Changes in the radioecological and ecotoxicological state of Lake Druksiai – cooler of the Ignalina NPP in 1988–2007

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Abstract: Ignalina Nuclear Power Plant (INPP) is located at Lake Druksiai utilized as a cooler. Like Chernobyl NPP, INPP is equipped by RBMK-1500 type reactors. The Unit One was decommissioned in 2005; the Unit Two must be closed in 2009. During exploitation of both reactors the lake was impacted not only by a thermal, but also by chemical and radioactive pollution. The aim of this study was to evaluate the influence of waste water (WW) from INPP on radioecological and ecotoxicological state of Lake Druksiai and the state of Natura 2000 habitats. The investigations were performed during 1988-2000 and 2007. The activity of Cs-137, Co-60 and Mn-54 in bottom sediments and plants of WW channels of INPP and biotopes of Lake Druksiai was measured. The toxicity of water and bottom sediments from WW channels of INPP and biotopes of Lake Druksiai on *Lepidium sativum* and *Tradescantia* clone 02 was assessed. The significant decrease of the activity of tested radionuclides in bottom sediments of WW channels of INPP and Lake Druksiai after the Unit One decommissioning was determined. A slight tendency of Co-60 and Mn-54 activity decrease was determined in plants of INPP channels. However, Cs-137 activity in them was in the same level during investigated period. The tendency of the radionuclides activity decrease was observed in lake biotope suffered from the direct impact of INPP WW. However, the comparison of phytotoxicity of water and bottom sediments from INPP WW channels and Lake Druksiai before and after Unit One decommissioning indicated no improvement in lake ecotoxicological state at all. It was found that of the 9 Natura 2000 habitats of the Lake Druksiai site only 4 are in a rather good state. The abiotic conditions of the growth of some plant species (from the list of Lithuanian Red Book) worsened during the investigated period and as the results the populations of protected plants decreased.

Keywords: pollution, waste water of NPP, phytotoxicity, standing water, reclamation of industrial and polluted areas

Introduction

Ignalina Nuclear Power Plant (INPP) is located at Lake Druksiai utilized as a cooling pond. The Unit One was decommissioned in 2005; the Unit Two must be closed in 2009. Until the beginning of the INPP operation Lake Druksiai belonged to the group of mesotrophic water bodies with traits of oligotrophicity (Baleviciene, 1997). Generally, during the first years of INPP exploitation (1984–1988), the trophic status of the lake remained almost unchanged. Later on the continuous pollution of lake with INPP discharges changed most of the main parameters of water quality, and the lake turned into a eutrophic water body during a very short period of time (Salickaite-Bunikiene & Kirkutyte, 2003). The aim of this study was to evaluate the influence of discharges of INPP on radioecological and ecotoxicological state of Lake Druksiai and the state of Natura 2000 habitats.

Materials and methods

Samples of water, bottom sediments and plants from INPP channels and Lake Druksiai for ecotoxicological and radioecological analysis were taken in 1988–2004 and 2007 at the most important INPP channels: in the industrial storm water and process water channel (ISW), in the area of penetration of this water into the lake (7-th monitoring station), cooling water discharge channel (CW), in channel of waste water (WW) of Visaginas municipal waste water treatment plant (WWTP), in small Lake Skripkos, to which these WW are discharged; at the area of inflow of small rivulet water with these

WW into the lake (6-th monitoring station); and in the 1-st. monitoring station) most distant from INPP facilities (Fig. 1).

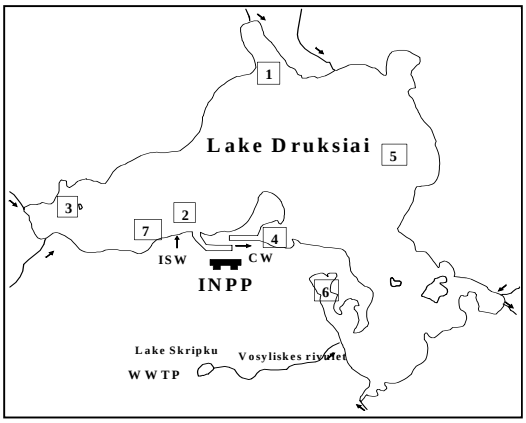

Fig. 1 Scheme of the waste water channels of INPP and monitoring stations of the Lake Druksiai

Activity of radionuclides in plants and bottom sediments was measured using the methods described in the publications (Gudelis et al., 2000; Luksiene et al., 2006). Phytotoxicity tests were carried out using garden-cress (*Lepidium sativum* L.) (Montvydiene, Marciulioniene, 2004) and spiderwort (*Tradescantia* clone 02) (Osipova, Shevchenko, 1984; Marciulioniene et al., 2004). The toxicity level of the tested water and bottom sediments was assessed following the methods suggested by Wang (1992) and Marciulioniene et al. (1996).

Results and discussion

Long-term radioecological investigations of Lake Druksiai showed that during the period of 1988–2004 when both Units of INPP were operating the highest values of Cs-137, C-134s, Sr-90, Co-60 and Mn-54 specific activity in flora, fauna and bottom sediments was estimated in 1988–1993. The tendency of decrease of the specific activity of radionuclides (especially of Cs-137, Co-60 and Mn-54) in flora, fauna and bottom sediments was observed from 1994 and in some cases from 1996. The values of Cs-137 and Sr-90 specific activity in plants and especially in bottom sediments of Lake Druksiai were higher than that in waste water (WW) channels of INPP. However, specific activity of Co-60 and Mn-54 in plants and bottom sediments of the lake were lower than that in WW channels of INPP. Investigations performed in 2007 showed, that after the decommission of the Unit One, the specific activity of radionuclides (especially of Co-60, Mn-54 and Sr-90) in plants and bottom sediments of Lake Druksiai and INPP WW channels decreased in the most cases. Though the values of Cs-137 specific activity in bottom sediments of lake diminished, they were markedly higher than that of the other tested radionuclides in flora, fauna and bottom sediments. According to 2007 data we can maintain that the radioecological state of INPP WW channels and Lake Druksiai are quite good, due to diminishing of specific activity of all the tested radionuclides in flora and fauna and Co-60, Mn-54 and Sr-90 in bottom

sediments as well. However, the bottom sediments of the lake remain Cs-137 deposit medium.

Long-term (1988–2000 and 2007) ecotoxicological investigations showed that in the most cases, water and bottom sediments of INPP WW channels and Lake Druksiai caused weak toxic impact or were non-toxic for garden-cress, for spiderwort they were medium or strongly genotoxic. The toxicity of water and bottom sediments of Lake Druksiai was the highest in 1993–1998. WW of Visaginas municipal WWTP was more phytotoxic than INPP WW directly flowing into Lake Druksiai. Ecotoxicological cartography performed in 1995 showed that radioactive and non-radioactive substances in INPP discharges may accumulate in the bottom sediment of the lake and form areas with the increased level of toxicity. These areas coincide with the borders of an area exposed to the highest level of geochemical contamination (Montvydiene et al., 2008). The strongest radioactive and chemical pollution in Lake Druksiai was determined during 1988–1993; as well as the greatest genetic changes in biological tests were observed in 1993. Such changes in biological tests could be one of the reasons that caused changes of lake ecosystems resulting in degradation of these communities due to extinction of species in them (Baleviciene, 1997).

The botanical investigations in the Lake Druksiai site, in the valley of river Druksos, and in littoral of the Lake Druksiai were performed in 1979–1983, 1993–1997, and in 2006–2007 (Stankeviciute, 2007). At the vicinity of INPP the 9 habitats from EU Habitat Directive Annex I and 8 plant species from the Lithuanian Red Book were identified. In the Lake Druksiai site 4 types of meadow habitats (6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates; 6410 *Molinia* meadows; 6450 Northern boreal alluvial meadows; 6510 Lowland hay meadow), 2 types of marshes habitats (7140 Transition mires and quaking bogs; 7230 Alkaline fens), 1 type of forest habitat (9080 Fennoscandian deciduous swamp woods) and 2 types of lake habitats (3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.; 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* – type vegetation) of EU Habitat Directive were found (Stankeviciute, 2007). Before the launch of INPP, Lake Druksiai was a mesotrophic lake. In its benthic vegetation dominated communities formed by *Characeae* (*Chara rudis*, *Ch. filiformis*, *Ch. aspera*, *Nitellopsis obtusa*) (Baleviciene, 1997). In nowadays the state of Lake Druksiai as the 3140 type habitat is worsened markedly. The areas of *Characeae* were contracted and changed by communities of *Ceratophyllum demersum* and *Myriophyllum spicatum* which are specific to eutrophic water bodies. The thick and various in size overgrow of *Schoenoplectus lacustris* and *Phragmites australis* are formed in the lake's shallows. They occupy the habitats suited for *Characeae* and rare species (*Alisma gramineum* and *Zannichellia palustris*); in the areas enclosed of waves the decayed plants concentrated; and the processes of water logging of the falls of rivers are observed. Only 4 habitats (6210, 7140, 9080, and 6450) are in a rather good state within 9 habitats of Natura 2000 of the Lake Druksiai site (Stankeviciute, 2007). The growth condition of some plant species (from the list of Lithuanian Red Book) – *Dactylorhiza incarnata*, *D. baltica*, *Eriophorum gracile*, *Hamatocaulis vernicosus*, *Alisma gramineum* and *Zannichellia palustris*) worsened during the investigated period.

Conclusions

Summarizing the results of radioecological and ecotoxicological investigations during the period of 1988–2007 it may be stated that radioecological situation of Lake Druksiai after the Unit One decommission is quite good. The ecotoxicological state of the lake changed little, however, in some cases the tendencies of the toxicity increase in water and bottom sediments were observed. Hydrochemical and botanical investigations showed the rather intense processes of Lake Druksiai eutrophisation. The processes of the lake ecosystem restoration did not observe and ecological state of habitat of Natura 2000 in the lake site did not improve after the Unit One decommission in 2005. It can be mainly caused by rather high thermal pollution and constant inflows of WW of INPP and Visaginas municipal WWTP into the lake. The other important factor is toxic substances accumulated in the bottom sediment of lake during the INPP operating period. Bioavailability of most is little; therefore, a greater danger is possible only for benthic organisms. However, in case of change of ecological conditions, hydrological and hydrochemical mode of Lake Druksiai, toxic substances existing in the bottom sediments (heavy metals, radionuclides, ect.), would be possibly penetrate into water again and having joined the biological circulation would accumulate in flora and fauna of the lake. The great challenge for Lake Druksiai and for the vicinity of the lake would be the construction of new nuclear power plant after decommission of INPP.

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