



Influence of land-based Kaliningrad (Primorsky) amber mining on coastal zone



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ABSTRACT

In this paper, we report on the pollution in the coastal zone of the South-Eastern Baltic Sea (Russian coast). It was studied through a range of methods, including analyses potential water quality indicators (WQIs) and potentially harmful elements (PHEs). A contamination factor and modified degree of contamination were used for describing the contamination of the sediments by toxic substances. Special attention was paid to activity of the Kaliningrad Amber Combine (KAC), the biggest world amber mining company, located onshore close to the coastal zone (Kaliningrad Region). The amber extraction contribution to the ecological state of the coastal zone was estimated. Contamination of the quarry by metals (Cr, Co, Ni, Cu, Pb, Zn) was comparable with contamination of abrasion bench. The pollution of the western coastal zone of the Sambia Peninsula is caused both by land-based anthropogenic developments (including KAC) and natural processes (coastal abrasion).

1. Introduction

Coastal areas worldwide are continuously being threatened by pollution issues, such as eutrophication, toxic substances, heavy metals, acidification and siltation resulting from human activities (Adams, 2005; Vaalgamaa and Conley, 2008). An estimated 80% of pollution load in coastal and marine environments originate from industrial, agricultural, urban/rural and other land-based activities (Hilfering et al., 2009). Despite measures to reduce the release of pollutants from anthropogenic sources, the indirect and direct waste discharges into coastal waters remain as a major management problem (Tiquio et al., 2017). The studied area is one of the most popular recreational zones of the Kaliningrad Region, and tourist attractiveness largely depends on the ecological state of the coastal zone. The operation of the nearby large industrial company (Kaliningrad Amber Combine – KAC) certainly has an impact on the coastal zone.

Amber is found on all continents except Antarctica. Its varieties are found both in the coals of the Upper Carboniferous and in the deposits of the Early Mesozoic (Sivkov and Zhamoïda, 2018). However, the actual “amber period” is Cenozoic, to which most of the known fossil resins belong (Weitschat, 2001). The Kaliningrad Region is the world leader in the amber mining. The combine is located near the of Yantarny town (the former Palmnicken) where about 90% of the proved world amber reserves are located, the age of amber being some 50 million years. The field deposits are estimated at 116 thousand tons.

Annually the KAC produces some 300 tons of raw material.

The aim of the study was to determine the impact of the amber combine on the overall ecological state of the coastal zone. A quantitative assessment of the pollution resulting from natural processes (abrasion of the shores, the input of rain and melted water from the adjacent area), as well as the discharge of wastewater and pulp by the combine.

2. Study area

2.1. Geological setting

The Kaliningrad (Sambia) Peninsula is a rectangular ledge of land in the sea (Fig. 1). Eastward the Taran Cape the shore has an almost latitudinal direction, and to the south it is meridional. The coastline of the Sambia Peninsula is poorly dissected, which is explained by the peculiarities of the geological structure.

Glacial deposits almost completely cover the pre-Quaternary formations. Sediments are brown sandy loam and loam with inclusions of pebbles, gravel, boulders. Pebble-boulder or sandy sediments cover the moraine on the bottom surface, as a rule (Atlas ..., 2010). In the lower part of the coastal bench the abrasion is developed, which is most pronounced during periods of severe storms. The amber-bearing Prussian Formation of the Priabonian Eocene Stage on the Sambia Peninsula (Fig. 2) has a thickness of 15–20 m and unites three horizons (from the

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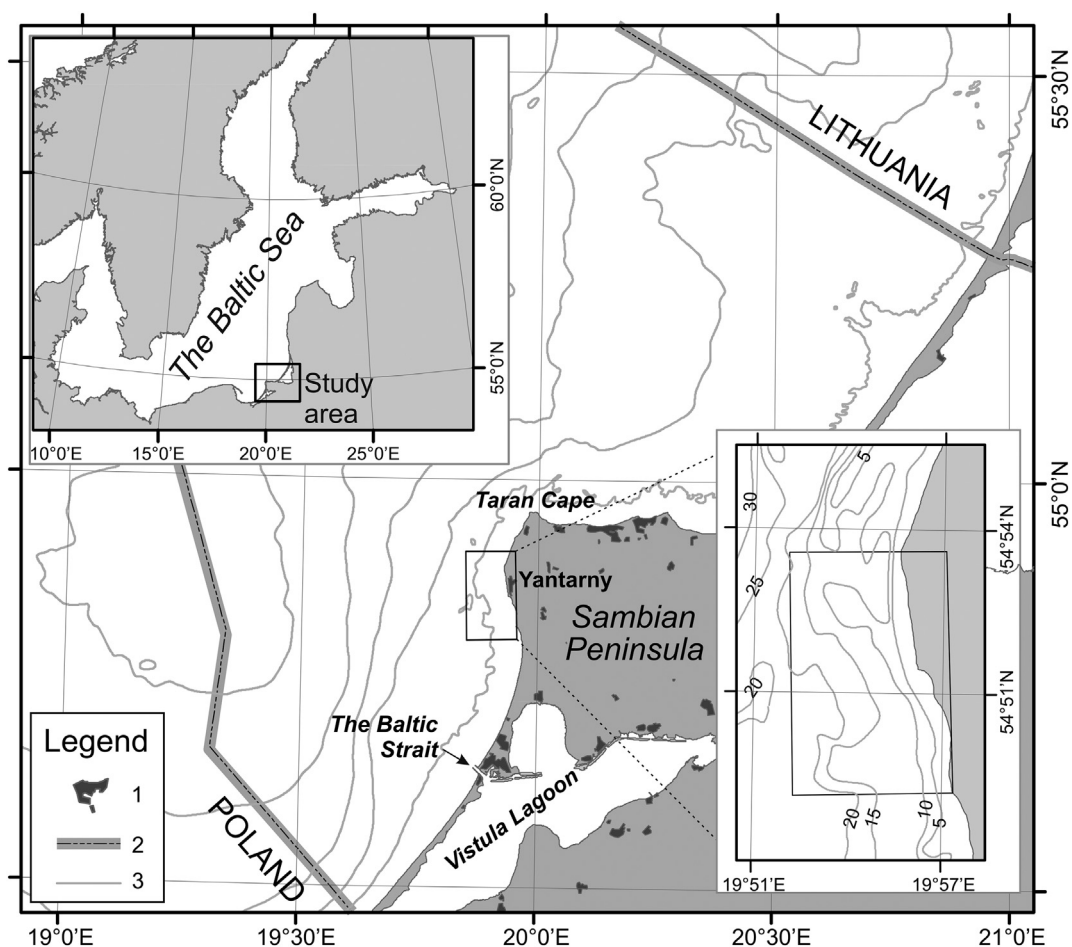


Fig. 1. Study area scheme. 1 - settlements; 2 - border of Russia, 3 - study area.

bottom to the top): (1) “wild earth,” (2) “blue earth,” and (3) “upper drift sand” (Katinas, 1971).

These layers outcrop on the day surface of the abrasion bench and the underwater coastal slope.

Sandy deposits of the coastal zone of the Sambia Peninsula are represented by minerals originating from crystalline rocks of the Scandinavian Peninsula and local pre-Quaternary sedimentary rocks. The predominant minerals are quartz, feldspar, glauconite. Garnet, zircon, carbonates, ilmenite, rutile, amphibole, epidote, zoisite, leucosene, rutile, disthene, pyroxene, apatite clay aggregates, sphene, titanomagnetite and mica are found in admixtures.

Hydrogeological conditions are quite complex and are characterized by the presence of several aquifers containing high-pressure groundwater both in the overproductive stratum and in the bottom of the productive horizon. Groundwater is confined to both quaternary and pre-Quaternary sediments.

One of the main factors of the coastline formation in the study area is the activity of the industrial enterprise of KAC (Boldyrev and Zenkovich, 1982; Ryabkova, 1987; Boldyrev, 1992; Zhindarev et al., 2012). The development of the amber deposit has been carried out by open pit way since 1976 and the overburden and waste rock is discharged to the coastal zone of the sea. At the end of the last century, an average of > 2 million tons of waste rock was received from the amber quarries annually. Then the discharges decreased by almost an order of magnitude, and since 2007 they have increased again up to 0.6–0.9 million tons per year (Burnashov, 2011).

2.2. Ecological setting

There are no other industrial facilities, farms or large cities in the area of the Primorsky quarry. Drainage from the adjacent fields, gardens, Pokrovskoe settlement (about 500 inhabitants) is received by the watercourse which starts in the quarry and flows to the sea. The discharge of sewage of the town of Yantarny (about 5000 inhabitants) is carried out in the coastal zone in the immediate vicinity of the discharge of the KAC waters.

The only few previous studies revealed the significant influence of the KAC to the coastal environment, especially the beaches width (Burnashov et al., 2010) and the suspended matter concentration, as well as concentrations of suspended Fe, Mn, Zn, and Cu in the shallow waters (Sivkov and Chubarenko, 1997). However these elements were determined by another method so it is impossible to compare with our data. Sivkov and Chubarenko (1997) concluded that the KAC is the source of large amounts of dispersed fine terrigenous sediments and of occurrences of trace metals associated with them. There are no other studies aimed the estimation of the pollution by other chemical elements from the amber extraction in the world.

2.3. Technology of amber mining

Currently, amber is mined at the Primorskoye deposit. Primorsky quarry has two industrial discharges to the Baltic Sea. Trench unwatering is carried out using a system of drains, located on different horizons. Drainable waters and atmospheric precipitation enter the two reservoirs of the quarry. After settling the water is pumped through pipelines to the watercourse flowing to the sea. This watercourse starts

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