НАУКИ ПРО ЗЕМЛЮ. ГЕОІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ МОДЕЛЮВАННЯ СТАНУ ГЕОСИСТЕМ

DESIGNING A CONCEPTUAL MODEL OF THE GEOSPATIAL DATABASE FOR HAZARDOUS ANIMAL BURIAL SITES AFFECTED BY ANTHRAX

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Abstract. The article presents the author's approach to the systematization and accumulation of geospatial and attributive data on dangerous burials of animals that died from anthrax. Anthrax is a zoonotic disease, the spores of which can remain viable in the soil for decades, posing a potential threat. Burials of animals not carried out in biothermal pits (mainly before 1954) do not provide an adequate level of safety. In the event of a shift in the soil cover, spores can reach the surface and cause new cases of the disease among wild and domestic animals, as well as infection of people. A significant part of such burials does not have clearly established boundaries of land plots and established regimes of limited use of adjacent territories, which complicates control over their condition.

As part of the study, the available geospatial and attributive data on dangerous burials were structured, and a conceptual model of a geospatial database was developed, which ensures the accumulation, structuring, and systematization of data. The model is built using UML notation and is presented in the form of a class diagram that reflects the main structural elements of the database and their attributes.

The results obtained can be used to create a physical model of a geospatial database for the registration (register) of lands with dangerous burials of animals that died from

anthrax, as well as for the further development of the monitoring system, planning of sanitary and protective measures, establishing regimes of limited land use, etc.
   Keywords: *geospatial database, conceptual model, anthrax*

Relevance

Human economic activity is one of the key factors influencing the state of the environment and determining its safety for the population. As a result of anthropogenic impact, various objects are formed, some of which can exert a negative influence on surrounding areas, wildlife, and human health for decades. Among such hazardous regime-forming objects are livestock burial sites containing animals that died from anthrax, particularly those burials conducted without the use of biothermal pits. According to research findings [1], the main cause of new anthrax outbreaks lies in the inadequate protection of old burial sites, which are often simple earthen pits and do not meet biological safety standards. Several scientific studies [1-2] emphasize the exceptional resilience of anthrax spores: they withstand boiling, dry heat, conventional disinfectants, and can persist in soil for decades. Meanwhile, data [3] show that between 1999 and 2022, 35 human cases of anthrax were recorded in Ukraine. Similar cases are reported across European countries, as reflected in weekly and annual reports of the European Commission – for instance, five cases were registered during a single week (18–24 September 2025) [4].

Existing burial sites of animals that died from anthrax remain a potential source of biological hazard. Disturbance of the soil cover in such locations may lead to the release of spores to the surface, posing a risk of infection for both wild and domestic animals, and repre-

senting a threat to humans, as anthrax is a typical zoonotic disease. Beyond the direct biological hazard, several additional factors contribute to elevated risk levels. These include the absence of clearly defined boundaries and appropriate informational signage, discrepancies between spatial data and the actual location of burial sites, loss of records regarding such sites, various types of surveying or excavation activities, and military actions that cause mechanical disruption of the soil cover.

Previous scientific developments, including [5], have focused on creating geospatial database models for the registration and monitoring of anthrax cases. However, these efforts have primarily concentrated on recording confirmed cases of the disease, without accounting for local territorial characteristics and associated risks. At the same time, European Union legislation [6] outlines the general principles for the prevention, detection, surveillance, and control of infectious animal diseases, including anthrax. Given Ukraine's status as an EU candidate country, it is necessary to harmonize national legislation with European standards, particularly regarding systems for registering and documenting the course of infectious animal diseases.

In this context, the creation of a geospatial database acquires particular significance and relevance, as it enables not only the registration of new disease cases but also the accumulation, structuring, and systematization of spatial and attribute data related to territories containing hazardous animal

burial sites. Such a database will serve as a foundation for further spatial analysis, risk assessment of disease spread, planning of sanitary protection measures, and the development of land-use management decisions. The first step in this process is the development of a conceptual model of the geospatial database, which defines its structure, key elements, and interrelationships.

Review of Recent Studies and Publications

The challenges of geospatial database modeling across various sectors, as well as the study of risks associated with zoonotic infections, have been the subject of numerous scientific investigations and publications. For instance, study [2] provides a detailed analysis of anthrax pathogen strains and their virulence characteristics. Research [7] offers an overview of the epizootic situation regarding anthrax in Ukraine and the condition of burial sites for animals that died from the disease.

Makovska I. and her co-authors [8] explored the potential of geographic information systems (GIS) for analyzing rabies spread in Vinnytsia Oblast. Study [9] presents findings on the identification of anthrax-prone areas in Kenya. Similarly, research [10] examines the current status and spatial patterns of anthrax outbreaks across geographic regions of Zimbabwe, taking into account climatic factors.

Issues of conceptual modeling of geospatial data are addressed in [11], which presents a catalog of object classes for the cadastral geodata database. Article [12] outlines the specific features of conceptual modeling tailored to the needs of ecotourism. Study [13] examines a conceptual model for geoinformation-based

assessment of the impact of hazardous animal burial sites – specifically those related to anthrax – on adjacent territories.

Particular attention should be given to practical developments, such as the interactive map [14] designed for reporting suspected and confirmed anthrax cases in Ukraine. The European Commission [15] regularly publishes consolidated statistics on recorded cases of this disease. However, these initiatives are primarily focused on quantitative indicators and do not account for local territorial characteristics, levels of transmission risk, or potential sources of contamination.

Consequently, recent studies and publications have insufficiently addressed the issue of developing a geospatial database structure for recording and registering territories containing hazardous animal burial sites related to anthrax. This gap highlights the need for further research and practical solutions.

Research aim

This study aims to provide a scientific rationale for the key components and structure of a geospatial database designed to record and register territories containing hazardous animal burial sites related to anthrax. The relevance of this issue stems from the high level of biological hazard that persists for decades in such locations, as well as the lack of up-to-date, reliable, and systematized information regarding their location, condition, and the legal status of the land plots involved.

At this stage, conceptual modeling plays a crucial role, as it enables the formation of a logical structure for the future database, including the definition of object classes, their attributes, and interrelationships. Thus, the objective of the study is not only to document existing

hazardous burial sites but also to develop an effective tool for ongoing monitoring, risk forecasting, and support for management decision-making.

Materials and Methods

The methodology is based on a combination of scientific literature review and analysis of regulatory documents, along with the application of modern conceptual modeling techniques for geospatial data. To describe the structure and logic of object interactions, the Unified Modeling Language (UML) was used. The class diagram developed within the study reflects not only the key informational elements but also the types of relationships between them, allowing for the consideration of potential data incompleteness or absence. This approach ensures the systematization, flexibility, and scalability of the geospatial database.

The application of the conceptual model is the first and essential step in developing a physical database model, which can subsequently be implemented within a GIS environment. This will enable spatial analysis, risk assessment of anthrax spread, mapping of hazardous areas, and improve the effectiveness of planning sanitary and environmental protection measures.

Results and Discussion

During the course of the study, a conceptual model of the geospatial database of hazardous animal burial sites related to anthrax was developed. It accounts not only for the spatial location of burial sites but also for their safety status, characteristics of the surrounding area, and the presence of warning signs and fencing (Fig. 1).

At the conceptual level, the model represents the structure of the entire geospatial database, including feature classes, their attributes, and the relationships between them.

In the developed model, the classes Region, District, and Community ensure the linkage of burial sites to the corresponding administrative-territorial units. The model accounts for temporal changes in administrative boundaries, including dissolutions, mergers, enlargements, and name changes. The Settlements class describes existing populated places within each community. Within an administrative-territorial unit, a burial site can be represented in two ways: via the LandParcel class — if the land parcel has been formally registered and its boundaries are defined in legal documents; or via the TerritorialPart class – in cases where no cadastral information is available in the State Land Cadastre.

The AnimalBurial class is central to the developed model and serves as the primary spatial object for assessing the risk of anthrax spore dissemination. The attribute functionality defines the burial site's status (closed or active). The BurialType and BurialClass classes perform a classification function, reflecting the type of animals, disease name, burial type, and the level/class of potential hazard.

The Restrictions class represents sanitary protection zones surrounding hazardous animal burial sites affected by anthrax. Safety measures – such as informational signs, fences, barriers, and other visibility elements – are modeled through the MarkingMeasures class. Additionally, the Soil class reflects the properties of the soil cover, which may either facilitate or inhibit the spread of dangerous spores. The Catchment class accounts for the location and area of the
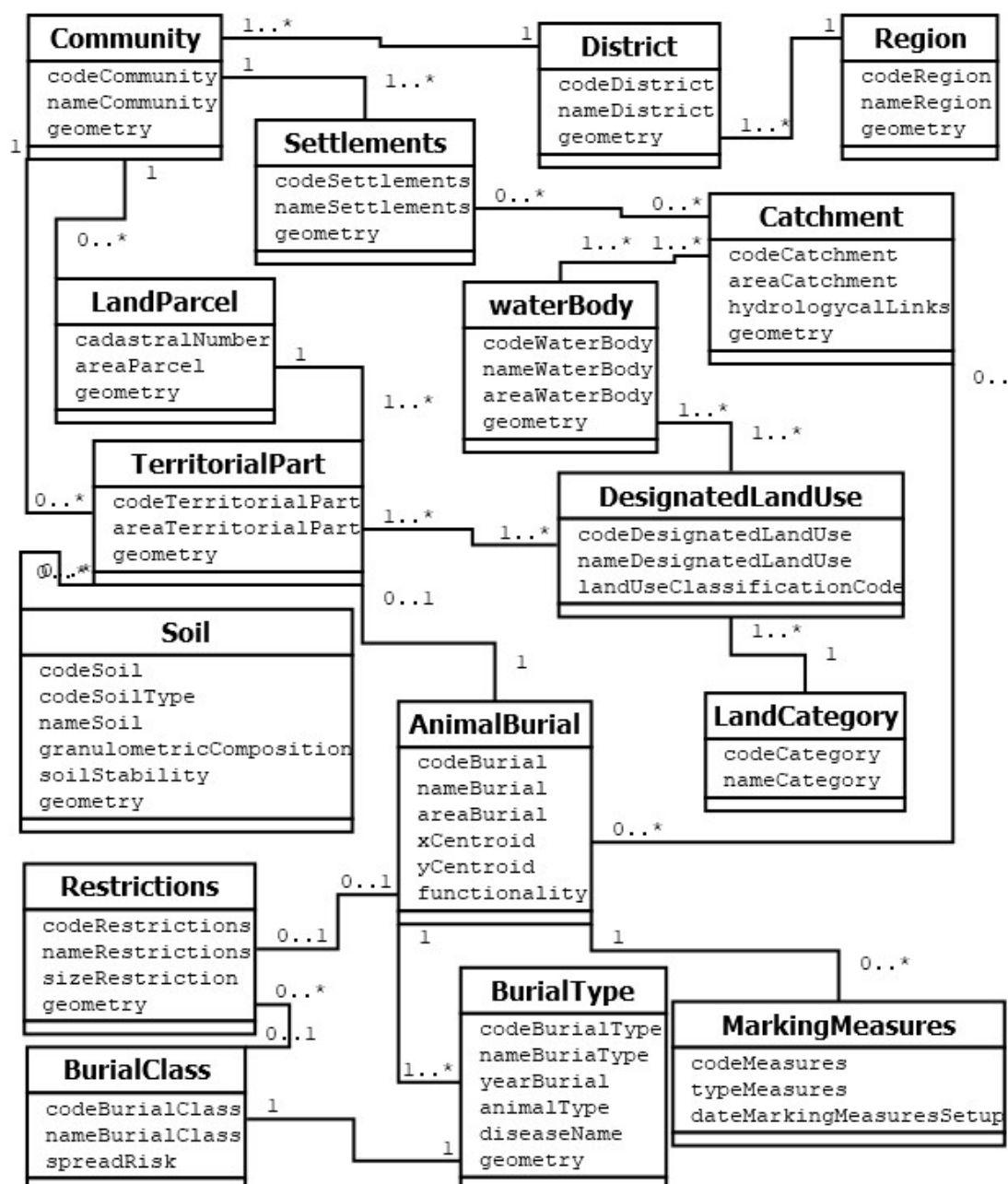
Figure 1. Conceptual model of the geospatial database for hazardous animal burial sites that died from anthrax

watershed, as well as hydrological links between the burial surface and aquifers.

Overall, the developed model provides a foundation for the subsequent creation of a physical database and enables the systematic organization of information required for monitoring and assessing the risks of anthrax dissemination.

Conclusions and prospects

The development of a conceptual model of a geospatial database of dangerous burials of animals that died from anthrax is an important step towards creating an effective system for monitoring and managing land use risks. The proposed model provides structur-

ing and integration of both spatial and attributive information, which allows forming a holistic register of such objects and increasing the efficiency of their accounting and analysis.

A key scientific value of the model lies in its consideration of a complex set of factors that determine the likelihood of anthrax emergence and spread: soil types, hydrological conditions, burial characteristics and types, land categories, the presence of sanitary restrictions, visibility and marking measures, among others. This comprehensive approach provides a foundation for constructing a physical database model that will enable rapid spatial risk analysis and forecasting of hazardous situations.

The practical significance of the study lies in enhancing the effectiveness of land-use planning and supporting evidence-based decision-making in the fields of public health, environmental protection, and agricultural production. Future research prospects include the development of a methodology for spatial zoning of anthrax risk areas and the automation of thematic map generation to support management decisions.

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РОЗРОБЛЕННЯ КОНЦЕПТУАЛЬНОЇ МОДЕЛІ БАЗИ ГЕОПРОСТОРОВИХ ДАНИХ НЕБЕЗПЕЧНИХ ПОХОВАНЬ ТВАРИН, ЯКІ ЗАГИНУЛИ ВІД СИБІРКИ

Анотація. *У статті представлено авторський підхід до систематизації і накопичення геопросторових та атрибутивних даних щодо небезпечних поховань тварин, які загинули від сибірки. Сибірка є зоонозним захворюванням, спори якого здатні зберігати життєздатність у ґрунті протягом десятків років і залишатись джерелом потенційної загрози. Поховання тварин, здійснені не у біотермічних ямах (головним чином до 1954 року), не забезпечують належного рівня безпеки: у разі зміщення ґрунтового покриву спори можуть потрапити на поверхню і стати причиною нових випадків захворювання серед диких і свійських тварин, а також інфікування людей. Значна частина таких поховань не має чітко встановлених меж земельних ділянок і встановлених режимів обмеженого використання прилеглих територій, що ускладнює контроль за їхнім станом.*

У межах дослідження було структуровано наявні геопросторові та атрибутивні дані про небезпечні поховання і розроблено концептуальну модель бази геопросторових даних, що забезпечує накопичення, структурування й систематизацію даних. Модель побудована з використанням нотації UML та представлена у вигляді діаграми класів, що відображає головні структурні елементи бази даних та їхні атрибути.

Отримані результати можуть бути використані для створення фізичної моделі бази геопросторових даних з обліку (реєстру) земель з небезпечними похованнями тварин, що загинули від сибірки, а також для подальшого розвитку системи моніторингу, планування санітарно-захисних заходів, встановлення режимів обмеженого землекористування та ін.

Ключові слова: *база геопросторових даних, концептуальна модель, сибірка.*