Journal of Environmental Protection, Safety, Education and Management
2015, Number 5, Volume 3, date of issue 28th Juni 2015 ISSN 1339-5270

PREPARING THE MEASURES FOR WATER SUPPLIES DURING PERIODS OF DROUGHT

Miroslav KYNCL - Veronika ŽIŽKOVÁ

ABSTRACT
Climatic changes as a consequence of global warming pose a potential threat for water supplies. Climatic changes will result in more extreme situations. These are periods of hot and drought which alternate with irregular intensive rain. Such periods pose a threat for continuous water supplies. This year, the drought struck a part of the Central Europe, including the Czech Republic. This results in major problems in supplies of drinking water and have negative impacts on agriculture and water management. This paper proposes a detailed evaluation of this period of drought as it will identify points of pressing urgency which need to be addressed in advance. It also recommends measures to be taken in order to supply water continuously during the expectedperiods of drought.

Keywords
Climatic change, drought, water suppliers

CHANGES IN THE CLIMATE AND FORECAST OF PERIODS OF DROUGHT

Changes in the climate have been for a rather long time among issues addressed by IPCC (Intergovernment Panel on Climate Change) [1] as this proves the global warming of the Earth. Warming of the Earth influences, in turn, changes in the climate which become more and more significant. Water management is considerably jeopardised by changes in the climate. Climate changes which influence water system have a considerable impact on availability of water. Such impacts include the increasing temperature and changes in variability of rain which influence limited inflow in water courses, little snow, and frequent and intensive snow thawing which results in water flowing out of the territory and little water remaining available for supplementing the aquifers. The consequence is potential risk of little water supplies which are needed as a source of drinking water for people and other customers. Another risk of such change is deterioration of quality of water which is used as a source for production of drinking water [2].

Impacts of drought on water system have becoming visible slowly only, but duration of such impacts is long. In case of surface water, the flow rate goes down in reservoirs and the level of water supplies is decreasing. Increased temperatures and reduced flow rates deteriorate quality of water and increase concentration of pollutants. This creates environment where euthrophication substances start spreading. In water reservoirs and other tanks a risk increases for “water bloom" incl. cyanobacteria.

Impacts of the drought onto ground water is less prominent than that on surface water. This, however, does not means that the surface water is influenced less by droughts than the ground water. One of key consequences of the drought is that sources of underground water are less abundant. This means, they are more susceptible to pollution. Another issue is that groundwater supplies need more time for recovery. This means that the problems with sources of ground water are long-lasting.
Periods of drought influence also operation of water systems. High temperatures and drought result in a higher demand for water, particularly in periods of time, where the water supplies might be limited. This results in a considerable gap between the water supply and water demand. If such problems exist for several months, an emergency situation may occur. The existing mechanisms and emergency plans exist for short failures in water supplies only.

According to the forecast from the Czech Hydrometeorological Institute, it is expected that average temperatures of air during a year will increase by 1.4 up to 1.8 °C between 2021 and 2015. In the period between 2071 and 2100 the temperature should increase by 3.3 – 3.7 °C (if compared with the reference period 1961-1990). [3]

Journal of Environmental Protection, Safety, Education and Management

2015, Number 5, Volume 3, date of issue 28th Juni 2015 ISSN 1339-5270

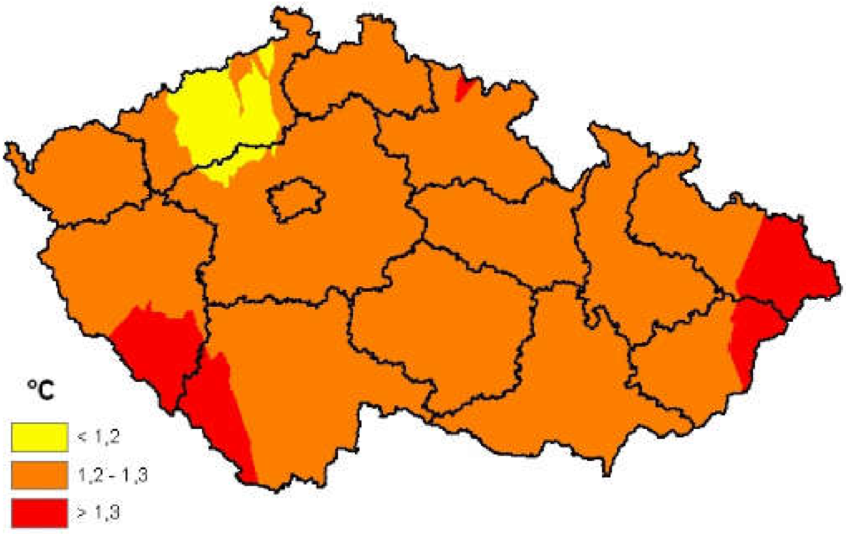


Fig. 1: Distribution of the annual average temperature (oC) in the Czech Republic until 2030 – compared with the period from 1961 to 1990. Simulated by RCM ALADIN-CLIMATE/CZ for the A1B scenario [3]

Those changes will result in more rainfall in winter and spring, while less rainfall is expected in summer. Extreme phenomena will also occur more often. On one hand, torrential rains are more likely, while on the other hand, periods of drought are probable in summer.

During one hundred years (1906 – 2005) the temperature in the world increased by 0.75 °C on average. In past 25 years the Earth has warmed by 0.18°C which is 2.5 times more than during the one hundred year period [4]. Simulations of future changes of average monthly temperatures indicated that not only the temperatures will change: it is also the character of the temperature changes which will alter.

In summer, it is expected that occurrence of tropical days and nights will increase, while in winter there will be less arctic days. Those climate changes, particularly the drought, pose a problem for water supplies. The Czech Republic depends entirely on rainfall in its hydrological balance – this is the consequence of the Czech Republic's position.

Regarding changes in the total precipitation, the situation is even more complicated. The simulation expects that there will be less precipitation in winter (as much as 20 per cent drop in some places), while in spring there will be more precipitation (between 2 and 16 per cent). In spring and autumn the situation will be different in different parts of the Czech Republic. In autumn there will a small drop of precipitation in some places - by several per cent, while in other parts of the Czech Republic, the precipitation will increase by as much as 20 – 26 per cent. In summer, some places will witness a slight drop in the precipitation, while in other places there will be as much as 10 per cent increase in precipitation. [5] This means, the precipitation will be very different for various parts of the Czech Republic. The precipitation models indicate considerable fluctuation of precipitation in territories. This means, lack of water needs to be addressed on a local basis.

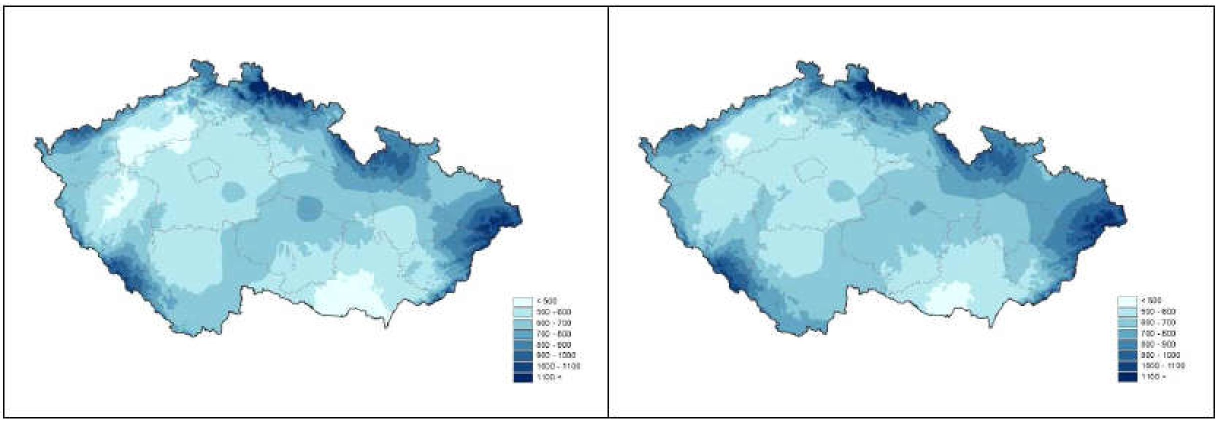
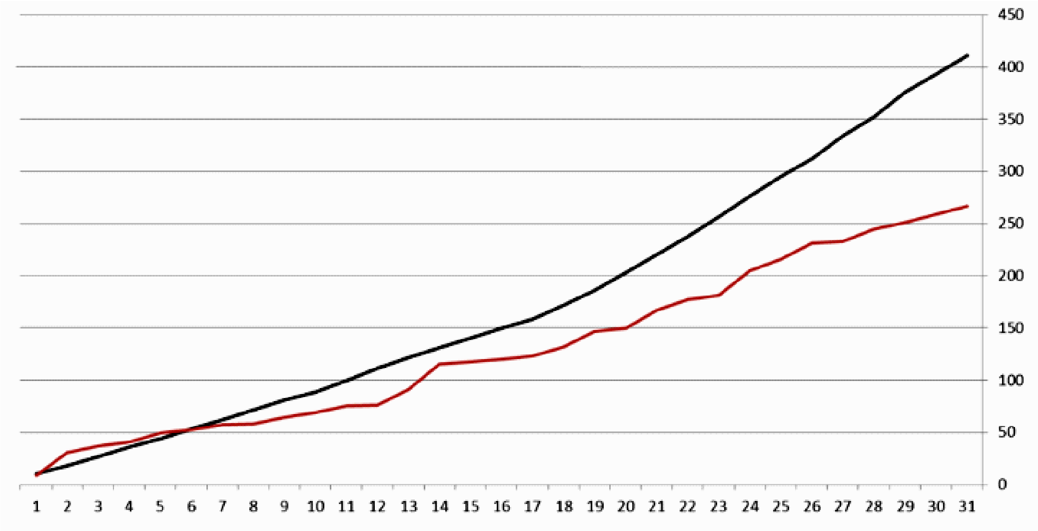


Fig. 2: Average year precipitation in the Czech Republic: 1961 -1990 (left) and estimate for 2010 – 2039 (right) [5]

Journal of Environmental Protection, Safety, Education and Management
2015, Number 5, Volume 3, date of issue 28th Juni 2015 ISSN 1339-5270

HYDROLOGICAL DROUGHT 2015

In the winter 2014/2015 there was very little precipitation. Since the end of February until now, there has been a drop in precipitation. In summer, more than 30 days were tropical. Most measuring stations recorded temperature records. Very warm and dry weather from June and July continued most of August. Since the start of the year, the decrease against the long-term reference precipitation was 150 mm. This means, only a one third of rain. [6]



rainfall
(mm)

A week in a year

Cumulated precipitation (average from 1981 until 2010)
Cumulated precipitation in 2015

Fig. 3: Precipitation since start of 2015 compared with 1981-2010 [6]

Flow rates in streams and rivers is very low. Typically, it ranges between 10 and 50 per cent of the typical flow rate of that part of the year. In some profiles, minimum flow rates were recorded for that day of observation. In the upper basin of the Elbe River, the flow rate in September was between 10 and 35 per cent of the average flow rate in that period. The lowest flow rate was recorded for the Cidlina River (5 % Q_{IX}). In the file profile of the Elbe River in Ústí nad Labem the average flow rate was 48 % Q_{IX}. This value is achieved thanks to dams in the Vltava River Cascade. In the basin of the Vltava River, upstream the Cascade, the situation is similar as in the upper profile of the Elbe River. The lowest flow rate for the Morava River was recorded in Moravičany (Q_{364}), while the final profile of this river in Strážnice achieved 37 % Q_{IX} on average. The situation was rather serious in the watershed of the Odra River though Odra catches water from the Beskydy Mountains and Jeseníky Mountains where rainfall is rather frequent. In the final profile of the Odra River in Bohumín the flow rate was 26 % Q_{IX}. The flow rate in a big tributary of the Odra River, the Olše River, was 13 % Q_{IX} only in the final profile in Věřňovice. Though there is a dam in the watershed of the Olše River, it does not play a major role in increasing of flow rates.

The long-lasting drought has been also considerably influenced the level of ground water. The health of ground water is based on the probability of exceeding the level in a drill bore in a certain calendar months. The drought is assessed using three categories of gravity which related to the reference period 1981-2010. Slight drought is the situation which is slightly subnormal and there is a chance of 75-75 per cent that the values will be exceeded. Moderate drought is heavily subnormal, the chance of exceeding the values being between 85 and 95 per cent. Severe drought is the situation which is extremely subnormal – it occurs in 5 % of observations only.

In 46 per cent of drill bores which were monitored, the heavily or extraordinarily subnormal levels were found – this means, moderate or severe drought occurred in almost all river basins in the Czech Republic. The situation is more positive in dams where water supplies mostly exceed 55 per cent [7].

Journal of Environmental Protection, Safety, Education and Management
2015, Number 5, Volume 3, date of issue 28th Juni 2015 ISSN 1339-5270

DRINKING WATER SUPPLIES

Almost 94 per cent of people are supplied now water from public water networks. Soon, the demand for drinking water supplies will be almost satisfied. 4 or 5 per cent of people only will be supplied from local sources, typically from wells. Those will be people who live in places with low density of population. Major achievements have been also reached in treatment of wastewater. 83 per cent of people are connected to public sewage networks. Wastewater treatment plants are located at ends of 97 per cent of the sewage networks. [8] It is believed that the wastewater treatment plants and water treatment plants which are under construction now or will be built soon should solve the issue by 2020. This should considerably improve quality of water in streams and rivers.

Development of drinking water supplies have undergone major changes in past years. Vast majority of people can use quality drinking water from public water networks. Consumption of drinking water has, however, dropped down to ca. 60 per cent. [9] The drop was caused by population as well as by other consumers. The descending consumption has not reached the breakpoint yet, thought the decrease is not steep.

A half of drinking water is produced from surfaces sources where dams are available. The other half is produced from ground water. Typically, these are shallow Quaternary sources and some rather deep sources dated back to the Czech Cretaceous era.

EFFECTS OF THE CURRENT DROUGHT ON THE DRINKING WATER SUPPLIES

It is obvious from the drinking water supplies that there is a rather big difference between demand and supply – the excess of water supply is 40 per cent. In times where most drinking water was produced, approximately in 1990, more than 1,250 million m^3 of drinking water was produced. In 2013, 600 million m^3 only was produced. The number of people connected to the public water supply has increased since that year by 1.5 million. One might believe that the drought cannot have negative impacts on drinking water supplies. This is true to a certain extent only because resources and needs are not distributed evenly.
If it is hot in summer, consumption of drinking water goes up by 10 up to 15 per cent. In some sites, an issue was water for swimming pools on gardens. Regarding the balance between the sources and demand for water, one could believe that there are not any problems. It is, however, necessary to keep in mind that the resources are not distributed evenly. And there are also certain areas where drought is more prominent. Typically, those areas are located to the north-west from Prague – these are the regions of Žatec and Louny. Drought is also typical to most of the South Moravia. A considerable precipitation deficit occurred for almost three months. Experience from this year has proved that group water networks and regional water networks are reliable in supplies of surface water from dams. Problems in water supplies appeared mostly in local water networks where water was taken from shallow sources of ground water and in some sources which took water from upper courses without any dams.

The maps below show soil drought which proves that lack of ground water is an issue. In the soil layer up to 20 cm the drought is much less prominent (left) than in deep layers up to 100 cm (right). This proves that the precipitation at the end of August and start of September was not intensive enough to penetrate into deep layers of soil. Maps also show uneven distribution of soil drought.

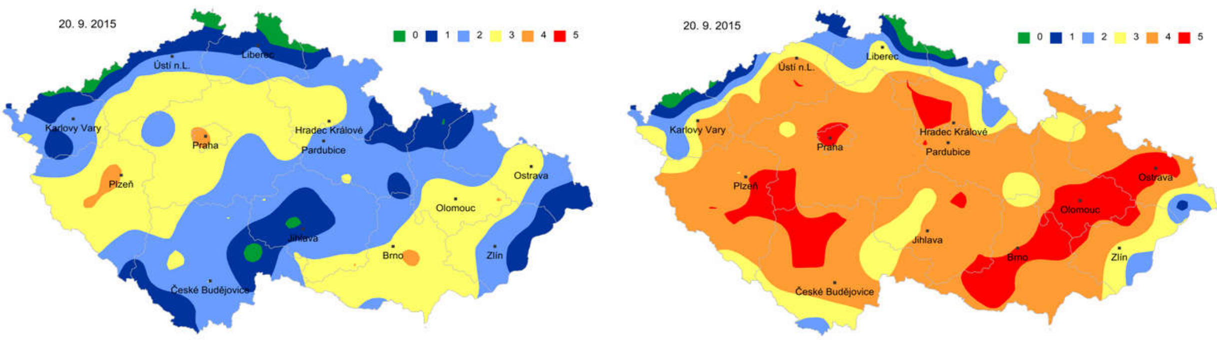


Fig. 4: Soil drought in 0-20 cm (left) and 0-100 cm (right) [10]

0 – no risk, 1 – slight risk, 2 – low risk, 3 – moderate risk, 4 – high risk, 5 – very high risk

PROPOSING THE MEASURES FOR WATER SUPPLIES DURING PERIODS OF DROUGHT

The climate changes and periods of droughts should be, on the basis of forecasts, more intensive and rather long. It is necessary to use the current knowledge and to prepare measures which could mitigate drought risks. Such measures are long-termed in terms of preparation and implementation. The purpose of the drought management measures and actions is to minimise negative impacts for drinking water supplies and living environment in general. Such measures should be prepared irrespective of the ongoing discussion about effects of the global warming on the climate changes. Development in past years has proved that such measures are really necessary as the climate changes are highly probable in the future.

The measures which are in line with the Report on Drought Management Plan (EU, 2007) can be divided into strategic-preventive measures and operational measures. Drought management plans should be available before they are needed. They should be based on local and regional environment.

The strategic-preventive measures should be taken as preparatory measures before periods of droughts. Those measures include the planning and preparation of such technical measures which will improve ability of the water system to resist drought and to supply drinking water at least in a limited scope.

The operational measures are taken if criteria are reached which indicate that a period of drought has started or will start soon. The purpose is to overcome the period of drought with as little as possible effect on the water system, emergency condition of the landscape and social life of the community.

The key task is to identify with a high probability those sites where deficit of water is expected to be a pressing issue in sources. Then, a special monitoring system should be established for surface water and ground water. That system is supposed to evaluate the drought well in advance in terms of relevance in time and space.

When planning, rules and procedures should be defined for water management in emergencies. Such rules should be supported by laws and regulations and should be in line with economic tools. It is recommended to use experience from countries which have similar infrastructure as the Czech Republic and have been dealing with drought issues. This might be, for instance, Spain. It is particularly price regulation which is used to manage water supplies in periods of drought. Spain has prepared a smart system where demand for water is regulated by the price of water. Water tariffs are billed depending on the consumption and several ranges of consumption exist. The principle is that in the high consumption range a higher unit price is paid for taken water. [11]

From the point of view of investment and technology, it is essential to improve regularly the condition of the water infrastructure. It is necessary to install treatment facilities in those sites where quality of water might deteriorate during droughts. If the water balance is not acceptable, dams should be built – this tasks, however, needs a long planning. An important measure which is not so time-consuming is interconnection of the water systems so that water could be transferred to territories with passive balance. For instance, water systems in the North Moravia could be connected to those in the Central Moravia and South Moravia. Regarding the investments, the interconnection of water systems and group water networks might be regarded as a very efficient measure. Thus, excessive capacity in one area will be used for needs of the other area. This measure can be used in other emergencies, not only during the period of drought.

This is an overview of measures only – systemic preparation is, however, needed. There are many other actions which should be taken in order to improve water management: to use rain water, to improve treatment of wastewater and to prepare operational and organisational measures to manage emergencies. The key task is, however, to change the approach to the entire system of management in sources in order to retain as much water as possible, to improve efficiency of transfer of water to consumers, to protect against contamination the infiltration areas used for catchment of ground water and to improve, in general, environmental stability of the landscape.

CONCLUSION

This-year period of drought has proved that measures should be taken in order to improve resistance of water systems in emergencies. Attention to drought should be paid irrespective of the climate change forecast. The sooner and the better the water infrastructure is prepared for drought, the easier the management of such emergency will be. What is important is the system of legislative, technical and organisational measures. They should be followed by investment projects. Economic aspects are of essence too as preventive measures are less expensive than management of acute emergencies.

REFERENCES

[1] IPCC – intergovernmental Panel on Climate Change – www.ipcc.ch

[2] Howard, G., Charles, K., Pond, K., Brookshaw, A., Hossain, R., Bartram, J.: Securing 2020 vision for 2030: climate change and ensuring resilience in water and sanitation services. Journals Water and Climate changes, volume 1, number 1, march 2010, page 2-16. ISSN 2040-2244

2015, Number 5, Volume 3, date of issue 28th Juni 2015 ISSN 1339-5270

[3] Český hydrometeorologický ústav-základní informace o změně klimatu: http://portal.chmi.cz/files/portal/docs/meteo/ok/klimazmena/files/cc_chap10.pdf
[4] Bartoš, M. a kol.: Vodstvo a podnebí v České republice. Praha 2009, 255 s. ISBN 80-903482-7-0.
[5] Ministerstvo životního prostředí: Strategie přizpůsobení se změně klimatu v podmínkách ČR. 2014. https://ezak.mzp.cz/document_3293/216455123e9a0c2cf-Příloha+č.+3+ZD+-+Návrh+Strategie.pdf
[6] Český hydrometeorologický ústav-Tisková zpráva: http://www.chmi.cz/files/portal/docs/aktuality/TZ_05082015_ok.pdf
[7] Český hydrometeorologický ústav-Týdenní zpráva o hydrometeorologické situaci a suchu na území ČR: http://www.chmi.cz/files/portal/docs/meteo/ok/SUCHO/zpravy/2015/tyden37.pdf
[8] Ročenka SOVAK 2015
[9] Český statistický úřad: Souhrnné údaje o vodovodech za rok 2013: https://www.czso.cz/documents/10180/25385875/20002443+33008414q2s1.pdf/3e5cb932-1014-46d6-9064-86a82c290084?version=1.0
[10] Český hydrometeorologický ústav – Půdní a klimatické sucho: http://portal.chmi.cz/portal/dt?action=content&provider=JSPTabContainer&menu=JSPTabContainer/P10_0_Aktualni_situace/P10_4_SUCHO&nc=1&portal_lang=cs#PP_SUCHO
[11] Marcet, E. C.: La tarifación, herramienta esencial en la gestión sostenible del agua. Universidad Politécnica de Valencia: http://www.magrama.gob.es/imagenes/en/0904712280047456_tcm11-17949.pdf

CONTACT ADRESS

Author: prof. Dr. Ing. Miroslav KYNCL
Workplace: Institut environmentálního inženýrství, Hornicko-geologická fakulta, VŠB-TUO
Address: 17. listopadu 15, 70800, Ostrava-Poruba, Czech Republic,
E-mail: miroslav.kyncl@vsb.cz

Author: Ing. Bc. Veronika ŽIŽKOVÁ
Workplace: Institut environmentálního inženýrství, Hornicko-geologická fakulta, VŠB-TUO
Address: 17. listopadu 15, 70800, Ostrava-Poruba, Czech Republic,
E-mail: veronika.zizkova.st@vsb.cz