BIOTIC AND ABIOTIC FACTORS INFLUENCING THE LONG-TERM STABILITY OF COVERS ON WASTE ROCK PILES IN THE URANIUM MINING DISTRICT OF SAXONY AND THURINGIA (GERMANY)

by

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Abstract: This report presents the results of basic investigations of root penetration on various partially covered excavation discard material mounds of the Saxonian-Thuringian uranium mining region (Germany) in comparison to root penetration in autochthonous (native) soils. Bioturbation is an essential, unavoidable impact to consider in addition to root penetration. With increasing age, the functionality of each layer of a cover system becomes diminished through the workings of the local flora and fauna. Pedological cover layers can only temporarily maintain their initial positions and technical functionality. Considering actual prevailing biotic and abiotic influences (e. g. site-specific transpiration rates), the planning and installation of cover systems should take into account (within acceptable balances) factors which are able to at least partially compensate for eventual diminishing of technical functionality.

Additional Key Words: uranium mining, cover systems, root penetration, bioturbation

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Introduction

The WISMUT Limited Liability Corporation as a successor to the former Soviet-German WISMUT Corporation was charged by the Federal Government of Germany to rehabilitate the abandonments of uranium mining in Saxony and Thuringia. These consist of mainly excavation discard rock dumps, tailings, and operation areas. The cover systems are an essential rehabilitation technology for these objects. To realize the rehabilitation tasks, both chemical and radiological investigations for excavation discard material mound characterization and comprehensive soil physical, pedological, and plant physiological investigations are necessary. Therefore a good knowledge with respect to root penetration and bioturbation has a great importance for the evaluation of long-term stability of cover systems.

Cover Systems of the WISMUT Limited Liability Corporation

Rehabilitation of excavation discard material mounds, whether in place or by replacement, requires a closure cover system. The design and installation of cover systems must take into account site specific conditions which determine how the qualitative and quantitative parameters of the individual cover layers and the complete layering system are to be optimized (Table 1).

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Table 1:
Presentation of a Maximum-Conception for Excavation Discard Material Mound Cover Systems

Layer	Function	Thickness (approx.)
Soil	use orientated, with soil improving additives if necessary	< 0.5 m
Storage	vegetation orientated usable field capacity, promotion of evapotranspiration, desiccation protection, drainage retardation, frost protection	0.6 - 1.0 m
Suffosion protection	protection of the drainage layer against fine grain intrusion	0.2 m
Drainage	Allowance of hypodermic drainage	0.2 m
Insulation	Prevention of water infiltration and radon exahaltion	0.3 - 0.5 m
Fill variable	Dump contour smoothing and correction	

With regard to the qualitative conception of individual layers within cover systems of mining excavation discard material mounds, the dimensioning and construction must be carried out according to the existing conditions of the individual rehabilitation project areas. The following are examples of preferred cover systems:

Cover system for excavation discard material mounds rehabilitated in place (Ronneburg site: i.e. Beerwalde mound)

Soil
Storage Layer (till)
Insulation Layer (loess loam)

Cover system for tailings (Seelingstädt site: i.e. Trünzig/Culmitzsch tailings)

Soil
Storage Layer
Drainage Layer
Insulation Layer (kf-value between 10^{-9} and 10^{-10})
Fill Layer
Geotextile and Excavation Rock

Cover systems for excavation discard material mounds (Aue site)

Soil
Storage Layer (till)

Cover Systems under the Influence of the Bioturbation

Bioturbation is generally defined as the mixing of soil by animals. Even so, included in this term are arboturbation (tree heave) and the so called "stomping" caused by the wind moving trees. All of these kinds of bioturbation are regionally different and influenced by ecosystem conditions. Therefore it is necessary for the WISMUT GmbH cover system designers to consider qualitative and quantitative factors of bioturbation in the rehabilitation conceptions of the abondonments of the uranium mining in Saxony and Thuringia. An extensive literature study and field investigations were carried out in consideration of this problem. In all planning of cover systems up to the present, bioturbation is viewed as essential, non-avoidable parameter of influence, as is root penetration.

But in opposition to root penetration, bioturbation has the tendency to homogenize individual technically designed cover layers.

The functionality of the cover system layers decreases with increasing age and is limited by the pedological development potential of the used substrata. All cover layers have a limited functional lifetime. Therefore acceptable balances with regard to biotic and abiotic factors of influence should be aimed at compensation for losses in technical functionality of the layers (increasing field capacity by bioturbation, root penetration of drain layers connected with loss of technical functionality). It is especially important to evaluate the influence of the bioturbation on succession and open land areas, since the lack of urbanization aids in the resettlement of relevant animal species (Table 3).

In any case, at least some measures in consideration of the bioturbation rate are always feasible and necessary. An initial evaluation of the faunistic influence potential on earthen cover systems shows the necessity to take preventative steps for the maintainance of the systems.

Table 3:
Depth influence by relevant animals (WEIHRAUCH und SCHEIBERT, 1998)

Species	**maximum depth of influence (m)**
soil eater (earthworms)	2.0
shovel digger (mole)	2.0
scrape digger (ants)	0.7
rooter	
- rabbits	2.7
- mice, pigs	0.5

To maintain qualitative and quantitative parameters of the cover systems, one possibility is to establish soil barrier layers that are unattractive to intrusive fauna. These layers are for the most part characterized by infiltration promoting properties that work in combination with drainage layers. A further possibility for influencing the rate of bioturbation is the intensity of later use. After installation of the cover and first cultivation, at least 3 to 5 years should be set aside for a homeostasis to be reached (through cultivation of forests and green cuts of open areas) to attain better conditions for the predators of the species which contribute to bioturbation. Stone debris (rip rap) placed on of the top of the cover can provide small habitat spaces, serving both nature protecting and bioturbation preventing ends.

Long Term Stability of Excavation Discard Material Mound Covers

Root penetration and bioturbation are essential influence factors on pedogenesis. After installation, the covers are exposed to the soil building processes. But decreases in the technical functionality of the covers is not inevitable. It is necessary to design and install the cover layers corresponding to the future use of the area. The effective field capacity is a decisive factor that determines the effective root space, which in turn restricts root penetration and protects the insulation layer. This is of key important in realization of the technical parameters of the cover.

Additional methods of regulation are possible through selection of suitable plant species and depend on the water content (infiltration water) given by root penetration intensity and depth (stability) associated with the particular species and their distribution density.

In the first years, substantial differences exist between the root penetration behavior of covers and comparable autochthonous soils. A explanation for this is the deviated soil physical parameters of the constructed cover systems in comparison to the autochthonous soils. The initial condition of synthetic cover systems is characterized by a disturbed soil texture. And so begins pedogenesis through its associated processes of root penetration (root growth, symbioses), bioturbation, and soil texture formation (suffusion, clay deposition).

The most essential and deciding optimization factors, in terms of long-term stability and promotion of rehabilitation progress, are founded in the assessment of the potential of the existing horizontal formation of the embedded substrata and its actual technical parameters (kf-value, dry bulk density) as well as the induction of this development through the design and installation of a cover configuration.

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