PROSPECTS OF RECLAMATION WORK IN THE CZECH REPUBLIC DURING THE PERIOD OF CLIMATE CHANGE FOCUSED ON THE MOST BASIN AREA

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ABSTRACT

The Brown Coal Research Institute j. s. c. is realising the long term research and survey in the field of restoration problems and it is realising the long term research of climate changes in the Czech Republic including impacts to mining operations during research programme of the European Union TEXMIN solving too. The input of expected temperature increasing and precipitation decreasing is favourable for mining operation from point of view of overburden and mining cuts stability, safety of mining and mining costs. The different situation is the field of reclamation works. The input of expected climatic change is very unfavourable in this case. The main reasons are primarily high level of the loss of seedlings during forest reclamation because of hot and dry periods and the necessity of very expensive, radical change of technical and biological reclamation methodology. The first results of this research are presented in this paper.

Keywords: climatic change, soil, reclamation, mining

1 INTRODUCTION

The Brown Coal Research Institute j. s. c. is realising the long term research of climate changes in the Czech Republic including impacts to mining operations during research programme of the European Union TEXMIN solving.

The Most Coal Basin area is known for its largest Czech brown coal deposit. It is situated in the region of North Western Bohemia - Czech mining region. Four main mining companies are situated here. The Most Coal Basin is in general known as dry part of the Czech Republic. The North Western Bohemia is very important industrial region of the Czech Republic.

The input of expected temperature increasing and precipitation decreasing is favourable for mining operation from point of view of overburden and mining cuts stability, safety of mining and mining costs. The different situation is the field of reclamation works. The input of expected climatic change is very unfavourable in this case. The main reasons are primarily high level of the loss of seedlings during forest reclamation because of hot and dry periods, the necessity of very expensive, radical change of technical and biological reclamation methodology.

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The methodology of research is composed of temperature and precipitation change evaluation, prognosis of future development, terrain mapping, sampling and sample analysis.

The paper briefly summarises present climate situation, prognosis of future development, the main impacts to mining and reclamation. At the end of the paper, some selected adaptation reclamation methodologies are proposed.

2 METHODOLOGY OF THE TERRAIN WORKS AND LABORATORY ANALYSES

Available data of the Czech Hydrometeorological Institute (ČHMU), regional weather stations Kopisty, Milesovka and Usti nad Labem - Kockov, data of mining companies and own data of VÚHU j. s. c. were used for the evaluation of the development of temperatures and precipitation. For forecasting further development of temperature and precipitation, the outputs of the regional climate model ALADIN-CLIMATE / CZ operated in ČHMÚ, were used.

The selection of the suitable dump locality, selection of areas with different restoration history and terrain pedological mapping [1] were used for the evaluation of the inputs to the mining and reclamation works. The next step of the research was sampling, photo documentation and laboratory analyses [4].

A wide scale of mineralogical, physical, mechanical, chemical and pedological qualities will be evaluated on the samples. Physically mechanical (granularity, porosity), mineralogical (X-ray analysis), and chemically pedological analyses (finding of pH/KCl, pH/H_2O soil reactions, C_{ox}, $CaCO_3$, N_c contents, S, T, V sorption capacities, acceptable P, K, Mg nutrients contents and. determination of the content of risk trace elements. All analyses were realised according to the guideline of the accredited laboratory No. 1078.

3 BRIEF SUMMARY OF CLIMATE DEVELOPMENT IN THE AREA OF NW BOHEMIA (THE MOST COAL BASIN)

3.1 HISTORY AND PROGNOSIS OF FUTURE DEVELOPMENT IN TEMPERATURE CHANGES

This chapter briefly summarizes the temperature development between 1961 and 2019 and the prognosis of its development by 2100. The summary is valid for the Czech Republic, with emphasis on the Most Basin area.

In the period 2015 – 2019, the incidence of dry periods in the growing season increased. Overall, a very dry growing season can be noted in 2015 and especially 2018, in 2019 the months April and July were exceptionally dry.

The temperature increase between 1961 and 2019 is shown in Figure 1 below. .

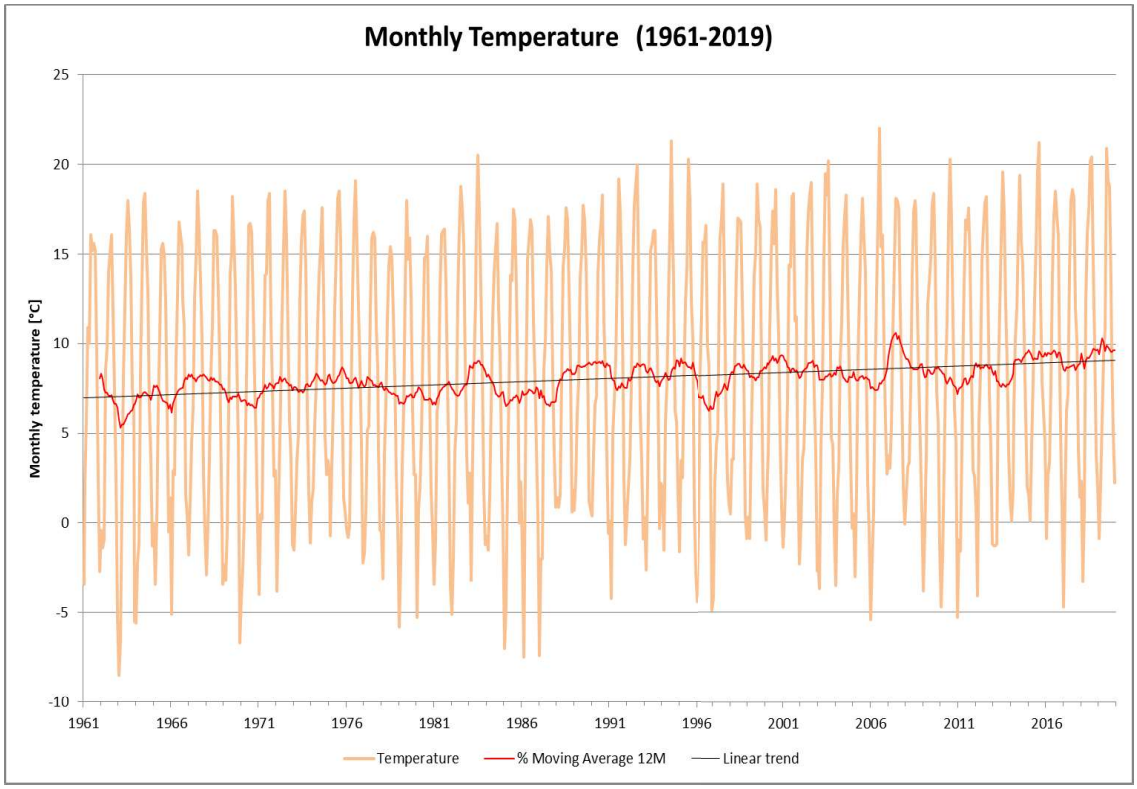

Figure 1. Increase in average temperature between 1961 and 2019

In the case of temperature, a clear increase in temperature in the Czech Republic and specific area of the Most Basin can be definite in the period under review. The evaluation of its causes is not the subject of this research.

Climate models agree that air temperatures will continue to rise, depending on the Representative Concentration Pathways (RCP) emission scenario. RCP 4.5 (assumption of moderate reduction of CO_2 in the air) and RPC 8.5 (does not foresee any change in CO_2 concentration) are most commonly used. By 2050, temperature growth will be the same regardless of the impact of the emission scenario, but developments in the second half of the century already depend on the emission scenario (see Figure No 2).

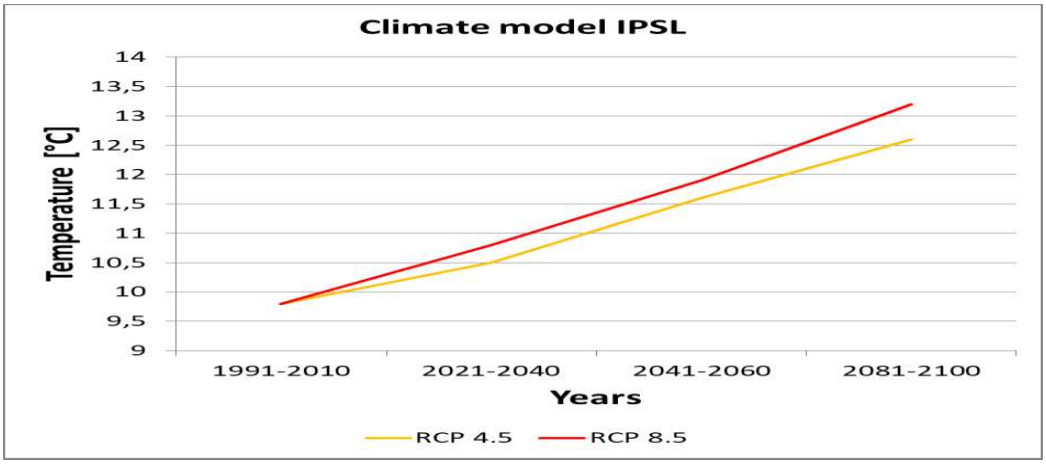

Figure 2. Development of average temperature in the Most Basin area until 2100

3.2 HISTORY AND PROGNOSIS OF FUTURE DEVELOPMENT IN PRECIPITATION CHANGES

This chapter briefly summarizes the development of precipitation in 1961 - 2019 and the prognosis of their development by 2100. The summary is valid for the Czech Republic, with emphasis on the Most Basin area.

The wider surroundings of the Most Basin in the rain shadow of the Krušné Hory Mts. are known as a dry area within the Czech Republic, regardless of climate change. As part of the TEXMIN project, as in the case of temperature, 1961 was chosen as the starting point for the evaluation of all European localities of interest. The development of precipitation is documented in Figure 3.

Evaluating the long-term development of precipitation is much more complicated than in the case of temperature. The trend is not clear, in the period 1991 - 2013 a rather slight increase in precipitation can be observed, the period 2015 - 2019 was, on the contrary, very dry. This, of course, complicates the forecast for further developments.

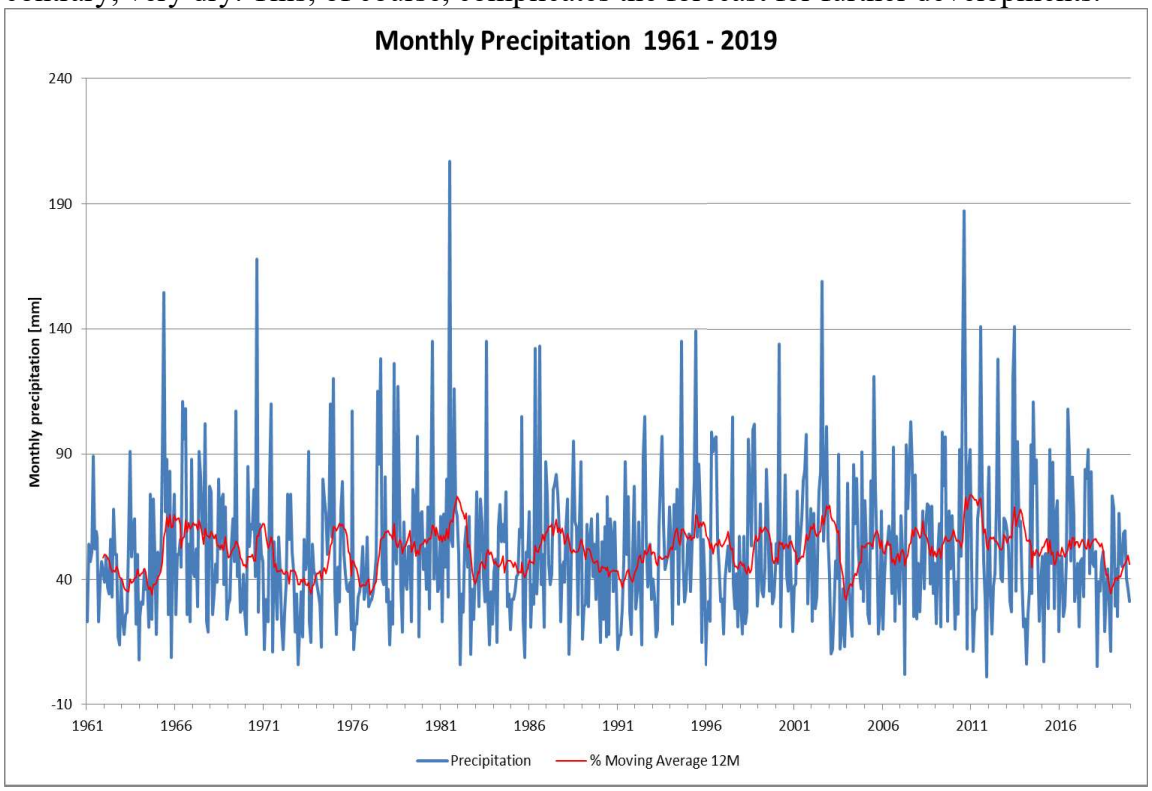

Figure 3. Average precipitation in the period 1961 - 2019

Similar models were used to predict the development of precipitation by the end of the century as in the case of temperature assessment. In this case too, emission scenarios RCP 4.5 (assumption of moderate reduction of CO_2 in the air) and RPC 8.5 (does not foresee any change in CO_2 concentration) were used.

Modeling the development of precipitation is significantly more difficult than temperature modeling. Therefore, the result may be burdened with a significant error.

4 IMPACTS OF CLIMATE CHANGE ON MINING AND RECLAMATION

The Most Basin area is known as a brown coal deposit and its wider surroundings are a very important industrial region. Overall, it is a dry and warm area within the Czech Republic, really extreme damage affected by the climate was not recorded here in the period under review. The aim of the paper is to assess the impact of climate change on mining activity and reclamation.

From the point of view of own mining activity, the documented increase in temperature and the likely occurrence of dry periods in terms of costs and safety at work are rather favourable. Torrential rainfall is more dangerous for mining activities. The wider area of the Most Basin is highly susceptible to erosion and landslides due to the geological situation. The exception is only the need to implement anti - dust measures in dry periods, which represent personnel and financial costs, including the need to provide enough water. The situation in the area of reclamation works is quite different. The dry period of 2015 - 2019 with an extremely dry year 2018 caused great damage mainly to forestry reclamation. In many locations the effect of drought on the mortality of seedlings is well documented. In this case, some simple measures have already been proposed by the authors of the paper for exposed areas, which may partially reduce the loss of seedlings.

Climate change is likely to have a negative impact on a number of other areas, such as agriculture, forestry [2], water regime, biodiversity [3] [5] and health, but these aspects go beyond the scope of the article. The following overview summarizes the more significant negative phenomena associated at least partially with the climate in the period 2000 -2019.

- Exceptional rainfall at the beginning of August 2002 was a source of flooding in large areas of the Czech Republic, especially in the southern, western, central and northern parts of Bohemia. The flood caused more than CZK 70 billion in damage, 17 people died. The damage to the mining activity was considerable.

- A very dangerous landslide was reactivated during January 2011. The landslide area was located on the slope of the ČSA open pit mine at the base of the Krusne Hory Mts. [3]. The main reason for this event was a combination of geological situation and torrential rainfall.

- The catastrophic landslide took place in July 2013 on the slopes of the Ceskr Stredohori Mts. near the village of Dobkovičky. Part of the D8 motorway and the local railway were destroyed (see Figure 4). The main reason for this event was the combination of a very dangerous geological situation and torrential rainfall, which caused floods in NW Bohemia. Another factor may have been the loading of the slope with the gravel benches of the quarry above the separating area of the landslide. The damage exceeded a billion crowns.

- The dry period of 2015 - 2019 with a period of extreme drought in May-November 2018 caused great damage in Czech agriculture and also in forestry reclamation of areas after lignite mining.

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Figure 4. Extensive landslide in the D8 motorway area (2013) [4]

5 CURRENT MAIN IMPACTS OF CLIMATE CHANGE ON RECLAMATION

As previous chapters show, climate change has a negative impact on reclamation more than mining. The most significant impact is the loss of seedlings in dry seasons, described in chapter 5.1). In the area of the DNT Mines is also significant the occurrence of natural gypsum (hydrogenetic rock), which affect the soil reaction of soils.

5.1 HIGH LEVEL OF THE LOSS OF SEEDLINGS AND PROPOSED ADAPTATION MEASURES

The number of dry climatic periods increased in 2015 – 2019 in the Czech Republic. It is possible to observe primarily very dry years 2015 and 2018 and April and July 2019.

These dry periods were the reason for unusually high level of the loss of seedlings during forest reclamation. In the area of the Most Basin, a number of reclaimed sites with very good soil characteristics and high mortality of seedlings were identified. The only explanation is the high frequency of dry periods. A typical example is in the Marianske Radcice area described in the past year. The seriousness of the situation is illustrated by Table 1 below.

Table 1. Situation of forestry reclamation - case study area Marianske Radcice (dry period 2015 - 2019)

Year	Loss of seedlings (%)
2014	22
2015	45
2016	40
2017	38
2018	63
2019	35
2020	20

According to our observation and laboratory analyses results, the drought was the main reason for the loss of seedlings in many locations. The dry period 2015 – 2019 is too short for precise evaluation but in case of continuation of this trend the number of localities damaged because of drought will increase. It is possible to propose initial, uncomplicated preventive measures. It is recommended to change the methodology of grass mowing. Grass is good for seedling protection and it is possible to eliminate damages to seedlings because of grass cutting such damage was observed in many locations. A further step would be to change of the range of woody plants with preference for woody plants resistant to drought and improve the water absorption capacity of the soils. The resistance of trees to heat and drought is shown in Table 2.

Table 2. Resistance of woody species to heat and drought

woody species		resistance to heat and drought
main trees used in forestry reclamation		
White oak	Quercus petraea Liebl.	middle
Summer oak	Quercus robur L.	low – drought/ heat – high
Red oak	Quercus rubra L.	middle
Common hahr	Carpinus betulus L.	middle to high
Sycamore maple	Acer pseudoplatanus L.	middle
Norway maple	Acer platanoides L.	middle
Heart lime	Tilia cordata Mill.	middle to high
Ash of the drunk	Fraxinus excelsior L.	low
Forest pine	Pinus sylvestris L.	middle – drought/ heat – high
Black pine	Pinus nigra Arn.	high
Larch	Larix decidua Mill.	high
White birch	Betula verrucosa Ehrh.	high

6 CONCLUSION

This paper attempted to summarize the development of temperature and precipitation in the period 1961 - 2019 and to forecast the development of these quantities until 2030 and the end of the century. For temperature, its gradual increase can be clearly demonstrated as a whole. In the case of precipitation, the forecast is much more complicated, but with some probability one can expect an increase in dry periods.

These development trends in climatic characteristics, with the exception of anti - dust measures in terms of costs and occupational safety, are favourable for their own mining activities, which are rather threatened by extreme rainfall or a combination of drought and torrential rains. However, this trend for reclamation, especially forestry, is very unfavourable. The main reasons are, above all, the high level of mortality of seedlings and the likely future need for very costly, radical changes in the methodology of technical and biological reclamation. Initial, simple measures are proposed in this paper.

In addition to reclamation, climate change is likely to have a negative impact on a number of other areas, such as agriculture, forestry, water regime, biodiversity and population health. In all these areas, the implementation of gradual adaptation measures will be necessary.

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