THE FUNCTIONAL POTENCIAL ASSESSMENT OF THE LANDSCAPE AFFECTED BY THE EXTRACTION OF RAW MATERIALS

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ABSTRACT

The article analyses the basic issues of procedural methods for evaluating the environment affected by the exploitation of mineral resources in the Czech Republic. The areas that were affected by the industrial activities in the past and are not used currently are called Brownfields. These areas create the side effects called externalities from their very beginning. The first part explicates the basic views of the methods of assessment and evaluation of the environment and related negative and positive externalities incurred. Another part of this paper assesses the affected area using two methodical manners. The first manner is the commonly used called Hessian method and the second is new proposed methodical manner so-called **FUPO** ,,The **Fu**nctional **Po**tential assessment and resultant externality in the industries areas" which has been created in VŠB-Technical University of Ostrava.

Keywords: COBRAMAN, brownfields, real functional potential, positive externalities, environmental evaluation

INTRODUCTION

The greatest destruction of landscape and environment in the Moravian-Silesian Region in the Czech Republic is associated with the mining of mineral resources. The area of Ostrava-Karviná Coalfield belongs to the areas where the mining industry is highly developed. An integral part of mining activities is spoil heap construction. In spite of the fact that generally spoil heaps are regarded as undesirable, they can be, on the contrary, understood as very valuable habitats with a high potential. Spoil heaps become suitable safe sites for endangered, often even critically endangered species, above all animals [1, 4, 5]. An integral part of mining activity is the emergence of side effects, or externalities, which can be called positive and negative externalities [3,7]. From an environmental point of view are examples of negative externalities of water contamination, air or soil, which may occur up at the wrong mining or reclamation. Conversely examples of positive externalities is increasing biodiversity, increasing the effects of societal functions of forest trees on a properly carried out the reclaimed land areas of mining subsidence basin or aquifer, which is in a relatively short time become Refugio many species of plants and animals [5].

MATERIAL AND METHODS

Sophia Spoil Heap

The Sophia spoil heap is situated in the Orlova - Poruba cadastral area in the Moravian-Silesian Region. The total area under study is 9.47 ha and is divided into 2 parts by a class II hard surface road No. 470. First mounds here were made as early as 1871 and was a total heap of stored 874,000 tons spoil rock. For evaluation of environment of Sophia spoil heap before human intervention was used materials and maps from the period prior to the 1871st. This was particularly the maps first, second and third military survey maps and the time of the so-called Theresian mapping. The reclamation of this spoil heap started in 2003 and completed in 2006. Biological reclamation consisted of planting trees: Pedunculate Oak **(***Quercus robur* **),** European Beech **(***Fagus sylvatica***),** European Hornbeam **(***Carpinus betulus***) ,** Hedge Maple **(***Acer campestre***) ,** European Ash *(Fraxinus excelsior***),** Small - leaved Linden **(***Tilia cordata***) ,** Black Alder **(***Alnus glutinosa***),** Sea buckthorn **(***Hippophae rhamnoides***),** Common Privet **(***Ligustrum vulgare***) ,** Viburnum **(***Viburnum opulus***),** Common Dogwood **(***Swida sanguinea***),** Hawthorn **(***Crataegus monogyna***).** [8]

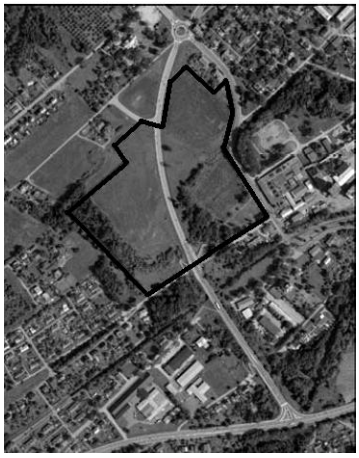

Fig.1 Sophia Spoil Heap (www.google.cz/maps, 2011)

Methods of landscape evaluation

In determining the economic values of environmental objects and services neoclassical environmental economics, in principle, preferential accesses and expert ways (modes) [7]: expert methods for example so-called Hessian method, which specifies the fees for a loss (or subsidies for improvement), the ecological function. Most recently, the Hessian method is also recommended by the EC Commission White Paper on environmental liability for damage to biodiversity assessment [9]. Hessian method uses two ways of direct recalculation of original value for the financial formulation. The first uses the actual exchange rate and the second the purchasing power parity, which is stated by EUROSTAT backwards to the previous year and as an extrapolation for next year. The current state is for purchasing power parity as follows:17,6059 CZK/€ - average 2010.1 point = 0,32 € = 5,6339 CZK. For practical application in Czech Republic was Hessian method modified [3,6]. This way of Hessian method defines the types of natural biotopes according to the system Nature 2000 in the Czech Republic, and they developed the types of biotopes stated in the Catalogue of biotopes of Czech

Republic [2]. They assigned the given point value based on eight criteria with the possibility of transfer this value into the financial expression. But this method does not evaluate the most important character of nature and that's the possibility of autoregulation and spontaneous regeneration. These characteristics are typical as well for the nature distant biotopes, which may thanks to their development in time and own conversion change the biotope at that moment with the low evaluation value for the biotope with much more higher value. [4] For this reason, the team of Technical University of Ostrava, started developing a methodological approach, which aims to calculate the real potential of the functional environment, which comes from Hessian habitat assessment methods, but is already considering a change in the rating of new biotopes due to their increasing value over time. This new methodology is called the Functional Assessment of Potential environment (for next FUPO assessment). All biotopes are evaluated in terms of quality with ecological factors (abiotic and biotic factors) and social factors (economic, technical and socio-economic factors), which indicates Fig.1. Point ecological and social value of each habitat further adjusted by coefficients and provides for the emergence of environmental and social potentials of the territory. Adding these two potentials arises functional potential of environment.

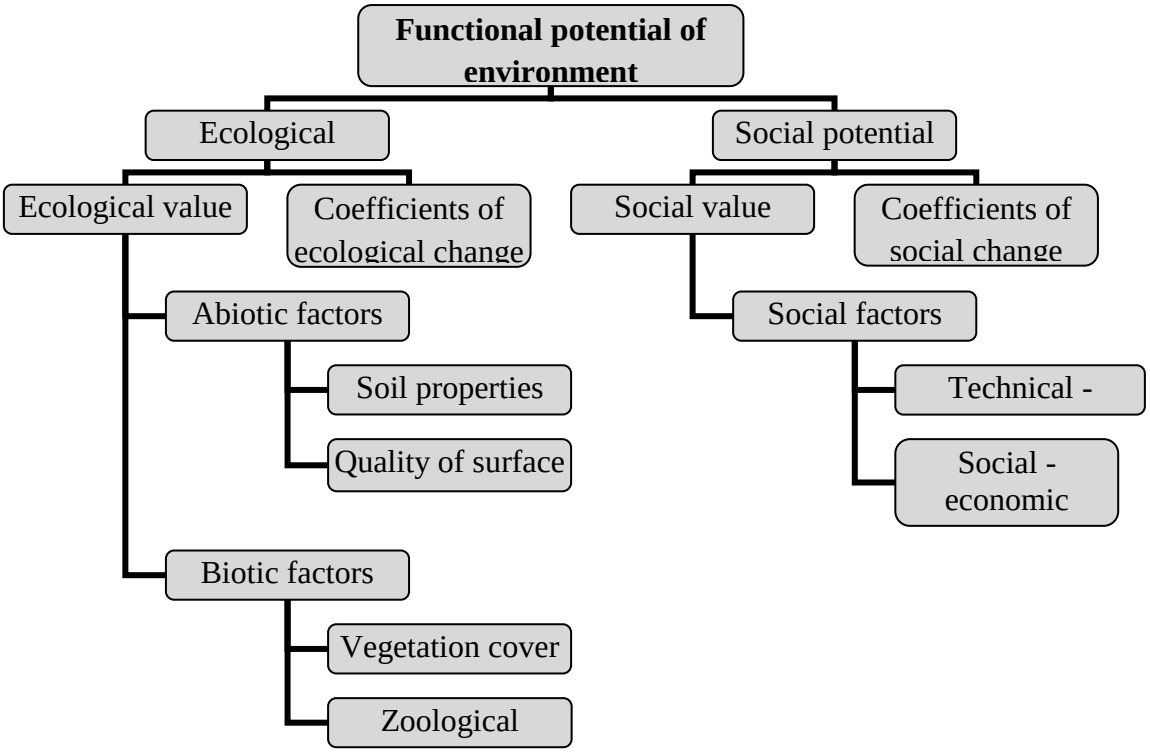

Fig. 2 Evaluation of functional potential of environment

The basic idea of the new methodological approach is concerned with evaluating habitat in terms of beginning and end of the industrial activities, ie. the calculated point value of each habitat present in the affected area before the start of industrial activities and after the completion of all reclamation activities.

By this will also be created by the potential of the two values:,, Last functional potential“ (before mining operations) and ,,current functional potential“ (after the reclamation). After deduction of each other potential values arises the Subtracted value of last and current functional potential (for next SV) which is either positive or negative and specifies whether the Long-term functional potential is low or high (table 1)

Tab.1 Long-term functional potential

Long-term functional potential	Subtracted value of Last and Current functional potential
High	- Number
Low	+ Number

This SV is influenced by factor of disturbance and by factor of local-regional preference. These factors determine the final location externalities, which can be either positive or negative. Externality resulting tells whether the area (caused by reclamation) is less valuable than a territory, which was here in the past (this is a negative externality) or on the contrary the successful reclamation and re-created habitats show the area much more valuable (positive externality).The area can have greater value after reclamation for example by creating high quality and ecologically valuable habitats (various planting trees, grasslands, creating small ponds and reservoirs etc. or creating job opportunities and residential occasions) compared to the monotonous surfaces for agricultural utilization before mining activities.

The factor of disturbance setting

The factor of disturbance indicates the extent of the territory damage and its fair chance to improve the situation. It is evaluated by particular points. The positive points indicate any or insignificant disturbance (point value 1) and moderate (point value 0.5) and slightly increased disturbance (point value 0.1). These positive points represent a disturbance, which leads to a temporary, short or medium term damage landscape. By negative points are assessed significant disturbance (point value -0.5) and irreversible disturbance (point value -1), which causes long-term damage landscape.

The factor of local -regional preference setting

The factor of local – regional preference indicates the measure of a specific social interest in a given place at any given time. The factor depends on the documentation of zoning, special long-term goals of regional authorities and landlords. The positive points indicate very high (point value 1), high (point value 0.5) and middle social interest (point value 0.1). By negative points we consider this interest as low (-0.5 points) or very low or none (point value -1).

RESULTS

Sophia Spoil Heap was initially evaluated by a standard Hessian method and then by the newly proposed methodological approach FUPO assessment. Tables 2 and 3 indicate the point value of each habitat before saving spoil substrate and after reclamation according to The Catalogue of biotopes of Czech Republic [2]. Fig. 3 gives the calculation of functional potentials by methodological approach FUPO assessment.

1) The environment of landscape evaluation by Hessian method

Tab. 2 Average point value of the area before mining operations

Number	Type or sub-types of biotopes	Biotope value (PV/m 2)	Area (m²)	Area (%)	Point value of area (AV_1)
70	T1.1 Mesic Arrhenatherum meadows	33	24,337.9	25.7	803,150.7
72	T1.3 Cynosurus pastures	39	7,197.2	7.6	280,690.8
89	T4.2 Mesic herbaceous fringes	41	2,178.1	2.3	89,302.1
112	L3.2 Polonian oak-hornbeam forests	55	1,136.4	1.2	62,502.0
159	XL1 Hedgerows and alleys	25	1,988.7	2.1	49,717.5
160	XL2 Lone trees	25	94.7	0.1	2,367.5
174	X4.4 One-year and autumn plants on arable land	10	48,297.	51.0	482,970.0
179	X5.2 Biotopes of vegetable gardens	14	9,470.0	10.0	132,580.0
	Sum		94,700.	100%	**1,903,280.6**

Tab. 3 Average area point value after the reclamation

Number	Type or sub-types of biotopes	Biotope value (PV/m 2)	Area (m²)	Area (%)	Point value of area (AV_2)
70	T1.1 Mesic Arrhenatherum meadows	33	34,565.5	36.5	1,140,661.5
89	T4.2 Mesic herbaceous fringes	41	2,178.1	2.3	89,302.1
151	XT3 Intensively managed and degraded mesic meadows	13	37,690.6	39.8	489,977.8
156	XK2 Fallow land with bushes and trees	24	2,462.2	2.6	59,092.8
157	XK3 Trees of railway or road embankments	17	568.2	0.6	9,659.4
159	XL1 Hedgerows and alleys	25	2,178.1	2.3	54,452.5
163	XL5 Glades, forest plants and restoration forest planting	17	15,057.3	15.9	255,974.1
	Sum		94,700.0	100%	**2,099,120.2**

The calculation of the area value by purchasing power parity:
AV = € (AV_1-AV_2) * 0.32 €
AV = € (1,903,280.6 - 2,099,120.2) *0.32 €
AV = - 195,839.6 *5.6339 CZK
AV **= - 1,103,340.7 CZK**
Where:
AV - value of area calculated by purchasing power parity
AV_1 - point value of site before mining operations
AV_2 - point value of site after reclamation

2) The environment of landscape evaluation by FUPO assessment

The Fig. 3 shows the calculation of functional potential of area before mining operations and after reclamation and subtracted value of these potentials.
With respect to limited scope of the paper is not published the total process of ecological and social factors calculating but only their final results.

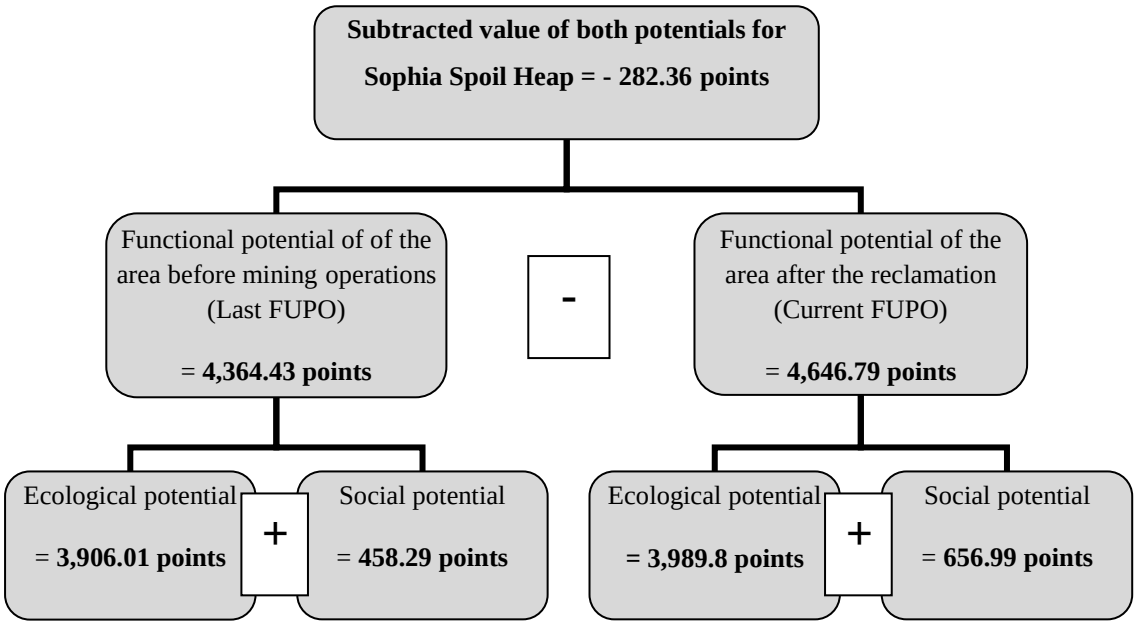

Fig. 3 Calculation of functional potential of area before mining operations and after reclamation

The subtracted value of last and current FUPO has **- 282.36 points**, so it is negative number and it predicate of **high** long-term functional potential because the value of area after reclamation is bigger than area before mining activities (see table 1).This situation is caused by new special conditions of the new area after reclamation, because the agricultural landscape before mining activities has quite one-way and straight potential for agriculture or grassland cultivation and single cropping. The new area has bigger potential especially social potential for new industrial and residential activities that can bring new job opportunity and economic development. The ecological potential for current situation has slightly more then before mining operation and this is the effect of well-done reclamation as well.

Calculation of resulting externality value

To calculate the final value of externalities is an important factor in disturbance and local - regional preferences. There has not been established relevant mathematical method of financial externality statement and that is why the current evaluation is conducted at the point expression.

The **factor of disturbance** was determined for Sophia Spoil Heap value of **+0.5**, which represents a slight disturbance, which leads to short-term damage the countryside, particularly in terms of climatic, biotic and social conditions. The **factor local - regional preference** is characterized by a value of **+1**, which represents a very high preference particularly diverse in terms of future land use, such as building industrial site and create new jobs, expansion of existing buildings, build playgrounds and in terms of natural phenomena to improve drainage conditions in the countryside, variety mosaic structure of habitats such as forest and meadow and creating new conditions for plants and animals.

DISCUSSION

Subtracting the point value of the area before mining and after reclamation by using both methods (Hessian method and newly proposed methodological approach FUPO assessment) we found that the result is a negative number. This number indicates a higher point value of the area after reclamation. Although the reclaimed area obtained by the Hessian method more points (than the area which was here before), that is not evident increasing value over time of each newly created habitats. There are especially the habitats that were established during the forestry reclamation in order to create full-value and ecologically stable forest ecosystems, such as Habitats XL5. These habitats represent currently young and less ecologically stable ecosystems, but over a few decades would be bring near natural biotopes which will be closer to forest biotopes typical for this landscape for example: L3.2 Polonian oak-hornbeam forests with value 55 points.

There are the questions: are newly created habitats, mainly regarded as anthropogenic denaturalized habitats really less valuable than near-natural habitats? And have they correctly set the pointed value? Maybe they are underestimated by reason than the application of this method does not calculate with properties of self-regeneration and self-reproduction habitats. The example of this underestimated habitat could be the habitat XL5. The value of habitats XL5 and L3.2. shows the difference 38 points. If the value of habitat is bigger would be bigger the value of the whole area. This confirms the creation of positive externalities and the fact that due to mining activities was established more valuable area after reclamation than area before the spoil storage of materials. The term, Positive externalities" are not widespread in the specialists subconscious but today it is confirmed that the emerging habitats, which were left to spontaneous regeneration or reclamation plan appropriately applied (e.g. by managing succession) form rare ecosystems with high ecological value [4]. The problem comes with the evaluation of these habitats because of their age and maturity, when some of them are in early stages of succession, and therefore they are assigned a low value. In practice this means that a habitat could get more points of assessment if it is credited with 10 to 30 years after the completion of reclamation and remediation. In addition, there was missing for the calculation, (using the Hessian method) variable value characterizing the social needs and requirements of the newly established area. In direct response to the absence of methodical procedure, showing the positive effects of mining activities and in particular the social requirements for the emerging area was at the VSB-Technical University of Ostrava initiated an expert analysis of the issue and prepared documents for the creation of new methodological procedure for determining the real potential function and the resulting externalities. The new proposed methodological approach reflects evolution of habitat age and allows with other procedures and the possibilities of land use. The proposed expert approach will assist specialists evaluation environment do not miss out the aspect of a future conversion and the subsequent creation of value over time. Thanks to this process will intensify upcoming events with a view to restore the functions of damaged landscape. The new approach will be a tool that will help to choose a rehabilitation actions and measures which are not only he most economical and best for the landscape at the moment, but which can (because of their future potential) help further increase value of the area.

CONCLUSION

In the present article has been evaluated the Sophia Spoil Heap by two expert methods: commonly used Hessian method and newly proposed methodological approach FUPO assessment. The heap was evaluated in terms of its present value in comparison with the value of area before storage spoil material. There was also calculated long-term potential of the area, which was established as a high. Then the factor of disturbance and factor of local-and regional preferences was set for future calculation of the value of the resulting externalities.

Acknowledgment

The subscription originated in relation to solution of **European project 1CE014P4: Manager Coordinating Brownfield Redevelopment activities – Central Europe Programme co-financed by the ERDF** and Czech grant SP/201097: Verification and application of a methodology for the purposes of evaluating the externalities of reclaimed and remediated areas of mining landscape.

REFERENCES

[1] BELL, L.C. Establishment of native ecosystems after mining-Australian experience across diverse biogeographic zones.Ecological Engineering,2001.17(2-3): 179-186.

[2] CHYTRÝ, M.; KUČERA, T.; KOČÍ,N. Habitat Catalogue of the Czech Republic. The Agency for Nature Conservation and Landscape Protection of the CZ, Praha, 2001.307 p. ISBN 80-86064-55-7

[3] PĚGŘÍMEK, R.; PELEŠKA, O.; KRUŽÍK, F. Kvantifikace externalit vznikajících těžbou a užitím hnědého uhlí a algoritmizace výpočtu externalit modifikovanou hessenskou metodou [online]. [cit. 2009-7-11]. URL: http://www.czechcoal.cz/cs/ur/spoluziti/CL/4_Peleska_externality_ExternH.pdf

[4] POLANSKÁ, J.; LACKOVÁ,E.;STALMACHOVÁ B. Evaluation of externalities in the long-time influenced mining area in orlová - poruba. Geoscience engineering, 2011, 57(1) ISSN 1802-5420

[5] SÁDLO, J.; TICHÝ, L.Sanace a rekultivace po lomové a důlní těžbě:Tržné rány v krajině a jak je léčit.1.vyd.Brno: ZO ČSOP Pozemkový spolek Hády, 2002.ISBN 80-9031-211-X.

[6] SEJÁK, J., DEJMAL, I. and others: Hodnocení a ocenování biotopu ČR (Evaluation and pricing habitat CR). Praha: Český ekologický ústav, *2003, 450 p.*

[7] ŠIMÍČKOVÁ, M. Environmentální ekonomie *I.* Ostrava: Učební texty VŠB-TU Ostrava, 1998. 148 s. ISBN 80-7078-530-6.

[8] Team of authors DIAMO, s.p., odštěpný závod Odra: Rekultivace odvalu Žofie. *GSP s.r.o. Ostrava-Poruba, 2002, č. 60020350, s. 8-17.*

[9] TURNER, K.; PEARCE, D.; BATEMAN, I. Environmental Economics. An Elementary Introduction. Harvester Wheatsheaf, 1994