

Article

How to Enhance the Environmental Values of Contemporary Cemeteries in an Urban Context

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Abstract: The cemetery is an important element of the city's natural system. It can create a system that has a great impact on shaping the city's climate if it is integrated with the local landscape, designed with respect for the natural environment along with other green areas. In the face of negative demographic forecasts, urbanization and suburbanization processes, and climate change, the use of pro-environmental solutions in the development of cemeteries cannot be overestimated. On the basis of analyses of contemporary cemeteries from Europe (78 objects), including Poland (8 objects), a catalog of pro-environmental solutions is developed. The catalog is created based on the proposed functional and spatial model of cemeteries as a multifunctional space, integrating natural and cultural environments. Environmental activities related to the context, burial space, architecture, and other spatial elements, as well as the vegetation of modern cemeteries, are included. Then, in order to increase the environmental values of the cemetery, these solutions were implemented by developing an integrated concept for the project of a multifunctional and ecological municipal cemetery in Gniezno, Poland (the Greater Poland voivodeship).

Keywords: cemetery; pro-environmental solutions; urban landscape; burial space; multi-faceted cemetery model

1. Introduction

The subject of cemeteries and their design is grossly neglected in Polish studies. Scientists from various disciplines have been researching and promoting integrated approach in the design of cemeteries and the idea of ecological cemeteries for years [1–4], while in Poland, this topic is marginalized [5–7]. The main stimuli that prompted the authors to scrutinize this topic is a report by the Supreme Audit Office on the management of municipal cemeteries in Poland [8]. The SAO report indicates a disturbing phenomenon: in the last decade, only a handful of local governments have decided to build or extend the boundaries of existing municipal cemeteries [8]. An obstacle in planning the urban cemeteries is the anachronism of the Act on Cemeteries and Burials of the Deceased [9] as well as restrictive sanitary and epidemiological criteria. It results in more intensive development of historic cemeteries and leads to the degradation of its composition. Therefore, it negatively affects the social perception of their space and the ecosystem in which the cemetery exists [6,7,10].

Cemeteries and cities are interlinked. Historical data support that the social functions of cemeteries have played an important role in the formation and development of early cities [11–14]. Cemeteries constitute some of the oldest and largest green and open spaces in the urban landscape [15–17]. Researchers agree that the cemetery is an important element of the urban infrastructure system [18–25].

Dynamic urbanization and an increase in the world's population pose new challenges for humanity [18]. Green space shortage, destruction of valuable ecosystems, and climate change is

challenging us to reconsider how we manage urban green spaces to make cities more robust and resilient [23], and this forces landscape architects and architects to look for spatial solutions that enhance the environmental values of contemporary cemeteries in urban context.

Cemeteries in Europe are considered permanent land use, important in creating urban natural systems. They have been well recognized and documented in terms of their cultural significance. The acknowledgement of the ecological significance of these sites and their potential impact on the existing green areas networks is referred to in the literature, but has been hardly studied as a research focus. The aim of the paper is to enhance the ecological value of European cemeteries in order to determine how to best increase the future ecological benefits they will provide, especially for the urban environment.

In connection with the above, some analysis was carried out in order to

1. Elaborate a methodological framework to show cemeteries as a multi-dimensional space requiring integrated design attitudes.
2. Create a catalog of pro-environmental solutions to be used in the process of building modern cemeteries. The study was based on analysis of some selected European cemeteries (Belgium, Denmark, France, Spain, the Netherlands, Germany, Slovenia, Sweden, Italy).
3. Verify the pro-environmental solutions at selected contemporary municipal cemeteries in Poland.
4. Develop a program and spatial concept for one municipal cemetery, integrating the pro-environmental solutions and implementing the idea of cemeteries as multidimensional space in Gniezno (a Polish town located in the Greater Poland voivodeship). The concept was developed in close cooperation with the town council in 2018. It contains a number of pro-ecological solutions, thanks to which the facility can now claim to be a “multi-faceted cemetery”.

This paper is organized into four sections. The first part presents the theoretical background of the methodological framework (multi-faceted cemetery model). The second part presents the research framework proposed by explaining its main phases and criteria for the selection of countries and cemeteries. The third part presents the catalog of pro-environmental solutions for European cemeteries (on the basis of a 78-feature analysis), assessment of Polish contemporary cemeteries in the aspect of implementation of the solutions, and the spatial concept of the municipal cemetery in Gniezno where the pro-environmental solutions are to be developed. In the last section, the results are discussed and provided.

2. Background: Multi-faceted Cemetery Model

A model of a cemetery was developed as a multidimensional space based on the legal regulations in Poland and written sources in the fields of landscape architecture, architecture, urban ecology, and history. Our review, therefore, concentrates exclusively on the cemeteries in urban environments, with a special focus on pro-environmental solutions and values. We have done literature research by using Google Scholar. The multi-faceted nature of cemeteries is manifested in the complexity of roles imposed on this space. Cemeteries, along with their main function as a burial site, play a number of roles: they serve as sacrum zone [26–28], archive, an open-air museum [13,29–31], a park [17,32], and an important part of the city’s natural habitat. They are considered a reserve of flora and fauna [33–37] and also a place of social importance e.g., [18,38–44] by researchers all over the world, regardless of their cultural background. Cemeteries are pieces of space made of elements of natural and cultural environments. In recent years, many researchers have recommended for cemeteries to be considered holistically, taking into consideration nature protection and cultural heritage [39,40,45,46]. The literature study has shown that cemeteries should be treated as multi-faceted space (Figure 1); therefore, while arranging its space, integration of solutions related to the natural and cultural environment is necessary. Especially in the face of the dynamically occurring climate changes, which are a consequence of excessive exploitation of environmental resources.

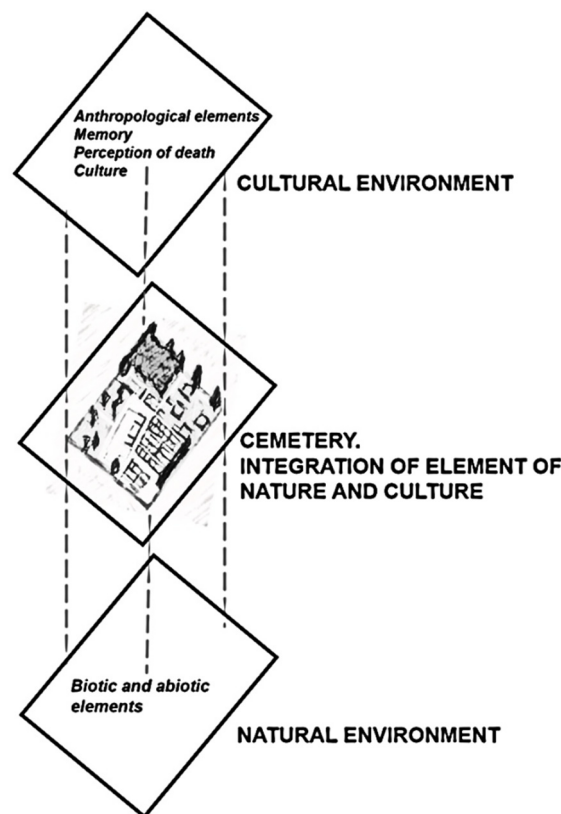


Figure 1. Multi-faceted cemetery model. Cemetery as an integration site of elements of nature and culture.

The basic acts regulating the issue of establishing and maintaining cemeteries in Poland are

- the Act of 31 January 1959 on Cemeteries and Burial of the Deceased [9],
- Regulation of the Minister of Municipal Economy of 25 August 1959 on determining which areas in terms of sanitation are suitable for cemeteries [47],
- Regulation of the Minister of Infrastructure of 7 March 2008 on requirements for cemeteries, graves, and other places of burial of corpses and remains [48],
- the Building Law Act of 7 July 1994 [49],
- the Act on Nature Conservation of 16 April 2004 [50].

Polish law identifies cemeteries with green areas and recommends designing and maintaining them as park sites [9,48,50]. At the same time, it is a building [49] and a religious facility, as indicated by the Polish Classification of Building Facilities [51]. This interpenetration and overlapping of approaches indicate the natural and architectural nature of cemeteries and the need for an integrated approach when planning, designing, and maintaining. The cemetery as an element integrating the natural and cultural environments is treated as a whole, which consists of burial space, vegetation, spatial elements, and transportation systems (hardscape and softscape elements) [7,9,52–54] (Figure 2). Therefore, when developing a catalog of pro-environmental solutions, attention was paid to the spatial and landscape context (location factors) and elements of cemetery development.

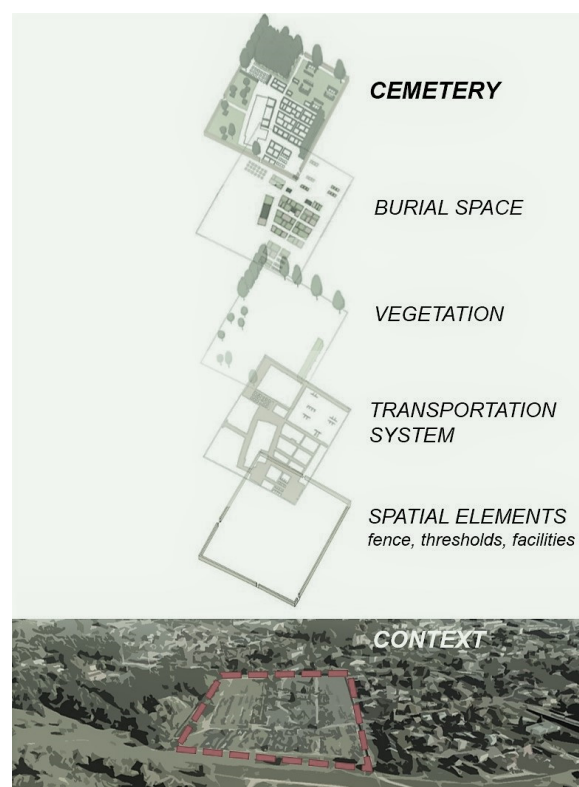


Figure 2. Multi-faceted design of cemeteries. The cemetery model as a whole. Own elaboration based on [7,9,52–54].

3. Methodological Approach

The process of our study went through three stages for answering the research question “How to enhance the environmental values of contemporary cemeteries in an urban context”.

The overall research process is presented in Figure 3, and the following subchapters describe each phase in detail [55,56].

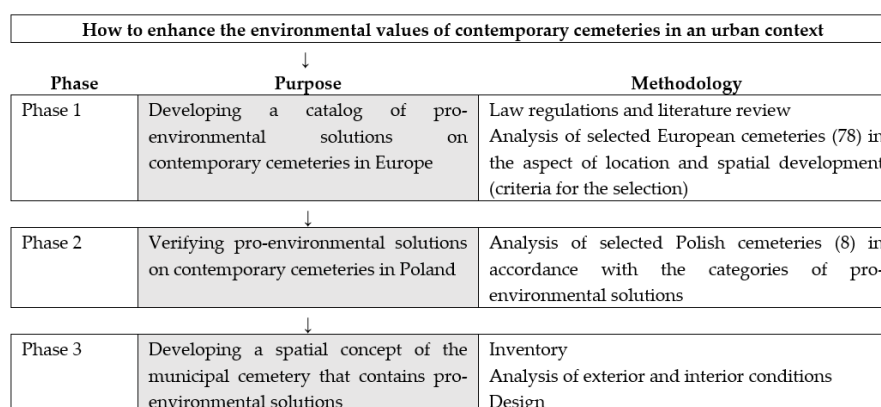


Figure 3. Research flowchart.

3.1. Phase 1: Developing a Catalog of Pro-environmental Solutions on Contemporary Cemeteries in Europe

The following selection criteria were adopted to develop a catalog of pro-environmental solutions for use in modern cemeteries [5,57]. The catalog is supposed to be the basis for recommendations when developing the program and spatial concept of the municipal cemetery for Gniezno:

- Spatial scope: Europe. The choice of research facilities only from Europe has its cultural justification, which touches on the settlement tradition, urban history related to European culture, shaped on the basis of ancient Greek and Roman spiritual and material culture (spiritual culture of the ancient Greeks, and spiritual culture of ancient Rome), and Christianity [58,59].
- Time frame: The spatial assumptions designed between 1999 to 2019 were qualified for the research. The choice of the cemeteries with modern metrics was determined by the globalization processes and political changes that opened the borders of the Eastern Bloc countries (including Poland), which were isolated before from Western European influences.
- The ecological significance of historic cemeteries is largely the result of their natural components remaining undisturbed for many decades [17,27,60]. It was decided to verify what solutions are being implemented at newly established sites in the face of the demographic changes and the decreasing burial space in historic cemeteries.
- Diversity: Countries representing differentiated geographical conditions were chosen (representing different European regions: Scandinavian countries, Mediterranean countries, Western Europe, Central Europe), legal provisions regarding the arrangement of cemeteries (restrictive provisions not allowing burial outside the cemetery, liberal provisions) and the cremation index.

These criteria were applied in a study on cemeteries from the following countries (Table 1): Belgium (6 objects), Denmark (9 objects), France (6 objects), Spain (9 objects), the Netherlands (7 objects), Germany (9 objects), Norway (6 objects), Slovakia (1 site), Slovenia (8 objects), Sweden (7 objects), Italy (8 objects). Cemeteries established in the urban landscape were selected from each country (which allowed us to show solutions not only on the scale of cemetery space but also the object's relation to the environment), which amounted to 78 objects covered by the study.

Table 1. List of cemeteries from Europe covered by research for the purposes of defining the catalog of pro-environmental solutions. Own elaboration based on [5] and websites of architecture, landscape design studios.

Country	Number of Cemetery	Location (Date of Establishment)
Belgium	6	Diestseveld (2001), Wervik (2001), Koksijde (2013), Hoog-Kortrijk (2014), Vleteren (2014), Kemmel (2018)
Denmark	9	Herstedvester (2001), Tilsted (2002), Alderslyst (2007), Holme (2007), Ensted (2008), Egense (2011), Fonnensbeak (2009), Østerhåb (2011), Gjellerup (2011)
France	6	Lognes Sélestat (2001), Laroque des Alberes (2005), Longes (2006), Carantec (2007), Les Sorinieres (2009), Rousset (2009)
Spain	9	Gijón (1999), Moraleja (2001), Punta Umbria (2001), Ponte Caldelas (2002), Añorbe (2006), Pedreguer (2009), Utebo (2009), Robregordo (2012), Alcarräs (2019)
The Netherlands	7	Duinhof Lisse (2005), De Nieuwe Ooster (2008), Langedijk (2009), Groene Kerk (2009), Hettingen (2012), Stuivenberg w Montfoort (2012), Hooge Zeedijk w Maassluis (2016)
Germany	10	Neubiberg (2000), Langenargen (2001), Eriskirch (2003), Tuttligen (2005), Friedenshügel (2007), Neuhausen ob. Eck (2008), Garching (2009), Hettingen (2012), Bödingen (2013), Deisslingen (2013)
Norway	6	Åsane (2003), Havstein (2009), Sandnessund (2010), Lommedalen (2013), Tiller (2017), Alstadhaug (2018)
Slovakia	2	Prírodný Cintorín Zvolen (2017), Prešov (2018)
Slovenia	8	Srebrniče (2001), Dolenjske Toplice (2001), Krašnja (2009), Želimlje (2013), Krško (2016), Šembijah (2017), Ptuj (2018), Polje (2019)
Sweden	7	Skurup (2005), Solna (2006), Helsingborg (2006), Ulriksdal (2010), Täby (2010), Sunne (2010), Boo (2014)
Italy	8	Giussano (2001), Bagnolo Mella (2002), Armea (2003), Borgaretto (2005), Santo Stefano (2006), Tavazzano (2008), Silvi (2009), Monteprandone (2014)

Ecology and the applied solutions have always been present; nowadays, an additional scientific dimension is required, especially in the light of urbanization as one of the main global changes in our biosphere [60]. Research in the field of modern urban ecological science and urban ecology is gaining popularity [61–66]. Pro-environmental activities concern space creation regarding the rational use of natural resources and the qualities of the natural environment and its proper protection. The cornerstone is putting emphasis on environment protection and its sustainable development, climate protection, reduction of harmful gas emissions, soil and water protection from pollution, energy efficiency, decrease in electricity and heat energy, renewable energy sources, and the green construction sector. Still, the most essential are activities increasing the level of ecological awareness

in local communities by educating and supporting environment-friendly attitudes comprising water and sewage management, municipal and communal waste disposal management, as well as the implementation of renewable energy sources [63,66]. We are legally bound to run such policies due to regulations placed in the European Landscape Convention ratified by Poland in 2006. Its aim is to promote ecological activities, and environment protection, planning, and management [67]. As cemeteries are elements of the environment, its planning and maintenance should be in compliance with principles of sustainable development. The analysis of the location of the composition in the cultural landscape and the development of the space of 78 selected European cemeteries (cf. Section 3.2) allowed us to work out a catalog of pro-environmental solutions. These solutions were assigned to 4 categories, in accordance with the adopted definition of cemetery treated as a whole (cf. Section 3.1), which consists of burial space, vegetation, spatial elements (architecture, transportation systems) embedded in the natural and cultural environmental context (Figure 2).

Context. When characterizing the context of modern cemeteries, their location in functional and spatial structures (location in regard to the natural system of the settlement unit, communication accessibility) and composition (verifying whether the cemetery plan results from local conditions or includes the surrounding values) were taken into account.

Burial space. While characterizing the burial space of modern cemeteries, a range of available burial forms (inhumation, cremation) and spatial solutions dedicated to them (traditional grave fields, urn fields, columbaria, catacombs) were identified. The specific attention was paid to the spaces dedicated to crematory burial available in the analyzed cemeteries. After all, one alternative to inhumation, which is becoming increasingly popular in the world, is cremation, recognized by researchers and cremates as an ecological solution [68–71].

Architecture and elements of spatial development. In addition to religious buildings (chapels and other religious ritual facilities), cemetery buildings are administrative, service, and technical facilities. When characterizing cubature objects, the focus was on their spatial form (block, architectural style, material solutions used, including the use of plant material) and location in regard to the borders of the cemetery. Moreover, when analyzing the spatial development of 78 cemeteries, the concentration was on such elements as the communication system (types of communication routes, materials used), lighting, hydrographic objects.

Vegetation. When characterizing the vegetation of modern cemeteries, a distinction was made between the layers of trees, shrubs, creepers, and herb layer. It was assessed whether the vegetation used in cemeteries is diverse (there are plants typical of different layers) and what role it plays in the composition layout of the cemetery (decoration, structuring of space).

3.2. Phase 2: Verifying Pro-environmental Solutions on Contemporary Cemeteries in Poland

The next stage of the research was to verify whether pro-environmental solutions, which were identified by analyzing the development of 78 European cemeteries, were used in contemporary Polish cemeteries. This process of identifying the pro-environmental solutions was based on a three-point scale: 0, 0.5, 1, where 1 means presence and 0 means absence. Cemeteries with similar conditions in the aspect of date of establishment (cemeteries from 1999 to 2019), type (municipal object) and area (over 2.5 ha), as well as, at the same time, differing in administrative affiliation (various regions—voivodeships of Poland), were selected for the research.

The research covered eight cemeteries: Antoninów (Masovian voivodeship), Bartosze (Warmian–Masurian voivodeship), Częstochowa (Silesian voivodeship), Grudziądz Kobylanka (Kuyavian-Pomeranian voivodeship), Jazków (Lower Silesian voivodeship), Stargard (West Pomeranian voivodeship), Strzelce Opolskie (Opolskie voivodeship), Zielona Góra (Lubuskie voivodeship) (Figure 4). The research focuses on cemeteries dedicated to the urban environment because the audit carried out in 2016 at selected municipal cemeteries proved that municipal governments have the greatest difficulties in obtaining new land for cemeteries [70]. Based on a source query, an analysis of planning documents and a field vision carried out in July and August 2019, the above-mentioned

cemeteries were identified in terms of basic features (area, year of establishment, composition), location, and spatial development (burial space, cubature objects, plant cover) (Table 2). Due to restrictive requirements, modern cemeteries are located on the outskirts of cities (in a rural context) but serve as the burial location of the city's residents.

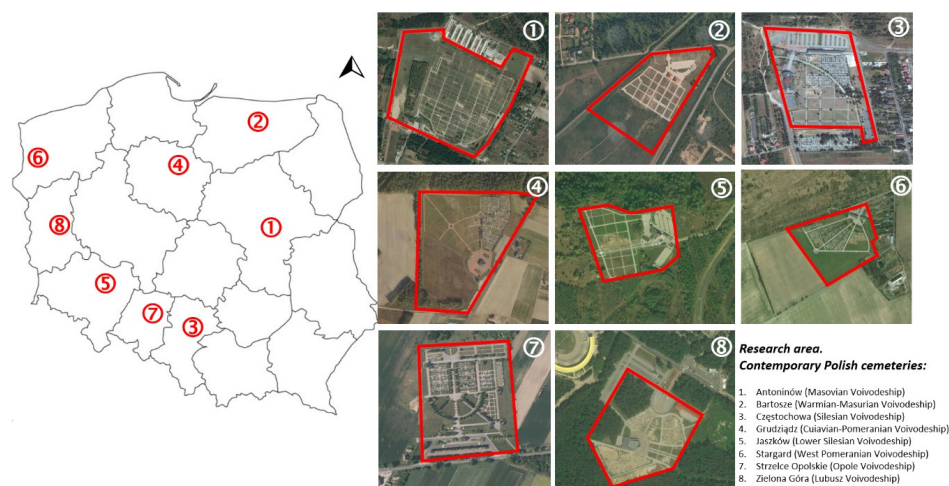


Figure 4. Spatial distribution of the selected Polish contemporary cemeteries (8 objects), including division into 16 voivodeships (left) and spatial layout of cemeteries in an aerial photograph (right). Own elaboration based on [72].

Table 2. Characteristics of selected Polish municipal cemeteries. Own elaboration based on [6] and field research.

L.p.	Cemetery Name/Location	Voivodeship	Establishment Date	Area (ha) First Stage (total)	Context	Composition
1	Antoninów	Masovian	1999	31.2 (44.0)	rural	Orthogonal
2	Bartosze	Warmian-Masurian	2014	3.8 (18.6)	rural	Orthogonal
3	Częstochowa	Silesian	2003	9.4 (14.7)	suburban	Complex, symmetrical with a distinctly arched avenue of trees
4	Grudziądz Kobylanka	Kuyavian-Pomeranian	2002	10.0 (15.6)	rural	Symmetric, radial with a central object
5	Jasków-Legnica	Lower Silesian	2013	11.0 (33.0)	rural	Orthogonal
6	Stargard	West Pomeranian	2002	10.5 (23.7)	suburban	Orthogonal
7	Strzelce Opolskie	Opole	2000	3.9 (14.0)	suburban	Complex, radial and orthogonal with fragments, liner system
8	Zielona Góra	Lubuskie	2008	9.2 (12.8)	suburban	No clear composition, symmetric layout irregular shape of plots

3.3. Phase 3: Developing of Spatial Concept of the Municipal Cemetery in Gniezno

The analysis of 78 cemeteries from the selected European countries formed the basis for the development of a catalog of pro-environmental solutions, which was then verified based on the research carried out at eight contemporary municipal cemeteries in Poland. The studies have allowed us to identify the main problems in the aspect of implementing environmentally friendly solutions and showed some trends in the aspect of developing and arranging cemeteries serving Polish cities in the 21st century. The obtained information constituted the basis on which the concept of developing the municipal cemetery in Gniezno (Greater Poland Voivodeship) was based. It was assumed the designed cemetery would be a multifunctional space, integrated with the surrounding landscape and implementing a rich pro-environmental program.

At the pre-design stage, external conditions analysis (demographic situation, historical study, planning, and strategic documents, location of the cemetery area in the natural system, spatial structure and functional program of Gniezno, including death mapping, communication accessibility of the area) and internal (terrain, scenic aspects). On their basis, barriers, disadvantages, and capability of the

place were determined, which was the cornerstone of the program and spatial concept of the cemetery integrated with the local landscape.

4. Results

4.1. Pro-environmental Solutions used in European Cemeteries

As a result of the literature review and research on 78 European cemetery objects, a list of pro-environmental solutions worth applying in contemporary design works was developed, which are presented in Table 3 below.

Table 3. List of pro-environmental solutions identified during the research of European cemeteries (divided into the layers in accordance with the model in Figure 2).

Pro-environmental Solution	Description	Meaning (Environmental Benefits)	Examples of Cemeteries Implementing the Solutions
SPATIAL CONTEXT			
Cemetery in natural city's system	Cemetery inclusion in the existing environmental conditions	Continuity in landscape/space, dwelling, vitality of species, maintenance of ecological and aeration corridors	Täby (SWE) Tuttlingen (GER) Srebrnice (SLO)
Transportation accessibility	Well-balanced mobility (area accessible for municipal transport, bikes, car parks)	Increased interest and care, development of cemetery, higher spendings on maintenance	Srebrnice (SLO) Polje (SLO)
Site composition	Composition layout adjustment to abiotic conditions	Minimal impact on area relief, decrease in cost of earthworks	Sunne (SWE) Dolenjske Toplice (SLO) Srebrnice (SLO)
BURIAL SPACE			
Columbaria	Wide range of columbaria solutions: urn walls, urn steles, courtyards	Widespread use of cremation, reduction in burial space, potential expansion of plant compositions	Langedijk (NL) Srebrnice (SLO)
Urn fields	Unified tomb inscriptions, areas covered with turf	Reduction in rainfall-runoff on the surface, avoidance of standing water, widespread use of cremation, smaller burial space area	Skurup (SWE)
Grass buried fields	Tombstones for traditional burial, covered with turf	Reduction in rainfall-runoff, avoidance of standing water	Tilsted (DK)
Memorial meadows, memorial gardens	Distinct space dedicated to forms of burial other than inhumation	Widespread use of cremation, smaller area of burial grounds, potential expansion of plant compositions	Sunne (SWE) San Pancrazio (IT)
ARCHITECTURE. SPATIAL ELEMENTS			
Funeral parlor, cemetery chapel, service and administration buildings	Ecological architecture, sustainable constructions	Well integrated with environment, natural resources protection, lower costs of maintenance and heat emissions, increase of social awareness	Monteprandone (IT) Krašnja (SLO) Šembijah (SLO) Kemmel (BE)
	Use of creepers on building facades (green walls)	Reduction of heating or cooling energy in buildings	Srebrnice (SLO) Želimlje (SLO)
	Planting gardens on roofs	Natural thermal insulation, additional biological active area	Hoog-Kortrijk (BE) Monteprandone (IT)
Lighting	Solar energy, LED lighting	Energy reduction, lower costs of maintenance, lower "pollution" by light	Sunne (SWE) Prešov (SVK)
Transportation system surfaces	Use of permeable surfaces. Big share of area with ruderal species	No runoff, water returns to its natural flow (circulation)	Duinhof Lisse (NL) Laroque-des-Alberes (FR) Longes (FR)
Hydrological objects	Water reservoirs, rain gardens	Stable flow (circulation) of water, smaller runoff, and loss of precipitation	Boo (SWE) Pedreguer (ES) Zuiderveld (NL) Beausoleil (FR)
VEGETATION			
Perennials	Flower meadows, native plants	Lower costs of maintenance, reduction in workload and measures, anti-monoculture	Wervik (BE) Diestseveld (BE) Deisslingen (GER)
Shrubs	Hedges surrounding burial units, land zoning regarding functionality, long-life plants	Prevention from monocultures, erosion reduction, increase in biodiversity	De Nieuwe Ooster (NL) Hettingen (GER) Skogskyrkogården (SWE)
Trees	Trees planted in fields, parkways, groups of trees	Better air circulation, counteracting winds, aeration corridors, wind erosion reduction	Haslum (NO)
Climbers	Climbers covering buildings, on pillars and constructions	Increase in biodiversity	Carantec (FR)
Vegetation diversity (gradation: low vegetation, high vegetation, grassland)		Roots improve soil structure, permeability, higher water saturation, precipitation is saturated and not lost, increase in air moisture, increase in biodiversity	Srebrnice (SLO) Deisslingen (GER) Groene Kerk (NL)

4.2. Contemporary Municipal Cemeteries in Poland and Pro-environmental Solutions

Spatial context. Planning and strategic documents do not include cemeteries as facilities strengthening the natural system, supplementing ecological corridors. The exception is the cemetery in Antoninów, which is located on the grounds of the Warsaw Protected Landscape Area. These areas are characterized by exceptional landscape values and act as a link between other protected areas of greater natural value enabling the migration of plant and animal species.

Burial space. Most of the modern municipal cemeteries commissioned for use do not have compositional and spatial connections with vicinity, which makes them objects detached from local conditions. Their form is sometimes accidental, except the cemeteries in Antoninów, Częstochowa, and Strzelce Opolskie. Although space dedicated to traditional burial still dominates in Polish cemeteries, one has to find the development of columbaria in the land use (columbaria was identified in all studied cemeteries) very remarkable (Figure 5). Cremation as a form of burial characterized by lower demand for cemetery area allows us to significantly reduce the size of burial space, increase the comfort of servicing residents in the field of cemetery services and make cemeteries more environmentally friendly [68,73]. Cremation allows us to implement the idea that, among others, "La Flamme" (French "Flame"; a quarterly magazine of the French Cremation Federation) tries to popularize, namely: "Save the Earth for the living" [74]. In Częstochowa, the location of the columbaria squares determined the terrain. They are placed on local hills.



Figure 5. Forms of cremation burial in municipal cemeteries in Poland with the arrangement of space, including vegetation and park furniture. Columbaria in Antoninów (A), Częstochowa (C), and Strzelce Opolskie (D) and an urn field in Częstochowa (B).

Architecture and spatial elements. In compliance with the provisions currently in force in Poland, the necessary elements of a cemetery's development are fencing, passages between tomb fields with a width of minimum 50 cm, parking spaces, water intakes, cubature buildings (funeral parlor, cemetery chapel), as well as burial space and vegetation (discussed in separate items) [9,49]. Only at the cemeteries in Antoninów and Częstochowa pro-environmental solutions were identified in terms of architecture. A multi-functional building (administration, funeral parlor, crematorium) was built in Antonów, whose spatial form evokes associations with Slavonic burial mounds. It has an exposed pediment decorated with raw columns (here you can find the echoes of the "Woodland Crematorium" portico by architect Gunnar Asplund). The eco-friendly nature of the object is determined by hiding

some of the facilities below ground level and covering the roof with greenery (thyme, turf, creeping bushes). In Częstochowa, the ellipse-shaped funeral ceremony building was covered with clinker. The side reinforced concrete wings are monumental support structures for vines (Figure 6).



Figure 6. Pro-environmental solutions: the green roof of a multifunctional building at the cemetery in Antoninów (**top**) and creepers (three-flap vines) growing on the funeral building at the cemetery in Częstochowa (**bottom**).

Vegetation. Pro-environmental activities, especially those regarding vegetation, are extended in time. In order to make cemeteries a reservoir of biodiversity and to enrich the natural urban environment, it is necessary to conduct, at least, frame plantings of greenery in the period preceding the establishment of the cemetery (about 5 to 10 years), like, e.g., in Antoninów, Strzelce Opolskie (Figure 7).



Figure 7. Birch grove founded at the cemetery in Antoninów (**left**). Still unused, but already separated, thanks to the composition of trees and shrubs, the burial quarters at the cemetery in Strzelce Opolskie (**right**).

The verification of the sub-criteria (Table 4) showed that, currently, a few pro-environmental solutions commonly used in Europe (Table 3) have been implemented in the municipal cemeteries in Poland.

Table 4. Verification of pro-environmental solutions in the selected contemporary municipal cemeteries in Poland, where each sub-criterion (pro-environmental solution) has been evaluated by using the scores of 1 (presence), 0.5 (moderate presence), and 0 (absence).

Pro-environmental Solutions	Polish Municipal Cemeteries according to Table 2								Σ
	1	2	3	4	5	6	7	8	
CONTEXT									
Cemetery in natural system	1	0	0.5	0	0	0.5	0.5	0.5	3
Transportation accessibility	0.5	0	1	0.5	0.5	1	1	1	5.5
Site composition	1	0	1	0	0.5	0.5	1	0.5	4.5
BURIAL AREA									
Columbaria	1	1	1	1	1	1	1	1	8
Urn fields	1	0	1	0	0	1	1	0	4
Grass buried fields	1	0	0	0	0	0	1	0	2
Memorial meadows, memorial gardens	1	0	0	0	0	0	0	0	1
ARCHITECTURE AND SPATIAL ELEMENTS									
Funeral parlour, cemetery chapel, service and administration buildings	1	0	1	0	0	0.5	0	0	2.5
Lighting	0	1	1	0	1	0.5	1	1	5.5
Transportation system. Surfaces	0.5	0.5	0.5	0.5	0	0	1	0.5	2.5
Hydrological objects	1	0	0	0	0	0	0	0	1
VEGETATION									
Perennials	0	0.5	0.5	0	0	1	1	0.5	3.5
Shrubs	1	0.5	1	0.5	0.5	1	1	1	7.5
Trees	1	0.5	1	0.5	0.5	1	1	1	6.5
Climbers	0	0	1	0	0	1	0	0	2
Variety of greenery (gradation, perennials, shrubs and trees)	0.5	0.5	1	0	0	1	1	0.5	5.5
Σ	11.5	4.5	11.5	2.0	4.0	9.5	11.0	7.5	58.5

The conditions determining the poor implementation of pro-environmental solutions at selected contemporary Polish cemeteries are

- A lack of consistent interpretation in Polish regulations when it comes to defining cemeteries. A cemetery is considered a building (according to [49]) and at the same time a green area [50]. Additionally, in the Act on Spatial Planning and Development, the term "greenery of cemeteries" is used for a necropolis. To build a cemetery, complete technical documentation must be prepared, for which a certified specialist in construction is in charge. In accordance with the legally binding professional standards in Poland, the professional group responsible for designing cemeteries are architects. Therefore, it is only up to the goodwill of an architect as to whether an interdisciplinary team with landscape architects will be constituted. It is unlike in other European countries, where landscape architects are in charge of the overall design and arrangement of cemeteries, which is also emphasized by the EFLA (European Foundation of Landscape Architecture), e.g., Belgium, Denmark, France, the Netherlands, Germany, Norway (Table 5).
- Predominant Catholicism and the position of the Catholic Church. Despite allowing cremation, it, nevertheless recognizes inhumation burial as more adequate, referring to the martyrdom of Jesus Christ [75,76]. Consequently, it is one of the reasons for which, in the burial space design, a vast majority is allocated to traditional grave fields that occupy a much larger area, while in Europe, one can observe the domination of cremation, including the possibility of scattering cremated ashes, which is not allowed by restrictive Polish regulations [6,77]. The predomination of cremation leads to "freeing" cemetery areas and allocating them to arrangements with vegetation.

- Marginalization of the topic of death, demonstrated in the state of research and the absent models of cemeteries in Polish literature as multidimensional space that impacts cultural and natural environments.

Table 5. Poland and other European countries in cemetery planning. Conditions for pro-ecological solutions implementation.

Country	Cremation Index	Legal Act Regulating Cemetery Planning	Professional Group Responsible for Cemetery Design
Belgium	54.0	Law on Cemeteries and Corpse Disposal (Wet op de begraafplaatsen en lijkbezorging, 1971)	Landscape architect
Denmark	80.9	Act on Burial and Cremation (lov om begravelse og ligbrænding, 2010) Act on Church Facilities and Cemeteries (Lov om folkekirkens kirkebygninger og kirkegårde, 2014)	Landscape architect
France	34.5	Code of Local Authorities (Code Général des Collectivités Territoriales, 2020), Funeral Act (Loi n° 2008–1350 relative à la législation funéraire, 2008)	Landscape architect
Spain	41.2	Sanitary regulations for burial of deceased (Decreto 2263/1974 por el que se aprueba el Reglamento de Policía Sanitaria Mortuoria, 1974)	Architect
The Netherlands	65.3	Burial and Cremation Act (Wet op de Lijkbezorging, 1991)	Landscape architect
Germany	55.0	Act on Cremation (Feuerbestattungsgesetz, 1934)	Landscape architect
Norway	42.7	Regulations for cemeteries, cremation and burials (Forskrift til lov om gravplasser, kremasjon og gravferd (gravferdsforskriften), 1997) Funeral Services Act (Gravferdsloven, 1996)	Landscape architect
Slovakia	no data available	Funeral Services Act (Zákon o pohrebníctve, 2010)	Architect
Slovenia	83.9	Funeral and Cemetery Services Act (Zakon o pogrební in pokopališki dejavnosti, 2016)	Architect
Sweden	80.1	Burial Act (Begravningslag, 1990)	Landscape architect
Italy	19.7	Sanitary Law (Leggi Sanitarie n. 1265, 1934)	Architect
POLAND	24.0	[9,47–51]	Architect

4.3. The Concept of Municipal Cemetery Implementing Environmentally Friendly Solutions

The concept prepared for the area of 20 hectares implies division into stages during construction works, which allows us to fully realize the aims in terms of program, space, environment policy, and rationally manage maintenance costs. The design idea articulated that the multifunctional cemetery, integrated with the local landscape, creates favorable living conditions for various species of plants and animals, increases the natural and landscape values of the town, and, as a result, enhances the quality of residents' lives. The location of the cemetery in the structure of the city's green areas is completed by the Gniezno greenery ring and the municipal ecological corridor running north–south (Figure 8).

Context and vegetation. Some pro-environmental solutions involve the location of the designed cemetery in the environmental system of “City on Seven Hills”, taking into consideration the existing conditions of climate and hydrology. Some examples are the use of hills; the least possible impact on the character of the area without any leveling (leveled areas serve to conventional burial, scarps filled with columbarium, unleveled areas used to plant trees or ossuary fields with flower meadows); reduction in precipitation flow on surfaces; water erosion of the area by planting turf, flower meadows, turfed shrubs; planting shrubs and trees in order to scarify and increase the permeability and porosity of soil. Additionally, by planting trees, the open space becomes esthetically more attractive, providing shadow and improving air circulation, which impairs winds.

Burial space, architecture, and spatial elements. Due to the terrain character, the cemetery was divided into two; the burial part with its orthogonal space division and the natural part of the composition accompanying the river Struga (Figure 9). Its core is vegetation constituting the source of biodiversity. The designed reservoirs serve not only as area embellishment but are also used as storage reservoirs. Other measures used to improve precipitation collection are rain gardens located by drainpipes, spots of runoff, and numerous drainage holes.

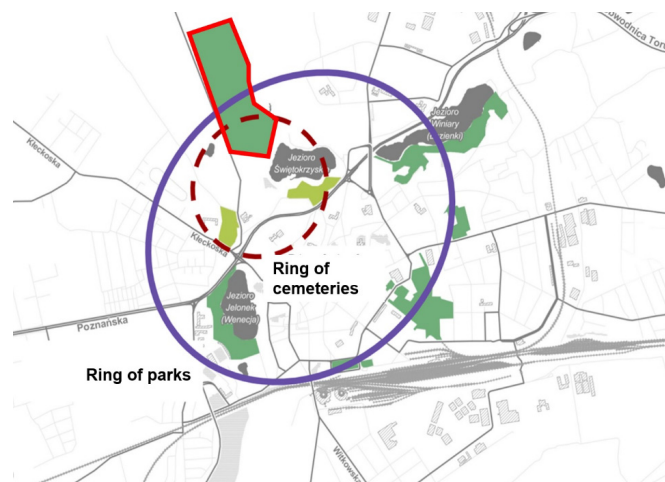


Figure 8. Location of the proposed municipal cemetery in relation to arranged (including cemetery) and unorganized greenery by Długozima, Dutkiewicz, Kosiacka-Beck, et al. [78].



Figure 9. The study area of the municipal cemetery in the town of Gniezno (**top**) [72]. The spatial concept of the municipal cemetery for Gniezno with the coverage of the investment first stage—the center of the foundation (**bottom**) by Długozima, Dutkiewicz, Kosiacka-Beck, et al. [78].

Regarding the character of place and ergonomics, the size of buildings is reduced (works in stages). Buildings placed orthogonally to each other were connected with colonnade, creating a courtyard with a pond (Figure 10). The crematorium was equipped with renewable energy technologies (photovoltaics). The funeral parlor and administration buildings have green roofs and walls, which are natural thermal insulation and additional biologically active areas.



Figure 10. Fragment of the project presenting the central part of the municipal cemetery in Gniezno by Długozima, Dutkiewicz, Kosiacka-Beck, et al. [78].

In addition to the above-mentioned actions, the cemetery includes permeable surfaces, green parking spaces, the lighting of places with solar lamps, economic facilities where waste (generated on account of the year-long operation of the cemetery) management is going to take place (recycling, composting, cultivation of plants).

5. Discussion and Conclusions

Cemeteries are constantly present in people's lives as they constitute a vital element of the surrounding landscape.

Originally, legal and cultural issues determined the locations of cemeteries. Transportation and ecological-landscape factors began to be taken into consideration in the 18th and 19th centuries, when, based on sanitary examinations carried out in French cemeteries, an edict was issued ordering the liquidation of “intra muros” cemeteries and moving them outside the city gates [11,12]. Nowadays, the growing ecological awareness, the idea of sustainable development used in spatial planning and global environmental problems force the ecological and landscape factors and associated pro-ecological solutions to be the main determinants conditioning the location of cemeteries and the nature of its development [79–81]. Ecological guidelines for locating cemeteries that have been developed after analyses carried out on 78 European and 8 Polish cemeteries are location of facility by a public road,

which reduces costs of equipping the area with facilities and infrastructure, emphasizing links of greenery, accessibility of the area by walking or cycling, and the incorporation of the cemetery into village structures. They coincide with the observations by Richter [79].

As Nordh and Evensen pointed out in [18] (p. 80), cemeteries are green spaces, but in planning documents, they are assigned a limited number of environmental qualities. Cemeteries are publicly accessible spaces, but treated as private spaces in municipal plans. To strengthen the pro-environmental meaning of cemeteries and to link them more with the functional and spatial structure of cities, the authors have developed guidelines that are universal and can be implemented to other urban cemeteries.

Background. Cemeteries as multi-faceted space. Cemeteries, as a complex structure, are comprised of basic elements: burial space, vegetation (softscape), architecture, and spatial elements (hardscape) are situated in the local landscape (context). Its design and management consists of shaping and preserving these elements.

Pro-environmental solutions for designers. Considering its multifunctional character, the process of becoming an integral part of the cultural landscape should follow in accordance with an integrated plan combining a set of activities on different levels and scales of cultural landscape (including pro-environmental solutions). Its aim is optimal development. Interdisciplinary design (engaging in cemetery planning architects, landscape architects, gardeners) undoubtedly allows us to keep a balance between the works of humans and the natural environment. Cemeteries are frequently visited places and a meeting point for relatives and, as such, should make architects and designers properly arrange its space that would remind them of a real park setting. The conducted analyses of the selected European objects constituting the reference base allowed us to indicate the attributes which should be remarkable for an ecological cemetery. These solutions were taken into account when designing the municipal cemetery for the town of Gniezno. The solutions proposed for Gniezno are universal and can be transposed to other municipal cemeteries, especially in the field of adapting spatial layouts to the topography of terrains, differentiating the burial space, differentiating the composition of the cemetery (formal and informal solutions), taking into account the program services and education, the use of various vegetation, including pro-ecological solutions in the program and performance of the cemetery space (own cultivation of plants, composting biodegradable waste, and use of rainwater). The universality of the applied solutions results from working on the cemetery model as a multi-faceted space.

Pro-environmental solutions for the community. Researchers agree with cemeteries' crucial role in the functioning of local communities [41,82]. Well-designed cemeteries should be a proper site for people after they have passed away. Moreover, cemeteries as a public space and important component of the urban green infrastructure can also be a park, a public garden, a therapeutic garden, a sacred place, an open-air museum, and a tourist attraction.

Pro-environmental solutions for municipal authorities. On the basis of research carried out by ecologists, landscape architects, and urban planners [32,36,37,80], it should be stated that cemeteries complement the urban natural system. Due to the constantly deteriorating quantity and quality of public green areas in cities, the rank of cemeteries as a public garden may increase significantly in the future. More attention should be paid to cemetery pro-ecological solutions, focusing more on shaping plant cover, which cannot be overestimated in the face of climate change. In accordance with the Polish law, land that meets the requirements imposed by legal regulations are most often wasteland or agricultural land with low crop levels. As a result, grounds for cemeteries are often devoid of high greenery. Varied vegetation with a rich stand is a desirable element of cemetery development and one of the conditions creating an ecological dimension of cemeteries.

To sum up, planning a cemetery location should refer to the concept of a common good. After all, cemeteries are a matter of concern for both the hosts (local authorities, managers) and local communities (residents, associations, social movements, associations, visiting family graves, tourists). All these individuals and entities wish the cemetery to have not only a good location but also an attractive

composition that is adequate to the character of the place. Therefore, ecological solutions should not only be embedded in the search for an optimal location, but also functional and spatial aspects.

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