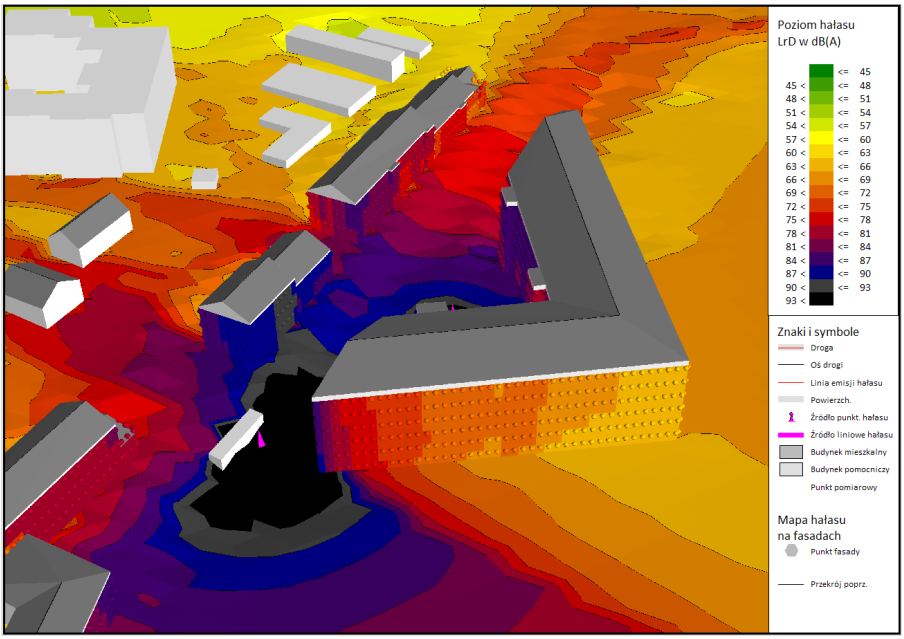

Fig. 9. Noise map and 3D facade noise map for test area (prepared by B. Walicka-Góral)

6. Conclusions

EU countries introduced a policy for the limitation of noise relating to the collection and disposal of solid waste. In compliance with the EPA guidelines (EPA, 2013)., the relocation of solid waste collection points and the construction of acoustic screens for collection areas are recommended to improve the acoustic climate.

One possibility to limit the noise is to use state-of-the-art equipment with "quieter" processes, such as silent running bucket elevators. It is recommended to keep the refuse collection vehicle and its brakes in the best possible condition to limit or eliminate noise from such sources as squeaky brakes. Another part of the noise protection policy is to educate drivers that they should be careful and introduce quiet working practices and establish an appropriate period of the day for garbage collection. It is advisable to introduce a requirement for the marking of mobile rubbish thickeners with the maximum level of noise of such vehicles, which may result in the purchase of low-noise collection vehicles in the future by the services responsible.

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Hałas związany z gromadzeniem i wywozem śmieci na terenie zabudowy mieszkaniowej na tle polskich uwarunkowań formalno-prawnych

Streszczenie

Powstające śmieci są jednym z globalnych problemów środowiskowych świata. Segregacja, przechowywanie w pojemnikach i wywóz śmieci to sprawy, które wymagają odpowiedniego rozwiązania. To architekt odpowiada za zaprojektowanie poprawnego miejsca do gromadzenia odpadów stałych na terenie zabudowy mieszkaniowej, a zadanie to jest złożonym problemem. Miejsce do gromadzenia odpadów stałych i ich wywóz jest szczególnie ważna w kontekście przyjaznego klimatu akustyczny i zdrowego środowiska zamieszkania. Autorka przeprowadza analizę dotyczącą wielkości odpadów stałych powstających na terenie zespołu zabudowy mieszkaniowej oraz wymogów związanych z segregacją śmieci. Istotnym elementem przeprowadzonych badań jest zbadanie wymogów formalnych i wytycznych projektowych dla miejsc gromadzenia odpadów stałych na terenie zabudowy mieszkaniowej wielorodzinnej. Autorka opisuje wpływ poszczególnych elementów procesu gromadzenia i wywozu śmieci na klimat akustyczny panujący w najbliższym miejsca zamieszkania.

Słowa kluczowe: odpady stałe, uciążliwości hałasowe, klimat akustyczny, zabudowa mieszkaniowa wielorodzinna, zdrowe środowisko zamieszkania