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SPECIFICATION OF THE METHODOLOGY FOR THE REVIEW OF CLUES OF CONTAMINATED SITES OBTAINED WITH THE USE OF REMOTE SENSING

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KEYWORDS

Inventory of contaminated sites, methodology, remote sensing, clues of contamination, interpretation of clues

ABSTRACT

In the initial phase of the 2nd stage of the National Inventory of Contaminated Sites (NIKM), we are focusing on the collection of clues of contaminated sites using Remote Sensing methods. Looking over the first batch (about 38,7 % of the territory is evaluated) of data recorded in the ORPs ("small districts"), we set the details of the methodology for the 2nd degree of interpretation of the clues, i.e. for the review of the data from the 1st degree of interpretation. Four reviewers (review interpreters) are involved in the review of the clues interpreted by twelve 1st degree evaluators. A simulation of three kinds of approaches to the interpretation was done in one "average" ORP. A considerable part of the clues from the 1st stage of interpretation was eliminated via unification in the case of multiplied clues, or deleted in the case of misinterpretation and/or of their little importance or insignificant interpreted volume. In some cases, retyping was applied. Final selection of clues is considered to be the result of the standardized approach of the reviewers. Comments from the discussion forms a set of recommendations for the review process.

1. INTRODUCTION

The 2nd stage of the NIKM project is focused on the inventory and evaluation of information on contaminated sites throughout the Czech Republic. The partial project task "Support of the Inventory by Remote Sensing Methods and Map Services" is taking place from January 2018 to April 2019 and it is provided by CENIA. Inventory methodology includes analysis of raster data (aerial photomaps and satellite images). The supplier's mapping teams for the field inventory will obtain, among other data sources, a data layer containing information about the type of clue of the contaminated site.

2. TYPOLOGY AND KNOWLEDGE BASES OF OBJECTS OF INTEREST

Types of clues were already defined in the 1st stage of the NIKM project, being based on the published methodology [1] [2] [3]. In February 2018, at the beginning of the 2nd stage of the NIKM project, the types were slightly updated, i.e. - completed with three new types *b*, *t* and *r* [4] – see Table 1. The knowledge base of the expressions of clues and the specification of their typology were included in the methodical aid - the interpretative key (manual).

Tab. 1 Types of clues of contaminated sites used for interpretation within the NIKM 2nd stage project

Code	Contamination type	Code	Contamination type
<i>a</i>	industrial park with an impact on the environment	<i>p</i>	suspicion of illegal dump site
<i>b</i>	industrial brownfield	<i>s</i>	a new clue linked to the site already included in SEKM database
<i>c</i>	illegal dump / landfill	<i>v</i>	scrapyard
<i>h</i>	dunghill	<i>z</i>	abandoned agriculture object/farm / agricultural brownfield
<i>j</i>	silage pit	<i>n</i>	unrecognized, other type of clue
<i>l</i>	abandoned quarry	<i>t</i>	waste dumps within the industrial area
<i>o</i>	abandoned property	<i>r</i>	object identified only in DMR (Hill Shaded Digital Terrain Model)

2. SCHEDULE AND STATE OF THE INTERPRETATION WORK

Work started in early 2018. In January and February, a preparatory phase took place, including the updating and optimization of the methodology for the interpretation of the clues in raster documents and the training of the team for the use of the QGIS software and the development of methodological instructions (interpretation key). As a mapping unit we chose regional districts – ORP (Municipality with extended competence = "small districts", there are 206 in Czechia). Their areas are very different in size (the smallest is 45 km², while the largest is 1242 km²),

but their number (206) allows for a fairly accurate division of tasks among team members. Working standards were set so that the entire task of interpreting the clues would be completed by a set deadline of April 30, 2019.

As to the basic statistical characteristics of the information already obtained, until 10. 9. 2018 the area of 38,7 % of the territory of Czechia where the inventory will occur (approx. 78 000 km²) has been already covered with the 1st degree interpretations. On 10. 9. 2018, a few days after the beginning of the review works (2nd degree of interpretation) we have covered 1760,5 km² (i.e. 2 % of the territory subjected to NIKM inventory).

3. STANDARDIZATION OF PHOTOINTERPRETATION OF CLUES FOR USE IN THE REVIEW PROCESS

3.1 Simulation of inputs to interpretation and to the review process

Primary data on contaminated sites and potentially contaminated sites are collected by a team of 12 trained specialists. In spite of the fact that already during the design of the primary data collection process, the phenomenon of individual approach to interpretation has been foreseen, it is necessary repeatedly to consider the individual differences in the evaluation of clues. Therefore, it is necessary to find a way how to get the optimal set of clues for the field survey, to capture the clues of the most serious suspected contaminations and to suppress the less serious ones. For the review interpretation stage, we simulated possible different approaches to evaluations. For modelling of variation in primary interpretation, independent interpretations of clues were carried out on ORP Jaroměř by 4 leading reviewers. The goal was to homogenize and standardize the quality of the data acquired. Each reviewer took a different approach (simulation role) to acquiring primary data, close to his own evaluation method, so that we can obtain sets of clues in a given ORP of different density and different spectrum of types. Emphasis was placed on the consensus assessment of localization and on accuracy of the assigning to the type of clue. The following Figures 1 and 2 show the results of the interpretation achieved with these different approaches.

The comparison of reviewers' approaches took place on the predominantly industrial and agricultural ORP Jaroměř district. Its area is 139 km². Figure 1 shows a superposition of the data of each interpreter used to compare the results of the primary interpretation according to different approaches. The triangular signs of the clue differ in colour by four interpreters (see legend in Table 2). Blue and orange colours indicate clues from a very economical interpretation (interpreters A and B), red coloured clues are from the optimal access to interpretation (interpreter C), and green signs are for clues from a thorough evaluation (interpreter D).



Fig. 1 Summary of the clues recorded in the ORP Jaroměř by four interpreters (the 1st degree of interpretation)

3.2 Comparison of different approaches to the interpretation

For economic reasons, it is necessary to select from the collected records only those clues that necessarily require a visit by field groups. Comparison of the reviewers outputs therefore took place in three steps: In the first step the results of the 1st degree evaluation were aggregated into one common file in which multiplicities were solved. In the second step we worked on the merged first step output and a review of all recorded clues was subsequently performed. Above each record, there was a discussion of the type of clue and its inclusion or exclusion from the final set of clues. Several findings were reassigned to a more appropriate type of clue. The final – third step was merging the result of primary interpretation and review. Removal of redundant and reassignment of misidentified clues were performed by operations within the attribute table in the QGIS software application. For the field survey, evaluators and reviewers' comments (limited to 50 characters) are also important.

In the case of simulation and standardization of the performance of the 4 reviewers in the ORP Jaroměř, out of the 385 clues (the sum of the interpretations of the 1st degree from 4 interpreters) 139 clues there remain for a mandatory, on-site visit and assessment within the future field survey – see Table 2. This is the result of a collective, standardized review.

Tab. 2 Data and comments from common interpretation and review of clues in ORP Jaroměř

Type of clue	Interpreters and the signs of their clues in photomaps				No. of clues	Comments and recommendations for reviews
	A 	B 	C 	D 		
<i>a</i>	0	0	0	4	7	The "a" type includes also agricultural areas, specify in comments (e.g. includes "p", "t", "v").
<i>b</i>	2	2	1	5	5	Do not record individual houses / objects in destruction.
<i>c</i>	2	18	0	3	3	Mark only obviously operated landfill, which is not registered in the IPPC and SEKM
<i>h</i>	6	2	6	4	8	Mark only long-term and unsecured dunghill, from 100 m ² . Do not delete. Mark "d".
<i>j</i>	0	3	0	0	1	Rare, if possible keep it.
<i>l</i>	14	2	0	2	16	Visible in the image even without DMR.
<i>n</i>	0	4	0	3	3	If it cannot be assigned to other types, keep it.
<i>o</i>	0	0	4	3	2	Do not record individual houses / objects in destruction.
<i>p</i>	21	33	71	41	63	The key to include in "p" is the size, which should be at least 20 m ³ . Already recorded clues do not delete, just mark "d". Do not record the earth from excavations and storages of bulk materials (gravel, sand, coal, peat, compost etc.).
<i>r</i>	0	0	5	23	3	From the DMR, to assess taking into account the neighbourhood, obvious old quarries mark directly "l".
<i>s</i>	0	0	1	1	1	Mark only new superimposed clues to older SEKM sites.
<i>t</i>	1	17	4	20	4	Mark only individual "technological" landfills suspected to risk management, otherwise to mark the whole site as "a".
<i>v</i>	1	3	1	16	3	An irrelevant scrapyards just mark ,d'. In case of a small number of up to 5 wrecks on private area do not record if manipulation is not apparent (e.g. dismantling).
<i>z</i>	13	3	2	18	20	Do not record individual houses / objects in destruction.
Sum	60	87	95	143	385	Total number of interpretations from interpreters and sum of all clues. The average number per interpreter is 96 clues.
Number of eliminated multiplicities					120	Fusion of the clues of the same type or of different but aggregatable type on one site or on one area.
Number of deleted clues ("d")					126	The clues misinterpreted or non-conforming to size requirement .
Total of discarded clues					246	They are not the basis for field survey.
Final number of clues (=385-246)					139	Total number of clues after review. In subsequent field survey, they will be required to be visited and assessed. 36% of the original number of clues from the 1 st degree of interpretation.

In Figure 2 the result of the common review is presented in graphical form. The white crosses represent excluded clues and the clues prepared for subsequent field investigations are indicated by the red triangles.



Fig. 2 The result of the standardization of the interpretation of the clues by a common interpretation of the 2nd degree (review), ORP Jaroměř

3.3 Standardized output from discussion of interpretations of clues in the ORP Jaroměř district

It is quite rare to see the exact match of the assessment of the same location even with experienced specialists. However, a more detailed view shows important insights:

- Despite a different approach, many clues are placed relatively close to similar clues from another evaluator.
- The indices tend to concentrate on certain areas of which have favourable conditions for emergence.
- A too economic (“low-density”) approach leads to a lower number of indications from the 1st degree of the evaluation, but there is a risk of omission of significant clues.
- Review work with a higher number of clues is paradoxically faster, as the reviewer no longer has to deal with the risk of omitting a significant finding and evaluate the entire ORP again.
- It seems to be optimal to make a record of medium-density, and then to evaluate each of them in a detailed view, usually above the actual photomap.
- The reviewer should no longer go through the whole ORP, but only assess the clues already recorded.

3.4 Feedback to primary photointerpretation

In the case of a larger number of evaluators (12) their different individual approaches have to be taken into account. These differences are reflected in the collection of primary data, as there are not mathematically precisely defined requirements for data form, but rather the use of personal experiences and their projection into graphic and text recordings in a relatively free form. The task of the reviewer is to unify and optimize the records. The content of feedback from the reviewer to the primary evaluator is especially important and can help with the quality of input for review. The recommendations for evaluators are mainly:

1. Accurately record the observed phenomena, but avoid obviously unnecessary records.
2. Not try to play a role of a reviewer, an important finding could be omitted.
3. In case of doubt it is better to record the clue instead of omitting it. If the clue is irrelevant, it will be eliminated in the review process.

3.5 The procedure for 2nd degree interpretation (review) and the first data acquired from it

The process is paradoxically simpler in the case of a sufficient density of clues. It is enough to browse row by row through the attribute table in the QGIS software environment and display each clue in a scale of 1:1000. In the case when the reviewer decides to exclude an inappropriate clue, then fills the "d"(deprecated) character in the

REV column in the attribute table. If he finds that the finding is correct but differs from the type of clue, he will enter the correct type of clue in the REV column. If one of the primary evaluators applies a very restrictive approach with a small number of clues, it is necessary to go through the entire ORP at least briefly, or randomly, for example, on every 10th square (4x4km), and by a new interpretation to check that obvious clues are not systematically neglected. The first set of data from the review works is provided in Table 3.

Tab. 3 Summarization of the data from recently started reviews in 4 ORPs (1,8 % of the inventory area of Czechia)

ORP	Area in km ²	Number of clues			
		1 st interpretation	2 nd interpretation (review)	Difference	Reduction in %
Jaroměř	138,6	143	139	-4	97
Kutná Hora	643,1	362	171	-191	47
Nepomuk	308,7	139	119	-20	86
Nové Město na M.	292,8	148	104	-44	70
Říčany	377,3	388	271	-117	70
Total	1 760,5	1180	804	-376	67

5. CONCLUSIONS

According to the first findings, we are achieving the goal of the optimal coverage of the territory subjected to inventory using the established review procedure.

The monitored parameters are the numbers, respectively density of clues and their importance. The standardization of interpreters' performance and the optimization of quantity and credibility of recorded clues is crucial to streamline financial and logistically demanding field surveys within the NIKM 2nd stage project.

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