

Typology of problem sites in the Silesian Voivodeship, target types of green infrastructure sites and types of solutions

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Introduction

This document was developed as part of the LIFE integrated project *'Silesia. Blue Sky Restored. Comprehensive implementation of the Air Protection Programme for the Silesian Voivodeship'*, carried out under the European Union's LIFE programme. One of the measures (C.4) of this project is dedicated to the regional concept of transforming problem sites into green sites. The first stage of this task involves developing rules for selecting locations for green infrastructure (GI) and rules for selecting solutions. In addition to this document, the product of the first stage will be a database of problem sites – potential locations for the implementation of GI, submitted by the gminas participating in the project. The results of the first stage of measure C.4 will be used to select multiple locations for demonstrative implementations of GI and to develop concepts for these implementations. Further stages of measure C.4 will include the implementation and monitoring of the results of demonstrative projects and the development of a GI guide for local authorities.

The vast majority of inhabitants of the Silesian Voivodeship live in areas where air quality requirements in terms of health protection are not met; such areas account for the majority of the voivodeship's area, including all major urban centres. The exposure of city inhabitants to air pollution can be radically reduced, provided that municipal and residential emissions from individual heating of residential buildings are eliminated. However, experience from various European regions shows that this may not be enough to ensure good air quality, and that the energy transition should be accompanied by the greening of cities. In this context, it is particularly significant that around half of the voivodeship's urban residents live in areas with a shortage of public green spaces¹.

The Air Protection Programme (APP) for the Silesian Voivodeship ², task *'Increasing greenery areas and developing green infrastructure'*, reads:

(...) spatial policy should take into account the increase in greenery areas, which, especially in cities, serve the residents by ensuring air regeneration in densely built-up areas and mitigating the adverse effects of climate change. Increasing the area of green spaces in cities improves air quality and isolates industrial areas and heavy traffic from residential areas. Compact areas of greenery, especially tall vegetation, serve a practical purpose for residents by reducing air pollution, stabilising temperatures (which is particularly valuable during heat waves) and increasing air humidity in urban areas.

According to the APP, the following are expected to contribute to improving air quality:

(...) taking into account, in newly created or revised zoning plans and at the stage of issuing decisions on development conditions, the preservation of green sites, and

(...) building planning with a view to maintaining urban ventilation and specific air protection requirements.

¹ See. <https://www.arcgis.com/apps/dashboards/c457bc0da5a34687b8bcfd169ff87e8> – data provided by the Urban Policy Observatory of the Institute of Urban and Regional Development (IRMiR).

² See. *Air Protection Programme for the Silesian Voivodeship*. – Resolution No. VI/21/12/2020 of the Silesian Voivodeship Assembly

The APP also highlights the importance of urban ventilation corridors: *natural wedges or specially designed areas free of buildings and structures are designed to improve air flow through the city in order to enhance the dispersion of pollutants.*

This document assumes that a problem site is one where:

- air quality requirements in terms of health protection are not met with regard to the levels of PM10, PM2.5 or benzo(a)pyrene (BaP) in the air, and;
- the requirement for access to public green spaces is not met, including in particular the requirement to live within a 5-minute walk of green spaces of an appropriate size (at least approximately 0.5-1 ha) and quality (with a significant proportion of trees/shrubs)³.

It is also assumed that:

- preserving open and wooded areas, especially on the outskirts and in the vicinity of cities, promotes air exchange and regeneration in the city;
- creating a network of greenery sites supports the health and safety of city residents. In densely built-up residential areas, where there is little space to utilise, it is necessary to saturate it with small solutions;
- enhancing urban and suburban areas with greenery, especially trees and shrubs, will not be sufficient to resolve the issue of air quality, as it will not eliminate pollutant emissions. However, it can be highly beneficial.

³ See previous footnote, and: https://www.euro.who.int/__data/assets/pdf_file/0010/342289/Urban-Green-Spaces_EN_WHO_web3.pdf

The problem of air quality in the Silesian Voivodeship

Since the Air Protection Programme for the Silesian Voivodeship (APP)⁴ presented the assessment of air quality based on data from 2018, the nature and scale of the problem have not changed significantly. According to the annual report of the Chief Inspectorate of Environmental Protection (GIOŚ) for 2021, almost the entire area of the voivodeship, including all major population centres, continues to experience periods of exceeded permissible concentrations of PM₁₀, PM_{2.5} or benzo(a)pyrene in particulate matter. According to calculations, a significant majority of the voivodeship's population lives in areas where pollutant limits are exceeded. This affects 78% of residents for PM₁₀, 74% for PM_{2.5}, and a staggering 96% for BaP (benzo[a]pyrene) concentrations within PM₁₀. The main cause of exceeding the permissible concentrations of particulate matter and BaP levels in PM₁₀ in the Silesian Voivodeship is emissions from municipal sources, including from combustion processes in the residential sector. Road transport and industrial emissions have a significantly smaller, though locally significant, impact.

There are only 26 state air monitoring stations operating in the voivodeship, and the assessments contained in the annual GIOŚ reports are largely based on mathematical modelling of concentrations in specific areas. However, there is no basis for questioning the above diagnosis as overly pessimistic. A fuller picture, essentially consistent with that presented in the GIOŚ reports, can be obtained by tracking data shared in real time on international websites such as airly.org, aqicn.org or waqi.info, which feature significantly more measuring stations. Furthermore, some cities in the voivodeship have dense local air pollution monitoring networks (e.g. in Katowice, there are 127 sensors, or 0.77 sensors per km²), which provide real-time results online.

Monitoring data and scientific studies [1, 3, 13, 17, 24, 25, 26] show that even within the same city district, the exposure of users of public spaces to particulate air pollution can vary greatly at any given time. Differences of an order of magnitude can occur even between measuring points located only a few hundred metres apart. This is because, in addition to pollutants migrating over long distances (regional background and urban background), emissions from the heating of individual low-rise buildings (or from local boiler rooms) and from nearby busy roads also come into play. In the case of roads, both car engines and traffic itself are significant sources of air pollution, causing pollutants to be lifted from the road surface or roadsides.

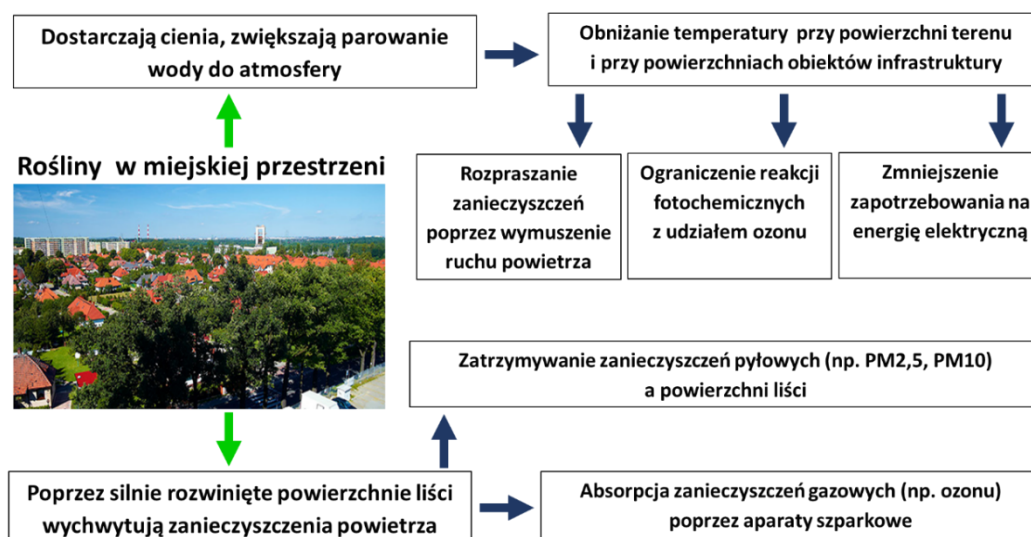
⁴*Air Protection Programme for the Silesian Voivodeship.* – Resolution No. VI/21/12/2020 of the Silesian Voivodeship Assembly

The significance of plants for urban air quality

As shown in Fig. 1, the positive impact of plants on urban air quality relies on several mechanisms [2, 5, 7, 11, 15, 19, 20], one of which is the retention of particulate matter on the surface of leaves, needles and branches. In inner-city areas, where there is little space for greenery, plants can only reduce the amount of pollutants in urban air to a limited extent, as particulate matter deposition and gas absorption are limited by the plants' surface area [3, 5, 16, 18, 21]. The mechanism of permanent pollutant retention is more significant in the case of larger, multi-hectare parks and forests, i.e. areas most often located in suburbia [4, 14, 29]. Fortunately, the importance of plants for air quality also comes from their ability to change the distribution of pollutants, especially by dispersing them and creating barriers to their spread [13, 17, 24, 25, 26, 30]. Strips of greenery connecting suburban areas with city centres serve as corridors for the migration of cleaner air, not only because they are free of buildings, but also because the presence of living plants forces air movement [11].

Once particulate matter is captured on the surface of a plant, it will not rise back into the air. This is because the surface of every leaf, branch or trunk is covered with a very thin, invisible coating of a wax-like substance to which particulate matter adheres strongly and may even sink into. Some of the captured particulate matter may be washed away by rainfall, and the rest will enter the soil in autumn along with falling leaves.

Thanks to the phenomena depicted in Fig. 1, well-chosen greenery can significantly reduce human exposure to urban air pollution. It is also well worth noting that the beneficial impact on air quality, including both the dispersion and permanent retention of particulate matter, also occurs (albeit to a lesser extent than during the growing season) when the trees are bare [29].



Według: Fallmann i wsp. (zob. Piśmiennictwo, poz. 11).

Figure 1 Benefits to urban air quality provided by well-designed and well-maintained green spaces, including from the retention of particulate matter on leaf surfaces

Types of problem sites: classification based on origin and present use

This document identifies 10 types of problem sites. Two of them (1, 2) are public spaces that differ in terms of exposure to air pollution caused by car traffic and, consequently, recommendations for 'green' solutions (see further in the text). The types of areas numbered 3-10 are areas of highly diverse origin, but currently remain outside organised use and do not function as public spaces.

A given problem site, especially an extensive area, may have mixed origins (e.g. partly post-transport, partly post-industrial). It may also be the case that part of it functions as a public space, while the rest is outside organised use. With this in mind, this document assumes that a single problem site may comprise one or two or even more of the types described in the following paragraphs.

Types 1-2. Areas already used as public space but lacking tall greenery

Public spaces with a permanent shortage of greenery are mostly streets and city squares located in densely built-up areas, generally at the heart of the city. Due to their settlement history, many cities in our region have a polycentric structure, which means that dense development with a lack of space for large grasslands is also found in formally peripheral districts.

Dense development severely limits the opportunities for ventilation and exchange with cleaner air from outside the city. At the same time, the lack of greenery means that the opportunities for local air regeneration are limited.

Where there is no space for parks or large green squares, arranging numerous publicly accessible green spots can help reduce people's exposure to air pollution. These will be Urban Green Acupuncture (UGA) projects, as described in the target site types II and IV.

It is assumed that over the years, as municipal and residential emissions in the city are eliminated and the background level of pollution is reduced, the dependence of air quality at a given point in the city on its location in relation to heavy-traffic roads will be more and more apparent. For this reason, types 1 and 2 have been identified among problematic public spaces.

Type 1. Public space in the vicinity of a street with heavy motor vehicle traffic

In the immediate vicinity of heavy-traffic roads, poor air quality is caused not only by pollution from municipal and residential emissions and background pollution, but also by road transport emissions. According to the APP, the concentration of PM₁₀ air pollution from road transport alone can reach 20 µg/m³, which is half the permissible level. The main objective of the intervention is to reduce the local exposure of pedestrians to particulate matter pollution emitted from the road and its verges by separating pedestrians with a green barrier that partially

absorbs and partially disperses pollution. The intervention is also intended to disperse and absorb pollutants from other sources.

At the same time, the choice of solutions must not restrict air flow along street canyons or city square frontages, or between pavement level and building roofs. This will prevent the accumulation of air pollution from road transport in areas used by pedestrians. Correctly identifying the nature of the problem will be key to selecting the right solutions. For example, excessive restriction of vertical air exchange caused by excessive density of the canopy of trees may result in such a large increase in the local concentration of pollutants from road transport that the air quality in the pedestrian zone will be even worse than in a place without any greenery.



Figure 2 Linear park in Ruczaj, Krakow (2aX-III); <https://zsm.krakow.pl/zsm/parki/858-park-linearny.html>.

Type 2. Public space not in the vicinity of a street with heavy motor vehicle traffic

The most important objective of intervention outside the vicinity of high-traffic roads is to reduce local exposure of pedestrians to particulate matter pollution from urban background and regional background sources and from municipal and residential emissions. Intervention does not need to, and indeed should not, lead to the creation of barriers to air mixing both along and across street canyons or the city square. In this case, separating the pedestrian zone from the road with a dense, tall hedge will not achieve the desired air quality. The aim is to maximise the dispersion and absorption of pollutants by plants while ensuring the free flow of air along the street canyon or city square frontage. The greater the exposure to local municipal and residential emissions and background pollution, and the lower the exposure to pollution from nearby roads, the more sensible it is to introduce vegetation barriers in the form of dense, wide tree crowns, which limit particulate matter fall from above. Various vertical solutions (green walls, green façades, green roofs) are also becoming increasingly important, as they expand the surface area for absorbing pollutants while also enhancing convective air movement.



Figure 3 Woonerfs in Łódź, including at ul. 6 Sierpnia; <https://pdm.irmir.pl/narzedziownik/lad-przestrzenny-i-urbanistyka/woonerf-6-sierpnia>

Types 3-10: Areas outside organised use, not functioning as public spaces

The urbanised areas of the Silesian Voivodeship face a major challenge, but also an opportunity, related to the presence of various types of wasteland, most of which are remnants of the industrial era or an indirect product of the economic transformation that has taken place in recent decades. Polycentric settlement systems, especially in the Metropolis GZM (GZM) region and in the Rybnik-Wodzisław and Bielsko-Biała agglomerations, are characterised by a mosaic of residential and industrial buildings, transport networks, but also fragmented open spaces. The region is undergoing rapid suburbanisation, partly in the form of cities spreading outwards to the outskirts. The ongoing trend continues, primarily at the expense of green sites. Forest remnants, post-agricultural land, and spontaneously greened wastelands are all treated as obvious reserves for new residential, commercial, or industrial development and for transport routes.

The opportunity lies in the fact that at least some of the wasteland located on the outskirts of the built-up area (and sometimes, due to its industrial history and subsequent transformation, in the core of the city) lends itself to being converted into green public spaces. This fits into the concept of green land recycling and, at the same time, the circular economy paradigm. New green spaces can be shaped, for example, as part of local regeneration programmes, and under the fair transition programme or the Regional Operational Programme.

Grasslands created by transforming type 3-10 areas in suburban zones should be as extensive as possible and adjacent to built-up areas, ideally connecting to inner-city green spaces. While greening a small wasteland (type 'c' geometry) located in open, non-urban space will not contribute to the regeneration of urban air, a similar wasteland surrounded by residential areas can be one of the key locations for creating an UGA.

Type 3. Post-urbanised area

This category includes extremely degraded residential areas, incorporating streets and, usually, tram tracks. These are typically remnants of workers' housing estates or former State Agricultural Farms (PGRs). They are most often located in the immediate vicinity of functioning urban areas, although there are also examples of former colonies now surrounded by degraded post-transport, post-agricultural or post-industrial areas.

Introducing greenery will generally involve partially removing and partially adapting existing buildings and/or infrastructure for a new function. The target type of green space – whether created across the entire post-urbanised area or complementing a new form of land use – will depend on the geometry of the area in question, its location relative to the existing urban fabric, and the proportion of infrastructure planned to be retained or removed. If the area is located

in the city's core zone, greening it will always contribute to improving air quality in that part of the city; the more extensive the area for introducing trees and shrubs, the more sensible such an intervention becomes. If the area does not have the conditions for introducing greenery as a compact patch, the aim should be to create as many green points as possible, based on UGA.

For locations outside existing buildings and structures, only the greening of a large area can impact air quality, ideally if it is ultimately connected to a green ventilation corridor for the city. Post-urbanised areas are usually dominated by embankment soil; even if remnants of natural soil have been preserved in some places, it is heavily degraded. For this reason, introducing trees, shrubs, and other solutions in contact with the ground may require complex technical remediation measures, alongside the use of specific NBS in combination with smart soil.



Figure 4 Park Mieszczański, Wrocław (under construction, visualisation); <https://www.wroclaw.pl/zielony-wroclaw/galeria/park-mieszczanski-kepa-mieszczanska-nowy-park-we-wroclawiu-wizualizacje,p,3>

Type 4. Post-transport area (former road, railway line)

Many sections of old, disused road and rail transport routes that once served industry or mining have been preserved in the Silesian Voivodeship. Regardless of whether they run on flat terrain, embankments or in excavations, they are particularly well suited to function as corridors for ventilating the city or bringing cleaner air into it. This suitability stems from their location – even when a route crosses a city, it remains next to dense development rather than within it. In a typical case, the former route includes not only the surface or track but also an adjacent strip of land

several metres wide on each side; this is an area that deserves to be greened, while at the same time being adapted for recreational use and for travelling on foot, by pushchair or by bicycle between cities or between city districts.

Landscaping along a former transport route is usually relatively easy. A significant challenge may be to combat invasive plants if they have permanently colonised the abandoned land. Conversely, some land – both natural and embankment – accompanying transport routes is susceptible to spontaneous succession of pioneer tree and shrub species. The resulting vegetation cover needs to be enhanced for its adaptation to functioning in the planned public space. However, the presence of pioneer trees and shrubs does not necessarily mean that the introduction of target species, which are usually more demanding in terms of habitat, will be easy. It may be necessary to use plant material and technical solutions similar to those used in tree planting in inner-city problem sites.

The transformation of post-transport land into public space (most often representing the third type of green space) requires a thorough assessment of the technical condition of all existing underground infrastructure remnants and the surface area, regarding adaptation to the planned function or removal. This may involve specialist expert services.

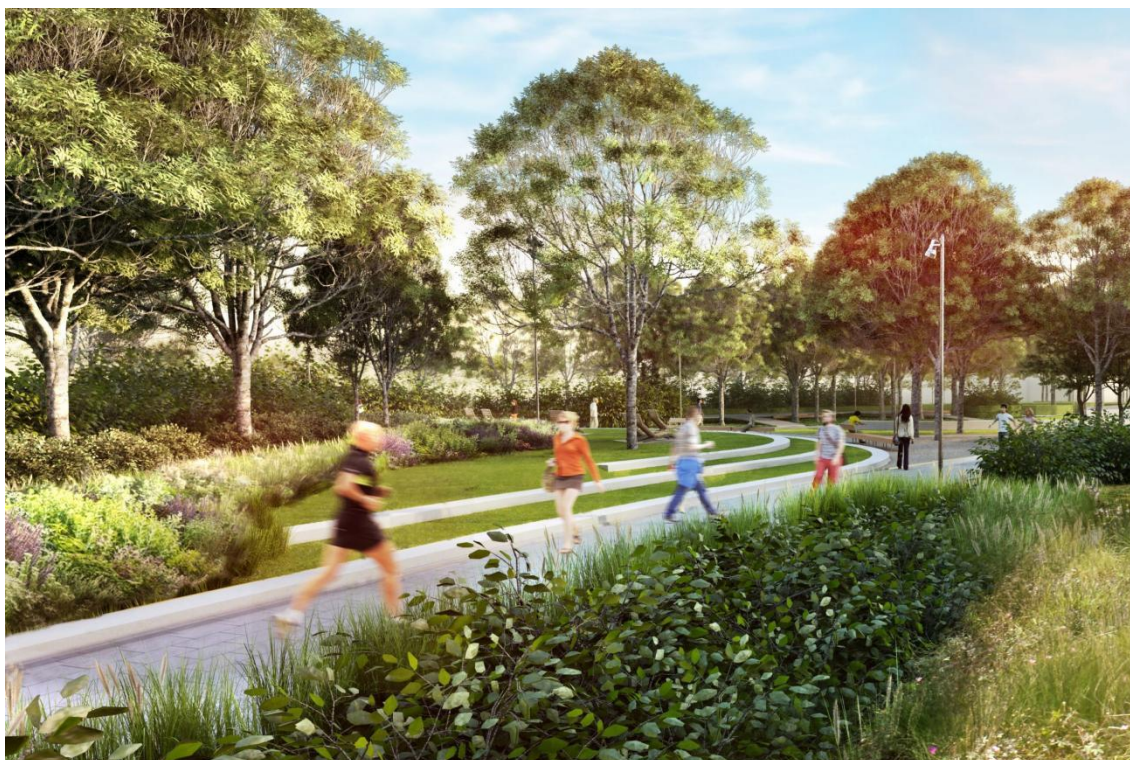


Figure 5 Linear Park, Suwak, Służewiec (under construction, visualisation), at the junction of Mokotów, Ursynów and Ochota; (<https://um.warszawa.pl/-/rozpoczyna-sie-realizacja-inwestycji-park-linearny-suwak>; <https://zzw.waw.pl/2021/07/19/park-linearny-suwak-nowa-zielona-przestrzen-dla-mieszkancow/>)

Type 5. Build-up land formerly used for industrial or logistics purposes (e.g. steelworks, mines, transport hubs)

This type of land possesses similar characteristics to post-urbanised and post-transport areas. The decision to restore it to use, including its conversion into green public space, is contingent upon a thorough assessment of potential environmental risks. Of all wasteland types (3-10), areas in this group may require the most extensive expert assessment. In some cases, this assessment may cover almost the entire range of issues included in the description of the area within the OPI-TPP⁵ database dedicated to degraded post-industrial and post-mining areas in the Silesian Voivodeship. Consideration must be given, for example, to the possibility of hazardous substances being deposited here (usually in the soil), or to geotechnical or construction-related hazards, e.g. related to the stability of anthropogenic soils, remnants of underground utilities or infrastructure elements. In the case of certain former activities, such as the chemical industry, coking, fuel storage, etc., the need for soil remediation over a large area (e.g. through the use of plants with specific bioremediation properties), or even its replacement, must be taken into account.

Post-industrial sites free of environmental hazards present attractive locations for business activities and even new residential development. There are also well-documented examples of the successful transformation of a large post-industrial site into a city park, with new activities being established on the remaining part of the site.

The degree of complexity and the type of challenges associated with transforming a post-industrial site into a green public space depend to a large extent on the type of previous activity and the time that has elapsed since it ceased. Sometimes, as a result of spontaneous natural regeneration, valuable elements such as trees, wetlands, and even shelters for birds and bats have developed in some parts of the area, which are worth preserving.

⁵<https://opi-tp2.pl/>



Figure 6 Ekopark Ursus and Phoenix Park in Dortmund; (<https://sozosfera.pl/ochrona-przyrody/ekopark-w-ursusie/>)

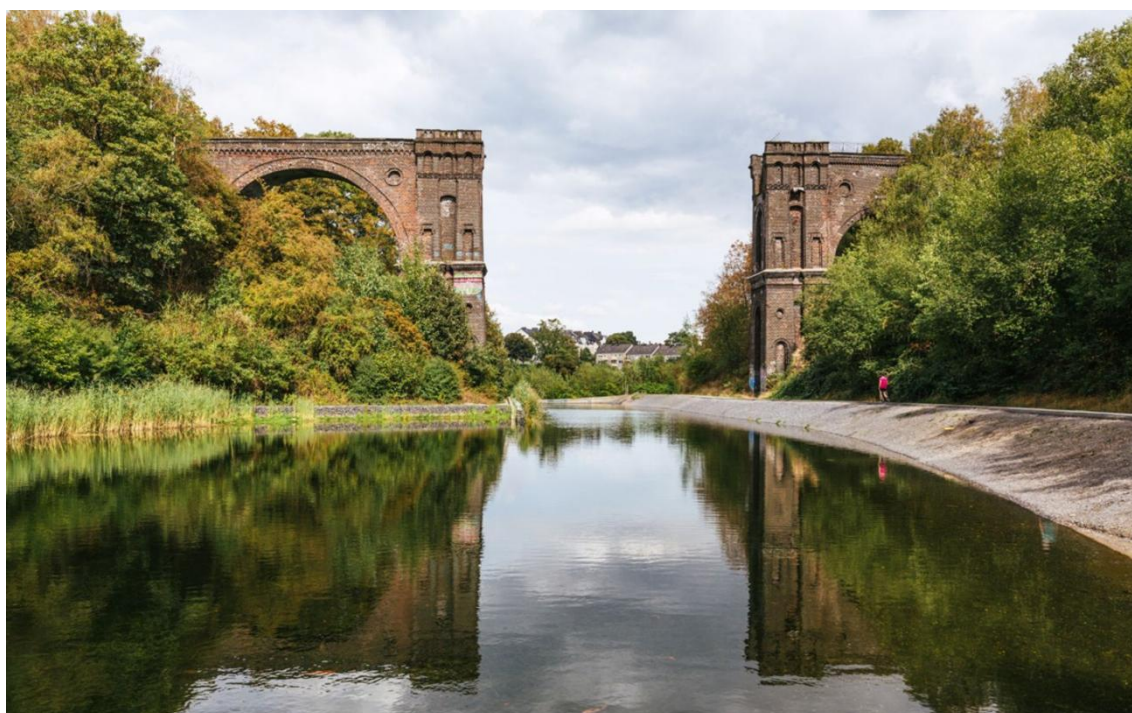


Figure 7 Phoenix Park in Dortmund; (<http://www.phoenixdortmund.de/de/fakten/phoenixpark.html>;
https://www.geo.de/reisen/reiseziele/hympendahlbruecke--dortmund_30142386-30167312.html)

Type 6. Surface excavation – unlevelled, unreclaimed.

Former excavation sites, areas where the natural soil cover was previously stripped, experience slow spontaneous vegetation succession, often with a predominance of trees or shrubs. When planning green public spaces (e.g. type I or III), it is advisable to begin with an assessment of the existing vegetation cover, particularly trees and shrubs, in the context of possible adaptation to the target function. Old excavations often serve as habitats, frequently the only ones in the area, for rare, protected species of plants and animals.

For this reason, nature conservation must be treated as an essential element of the assessment of local conditions, and the results of this assessment will influence the shape of the target solution and the manner of its implementation. In order to accelerate the afforestation/shrub introduction to the area through appropriately selected plantings, it may be necessary to use a suitable substrate containing natural soil, preferably enriched with smart soil. However, the key task will be to accurately match the planting technique and the selection of plant material to the local water and soil conditions and the type of parent rock. In the case of complete isolation from the groundwater table, ensuring an optimal irrigation system during the first few years after planting will be crucial for effective and rapid afforestation. In some cases, especially if the project concerns a former quarry, special attention must also be paid to adapting the site to the requirements of work safety and human safety.



Figure 8 Gródek Park, Jaworzno; (www.facebook.com/parkgrodek/?locale=pl_PL)

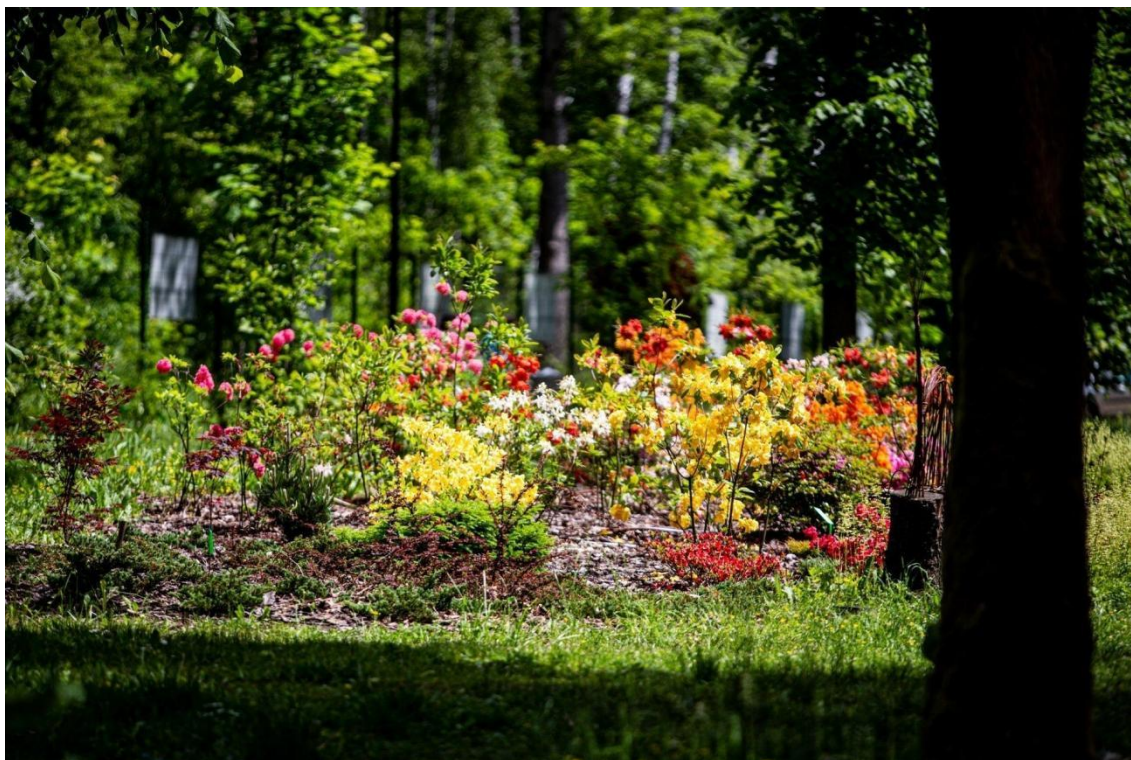


Figure 9 Silesian Botanical Garden, Radzionków; (<http://www.obradzionkow.robia.pl/>;
<https://dziennikzachodni.pl/slaski-ogrod-botaniczny-w-radzionkowie-wstep-bezplatny-a-widoki-jak-z-pocztowek-jest-tu-jak-w-bajce/ga/c7-15010794/zd/43673450>)

Type 7. Former industrial/mining/municipal waste landfill.

Former waste landfills are a very heterogeneous group of areas in terms of form (subsurface piles, flat piles, heaps, settling ponds), economic sector (municipal, industrial), type of waste stored depending on the industry, production technology (barren rock, iron metallurgy waste, zinc waste, power plant waste, post-flotation, chemical industry, pesticide burial sites, etc.), and the nature of potential hazards (e.g. the presence of persistent substances from the hazardous waste group, secondary chemical transformations, landfill gas emissions, thermal activity, toxic leachate, insufficient geotechnical stability, secondary particulate matter emissions). Individual landfills vary greatly in terms of the time that has elapsed since their closure and the remediation or isolation techniques already used, and not all old landfills are fully recognised in terms of the scale of risks to the environment and human health. For all these reasons, any decision to transform a landfill into a green public space must be supported by reliable knowledge about the site, covering its entire history from its creation to its current state. The scope of the necessary expert assessments may include most of the issues covered by the site description in the OPI-TPP database.

The afforestation or reforestation of a former landfill and its conversion into a green public space is almost always feasible and beneficial for many reasons, including the quality of urban air. However, the correct design and execution of the work requires exceptional care in identifying the conditions of the site. In addition to the above-mentioned risks, another source

of difficulty may be soil that is unfavourable for the growth of trees and shrubs (e.g. heavily compacted waste rock dumps with steep slopes). In some cases, the costs of technical preparatory work necessary to eliminate environmental hazards may be very high. However, these costs will not usually exceed those that would have to be incurred to enable other uses of the land.



Figure 10 Alfred Park, Czeladź; (https://wazki.pl/czeladz_alfred.html; <https://bedzin.naszemiasto.pl/w-parku-alfred-w-czeladzi-pojawily-sie-nowe-drzewa-a-to-nie/qa/c1-7990049/zd/57755853>)



Figure 11 Silesia Park, Chorzów; (<https://parkslaski.pl/> ; <https://parkslaski.pl/7-parkslaski-rosarium>)

Type 8. Abandoned areas of subsidence/sinkholes/post-mining floodplains

The Silesian Voivodeship, including its urban areas, contains numerous post-mining subsidence zones where vegetation is regenerating, either spontaneously or with human assistance. Often located in urban or suburban stream valleys, these areas are particularly well-suited to serve as corridors for cleaner air to reach city centres. Over time, some have developed into blue-green public spaces, such as the Katowice Forest Park in the Valley of Three Ponds, while others, like the Bytomka and Kochłówka Valleys, hold similar future potential. In many cases, intervention would primarily involve enhancing natural regeneration processes whilst introducing architectural elements to facilitate comfortable public access and recreation. This can be achieved through initiatives such as river valley renaturation or a local revitalisation programme.

A crucial element of the site assessment is the natural value, as disused areas of former subsidence often serve as habitats for protected plant and animal species. It is also necessary to examine the water and soil conditions, since these are frequently waterlogged areas; the variable, periodically high groundwater level greatly restricts the range of tree and shrub species that can be selected and strongly influences the selection of NBS using the local soil. Furthermore, it is worth investigating the history of land use and the distribution of any embankments, which may have been introduced to limit the local effects of land subsidence. Geophysical, water, and soil conditions also have a strong influence on the technical solutions and small-scale architecture that complements the introduced greenery.



Figure 12 Żabie Doły-Bytom, Chorzów, Piekary; (https://pl.wikipedia.org/wiki/Zesp%C3%B3%C5%82_przyrodniczo-krajobrazowy_%E2%80%9E%C5%BBabie_Do%C5%82y%E2%80%9D; <https://www.belekaj.eu/pl/zabie-doly/>)

With a proper understanding of local conditions, particularly the good availability of water in the soil, the permanent afforestation and planting of shrubs in such an area can prove remarkably straightforward and effective. However, consideration must be given to the need to introduce relatively expensive technical solutions that ensure comfortable access and amenities for people.

Type 9. Post-agricultural wasteland

In the vicinity of residential buildings, often within the administrative boundaries of towns, there are numerous areas of post-agricultural wasteland that were until recently used as arable land. These areas sometimes represent the only land reserve available for the creation of public green space. Although transforming such land into a park, a large green square, or a tree-lined route to channel cleaner air into densely built-up areas may seem relatively easy, in reality, restoring the soil to a condition that allows for the rapid and healthy growth of trees and shrubs can require significant work and expense. An effective solution may be to combine planting with the use of smart soil or soil deacidification. Establishing the target vegetation cover may also require managing invasive plants, such as goldenrod and knotweed, and in some cases, invasive tree species like the ash-leaved maple.

On land that has been used for intensive agriculture, the details of soil preparation, planting techniques, and the species composition of trees and shrubs should typically be selected based on specialist soil testing and an assessment of the course of spontaneous succession to date. It should be borne in mind that in the future public space into which the post-agricultural land is to

be transformed, both the target tree stand composition and the agrotechnical measures will usually differ from those used in the ordinary afforestation of such land.

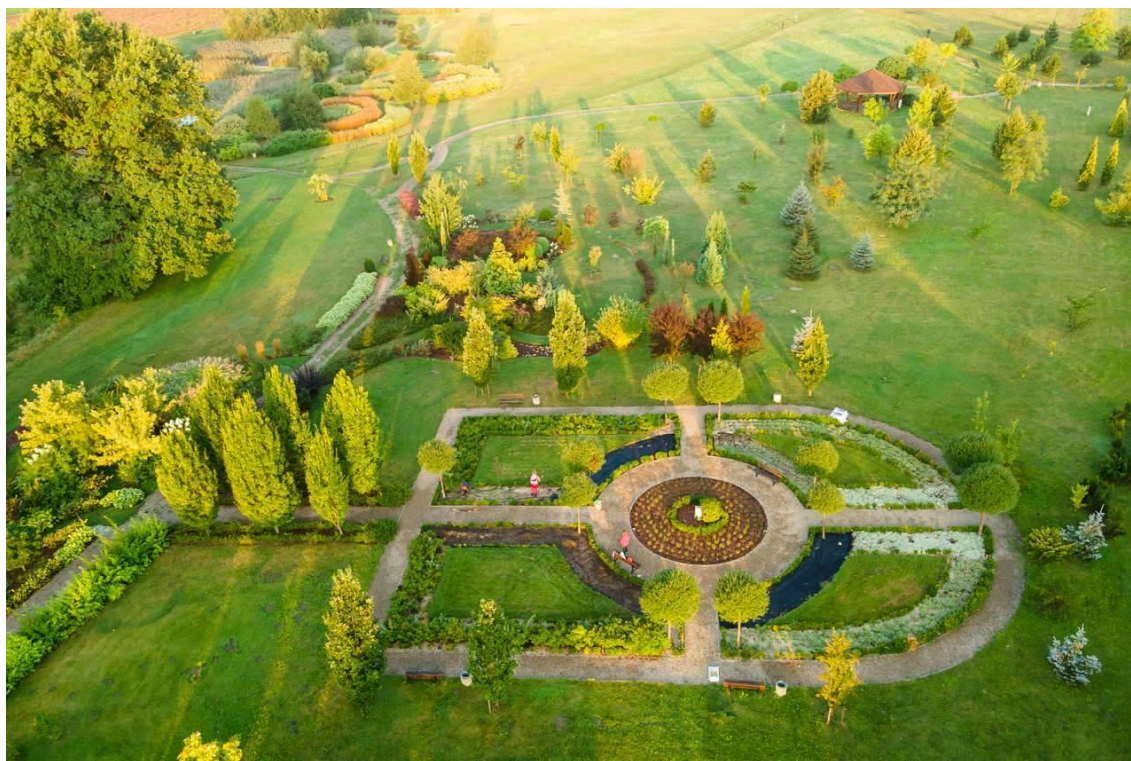


Figure 13 Silesian Botanical Garden, Mikołów – ‘Red Garden’ <http://www.obmikolow.robia.pl/>

Type 10. A strip of open, undeveloped urban/suburban space with natural soil, sodded, distant from the road network (e.g. vicinity of a watercourse/reservoir, former drainage ditch)

These open areas have various origins, most often forming from the spontaneous regeneration of post-agricultural land and pastures, drained riverside areas, or former grassy recreational areas. Generally, they are zones where soil regeneration and vegetation succession have occurred over many years without significant colonisation by trees and shrubs. If located near residential areas, they represent a particularly valuable reserve for creating a large park, green space, or a segment of a tree-lined route to channel cleaner air into intensively developed areas. Even a sufficiently large area far from human settlements may be worthy of afforestation to help reduce the level of urban background pollution.

Introducing trees and shrubs may prove easier on such land than on areas that were, until recently, used as arable land. In addition to standard soil tests, an analysis of the spontaneously formed plant communities will provide a valuable guide for selecting appropriate tree and shrub species.



Figure 14 'Małpi Gaj' Park, Będzin, <https://dziennikzachodni.pl/bedzin-malpi-gaj-po-modernizacji-wyglada-ciekawie-i-zacheca-do-wypoczynku-zdjecia/ar/c1-14255173>

Geometry and location of problem sites

In addition to their origin and current use, problem sites can be classified according to various criteria. Within the context of this document, their location relative to the urban fabric and their geometry, understood as their size and shape, are particularly significant. Consequently, each of the 10 types is additionally described according to these location and geometric criteria.

Description of problem sites according to geometric criteria

This document distinguishes three categories of problem site geometry:

a/ Compact area larger than 0.2-0.3 ha

This category can include an area of less than one hectare, but also one of several or even tens of hectares. Its origin may vary, though it is usually suburban wasteland (any of types 3-10) and much less frequently public space. Given that the intervention aims to both improve local air quality and increase the capacity for urban air regeneration, it is advisable to use as much of site 'a' as possible for planting trees and shrubs.

b/ Linear area extending beyond the scale of a street accompanying a building quarter

The length of such an area can range from several hundred metres to several kilometres, with a width typically of tens or hundreds of metres. It may connect districts within a city or run across municipal (gmina) boundaries. This category includes, for example, a small watercourse valley, a former railway embankment, a disused service road, or the route of a former industrial

conveyor belt. As the intervention aims to improve local air quality and, above all, to increase the transfer of cleaner air to densely built-up areas, whilst also potentially connecting isolated green sites, it is advisable that such an area ultimately contains a continuous strip of tall greenery that is as long and wide as possible.

c/ Area not exceeding 0.2-0.3 ha

Owing to its small size, such an area is not suitable for conversion into a park or an extensive green space. It is most often a fragment of public space (site type 1 or 2) in an intensively built-up zone, limited to a small section of a street, a city square, or a small block of buildings. Since the purpose of the intervention is to locally reduce people's exposure to air pollution, the recommended approach is Urban Green Acupuncture (UGA), where a single action covers multiple 'c' sites.

Problem site description based on the location criterion

This document distinguishes three categories of problem site locations:

- X – an area located within or on the edge of a densely built-up area. Such a location usually, though not always, corresponds to the core part of the city;
- Y – an area located among low-density buildings and structures (suburban, residential, rural) or at their junction with extensive open space;
- Z – an area located outside a built-up area, surrounded by open spaces.

The distinction between location categories is very important. For example, in an extensive open space (type 'a' area) located outside a built-up area, it does not make much sense to create 'green points' similar to those recommended for inner-city areas (as UGA). Such an extensive area is usually suitable for conversion into an extensive green public space with supra-local significance for air quality. In suburban built-up areas, particularly significant benefits can be achieved by greening type 'b' areas, which can also serve as a bridge for transferring cleaner air to densely built-up areas. In densely built-up areas, especially in old city centres, type 'c' areas, which are suitable for the implementation of UGA, are gaining in significance.

In the proposed notation, abbreviated descriptions of terrain types may be as follows:
(where '4' refers to the type of terrain, 'a' to the geometric criterion, and 'Z' to the location criterion)

- 4aZ – an extensive unused post-transport area surrounded by open spaces;
- 1bX – an open public space stretching along a significant section of a busy road amid a densely built-up urban environment;
- 7cY – a small, unused area that was formerly a landfill, surrounded by suburban buildings and structures.

Catalogue of solutions

Types of public spaces created by transforming problem sites

Publicly accessible green sites can be classified according to various criteria. In this document, it has been assumed that, bearing in mind the common understanding of the types of green sites (e.g. park, square, garden) and the categories adopted in zoning documents, it is also worth considering:

- the criterion of benefits for air quality, and
- the link with the typology of problem sites.

As a result, five types of target green sites have been identified. Figure 2 summarises the main benefits for air quality that can be attributed to each of them.

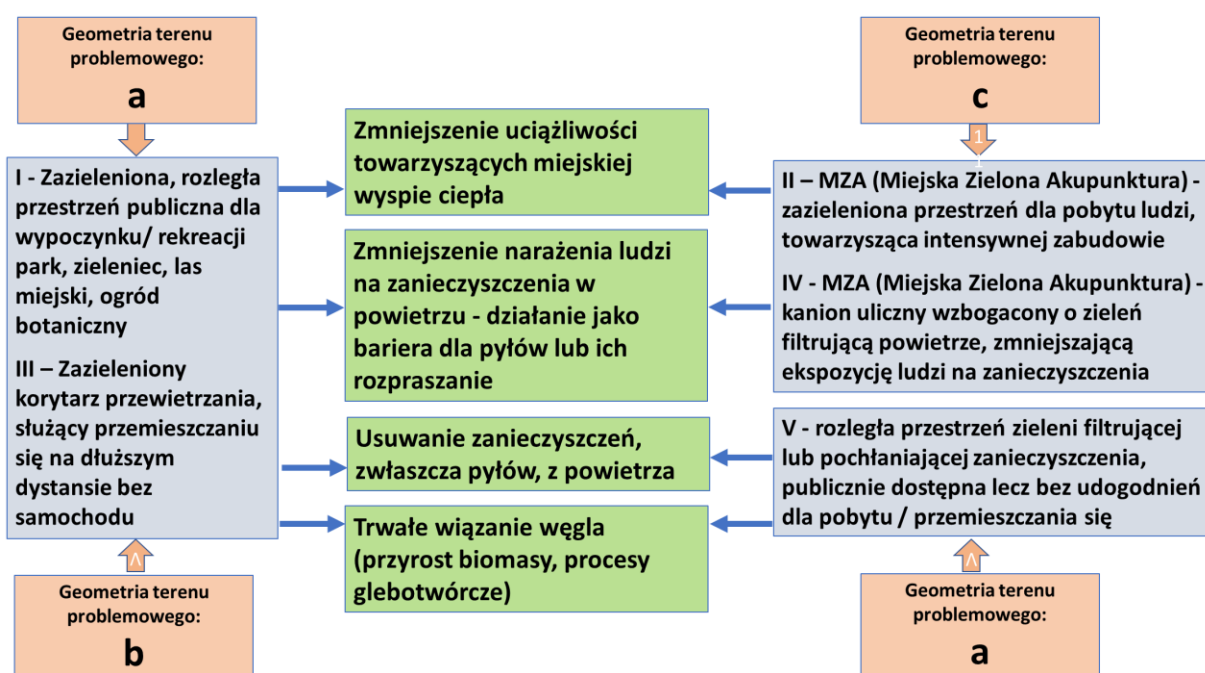


Figure 15 Main air quality benefits resulting from the conversion of problem sites into green public spaces

Not every problem site is homogeneous in terms of its origins and specific local conditions. Particularly in the case of an extensive problem site with mixed origins and morphological diversity, it may be the case that the optimal type of intervention is one that will lead to the creation of two or even more adjacent types of green sites.

Type I: Greened, extensive public space for leisure/recreation

This type of site encompasses parks, extensive green spaces, urban forests and botanical gardens. The benefits for air quality include the permanent elimination of some pollutants and a reduction in the exposure of users of public spaces to pollution, with the improvement being particularly noticeable in leisure and recreational areas. The edge of the park creates an

effective barrier to the movement of pollutants from adjacent urban areas, and the entire area serves to transfer cleaner air to densely built-up areas (29, 30). This is generally a desirable type of usable green area in use, promising the greatest environmental and social benefits, not only in terms of air protection.

In existing urban developments, it is hardly feasible to create extensive green sites, whereas various types of extensive wasteland located near population centres, preferably in the vicinity of or within the core area of the city, easily accessible by various forms of public and private transport, are predestined for this function. A decision to 'green recycle' such an area, similar to the one that once resulted in the creation of the Voivodship Park of Culture and Recreation (now Silesian Park) in Chorzów, will most often involve the need to limit the development of logistics functions and certain forms of business activity. A decision to create a new, extensive park on a site considered attractive for business may be politically difficult, but in the long term it can bring significant environmental, social and financial benefits. [28]. There are well-documented cases where extensive parks have been created on urban and suburban "wastelands", such as – according to the typology adopted herein: 3a, 4a, 4b, 5a, 5b, 6a, 7a, 8a, 8b, 9a, 9b, 10, 10b.

Type II: UGA – small green enclaves for human occupation, accompanying intensive development

Green enclaves (green points) can be created by transforming areas with type 'c' geometry located within multi-family residential, service, educational and industrial developments, as well as in public transport infrastructure areas. The benefits for air quality consist in a local reduction in the exposure of users of public spaces to pollution. The impact of trees, shrubs and vertical solutions (green walls, facades) mainly consists in creating a barrier that protects users of public spaces from the influx of more polluted air from roads or nearby residential and municipal emitters, while also dispersing pollutants contained in the air. In such cases, the balance of permanently absorbed pollutants is of little significance, whereas reducing the maximum instantaneous levels of pollutants (especially particulate matter) in areas where people are present is very important. There are over 20 types of UGA areas, including pocket parks, green city squares, green courtyards, school educational gardens, woonerfs and other [8, 9].

Creating small green enclaves (green spots) in public spaces makes sense, especially in densely built-up city centres, where there is a permanent lack of opportunities to create more extensive green sites (problem site types: 1, 2). In type 3-10 problem sites, using UGA can also improve air quality, but this is more likely to be the case in the city centre, where the problem site is surrounded by dense residential buildings.

In principle, one should strive to create as many (for example, a dozen or so) well-located green spots as possible in areas affected by poor air quality and a lack of greenery. This can reduce the environmental nuisances typical of heavily built-up areas to a certain extent, but a significant positive impact on the quality of life of residents will only occur with a sufficiently large number of well-chosen and well-located interventions. The environmental and social impact can be measured both in terms of the city's adaptation to climate change and the enhancement of ecosystem services. Specific benefits include: alleviating the nuisance associated with the urban heat island effect, creating friendly leisure and neighbourhood spaces,



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dispersing air pollution, increasing rainwater retention in urban areas, and improving the city's aesthetics.

Type III: Greened ventilation corridor for the city

The corridor will serve as a means of long-distance travel without a car (a green cycle path or cycle and footpath with accompanying trees), combined with the possibility of a comfortable stay (linear park). The benefits for air quality are similar to those of large parks and green sites, but the transfer of cleaner air to densely built-up areas may be particularly important. The wider the green belt, especially the strips of trees and shrubs, the greater the benefits in terms of pollutant absorption.

This type of green space is easiest to create if it has been reserved in planning documents as a corridor free of development, serving as an axis for ventilating the city. Particularly significant environmental and social benefits, not only in terms of air protection, can be achieved if the corridor connects not only densely built-up districts or the outskirts of the city with the core area, but also two or more extensive green sites.

Obvious resources for a green corridor are 'waste land' (land types 3-10), linear areas (geometry 'b'), especially post-transport areas. On the other hand, when planning to transform extensive wasteland (geometry 'a') into type I or type V land, one must always consider the possibility of its future functioning in a supra-local, spatially continuous green infrastructure network. If this possibility exists, it is worth arranging part of this wasteland as a section of the target green corridor.

Type IV: UGA – street canyon enriched with greenery

The main function of greenery will be to filter the air and disperse pollutants. Due to the limited size of the area (the scale of a single street section), despite its linear geometry, the street canyon falls into the geometric category 'c' of problem sites, and the target type of solution is appropriate for UGA. The catalogue of benefits for air quality is similar to that for type II areas – the main task of greenery is to locally reduce the exposure of users of public space to pollution, especially dust.

Regardless of the details of the solutions adopted, the trees and shrubs introduced must not restrict ventilation (i.e. free air movement along the canyon must be ensured), and the form of greenery and the method of planting will depend on the locally dominant cause of air pollution. If, in the long term, the main source of pollution is traffic (type 2 problem site), it is most important to create a plant barrier to limit the migration of pollutants from the roadway to the pedestrian (or pedestrian-cyclist) zone; the barrier may take the form of a tall hedge of densely leafed shrubs, for example. In such a situation, it does not make much sense to plant park-type trees, as their extensive crowns could limit the discharge of polluted air above the roofs of buildings [1, 13, 24, 25].

If a less frequented road with smooth traffic runs through the street canyon (problem site type 2), the main cause of poor air quality may be municipal and residential emissions from nearby buildings; in such a situation, the importance of the barrier separating the carriageway

decreases, but it is worth creating a plant canopy to limit the inflow of particulate matter into the pedestrian zone from above. Depending on local conditions, this can take the form of wide tree crowns or vertical solutions such as green walls, green façades, or green roofs, and the higher the level of urban background pollution, the greater the importance of vertical solutions.

Type V: Extensive green space that filters or absorbs pollution and CO₂, publicly accessible but without facilities for people to stay/move around

The benefits for air quality include, as in the case of large parks (I) and wide green corridors (III), the permanent elimination of some pollutants, the reduction of pollutant transport from adjacent urban areas, and the transfer of cleaner air to densely built-up areas [12, 18, 30]. However, due to the lack of amenities for people to stay, reducing the exposure of public space users to pollution is of lesser importance.

The creation of such areas in open suburban spaces is recommended, especially if residential development is planned nearby or if good transport links, including cycling, are planned. This category includes both large public spaces (types 1 and 2 problem sites) and all kinds of large 'wastelands' (types 3-10), primarily with an area geometry ('a') as well as a linear geometry ('b'). This method of greening should be treated as a prelude to the creation of a large park (or a wide ventilation corridor) at a later date. Therefore, when selecting species and details of the location of tree and shrub plantings, it is important to take into account the planned amenities for users of the area that are expected to be introduced.

The benefits on a supra-local scale – both environmental and social – will be greater the larger the area of planting; even more important may be whether greening the area will contribute to increasing the spatial continuity of the green infrastructure network and, at the same time, the natural system.

Recommended directions for transforming problem sites into green public spaces

Not every problem site, irrespective of its geometry or location, can (and should) be transformed into any type of green space. The tables provided in this chapter guide the selection of appropriate transformation strategies for problem sites. To achieve this, accurate classification of the problem site according to the typology outlined in this document is essential.

The origin, size, and shape of a problem site, its current or recent use, its proximity to buildings (including residential ones), and its relationship to the road network are critical factors determining the scope and direction of interventions. These interventions aim to enhance air quality and create high-quality green public spaces. Comparing public expectations and local government plans with these factors at the initial planning stage, before developing a concept, is advisable.

While greening public spaces consistently yields benefits, these do not always include significant reductions in exposure to air pollution or substantial improvements in urban air regeneration. This document stipulates that at least one of these benefits is required for a particular transformation direction to be recommended. Tables 1-10 present recommendations for transformation directions for individual types of problem sites (1-10). These tables show that within built-up areas, the most obvious type of action will be the introduction of greenery (UGA), while in open spaces, it is recommended to make maximum use of the possibilities for greening large areas.

In the immediate vicinity of human settlements, especially on the outskirts of cities, there are still vast open areas that are abandoned or excluded from normal use (types 3-10). Such areas, provided they do not pose significant environmental hazards of a chemical, biological, physical or geophysical nature, are usually easy to transform into extensive, green, multifunctional public spaces. Once greenery has been planted and facilities for people to stay and move around have been introduced, they can offer relaxation in contact with nature, recreation, alternative modes of transport to the car (cycling and foot paths), and in their functioning, they can accommodate complementary economic activities that do not involve the emission of air pollutants. The direction of transformation (Tables 1-10) and the selection of nature-based solutions (NBS, see next subsection) should always aim to achieve a variety of benefits in terms of ecosystem services. In addition to achieving a positive impact on air quality, other aims include reducing the urban heat island effect (UHI), facilitating rainwater management, reducing emissions and increasing greenhouse gas retention.

The greatest social and environmental benefits, including improved air quality, can be achieved by greening large areas with a shortage of permanent vegetation cover, especially trees and shrubs, particularly if they are suitable for the intended development without the need for costly technical reclamation, demolition work or removal of old infrastructure remnants. The category of areas that are relatively easy to green and make available to the general public includes old mining and post-industrial spoil heaps of various origins, excavations, the edges of reservoirs (water sinkholes, floodplains, post-mining areas), and areas of excavations (or settling ponds) that have been levelled or filled with inert material. Certain areas

that are permanently waterlogged/flooded as a result of past hard coal or ore mining activities also lend themselves well to being transformed into areas with nature and recreational functions.

Areas that could become “bridges” between urban green infrastructure and non-urban green spaces, including forests, are particularly worthy of greening. Greening these bridging areas would be particularly desirable if, due to their location, they were to contribute to the ventilation of nearby urban areas suffering from poor air quality, and to transferring better quality air from neighbouring areas. Linear forms of land that are currently unused, such as old service roads, areas where heating pipes used to run, old conveyor belts, industrial lines, railway sidings and junctions, embankments of various origins as well as open spaces of urban (suburban) river valleys and streams that were once transformed into open canals, can be good locations for creating publicly accessible green corridors. Such islands, strips and wedges should combine easy accessibility, a high-quality environment, and, thanks to the careful selection, design and arrangement of vegetation, the ability to be self-sustaining with minimal labour and maintenance costs. The desired actions include not only creating vegetation cover from scratch, but also planned enhancement of the tree and shrub cover that is already forming spontaneously.

Multi-point greening (UGA) of public spaces in ultra-urbanised areas permanently deprived of large green sites can have a significant impact on local air quality, contributing to improved air quality (as well as reducing the heat island effect) in public spaces that are key for residents/users of the city. This involves greening places such as: city squares, sections of street canyons, the edges of recreational sports fields, the edges of playgrounds, urban riverside spaces, pedestrian streets intended for recreation, boulevards and promenades. This category includes creating pocket parks and greening the surroundings (and sometimes also the facades or roofs) of facilities such as care homes, educational/cultural institutions, office or industrial buildings, high-rise residential buildings, and recreational facilities for children or young people.

Tables 1-10 present recommendations derived from the analysis of a large number of practical cases. The expert team based its work on extensive experience gained through observations of existing facilities in cities across the Silesian Voivodeship and numerous other Polish cities, as well as during visits to various European urban areas. In addition, numerous planning and design documents were examined, along with several dozen publicly available case studies. The recommendations were further informed by publications in the form of scientific articles and practical guides, all cited in the references.

The coloured background used in the cells of Tables 1-10 represents the following conclusions:

	recommendation for transformation without reservations; with varying origin, location, geometry of the problem site, state of use and target type of green site
	conditional recommendation; depending on specific conditions resulting from the origin, location, state of use, terrain geometry and target type of green site, there may be circumstances that both favour and disfavour this type of transformation
	This direction of transformation is not recommended.

Table 1. Recommended directions for transforming type 1 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Existing public space in the vicinity of a street with heavy motor vehicle traffic – 1a	In a heavily built-up area (X)	unfeasible due to lack of space in the urban built-up area	yes – efforts should be made to designate multiple UGA locations	if this is not a shared street canyon with a busy road	yes – efforts should be made to designate multiple green canyons	unfeasible due to lack of space in the urban built-up area
	In a suburban built-up area (Y)	limited benefit for air quality in public space	limited benefit for air quality in public space	on the condition that the roadway is separated by a wall of shrubs	yes – efforts should be made to designate multiple green canyons	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes

Existing public space in the vicinity of a street with heavy motor vehicle traffic – 1b	In a heavily built-up area (X)	unfeasible due to lack of space in the urban built-up area	yes – efforts should be made to designate multiple UGA locations	on the condition that the roadway is separated by a wall of shrubs	yes – maximum use should be made of the space for greenery	unfeasible due to lack of space in the urban built-up area
	In a suburban built-up area (Y)	limited benefit for air quality in public space	yes	on the condition that the roadway is separated by a wall of shrubs	yes – maximum use should be made of the space for greenery	limited benefit for the local community
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Existing public space in the vicinity of a street with heavy motor vehicle traffic – 1c	In a heavily built-up area (X)	unfeasible due to the very nature of area 'c' (small size)	yes – as a single UGA location	unfeasible due to the very nature of area 'c' (small size)	yes – maximum use should be made of the space for greenery	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	unfeasible due to the very nature of area 'c' (small size)	limited benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)	yes – maximum use should be made of the space for greenery	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	unfeasible due to the very nature of area 'c' (small size)	no significant benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)	no significant benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)

Table 2 Recommended directions for transforming type 2 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Existing public space not in the vicinity of roads with significant traffic – 2a	In a heavily built-up area (X)	unfeasible due to lack of space in the urban built-up area	yes – efforts should be made to designate multiple UGA locations	on the condition that safe separation from the roadway is ensured	yes – efforts should be made to designate multiple green canyons	unfeasible due to lack of space in the urban built-up area
	In a suburban built-up area (Y)	limited benefit for air quality in public space	limited benefit for air quality in public space	on the condition that safe separation from the roadway is ensured	limited benefit for air quality in public space	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Existing public space not in the vicinity of roads with significant traffic – 2b	In a heavily built-up area (X)	unfeasible due to lack of space in the urban built-up area	yes – efforts should be made to designate multiple UGA locations	on the condition that safe separation from the roadway is ensured	yes – efforts should be made to designate multiple green canyons	unfeasible due to lack of space in the urban built-up area
	In a suburban built-up area (Y)	limited benefit for air quality in public space	limited benefit for air quality in public space	on the condition that safe separation from the roadway is ensured	limited benefit for air quality in public space	limited benefit for the local community
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Existing public space not in the vicinity of roads with significant traffic – 2c	In a heavily built-up area (X)	unfeasible due to the very nature of area 'c' (small size)	yes – as a single UGA location	unfeasible due to the very nature of area 'c' (small size)	yes – maximum use should be made of the space for greenery	unfeasible due to the very nature of area 'c' (small size)

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
	In a suburban built-up area (Y)	unfeasible due to the very nature of area 'c' (small size)	limited benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)	limited benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	unfeasible due to the very nature of area 'c' (small size)	no significant benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)	no significant benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)

Table 3 Recommended directions for transforming type 3 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Post-urbanised area – 3a	In the city's core zone (X)	yes	yes – efforts should be made to designate multiple UGA locations	yes	yes – efforts should be made to designate multiple green canyons	limited benefit for the local community
	In a suburban built-up area (Y)	yes	yes – efforts should be made to designate multiple UGA locations	yes	limited benefit for air quality in public space	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Post-urbanised area – 3b	In the city's core zone (X)	yes	yes – efforts should be made to designate multiple UGA locations	yes	yes – maximum use should be made of the space for greenery	limited benefit for the local community
	In a suburban built-up area (Y)	as part of a green corridor connecting to the core zone	yes – efforts should be made to designate multiple UGA locations	yes	limited benefit for air quality in public space	limited benefit for the local community
	Outside built-up areas (Z)	as part of a green corridor connecting to the core zone	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Post-urbanised area – 3c	In the city's core zone (X)	unfeasible due to lack of space in the urban built-up area	yes – as a single UGA location	unfeasible due to the very nature of area 'c' (small size)	yes – maximum use should be made of the space for greenery	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	as part of a more extensive area to be greened	limited benefit for air quality in public space	as part of a green corridor	limited benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	as part of a green corridor	no significant benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)

Table 4 Recommended directions for transforming type 4 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Post-transport area (former road, railway line) – 4a	In the city's core zone (X)	yes	yes – if it is impossible to create a green corridor	yes	if roads are planned to be used within built-up areas	limited benefit for the local community
	In a suburban built-up area (Y)	yes	yes – if it is impossible to create a green corridor	yes	if roads are planned to be used within built-up areas	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Post-transport area (former road, railway line) – 4b	In the city's core zone (X)	yes	yes – if it is impossible to create a green corridor	yes	if a road is planned to be used within built-up areas	limited benefit for the local community
	In a suburban built-up area (Y)	as part of a green corridor	limited benefit for air quality in public space	yes	if a road is planned to be used within built-up areas	limited benefit for the local community
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Post-transport area (former road, railway line) – 4c	In the city's core zone (X)	unfeasible due to lack of space in the urban built-up area	yes – as a single UGA location	as part of a green corridor	if a road is planned to be used within built-up areas	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	as part of a more extensive area to be greened	limited benefit for air quality in public space	as part of a green corridor	if a road is planned to be used within built-up areas	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	as part of a more extensive area to be greened	no significant benefit for air quality in public space	as part of a green corridor	no significant benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)

Table 5 Recommended directions for transforming type 5 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Build-up land remaining after industrial or logistical activity (e.g. metallurgical, mining, transport base) – 5a	In the city's core zone (X)	yes	yes – multiple UGA locations should be designated	yes	if it is planned to reuse the roads	limited benefit for the local community
	In a suburban built-up area (Y)	yes	limited benefit for air quality in public space	yes	if it is planned to reuse the roads	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Land formerly used for industrial or logistics purposes (e.g. steelworks, mines, transport hubs) – 5b	In the city's core zone (X)	yes	yes – multiple UGA locations should be designated	yes	if it is planned to reuse the roads	limited benefit for the local community
	In a suburban built-up area (Y)	as part of a green corridor	limited benefit for air quality in public space	yes	if it is planned to reuse the roads	limited benefit for the local community
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	yes	no significant benefit for air quality in public space	yes
Land formerly used for industrial or logistics purposes (e.g. steelworks, mines, transport hubs) – 5c	In the city's core zone (X)	unfeasible due to lack of space in the urban built-up area	yes – as a single UGA location	as part of a green corridor	if it is planned to reuse the roads	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	as part of a more extensive area to be greened	limited benefit for air quality in public space	as part of a green corridor	if it is planned to reuse the roads	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	as part of a green corridor	no significant benefit for air quality in public space	unfeasible due to the very nature of area 'c' (small size)

Table 6 Recommended directions for transforming type 6 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Surface excavation – unlevelled, unreclaimed – 6a	In the city's core zone (X)	yes	yes – if it is not possible to create an extensive green site	yes	no	limited benefit for the local community
	In a suburban built-up area (Y)	yes	limited benefit for air quality in public space	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no	yes
Surface excavation – unlevelled, unreclaimed – 6b	No such category is distinguished because excavations have an area geometry (type 'a', less frequently type 'c' rather than a linear geometry					
Surface excavation – unlevelled, unreclaimed – 6c	In the city's core zone (X)	unfeasible due to the very nature of area 'c' (small size)	yes – as a single UGA location	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	as part of a more extensive area to be greened	limited benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)

Table 7 Recommended directions for transforming type 7 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Former industrial/mining/municipal waste landfill – 7a	In the city's core zone (X)	yes	yes – if it is not possible to create an extensive green site	yes	no	limited benefit for the local community
	In a suburban built-up area (Y)	yes	yes – if it is not possible to create an extensive green site	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no	yes
Former industrial/mining/municipal waste landfill – 7b	No such category is distinguished because landfills have an area geometry (type 'a', less frequently type 'c' rather than a linear geometry)					
Former industrial/mining/municipal waste landfill – 7c	In the city's core zone	unfeasible due to the very nature of area 'c' (small size)	yes – as a single UGA location	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area	as part of a more extensive area to be greened	limited benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
	Outside built-up areas	limited benefit for air quality in public space	no significant benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)

Table 8 Recommended directions for transforming type 8 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Abandoned areas of subsidence/sinkholes/post-mining floodplains – 8a	In the city's core zone (X)	yes	no significant benefit for air quality in public space	no significant benefit for air quality in public space	no	limited benefit for the local community
	In a suburban built-up area (Y)	yes	no significant benefit for air quality in public space	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no	yes
Abandoned areas of subsidence/sinkholes/post-	In the city's core zone (X)	yes	no significant benefit for air quality in public space	no significant benefit for air quality in public space	no	limited benefit for the local community

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
mining floodplains – 8b (linear floodplain shape, e.g. along a ditch, watercourse valley)	In a suburban built-up area (Y)	as part of a green corridor	no significant benefit for air quality in public space	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	yes	no	yes
Abandoned areas of subsidence/sinkholes/post-mining floodplains – 8c	In the city's core zone (X)	unfeasible due to the very nature of area 'c' (small size)	yes – as a single UGA location	unfeasible due to the very nature of area 'c' (small size)	no	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	as part of a more extensive area to be greened	yes – as a single UGA location	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)

Table 9 Recommended directions for transforming type 9 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
Post-agricultural wasteland – 9a	In the city's core zone (X)	yes	yes – if it is not possible to create an extensive green site	yes	no	limited benefit for the local community
	In a suburban built-up area (Y)	yes	limited benefit for air quality in public space	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no	yes
Post-agricultural wasteland – 9b	In the city's core zone (X)	yes	yes – if it is impossible to create a green corridor	yes	no	limited benefit for the local community
	In a suburban built-up area (Y)	yes	limited benefit for air quality in public space	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	yes	no	yes
Post-agricultural wasteland – 9c	In the city's core zone (X)	as part of a more extensive area to be greened	yes – as a single UGA location	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	as part of a more extensive area to be greened	limited benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)

Table 10 Recommended directions for transforming type 10 problem sites into green public spaces

Type of problem site according to origin and current use, considering geometry	Problem site location	Target types of green sites				
		Type I: Greened, extensive public space for leisure/recreation	Type II: UGA – small green enclaves for human occupation, accompanying intensive development	Type III: Greened ventilation corridor for the city	Type IV: UGA – street canyon enriched with greenery	Type V: Extensive green space, publicly accessible but without facilities for people to stay/move around
A strip of open, undeveloped urban/suburban space with natural soil, sodded, distant from the road network – 10a	In the city's core zone (X)	yes	yes – if it is not possible to create an extensive green site	yes	no	limited benefit for the local community
	In a suburban built-up area (Y)	yes	limited benefit for air quality in public space	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	yes	no significant benefit for air quality in public space	yes	no	yes
A strip of open, undeveloped urban/suburban space with natural soil, sodded, distant from the road network – 10b	In the city's core zone (X)	yes	yes – if it is impossible to create a green corridor	yes	no	limited benefit for the local community
	In a suburban built-up area (Y)	yes	limited benefit for air quality in public space	yes	no	limited benefit for the local community
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	yes	no	yes
A strip of open, undeveloped urban/suburban space with natural soil, sodded, distant from the road network – 10c	In the city's core zone (X)	as part of a more extensive area to be greened	yes – as a single UGA location	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	In a suburban built-up area (Y)	as part of a more extensive area to be greened	limited benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)
	Outside built-up areas (Z)	limited benefit for air quality in public space	no significant benefit for air quality in public space	as part of a corridor to be greened	no	unfeasible due to the very nature of area 'c' (small size)

Nature-based solutions (NBS) crucial for air quality

Transforming a problem site into a green public space must be precisely designed, taking into account all constraints resulting from the specific nature of the site; it must also be durable, and its effect must be in line with social expectations whilst being easy to maintain. Practice shows that solutions based on natural systems meet these requirements better than completely artificial landscaping. For the above reasons, this document recommends the use of Nature Based Solutions(NBS), as defined in Annex 1 to the official European Commission document on NBS for cities⁶, which is the final report of an extensive international research project. The key features of NBS are as follows:

- they are inspired, supported by or copied from nature;
- they help communities to sustainably address environmental, social and economic challenges, both by using or improving existing solutions and through more innovative solutions;
- they utilise the characteristics of the natural system and the complex processes that occur within it so that the state of the environment promotes human well-being and inclusive green growth;
- they are adapted to local conditions, which makes them resilient to change, energy- and resource-efficient.

According to this catalogue, the recommendations include a set of NBS that will contribute to the greatest possible extent to addressing the problem of urban air quality. At the same time, these solutions can serve to strengthen the city's green infrastructure by operating on different scales and in different types of locations, from a single property in an extremely urbanised area to vast suburban open spaces. In addition, each NBS must meet the following conditions:

- contribute to improving the quality of public space;
- have a long-lasting effect (at least several years), with benefits from its application that are as comprehensive and rapid as possible;
- be a solution that has been proven in European cities, and whose application does not require unique knowledge and skills;
- not create unpredictable conflicts with urban infrastructure;
- require relatively low labour input, as well as low implementation and subsequent maintenance costs;
- be easily combined with other NBS, as well as with elements of grey urban infrastructure.

Findings from various projects, including international research projects and urban practice, show that some NBS have a particularly beneficial effect on urban air quality. Following a detailed analysis of the content of such studies [6, 9, 10, 12, 22, 23, 27, 28], this document recommends 22 types of NBS that combine a particularly beneficial impact on air quality with various other environmental and social benefits (Table 11).

Cecchi, C (2015). Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities. Final report of the Horizon 2020 expert group on nature-based solutions and re-naturing cities. European Commission. 10.2777/479582



Table 11 List of NBS recommended for use in greening problem sites in terms of air quality

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Green cycling paths/walking and cycling paths	The green cycling and walking path is part of the city's green infrastructure network. In addition to its transport function, it provides recreational opportunities, promotes public health and well-being, and offers opportunities to connect with nature. Such a multifunctional walking and cycling path provides a habitat for wild plants and animals, supports flood protection, improves surface water quality, provides resources for outdoor education, etc. Achieving benefits depends largely on the nature and type of green cycling and walking paths implemented. The newly designed path integrates other solutions such as shade-giving trees, green surfaces, hedges, rain gardens, etc. Modernising an existing road/path involves supplementing it with appropriate NBS.	4	5	3	3
Area afforestation on the outskirts of city centres, connecting with rural areas – as future neighbourhood parks	This NBS covers larger forest areas on the outskirts of cities, but also smaller groups of trees and even individual street trees if they form a bridge connecting urban developments with wooded peripheries. This solution consists in planting trees that will eventually grow large, providing shade and coolness, reducing the heat load on buildings and providing islands of refuge from high temperatures in urban areas. This can be a good alternative to temporary car parks created in areas that are temporarily out of use. Creating new forest areas connecting densely built-up urban centres with green suburban areas is expected to produce a positive effect that will gradually increase over the years.	4	4	3	4

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Green pedestrian corridor in an urban or suburban area, with shade-giving trees (<i>urban carbon sink</i>)	The <i>Urban Carbon Sink</i> is an NBS involving the planting of trees along a new green corridor with a special ability to absorb carbon dioxide and retain particulate matter. An equally important effect is air purification by removing nitrogen dioxide (NO ₂), ozone (O ₃) and sulphur dioxide (SO ₂). Increasing the shaded area and reducing the nuisance associated with urban heat islands is another objective of this measure. Fast-growing tree species that can meet all these expectations include, above all, lime trees, plane trees, plane trees and chestnut trees. Also supplementary spot/small-area NBS, and within them, a detailed selection of plant species serve to rapidly increase biomass and quickly create a wide range of ecosystem services, such as regulating rainwater infiltration, reducing the urban heat island effect, providing food and habitats for small animal species, and providing recreation and nature education for the city's residents.	4	2	4	2
Ground-level rain gardens (for car parks, walkways and roads)	A rain garden is a garden of native shrubs and perennials capable of phytoremediation, planted in a small depression, usually formed on slightly sloping ground. It is intended for temporary retention and absorption of rainwater flowing from the surfaces of car parks, roofs, driveways, terraces and lawns. The main purpose of using this NBS is to improve water management, adapt to climate change and protect biodiversity. Mitigating the air quality problem falls within the broad spectrum of ecosystem services provided by this multifunctional NBS. A rain garden can be located upstream of a storm drain inlet or serve as a stand-alone solution. In the latter case, it is designed to capture runoff water from a 2-hour rainfall. This is achieved by using highly porous substrates for plants and drainage to ensure that the treated water is infiltrated into the ground.	4	4	5	3

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
<i>Urban catchment forestry</i> – serving to slowing down rainwater runoff from urban catchment areas	Catchment forestry is an NBS covering extensive tree stands in cities and outskirts, as well as smaller groups of trees and even individual street trees. The distinctive feature of this solution is that it is closely linked to the rainwater drainage system in urban catchment areas, including storm sewers. The general idea is to slow down the flow of rainwater through the urban catchment area. A well-planned intervention reduces the risk of flooding and the amount of polluted water entering the sewerage system. Therefore, this measure includes the traditional protection of suburban forests, but also the selection of trees with large and dense crowns in urban and suburban areas, the protection of trees in built-up areas and the increased use of trees in storm water drainage systems. In built-up areas, when planting small groups or individual trees, it is particularly important to adapt tree pits to retain water, while ensuring proper aeration, irrigation and sufficient space for the root system.	4	3	4	3
Floodplain park with trees and shrubs (green detention basin for rainwater)	A floodplain park is a shallow earthen retention reservoir with a flat bottom, covered with permanent vegetation, free of water in dry weather, designed for short-term temporary retention of rainwater flowing from urban catchment areas or excess flow from nearby streams, ditches or open canals. After the rain stops, the water is slowly released through a regulated outlet to a nearby watercourse or to the sewerage system. In addition to mitigating the risk of flooding caused by surface runoff from the catchment area or flooding of a nearby small watercourse, an attractive public space and benefits for biodiversity can be achieved. Planting native species of trees and shrubs around the edges of the reservoir is particularly beneficial for improving air quality.	4	2	4	2
Green sites for passive recreation (green resting areas)	Green resting areas (for rest, relaxation, nature observation and social contact) can be defined as an area in a city park, or a district park, or even a street park where numerous seating areas have been created surrounded by greenery. Such an area consists of modular micro-spaces. A standard module consists of: native soil, a compacted soil mixture consisting of 20-30% sand, 20-30% compost and 30-40% topsoil, a draining layer of gravel to facilitate the infiltration of excess water into deeper soil layers, a park tree (optionally with an irrigation system), shrubs (optionally with an irrigation system), lighting equipment ensuring comfort and safety, a bench attached to a concrete foundation, and a pavement surface ensuring convenient access for all visitors.	5	5	5	5

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Woody plants growing spontaneously but remaining under control	Urban wilderness areas are areas where vegetation succession occurs spontaneously, under human control but without excessive human interference. Such an area can be defined (according to the IUCN) as 'a protected area, usually large, unmodified or slightly modified, retaining its natural character and interactions with the surrounding environment, without permanent or significant human habitation, and maintained in such a way as to preserve its natural condition'. Similar thinking applies to such areas in the city where spontaneous succession is allowed (or possibly supported) in order to create (restore) permanent vegetation cover with trees and shrubs. The desired direction of succession changes is one that leads to the development of a wide range of ecosystem services, including air quality regulation (mainly thanks to the presence of trees and shrubs), recreation in contact with nature, and CO ₂ sequestration.	4	3	4	3
Street trees (single tree or tree row)	A street tree is any tree growing as a solitary tree or in a single row within the boundaries of a strip, usually between the kerb and the pavement. These trees improve air quality by absorbing pollutants, both particulate matter and gases such as nitrogen dioxide, and also provide shade for people and buildings, cool the air, reduce wind strength and noise propagation. When selecting a planting site, sufficient space must be provided for tree growth, taking into account the selection of species and varieties, their maximum height, crown spread and root system spread. The benefits to air quality depend on the size and species of trees, the condition of the foliage, the density and spread of the crowns, the health of the trees, their detailed their location, the availability of water to the roots, and the density of the planting. Decades will have passed before the newly planted trees fulfil the functions of mature trees. For this reason, it is very important to protect existing trees.	5	5	4	3

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Park trees (single trees or tree group)	Park trees create a substitute for forest or its edge in an urban environment. They can be an option, for example, when designing shaded squares, courtyards or as a contrasting element in a densely built-up area. In order to quickly achieve a positive impact on the urban microclimate, it is necessary to plant sufficiently large trees which have been appropriately shaped in the nursery, and belong to species and varieties that tolerate urban conditions well. The trees are planted quite densely and require irrigation in the first few years (and possibly later as well). Ideally, the water for irrigation comes from the surface and from roofs. The types of beneficial effects on air quality and microclimate are similar to those of street trees. Due to the size of its crown, a mature park tree has a greater impact than a single street tree.	5	5	4	5
Large shrubs (single or group)	Shrubs can be categorised based on foliage density: dense (70% to 100% foliage coverage); medium (only 30% to 70% foliage coverage) and sparse (less than 30% coverage). Large shrubs, i.e. usually reaching 6-8 m in height, are planted individually or in loose groups, especially in the case of species with impressive flowers or, more often, particularly decorative leaves. An advantage of large shrubs, which is very important in urban conditions, is that they provide foliage cover not only at a height of several metres, but also at ground level. Species with dense foliage can perform many functions simultaneously – dispersing and absorbing air pollutants, including particulate matter, providing shade for people and lowering temperatures, and protecting urban soil surfaces from drying out. Large shrubs planted in rows can form loose barriers and screens.	4	5	4	3

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Smart soil	The main component of smart soil is biochar obtained through pyrolysis (thermochemical conversion with limited oxygen content) of plant biomass, e.g. agricultural waste; it also contains ash and biomass. An integral part of smart soil are bacteria that accelerate nitrogen circulation in the soil, absorbing various pollutants from the air, including nitrogen oxides, while enriching the substrate with nitrates available to plants. This soil contains a large amount of organic matter, which improves the availability of nutrients and increases water retention, reducing the need for irrigation. Smart, self-fertilising soils are increasingly being used to enrich and restore degraded soils in densely populated urban areas. Various versions of these are also used in the restoration of soil cover in post-industrial, post-mining, post-extraction, post-transport and post-agricultural areas. They can be used in combination with various NBS, including those serving to improve air quality.	5	4	5	2
Plant reinforcement of slopes with green fences	The plant reinforcement of the slope consists of a 1.2-1.5 m high fence made of impregnated wood, climbing plants and low, densely leafed shrubs. The fence and climbing plants are placed on the upper edge of a steep, short slope, while the shrubs are placed on its slope, reinforced with soil and stakes. This solution is used for all types of ditches, earth faults, on the banks of urban streams, etc., most often to separate the space for pedestrians or cyclists from the river/ditch. It can also be used to renaturalise banks and create habitats for small animals. It combines the function of a vertical green surface and a safety element. However, it should not constitute a continuous fence. Its height and configuration should be designed so that it does not create a visual barrier for people.	4	4	4	4
Tall hedges, trimmed or untrimmed	A hedge is a line of various types of shrubs and small trees growing very close together. The selection of species and varieties, as well as the method of care, ensures that the hedge forms a thicket of shoots and leaves that is impenetrable to airborne particulate matter. Tall hedges planted on the sides of busy roads or between industrial facilities and public spaces act as a green barrier that captures and disperses air pollution from vehicle traffic or industrial operations. They also serve to reduce noise pollution, aid in the capture, retention and controlled release of rainwater, and create a habitat for small animals. A hedge separating the pavement from the road should be about 2.5 metres high to adequately protect pedestrians from exposure to particulate matter raised from the road.	4	5	4	3

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Plant modules for pollinators (soil-based)	A micro-space with an area ranging from several to several dozen square metres consists of small, densely leafed trees and shrubs, abundantly flowering perennials that provide benefits for insects, small architectural elements (e.g. benches, pergolas) that ensure comfort for people, as well as shelter and a source of water for small animals (insects, birds and bats). The plants are planted in soil enriched with smart soil. The module may include a rain garden or a fence made of thorny shrubs. The modules are installed to create or strengthen links between urban (blue)green sites. The module is an inner city enclave with better air quality, lower temperatures during hot weather, a place for people to rest, a space for rainwater retention and, at the same time, a habitat for biodiversity, especially for pollinating insects.	5	4	4	4
Green pergolas/gazebos.	A green pergola or green gazebo is defined as a sturdy structure in the form of wooden or metal frames with an open roof supported by two or more posts/columns. This structure supports climbing plants and, together with them, creates a shaded or semi-shaded space for people to relax. It can be erected next to a building or freestanding, e.g. near pavements or colonnades. There are many suitable native or exotic climbing plants, e.g. vines, climbing roses, clematis, wisteria, common ivy and honeysuckle. Depending on the species composition of the climbing plants, a pergola can provide various benefits, including protection from air pollution, wind and noise, oxygen supply, shade, aesthetic and recreational functions, and habitats for small animals.	4	5	4	5
Light green roofs	This type of green roof is characterised by a light-weight and thin substrate and is suitable for use in structures that cannot bear heavy loads, such as bus shelters. The selection of plants must meet the following conditions: very small perennials, growing well on flat, curved or sloping surfaces, low water requirements, thin substrate, low maintenance requirements. Various species of sedum and moss are particularly popular. The roof structure consists of the following layers: bottom layer – waterproof and resistant to overgrowth, separating layer (made of geotextile), hydroponic substrate, and mineral wool panels for plant growth. It is complemented by a drip irrigation system and a surrounding layer of gravel.	4	5	4	3

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Green façades with climbing plants.	A green façade is a wall completely or partially covered with greenery. It uses a trellis system to support climbing plants that are rooted in the ground or in horizontal containers. Unlike panel structures, a trellis anchored in the ground does not place a heavy load on the building wall; it can also be easily dismantled if necessary. There are no special structural requirements; one only needs to protect the foundations from root penetration and water leakage. The trellis is usually additionally attached to the wall, but it can be attached to other elements or even be free-standing. To provide support for the plants, self-climbing or adhesive fasteners can be used. The benefits for the urban environment, including air quality, are similar to those of living walls.	5	4	5	2
Living walls constructed on building walls	This solution consists of a vertical structure permanently fixed to the wall at multiple points. Plants are rooted in a vertical substrate, which can be soil or a substitute mineral substrate. In certain situations, it is appropriate to use a hydroponic, integrated irrigation and fertilisation system. Plant species that root easily in vertical artificial substrates and possess characteristics of cover plants are used; these can include flowering perennials, ferns, shrubs, and small bushes, although climbing plants are used less frequently. Living walls, especially those with large surfaces, can capture significant amounts of particulate matter and gas pollutants contained in urban air, absorb significant amounts of CO ₂ , lower the temperature in the building and its vicinity, as well as provide a habitat for small animals and retain excess rainwater.	5	4	5	2
Mobile hydroponic living walls/vertical gardens	This solution has the form of a free-standing module on wheels or hinged to a building wall, with its own vertical structure and irrigation system. The supporting elements are waterproof plastic panels and metal scaffolding. The vertical hydroponic substrate for plants, mounted on plastic panels, is always wet and consists of mineral wool interwoven with drip irrigation pipes. The tank, equipped with a pump system and water supply and drainage, forms the lower part of the structure. This NBS can be located anywhere in the city, provided that a water source and a connection to the power grid are available. Plants with low nutritional and water requirements that tolerate the local climate well are used. The benefits of this solution include a local improvement in air quality, the provision of shade, and enabling contact with nature.	5	3	3	4

NBS name	NBS technical description (for more information, see the References: 6, 9, 10, 12, 22, 23, 27, 28)	Benefits of NBS related to air quality and the environmental component of quality of life (scale 0-5): 0 – no benefit, 5 – very strong benefit			
		microclimate/air quality	public health and environmental wellbeing	climate change adaptation	social cohesion
Compact plant modules for pollinators	This NBS is particularly useful in ultra-urbanised city spaces where there is no access to natural soil. The entire module is limited to a container with an area of several square metres, which has a sealed bottom, is filled with soil enriched with smart soil, and contains a single or several dwarf trees or low shrubs, and above all, abundantly flowering perennials that provide benefits for pollinating insects. Essential elements of the module also include shelters for insects and other small animals, as well as a water source (in the simplest case, a periodically refilled drinking trough). The module may also include small architectural elements that allow people to stay there. The purpose of this solution is to create a network of numerous microhabitats (modules) in a densely built-up area where it is permanently impossible to introduce greenery rooted in the ground.	5	4	4	4
Compact rain gardens	This type of rain garden is fed by water from the roof. It entirely fits into a container of any shape (e.g. a box or pot) made of wood, concrete or stone, with a sealed bottom and a drain, filled with a layer of gravel at the bottom and a mixture of sand and garden soil at the top. The garden is planted with native perennials that are strongly rooted, grow well in permeable soil, and tolerate large changes in moisture and even periodic flooding; in larger gardens (several square metres in size), large perennials and even small shrubs can be planted. When selecting plant species, foliage density and benefits for pollinating insects are also taken into account. This type of rain garden is used in densely built-up areas where there is no space for creating green spaces using the ground.	4	3	4	2

Recommendations for selecting NBS for problem sites and types of public spaces created by transforming problem sites

Although the recommendation for a specific NBS is always contingent upon local conditions, several general rules apply. These relate to the problem site's geometry, its location within the urban fabric, and its origin and current use. In addition to highly versatile NBS (e.g. smart soil), some solutions are recommended only for UGA projects (e.g. green facades), whilst others are dedicated to large open spaces (e.g. area afforestation).

To select optimal solutions that yield maximum benefits, utilising NBS selection matrices is recommended (Table 12, Table 13). In practice, greening a problem site will typically involve applying not one, but several complementary solutions. During the selection process, it is also important to consistently consider the various environmental and social benefits associated with a given NBS (see Table 11).

The applicability of individual NBS dedicated to improving air quality in public spaces depends to a large extent on the size and shape of the intervention area (availability of space) and its location relative to the urban fabric (Table 12). However, the optimal selection of NBS for a specific problem site may simultaneously vary depending on the planned direction of transformation. For this reason, an NBS selection matrix for target types of green sites has also been developed (Table 13).

When faced with the practical choice of NBS, the owner of the problem site will seek solutions that are adequate in terms of type, geometry, and location, as well as for the intended type of green site. For example, the selection of NBS for a large problem site (geometry 'a' or 'b') belonging to one of types 3-10 and located outside existing development, depends largely on the area's origin. Nevertheless, it is always possible and advisable to introduce appropriately selected trees or to adapt and supplement the already developing tree stand, and to create green resting areas. Almost always, the supplementary use of certain spot-type NBS will also be possible, provided they do not require a connection to buildings.

In the case of small areas (the scale of a place or a single street), the dependence of a given NBS's applicability on the area's history (1-10) is generally weaker. Amongst buildings, in already functioning public spaces (problem sites – types 1 and 2), the choice of NBS is determined by the specific nature of the place and the limitations resulting from the details of the location. This is precisely the reason for the particular structure of Table 12.

The coloured background used in the cells of Tables 12, 13 represents the following conclusions:

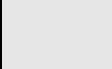
	recommendation for NBS application without reservations; with varying origin, location, geometry of the problem site, state of use and target type of green site
	conditional recommendation; depending on specific conditions resulting from the origin, location, state of use, terrain geometry and target type of green site, there may be circumstances that both favour and disfavour this type of NBS
	Using this NBS is not recommended

Table 12 NBS selection matrix for different types of problem sites

NBS name	NBS recommendations for public spaces (problem site types: 1, 2) in built-up zone X or Y (especially for problem sites 1b, 1c, 2b, 2c)				NBS recommendations for large unused problem sites (areas 'a' and 'b') of types 3-10, located outside existing built-up areas (including in zone Z);							
	area 1 zone X	area 2 zone X	area 1 zone Y	area 1 zone Y	areas 3a, 3b	areas 4a, 4b	areas 5a, 5b	area 6a	area 7a	areas 8a, 8b	areas 9a, 9b	areas 10a, 10b
Green cycling paths/walking and cycling paths												
Area afforestation on the outskirts of city centres, connecting with rural areas												
Urban carbon sink (green pedestrian corridor in an urban or suburban area, with shade-giving trees)												
Ground-level rain gardens (for car parks, walkways and roads)												
Urban catchment forestry (serving to slowing down rainwater runoff from urban catchment areas)												
Floodplain park with trees and shrubs (green detention basin for rainwater)												
Green sites for passive recreation (green resting areas)												
Woody plants growing spontaneously but remaining under control												
Street trees (single tree or tree row)												
Park trees (single trees or tree group)												
Large shrubs (single or group)												

NBS name	NBS recommendations for public spaces (problem site types: 1, 2) in built-up zone X or Y (especially for problem sites 1b, 1c, 2b, 2c)				NBS recommendations for large unused problem sites (areas 'a' and 'b') of types 3-10, located outside existing built-up areas (including in zone Z);							
	area 1 zone X	area 2 zone X	area 1 zone Y	area 1 zone Y	areas 3a, 3b	areas 4a, 4b	areas 5a, 5b	area 6a	area 7a	areas 8a, 8b	areas 9a, 9b	areas 10a, 10b
Smart soil												
Plant reinforcement of slopes with green fences												
Tall hedges, trimmed or untrimmed												
Plant modules for pollinators (soil-based)												
Green pergolas/gazebos.												
Light green roofs												
Green façades with climbing plants.												
Living walls constructed on building walls												
Mobile hydroponic living walls/vertical gardens												
Compact plant modules for pollinators												
Compact rain gardens												

Table 13 NBS selection matrix for target types of green sites

NBS name	NBS recommendations for target types of green sites (I-V)
----------	---

	I	II	III	IV	V
Green cycling paths/walking and cycling paths					
Area afforestation on the outskirts of city centres, connecting with rural areas					
Urban carbon sink (green pedestrian corridor in an urban or suburban area, with shade-giving trees)					
Ground-level rain gardens (for car parks, walkways and roads)					
Urban catchment forestry (serving to slowing down rainwater runoff from urban catchment areas)					
Floodplain park with trees and shrubs (green detention basin for rainwater)					
Green sites for passive recreation (green resting areas)					
Woody plants growing spontaneously but remaining under control					
Street trees (single tree or tree row)					
Park trees (single trees or tree group)					
Large shrubs (single or group)					
Smart soil					
Plant reinforcement of slopes with green fences					
Tall hedges, trimmed or untrimmed					
Plant modules for pollinators (soil-based)					
Green pergolas/gazebos.					
Light green roofs					
Green façades with climbing plants.					
Living walls constructed on building walls					
Mobile hydroponic living walls/vertical gardens					
Compact plant modules for pollinators					
Compact rain gardens					

Typology of problem sites submitted by gminas participating in the project 'Silesia. Blue Sky Restored'.

In the first stage of the implementation of measure C.4, 96 areas from 60 gminas were submitted to the database of problem sites and also as potential sites for pilot investments; the submissions were sent in the form of questionnaires, which did not require the area to be classified as a specific type, but only a concise description in the form of closed answers to questions (single choice).

The scope of data contained in the completed questionnaires was sufficient for the team implementing measure C.4 to identify the area and to verify and supplement the necessary information based on resources and services available on national geoportals of various sectors, resources of local geographical information systems, documents contained in the Public Information Bulletins of the gminas, and various types of specialist studies placed in e-space resources by various entities. . The analysis of the surveys revealed that:

- the submissions cover all (1-10) types of problem sites, all geometry categories (a, b, c) and all location categories (X, Y, Z);
- the intention to create all (I-V) types of target green sites has been declared;
- the submissions include problem sites of mixed types;
- the submissions include declarations of mixed types of target green sites.

At the same time, there were no doubts as to the classification of any of the submitted problem sites according to the typology developed in this project. The results of the analysis are presented in Table 14.

Table 14 Typological classification of areas submitted by gminas participating in the project

Problem site name	Problem site type	Problem site geometry	Problem site location	Target type of green site
Bielsko-Biała 1	1	c	X	II, IV
Bielsko-Biała 2	2	a	X	II, IV
Bielsko-Biała 3	1	a	X	II
Bieruń 1	7	a	Z	I, III, V
Bojszowy 1	2	a	Y	I
Boronów 1	2.1	a	Z	I
Bytom 1	4	b	Y	III
Bytom 2	7.1	a	Y	I, V
Chorzów 1	2	c	X	II
Chorzów 2	2	c	X	II
Ciasna 1	5.9	a	Y	I, II
Cieszyn 1	2	a	Y	I, II, V
Czeladź 1	2	c	Y	II
Częstochowa 1	2	c	Y	II

Problem site name	Problem site type	Problem site geometry	Problem site location	Target type of green site
Godów 1	2	a	Z	I
Gorzyce 1	2	a	Y	I, II, V
Jastrzębie 1	2	c	X	II
Jastrzębie 2	2	c	X	II
Jastrzębie 3	2	c	X	II
Kalety 1	1	a	Y	I
Kalety 2	2, 7, 10	a	Y	I
Kalety 3	2.1	a	Y	I
Kalety 4	2	a	Y	I
Kalety 5	2	c	Y	II
Kalety 6	2	a	Y	I
Knurów 1	1	a	Y	I
Kochanowice 1	10	a	Y	I
Koszęcin 1	9	a	Y	I
Koziegłowy 1	2	c	Y	II
Kroczyce 1	1	c	Y	II
Krzanowice 1	6	a	Z	V
Krzepice 1	9	a	Y	I
Krzyżanowice 1	2	a	Y	I
Lubliniec 1	3	c	Y	V
Lubliniec 2	6	a	Y	I
Lyski 1	9	a	Y	I
Miedźno 1	9	a	Z	I
Mikołów 1	1	c	X	II
Mszana 1	10	a	Y	I, V
Nędza 1	2	a	Y	I
Ogrodzieniec 1	2	a	Z	I
Opatów 1	10	b	Z	III
Ornontowice 1	1	c	Y	II
Ornontowice 2	9	c	Y	II
Ornontowice 3	1	c	Y	II
Ornontowice 4_5	9	a	Y	I

Problem site name	Problem site type	Problem site geometry	Problem site location	Target type of green site
Pawłowice 1	10	a	Y	V
Pawonków 1	2	a	Y	I
Piekary Śląskie 1	10	a	Y	II, V
Pilchowice 1	2.9	a	Y	V
Pilchowice 2	1	c	Y	II
Poraj 1	2	a	Y	I
Poręba1	2	a	Y	I
Psary 1	2	a	Y	I
Pszczyna 1	1	a	Y	I
Pszczyna 2	2	a	Y	I
Racibórz 1	2	b	Y	III
Racibórz 2	1	c	X	II
Racibórz 3	1	b	X	IV
Radlin 1	2	a	Y	I
Ruda Śląska 1	2.7	a	Y	I, III
Ruda Śląska 2	2.7	a	Y	I
Ruda Śląska 3	2	a	Y	I
Ruda Śląska 4	2	a	Y	II
Ruda Śląska 5	2	c	Y	II
Rybnik	2	c	X	II
Rydułtowy 1	2	c	Y	II
Rydułtowy 2	2	a	Y	I
Rydułtowy 3	2	a	Y	II
Rydułtowy 4	2	a	Y	I
Siewierz 1	9	c	Y	II
Siewierz 2	10	b	Y	I, III
Skoczów 1	2	c	X	II
Sośnicowice 2	9	c	Y	IV
Sośnicowice 1	9	c	Y	III, IV
Świerklaniec 1	2	b	Y	III, IV
Świerklany 1	8	c	Y	II
Tarnowskie Góry 1	1	c	X	II
Tworóg 1	2	c	Y	II
Tychy 1	1	b	X	III, IV, V

Problem site name	Problem site type	Problem site geometry	Problem site location	Target type of green site
Ustroń 1	1	c	X	II
Wodzisław Śląski 1	1	b	X	II, IV
Wodzisław Śląski 2	2	c	X	II
Woźniki 1	1	c	X	IV
Wry 1	2	a	Z	I
Zabrze 1	1	c	X	II
Zawiercie 3	10	a	Y	I
Zawiercie 4	2	a	Y	V
Zawiercie 5	2	c	Y	II
Zawiercie 6	2	c	Y	II
Zawiercie 7	2	a	Y	II
Zawiercie 1	1	c	Y	IV
Zawiercie 2	1	c	X	IV
Zbrostawice 1	1	a	Y	I
Żarnowiec 1	2	a	Y	I
Żory 1	1	a	X	I, IV

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Województwo
Śląskie

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Glossary

Municipal and residential emissions – these are emissions related to individual heating, waste collection and disposal. Simply put, they are referred to as area emissions due to the high concentration of small emitters in a relatively small area. This group primarily includes emissions from individual heating systems.

Fugitive emission – the release of pollutants into the air in an unorganised manner: from waste dumps, landfills, during the handling of loose or volatile substances, from production halls, through roof and window vents, etc.

Secondary emission – particulate matter pollution resulting from reactions and processes occurring during the long-distance transport of gases (SO₂, NO_x, NH₃ and volatile organic compounds) and re-emission, i.e. the lifting of particulate matter from the ground (especially in urban areas).

Road transport emission – individual emitters of pollutants are considered to be road sections for which emissions are determined by the intensity and structure of vehicle traffic. Road transport is the most prominent source of nitrogen oxide emissions, as well as a major source of particulate matter and aromatic hydrocarbon emissions. Emissions from transport are the sum of secondary emissions caused by the lifting of pollutants (particulate matter) from the road and emissions from vehicle combustion engines, tyre wear and brake linings.

Metropolis GZM (GZM) – a metropolitan union located in the Silesian Voivodeship, in the Upper Silesian conurbation. The metropolis was established based on the Act of 9 March 2017 on the metropolitan union in the Silesian Voivodeship, and its name, seat and scope were specified by the Ordinance of the Council of Ministers of 26 June 2017. The metropolitan union was established on 1 July 2017, but it began performing its tasks on 1 January 2018. The boundaries of Metropolis GZM, established in 2017, covered 41 gminas, including 13 cities with powiat rights and 13 urban gminas (<https://stat.gov.pl/statystyka-regionalna/jednostki-terytorialne/inne-jednostki-przestrzenne/gornoslasko-zaglebiowska-metropolia-gzm/>).

Urban Heat Island (UHI) – a climatic phenomenon involving higher air temperatures in cities compared to surrounding areas. An UHI develops as a result of the functional and spatial structure typical of cities – an accumulation of artificial surfaces, only a small proportion of green sites and reduced ventilation. Materials such as concrete, asphalt and brick absorb more sunlight than they reflect, and then release the energy, raising the temperature in the surrounding area. In addition, human activity contributes to raising the air temperature in the city – heating and air conditioning in buildings, car traffic, and the production of goods. An UHI aggravates the negative effects of air pollution on human health.

Urban Green Acupuncture (UGA) – introducing greenery into the urban fabric in specific locations. UGA aims to strengthen the city's green infrastructure system, including at least a partial increase in its functional continuity, in order to improve aesthetics, quality of life, thermal comfort, and strengthen ecosystem services within the city. In order to achieve the desired outcomes, a large number and good selection of application points are required, similar to medical acupuncture. In practice, this



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involves the optimal use of small areas within the city, mainly in public spaces, to introduce permanent greenery, both horizontally and vertically, with or without contact with the ground, but, as a rule, with particular emphasis on native species that thrive in urban conditions.

PM10 – particulate matter with an aerodynamic diameter of less than 10 μm , which can enter the upper respiratory tract and lungs.

PM2.5 – particulate matter with an aerodynamic diameter of less than 2.5 μm , which penetrates deep into the lungs, reaches the alveoli and enters the bloodstream.

State Agricultural Farm (PGR) – large, socialist agricultural enterprises owned by the state, operating on the basis of full or limited economic settlement. They were established in 1949 as a result of the merger of State Land Properties, State Horse Breeding Farms and State Plant Breeding Farms, as well as the development of abandoned land. In 1976, State Agricultural Farms were renamed to State Agricultural Enterprises (PPGR).

[http://encyklopedia.warmia.mazury.pl/index.php/Pa%C5%84stwowe_Gospodarstwa_Rolne_\(PGR\)](http://encyklopedia.warmia.mazury.pl/index.php/Pa%C5%84stwowe_Gospodarstwa_Rolne_(PGR))

Nature-based solutions (NBS) – these are solutions based on nature, i.e. deliberate interventions that draw on the properties of nature to address the challenges facing societies. The European Commission defines them as: *cost-effective (economically efficient), delivering environmental, economic and social benefits simultaneously, and supporting adaptation to climate change. These solutions introduce elements and processes found in nature and in unaltered landscapes into cities and other areas of land and water developed by humans, through systemic measures adapted to local conditions and efficient in terms of resource use.*

Urban background – average air pollution levels in a given city caused by pollutants coming from outside the city, calculated using mathematical modelling methods based on monitoring results from urban background measuring stations.

Regional background – average air pollution levels in a given zone (the Silesian Voivodship is divided into 5 zones: the Upper Silesian agglomeration, the Rybnik-Jastrzębie agglomeration, the city of Bielsko-Biała, the city of Częstochowa, and Silesian zone), caused by inflows from sources located within a 50 km radius of this zone, calculated using mathematical modelling methods based on the results of monitoring carried out by regional background measurement stations.

Background level of pollution – the level of gases or particulate matter in polluted atmospheric air in a given area, originating from pollution sources located outside that area. Defined as the average value for the year, it is determined primarily for those pollutants for which permissible concentration values have been established. The general background level consists of the supra-regional, regional and urban background levels.

Green Infrastructure (GI) – a type of “natural technology”, a tool designed and managed to create nature-based solutions (NBS). GI may include urban green sites, e.g. in the form of gardens and city parks, as roadside greenery, accompanying recreational areas, on school grounds and in other areas. Through its links with NBS, GI develops areas that are unusual for traditional urban greenery, such as roofs, vertical building surfaces, street screens, green tram tracks, bus shelters, etc. GI is created as part of the reclamation of degraded areas, e.g. post-industrial areas.

