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Lake Peipsi as a biggest transboundary lake in Europe

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Abstract

Lake Peipsi sensu lato (s.l.) (Chudskoe or Chudsko-Pskovskoe in Russian) (3555 km²) is the biggest international lake in Europe and the fourth largest lake in Europe after the Ladoga, the Onega, and the Vänern with respect to surface area and is located in the Baltic Sea water basin. Three states share its water basin – the Russian Federation 59%, Estonia 34% and Latvia 7% of the basin area. The formation and distribution of the structural types of bottom deposits of Lake Peipsi is determined by hydro-meteorological (waves, currents, seasonal water-level fluctuations, lake ice impacts) as well as by the local geologic and geomorphologic factors like the topography and coastal morphology. The central part of the Lake Peipsi s.s. is 9–11 m deep; the coastal zone is shallow and the rather monotonous floor descends for some kilometres in the eastern and western coasts. The main land cover of the Lake Peipsi catchment is forest (50–70%) and agricultural lands (~30%). The water quality of the Lake Peipsi basin depends on natural processes and human activities. The trophic level of Lake Peipsi has increased step by step from

Sunset over Lake Peipus (photo by Modris Putns, 2014, wikimedia commons, CC BY-SA 3.0).

mesotrophic-eutrophic to eutrophic-hypertrophic during the past decades. The main commercial fishes of Lake Peipsi are lake smelt, perch, ruff, roach, bream, pike, vendace and pikeperch. Being officially approved by the Estonian-Russian Transboundary Water Commission, the Lake Peipsi basin Management Programme forms a base for the future joint actions in the basin. River Basin Management Plan (RBMP) has been established for the shared river basin district, but separately in Estonia and Russia. Both sides notify each other regularly on the planned and implemented measures, however, the implementation of such measures is decided and done independently from each other. The management measures in Estonia should prioritize land use issues, such as a reduction of diffuse emissions from agriculture; in contrast, the Russian policy should focus on improved municipal and industrial waste-water treatment and the drinking water quality.

Key words

Lake Peipsi, eutrophic, transboundary, River Basin Management, water level.

Introduction

Lake Peipsi *sensu lato* (s.l.) (as well as used Lake Peipus in English or German, Chudskoe or Chudsko-Pskovskoe in Russian) (3,555 km²) is the biggest international lake in Europe and the fourth largest lake in Europe after the Ladoga, the Onega, and the Vänern with respect to surface area and is located in the Baltic Sea water basin. Three states share its water basin – the Russian Federation 59%, Estonia 34% and Latvia 7% of the basin area (figure 1). It is of great importance for both Russia and Estonia as a resource of drinking water, but also from the point of view of fishery, recreation, and traffic. In general, Lake Peipsi has attracted specialists of different professions since long. A set of monographs were published including: in English – “Lake Peipsi. Geology” (Miidel, and Raukas 1999); “Lake Peipsi. Flora and Fauna” (Pihu and Haberman 2001) and “Lake Peipsi. Meteorology. Hydrology. Hydrochemistry” (Nöges 2001); in Estonian – “Peipsi” (Pihu and Raukas 1999) and “Peipsi” (Haberman et al. 2008); in Russian – “Lake Chudsko-Pskovskoe” (Sokolov 1941); “Bottom Deposits of Pihkva-Peipsi Lake” (Raukas 1981); “Hydrological Regime of Lakes and Reservoirs in the USSR: Lake Chudsko-Pskovskoe” (Sokolov 1983); “Pskovsko-Chudskoe Lake” (Raukas et al. 2012).

Figure 1. Location map of the Narva River – Lake Peipsi catchment basin (map created in ESRI ArcMap and Inkscape, source https://commons.wikimedia.org/wiki/File:Narva_basin_map.svg 2009) (p. 251).

Lake Peipsi s.l. belongs to the watershed of the Narva River, that connects the Lake with the Gulf of Finland of the Baltic Sea. After the Neva, the Narva River is the second largest river (77 km long) flowing into the Gulf of Finland. The Narva-Peipsi watershed (56,225 km²) is a major international basin in the Baltic Sea area and Europe. The watershed is approximately 12 times larger than the lake surface itself. The catchment

basin of Lake Peipsi s.l., which extends from 59°13' to 56°08' N and from 25°36' to 30°16' E (figure 1), is divided between two EU-states (Estonia and Latvia) and one non-EU state (Russian Federation). The drainage basin is flat, with a highest point of 317 m above sea level and an average elevation of 163 m. This basin is a typical North-European lowland area of glacial origin, characterized by Palaeozoic bedrock, covered by unconsolidated glacial materials of variable thickness. Directly on the northern coast of Lake Peipsi, dunes with specific morphology, called “basket-trap” dunes by Orviku (1933), are common, formed behind rather huge parabolic wind ditches (Raukas 2011). Lake Peipsi s.s. near Alajõe, about 4 m high new bluff formed in ancient dunes (figure 2). The lake consists of three parts: the largest and deepest northern part Lake Peipsi *sensu stricto* (s.s.) (Chudskoe in Russian), the middle strait-like part Lake Lämmijärv (Tyoploe in Russian) and the southern part Lake Pihkva (Pskovskoe in Russian) (figure 1, table 1). Lake Pihkva is almost entirely under Russian jurisdiction.

Figure 2. The reeds of Lake Peipsi have increased through the last 30 years, from 20 g m⁻² in 1970 through 789 g m⁻² in 1989 to 1563 g m⁻² in 2002 (the mean air-dry biomass, of the northern part of the lake) (Mäemets and Freiberg 2004)“container-title”:“Limnologia - Ecology and Management of Inland Waters”,“page”:“83-89”,“volume”:“34”,“issue”:“1-2”,“source”:“Crossref”,“abstract”:“The reeds of Lake Peipsi (surface area 3555 km², mean depth 7.1 m, max. depth 15.3 m, notregulated. Photo by G. Kapanen (p. 252).

There are about 240 inlets into Lake Peipsi s.l. The largest rivers are the Velikaya, the Emajõgi, the Võhandu, and the Zhelcha. The catchment area of the Velikaya River is 2.6 times as large as that of the Emajõgi River and its mean discharge is 2.5 times as high (188 and 75 m³ s⁻¹, respectively) (Blank et

al. 2017). The lake average depth is 7.1 m, maximum depth is 15 m and the residence time of water is about two years (Jaani and Raukas 1999) (table 1). The Lake Peipsi wetland areas Emajõe Suursoo (Estonia) and Remedovsky (Russia) are listed as Ramsar sites.

Table 1. Morphometric data on Lake Peipsi s.l. (at water level 30 m a.s.l.). Sources: (Sokolov 1983); (Jaani and Raukas 1999) (p. 252).

Climatically Lake Peipsi is located in the continental climate zone whose weather is moderated by the relative closeness of the Atlantic Ocean. Summers are comparatively warm and wet, and winters are rather mild. The average air temperature in the Lake Peipsi s.l. catchment is **14,7°C in June and -3.3°C in December** (Tiirikoja meteorological station, period 1923-2017). The mean annual precipitation during 1957–2009 is 600–660 mm (Tammets and Jaagus 2013) droughts appear mostly in the first half of summer, while in the eastern Estonia, they are usually observed during the second half of summer. Extreme precipitation events have become more frequent and intense. Statistically significant increasing trends were, first of all, found in the time series of winter extreme precipitation indices. In summer and autumn, trends existed in some indices, but in spring, there were no trends at all. There were no trends in time series of dryness indices in Estonia in 1957–2009. The average velocity of the wind is 4-5 m s⁻¹. Waves are steep and short and with the wind force of 8 m sec⁻¹ their height is 60–70 cm (Sokolov 1983). Waves of this height are most common (57%) in L. Peipsi s.s. The highest waves (240 cm) were recorded in 1961 and 1962 with the wind force of 20 m sec⁻¹ (Terasmaa et al. 2013).

The formation and distribution of the structural types of bottom deposits are determined by hydro-meteorological processes (waves, currents, seasonal water-level fluctuations, lake ice impacts) as well as by

lithological and geomorphological factors. In large and shallow lakes like Lake Peipsi – characterized by its high dynamic ratio (DR = 6.16, calculated according to (Håkanson and Jansson 1983; Lindström et al. 1999) – sedimentation is influenced mainly by currents and waves, and also by rivers flowing into the lake (Vaasma and Terasmaa 2010).

The water regime varies greatly from year to year, depending on the annual variability of precipitation and temperature in the region. In general, ice starts to cover Lake Peipsi s.l. by the end of December and the lake becomes ice-free in April–early May. In normal winters ice is 50.60 cm thick and in a harsh winter may be over 80 cm still in April. The thickest ice ever in Lake Peipsi – 120 cm – was measured at the centre of the lake in April 1965 (Reinart and Pärn 2006).

The changes of hydrological conditions, which are reflected by cyclic fluctuations in the water regime over a long period, were discussed already at the end of the 19th century and various plans were proposed for water-level regulation (Kening and Zhivilov 1909; Shpindler and Zengbush 1896). The first scientific studies of the lake were started after the catastrophic inundations in the 1840 s, which had caused great damage to adjacent areas (Anto Raukas and Tavast 2011). K.–E. Baer (1860) guessed that catastrophic floods had been caused by meliorative works and down cutting of forests in the watershed. To avoid big floods G. von Helmersen (1864) proposed to lower the water level of the lake by four feet (about 1 m), dredging the upper course of the Narva River. Lowering the lake's water level became a topical matter again after the extremely water-rich years in the beginning of the 1920 s. In Nina Village on the western coast of Lake Peipsi south of Kallaste Town, local inhabitants had to be resettled and shore defence constructions were built (Vichmann 1929).

The water level is not regulated; the reference water level is 30 m a.s.l. (200 cm according to the Tiirikoja/Mustvee hydromet-

ric station). The beginning of hydrological exploration in the Peipsi basin is related to navigation on the Narva River (Raukas and Tavast 2011 and references therein). Commissioned by the Russian Ministry for Roads, the engineer E. König began preparations for designing a Tartu—Pihkva—Narva waterway in 1902. At the same time, seven water level measurement stations were built on the banks of the Narva River. In addition to those, one station was built at Praaga in the mouth of the Emajõgi River. But the first water level measurement station on River Emajõgi in Tartu had already been built 35 years earlier, which means that information about the water level fluctuations in Lake Peipsi is available for a period ~150 years.

The seasonal and especially long-term water level fluctuations in Lake Peipsi are considerable and rather well studied. Distinct rhythmicity is observed in lake-level fluctuations. Jaani (1973, 1999, 2001) and Kullus (1990) distinguished six long-term cycles with a duration of 19-34 years, which are close to the so called Brikner cycles (Pérez-Peraza et al. 2005). The short period cycles with a mean extension of approximately 5.1 years were found as well. (Reap 1986) carried out the spectral analysis of the same series, detaching cycles (in years) of 6.1-6.4, 10-11 and 80-90, whereas in the series of floods of the River Neva detached cycles of 5.1 years, 6.1-6.3, 10.5-11 and 29.3 years.

Every cycle has an average water level, but there are also short-time deviations. Due to the considerable water-level fluctuations in the lake both the surface area and the volume of the lake water vary greatly. During the highest water level (May, 12, 1924; 31.76 m) the surface area of Lake Peipsi was estimated at 4,330 km² and the volume of water at 32 128 km³. At the lowest water level (November, 7, 1994; 28.72 m), these values were 3,480 km² and 20.98 km³, respectively. The surface area may vary by 850 km² and the water volume by 11.15 km³ (Eipre 1964; Jaani and Raukas 1999; Sokolov 1983). The

amplitude of natural fluctuation between annual averages of the water level of Lake Peipsi is about 1.5 m. The maximum amplitude of water level fluctuations is 3.04 m.

The water quality of the Lake Peipsi basin depends on natural processes and human activities. The trophic level of Lake Peipsi has increased step by step from the mesotrophic-eutrophic state to the eutrophic-hypertrophic state during the past decades, depending on the lake part (Frumin et al. 2017; Kangur et al. 2002; Starast et al. 2001; Tammearg 2014) as a consequence of a decline in agricultural production in the watershed and a decrease in the amount of waste water discharged into rivers, the nutrient load carried from the catchment area into large, shallow, eutrophic Lake Peipsi (area 3,555 km². Riverine transport is the most important pathway for input of nutrients to the Lake Peipsi. In the 1960s, Lake Peipsi s.s. was almost mesotrophic and Lake Pihkva was eutrophic (Starast et al. 2001). Further, eutrophication of surface waters started from the 1970s. The pollution load was the largest at the beginning of the 1980s due to intensive human activity in the catchment area. Because of inefficient use of fertilisers and improper manure handling during the Soviet period, agriculture caused high emissions of nutrients (total N, total P) into rivers and lakes and subsequent eutrophication problems. The pollution load dynamics has changed since the breakup of the former Soviet Union. The economic recession followed the collapse of Soviet Union as well as increased wastewater treatment capacities of big settlements. In 1990s diffuse loading decreased sharply, by 53% and 44%, as regards N and P loading, respectively (Loigu and Leisk 1996). However, in spite of the drop in the external loading, the P content in the southern part of the lake continued to increase in the 1990s. The ecological condition of Lake Peipsi s.s. and especially that of Lake Pihkva began to be characterized by massive potentially toxic cyanobacterial blooms, drastic nocturnal oxygen shortages, and fish kills (Haberman et al. 2010; Kangur et al. 2013). According to (Kangur

et al. 2002) as a consequence of a decline in agricultural production in the watershed and a decrease in the amount of waste water discharged into rivers, the nutrient load carried from the catchment area into large, shallow, eutrophic Lake Peipsi (area 3,555 km², at the beginning of 21 century judging by the state of the biota, the trophic situation in the lake has not improved. For the period 2000–2015 the quality of water in Gdovka (river station Gdov city), Piuza (Pechory), Plyussa (Slantsy), and Zhelcha (Yamm settlement) may be graded as “slightly dirty,” and in Emajõgi (Kavastu) and Rannapungerja rivers (Iisaku-Avinurme), as “dirty” (Frumin and Fetisova 2017). The net annual load of P to Lake Peipsi in 2006–2010 was 723 t (Piirimäe et al. 2015). Roughly half of that was retained in the lake while the other half flowed on to the River Narva (estimated by Kondratyev 2011). Pskov (Russia) and Tartu (Estonia) with 206 000 and 100 000 inhabitants, respectively, contribute the majority of the point source pollution (Buhvestova et al. 2011). Blank et al. (2017) compared the two sub-periods – 2003–2007 and 2008–2012 – and argue a decline of nutrients in loadings to Lake Peipsi s.l., and also in in-lake water, that showing a small shift towards the recovery of the lake. The recovery may be a slow process and as biotic communities differed in the timing of their responses to changing nutrient conditions.

In the large shallow Peipsi, the increase in reeds has been the most remarkable consequence of nutrient enrichment during the past fifty years (Mäemets and Freiberg 2004). The assessment of ecological status at the minimum and the maximum water level differs at least by one quality class (Mäemets et al. 2018). The most significant increase of the reeds has taken place in the northern part of Lake Peipsi (figure 3). The area of reeds (mainly *Phragmites australis* (Cav.) Trin. ex Steud.) made up about 1% of the lake area, inside the lake borders in 2013, according to the calculations based on satellite images (Peterson and Liira 2016) or about 1.3% of the lake area, according to calculation based

on the results of field studies from the 2000s (Mäemets and Freiberg 2004).

Figure 3. About 32 km of coastal sand dunes have formed on the northern shore of Lake Peipus s.s. Sand dunes can be as high as 5–8 meters; in Alajõe, their height can reach 20 meters. Photo by G. Kapanen (p. 254).

Considering annual fish catches Lake Peipsi (9000–12000 tons or 25–40 kg ha⁻¹) surpasses all large lakes in North Europe (Nöges et al. 1996). Structural changes in the fish community of Lake Peipsi during the last 70 years have shifted from clean and cold-water species like vendace, whitefish and burbot, to more pikeperch preferring productive warm and turbid waters (Kangur et al. 2007). The main commercial fishes of Lake Peipsi are lake smelt, perch, ruff, roach, bream, pike, vendace and pikeperch. The stock of vendace has sharply decreased in the last years, while the amount of pikeperch has increased.

Land Ownership

According to Samuel P. Huntington (1998) “...the great historical line that has existed for centuries separating Western Christian peoples from Muslim and Orthodox peoples [...] runs along what are now borders between [...] the Baltic states (Estonia, Latvia, Lithuania) and Russia [...]”. Estonia’s geopolitical location on the border of two civilizations and its recent history make it an interesting subject for studying the driving forces and the mechanisms of emergence of cooperation between two countries differing substantially by size, importance on the international arena and cultural background.

The Russian Federation (total area is 17,075,200 km², included land 16,995,800 km² and water 79,400 km²) has borders with fourteen European and Asian states. There are 102 large and medium-sized transboundary watercourses: sixty-two rivers flowing from the territory of Russia and forty rivers flowing into Russia. The total number of riv-

ers, lakes and other water bodies crossing the border amounts to a thousand (Kukosh and Nabrodov 1998). To the other side with an area of 45,000 km², Estonia is larger for example than Slovenia, Holland, Denmark or Switzerland.

The Estonian Peipsi catchment area a total area is 11,224 km² (¼ of Estonian territory) and total population of about 444,500 (~¼ of Estonian population). The total population of the Russian Lake Peipsi catchments area is about 421,400 inhabitants, out of which 325,000 live in towns. The region is comparatively rich in natural resources. This fact is important especially to Estonian side because, how was mentioned above, the Peipsi region cover ¼ of Estonian territory. Great such differences, which became of territory and population like government structures, economical interests, investments etc. have brought difficulties and problems to the management of transboundary water shared between Estonia and Russia.

The Estonian Peipsi catchments area embraces four counties – Ida-Viru, Jõgeva, Tartu and Põlva. Local municipalities covering 3,600 km² with 30,800 inhabitants are in direct contact with the lake. On the Russian side, the Leningrad and Pskov Regions (oblast) border the lake. Five districts and two towns (Pskov and Ivangorod) are major administrative entities in this region for Lake Peipsi with the total area of 13,212 km².

The main land cover of the Lake Peipsi *s.l.* catchment is forest (50-70%) and agricultural lands (~30%), the latter concentrated in Estonia. The rest of the land cover consists of peat bogs and built-up areas (Mourad 2008). Agriculture in the Lake Peipsi catchment includes animal husbandry and the production of crops, mainly cereals (Iital et al. 2005) .

The central and southern parts of lake catchment are rural, sparsely populated area with forestry and agriculture as the main sources of income for inhabitants. The

northern part of the lake catchment is the most industrial and is intrinsically linked to oil shale.

The main natural resource of industrial importance in the Lake Peipsi basin is the oil shale. The oil shale in the Baltic Basin is one of the most unique by virtue of its composition and high quality. Estonian oil shale (known by the scientific name of *kukersite*) is an Ordovician sedimentary rock containing up to 65% of a combustible organic matter, kerogen, with a net calorific value that varies in the range of 8.0 to 11.0 GJ t⁻¹ (Kattai et al. 2000).

The artificial Narva Reservoir was established in 1956 by flooding about 200 km² on the upper course of the Narva River, of which 80% is nowadays on the Russian territory (Järvik et al. 2000). The reservoir belongs to a huge power complex, which includes hydro-electric and thermal power stations. The total output of these oil-shale operated power stations can be up to 3000 MW (Jaani 2001). Some 80% of the oil shale production is for energy production. The remaining 20% is used as raw material for chemical enterprises in towns like Kohtla-Järve (Estonia), and Slancy (Russia).

The wastes generated by the Kohtla-Järve shale oil factory and thermal power plants have been dumped onto the ground surface in the close vicinity of these enterprises since 1938. No artificial barrier impeding the vertical movement of landfill leachate was arranged on the dumping site. Approximately 108 t or 8 × 10⁷ m³ of wastes were stored in an area of 2.14 km² until 2010 (Vallner et al. 2015) which is likely the largest of its kind in the World, was started in 1938. The environmental risks connected with the landfill were assessed and prioritized. The most significant hazard to human health is emission of harmful landfill gases and the water contamination in the local river network is harmful for aqueous organisms. The spatial expansion of subsurface contamination predicted by the groundwater transport model completed is

practically insignificant from the viewpoint of health services. The landfill's leachates must be captured and purified, and the closed part of the landfill should be covered by greenery. The partial landfill capping recently executed is useless. The EU Landfill Directive requirements imposed on the hydraulic resistance of geological barriers cannot prevent the leakage of contaminants from a landfill. Total fly-ash emission to the atmosphere from the power plants reached annually more than 300 kilotonnes at the end of the 1970s (Punning et al. 1997), among this more than 100 kg consisted of PAHs. Therefore, in the 1970s-1980s much attention was paid to power plant emissions as a potential source of the pollution to Lake Peipsi and its catchment. Since that time serious measures to decrease emissions have been implemented and by 2002 fly-ash emissions from the power plants had decreased more than 10-fold compared with the maximum rates during the late 1970s.

Besides oil shale and locally used small deposits of construction materials, there are renewable resources like water, fish, forests and peat.

The lakeside municipalities both in Estonia and Russia are periphery areas: unfavorable demographic situation, depopulation of the region, economic recession, and underdeveloped physical infrastructure. All these municipalities rank below the national average living standard. And they all see their development potential in the lake and local small and medium size entrepreneurship focusing on fishery, organic farming and tourism.

Tourism

Tourism is a perspective but little developed sector. Some work has already been done but the building of infrastructure has not yet been completed. There has also been little development in the lakeside areas including the islands of lake. However, these environmentally clean, quiet and safe places could attract a large number of tourists, both

foreign and Russian especially from St-Petersburg.

At the present moment, there is no institution that is responsible for promoting tourism in the whole Lake Peipsi area. Obviously, this is one of the reasons why relatively little attention has been paid to tourism opportunities associated with Lake Peipsi in the development plans. The weak side of tourism development is also the water transportation possibilities and the infrastructure of lake ports in both countries. The Tartu port (on the Emajõgi River) has ambitions to be the biggest port for tourism and water trade in Lake Peipsi in Estonia, but nowadays has still underdeveloped infrastructure. The possibilities on economic cooperation through Lake Peipsi have been already discussed for at least 20 years. Pollution risk from tourism is low due to a moderate number of tourists, which is caused by undeveloped infrastructure (hotels, restaurants, shops, organised beaches etc.) (Raukas and Tavast 2011). Building a better infrastructure is essential to support tourism and recreation.

River Basin Management

The Estonian and Russian governments have signed a bilateral intergovernmental agreement on the use and protection of their transboundary waters in 1997. According to the agreement, the Estonian-Russian Transboundary Water Commission (further the Joint Commission) was established. The Commission organizes exchange of monitoring data between the Parties in accordance with the agreed monitoring program, defines priority directions and programmes of scientific studies on protection and sustainable use of transboundary waters, and agrees on common indicators of quality for transboundary waters, methods of water testing and conducting analyses. At occasions when an extraordinary situation occurs on transboundary waters, the Parties will immediately inform each other through the competent agencies and the commission.

Besides the agreement signed in 1997, Estonia and Russia have also set an agreement on fisheries of Lakes Peipsi, Lämmijärv and Pihkva (1994), an agreement on mutual fishing relationships (1994) and an agreement on environmental protection (1996).

On the transboundary basin level, preparation of the joint measures, based on the common environmental objectives for the whole transboundary water basin, is coordinated across the border through developing an umbrella Lake Peipsi/Chudskoe Basin Management Program for the whole transboundary water basin. The program addresses environmental issues of importance for the whole transboundary water basin and includes practical recommendations for the Lake Peipsi/Chudskoe nutrient load reduction and prevention, and the sustainable conservation of habitats and eco-systems in the cross-border regional context. This Programme was a first Transboundary Basin Management Program, developed for the external EU borders, taking into account EU WFD requirements and national legislation. Being officially approved by the Estonian – Russian the Joint Commission, the Programme forms a base for the future joint actions in the basin. At the same time, the development and implementation of the joint Programme is complicated due differences in the official requirements and deadlines. The management measures in Estonia should prioritize land use issues, such as a reduction of diffuse emissions from agriculture; in contrast, the short-term Russian policy should focus on improved municipal and industrial waste-water treatment (Piirimäe et al. 2015).

Estonia

In Estonia, the Ministry of the Environment is responsible for environmental policy making and planning, development of environmental legislation covering the areas of air, marine-, surface- and groundwater, nature conservation, and use of natural resources. The center piece of EU water legislation is the so-called Water Framework Directive (WFD)

adopted in 2000 ("WFD" 2000). The WFD sets a ground for transboundary cooperation in cross border waters and significant water issues. The main objective of the WFD is to achieve good chemical and ecological status or ecological potential for all surface waters (as well as coastal waters) and good chemical and quantitative status for all groundwater bodies. The last report describes the environmental objectives that shall be achieved and measures that shall be implemented now in 2016–2021.

On the basis of regulation of the Government of the Estonian Republic no 132, 9 September 2010, the territory of Estonia is divided into 3 river basins: The West Estonian river basin, the East Estonian river basin, and the Koiva river basin. The river basin of East-Estonia (19,047 km²) is a cross-border river basin that is comprised of the basin of Lake Peipsi and the River of Narva and divided in turn into the following sub-basins: the Viru sub-basin, the Peipsi sub-basin, and the Võrtsjärve sub-basin. River basins and sub-basins are water management units, which do not follow county or rural municipality administrative borders. East Estonian river basin (official number EE2) includes 267 rivers and 40 lakes (table 2). The Programme of Measures for the East-Estonian River Basin Districts (RBD) has been established for the part of the shared river basin district lying in the Estonian territory. Both sides (Estonia and Russia) notify each other regularly on the planned and implemented measures, however, the implementation of such measures is decided and done independently from each other. The quantitative monitoring programme has changed in East Estonia RBDs since 2009: the surveillance monitoring programs have considerably (2–3-fold) decreased; operational monitoring has been decreased from 44 to 15.

Table 2. Water bodies (WB) in the East-Estonian (EE2) River Basin District (RBD) (surface water –SW; groundwater – GW), source (CWD: Member State Estonia 2012) (p. 259).

The water management plan is a single document containing the following primary surface water and ground water objectives: supplying the entire population with drinking water; the maintaining of surface water bodies in a condition as close to their natural state as possible depending on the type of water body and area of application; the preservation of aquatic biotic diversity in aquatic environments; the preservation of the ecological value of coastal waters and coasts; the clear stipulation of water supply use possibilities and restrictions that support sustainable economic development.

The first River Basin Management Plans (RBMP) (for 2009-2015) for these river basins were approved in 2010. Updated water management plans have been prepared for the next six-year period, 2015-2021. The preparation of water management plans is organized by the Ministry of the Environment; plans are approved by the Government of the Estonian Republic. Last East Estonian RBMP was approved on January 7, 2016 ("East Estonian River Basin Management Plan for period 2015-2021", 2016). The baseline scenario for the year 2021 was prepared as part of the program of measures. The East Estonian basin the baseline scenario is based on two aspects: (i) trends of the pollution loads; (ii) the implementation of the existing / planned environmental policy.

In the East Estonian basin, 193 water bodies were in good or very good condition in 2013. There were 103 streams, 12 terrestrial standing bodies (lakes) and 2 coastal bodies in moderate, poor or bad condition. Compared to the previous period, the state of the 31 water bodies has improved and the status of the 57 water bodies has deteriorated. In this regard, it is important to note that a large proportion of water bodies have been assigned to a worse state class compared to the previous water management plan due better knowledge of state of water. In 2014, updated state assessments do not show a major change in the status of water bodies – in the better state class there are 7, in the

worst state class – 14 surface water bodies. About 60% of the surface water bodies in the East Estonian basin are in good or very good condition.

The 26 Estonian groundwater bodies are generally in good quantitative and chemical status with the exception of the one – the Ordovician Ground Water Basin (GWB) of East-Viru oil-shale basin in East-Estonian RBD, which is in poor status, caused by drainage water pumped out from oil shale underground and open cast mines for technological purposes. Based on all groundwater analyses for East-Estonian RBD from periods 1988–2005 and 2006–2009, the content of benzene and oil products has decreased, that of monophenols does not have a trend, whereas the occurrence of polyaromatic hydrocarbons (PAH) is episodic not allowing to determine a trend.

Individual decisions in principle need to be reviewed when environmental objectives are unlikely to be met. The RBMP has a legal effect in the sense that it complements the regulation in the Water Act and also due to the principle that all relevant facts and interests have to be taken into consideration in exercising discretion e.g. when granting a permit. The effect depends on the legal nature of the RBMP, which in turn depends partly on the detail of regulation provided by the RBMP. On the basis of available information, it seems, however, that the plans do not have any significant effect on individual decisions in practice. It seems that the management plans are conceived as some type of strategy documents (not legal acts), which cannot limit discretion. The Water Act provides that, if it appears that environmental objectives are unlikely to be achieved, then emission limit values and environmental quality limit values set out in the water permit should be reviewed.

Russia

In Russia, the fundamental legislative framework on the use of water resources is

laid out in numerous documents (e.g., RF Water Code, 1995). On the national level, the main body currently working in the sphere of use and protection of water resources is the Ministry of Natural Resources of the Russian Federation. The Russian Water Code is based on a river basin approach. Water basin management boards were created under the Ministry of Natural Resources to prepare and organize implementation of river basin management plans. According to the Water Code, regions of the Russian Federation sharing a river basin have to sign a basin agreement that defines a procedure for cooperation on implementation of a river basin management plan; river basin councils are to be established that should represent interests of local stakeholders to advise water basin management boards on implementation of the basin plans. The management plan of the Russian part of Narva River basin was approved in 2014 year ("River Narva basin management plan" 2014).

According to modern hydrographic and water management zonation, the Narva River enters to the Baltic Basin District (code 01). Code of the hydrographic unit of Narva River basin (including the lake) is 01.03.00. In the Basin of Narva, four water management sub-basins (including 14 water management sites) are identified. In 2006 water pollution index surface waters of Lake Pihkva (Pskovskoe), Lämmijärv (Teploe) and eastern part of Peipsi (Chudskoe) are related to III-IV classes of quality, i.e. they are moderately polluted and/or polluted. In 2009 four water management sites were very polluted, 8 – contaminated, and two – slightly contaminated. In 2009 there are no rivers in the Narva River – Lake Peipsi with 1st class water quality – conditionally clean water. The main cause of the unsatisfactory ecological condition of water bodies is the discharge of untreated or insufficiently treated sewage and non-point loading. The surface water bodies of the River Narva basin in the Leningrad region (oblast') (together with sewage, land runoff, precipitation, drainage, and mine waters) from 7.5 to 13.3 tons of total phosphorus; from 67.5 to

221 tons of nitrate nitrogen; from 0.69 to 1.0 tons of manganese; from 5.03 to 17.4 tons of iron total; from 0.65 to 1.24 tons of surfactants received for the period 2003-2009. During the same period to the surface water bodies of the Pskov region (oblast') from 45.6 to 69.9 tons of total phosphorus; from 0.9 to 1.38 tons of manganese; from 1.6 to 16.23 tons of iron total was supplied. The high level of anthropogenic pollution of water bodies is the main problem with the drinking water quality. Moreover, the complex of measures to decrease phosphorus load on the lake from agricultural activity in the catchment is under realization. This complex includes the strict observance of fertilizers application technology, organizing storehouses for mineral fertilizers.

The number of the sampling sites in Russia is substantially lower. Such "unbalanced" data is rather typical for transboundary basins and illustrate the critical issues of the sound harmonized assessment of basic information such as riverine load (Gooch and Stalnacke 2006). Even so, several Estonian-Russian joint monitoring expeditions have been organized and conducted by the Joint Commission.

Already 12 years ago Gooch and Stalnacke (2006) showed major problems, which are still in preliminary stages in the field of joint water management of the Lake Peipsi catchment. The first is the lack of resources, both financial and administrative, of the local environmental authorities and as well as research; the second is the complicated, also with regular reconstitution, the environmental management systems, especially in Russia; the lack of knowledge and means of nature of environmental problems in a transboundary context on some levels.

This situation and the obligation for Estonia to comply with European legislation and WFD, prompted several big projects with the aim to help in improving the water resource status and water management in the area, implement different key aspects of the WFD

on the Estonian side, as well as partly on the Russian side. The projects were funded by the Global Environment Facility, European Union programs like LIFE, FFEM (French Fund for Global Environment), BRGM (French Geological Survey), GTK (Finnish Geological Survey), Dutch Government, EU TACIS, EU FP5, EUFP7. The projects obviously cannot pretend to solve all problems and ensure that upon completion the Lake Peipsi transboundary water resource system will be entirely in line with the requirements of the WFD, the projects mostly focus on key aspects and limited number of demonstration actions. A common and concerted effort is needed from all the parties involved. This is already complicated inside of Europe, and it is even more so in the Lake Peipsi catchment as it is located at the frontier of Europe (Ganoulis et al. 2013).

Conclusions

Despite of observed in last decades some improvements in an ecological condition of Lake Peipsi, it still continues to remain under strong anthropogenic pressure. For the successful joint management of the transboundary Lake Peipsi basin a common and concerted effort is needed from all the parties involved.

The problem of restoration of water quality continues to remain actual. The accepted legal acts, undoubtedly, promote the decision of nature protection questions, however they not always take into account a number of the

specific problems at the local level. The main wastes of the Estonian shale oil industry – oil shale semi-coke and ashes – are deposited in landfills. There should be some options to restrict the expansion of pollutants in groundwater.

The EU does not have a specific dedicated institutional framework for transboundary issues. The UNECE Water Convention remains the overarching legal framework for transboundary cooperation. Being officially approved by the Estonian-Russian Transboundary Water Commission, the Lake Peipsi basin Management Programme forms a base for the future joint actions in the basin. At the same time, the development and implementation of the joint Programme is complicated due differences in the official requirements and deadlines. Both sides (Estonia and Russia) notify each other regularly on the planned and implemented measures, however, the implementation of such measures is decided and done independently from each other.

The further water resources management demands more precise inter-branch coordination in water protection, water use and management as well as in the monitoring programs. The monitoring and research shall be continued and new collaboration projects could be initiated with clear governmental funding.

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