Modelling air quality according to INSPIRE data specifications, ISO standards and national regulations

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Abstract

Protection of the environment is an activity of many institutions, organizations and communities from global to regional and local scales. Any activity in this area needs structured database records, using advanced methodology, given, among others, in INSPIRE documents, ISO standards of 19100 series, and national regulations. The goal of this paper is to analyse both the legal provisions related to the air quality and also data sources associated with the prevention of air pollution. Furthermore, the UML application schema of the spatial data related to the air protection is proposed, for the use by urban planners. Also, the overview of the methodology of geographic information is given, including the Unified Modelling Language (UML), as well as the basic concepts of conceptual models within the INSPIRE project. The study is based on the relevant literature and documents, as well as on the expert knowledge gained through urban planning practice, as well as on the analysis of the spatial planning regulations. The UML application schema for different aspects related to the air protection, as presented in this paper, is an example of how to use the methodology also in other fields of the environment protection. Spatial planners know how to improve the air quality, but in the present state of law they often suffer from the lack of planning tools for real actions. In the spatial planners work an important issue are data that allow a thorough analysis of the area.

Key words: *air pollution, application schema, INSPIRE directive, ISO standards of 19100 series, the Unified Modelling Language (UML), urban planning*

INTRODUCTION

Supporting environmental policies, including a number of thematic branches, essential for sustainable development of the country and society, is one of the main goals of the spatial data infrastructure, built and developed under the Polish national act on spatial information infrastructure [Ustawa… 2010], the INSPIRE directive [Directive 2007/2/CE], and the INSPIRE implementing rules. The INSPIRE directive and implementing acts use the concepts of methodology and technology for spatial information. This knowledge is contained mainly in the ISO 19100 series of standards.

Among the 34 spatial data themes of INSPIRE, listed in the Directive 2007/2/CE there are more than 20 directly related to the geographical environment and its protection. Many of the remaining topics are also related to the environment, however. The directive, as well as the implementing rules and specifi-

cations, present methodological concepts how to describe information models in any of the various themes. The methodology combines the methods of spatial location of geographic objects, which belong to the domain of geodesy and cartography, with the methods of data management that belong to information technology (computer science). Thus, this is a consistent methodology for modelling and development of geographical information systems, which is usually recognized as a subject of geoinformatics and is fully presented in the ISO standards of the 19100 series.

The aim of the paper is to analyse both the legal provisions with regard to the quality of the air and also data sources related to the air protection, in the issues of urban planning. Furthermore, the UML application schema of the spatial data related to the air protection is proposed, for the use by urban planners. Also, the overview of the methodology of geographic information is given, including the Unified Modelling Language (UML), as well as the basic concepts of conceptual models within the INSPIRE project.

OVERVIEW OF LEGAL PROVISIONS REGARDING AIR QUALITY

One of the ways to support clean air is urban planning (e.g. JAKUBIAK, URBAŃSKI [2016]). SECOMSKI [1972] in an analysis of trends in the theory of spatial planning shows that the most noticeable are works dedicated to the environment protection. According to BARTKOWICZ [1975] the goal of urban planning is first of all to reduce the existing and possible in the future expansion of atmospheric pollution.

Basic concerns for the protection of the environment and conditions for the use of its resources are determined by the law of the environment protection [Ustawa… 2001]. In addition to the definition of sustainable development (significant for urban planning) the act contains a number of regulations, also for national environmental monitoring. Specific information are contained in the implementing acts to the law of the environment protection, of which the most important is the regulation of the minister of the environment on the levels of content of certain substances in the air [Rozporządzenie MŚ... 2012a].

Moreover, assemblies of the regions may, by a resolution, in order to prevent negative effects on human health or on the environment, introduce restrictions or prohibitions as to the burning of certain substances. The first Polish resolution against smog was adopted in the Małopolskie Voivodeship.

Certainly a change in policy on the protection of the air (also in Poland) took place after the adoption of the Directive on air quality and cleaner air for Europe [Directive 2008/50/CE]. In addition to the need to reduce pollution and improve the monitoring and assessment of air quality the Directive drew attention also to the need to inform the public. It highlighted the need to adapt the procedures for data exchange, assessment of and reporting on the quality of the air,

and (importantly) ensure the coherence of these procedures with the Directive establishing an infrastructure for spatial information (INSPIRE) [Directive 2007/2/CE]. From the point of view of a spatial planning, as this activity refers to the space, it is important that the directive [Directive 2008/50/CE] indicated that, in order to ensure proper information about the spatial distribution of air quality, the measurements can be supplemented by indicative measurements or modelling techniques.

The Polish Act on spatial planning does not raise directly the need of air protection [Ustawa… 2003]. It refers only to the environment as a whole, of which the air is an element.

DATA SOURCES FOR URBAN PLANNING RELATED TO THE AIR POLLUTION PREVENTION

In the spatial planning an important issue are data that allow a thorough analysis of the area. The larger is the scope of the study, the more difficult is to obtain homogeneous data. On the other hand, by analysing a small area, for example referring to a single parcel, it could be found that there is no reliable data in such detail.

Currently, the spatial data infrastructure (e.g. ZWIROWICZ-RUTKOWSKA, MICHALIK [2016]) provides the ability to exchange information. Widely understood geographical information systems enable users to perform advanced analyses, and with the right data allow them to automate some of the calculations (e.g. BOUGUERRA et al. [2017]). The analysis of the data sources presented in this section focuses on the internet sources, geoportals and geoinformation websites.

Spatial planning activities (in the development of planning documents), focused on possible improvement of the air quality in a particular area, can be divided into four main stages: identification of the problem, collecting data and materials, and analyses, studies and design work.

The first stage, the identification of the problem, is the most important issue. The question whether the degree of air pollution in the past, present or as a forecast for the future can adversely affect the health of the inhabitants has to be answered. Extremely valuable data are collected in Poland by the Main Inspectorate of Environmental Protection (Pol. Główny Inspektorat Ochrony Środowiska – GIOŚ); they concern both the current measurement data, as well as warnings. Part of the information is referred to points (stations), part to the zone. New feature is the ability to download certain data in the shp format. On the website of GIOŚ the location of industrial units and air releases can be found.

The second stage within the spatial planning consists in gathering any source materials relating to the characteristics of the area. Spatial data should be supplemented with a descriptive information. Available services may be helpful, including Web Map Service/Web Map Tile Service (WMS/WMTS). Valuable

are maps of CORINE Land Cover – among 31 land cover classes, particularly important are those relating to the continuous urban fabric, industrial units, transport areas, as well as green areas. From the point of view of the spread of air pollution, it is also important the topographical relief, which can be analyzed using the Information System of Flood Protection (Pol. Informatyczny System Osłony Kraju – ISOK) numerical terrain model – shading and hipsometria, also available as WMS through the national geoportal. Important is also the wind speed and direction, which can be helpful in the design of both city-wide and individual investments. A valuable source of information on forests are websites of the company State Forests (Pol. Lasy Państwowe) that provide not only maps of forest stands, but also of the spa forests and industrial damage zones. On the other hand, maps of plant communities or forest habitats can be obtained directly from the data bank of the forests (Pol. Bank Danych Lokalnych – BDL). In the publication by RÓŻAŃSKI [1959] it turns out that the size and nature of the surface of the city and of the lake affect greater ability to exchange air and self-cleaning of the atmosphere. For this reason, it should be considered location of surface water, for example, by using the webservice of the National Board of Water, Flood Risk Monitoring System (Pol. Krajowy Zarząd Gospodarki Wodnej, System Monitoringu Ryzyka Powodziowego) or WMS presenting the hydrographic map of Poland. Spatial data concerning communication networks are important from the perspective of determining ecological corridors and natural breaks between the high buildings in the cities.

The third phase in spatial planning in drawing up the planning document should focus on the analyses and studies. CZARNECKI [1964; 1965] lists meteorological and climate research. Due to the time required for an advanced analysis it is worth taking advantage of the rich and effective GIS tools. Collected in the second phase materials is requires supplementing with vector data.

The most important of the editable data provided by GIOŚ is the air quality assessment for each zone, longstanding evaluation, and long-term forecasts. Relevant data also having an indirect impact on the level and scale of air pollution, are provided by different institutions, for instance by the General Directorate for the Environmental Protection (Pol. Generalna Dyrekcja Ochrony Środowiska), which shows the location of the forms of nature conservation and the projects of ecological corridors.

A great move was free sharing by Geodetic and Cartography Documentation Centre (Pol. Centralny Ośrodek Dokumentacji Geodezyjnej i Kartograficznej– CODGiK) of the data, including, in particular BDOO (Pol. Baza Danych Obiektów Ogólnogeograficznych – Geographic Database) and BDOT (Pol. Baza Danych Obiektów Topograficznych – Topographic Database) databases. RÓŻAŃSKI [1959] noted that a significant number of buildings, chimneys, streets is very rough background on which the wind loses its energy. LASKOWSKI [1987] introduces the wind speed profiles with different surface roughness of the terrain. Data on the land use affecting the coarseness or roughness, could be found in the BDOO. CODGiK provides data for the numerical terrain model of the grid interval at least 100 m (NMT_100). Based on study of the terrain and spatial objects located in a specific area new air corridors could be designed or existing ones could be verified.

The next phase of spatial planning should include design activities. These works may have a significant impact on air quality, although the planning tools are sometimes inadequate to conduct consistent spatial policy.

METHODS

The above conditions and features compose a frame for building up an information system for compound monitoring air quality. This requires a special formalism, which, according to INSPIRE and ISO standards, is covered by a methodological concept, the so-called MDA (Model Driven Approach), consisting of the following four phases:

1) CIM (Computation Independent Model): general specification of the data model, showing the technical and operational assumptions and the roles of the participants;
2) PIM (Platform Independent Model): the basic phase of this methodology, providing a conceptual model;
3) PSM (Platform Specific Model): a logical model, adopted to a specific, out of the various possible, implementation techniques; the INSPIRE and ISO standards recommend using the languages XML and GML for geographical information; advanced tools such as Enterprise Architect, allow for full or partial automation of transformation from conceptual to logical model;
4) implementation: the creation of the so-called a physical model regarding a given hardware – software platform; concerns transforming logical structures to the platform specific architecture.

Among the existing formal languages and notations for conceptual modelling (the phase PIM) the most advanced is the conceptual schema language called the UML – Unified Modelling Language. This language is widely used and recommended by ISO 19100 series standards and INSPIRE s to describe conceptual models built in all areas of geographic information.

A conceptual model is in UML basically a class diagram, of which main categories are (ISO 19103 2015):

− class: a description of a group of objects that have the same meaning, attributes, operations, methods, and associations;
− stereotype: an extension of the meaning of data types and classes;
− attribute: a representation of features common to all objects of a particular class;
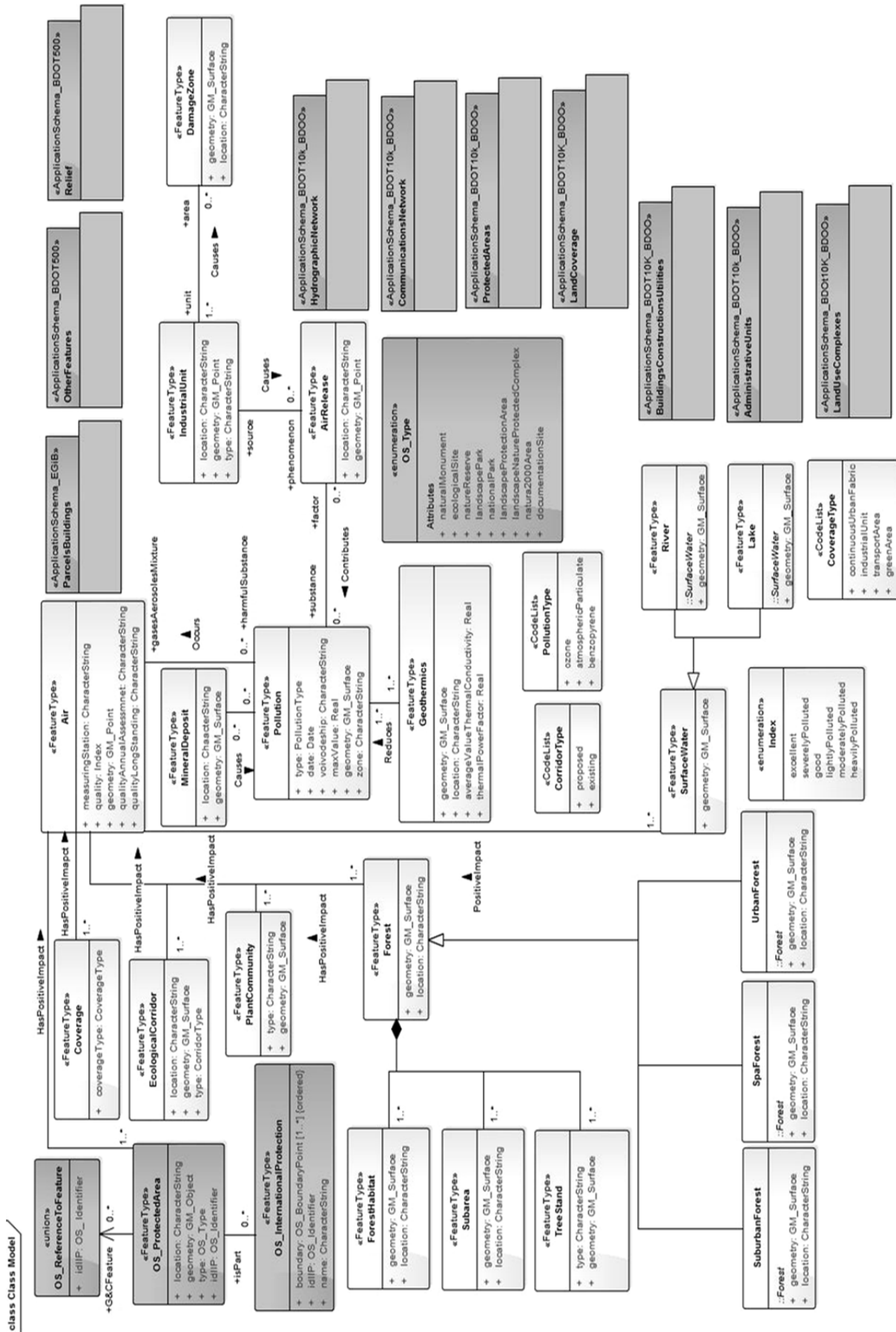
Fig. 1. The Unified Modelling Language application schema for spatial data used in tasks of urban planners related to the air pollution prevention; source: own study

- operation: representation of the services.
- different types of relationships between the classes in UML are the following:
- association: a semantic connection between two instances;
- navigation: directed association;
- aggregation: "components" are parts of "container";
- composition: strong aggregation – "components" do not exist without the "container";
- generalization: a relationship between an element and the sub elements;
- dependency: the use of one element by another.

AN UNIFIED MODELLING LANGUAGE (UML) APPLICATION SCHEMA FOR SPATIAL DATA RELATED TO AIR PROTECTION

Figure 1 shows the data model as an UML conceptual schema (class diagram) for air protection using the perspective of the urban planning and taking into account features discussed in sections 2 and 3.

The basic conceptual categories of the model shown in Fig. 1 are: classes (e.g. *Air*), packages (e.g. *AdministrativeUnits*), attributes (e.g. *measuringStation* in the class *Air*), stereotypes (e.g. <<*FeatureType*>>, <<*CodeList*>>), associations with multiplicities, roles, names (e.g. association between classes *Pollution* and *AirRelease*), a navigable association (classes *OS_ProtectedArea* and *OS_ReferenceTo Feature*) and associations with either the composition or shared aggregation (e.g. there is the composition between classes *Forest* and *ForestHabitat*), as well as generalizations or specifications (e.g. between classes *Forest* and *SuburbanForest*).

The classes *OS_ProtectedArea*, *OS_ReferenceTo Feature*, *OS_InternationalProtection*, as well as the enumeration *OS_Type* are taken from the data model "Environmental protection" [PARZYŃSKI, CHOJKA 2013], which refers to the regulation of the Minister of Environment on the central register of forms of nature protection [Rozporządzenie MŚ... 2012b]. According to PARZYŃSKIand CHOJKA[2013] some forms of complete or partial protection may be a subject of international protection.

The UML packages, which are a general purpose mechanism for grouping items, refer to information structures of the registries held by the geodetic and cartographic service. The names of the packages are taken from the UML application schemas described in the regulations concerning BDOT 10K (Pol. Baza Danych Obiektów Topograficznych, Database of Topographic Objects), scale 1:10 000, BDOO (Pol. Baza Danych Obiektów Ogólnogeograficznych, Database of Geographic Objects) and EGiB (Pol. Ewidencja Gruntów i Budynków, Cadastre) databases [Rozporządzenie MRRiB… 2001; Rozporządzenie MSWiA… 2011; 2015]. Data from these registers are important reference data, also in spatial planning associated with air protection.

CONCLUSIONS

The presented here Unified Modelling Language (UML) application schema for environmental aspects related to air protection in tasks of spatial planners proposed in this paper may be in general considered as an example or case study of using the Model Driven Approach (MDA) according to ISO standards and IN-SPIRE also in other fields of environment protection.

From the point of view of the air pollution prevention issues and realization of this task by urban planners and use of many data sources it should be continued acquiring reliable spatial information with high accuracy. Valuable are also data presented in terms of time, not only historical one, but also projected one.

It is strongly recommended to share data in an editable format which will facilitate their exchange. In this much helpful may be the GIS technology with its wide range of forms of data sharing, including WFS and GML. Data on air quality are specialized. Some impediment in the work of the spatial planners and urbanists is the lack of a single, clear terminology concerning data on air quality.

Spatial planners have knowledge on how they can improve air quality, but in the present state of law sometimes there is a lack of planning tools for concrete actions. It should be also pointed out that the protection of the air in the work of the urbanists is one of the many elements that should be taken into account.

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Modelowanie zagadnienia jakości powietrza według specyfikacji danych INSPIRE, norm ISO i rozporządzeń krajowych

STRESZCZENIE

Ochrona środowiska jest przedmiotem działalności wielu instytucji, organizacji i środowisk w skalach od ogólnoświatowej do regionalnej i lokalnej. Wszelka aktywność w tym zakresie musi być z konieczności oparta na usystematyzowanych formach rejestrów bazodanowych, wykorzystujących zaawansowane koncepcje metodologiczne, zawarte m.in. w dokumentach INSPIRE, normach ISO serii 19100 oraz krajowych regulacjach prawnych. Celem publikacji jest analiza przepisów prawnych, w odniesieniu do zagadnienia jakości powietrza, a także źródeł danych wykorzystywanych w pracach planistów, związanych z zapobieganiem zanieczyszczeniom powietrza. Ponadto zaproponowano schemat aplikacyjny zunifikowanego języka modelowania (UML) odnoszący się do danych przestrzennych wykorzystywanych w zadaniach urbanistów w zakresie ochrony powietrza. Oprócz tego zaprezentowano przegląd koncepcji z zakresu metodologii informacji geograficznej, w tym języka formalnego UML, a także podstawowych koncepcji przedmiotowych w postaci modeli pojęciowych używanych w ramach projektu INSPIRE. Badania bazowały na przeglądzie literatury oraz dokumentów, a także wiedzy eksperckiej autorów oraz analizie przepisów prawnych dotyczących planowania przestrzennego. Zaprezentowany schemat aplikacyjny UML dotyczący aspektów środowiskowych związanych z ochroną powietrza jest przykładem wykorzystania norm ISO serii 19100. Urbaniści posiadają wiedzę, w jaki sposób mogą poprawiać jakość powietrza, ale w obecnym stanie prawnym czasami brakuje narzędzi planistycznych do konkretnych działań. W pracy urbanisty ważnym elementem są dane, które umożliwiają dokładną analizę obszaru.

Słowa kluczowe: *dyrektywa INSPIRE, normy ISO 19100, schemat aplikacyjny, urbanistyka, zanieczyszczenie powietrza, zunifikowany język modelowania (UML)*