RECLAMATION WITH TOPSOIL SUBSTITUTION BY ENHANCED BIOLOGICAL RECULTIVATION PROCESS[1]

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Abstract.--A reclamation method called Biological Reclamation Process (BRP), developed in Europe, requiring no topsoil storage, handling and redistribution, has proven that successful reclamation of surface mined land can be accomplished whereby ecological balance and fertility will be restored within one year after mining. The purpose of this paper is to discuss the feasibility of the application of BRP in the United States of America.

INTRODUCTION

Coal strip mine operations can temporarily cripple a large quantity of farmland from production and bring about alterations to the original composition and layered structure of the soil. To minimize surface damage and environmental problems, the Office of Surface Mining (OSM) in the United States has put forth stringent regulations that require, in certain instances, about 1.2 m (48 inches) of topsoil to be placed over the rock spoil for the reclamation of disturbed land after the completion of strip mine operations. The topsoil replacement, one of the cornerstones of OSM regulations, is considered necessary to make this land at least as productive as it was before mining. Otherwise, as believed by many of the experts due to the lack of knowledge, the vegetation cover may be difficult to re-establish, for the absence of the inorganic nutrients and biological life forms in some waste materials and weathered rocks surfacing the spoil piles. The microbiological content in the surface layer of soil, no doubt, can be destroyed by mining and takes considerable time to recover without help.

To eliminate a few of these difficulties, the conventional reclamation methods proceed as: removing topsoil before mining, segregating, stockpiling, seeding, and, after a certain period of time, redistributing it on the regraded area. Often times, the topsoil is fertilized and sown with pioneer plants. Normally, it will take four or five years, if all essential factors are favorite for reclamation, for the full agricultural production to come around.

The Biological Reclamation Process (BRP), a novel method of reclamation developed in Hungary has proven that the vast majority of spil banks can be quickly revegetated without topsoil replacement. This method has been acknowledged effective for reclaiming surface mined land, and also been used to rehabilitate productive areas destroyed by mine waste dumps resulting from underground mine operations or mineral processing and coal preparation plants.

The BRP has been under development since 1967 at the Matraalja Coal Mines in Hungary where many less effective reclamation methods had been tried. The full-scale applications of BRP since mid-1970's proved this new technique both effective and economical. The list of BRP applications includes successful reclamation sites in three continents. The authors of this paper take pride to be part of the effort to promote the BRP applications in the United States of America.

BIOLOGICAL RECLAMATION PROCESS

The full-scale application of BRP is preceded by a series of analyses. The main steps of this procedure is highlighted in the following paragraphs.

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After a strip mining operation is completed, samples from redistributed overburden are collected and tested to acquire data on physical and chemical characteristics of the top layers, including pH, calcium carbonate, phosphorus, potassium, nitrogen, sulfate content and organic. During and after mining operations, samples of soil and rock can be gained from both high walls and spoil pile surface. In addition, information relative to the climate and biological pattern of the site is obtained.

Under certain circumstances, such as presence of extremely toxic substances in the overburden, analysis and data evaluation will be followed by reclamation experiments conducted in laboratory and in-situ simultaneously to determine whether bio-activation will be successful on that spoil material. The effects on plant growth from treatment ingredients and additions, as well as due to soil preparation and climatic conditions are considered. Appropriate bio-active organic matter and BRP mixture containing nitrogen, phosphate and potassium with micro-elements necessary to support plant life, and micro-organisms of various amounts are selected.

BRP APPLICATIONS IN EUROPE

In Europe, the BRP exclusively deals with the mixed spoil piles brought by optimally mechanized surface mining operations without selective topsoil stripping and storage. For example, at the Visonta lignite mine in northern Hungary, the surface of the spoil piles consists primarily of Pannonian clay, sand and laminated sandstone, also andesite tuff and small amounts of recent sediments. Definitely, the ingredients of a spoil pile influence its physical behavior.

Quite contrary to the common conception, the spoil piles from surface mines with continuously operating excavation systems, have no loose surface areas, but become compact and airless if the mechanically and biologically concerted reclamation is not followed shortly after mining. However, the hydrological conditions of piles are favorable to plants, because the ground water levels developing parallel to the piles' surface and change identically with those in the surrounding area. Therefore, the penetrability of piles for water is strongly required to be under control. For this reason, trenches are constructed immediately after leveling the spoil piles, meanwhile the Biological Reclamation Process commences.

One of the European BRP applications is illustrated in figure 1. The over- and interburden removal operations at this multiple seam lignite mine, designed to supply the fuel for a nearby power generating plant, disturbed a large acreage of high-productive primary farmland. The traditional agricultural production activity resumed without difficulty on the fully reclaimed surface mine land within unbelievable short periods of time. The conventional grain production is characterized with the data shown in table 1. In addition, an intensive gardening has been initiated by the coal company in cooperation with the individual agricultural associations which is expected to widen in the future. Typical laboratory test results representing a few of the main vegetable types are provided in table 2.

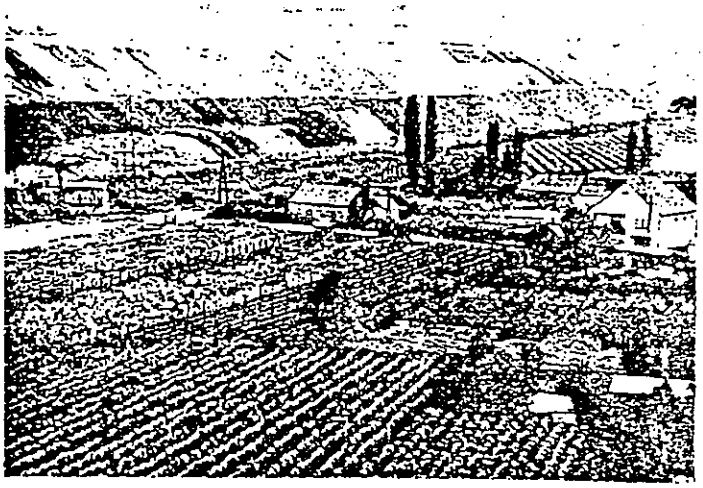

Figure 1.--General view of reclaimed spoil pile slopes and pit floor at Visonta lignite mine in Hungary (Courtesy of Matraalja Coal Company, Gyongyos, Hungary).

BRP PROJECTS IN AMERICA

The American surface mining operations have quite a few similarities compared to those in Europe. The rates of land disturbances are also comparable. The unavailable or damaged topsoil has been considered as one of the main reasons for high coal production costs. In many cases, even the newly developed and cautiously applied alternative reclamation methods failed to achieve the full success in land productivity restoration.

The Biological Reclamation Process, as demonstrated via considerable large area in State of Kentucky, opened new avenues to solving acute reclamation problems. As of the date of manuscript preparation, the following coal mine companies are involved in BRP application: River Processing Coal Company, Falcon Coal Coampny, Haz Coal Company, Hard Dollar Coal Company, Ball Branch Coal Company and Pine Branch Coal Company.

The total surface mined area reclaimed by BRP in eastern Kentucky is about 150 acres. The lowest pH value of redistributed overburden material was 2.8. The other physical and chemical characteristics of the spoil required a careful planning and application of the novel reclamation technique. No topsoil was available at the Coal Ridge Fuels mine for reclamation purposes. The BRP mixture has been applied with conventional reclamation equipment (fig. 2).

Table 1.--Laboratory test results of cereal grain samples from reclaimed area

Description	Date of Sampling	Dry Matter (%)	Ash (%)	Calcium (mg/100g)	Protein Content (%)	P205 Content (mg/100g)	Starch Content (%)	Weight (kg/liter)
Wi. wheat	7/24/86	90.5	1.8	146.4	13.4	1,422	46.9	0.763
Rye	8/01/86	90.9	-	181.7	12.1	1,543	46.5	0.800
Sp. barley	7/24/86	90.6	2.8	80.0	12.1	1,590	48.7	0.694
Wi. barley	7/24/86	91.2	2.6	140.0	12.4	1,665	63.4	0.639

Table 2.--Laboratory test results of vegetable samples from reclaimed mined land

Description of Sample	Dry Matter (%)	Ash (%)	Protein (%)	Sugar (g/100g)	Vitamin C Content (mg/100g)	Phosphorus Content (mg/100g)	Weight (g)
Red beet	19.4	0.87	1.4	8.0	42.2	37	105
Cabbage	11.8	0.85	3.7	3.1	62.0	79	224
Carrots	16.0	1.21	1.1	7.2	22.3	56	105
Turnip	12.6	1.08	2.1	2.8	56.9	79	173
Celery	21.4	0.96	1.5	1.1	22.0	64	133
Parsley	27.2	1.28	1.3	2.9	8.6	38	66
Fodder beet	18.6	-	2.8	-	-	-	1,220
Tomatoes	8.0	0.69	1.2	5.4	36.3	42	37

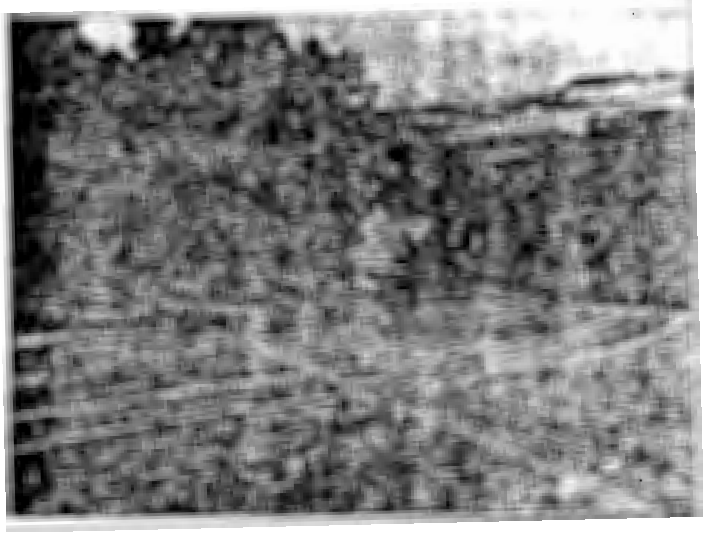

Figure 2.--BRP application at River Processing - Coal Ridge Fuels mine in eastern Kentucky. Soil pH is 3.4. (Courtesy of Geological Sciences and Laboratory, Inc., Hazard, KY).

Reforestation of the surface mined land was one of the final land uses at the Sierra Coal mine demonstration site. White ash was considered as the best tree for the project (fig. 3). In the interest of truth, it is mentionable that no top-soil was used at the site. Actually, it was not required to do so. The main BRP application took place in fall 1985. The trees have been planted in spring 1986. Despite the fact that the summer of 1986 has been extremely dry, the survival rate of trees seems to be excellent.

The Golden Oak mine BRP demonstration site involves black walnut planting as shown in figure 4. The basic parameters of the spoil material are similar to those of possible reclaimable surface mined lands as mentioned in the previous sections.

APPLICABILITY OF BRP IN AMERICA

The objective of the OSM-sponsored research program completed by the staff of the Ohio Mining and Mineral Resources Research Institute was to elaborate the feasibility of transferring BRP to restore the productivity of surface mined lands in the United States (Konya and Gozon, 1981). Specific tasks of this program were: (1) to sample strip mine spoil banks in the Appalachian coal producing region and determine their physical and chemical properties; (2) to categorize the spoil types as easily reclaimable, possibly reclaimable, and not reclaimable with BRP; and (3) to develop a method

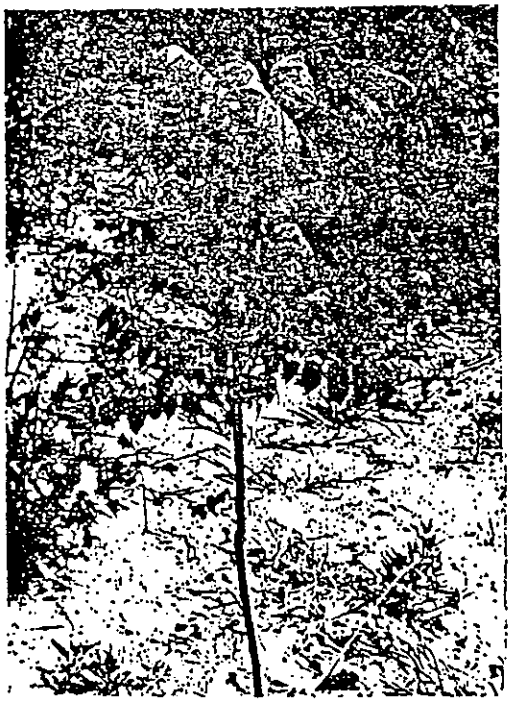

Figure 3.--White ash seedling in reclaimed surface mined area of Sierra Coal mine in Breathitt County, Kentucky; planted in May 1986 (Courtesy of Geological Sciences and Laboratory, Inc., Hazard, KY).

Figure 4.--Black walnut seedling at Golden Oak mine in Kentucky. Planted in April 1986 (Courtesy of Geological Sciences and Laboratory, Inc., Hazard, Kentucky).

of cost calculation and comparison with conventional reclamation techniques.

Within an 18-month research work, ten surface mine sites were sampled and related data were analyzed. Based on the results of the project evaluation, three treatment types of BRP were proposed. The valuable output information has been published in the proceedings of a national symposium on reclamation (Gozon et al., 1982).

ADVANTAGES OF BRP APPLICATION

The published results of post-reclamation investigations with respect to surface mined lands in Appalachia (Popp, 1984) indicate that the main goals of the reclamation technique evaluation were:

- to conduct an overall assessment of the combined efforts on the re-establishment of vegetation on disturbed lands;
- to determine relative effectiveness of various reclamation methods;
- to analyze the need of any corrective procedures including revegetation, sediment control, and earthwork; and
- to evaluate the relative cost of the resoiling and revegetation materials, such as mine spoil, fly ash, municipal compost, paper pulp sludge, and various kinds of their mixtures.

These large scale projects proved that by using revegetation materials as mentioned above, certain elements are introduced into the surface layers which might endanger the plant life rather than support it. At this point, it is worthwhile to be mentioned that the BRP application will not cause any danger to the ecological system of the reclaimed land.

The main advantages of the BRP application are as follows:

- no topsoil is required;
- low pH areas can be treated with this method;
- effective erosion control can be achieved;
- long term success is foreseen;
- reforestation and cropland establishment can be considered;
- BRP is cost effective and easy to apply; and
- earlier bond release is obtained.

CONCLUSIONS

The advantages of using the Biological Reclamation Process for restoring the productivity of surface mined lands in the continental region of the United States are obvious and demonstrated through a number of reclamation sites. The promotion of this novel technique could lead to a considerable reduction in reclamation costs without causing any hazard to the environment. The BRP application can be the ultimate solution to numerous reclamation problems associated with the missing topsoil. A new approach free from partiality is required from the surface coal mine operators and individuals involved in reclamation projects in

order to achieve the best results in the end use of disturbed lands.

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