

## **IMPACT OF THE MUNICIPAL WASTE COLLECTION SYSTEM IN CITIES ON URBAN SPACE AND THE FUNCTIONING OF THEIR INHABITANTS**

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### **A b s t r a c t**

The article looks at the latest trends in solving the problem of garbage collection, segregation and disposal in urban housing estates in the scope of design, architectural and spatial solutions. The paper adopts a method of analysing existing applications in view of globally shifting living conditions. As a result of the conducted analyses, a set of features and factors was singled out, ranging from functional-spatial, through transport and ergonomic to social and aesthetic ones. Also, conclusions that should be taken into account when determining the principles for designing these structures were presented.

**Keywords:** city, waste segregation, garbage, street furniture, city logistics, garbage shelters, ergonomics

### **1. INTRODUCTION**

Living in cities is still the most attractive option for societies across the world. The modern-day vision of cities is changing under the influence of rapid urbanization. It is influenced by elements of urban policy, opportunities for expansion resulting from existing building techniques (upward growth), but also, to an increasing extent, the ecological awareness of city dwellers. Futuristic proposals, which in the 1960s and 1970s (e.g. 'Walking City' by the Archigram

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group) portrayed a world of concrete, glass as well as new forms and construction materials, have in recent years given way to visions (e.g. Vincent Callebaut's), where living greenery is an integral part of architectural forms, both in the case of residential and prestigious public buildings, as well as an essential part of cities' functional infrastructure, with urban farms, air purification, temperature control and water management. Environmental awareness has a huge impact on urban and spatial solutions and change in this area is no longer just a fad but an inevitable necessity. The age-old problem of cleaning cities is one of the biggest challenges of civilization in the 21st century. It is hard to imagine a city that is not struggling with the increasing generation of waste, both by residents and tourists. While residents can be educated through local activities and legal regulations, the problem persists in the case of tourism, although attempts are being made to collect sorted waste in public places. For example, as of 2019, Venice will introduce a mandatory fee of 3-10 Euros for every tourist visiting the city, which will be earmarked specifically for cleaning the city. For the Venetians, in turn, the waste problem is a daily reality because they do not have standard waste collection points due to logistical reasons. Each street has designated days and hours for manual waste collection (with strict segregation requirements), which is collected from homes and then transported away by gondolas.

The problems of waste collection and disposal concern both city centres and residential districts and are diverse. While the problem is more complicated in city centres, where public buildings dominate in public spaces and are used by diversified recipients (including tourists), in urban housing districts it is theoretically possible to attain 100% efficient selective waste collection through appropriate regulations, modern infrastructure, including individual access codes to containers, smartphone applications and education of residents. We are already seeing results in the case of single-family homes. As for multi-apartment buildings, the issue of implementing segregation is much worse as some tenants do not segregate at all, others do it poorly. Housing cooperatives and communities deal with these problems with varying results. In rural areas, some households are not included in the collection and disposal of waste in a fully organised manner. An important guideline is to make the process of segregation easy and intuitive in order to achieve optimal satisfaction, alongside education in waste management at an individual level, so that e.g. the level of waste segregation is as high as possible, which has a direct impact on economic benefits for cities. Interestingly enough, positive or negative feelings are not related to the size of the city itself (apart from equally important transport solutions), but rather to the efficiency of the municipal waste management system, cleanliness and visual attractiveness of urban spaces, including the

spatial elements of waste collection points and the look of the waste bins. Those located in the city's most attractive spots are often even designer works of art. This article concerns the functional and spatial problems of shaping waste collection and segregation sites in the immediate vicinity of residents. These problems are linked to the architectural form of the elements used for this purpose, but also the urban scale of the city components changing under the influence of its new constituents, implementation of raw material recovery, etc., in the context of sustainable development objectives. The definite necessity of minimizing the amount of generated waste, as well as effective waste management on a global scale, have now become aspects predominantly shaping modern cities, right alongside the need to minimize the amount of energy necessary for their proper functioning.

## **2. SPATIAL FORMS OF WASTE COLLECTION POINTS**

For quite some time now cities have been faced with the necessity of coming up with an efficient and systemic solution to the challenge of collecting waste produced in increasing quantities by city dwellers, an issue which is crucial for the cleanliness of the urban environment. At present, the ways of managing waste fall under legal obligations while detailed regulations are becoming more and more unified, mainly thanks to the provisions of relevant EU directives.

Waste collection points in built-up areas, guidelines for designing and locating them as well as the scope of their functions and the number of containers in Poland are all defined by the provisions of the European Union law, local law (local spatial development plans, city ordinances) [3], regulations related to environmental protection, construction law alongside hygiene and sanitary regulations applied separately for residential buildings, public buildings and industrial facilities.

### **2.1. Legal requirements**

From a practical standpoint, not all types of waste will be detrimental to the environment in the same way, and not all of them will pose similar sanitary, epidemiological or fire hazards. While, for example, odours, animal attraction and a potential disease risk may be an important factor in the case of biodegradable, green and mixed household waste, most plastics, paper, electronics and clothing rather pose a real fire hazard [1].

In the current legal situation in Poland, the act which most precisely specifies the location parameters concerning sites of provisional solid waste collection is the regulation of the Infrastructure Minister on technical conditions to be met by buildings and their location [2, 4]. The document contains a chapter solely dedicated to this issue. Section 22 of the regulation stipulates, first and foremost,

that each building plot should have such a place, enabling segregation and collection of the sorted waste.

A temporary solid waste storage facility on a plot of land must conform to one of the four options listed by the legislator. In accordance with section 22.2 these are primarily "canopied shelters or stand-alone structures with solid or openwork walls; separate rooms in a building, with a floor above the access surface level of the vehicle collecting the waste, but not higher than 0.15 m, and with lower chute chambers with a direct exit to the outside, equipped with a roof with a reach of at least 1 m and extended to the sides by at least 0.8 m, with washable walls and floors, a water intake point, a sewage grate, ventilation and artificial lighting; hardened surface yards for placing containers with lockable inlets and hardened surface yards with aboveground inlets and underground or semi-underground containers." Allowing the use of underground or semi-underground containers significantly increases the spatial arrangement capacity of this type of elements in minimally invasive forms, limited only to the external inlet with dimensions similar to the size of a standard container for municipal waste. In the case of underground tanks, an analysis of provisions arising from regulations concerning the protection of soil, water and air will also play an important part. However, as an earlier analysis has shown, these clauses do not fully protect against faulty selection of location, especially in the case of waste collection points of greater significance than individual ones.

### **3. DESIGN GUIDELINES: FUNCTIONAL, TECHNICAL AND ERGONOMIC PARAMETERS**

The location of waste storage and collection points is an important part of urban spatial planning and the adopted transport strategy. Their spatial form depends to a large extent on the location, i.e. it is determined by the number of inhabitants, the floor area ratio, status of the site (prestigious, urban, suburban, peripheral), functional and spatial structure of the urban layout, accompanying infrastructure and equipment. They must also maintain a distance from other land development elements, such as children's playgrounds, municipal gyms, dog runs, recreation areas, squares, parking lots, etc., but first of all – from sanitary protection zones, which stems from the need to protect residents from potential epidemiological and sanitary threats. In practice, this means that each place is different and requires an individual approach, also in terms of functionality.

However, due to the direct proximity of city residents, it is not the collection points used to accumulate waste that are more important for architectural reasons, but rather the individual points with which the residents have daily contact, i.e. the household or housing estate points that are local to individual dwellings and workplaces.

### **3.1. Two basic design models**

In design practice, there are two directions of designing and setting up waste collection points. One of them is based on standardization, i.e. a structure with a coherent style and form, applied regardless of location and size in a given – supra-local area. These are mainly the so-called standard shelters and bins, that are homogeneous in appearance, similar or identical in different cities or uniform across cities, made of modules that can be used alternately, adjusting their quantity and the manner of combining them. Standardization for a given area can, however, also be created from specially designed modules and elements, using symbols, e.g. icons containing the city's coat of arms, use of characteristic materials or elements that are distinctive for a given area.

The second model of design is connected to the goal of enhancing visual attractiveness. The spatial form of the collection points is characteristic and individual, rendering them showpieces of a given area. Sometimes they consist of specially designed, technologically specialized modules in various spatial and urban furniture arrangements, giving the possibility of capturing an individual character of a place and form. It is a comprehensive approach covering a global location analysis (on the scale of the city, region, in the scope of social structure and development strategy), analysis of the location, its function and significance, size, as well as pedestrian and vehicle transport connections. Apart from eliminating inconveniences linked to usage, such as making their use independent of weather conditions, one of the design tasks based on the above model is to provide visual attractiveness, affecting the shaping of the identity of the place, which facilitates their perception and identification. What is more, in this model, creative efforts may target both street furniture items that are minimalist in form, as well as graphic information educating the residents about methods of segregating waste and rules for composting, etc. The individual form allows for the identification of space related to emotions, adjustment to the needs of the environs with the option of cohesive embedding in the city's existing visual and transport system (logo, pictograms, symbols, intelligent systems). These sites may be the subject of tenders, however, beforehand their form is assessed by future users (through social consultations, direct votes), who may influence the choice of solutions. Another function is the ability to define and identify space with the use of signs, which are a better and more intuitive means of information compared to descriptions or inscriptions.

### **3.2. Criteria for the selection of design principles**

The priorities in determining the principles of designing local selective waste collection points in cities are: location, size, form, construction and material possibilities, local and environmental opportunities for the use of new materials, trends and forms, which must be safe and resistant to vandalism. Intelligent

logistic solutions, applications and digital communication systems are also an integral part of the process. From the utilitarian perspective, it is also important to have adequate lighting and other elements of space that boost the sense of security also at night (using as many transparent elements as possible, ruling out obscure spaces, providing a hiding spot allowing for possible attack, lack of no man's and functionless spaces) and the ability to maintain cleanliness and order. Ergonomic solutions of modern waste disposal shelters are aimed at attaining optimal space utilization in a maximally limited area, while ensuring utmost safety and convenience. The elements are adapted to the anthropometric features of users, providing them with the greatest possible comfort of use.

An example of a sound ergonomic solution is height differentiation for different target groups (adults, the elderly, disabled, blind, etc.). Appropriate spatial relationships of the elements are also often ignored, although they significantly increase the comfort of use. This applies in particular to the correct placement of containers inside the shelters to ensure adequate cleanliness and ease of access to all of them. Transport accessibility is ensured primarily by an even, non-slip surface that is on the same level as the surface of the pavement, adaptation of elements to the needs of disabled people with reduced mobility or sight impairment; safe, non-threshold access, glare-free lighting [8]. Important utility parameters also encompass the availability of space, adjustment of the scale of functional and spatial arrangements to the mobility and perception capabilities of users, colour coding of containers and clear marking, which facilitate the use of elements also for the disabled. An analysis of the demographic landscape points to rapidly progressing ageing of the population, which should be taken into account when creating spaces that are to remain useful in the future. It is important to create solutions focused on extreme users such as children, the disabled and senior citizens. Good ergonomic solutions also allow freedom of choice (the rule of flexible use). They take into account a wide range of individual preferences and capabilities of users, including right- and left-handed users, and allow intuitive use (the rule of simple and intuitive use), therefore the best solutions cover elements that are consistent with the knowledge and expectations of users, and are also comprehensible and easy to use. Moreover, the structure should not pose a hazard, e.g. structural elements should not allow for climbing, no structural elements should potentially cause collision with the user.

#### **4. DESIGN GUIDELINES FOR SETTING UP WASTE COLLECTION FACILITIES IN CITIES**

Street furniture items, including garbage shelters and waste collection bins, are part of the technical infrastructure of the city's system and at the same time

integral visual and spatial components of residential areas. Therefore, apart from their utilitarian function, they are often used as contemporary icons that visually identify a modern city management system (in the informational, economic and aesthetic sense) and as symbols carrying out new environment-oriented tasks in society [6]. A set of features and factors has been listed, ranging from functional and spatial, through transport and ergonomic, to social and aesthetic (symbolic) ones, which should be taken into account when outlining the guidelines for designing these structures [9]. At the same time, these are problems that need to be taken into account in the designing process. Elements of the design guidelines are listed below, divided into above-mentioned group of factors.

#### **4.1. Functional and spatial system**

- expanding the basic function of the structure (waste collection and segregation) in order to increase the frequency of use, e.g. by adding a place to rest for a short time, shading the area, etc;
- ease of use (in terms of accessibility to the service, technology, function and ergonomics);
- ventilation of the shelters, which, at the same time, prevents the excessive spread of unpleasant odours;
- safety of use in terms of construction safety;
- durability and logic of construction;
- proper location ensuring safe and simple access, including supplementing by necessary infrastructure elements such as lighting and entrance zone visible from public areas;
- adequate dimensions of the shelter, including the width of entrances, adapted to the transport of containers;
- correct planning of the arrangement of containers inside the structure as to be easy accessible and not queued;
- advocating the introduction of composters as an element of land development together with the local use of organic matter thus produced;
- location in relation to entrances, garbage collection access roads and windows, while keeping the necessary distances;
- location in relation to the directions of the world; proper shading should be provided, southern exposure lighting should be ruled out or, alternatively, specially designed, sealed containers should be used;
- introduction of an educational functions;

#### **4.2. Transport**

- ensuring collision-free waste collection, including access routes, without crossing the daily pedestrian traffic;

- appropriate slope of the floor ensuring drainage and making it easier to clean so as to prevent contamination of the land and vegetation;
- collision-free routes for pedestrian and car traffic;
- integration with mobile information systems;

#### **4.3. Ergonomics**

- appropriate artificial lighting, e.g. equipped with motion detecting sensors;
- visibility that ensures an unobstructed field of vision (use transparent or partially opened walls);
- physical properties of materials directly touched by users – the presence of greenery, intuitively harmonious ease of use encompassing instinctive reflexes, movement control (preference is given to uncomplicated space that facilitates orientation);

#### **4.4. Prosocial solutions**

- clear marking of bins making segregation intuitive, e.g. providing information leaflets so that the user has no doubt about how to sort waste, especially in the case of problematic materials such as styrofoam;
- including markings for disabled, like captions in the Braille language, markings with high levels of contrast or with variable texture followed by properly prepared instruction of use;
- sufficiently regular collection of waste so as to prevent the overfilling of containers and the storage of waste outside the bins;

#### **4.5 Aesthetics**

- creating mimetic structures that blend in with the environment and are not formally invasive;
- visual consistency with other elements of the local landscape
- formal reference to the surrounding architecture or creating structures that are mimetic hidden in the landscape, visually non-invasive.

### **5. GREEN WASTE TREATMENT SITES - GREEN REVOLUTION IN CITIES**

The issue of urban composting is a relatively new topic and is directly linked to the development of the so-called zero-waste concept, the goal of which is to reduce the amount of produced waste to an absolute minimum. While the selection imposed by Polish legislation is already known [1], there is still the issue of the remaining waste, especially organic waste, which is left in households after the process of segregation [5]. Recently, the approach to

organic waste, mainly plant waste, has been changing to a large degree. It is becoming a valuable raw material considering soil deficit in urban gardens. Easy to process, this end product of composting can easily serve as a soil fertilizer. The creation of municipal composters even for public green areas alone would open the way for obtaining significant amounts of free municipal fertilizer [7]. However, urban composting is feasible not only on a city-wide scale. It is possible to designate a place intended for gathering and processing plant waste in an apartment or house, regardless of their parameters. Urban composting is also slowly becoming an element affecting the architecture of residential interiors, not just land development itself. Recent years have ushered in systems of sealed plastic containers, the so-called composting buckets, such as EM Bokashi or Organko, which enable odourless composting inside the house or systems of practically maintenance-free electric, sterile household composters, such as NatureMill. Complex solutions are used as community-based or inter-neighbourly composters for the production of fertilizer for the community.

## **6. SUMMARY**

Innovative solutions implemented in recent years across the world concern both the manner of functioning of cities, waste segregation as early as at the household level, technologies for processing and recycling of waste subject to segregation or composting, raising environmental awareness of societies, as well as enhancing the aesthetics of waste collection sites. Street furniture items are part of the technical infrastructure of the city system and at the same time constitute integral visual and spatial elements of residential areas. Therefore, apart from their utilitarian function, they are often used as modern forms of visual identification of a modern city management system and as symbols that carry out new environment-oriented tasks in society.

Inhabitancy inevitably entails waste generation and the key challenge is to dispose of it in the least harmful way possible for the environment. Practice shows that public awareness is growing and, together with globally changing regulations and environmental protection policies, investment in modern waste management systems is an urgent issue, which impacts the image of cities and the quality of life of their inhabitants. This article shows that in order for the role of a waste collection point to be completely fulfilled, it cannot be designed in isolation from local conditions, the urban layout of the housing estate, waste collection transport capacity, installation equipment, pedestrian traffic, information, ergonomics and accessibility, sustainable and universal design, safety requirements, as the key element and the weakest link in the chain is the human, whose behaviour is chiefly determined by knowledge, education, habits and perception. And these can be consciously shaped through the use of spatial

solutions and provision of information. Enhancing the quality of urban environment cleanliness translates to an improvement of the city's image. Investment in innovative solutions may bring measurable social benefits, such as life satisfaction of the inhabitants, economic benefits, but most of all, it may increase control over the growing amount of rubbish every year and ensure appropriate levels of waste recovery and recycling.

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