SUSTAINABLE DEVELOPMENT AND ENVIRONMENTAL QUALITY ENHANCEMENT AS A MOTIVATION FACTOR FOR LAND MANAGEMENT METHOD RESEARCH

Aleksandar Trifunovic[1], Ivan Stevovic[2], Svetlana Stevovic[1]
1- Faculty of ecology and environmental protection,
University Union Nikola Tesla, Belgrade, Serbia
2- Faculty of Business Economics, Singidunum University, Belgrade

Abstract

Environmental quality increase and global worming prevention are strong motivation factor for research in the field of land management recovering. Coal, as non renewable resources and its exploitation causes immense disturbances in the environment and on the globe. Large land areas are damaged and destroyed in the mining industry, much more than in other industries. Open mines, deep depressions, mining pits and holes are economically unutilized areas. Disturbance of natural assembly of agricultural land in the vicinity of open mines areas leads to the inability of lend use for crop production, because the land lost productive capacity and therefore this land is out of agricultural land fund. It makes a big loss for the country's economy, directly in financial sector and indirectly through environmental damages and increase of global warming. This paper is dealing with the investigation of the most suitable contemporary methods in long term land management and motivation factor for it. The methods are developed theoretically and through experimental results on Kostolac open coast coal sites as a case study. Optimal land management recovery method is selected and recommended.

Keywords: *Environmental quality, motivation factor, land management, recovery method, Kostolac enterprise.*

1. INTRODUCTION

Thermal power plants, opencast mines, ash dumps and accompanying pollution are some of the major agents of human health disorders [27], environmental disturbance and global heating [24]. The opencast mine Drmno was opened in 1987 and has remained the only coal supplier to the enterprise Kostolac. The mine development triggered deterioration of environment, degradation of agricultural land [30] and its transformation into new morphological forms [9]. Since then, about 890 ha of arable agricultural land have been degraded. For overburden disposal, 180 ha beyond the mine borders have been occupied (external dump). Nowadays, the overburden is disposed of within the mine (internal dump), where approximately 1,938,360,000 m^3 of overburden are planned to be disposed of. By mine expansion to reach the capacity of 9×10^6 tons of coal a year, as required for continuous plant operation, another 1740 ha of arable land shall be degraded by the end of the mine's operation lifetime. This paper presents the results of research on contemporary methods which are most suitable for renewal of areas affected by opencast mines, in long-term land management, in the context of sustainable development [16]. The methods are theoretically developed and tested on the example and experimental results from the opencast mines of the Kostolac enterprise. The optimal method of land recovery management is selected. If the environmental quality [8] should be defined as the goal, then it becomes a motivation factor for research in the domain of damaged land recovery management methods [19].

2. EXPERIMENTAL SAMPLING

The natural land is completely deteriorated by removal of overburden [15]. This manner of overburden excavation and disposal results in creation of a substrate of very heterogenous composition, belonging to sandy-clayey loams [2]. Physical properties of such soil are presented in Table 1.

Table 1. Physical properties of soil

Soil depth per profile (cm)	Participation of fractions (%)						Texture
	Sand		Silt	Clay	Sum		
	Coarse-grained >0.2	Fine-grained 0.2-0.02	0.02-0.002	< 0.002	Sand < 0.02	Clay >0.02	
0- 20	3.10	15.90	28.90	52.10	19.10	81.00	Clay
20- 40	4.60	36.70	45.00	13.70	41.30	58.70	Loam

The soil fertility depends on its chemical properties. Chemical composition of overburden depends on the composition of substrates it is formed of and on the chemical processes[26]. The chemical composition includes numerous macro and micro elements (Ca, Mg, Zn, Mn and others) [14], as well as humus and main biogenic elements N (nitrogen), P (phosphorus), K (potassium).

Humus is of immense relevance for forming of deposol structure, meaning that not only the mineral NPK fertilizers but also organic matters of plant origin and stable manure need to be imported in deposols, or the green vegetation mass needs to be tilled. All this makes up the agrochemical properties of soil as presented in Table 2.

Table 2. Agrochemical properties of soil

Profile depth (cm)	pH in KCl	Chemical composition				
		Humus	$CaCO_3$ (%)	N (%)	P_2O_5mg/100g	K_2O mg/100g
0- 20	7.50	1.67	4.99	0.02	5.40	27.90
20- 40	7.50	1.67	6.30	0.02	5.20	30.00

3. RESEARCH METHODS

Various experimental and numerical methods of ecological parameters incorporation in technical systems optimization models have been explored so far [12]. The sustainable and holistic development, and the imperative of environmental quality preservation, are motivation factors for development and research of possible land recovery methods within strategic management of land as a resource.

3.1. Method of Land Preservation – Selective Excavation of Materials

Selective soil disposal in the overall recultivation procedure is exceptionally important and mandatorily applied. The remark that soil solum is particularly separated by selective disposal is highlighted because in the recultivation procedure so far the soil solum material was homogenized with geological substrate. Recultivated surfaces are sooner or later engaged in active plant production, which is unfeasible without properly planned selective soil disposal.

Legislation stipulates that the recultivation process includes a special measure called *selective disposal*. By its application, upper soil layers are separately removed, and then returned to newly formed surfaces after completion of utilization. However, the practice so far has provided for performance of this task by unselective removal of part of soil profile.

From all of the above, it is concluded that selective disposal of overburden can no longer be considered, because its recultivation does not activate the productive ability of land in an economically justified manner. It is required to carry out selective disposal of soil, i.e. its solum, which is the carrier of its fertility.

3.2. Method of Discontinuous Application of Selectively Excavated Material

Unlike continuous application, where the adverse properties of previously destructed land are carried over to the newly formed one, the discontinuous application has no such properties. By proper engineering, knowing the properties of overburden dumps, it is possible to constitute a new substrate with even superior features to those of previously destructed land, which would pay off in economic terms.

Discontinuous application of a previously excavated part of solum, from the aspect of recultivation, is targeted towards creation of new substrate with optimal productive abilities. Application of selectively excavated material in this way, for recultivation purposes, has several advantages: higher quality of newly created substrate; accurate planning of required cubage to be used, depending on the location; capability to plan the excavation, i.e. its required volume per locations; and capability to plan the required machinery and organization of works.

3.3. Data Processing Methodology

Theoretical procedure of degraded land recultivation implies two major phases, namely: technical and biological recultivation. Actually, since one phase depends on the other, they are analyzed, designed and implemented together, in order to achieve the best possible end results – in other words, to recultivate the degraded land as efficiently as possible.

The recultivation is implemented through the following procedures: The first condition for the beginning of recultivation is the fact that the land degradation process is certainly finished and that no subsequent degradation shall take place under normal circumstances; Analysis of degraded land which should result in reliable information on its composition, shape and surroundings; Selection of adequate planting material which takes into account the micro and macro conditions prevailing on the degraded land and in its surroundings; and Definition of minimal biological conditions necessary for proper development of selected plants, in fact for biological recultivation.

3.4. Technical Recultivation Method

Technical recultivation precedes the biological one and it includes land development on external and internal overburden dump (or on damaged land), including rough and fine terrain leveling, construction of roads and channel network and dump slope support. The technical stage of land recultivation includes land surface preparation for subsequent intended-purpose economic utilization, renewal of the fertile layer, surface leveling and removal of hazardous matters. Mines carry out the technical stage of recultivation which includes: Planning of damaged land surface (rough and detailed); Leveling or terracing of overburden dump slopes and lateral sides of opencast sites; Elimination of consequences of dump settlement; Erosion protection measures; Removal, transport, disposal and backfilling of fertile soil layer or suitable (fertile and potentially fertile) overburden on recultivated land areas; A set of land improvement measures, in order to improve the chemical and physical properties of overburden and its compounds, which make up the surface layer of recultivated land; and Construction of hydrotechnical and amelioration facilities, roads and other engineering communications.

It is very important that the works on technical recultivation are performed constantly for the most favorable possible recultivation results. Technical recultivation implies the most extensive engagement of machinery and human resources. Before a dump is formed, the first phase of technical measures is stabilization of subsoil for the future dump and its forming, drainage or installation of drainage system. After this phase, the overburden is backfilled and the dump is formed in phases.

The subsoil, i.e. the soil on which the dump is to be formed, may possess unfavorable geomechanical properties. To strengthen the subsoil, woven geotextile or geonet may be used. Reinforcing elements, which are made of textile, are more resistant to damages than polymer meshes with firm connection points. Geonets have lower strain coefficient than geotextile, and do not conform to the terrain and loads to the same extent.

Since dumps are exposed to actions of surface and ground water, it is necessary to set up drainage systems. Nonwoven geotextile may be used for lining of drainage pipes. In this case, water filtrations play an important role, so that minute soil particles cannot enter the drainage system. Drainage system tests, after an extended time period, have proved that a thin layer (2-3mm) of minute particles has formed on the geotextile outside, having partly protruded into the approximately 20mm thick granular layer. By use of nonwoven geotextile, it is possible to apply drainage without a drainage pipe.

Dump forming in phases implies backfilling of the overburden layer to certain thickness, thus creating the conditions for uniform mixture of geological strata. Upon completion of backfilling, the surface needs to be planned and all soil stabilization measures applied. After consolidation of this overburden layer, the next layers are backfilled, until filling up the dump to the designed elevation. For soil stabilization, the same as in the previous case, geonets and geotextile are used.

The next measure is planning of final horizontal and inclined surfaces of the dump towards achieving maximum terrain stability. The planning needs to be carried out in several phases. After completed planning, underground structures are to be executed, if envisaged by the design (irrigation and drainage systems, infrastructure facilities, planting pits, etc.), and they must be in the function of terrain stability.

3.5. Biological Recultivation Method

The biological stage of land recultivation includes measures for soil fertility rehabilitation after technical recultivation. It is performed as a group of agrotechnical and phito-

melioration measures targeted towards flora and fauna renewal. Biological recultivation continues and represents upgrading in terms of agrobiological land training for plant production. The recultivation is preceded by systematic pedological and geological field investigations. Suitability of overburden soil for biological recultivation is assessed based on the following parameters: Contents of nutrients; Reaction of the medium; Contents of toxic matters; and Water-physical properties.
The factors relevant for success of biological recultivation on overburden dumps are: 1. the overburden origin and method of disposal; dump configuration and position; 3. use of surrounding area and objectives of biological recultivation measures; 4. conditions for plant development; 5. climatic features of the region; 6. condition and contents of existing vegetation on dumps; 7. selection of overburden dump recultivation techniques; 8. selection and quality of seeding and planting materials; and 9. professional capacity to implement biological recultivation measures.
Agriculture-oriented recultivation of damaged land is preferred when all the other conditions are the same, particularly in densely populated regions where the agricultural production bears a broader general economic importance.
Forest-oriented recultivation is carried out when the agricultural recultivation is not appropriate due to natural and economic factors, when there is an outstanding economic demand for forest production and necessity of environmental improvement, creation of recreation zones in industrial basins or erosion protection.
Biological measures are applied in the final phase of recultivation. Biological recultivation implies growing of field and fruit crops, aforestation, etc. Freshly dumped materials, after technical recultivation, settle down for 1-2 years, and micro depressions are formed causing the following sequence of field and fruit crops sowing: Year I–small grains, Year II–peas or vetch as green manure and Year III–alfalfa as a long-term crop.
On dumped materials of an opencast mine, recultivation could be performed with low crops. To accelerate the process, it is necessary to import large quantities of mineral and organic matters, in order to compensate for the loss of main nutrients, particularly nitrogen and phosphorus. Beside the sowing of crops for green manure and alfaalfa, liquid manure and lime are also added to the soil. This phase is followed by forming of crop sequence of wheat, corn, barley, rapeseed, soy beans and sunflower.
So far, orchards have been most often grown on recultivated surfaces. Some fruit may be grown only if microdepressions are excluded, and clayey soil is provided with irrigation and drainage. On a sandy substrate, apples have the best yield, but also pear, plum, apricot and other fruit may be grown. In our country, at initial phases of opencast site development, the so called external dumps are formed. Tending to occupy the least possible fertile land, the dumps are raised to maximum altitudes, so they are impossible to transform into fertile land suitable for agricultural production. For that reason, the recultivation is in this case performed by aforestation.

3.6. Aforestation Method and Technology

The technology of aforestation is selected mindful of the kind of dump, kind of plant, and must be compatible with the method of substrate preparation. The most frequently applied method is aforestation by planting in pits at 2x2m spacing on flat parts, and 2x1.5m on slopes. The norm for a hectare is 2,500 to 3,000 seedlings.
For planting of seedlings, pit dimensions should be 40x40cm, because that depth and width are sufficient for proper settlement of the underground plant parts. A 5% reverse slope in planting pits should be formed on slopes, not only for water collection but also for erosion

prevention. On inclined parts of dumps, the species should best be planted by hand, and on flat parts it is possible to organize machine planting. The best season for planting is spring, before development of buds, and it lasts until mid summer when it abruptly diminishes in August and September, and then it restarts with lower intensity in autumn and lasts until winter frosts.

Incorrect planting is often the cause of poor seedling survival, which later induces new material costs for filling in the crops. Proper handling of planting material is also very important for the success of dump landscaping. Possible arid summer seasons can be solved by adaptive capacity of fragmented landscapes [28], or it needs additional irrigation to be provided in the first two years after planting.

4. RESULTS-OPTIMAL LAND RECOVERY MANAGEMENT METHOD

In the first year of work, foliaceous and deciduous species were grown on an experimental plot, and later on mixed crops. Among foliaceous crops, the following were used: black, white and Weymouth pine, larch, spruce and Douglas fir. Better results were achieved with coniferous species whose survival and growth do not fall behind the plantations on normal forest soils. The conducted experiment proved it best to use autochthonous species during biological recultivation. The productivity of artificial ecosystems of alfaalfa and spontaneously grown areas on ash and overburden was measured according to Collins and Weaver. This method included: Identification of habitat type; Identification of vegetation type which occupies the habitat; Measurement of all parameters of trees on areas 5 times 20 meters, classification of trees in 10 classes according to DBH, identification of yield and biomass of production of all parts above ground; Measurement of all brushwood parameters on isolated areas, identification of their biomass and productivity, measurement of tree top diameter in cm, classification in 6 classes; Measurement of all parameters of aboveground herbaceous floor on micro areas, calculation of production; and Calculation of mean value for all classes and standard deviation from the mean value. By surface exploitation of lignite and disposal of overburden and ash, deposols of diverse inclinations, physical and chemical properties were formed. In their contents, in broader terms, these deposols vary from sandy-clayey loam to loam and sandy soil. In line with their contents, their chemical properties vary as well, characterized by low contents of humus (1%), low contents of nitrogen, potassium, phosphorus and scarcity of micro and macro elements.

Within conducted research, next Adaptable kinds of conifers on damaged land (overburden) were: 1. Abies nordmanniana – Caucasian fir, 2. Larix europea- European larch, 3. Pinus nigra- Black pine and 4. Pinus silvestris- Scots pine. Adaptable species of foliaceous plants on damaged land (overburden) were: 1. Fraxinus excelsior L. – Common ash, 2. Betula verrucosa – European white birch, 3. Alnus glutinosa – Black alder, 4. Populus nigra – Black poplar, 5. Populus alba – White poplar, 6. Robiina pseudoacacia – Black locust, 7. Tilia sp. – Lime tree and 8. Salix sp. - Willow. Adaptable species of decorative brushwood on damaged land (overburden) were: 1. Spirea vanhoutteii - Bridalwreath, 2. Cotoneaster horizontalis – Rockspray cotoneaster, 3. Pyracantha coccinea – Firethorn and 4. Lonicera nitida – Boxleaf honeysuckle.

On recultivated areas of the opencast site Drmno, black locust (*Robinia pseudoacacia L.*), black poplar (*Populus nigra L.*) and black pine (*Pinus nigra Ehrh*) were planted. The best productivity was demonstrated by black locust, while the black pine lags in growth and is quite exposed to illegal removal. Planting of Siberian elm (*Ulmus pumila L.*) was also attempted, however, it produced negative results. Self-seeding plants encountered in this area were the white poplar (*Populus alba L.*), black poplar *(Populus nigra L.*) and willows

(*Salix sp.*).The largest success on the overburden dumps of the opencast site Drmno was achieved by locust tree, which demonstrates rapid initial growth and sprouting ability. In such stands of trees of incomplete composition, the herbaceous floor is well developed and has a high cover. On deposols of lighter mechanical composition, fine productivity was demonstrated by black and white poplar. Existing recultivated areas are exposed to adverse antropogenic impacts – burning, illegal cutting and extraction of seedlings, while illegal dumps are often formed in their vicinity. During future aforestations, this factor should be also taken into account, and the adverse effects should be prevented by appropriate educational programs and cooperation with local population.

5. DISCUSSION

5.1. Correlation Between Forest Vegetation and Degraded Land Improvement

By stripping of agricultural crops, a significant portion of mineral matters and nitrogen is taken away from the soil and, at the best, only the root is left in the ground. Accordingly, the role of an agricultural husbandry implies land fertility maintenance by various measures and methods, including additional import of nutrients in the form of fertilizers during appropriate tilling. Removal of nutrients with forest vegetation does not reach a considerable extent because the mean annual demand for nutrients in forest vegetation is much lower than in agriculture [29]. Most of the nutrients needed by forest vegetation are returned to the soil every year through bristles or leaves [31].

The roof system of trees spreads in the ground to the depth of 1.5 to 5 meters and, unlike agricultural crops, it can be supplied with nutrients from a much larger depth. Accordingly, the biological properties of trees are rather different from grass vegetation, particularly the annual plants.

Further to a research conducted in Germany, calcium reserves on sandy land for oak and beech are sufficient for 240 years, and in case of fir, pine and foliaceous plants, for 1200 years. Other important elements suffice for beech for 840 years, and for pine for more than 1600 years [22]. Starting from this, it is possible to give only a qualitative characteristic of oak, beech and fir which indicates to considerable differences in the demand for mineral matters in oak and beech as compared to conifers, and also confirms to some extent the ability to supply trees with nutrients.

There as positive and negative impacts of forest vegetation on improvement of degraded land [21]. The positive impacts include all those which give a new quality to the soil, producing positive effects on forest productivity growth. The negative or useless ones are those which do not provide for normal growth and productivity of forest trees. The most favorable impact of biological factors on soil is most reflected on modification of other – internal conditions of soil forming. For example, during groundwater level rising or excessive moistening from the surface [23], when surplus water cannot run off naturally, ponding of land takes place [13]. Then there are changes in forest crown, firstly the grass flora transformation into moss, and then forming and accumulation of peat. In modified natural conditions, trees first lag in their growth, then die. If the internal conditions of soil forming do not change, the change in soil properties under the forest influence occurs only as an effect of its growh.

5.2. Adaptable Species on Degraded Lands

The most drastic changes on land are caused by its occupation by industrial facilities, i.e. infrastructure building [21]. That way, the land is permanently deprived of its primary production. In the last couple of decades, rapid industrial development took place, causing increased energy demand, primarily for mineral raw materials and increased mining activities [10]. Those intensive urbanization and industrialization processes affected vast agricultural areas [17]. Many natural ecosystems have been affected by exploitation of natural resources. In basins of large mines [11], thousands of hectares of fertile land are covered by mining pits, ash dumps and overburden dumps. Such coal exploitation and its combustion in thermal power plants is happening in all parts of the world, from deserts to coastal areas. It produces adverse environmental effects. One of the main recultivation measures is the biological land recultivation. This program implies successive cropping up of land on dump parts which are formed and the land is prepared for fast growing of grass and other vegetation. During recultivation, biological measures should not be considered separately from technical ones. High efficiency of these measures lies in their combination.

5.3. Impacts of Grass Vegetation on Degraded Land Improvement

It is well-known that particular plant species may contribute to the stability of various loose soils by rapid development of their root system. Grass cover, as one of the most resistant species in landscaping, produces the best results, regardless of exterior conditions [25]. In permanent landscaping of flat areas – grassing up, such grasses are selected which have the ability to bond the substrate and to protect it against water and aeolean erosion.
Selection of a grass-leguminous mix presented in tables 4 and 5 mostly depends on the altitude and quality of substrate [1]. Grass mix seed should have good germination, and for that reason it should be supplied from specialized institutions. The objective of grassing of flat areas on mine dumps is to create green grass areas for the purpose of protection against aeolean erosion.

Table.4. Grass-leguminous mixes I

Name	Mass (kg)	Percentage (%)
Meadow fescue	15	30
Birdsfoot trefoil	15	30
Common vetch	6	12
Red fescue	9	18
English ryegrass	5	10
Σ	50	100

Table 5. *Grass-leguminous mixes II*

Name	Mass (kg)	Percentage (%)
Cocksfoot	13	26
Meadow fescue	10	20
Field brome	10	20
Birdsfoot trefoil	10	20
White clover	7	14
Σ	50	100

The following properties have to be taken into account as well:
- Resistance to specific conditions in the medium;
- Tolerance to climatic conditions;

- Distribution;
- Cover and
- Ability to bond substrate and maximum ground cover.

6. CONCLUSION

Strategic land management involves primarily holistic approach to the environmental quality system. The land is a resource, important for any state. Its optimal utilization implies the principle of sustainability. Therefore, it must not be allowed to one generation, or to some generations, to use it while leaving behind adverse effects of exploitation to future generations.

This paper presents possible land recovery methods and an experiment made on opencast mines Drmno, from which the thermalpower plant is supplied with coal. The imperative of environmental quality preservation was the motivation factor for the research conducted and implemented in the economy. From a series of analyzed methods, the optimal land recovery management method was selected and applied in the enterprise Kostolac in the function of sustainable development.

Acknowledgements

The results of herein presented research were achieved within projects of technological development of the Ministry of Education and Science of Serbia EE18031 and TR35030.

References

1. Đulaković, G. (2010): Recultivation and Landscaping, VTŠSS, Požarevac
2. Technical Design of Recultivation and Spatial Development of Areas Covered by Exploitation Works, (2007), Belgrade
3. Simić, S., Kotlajić, M. (1997): Possibilities for Recultivation of Land Damaged by Opencast Coal Mines, Land and Plant, Belgrade
4. Korunović, B. (1990): Land Improvement, Čačak
5. Dimitrijević, S., Ilić, S. (1993): Main Elements of Technical Recultivation of Opencast Mine Areas, gathering "Mining Industry at the Gate of 21st Century", Belgrade
6. Đulaković, G. (2010): Urban Ecology and Decorative Dendrology, VTŠSS, Požarevac
7. Čanak – Nedić, A., Gavrilović, M., Nedić, M. (1998): Importance of Selective Disposal of Coal Mine Overburden from the Aspect of Recultivation – II International Symposium: Mining and Environmental Protection, Belgrade
8. Arsic Milica, Nikolic Djordje, Mihajlovic Ivan N, Zivkovic Zivan D, Monitoring of Ozone Concentrations in the Belgrade Urban Area, Journal of environmental protection and ecology, (2012), vol. 13 no. 4, p. 2057-2067.
9. Mihajlovic Ivan N, Strbac Nada D, Djordjevic Predrag, Mitovski Aleksandra M, Nikolic Djordje, Zivkovic Ivan, Optimum Conditions for Copper Extraction from the Flotation Waste Using Factorial Experimental Design, Environment protection engineering, (2012), vol. 38 no. 4, p. 171-184.
10. Mihajlovic Ivan N, Strbac Nada D, Nikolic Djordje, Zivkovic Zivan D, Potential metallurgical treatment of copper concentrates with high arsenic contents, Journal of the South African Institute of Mining and Metallurgy, (2011), vol. 111 no. 6, p. 409-416.

11. Ivan Mihajlović, Nada Štrbac, Predrag Đorđević, Aleksandra Ivanović and Živan Živković, Technological Process Modeling Aiming to Improve its Operations Management, Serbian Journal of Management, 6(2) (2011), pp 135 - 144.
12. Mihajlović, I., Nikolić, Đ., Štrbac, M., Živković, Ž. (2010). Statistical Modelling in Ecological Management Using the Artificial Neural Networks (ANNs), Serbian Journal of Mangement, 5(1): 39-50.
13. Hranislav Milosevic, Namik Ahmetovich Geydarov, Yuriy Nikolaevich Zakharov, Svetlana Stevovic, Model of incompressible viscous fluid flow driven by pressure difference in a given channel, International Journal of Heat and Mass Transfer, pp 242–246, 2013.
14. Svetlana Stević, Vesna Surcinski Mikovilovic and Dusica Calic-Dragosavac, Full Lenght Research Paper 'Environmental impact of site location on macro and microelements in Tansy', Academic Journals – African Journal of Biotechnology, Vol 9(16), pp. 2408-2412, 2010.
15. Svetlana Stević, Vesna Surčinski Mikovilović and Dušica Ćalić-Dragosavac, Full Lenght Research Paper 'Environmental study of heavy metals influence on soil and Tansy (Tanacetum vulgare L.)', Academic Journals – African Journal of Biotechnology, Vol 9(16), pp. 2392-2400, 2010.
16. Andevski Milica, Urosevic Snezana and Stamatovic Milan, Discourse of Sustainable Development - a Base of Environmental Education in Serbia, Environmental Engineering and Management Journel, (2012), vol. 11 br. 9, str. 1611-1626
17. Zivkovic D, Pozhidaeva V, Molnar Robert, Documentation Accompanying the Lubrication of Agricultural Machines and Requirements Relating to Quality System Standards, (2009), Journal of the Balkan Tribological Association, vol. 15(2), pp 270-279
18. José I. Huertas, María E. Huertas, Sebastián Izquierdo, Enrique D. González, Air quality impact assessment of multiple open pit coal mines in northern Colombia, Journal of Environmental Management, Volume 93, Issue 1, January 2012, Pages 121-129
19. Z Miao, R Marrs, Ecological restoration and land reclamation in open-cast mines in Shanxi Province, China, Journal of Environmental Management, Volume 59, Issue 3, July 2000, Pages 205-215
20. M.S. Li, Ecological restoration of mineland with particular reference to the metalliferous mine wasteland in China: A review of research and practice Original Research Article
Science of The Total Environment, Volume 357, Issues 1–3, 15 March 2006, Pages 38-53
21. Shunsaku Miyagi, From spatial form to system and process through pattern making in the landscape: can landscape design contribute to nature restoration? Landscape and Ecological Engineering, (2005) 1: 71–76
22. Stephanie Sobek, Christoph Scherber, Ingolf Steffan-Dewenter, Teja Tscharntke, Sapling Herbivory, Invertebrate Herbivores and Predators across a Natural Tree Diversity Gradient in Germany's Largest Connected Deciduous Forest, *Oecologia*, Vol. 160, No. 2 (May, 2009), pp. 279-288
23. James M. Castro, Bruce W. Wielinga, James E. Gannon, Johnnie N. Moore, Stimulation of Sulfate-Reducing Bacteria in Lake Water from a Former Open-Pit Mine through Addition of Organic Wastes, *Water Environment Research*, Vol. 71(2), pp. 218-223, 1999

24. B.L. Turner II, Anthony C. Janetos, Peter H. Verburg, Alan T. Murray, Land system architecture: Using land systems to adapt and mitigate global environmental change, Global Environmental Change, Volume 23, Issue 2, April 2013, Pages 395–397
25. Héctor M. Conesa and Rainer Schulin, The Cartagena–La Unión mining district (SE spain): a review of environmental problems and emerging phytoremediation solutions after fifteen years research**, J. Environ. Monit.,** 2010, **12,** 1225-1233
26. Zheng Wang, Jungang Hou, Chao Yang, Shuqiang Jiao, Kai Huang, Hongmin Zhu, Hierarchical Metastable [gamma]-TaON Hollow Structures for Efficient Visible-Light Water Splitting, Energy Environ. Sci., 2013,
27. Denise Howel, Tanja Pless-Mulloli, Ross Darnell, Consultations of Children Living near Open-Cast Coal Mines, *Envir. Health Perspectives*, Vol. 109(6), pp. 567-571, 2001.
28. Mara J. Goldman and Fernando Riosmena, Adaptive capacity in Tanzanian Maasailand: Changing strategies to cope with drought in fragmented landscapes, Global Environmental Change, Volume 23, Issue 3, Pages 588-597
29. Pietrzykowski, M. and Krzaklewski, W., An assessment of energy efficiency in reclamation to forest, *Ecological Engineering* *Vol. 30, Issue 4* , pp 341-348, 2007.
30. Mummey, D.L., P.D. Stahl, and J.S. Buyer., Soil microbiological and physicochemical properties 20 years after surface mine reclamation: comparative spatial analysis of reclaimed and undisturbed ecosystems. *Soil Biology and Biochemistry* No. 34, pp 1717-1725, 2002.
31. Lü, C., and Huang, B., Isolation and characterization of Azotobacteria from pine rhizosphere. *African Journal of Microbiology Research* Vol. 4 No. 12, pp. 1299-1306, 2010.