THE RISKS OF THE RE-CULTIVATION PROCESSES OF BROWN COAL SURFACE MINES

G. PANDI, P. G. BERKESSY

ABSTRACTS.- The risks of the re-cultivation processes of brown coal surface mines. Brown coal is a vital source of energy to the world. Over the years new energy sources where looked for, but due to the high world wide demand due to the economic growth around the globe, brown coal production is facing more and more interest. Together with it go the geologic and natural related processes being affected due to the coal harvest, including surface, water, wildlife and as well humans. Illustrated by examples of the German area of Lausitz, given problems are being described. A mayor part of an approach of solutions to the future planning of the affected area, is the re-cultivation process, including its positive, negative aspects as well as the related risks. Taking all means into consideration, re-cultivation can lead to a long term benefit of land in ecological as well as economical conditions.

Key words: risks, brown coal mines , planning, rehabilitation, dump problems.

1. Introduction

Brown coal at present is gaining after the last years of decline, again strength in their potential of energy source used primarily for electricity in relation to their relatively low production costs. Former brown coal surface mines have been reactivated again. Looking at the present production of the overall demand, we can see that especially the new economy countries and the third world countries are depending in many aspects of the brown gold. The biggest producer of brown coal at present is Germany with more the 19% leading the statistics.

Beside the constant demand and search for new technologies and standards for power plants emitting less CO_2 into the air and like this help to decrease the pollution is one of the mayor goals at present. But it should not be forgotten, that all land used for surface mining over the last years also have to be looked at in detail.

As a important factor has become the re-cultivation of surface mines after their use, leading these very often wide and open areas after their use back into a future with perspectives. Different attempts and projects have been realised or are under way, including lake side areas for touristic use by flooding the old mines,

golf courts or off road parks. In all cases the ground has to go through a important phase of change, where all related aspects of these stages are effected. These affections can lead to serious risks not only for nature, but as well to natural resources like water, being in consequence a risk as well to humans and animals if not looked at carefully.

That's why the exact planning of the landscape and its use followed after the mining processes are necessary. Knowledge about geophysical and geochemical problems of the affected region is a basic element for this.

In most of the western countries, strict regulations by the authorities for the mining rehabilitation and re-usability as the goal of the reactivation of former mining areas guide the necessary steps and demand them legally from the companies operating the mines. These guidelines are regulated by the official law books related to mining issues, like for example in §4 Abs.4 BBergG of the respective German law, which defines the correct re-cultivation process, which must be taken into concern in regards to the used surface areas under the focus of the public interest. The means for this process in regards to technical and financial resources are very demanding and of a big quantity. Areas have to be recreated in a way, that the future planning can be realised and that a safe access can be guaranteed.

Due to the huge influence of the mining activities in the landscape, the consequences can never be hundred percent re-cultivated to the natural status. That's why there are remaining several problems in relation to the ground and water, which still are present and affecting its surroundings after the land has been given back and taken off the legal mining side. Only due to the self regulation of nature, landscapes can come back to a natural form, which can be compared with others.

Even though the self regulation process would bring back nature also without a legal binding of re-cultivation for the related industries, it would take much longer. That's why the legal regulations are important in order to make the effected areas usable again instead of letting 100 years pass without any safe access and future planning possibility.

2. General problems of rehabilitation of the brown coal mines

Most of the brown coal deposits are to be related to the epirogenetic typ. To realise the production of brown coal, there are used several techniques with which in many cases the ground water must be lifted. This swamp action is started to be realised some years before the actual surface mining start and finishes after the end of the mining activities.

To reach to the brown coal, a first exploration dump will be lifted, where the moved earth – at a maximum of app. 100 meters will be either dumped into a outside dump or in another surface mine by huge conveyor bridges or in a inside dump on the other side. In this process, tertiary substrates get in contact with oxygen of the air and water, where an iron hydroxide and sulphuric acid results. On the ground of the surface mine, is dug the brown coal, which is transported by big rubber bands or rail systems to the buyer. Due to the mass deficit of the generated coal, at the end remains a hollow mould, which forms the later lakes if flooded.

The problems relating out of the re-usability of the former brown coal surface mines in relation to the ground is lying within the moved land of the dump, which is not strong enough as natural land as well as the quality of the surface which is usually very bad due to the heavy acid content and little nutrients which have reached there by the substrates.

In relation to the water, is given a quantitative problem, as the former lifted ground water is now missing. A qualitative problem is only given, when the gained iron hydroxide and sulphuric acid reach into the lakes. That's when a sulphuric acid surface mining lake originates.

3. Water problems of rehabilitation of the brown coal mines with the example of the Lausitz region

Due to the former described swamp action, originates a cone of depression of the ground water, due to which the water resources of the surrounding areas is affected heavily. This can be best illustrated by the example of the German area of Lausitz, where huge amounts of ground water were and are used for artificial flooding. The results are water deficits in which former wet areas become dry. The land affected of these processes is always different and depending on the related surface mine areas, but always is by far bigger then the actual mining area. In the German region of Lausitz (see figure 1), more the 13 billion m³ of water will be used in total by the impact and regulations of the two bodies in charge of this area, being the LMBVmbh and the LAUBAG, to realise a lake site project in the former surface mining area, where in total 2.100 m² of land are effected, compared to the actual size of around 750 m². As a result there, the decline of water is not only affecting the area itself but as well near by rivers and so as well the surrounding cities.

To avoid any shortfall of water resources in the region, a high demand on a not only area specific water management is necessary. To guarantee this process of water flow for the rivers, the swamp action in the rehabilitation of surface mines will be reduced systematically. Also the neighbouring wetlands are affected in a way, that they would run dry without a constant flow of water. As a taken measure, other then ground water must be used additionally.

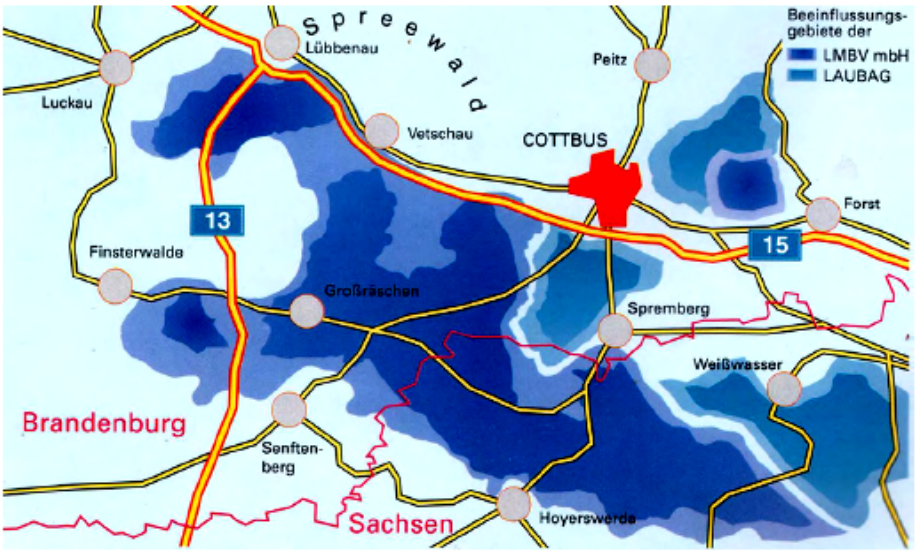

Figure 1. Overview of groundwater usage defined by the impact of the regulating bodies of LMBVmbH and the LAUBAG in the area of Lausitz / Germany
(Source: LMBV)

Surface mine lakes distinguish themselves from natural lakes due to their depth. They present a strong impact in all ground water flows, that's why their interdependency in this regards are quite intense. If surface mine lakes would need to be flooded by natural ways, it would take up to 100 years and problems as well as risks would be generated in regards to for example the banks slump. A regulated flooding takes an average of 1 to 20 years.

A mayor problem is the so far described iron sulphide alteration (see figure 2), in which iron hydroxide and sulphuric acid are transported by the ground water into the lake as well as the lake water generates it itself out of the surrounding dumps.

The very big disadvantage of a sulphuric acid surface lake is its limited usability, as lakes and its projects, which are planned for swimming and water sports, must have a certain legally European wide agreed quality level of a pH value of 6-9. In case of a lower level of quality, swimming is not permitted.

Further can these lakes also not used for fishing or water storage. The variety of biodiversity is very little, superior species like fish are not present. Pre flooding of the areas also can not be realised, as the contaminated water would enter into rivers and harm their system.

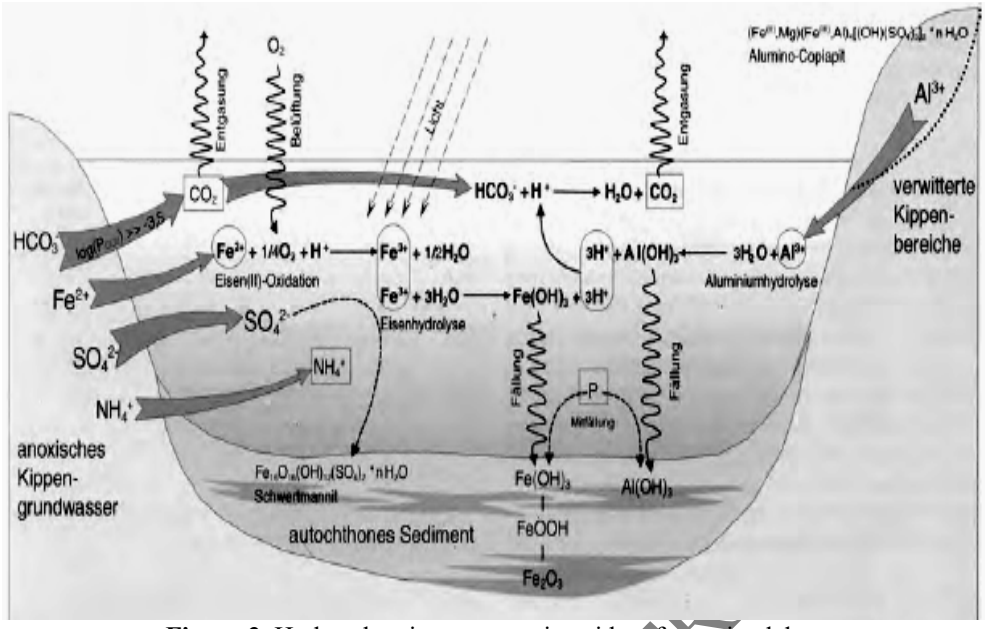

Figure 2. Hydro-chemic processes in acid surface mine lakes
(Source: Landesumweltamt Brandenburg)

To prevent a surface mine lake of being contaminated, can only be realised by an external flooding from the surrounding rivers. If the water in the lake rises faster by these measures then the ground water of the neighbouring dumps, water will flow into the dump and acid does not enter the lake. The contamination from the lake banks itself can not be influenced, but this process is time wise limited and finalized with the end of the flooding. Keeping all these facts in mind, even then not in all surface mine lakes can be generated neutral conditions with flooding.

A reason for this is the difference of the lakes in regards to the composite of the dumps substrates and the resulting contamination of the lakes bank.

Another reason is the very often not enough available flooding resources, meaning that the higher the amount of flooding water, the shorter is the duration of the flooding process and as well less risk for a danger of acidification.

Surface mine lakes can reach neutral conditions by natural ways in app. 70 years for smaller lakes and 100-120 years for bigger lakes. This timeline can be reduced with flooding by 70-90%. To reach a condition of stability in the lakes and no further contamination of the lake bank, constant flow of water must be guaranteed.

To neutralize an already contaminated lake, also chemic methods can be taken, in which the water will be added basic substances like lime. Experience with this procedure is still very little and results are due to the lakes volume very small

even though huge amounts of lime were added. Other methods involving biologic neutralization or electro chemic processes are still in a testing stage, but not very promising. Whatever method used, the cost side will not be very effective, as high investments have to be taken.

4. Dump problems of rehabilitation of the brown coal mines

A large amount of the areas surrounding the surface mines was erected during the active mining process. The quality of this area is distinguishing itself from a natural grown landscape depending on the density of the material. Planning with a former surface mine area must take a settlement, sinking and liquidation of the material into concerns. The self settlement of the dump due to its weight and the sinking with groundwater can be between 2-2,5 % of the total height of the dump. That's why the leftover land can not be used for agricultural or forestry, but must be adopted by improving the ground quality accordingly.

A special problem is the liquidation attitude, the settlement flow slump of the moved earth. Many settle flow slumps have lead to the death in the past. They are happening at surface mines under the conditions that a higher water level is given in the dump then in the lake, if the material has a corn density of less the 1mm or if the corn has a round form.

Weight pressure due to machinery, perpetration or tide in the lake itself, will lead to a loss of structure of the corn and further to a slump of the land into the lake. The dump material then reacts like a liquid. Like this, spontaneously huge amounts of land can fall into the lake. Even after decades, this possibility can never be excluded, also not by natural means.

To reduce these incidences, special substrates can be added to strengthen the density of the land as well as by flattering the lake bank. It these means are not enough further can be taken to stabilize the lakes by either blasts, jar pressure hardening, use of supporting shell in the relevant areas, high pressure injections or pore water barriers. These procedures can be used alone or be combined with others. In addition, very high costs are related but are absolutely necessary to guarantee the safe usability of the surface mine lakes.

5. Rehabilitation of the brown coal mines areas with the example of the Lausitz region

At younger surface mines, already during the mining process is the disposal realised in a way that a reusable landscape is generated which is necessary for the process of re-cultivation.

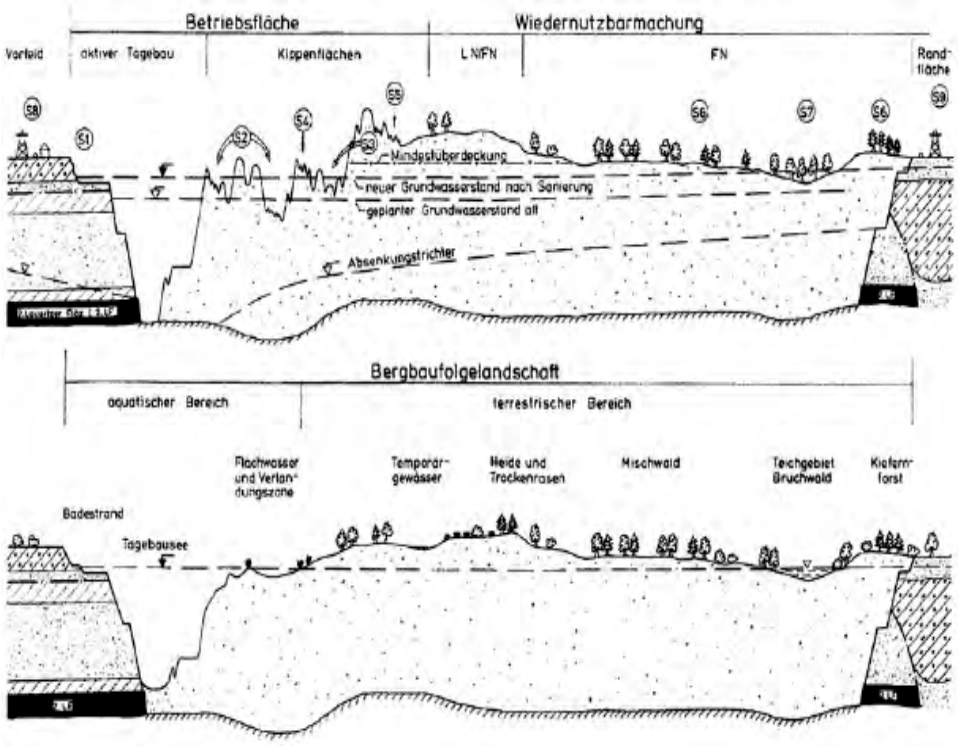

Figure 3. Focus of rehabilitation
(Source: Das Lausitzer Braunkohlerevier – Planungsgrundlage der Wiedernutzbarmachung)

The exact means and requirements are formulated in the mining regulations for brown coal re-cultivation and the future use determines the means of the re-cultivation process. In the heart of the process of re-cultivation as stated in the example of the Lausitz area (see figure 3) is the illustration description of the operated (including the active surface mine and dump areas) and the rehabilitated area (including the former dump re-cultivated areas) on the upper graphic and the resulting post mining landscape (including beach, lake, forestry and biotope) on the lower graphic. The focus is on the design of the grown lake side banks (see indication S1), the rest of the lakes design (see indication S2), the dump regulation (see indication S3), the waterside re-cultivation (see indication S4); the reusability (see indication S5), the improvement of already existing re-cultivation (see indication S6), the redesign of landscape (see indication S7) as well as the re-cultivation of surface mine front end and the neighbouring areas (see indication S8 and S9). For all realised work in this regards, are used the existing surface mine machinery and caterpillars.

Older surface mines using the conveyor bridges technique, have not taken this means at that early stage into account.

Most of the time former mining machinery is used in this process. Islands are avoided due to their high risk of slumps. The lakesides are flattened and strengthened by stones, the bigger lakes secured against wave hits.

Shallow water areas, which should be used for the protection of nature, must be arranged, if needed in the future planning. Steep lakesides are not allowed due to the high risk of slump. Future beaches become an especially flat structure and are filled to a depth of 2 meters with light fine sand. The landside of the dumps will be used according the planning with different methods and big differences from one to the other on the costing side. Estimated costs per hectare for agricultural use is expected to be around 9.000 €; for forestry around 10.000 €, or free succession at app. 800 €, but can not be recommended due to the contamination of the ground. If possible, friendly material can be placed over the contaminated ground, but these are normally not in a huge amount available. That's why ground supporting methods have to be used, to permit a future use in these ways. Lime is mixed into the ground to neutralize the acid, as well as dung to equability the given nutrient poorness. To guarantee an agricultural or forestry use, special plants are planted, to enforce the quality of the ground over the next years. Once these processes have been finalized, the further use can be started. Also here, it takes many decades until natural ground conditions can be put back, but due to melioration and seeding of special plants, this process can be speeded up.

In regards to the present mining buildings and structures, only those included in the future planning will remain in place. All other will be torn down and taken apart.

6. Protection of nature and future rehabilitated zones

Part of the re-cultivated areas, are used for the protection of nature. The given dump landscapes as well as the vegetation shall be free to its own development. There are distinguished between a free and a guided succession, which is following different phases. Starting from pioneer species who are developing slowly a vegetation surface to the ground across a vegetation encroachment and further to a stage of pre-forestry. The forest is then created by non demanding species including the birch and pine. Within their protection, demanding species like oak, beech and linden are starting to grow and after 100 to 150 years is created a natural mixed forest. Areas of succession in an early stage of evolution are very interesting, as many different animals and plants are settling, which on the one hand are characterised by a big multiplication and a wide spread, but on the other hand are not very resisting and that's why usually not or only rarely found in nature.

As the natural succession is always resulting in a forest, the guided succession shall be including and developing as well certain areas with biotopes. The protection of succession areas are especially a protection in regards to the overall process, as nowhere in the growing cultivated landscape can be watched, how a biotope is freely developing.

From the perspective of natural protection is criticized, that not enough areas are given to this process in the re-cultivation planning and also that the methods used are not always very nature friendly.

Conclusion

The necessity of the mining regulations and water hydro-engineering re-cultivation of former surface mines is resulting out of the irritated water resources, the danger of slump of lakeside banks due to settlement flow and the legal demands of a re-usability of the area in regards to its further planned use.

The design of the areal surface is in comparison to the re-cultivation of the water resources, a support and accelerator of the self regeneration and regulation of nature, not taking the areas for natural protection as a non primary goal into concerns.

usable landscape must be created, in which the powers of nature are used, but technical support and solutions are preferred most of the times because of the higher and more promising safety level. In the areas, which have been brought to level by the process, special attractive characteristics of the post surface mine landscape are lost including natural surface cuts of water erosions or little islands. But exactly these are the specials, which are interesting for a development of tourism. These uniqueness's making all the difference form other touristic areas. For all others then the experts, the landscape of a re-cultivated area will not look different at all to the rest of the region in a few years. Creating a unique characteristic region during the re-cultivation process of surface mines with the possibility of a touristic marketing strategy, as in most cases the only real future economic possibility, is unfortunately not realised in most of the cases. This is because the aspects of safety and healing of the interruption of nature is given priority, with the goal to make the destruction of nature unseen. As a result, most of the areas are brought to level and the watersides of the lakes are all straight. As a result you can say, that with a lot of money pumped into these processes is usually been given away special potential. Created has been a safe, but in relation to its potentials, a fairly boring landscape.

The landscape design is normally terminated after the re-cultivation process and further planning of for example touristic areas next to the lakes of the former surface mines can only begin after; where all given facts have to be taken into concerns.

In regards to all future plans of touristic aspects, the hidden dangers of former surface mines have to be taken into concern. The given diversity and size of generated lakes in these re-cultivated areas are the significant potential of a further possible touristic or economical use, whereas the quality of water is the most significant one. If the needed quality of water cannot be realised during the re-cultivation process, all further touristic plans can be cancelled or heavily delayed.

The danger of re-acidification of water is also still given after the re-cultivation process has been finalized. During the planning of settlement, characteristics of dump areas can be of negative impact, that's why further touristic planning shall only be realised usually only at grown watersides. In certain exceptions, also on filled up areas can be built on, taking the dimensions and weight of the planned structure in regards to the underground of the dump in concern.

Overall it can be said, that the re-cultivation of brown coal surface mines is not creating any special areas for further use, but implements the needed parameters on these areas.

REFERENCES

1. Abresch, J.,Bauer S., (1999), *Naturschutz und Braunkohlerekultivierung aus regionalwirtschaftlicher Perspektive*, Deutscher Rat für Landespflege, S.69-80
2. Ballon, A. (1994), *Umstrukturierung in den Braunkohlerevieren für Privatisierung*, Auslauf und Sanierungsbergbau, Treuhandanstalt, S.16-25
3. Beutler, D. (2001), *Perspektiven des Braunkohlenbergbaus in den neuen Bundesländern*, Bergbau 52, Nr. 11, S. 505-508
4. Bonekamp, B. (2001), *Perspektiven der deutschen Braunkohlenindustrie*, Surface mining Bruankohle & Other Minerals 53, Nr. 2, S. 230-238
5. Broll, G.; Dunger, W.; Keplin, B., opp, W.,(2000), *Rekultivierung in Bergbaufolgelandschaften*, Bodenorganismen, bodenökologische Prozesse und Standortentwicklung, Geowissenschaften + Umwelt,Springer, Berlin.
6. Donath, H. (1998), *Ungeahnter Artenreichtum auf ehemaligen Bergbaukippen*, Dachverband Bergbaufolgelandschaften e.V., S. 166-168
7. Drebstedt, C. (1998), *Das Lausitzer Braunkohlerevier – Planungsgrundlage der Wiedernutzbarkeit*, Braunkohletagebau und Rekultivierung, Heidelberg, S. 509
8. Ewers, J.,Renzenbrink, W. (2001), *Braunkohle*, BWK 53, Nr. 4, S.44-53
9. Fritz, W.; Tropp, P. & Meltzer, A.(2001), *Sanierungsstrategie nach Beendigung des Braunkohleabbaus im Geiseltal*, Surface mining Braunkohle & other materials 53, Nr. 2, S. 155-166
10. Großer, K. (1998), *Der Naturraum und seine Umgestaltung*, Braunkohletagebau und Rekultivierung, S.461-474

11. Grünewald, U., Nixdorf, B. (1995), *Erfassung und Prognose der Gewässergüte der Lausitzer Restseen*, Fachtagung Rezente Flutungsprobleme mitteldeutscher und Lausitzer Tagebaurestlöcher, Proceedings des DGFZ e.V., Nr.8,Coswig bei Dresden, 159-179
12. Herbst, B. (2001), *Studies on the Use of Limed Sewage Sludges in the Re-cultivation of Post-Mining Landscapes*, Surface mining Braunkohle & other Materials 53, Nr. 1, S. 128-129
13. Hüttl, R. (2001), *Rekultivierung im Braunkohletagebau – Fallbeispiel Niederlausitzer Bergbaufolgelandschaft*. Akademie Journal 1/2001, S. 7-12
14. Hüttl, R. F., Bradshaw, A. D., (2001), *Ecology of postmining landscapes*, Ecological Engineering Special Issue 17, No. 2/3.
15. Hüttl, R. F.; Klem, D. & Weber, E., (1999), *Rekultivierung von Bergbaufolgelandschaften*, Das Beispiel des Lausitzer Braunkohlereviers, Walter de Gruyters, Berlin, New York, S.295
16. Hüttl, R. F.; Weber, E., Klem, D., (2000), *Ökologisches Entwicklungspotential der Bergbaufolgelandschaften im Niederlausitzer Braunkohlerevier*, B.G. Teubner, Stuttgart, Leipzig, Wiesbaden, S. 384
17. Katzur J. & Haubold-Rosar, M., (1996), *Amelioration and reforestation of sulfurous mine soil in Lusatia* (Eastern Germany), Water, Air and Soil Pollution,S.91, 17-32
18. Lange, S. (2001), *Re-cultivation of Open Pit Mines,* VGB/EPRI-Tagung "Lignites and low rank coals: Operational and environmental issues in a competitive climate, Wiesbaden, 16.-18.05.2001, S. 1-9
19. Maier, H., Jolas, P. (2001), *Geotechnische Schwerpunkte bei der Verkippung von Kesselstrukturen im Tagebau Profen*, Surface mining Braunkohle & other materials 53, Nr. 2, S. 207-214
20. Schiffer, H.-W. (2001*), Die deutsche Braunkohlenindustrie*, BWK 53, Nr. 9,S.48-53