International Conference on HAZARDOUS WASTE . Sources, Effects and Management
12-16 December 1998, Cairo-Egypt

EG0000135

S-4

Pre-operational Study on Impact of Temelín NPP on Hydrosphere

E. J. Hanslík
T. G. Masaryk Water Research Institute, Prague, Czech Republic

ABSTRACT

Beginning of the construction of Temelín Nuclear Power Plant (NPP) in south Bohemia (CR) dates back to 1986. It is planned that the first water-cooled reactor could be put into operation in 2000. A research project, funded from the national budget and carried out under supervision of the Czech Ministry of Environment, has been aimed at examining pre-operational environmental conditions (a reference level) in terms of concentrations of radioactive and non-radioactive polluting substances in components of the environment, particularly in hydrosphere, and at predicting possible impacts of future operation of Temelín NPP. Special attention paid to the hydrosphere is associated with requirements for protection of water quality in the Vltava River, which serves as water resource for Prague capital. The paper summarises selected interim results of the project, particularly those concerning pre-operational environmental conditions and impacts predicted for standard operation of the plant. More detailed description of the results including possible impacts of the so called maximum project accident is presented in [1].

Key Words: Radionuclides / Operation of Nuclear Power Plant / Environmental Impacts / Radiological Monitoring

INTRODUCTION

The Vltava River is an important resource of drinking water for Prague. Its water affects also quality of the Elbe River on the territory of both the Czech Republic and the Federal Republic of Germany.

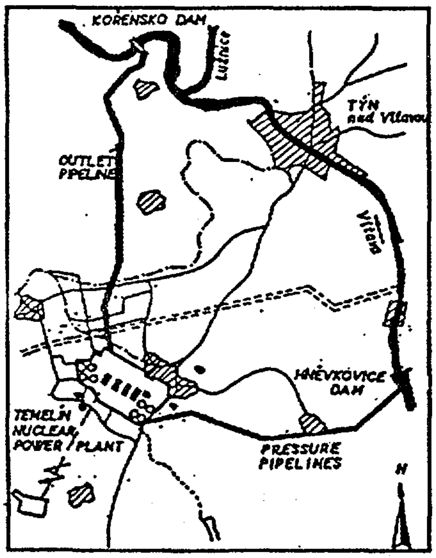

Figure 1 Temelin NPP water supply system.

Two of the reservoirs which have been constructed on the Vltava River will serve for water management purposes of Temelin NPP (see layout map in Figure 1). Water for the plant will be abstracted from the Hněvkovice Reservoir (put into operation in 1991) and pumped to storage tanks with capacity of 2 x 15 000 m^3, from which it will flow by gravity. For the operation of two reactors, the total mean abstraction will be 1 600 $l.s^{-1}$. The plant will return 500 $l.s^{-1}$ (as maximum) of remaining cooling water and purified waste water. This water will be discharged into the Vltava River at the Kořensko Reservoir through hydroelectric power station located at Kořensko Dam.

The observation and assessments of pre-operational environmental conditions involved radioactive and non-radioactive polluting substances in surface water, groundwater, precipitation water, suspended solids, bottom sediments and biomass in wider environs of the Temelin NPP, and also temperature and transport conditions in the Orlík and other reservoirs built downstream from the Temelín on the Vltava River. The examination of the hydrosphere prior to the operation of Temelín NPP is particularly important in terms of radioactive substances because some of the radionuclides (such as ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs) potentially present in effluent returns from Temelín NPP are identical to those remaining in the environment after the Chernobyl accident and tests of nuclear weapons.

Methods used in carrying the project were verified and recommended by the International Atomic Energy Agency in Vienna in the framework of its technical assistance organized in co-operation with the Ministry of the Environment of the CR and the State Office for Nuclear Safety [2]. These methods are described in report [3].

PRE-OPERATIONAL ENVIRONMENTAL CONDITIONS

The results of the study involve data on levels of naturally occurring and artificial radionuclides in the environment. Chernobyl accident in 1986 and tests of nuclear weapons performed in sixties are main factors responsible for the environmental levels of artificial radionuclides. A peak after the Chernobyl followed by a decrease is a typical pattern of their concentration in all of the observed components of the environment. This can be demonstrated by the following examples.

Concentrations of radionuclides in surface water have been observed in the Vltava River (upstream and downstream from Temelín) and in its main tributaries since 1990. Figure 2 shows trend curves derived from ^{137}Cs concentrations measured in the Vltava River at Hněvkovice (water abstraction for Temelín), in the Lužnice River (at Koloděje) which discharges into the Vltava upstream from Kořensko Dam, in the Otava River (at Písek) discharging into the Vltava upstream from Orlík Dam (downstream from Kořensko), and in the Vltava at Solenice (outflow from the Orlík Reservoir). We can see a decreasing trend in the concentrations at all of the above sites, and, in addition, the lowest concentrations in the Vltava at Solenice indicate that large amount of ^{137}Cs is deposited in the Orlík Reservoir.

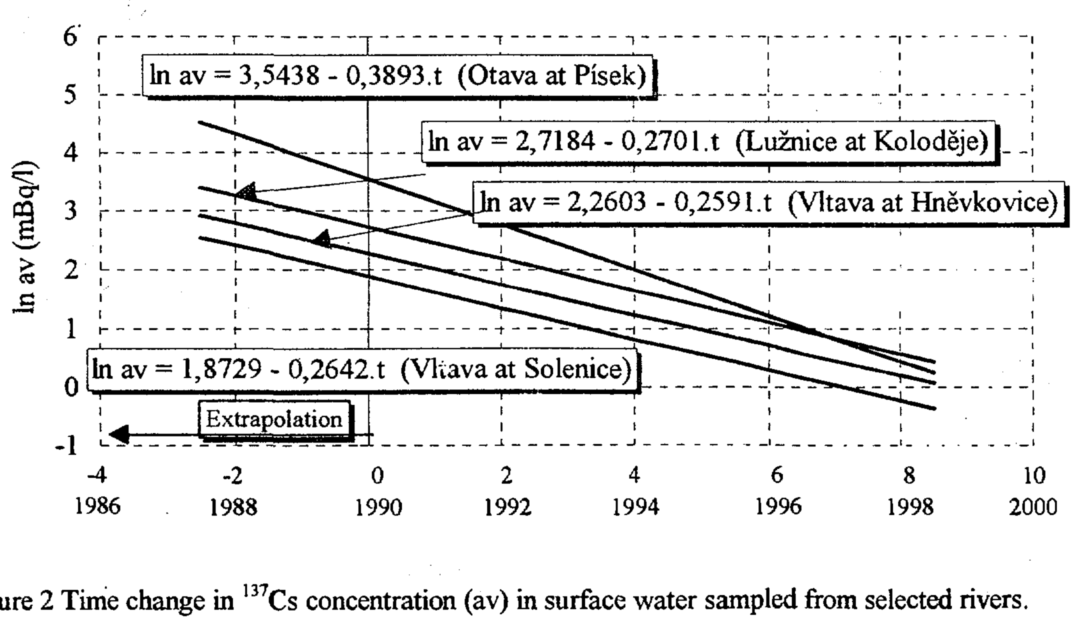

Figure 2 Time change in ^{137}Cs concentration (av) in surface water sampled from selected rivers.

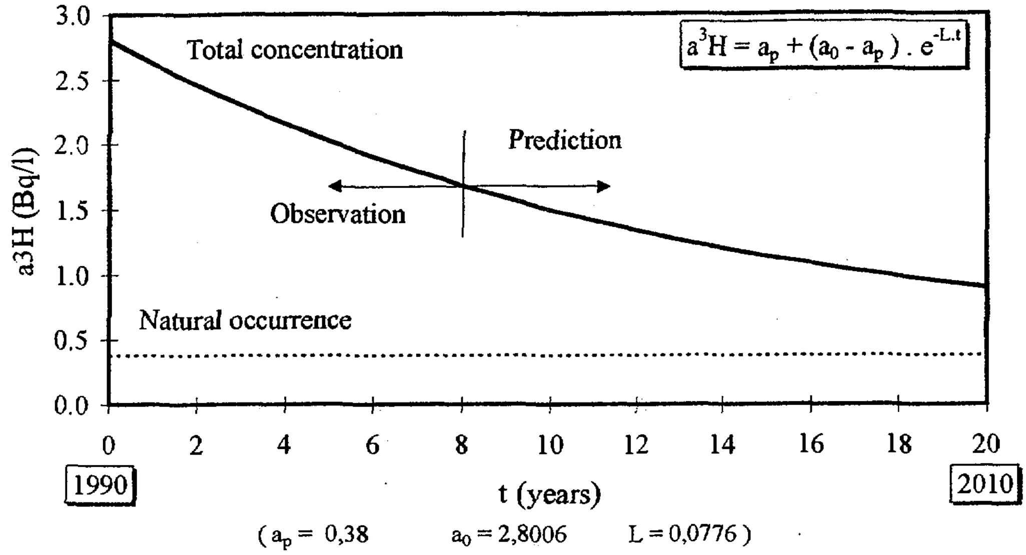

Figure 3 A trend curve predicting tritium concentration in surface water in the Temelín vicinity, derived from data observed in 1991-1997.

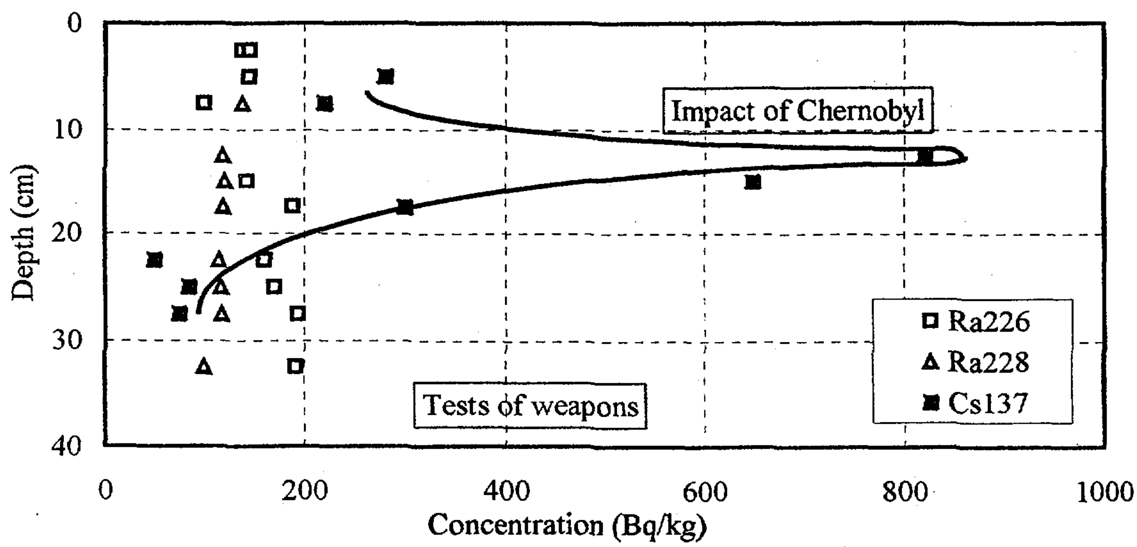

Figure 4 Vertical distribution of concentrations of natural and artificial radionuclides in bottom sediments in the Orlík Reservoir in 1995.

Data on tritium concentrations in surface water in the vicinity of Temelín from the period 1991-1997 were used for derivation of a trend curve and prediction of the concentration for time period till 2010 (see Figure 3). For the period when nuclear weapons were tested it was derived that the decrease in tritium concentration in surface water was relevant to radioactive decay with the half-fife of about 5 years. Since this period, the slope of the decrease has been decreasing which is attributable to natural tritium occurrence responsible for about 0.4 Bq.l^{-1} (see Figure 3). The decrease is presently at level relevant to half-fife of about 10 years and the mean concentration is about 2 Bq.l^{-1}.

Figure 4 shows vertical distribution of ^{226}Ra, ^{228}Ra and ^{137}Cs in bottom sediments in the Orlík Reservoir in 1995. Maximum concentration of ^{137}Cs amounting 820 Bq.kg^{-1} was observed in subsurface layer (in the depth between 10 and 15 cm), which indicates that contamination resulting from the Chernobyl is overlaid. Concentrations of ^{134}Cs, ^{137}Cs and ^{90}Sr in the bottom sediments are high. It was calculated, that about 57 GBq of ^{137}Cs is deposited in the upper 10 cm thick layer. However, the concentrations are decreasing with time. In 1990, the average concentration of ^{137}Cs was 214 Bq.kg^{-1}, while it was 57 Bq.kg^{-1} in 1995. For the period 1986-1997, Figure 5 shows time change in mean annual concentrations of ^{137}Cs and ^{134}Cs in the bottom sediments and their ratio calculated from observed data and from the Chernobyl mixture. Concentration of naturally occurring radionuclides is stable both in time and in vertical profile (see ^{226}Ra and ^{228}Ra in Figure 4). In the period 1990-1995, the mean concentrations were 72 Bq.kg^{-1} of ^{226}Ra and 96 Bq.kg^{-1} of ^{228}Ra.

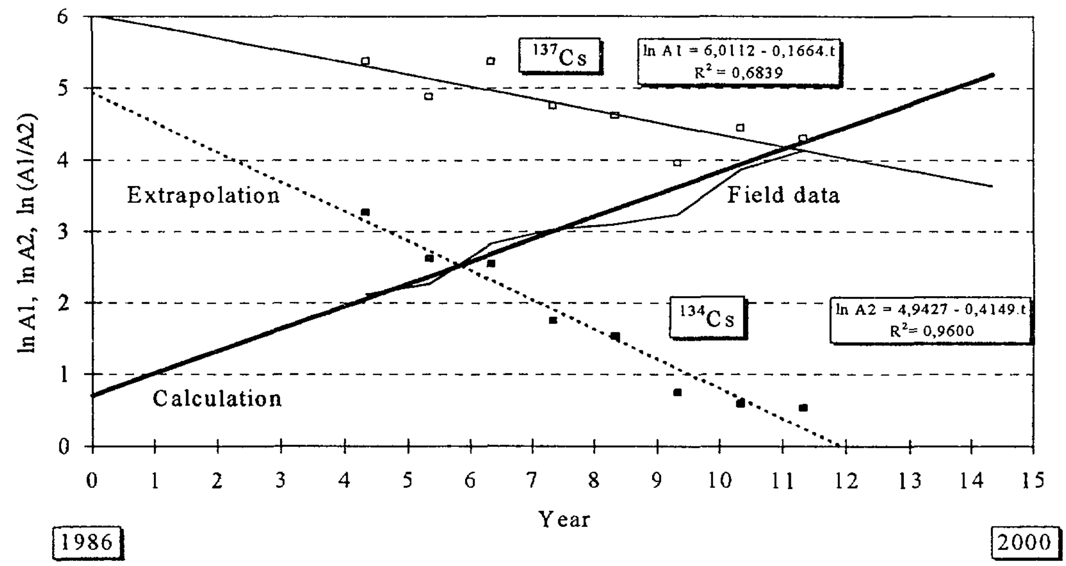

Figure 5 Time change in mean annual concentrations of ^{137}Cs (A1) and ^{134}Cs (A2) in the bottom sediments in the Orlík Reservoir and their ratio, calculated from observed data and from the Chernobyl mixture.

For assessing conditions of surface waters under which productivity of aquatic ecosystems would not deteriorate and diversity of aquatic species would not significantly decrease, fish species and aquatic macrophytes were explored in the Orlík Reservoir. A peak after Chernobyl and subsequent decrease was observed also in the concentration of artificial radionuclides (^{90}Sr, ^{134}Cs and ^{137}Cs) in the biomass. Time change in ^{137}Cs concentrations in fish sampled in Temelín vicinity is shown in Figure 6. These concentrations are presently at levels of units of Bq.kg^{-1} (fresh weight).

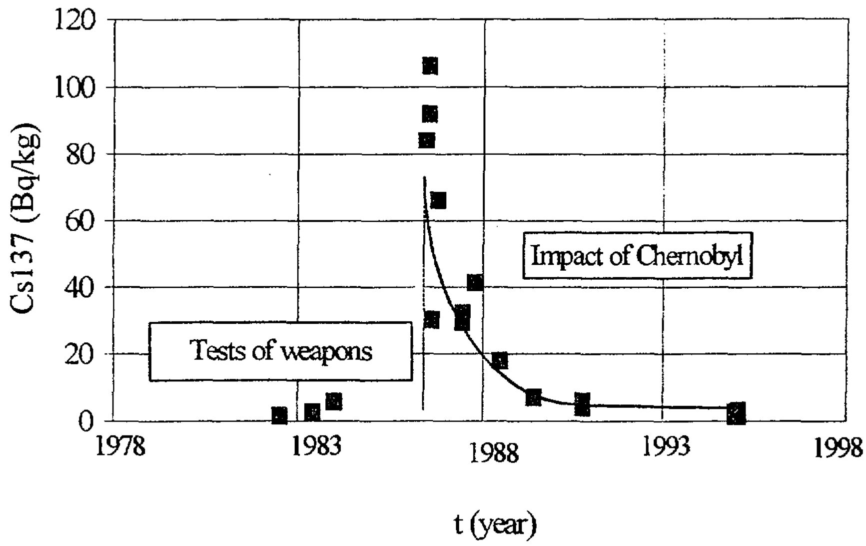

Figure 6 Concentration of ^{137}Cs in fish sampled in Temelín NPP vicinity in the period 1982 – 1995.

PREDICTION OF POSSIBLE IMPACTS

In predicting the impact of standard operation of Temelín NPP on the Vltava River at Kořensko, water quality observed at this site during 1994 and 1995 was taken as a reference level. As a consequence of the effluent returns discharged into the Vltava River at Kořensko, the concentration of polluting substances downstream from the outlet will increase by 0.2 – 12.1 %. This applies to BOD_5, COD_{Mn}, COD_{Cr}, N-NH_4, N-NO_3, P, Cl, SO_4, Ca, Mg and also to radioactive substances except for tritium. In terms of non-radioactive substances emitted from the plant under normal operation, the most important are the returns from the cooling system. The amount of these substances is proportional to quality of the abstracted water. This water, amounting for two reactors in average 1 600 $l.s^{-1}$, will substantially be concentrated by evaporation, which is main causing factor of the water quality deterioration. However, water quality affected by the increased concentration of the polluting substances will not exceed pollution limits specified by Czech Government Decree 171/92, which establishes indices for acceptable water pollution in the Czech Republic.

Tritium is most important in terms of concentration of radioactive substances. Waste water containing tritium is produced mainly in a reactor unit. Due to untightness in fuel rods, tritium could leak into a primary circuit and it can also be produced in cooling medium by activation of deuterium. Figure 7 shows results of a prediction of tritium concentrations in longitudinal profile of the Vltava River for conditions of the operation of two reactors of Temelín NPP and alternatively mean flow (Q_m) and minimum flow (Q_{355}) in the river. For the minimum flow, the average concentrations of tritium downstream from the outlet from Temelín would increase by 127 $Bq.l^{-1}$ while short-term maxima could reach 550 $Bq.l^{-1}$. However, these concentrations would be diluted by water from the Otava River and other tributaries and thus tritium average concentration in the Vltava River at Prague (the site where water is abstracted for drinking water supply purposes) will be at level relevant to 2 % of the limit, which is 700 $Bq.l^{-1}$ for drinking water supply watercourses (Indicators III of Czech Government Decree 171/92). Average concentration of tritium in the Elbe River at Hřensko (Czech-German boundary site) will be around 5 $Bq.l^{-1}$.

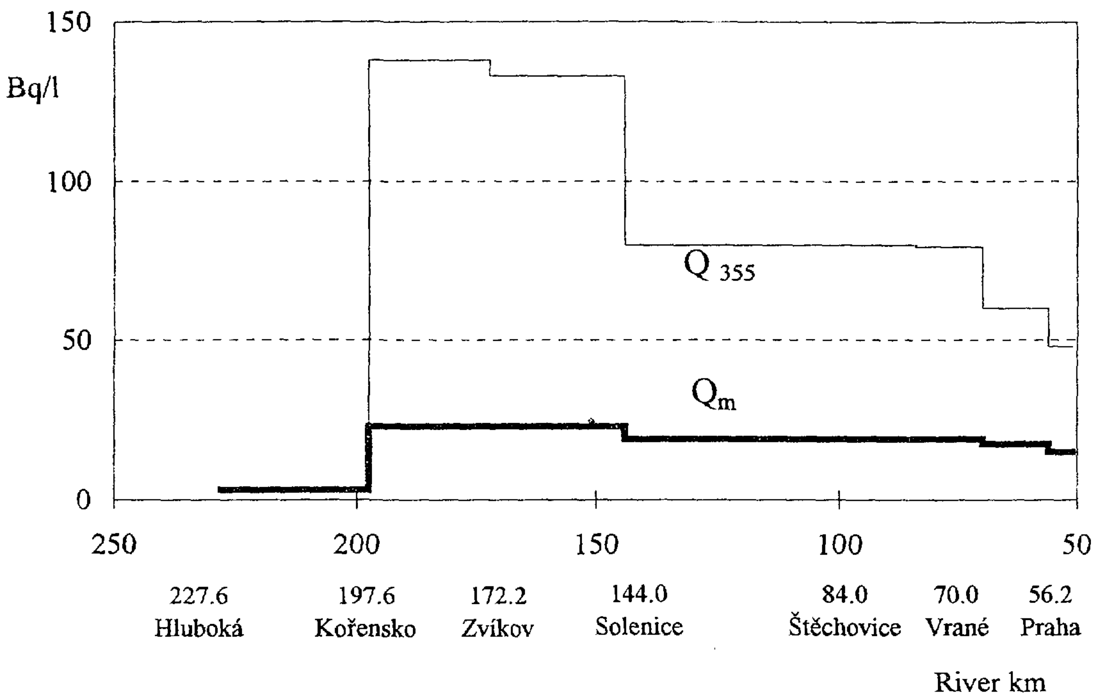

Figure 7 Prediction of tritium concentration in longitudinal profile of the Vltava River for conditions of the operation of two reactors of Temelín NPP and mean flow (Q_m) or minimum flow (Q_{355}) in the river.

CONCLUSIONS

The results of the study demonstrate that quality of water in the Vltava River at Kořensko (the site where water will be abstracted for Temelín NPP) is a dominating factor and its additional deterioration by pollution from Temelín would relatively be low. It is, therefore, important, that the quality of water in the Vltava has significantly improved (this is attributable to newly constructed waste water treatment plants). Results of a prediction of impacts of the operation of Temelín NPP on hydrosphere indicate that pollution limits, as specified in the Czech Government Decree No. 171/92, will not be exceeded.

Water quality deterioration is predicted in terms of tritium concentration, particularly in the Vltava River reach located directly downstream from the outlet of the waste and cooling water from the plant. However, the resulting concentration in Prague will be far below the limit specified for watercourses in use or intended to be used for drinking water supply purposes and thus the deterioration will not affect this use of the Vltava River in Prague. For Czech-German boundary site of the Elbe River at Hřensko, a fourfold increase in mean concentration of tritium is predicted as a consequence of the plant operation. However, the resulting concentration is relevant to 1 % as compared of the above limit.

Data and results of the analyses conducted within the framework of the project (which is intended to be continued) represent a reference level for future assessments of possible environmental changes resulting from the operation of Temelín NPP.

REFERENCES

[1] E. Hanslík: Impact of Temelín Nuclear Power Plant on hydrosphere. Research for practice (series), Volume 35, TGM WRI Prague, 1997.

[2] IAEA: Evaluation of water resources monitoring. Report on assessment of analytical methods for radioactivity monitoring. RU-6172 (CZR/8/002), Vienna 1996.

[3] E. Hanslík et al.: Výzkum vlivu jaderné elektrárny Temelín na hydrosféru (Research on Impact of Temelín NPP on hydrosphere). Final report. TGM WRI Prague, 1995.

NEXT PAGE(S) left BLANK