Water Management and Water Protection in Coal/Lignite Surface Mining Regions in Europe

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ABSTRACT

In Europe there are many regions, where coal or lignite is mined with surface methods. In most of these regions coal/lignite is mined below groundwater table and mining operations require pumping big volumes of water. Drawdown of groundwater table has influence on surface water and groundwater on adjacent areas. Mine drainage requires purification and its discharge changes flow in existing streams. Some of mine water is used by mining companies themselves, some is used by other industries, some for communal purposes and some for irrigation. However, majority of mine water is discharged to rivers without use. The above issues are discussed on the background of general, technical and water characteristics of such regions in 8 European countries. Conclusions and prospects for future complete the paper.

INTRODUCTION

Hard coal is mined in Europe with surface methods only in 4 (four) countries (U.K., France, Belgium and USSR) but lignite is mined this way in 11 (eleven) countries (West-FRG and East-GDR Germany, Poland, Czechoslovakia, Yugoslavia, Spain, Hungary, Bulgaria, Greece, Turkey and USSR).
In all countries these operations create some water problems even if mining is effected above groundwater table. The water management and water protection issues have been discussed at the meetings of the Group of Experts on Opencast Mining of UNO Economic Commission for Europe. This paper is a summary of national reports presenting the discussed topic as it is solved in U.K. France, FRG, GDR, Poland, Czechoslovakia, Bulgaria and Turkey.

GENERAL CHARACTERISTICS OF SURFACE MINING BASINS/REGIONS IN EUROPE

In particular countries there are from one to three so called surface mining regions discussed from the point of view of water management. The surface area of particular basins or regions is very differentiated. From very small isolated places (some tens of hectares in France), through average size being 100 to 800 km2 (most of the countries), up to large areas of 2500 to 10 000 km2 (East and West Germany and UK).

All basins are located at the elevation of 100-1200 m above sea level and their surface is flat or gently undulated (FRG, GDR, Poland, U.K.). Sometimes the basin itself is flat but is surrounded with the mountains several hundreds meters higher (Czechoslovakia, Yugoslavia). Sometimes the flat area of basin is cut by the valleys erroded by permament or temporary streams (Turkey).

All coal/lignite basins in Europe are in the moderate climate zone. Most of them are under Atlantic weather pattern (UK, GDR, FRG, Poland, Czechoslovakia, partially France), some in transitional zone between continental, Atlantic and Miditeranean climate (Bulgaria, partially France) and only one in typical continental climate (Turkey). The average anual temperature is mostly +8° to + 10°C, the exception is Bulgaria where it is +12° to +16°C. The extreme temperatures are mostly between -20°C in January, February to +30°C in summer. Only in Bulgaria and Turkey the maximum temperatures are higher (+35° to +40°C). The average annual precipitation is 500-800 mm, except France where is 900-1500 mm and Turkey where it is 380 mm only, but the years with precipitation below 200 mm occur here also. In some countries the precipitation rate is evenly distributed throughout the year with some seasonal variations and in some countries is concentrated principally in summer (France) or in winter (Turkey).

Most of the surface mining regions are drained with rivers of average flow $Q_{av.}$ = 1 to 10 m^3/sec. with many permanent or temporary tributaries. The big natural lakes in the vicinity of mining operations occur only in Poland. However in almost all other countries there are many small natural or man-made water reservoirs for industrial or agricultural purposes; sometimes there are abandonned flooded open pits. In some countries special reservoirs have been built on the streams or rivers to keep water for cooling adjacent power plants using the lignite mined over there (Bulgaria, Poland).

The hydrogeology of groundwater is very differentiated. In only few coal/lignite basins the main aquifers are within the fractured old bedrock formations. Those could be old, crystalline metamorphic rocks (Czechoslovakia, Bulgaria) or Mesozoic, mostly carbonaceous rocks, as limestones and marls (Turkey and some regions in Poland and in Bulgaria). The permeability and output of these deep aquifers is mostly low, except karstified limestones (Turkey and some places in Poland); however they can produce difficult problems due to high mineralization and high temperature of water (Czechoslovakia). In this last case occurs also some drainage of mineral/thermal springs in the near spaa, which is a serious problem. In some basins the main aquifers are in the sands underlaying the lignite seams. These sands (mostly Tertiary) play important role in the hydrogeology of lignite basins in Bulgaria, but predominantly in Central Poland. They have permeability of 2-5 m/day, but they are widespread with recharge both from deep and surface waters.

The aquifers within the overburden have sometimes character of closed lenses but sometimes are widespread and are main source of groundwater inflow. It happens first of all in FRG, GDR and in Poland (Belchatów lignite basin). The overburden aquifers are always very rich and have high recharge from mountains (FRG) or from precipitation and surface waters on large catchement area (GDR and Poland).In some mining regions small aquifers within the overburden, almost insignificant from the point of view of water management, can produce slopes stability problems during dewatering and mining operations (Turkey, Bulgaria).

Very different is the situation in France where there are almost no aquifers in the opencast mining areas and in UK, where groundwater problems come mostly from widespread, old and saturated underground workings.

The regions of opencast mining are mostly intensively developed. Beside mining operations themselves, there are coal/lignite fired power plants, briquetting plants, coking plants, heavy industry, chemical industry. Also the agriculture and cattle breeding is often intensive there. Thus these regions are characterized with high water demand (consumption) and high discharge of waste water. The demand for water is here often higher than its availability and is supplied from the intakes outside the mining region. The exceptions are here Turkey and partially Poland, where lignite surface mines are operated mostly in less developed rural areas and mining with associated electric power production is almost only one big industry of the region. In the last cases the balance of water consumption and availability is better. Also in FRG and GDR the volume of mine water is higher than its consumption in particular regions.

CHARACTERISTICS OF OPEN PITS

The number of open pits operated in particular region discused above is from one to 25 (GDR). Mostly it is one to four. The coal/lignite production from one region is from 2 mill. tons (hard coal in UK) to 197 mill. tons (lignite in Lausitz Region in GDR). Most frequently lignite production from one region is 15 to 40 mill. tons per year, in average 20 mill. tons. The hard coal production per one open pit is 100,000 - - 300,00 tons per year (France and U.K.), but for lignite is 1 to 40 mill. tons per year. Most of lignite open pits produces 3-20 mill. tons per year (Bulgaria, Czechoslovakia, GDR, Poland, Turkey). There are only three bigger open pits with production 30-40 mill. tons per year (FRG - Fortuna and Hambach, Poland - Belchatów). The total volume of overburden stripped in one region is from 22 mill. m^3 per year to 1 bill. m^3 per year but mostly it is between 35 and 200 mill. m^3 per year. Per one open pit those figures are from 2 mill. m^3 per year up to 176 mill. m^3 per year (mostly 10 to 100 mill. m^3 per year for lignite and 1.5 to 5 mill. m^3 for hard coal).

Overburden in lignite operations consists mostly of clays, sands and silts. Overburden in hard coal operations consists mostly of siltstones, mudstones and shales in U.K. and of loose rocks in France. The overall thickness of overburden is extremely from 2 meter to 450 meters, in most of operations being however between 40 and 150 meters.

The thickness of particular hard coal seams is from 0.15 m (UK) to 30 m (France), when for lignite it varies from 3 to 70 m. Most of mined seams of lignite have overall thickness 10 to 30 m.

The chemical characteristics of coal and lignite which has influence on water quality is very differentiated. The calorific value of lignite is between 770 kcal/kg (Bulgaria) and 2500 kcal/kg (FRG), mostly being 1500-2100 kcal/kg. Respective values for hard coal are 5200 to 6500 kcal/kg. Ash content is between 2 and 40 percent, mostly 10-25 percent.Sulphur content is between 0.5 and 7 per cent, mostly 1 to 3 per cent. Overburden is every where stripped with bucket wheel and bucket chain excavators of high capacity (10 000 up to 200,000 m^3/day), except UK and partially France where is stripped (after blasting) with shovels, dragelines and scrapers of bucket capacity 5 to 27 m^3. Lignite is mined always with bucket wheel and bucket chain excavators and hard coal with shovels and loaders.

Overburden and lignite is handled by belt conveyors and trains (Bulgaria, Czechoslovakia, GDR, FRG), belt conveyors only (Poland, Turkey), belt conveyors and dump trucks (France) and dump trucks only (UK). The overburden is dumped to the external dumps at the first period of operations and than to fill the mined-out void. The height of external dump is from 20 to 200 m. The only limitation of height is in UK - 20 m. In other countries the shaping and height is only limited by geomechanical factors and accessibility. In the regions where are more open pits,mined subsequently, overburden from the starting one is disposed to the abandonned one (FRG, GDR, Poland, Czechoslovakia). The overburden is sometimes toxic and produces high acidic water. In all countries reclamation (as forrest or farmland) is effected after the dump or its part is completed. However in case of big and deep operations the dump stay unreclaimed up to 10 years. In smaler operations this period is shorter - about 2 years.

HYDROLOGICAL AND HYDROGEOLOGICAL CHARACTERISTICS OF SURFACE MINES

In the immediate vicinity of open pits there are almost every where rivers and streams of different size. The average flow of those rivers is from 0.1 to 10 m^3/sec. and maximum of 10 years probability 10 to 245 m/sec. Some of those rivers have been diversified to enable the mining operations; almost all of them were regulated with embankements protecting against flooding. One river (Bilina River in Czechoslovakia) has been piped at the section running through the internal dump. Many small streams close to the mining operations are only temporary. Except Poland (Konin Region with 4 big lakes 300--500 m from the open pits edges) there are no big natural lakes in the close vicinity of opencast mining operations, which could have influence on water management. In some countries (France, U.K.) there are small ponds, often artificial reservoirs (Bulgaria) and sometimes created by flooding of abandonned open pits (UK, GDR, FRG, Poland).

Groundwater is present in the majority of surface mining operations. The deepest aquifers occur in the old Paleozoic or Mesozoic rocks, which form the Tertiary sedimentation basins. It reffers to lignite basins in most of the European countries. The groundwater is here in fissures and joints, but sometimes in karstic caves (Turkey, Poland). Sometimes old aquifers are connected with tectonics (Czechoslovakia). These aquifers have sometimes importance to the regional water management because they have influence on the drained water volume and quality, as well as drainage of these aquifers could have negative influence on the regional groundwater balance. These waters are sometimes highly mineralized and thermal (Czechoslovakia). Next aquifers occur in the Tertiary sands underlaying lignite seams. These aquifers have rather low permeability (1-5 m/day) and often high water pressure up to 30 Ba. In some regions their spreading is limited to small areas but in others they have wide regional spreading. Thus they have sometimes small but sometimes great importance to water management, as the main source of drained water from the open pits and widespread depression cone (Poland, GDR). These aquifers contain sometimes water with high content of iron (GDR), sulphates (Poland) or nitrates (Bulgaria). The other aquifers occur between coal/lignite seams and are mostly of lenticular character, with only static groundwater; so they have less importance to the water management.However they can produce geomechanical difficulties.

Very important aquifers occur in the overburden. These mostly Quaternary aquifers have high permeability (5-80 m/day), sometimes they are widespread and have hydraulic connections with surface waters. The quality of water is here rather good. The recharge of those aquifers is mainly from precipitation or through percolation from surface waters. They have great influence on regional water management because they produce high volumes of mine water. Also their drainage has direct impact on surface waters, precipitation infiltration rate and even vegetation conditions (FRG, GDR and Poland).

The quality of natural ground water in discussed mining regions is characterized by hardness 6-15° dH, pH 7 to 8, TDS from very low (below 500 mg/dm^3) in Poland and FRG to very high (up to 11 000 mg/dm^3) in some aquifers in Czechoslovakia. Sometimes original water contains some hydrocarbonates, bicarbonates, fluorides, sulphates, iron and manganese in higher concentration than required for drinking water. The temperature of original groundwater is 10-15°C, however in some places in Czechoslovakia it reaches even 50°C.

DEWATERING METHODS

Surface water control is effected by diversion of streams, construction of sealed channels and embankments for flood control. In most countries probability of rain 1 per cent (once per 100 years) is adopted for these constructions.Within the open pits the ditches and pumping stations with sumps are used to control rain water.

Groundwater control is effected through drilled wells with submersible pumps (FRG - 1100 wells, Poland - 700 wells, Turkey - 160 wells, Czechoslovakia - 70 wells under operation). The depth of wells is from 50 to 500 m and diameter up-to 1 m. Moreover in GDR, Poland and Czechoslovakia cutt--off slurry walls are used to cut flow through high permeable shallow aquifers. Only in Poland and GDR in some open pits operated for many years underground galleries with fall filters and overflow filters (for artesian aquifers) are used. In France only horizontal draines and ditches are applied. In UK and Bulgaria only ditches and pumping stations are used for groundwater control. The volume of water drained in particular regions is as follows:
C z e c h o s l o v a k i a - SC Basin - 53 m^3/min.(11m^3/min deep wells and 29 m^3/min. from pumping stations), Sokolov Basin - 40 m^3/min.; G D R - Lausitz Basin - 2650 m^3/min(2400 m3/ min. from deep wells and 265 m^3/min. from pumping stations), Bitterfeld Basin - 760 m^3/min. (680 m^3/min. from deep wells and 80 m^3/min. from pumping stations); F R G - Erft Basin - 1540 m^3/min. (1500 m^3/min. from deep wells and 40 m^3/min. from pumping stations); Ville Basin - 228 m^3/min. (219 m^3/min. from deep wells and 9 m^3/min. from pumping stations), Ruhr Basin - 134 m^3/min. (125 m^3/min. from deep wells and 9 m^3/min. from pumping stations); F r a n c e - 3.5 m^3/min.; P o l a n d - Bełchatów Basin - 400 m^3/min. (from wells - 370 m^3/min.,from pumping stations 30 m^3/min.), Adamów Basin - 203 m^3/min.(from wells - 93 m^3/min., from pumping stations - 110 m^3/min.), Turów Basin - 65 m^3/min. (from shafts 20 m^3/min., from deep wells 10 m^3/min. and 36 m^3/min. from pumping stations),Konin Basin - 216 m^3/min. (from shafts - 104 m^3/min., from wells - 26 m^3/min. and from pumping stations 86 m^3/min.); T u r k e y - Elbistan Basin - 35 m^3/min.

QUALITY OF MINE WATER

Quality of mine drainage depends on: quality of original groundwater, contact of water with the geological formations within the open pit on the slopes and its bottom (coal/lignite, sterile) and type of dewatering arrangements.

In general the cleanest water comes from drilling wells with submersible pumps (if use of asbesthos casing and pipes is prohibited). Water from pumping stations located at pit bottom contains more organic (lignite) and inorganic (silts) suspended solids. This one from shafts has high content of organic suspended solids and low pH:
B u l g a r i a - Total hardness 24-38° dH, pH 2.5 - 5.0. Dry residue 3-9 g/dm^3; C z e c h o s l o v a k i a - TDS 600 - - 1000 mg/dm^3. High content of sulphur ions, iron, and suspended solids, low pH; G D R - Total hardnes 5-25° dH, pH 3.8 - 7.8. Total iron content 2-100 mg/dm^3. Suspended solids 5-80 mg/dm^3. F R G - Good quality, only iron content 2-5 mg/dm^3 and 50-100 mg/dm^3 of carbonic acid; F r a n c e - Suspended solids 70-300 mg/dm^3; P o l a n d - From wells - potable water except iron content (up to 5 mg/dm^3), from open pits high content of suspended dolids 200-1000 mg/dm^3; T u r k e y - pH - 7.5, total hardness 10 to 15° dH. Suspended solids up to 2000 mg/dm^3, U. K. - Suspended solids up to 600 mg/dm^3, pH - 2.5 to 9.

REQUIREMENTS OF WATER AUTHORITIES CONCERNING THE QUALITY OF WATER DISCHARGED FROM MINES. TO LAKES OR STREAMS

B u l g a r i a - So called 3 rd category of purity; C z e - c h o s l o v a k i a - pH - 5-9, Total iron-less than 1.5 mg/dm^3, SO_4^{-2} - less than 300 mg/dm^3, Suspended solids - less than 30 mg/dm^3; G D R - pH - 6-8, Total iron-less than 5 mg/dm^3, Suspended solids-less than 50 mg/dm^3; F R G - Reduction of iron and carbonic acid to meet industrial or drinking water standards; F r a n c e - Temperature below 30°C, pH 5.5 - 8.5, Suspended solids - less than 30 mg/dm^3, Hydrocarbons - less than 20 mg/dm^3; P o l a n d - Suspended solids-less than 30 mg/dm^3, TDS - less than 1000 mg/dm^3, Cl - less than 300 mg/dm^3, SO_4 - less than 200 mg/dm^3; T u r - k e y - No requirements; U K - Suspended solids 30-150 mg/dm3 pH 5-9, oil 5-10 mg/dm^3. In Yorkshire also flow rate limitations.

MINE WATER PURIFICATION

The differences between mine water quality and requirements of water authorities indicate the mine water purification:
B u l g a r i a - no purification, standards are often not met; C z e c h o s l o v a k i a - natural sedimentation to reduce suspended solids, neutralization and defferization with use of calcium hydroxide and soda - required standards are observed in general; G D R - natural sedimentation in artificial ponds or in abondonned open pits; also circular or rectangular lagoons with bridge type scrapers, neutralization with lime efects iron precipitation in the form of hydroxide sludge; sludge is left in ponds dead zones and removed from lagoons. Approx. 60 percent of mine water requires purification and 40 percent can be discharded without

treatment. Standards are met; F R G - reduction of iron by gravel filters, injection of air or cascading reduces carbonic acid and in effect mine water meets required standards; F r a n c e - small volume of mine water, no purification in use; P o l a n d - suspended solids removed in gravitational sedimentation ponds (300 m^3/min.), in ponds with grass filter (80 m^3/min.) and in ponds with use of flocculants (50 m^3/min.). After treatment suspended solids are mostly below 30 mg/dm^3 and water meets standards. Difficulties appear after heavy storms and during strong winds parallel to flow direction in the pond; T u r k e y - no purification; U K - suspended solids removed in natural sedimentation process in special ponds (lagoons) or with use of flocculants.

EXTENSION OF DEPRESSION CONE

As effect of groundwater table lowering (within the open pit) in the surrounding aquifers occurs often the depression cone. The depth and spreading of depression cone is monitored in piezometers. Number of piezometers is from several up to 200 pcs (in Belchatów, Poland):
B u l g a r i a - radius of depression cone reaches 4-6 km; C z e c h o s l o v a k i a - no deppression cone in the close to surface aquifers, but the mineral water springs dozen kilometers away are endangered by drainage of deep Paleozoic aquifers and it is a real ecological and economical problem to be solved; G D R - radius of depression cone is from 3 to 7 km, but due to large number of open pits (47) it is a serious problem; F R G - area of the depression cone in Reinish Region is 2500 km^2. The phenomena occuring is surface sinking and old castles wooden foundations damaged. River has more water due to mine water discharge. Crops used always rainwater so they are not effected; P o l a n d - Konin Region - the cone of depression has radius 7 to 8 km in lignite underlaying aquifer, and causes disappearance of water in shallow wells. Adamów Region - the cone of depression has radius 3 to 10 km and causes dessication of shallow wells and some reduction of crops. Bełchatów Region - the cone of depression has radius 9 to 21 km in Quaternary shallow aquifer and causes reduction of flow in streams, dessication of shallow wells, decrease of crops from meadows in stream valleys and some terrain surface sinking (max. 0.5 m); T u r k e y - data about the size of depression cone are not available, but some natural springs and domestic wells dessicated around the open pits; I n F r a n c e a n d U K - the phenomenon doesn't exist.

FACILITIES FOR QUANTITATIVE PROTECTION OF WATER

In most of the European countries there are no big facilities in use to provide quantitative protection of groundwater around. In almost all countries, where the problem exists, was found that is cheaper to repair damages than to build special constructions. In Czechoslovakia where mineral springs have to be protected the mining operations are limited to the area warranting no impact. In FRG, Poland, Czechoslovakia and UK surface water (rivers and streams) endangered by percolation and dessication are protected by construction of sealed beds with use of clays sometimes with geotextile (UK). Shallow vertical cutt-off walls are used along the rivers in UK (steel sheets) and in Poland (slurry), to protect the rivers (and their gravel beds) adjacent to openpits, against losses of water. In the GDR deep slurry cutt-off walls are in use down to the depth of 100 m. They prevent infiltration of surface waters and formation of subsidence bowls, around open pits.

REPAIRING DAMAGES ENCOUNTERED IN WATERS

Despite protection measures, as mine water purification or other facilities, some damages in the water environment in surface mining regions are unavoidable and shall be repaired.

Although this activity is limited to only few countries. In GDR in some most important areas the lowered groundwater table is recharged through the special recharge wells. The groundwater pumped from drainage wells of the open pit is next discharged to the protected area and then injected to the damaged aquifer, to bring groundwater table back to its natural level. In FRG mine water is given to wooden fundaments of old castles to keep them stable. In Poland deep and efficient drilling water wells and drinking water supply networks are commonly constructed to replace dried local shallow wells. This improves considerably water supply standard of farmers in mining regions.

Mine water is discharged to the rivers. In some cases the rivers have lost some of the flow upstream (within the cone of depression) so the discharge of mine water brings back their flow to the natural volume, or even increases it downstream of mine. In Turkey mine water is discharged to the perimeter channel where from is taken for irrigation.

UTILIZATION OF MINE WATER

Some of mine water is used by mining companies to cover their own demands (dust control, baths, canteens, workshops etc.). This is a case in Czechoslovakia (for fire and dust control) in FRG (2.5 percent of total volume of mine water), in Poland (1 percent), in Turkey (0.5 percent of mine itself and another 0.5 percent for workers lodging facilities), and in UK (for dust control on internal handling roads in dry summer periods).

Another part of mine water is used for other industries in the region, in this for cooling of power plants burning local coal or lignite. This takes place in Czechoslovakia, in FRG (power plants cooling - 315 m^3/min. which is 17 percent of total volume of mine water), in Poland (cooling of power plan Belchatów - 160 m^3/min., which is 40-50 percent of total mine water in this region) and in Turkey (as reserve water for cooling in near power plant). In GDR (Lausitz Region) mine water is supplied to lignite briquetting plant (0.2 percent) and to other industries in the region (35 percent) in the untreated form and than up-graded by the receiver to his own required standard.

For communal purposes within the mining region mine water is used only in FRG (72 m^3/min. which is about 4 percent of total mine water) and in GDR (60 m^3/min. which is 1.6 percent). In Poland the economical studies shown that drilling wells with local pipe networks are cheeper than long distance pipelines with pumping stations for widespread mine water transmission.

Directly for irrigation mine water is used in Turkey along the perimetric dewatering channel of the open pit and in GDR (110 m^3/min. - 2 percent of total mine water). For other purposes in agriculture as fish ponds, animal husbandary e.t.c. mine water is not used, except small scale fish ponds in Poland and keeping of stable level in fish ponds in GDR. However mine water discharged to the streams or lakes is later on taken from those receivers for different uses. Examples could be here:
C z e c h o s l o v a k i a - some of the best mine water is pumped to special reservoir and is used to improve water quality in the downstream of local polluted river; P o l a n d - mine water after purification in Konin Region is discharged to the adjacent lakes, where from is taken for cooling two lignite fired power plants of the capacity 2,400 MW, operated in the open cooling system. In the same lakes having higher than regular temperature (by about 10°C) intensive fish breeding is run. Some mine water in Adamów Region discharged to the small river is some kilometers downstream taken for irrigation of meadows in the river valley.

Similiar but unidentified situation is in UK, where mine water is discharged to the rivers, but there is no information how is used downstream. In FRG huge volumes of mine water - 1468 m^3/min. (77 percent of total) is discharged to the Rhine River and in there functions as river water. The respective figure for GDR is 62 percent but mine water is discharged to several smaller rivers. The whole mine water is discharged to the rivers, without any future use in Bulgaria, France (very small amounts) and in Turów Region in Poland.

SATISFACTION LEVEL AND PLANS TO IMPROVE WATER MANAGEMENT AND MINE WATER UTILIZATION

In all countries mine water management and utilization is considered by mining companies as satisfactory. This is because the companies are intersted mainly to avoid problems and as long as they are not in troubles and don't pay fines they are satisfied. Generally the local and water authorities are also satisfied as long as mining companies keep the official discharge permit and standard conditions. The compromise between mining and local/water authorities plays here an important role (FRG, Poland). However in some countries(GDR, Poland-some regions and Czechoslovakia) there is a feeling that mine water should be better used in the region and less percentage should be discharged to rivers and "spoiled" that way.

Research programs to improve mine water purification are being carried out presently in some countries. In Bulgaria the research covers also utilization of mine water. In Czechoslovakia beside new mine water treatment plants implementation (including desulphurization), special mine water discharge management program is ongoing. In FRG permenent research on minimazing damages effected by groundwater table drawdown are conducted. In Poland mine water purification methods have been investigated and implemented in last 7 years; present research is on water balances in mining regions and on the challange of salted groundwater which is expected (probably) in the Bełchatów Region in next decade. In UK permanent efforts are devoted to improve efficiency of settlement laggons. In GDR the research is focussed on large scale regional hydrogeological studies, groundwater table recovery after mining and on multiplication for mine water use.

FINAL CONSLUSIONS

Large scale water management problems exist in several European countries in this GDR, Czechoslovakia, FRG and Poland. Those are countries where high production of lignite is concentrated on small area (Lausitz Region, Severoceski Region, Rhine Region and Bełchatów Region respectively) and surface mining operations have important influence on water management. In France and UK it is rather a minor problem, which comes from rather small size of disseminated operations and small water inflow to the openpits. In Bulgaria and Turkey the problem is of medium scale but is still under preliminary phase of development.

In almost all countries mine water discharges meet or mostly meet the required standards, but there is still feeling that some improvement in mine water management and utilization is still possible and more efforts have to be put on this matter.

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