INFORMATION MODELING OF WASTE DISPOSAL SITES

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Abstract. The paper proposes a methodology for developing information model or database of waste disposal sites /WDS/ or landfill sites, applying received remotely and in-situ data from Earth surface monitoring, especially including procedures of morphological processing, data normalization and visualization models. The overall structure and composition of the information model, described subsystems, classes, objects, and attributes (properties) of the data, are presented. The possibility of formation of new information relations, that arise between different kinds of information, through morphological (in particular, the morphemic) processing “raw” information at the input, for example, between the classifiers (waste products, settlements, economic activities, etc.), is described. The paper used methods of system analysis, methods of mathematical linguistics, space monitoring methods. For example a structure of constructing the database, the archive and the classifier of unauthorized waste disposal facilities (solid waste landfills, waste piles, municipal landfills, and others) is presented. The scheme of data model describes the components (tables) as part of the model: general information, geometric and geographic parameters of geo-referenced data, including data for adjacent territorial-administrative facilities, etc.

Keywords: waste disposal sites, landfills, information model, database, classifier, waste disposal object classification, state register, object attribute data

INTRODUCTION

Waste disposal sites /WDS/ store huge amounts of information. To organize such a large volume of information, a special program of data base and information models of other types, organically related to each other is used. Now there is little practically significant and actually functional technical documentation on the problem of littering in the Ministry of natural resources, in the institutions under its jurisdiction and in the organizations that operate landfills of municipal solid waste (MSW) and industrial waste (IW), specially designed according to the results of scientific and practical research. In particular, data

model structuring information on solid waste landfills /SWLs/, storing all sorts of information about current and historical SWLs and their characteristics, is useful in the field of co-ordination and efficiency of environmental actions aimed at improving the ecological condition of various regions of the Russian Federation and other states.

ALGORITHM FOR CONSTRUCTING THE INFORMATION MODEL

General structure of the information model (data base) for SWL is shown in Fig. 1.

Fig. 1. Structure of information model obtained for SWL

As the input data of the algorithm for developing the information model there are the "raw" data of the aerospace monitoring results [1-4], field and laboratory studies, information from Internet sources and regulating documents. These include different data:

1) data directly related to SWLs - information about authorized SWLs, information on

unauthorized SWLs; data on waste; remote SWLs monitoring data; contact field and laboratory SWL monitoring data, (for example, data about the company and the location of SWLs, about the contents of the wastes and their placement, SWL photos, eyewitnesses comments, state register data about waste disposal facilities [5], details of the design, operation and reclamation of landfills [6]);

2) data indirectly related to SWLs - data on human settlements; metadata; weather information; activity data, data on legal entities, data on kinds of products, population data, data on satellite systems and satellite images (for example, satellite images and satellite systems [7-10], weather and climate data [11], the data on classifiers of various objects related to SWLs (Table 1).

Morphological operations include alphabetical sorting, calculation of words and phrases, the search

for one-root words and words with specified morphological characteristics, transpose of the text language, etc. [12-16]. Normalization is bringing data to a particular structural form. The structure of the model is represented by a database consisting of the classes, objects and attributes (see Figure 2.). During visualization the data set by the user in one form or another (in table, graphical, schematic, text, graphic, etc.) are displayed in special interactive software.

Table 1. Classifier (input data)

Name	Information view
<i>FKKO</i>	Data about manufacture wastes (data of municipal solid and radioactive wastes don't include)
<i>OKATO</i>	Data about political division objects
<i>OKTMO</i>	Data about municipal objects
<i>OKTMO</i>	Data about national economy objects
<i>OKVED</i>	Data about type of economic activity
<i>OKPO</i>	Data about entity (company and organization)
<i>OKP</i>	Data about type of the production
<i>OKIN</i>	Data about population

Fig. 2. Structure of the SWL information model

Fig. 2 shows a general structure of a model [17-20]. Information is divided into types, constituting subsystems A, B, ... (for example, information about the waste, product data), structured by external links (auxiliary attributes). Each subsystem is divided into classes I, II, ... (for example, as part of the subsystem "Data on waste classes' characteristics of waste", "waste management", etc., derived from the FWCC.), structured by internal links (also by auxiliary attributes). Each class is represented by a plurality of objects 1, 2, ... , or, values, instances of classes, on the one hand , and on the other hand, the objects of the class are characterized by a set of properties a, b,... For example, attributes (fields, properties) of the class "characteristics of the waste" are "dangerous

properties", "hazard class", "physical state", etc., and objects are specific types of waste: " households waste", " street garbage " etc. Each attribute can have a set of values a', a'', ..., for example, "the hazardous properties" can be "toxic", "ecotoxic", "fire hazard", "risk of explosion", "high reactivity", "infectious diseases", "activity et al.", various combinations thereof. Attributes themselves have attributes 1, 2, ..., they are common to all of them (indicated in capital figures): "Code", "name", "value", "data type", "presentation format", "note", etc.

By implementation and morphological normalization of "raw" data, the interrelationship is established between any two classes of different types of information. In particular, the joint

processing of classifiers directly related to the object of information modeling (FKKO-the Federal Classification Catalogue of Waste, the state register of landfills, the SWLs classifier) and those, that have no direct relation to it (ARCPS (Russian Classifier of Administrative - Territorial Division), OKATO (Russian Classifier of Territories of Municipal Units), OKONKh (Russian Classifier of Economy Branches), OKVED (Russian Classifier of Types of Economic Activity), OKPO (Russian Classifier of Enterprises and Organizations), IEC (Industrial Enterprises Classifier), OKIN (Russia Classifier of population) allows to establish new connections

between the objects of the world having the correlation. In the SWL-case, for example, the following connections are set: SWL and the sources of their origin, type of production and formulation of industrial landfills, legal persons and the risk spectrum of outgoing types of waste, production waste and outgoing types, population and volume of debris, etc. For better structuring correlation of information relationship between the connections of "external" classifiers, such as OKATO and OKTMO, OKONH, OKVED, OKP are calculated by means of morphological processing.

Fig. 3. Structure of resulting classifier and database of unauthorized SWLs

Fig. 3 shows a special case of the structure in Figure 1, where information models - the database, qualifier and archive of unauthorized SWLs as special cases of information models of SWLs, are missing now (note that there is a qualifier of authorized SWL: State Register of waste disposal facilities). The detecting block of unauthorized SWLs calculates the detection areas on the images of medium and high resolution in accordance with the procedure of SWL-detection [1-4] and compares them with SWL-sanctioned maps. The results of detection of unauthorized SWLs according to space monitoring data in on-line mode arrive to the input of data-forming block of data patterns. According to the results of morphological processing procedures and normalization of data, updated models are built in the current mode t (or historical t') time. In accordance with the imaging parameters (information, shape and display range) given by the operator, the normalized

data are properly visualized. As far as the structure of the database is concerned, it is represented by common parameters (name, type, location, comments, notes, etc.); geographical parameters (coordinates in different geographic projections, surrounding and including the administrative and territorial units (AU), etc.); geometric parameters (area, perimeter, debris concentration estimation accuracy, etc.), and others. Here also are the photos and images, links, online resources, severity, time of occurrence and disappearance t_1 t_2 (they are detected in the images), notes. The model of SWL-classifier is represented by the classification code in the form of $X.Y$, where X is the classification code OKATO and $Y = ZZZZ$ - serial number of SWL in the composition of the limit for the hierarchical structure of AU X (unsaturated sites, such as the Balashikha District of the Moscow Region, have $Y = 0000$). For complete identification of SWL an additional code that identifies the

geographic location of SWLs at the Earth's surface is introduced in the AB format, where A is width, B - longitude in HHHMMSS.SSSS format (HHH - degrees, MM - minutes, SS.SSSS - seconds; 4 digits S set the maximum geographic detection accuracy). The qualifier keeps current SWLs, i.e. those that exist at the current time t (t').

Each next input in the SWL data model is assigned a serial number N, binding database, and the archive classifier of SWLs. Historical SWLs, that has already disappeared by the time $t_2 < t$, are transferred from the classifier to the archive, and each new SWL is assigned the next sequential number. The database contains information on all SWLs (current and historical).

RESULTS - EXAMPLE ON A PART OF INFORMATION MODEL

Here is an example of the information model of large SWLs within the Russian Federation (municipal landfills, illegal dumps, large operating and recycled landfills, waste piles, recycled quarries, etc.). Figure 4 shows authorized SWLs database structure.

Table 2 presents model components (database table): 1) "general information" (name and type of SWL, the name of the works on NEOs, Internet links and other sources of information, physical location, including AU); 2).

"The geometric parameters of NEOs" (height, area, number of storeys, the average angle of the slope, the shape of the object); 3) "data georeference" (geographical coordinates in angular and metric units, geographic coordinate system and projection distance to the nearest town); 4) "data on AU" (the types and names of all "address" to limit AU, including "way" and the name of AU characteristics (OKATO, ZIP code, population); 5) "data on legal persons" (type and company name, VAT number, postal code, type, and name of the settlement, the type and name of the street, house number, OKPO code, email address, etc.); 6) "data on individuals" (last name, first name, position, phone, e-mail address, etc.) 7) "data about licenses objects" (period of operation and location, date of issue, limit the placement and to use, a limit on the ground, the number and duration of the license limit number, date of registration, etc.); 8) "data on waste" ("e" waste, FWCC code, hazard class, limit, license number, waste status, hazardous properties, aggregate state, etc.); 9) "Data on types of economic activities" (NACE at the code index, the name of

economic activity, and others. In the connecting tables related objects of proper classes, for example, in T51 - under the jurisdiction of what institutions are these or those large SWLs are included. Classes that characterize corresponding model tables are set, on the one hand, by many objects of these classes (Table 3), and on the other hand, by a plurality of attributes of the class (Table 4).

CONCLUSIONS

The use of information modeling in the task of SWLs space monitoring improves the performance of the work of environmental authorities and also improves the efficiency of the SWL-monitoring in different scales (space borne, airborne and ground). The morphological processing of extensive neighborhoods round the model object (not just SWLs) increases the amount of information links and allows to acquire an access from one class of information to another, located on a large "distance" from each other and seemingly unrelated to each other, or related but this relationship has not been calculated yet.

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Figure 4. The structure of the database of authorized NEO

Table 2. Components of the information model

№	index	Name
<i>Custom classes</i>		
1	T1	General information
2	T2	Geometric parameter of NEOf
3	T3	Data georeference
4	T4	Data on AU
5	T5	Data on legal persons
6	T6	Data on individuals
7	T7	Data about license objects
8	T8	Data on waste
9	T9	Data on type of EA
<i>Link-classes</i>		
10	T51	Link object – legal person
11	T56	Link legal person – individual
12	T89	Link waste – type of EA

Table 3. Part of the data from T1, 2009

Object code	Name	Type	...
1	Kutchino	Current municipal landfill	...
2	Yadrovo	Current municipal landfill	...
3	Ashitkovo	Current municipal landfill	...
4	Dolgoprudny	Current municipal landfill	...
5	Domodedovo	Closed municipal landfill	...
...	...	...	...

Table 4. Class structure, table T1 (attributes)

№ Fields	Name	Type	Description	...
1	Code T1	Indicator	Number of the object (SWL)	...
2	SWL name	Short text	Official or well-known name of the SWL	...
3	SWL type	Short text	Type of the SWL (municipal dump, cluttering, landfill etc.)	...
4	Work name	Long text	Work name for creation, exploitation or reclamation of the SWL)	...
5	References	Short text	References to the articles, photos, other data, published in the Internet)	...
6	Placeme nt	Long number	Territorial placement of the SWL, the way of the replacement to the point (markers, distance, nearest locality etc.)	...
7	Code T4	Long number	Number of the AU, giving the strict address of the SWL, including the locality	...
...	...	...	...	...

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Информационно моделиране на обекти за съхранение на отпадъци

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Резюме. В настоящата работа се предлага методология за разработване на информационен модел /база данни/ за обекти за съхранение на отпадъци /ОСО/ като се използват данни от дистанционен мониторинг на Земята и in-situ данни. Методологията по-специално включва процедурите на морфологични обработка, нормализиране на данни и модели за визуализация. Цялостната структура и състав на информационния модел е представена и описана в подсистеми, класове, обекти и атрибути (свойства) на данните. Описана е възможността за формиране на нови информационни отношения, които възникват между различните видове информация, чрез морфологичното (и частност морфемното) обработване на "сурова" информация на входа, като например между класификаторите (отпадъчни продукти, селища, стопански дейности, и т.н.). В представената работа са използвани методите за системен анализ, методи на математическата лингвистика, методите за космически мониторинг. Като пример е представена структурата за изграждане на база данни, архивът и класификаторът на неоторизирани съоръжения за депониране на отпадъци (сметища за твърди отпадъци, строителни отпадъци, общински сметища и други). Схемата на модела на данните описва компонентите (таблици) като част от модела: обща информация, геометрични и географски параметри, данни за гео-привръзка, данни за включени и прилежащи териториално-административни единици и др.

Ключови думи: обекти за съхранение на отпадъци /ОСО/, сметища, информационен модел, база данни, класификатор, класификация на обектите за съхранение на отпадъци, държавен регистър, данни за атрибутите на обектите

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