Short communication

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Mercury concentrations in the surface bottom sediments and cores of the East Siberian and Laptev seas and the adjacent area of the Arctic Ocean

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ABSTRACT. The mercury content in the bottom sediments of the East Siberian, Laptev, Chukchi seas and the adjacent part of the Arctic Ocean was studied. The dependence of its contents on the granulometric composition of sediments and redox conditions of bottom waters is established, which generally manifests itself as the bathymetric zonality of the distribution.

Keywords: geochemistry, geoecology, ecology, mercury, heavy metals, anthropogenic pollution, natural sources, Arctic and Far Eastern seas

1. Introduction

Bottom sediments are the most informative part of aquatic ecosystems in terms of assessing the degree of their permanent pollution. They are undoubtedly associated with all other components and can accumulate contributions from different sources. Typical mercury concentrations in bottom sediments are three or four orders of magnitude higher than in the water. This removes many analytical difficulties and, as a rule, makes the bottom sediment-based assessment of the pollution pattern in the basin much more reliable than the water-based one.

2. Materials and methods

Mercury concentrations were detected in 79 surface bottom sediments and 15 cores (multi-cores) with undisturbed surface (Fig. 1). To determine mercury, an RA-915M+ mercury analyzer with a PYRO-915 pyrolytic attachment was used. The lower detection limit was 0.5 ng/g. The analysis error was 2-3%. GSO 7183-95, SPDS-1,2,3, HISS-1, MESS-4, and PACS-3 served as reference materials for mercury. External control was carried out annually in the manufacturer's laboratory (Lumex LLC, St. Petersburg). Statistical distribution parameters were determined with the GeoStat programme.

3. Results and discussion

The data processing revealed that the mercury concentration changed with bathymetric level (Fig. 2). The study area was characterised by a selection of 79 samples of surface bottom sediments (0 to 5 cm), which were divided into two groups: i) to a depth of 100 m (n = 67) and ii) within the depth range from 100 to

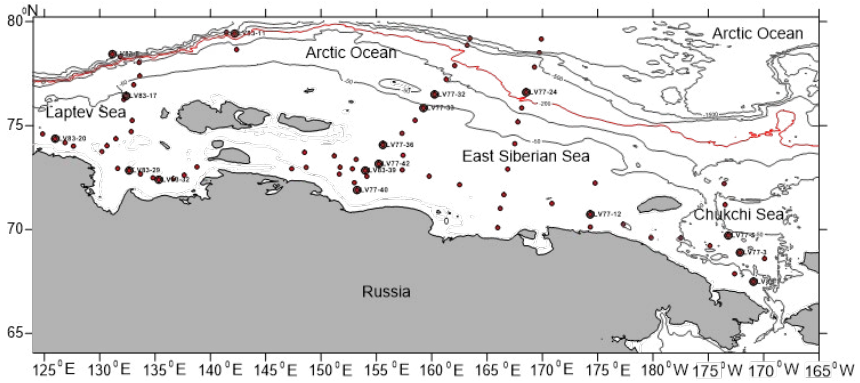

Fig.1. Map of stations in the Chukchi, East Siberian and Laptev seas and the adjacent area of the Arctic Ocean. The dots highlight sampling stations. Isolines indicate bottom topography (m). The labeled stations mark the cores where mercury was detected vertically.

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260 m (n = 12). Mercury concentrations for this area varied from 3 to 92 ppb, with mean and median concentrations of 31 and 29 ppb, respectively. The median value served as the background concentration, which was well correlated with the previously determined background of 28 ppb for the bottom sediments of the Chukchi Sea and the adjacent area of the Arctic Ocean (Ivanov, 2014).

The presence of oxidized or reduced sediments is the main factor that determines the variability of mercury concentrations in the bottom sediments. The twofold excess over the background is typical of the deep part (depth 100 to 2600 m) where oxidized sediments are widespread. In the shallow part (0 to 50 m) of the Laptev Sea, where reduced sediments with various compositions are widespread, the mercury concentrations were much lower, but there was also the influence of the Lena River. It is necessary to take into account that the products of thermal and wave abrasion of the material from the nearshore ice complex determine the influx of terrigenous organic matter to the sea. Samples of the surface bottom sediments taken at the estuary of the Lena River in 2008 to 2009 had the same mercury concentrations (Ivanov, 2011). Also, elevated concentrations at stations LV77-30, 31 and 32 were associated with the presence of ferromanganese nodules at the bottom.

A similar pattern of mercury distribution in the surface bottom sediments was typical of other Arctic areas with its natural sources. In the central part of the Arctic Ocean, where oxidized sediments are widespread, mercury concentrations were 80 to 100 ppb; in the surface sediments of the coastal area of the Beaufort Sea – 20 to 100 ppb; in the coastal part of the East-Siberian and Laptev seas – 20 to 40 ppb, and near the estuaries of large rivers – about 60 to 80 ppb (Table).

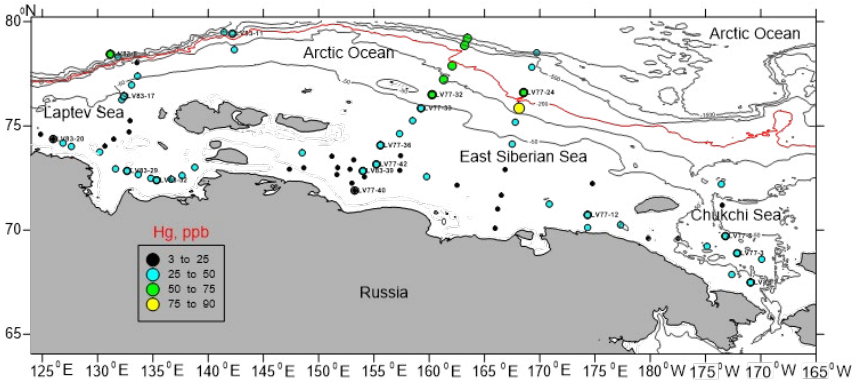

Fig.2. Mercury concentrations in the surface bottom sediments of the Chukchi, East Siberian and Laptev seas and the adjacent area of the Arctic Ocean. The dots highlight sampling stations. Isolines indicate bottom topography (m).

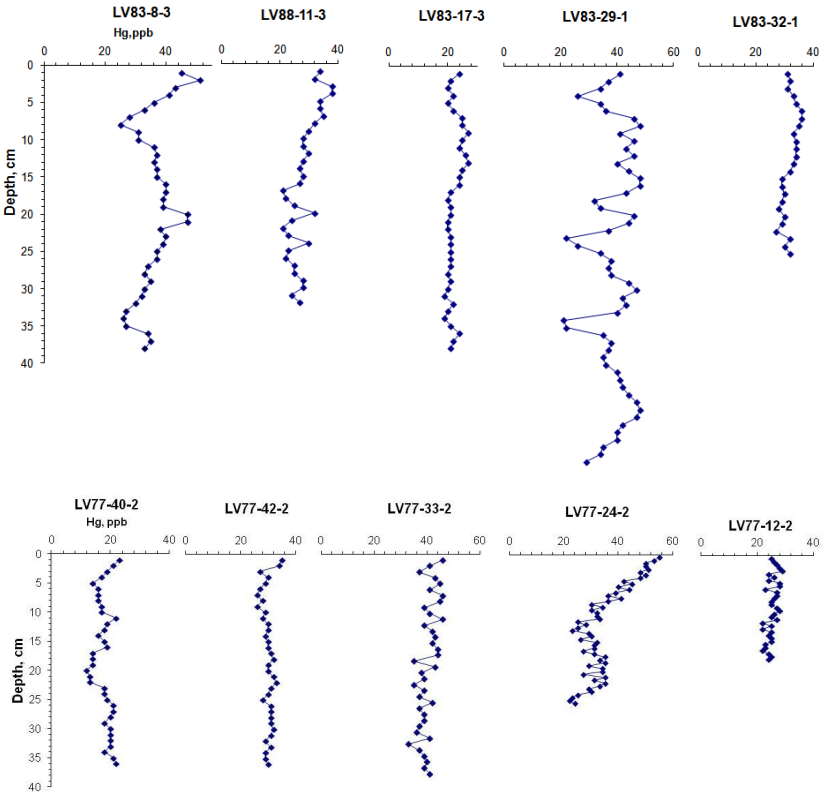

Fig.3. Mercury concentration (ppb) in some multi-cores.

Table. Mercury concentrations (ppb) in the surface bottom sediments of the Arctic and Far Eastern seas.

Object	Number of samples	Hg, mean	Background	Background variation limits	Abnormally high concentrations	Reference
Chukchi Sea and adjacent area of the Arctic Ocean	263	36	28	7-92	146	Ivanov, 2014
Deryugin Basin of the Sea of Okhotsk	51	61	29	6-197	371	Ivanov, 2014
Amur Bay of the Sea of Japan	119	50	13	12-198	550	Ivanov, 2014
East-Siberian Sea and Laptev Sea	79	31	29	3-92	-	This study, 2017-2018
Kara Sea	-	28	-	-	-	Fedorov, 2018
Beaufort Sea	-	-	-	17-74	-	Fedorov, 2018

Analysis of the mercury distribution in multi-cores of bottom sediments indicated that in the deep part it was characterised by a rather high vertical variability that was associated with the alternating oxidized and reduced sediments in the section, which accumulated, respectively, during the warming and cooling periods. Mercury concentrations in multi-core LV83-8-3 sampled in the deep area ranged from 25 to 51 ppb (Fig. 3). In multi-cores LV83-1-2 and LV83-17-3 located on the shelf (Figure), mercury concentrations were much lower, about 25 μg/kg.

4. Conclusions

The study results revealed that the presence of oxidized or reduced sediments was the main factor determining the variability of mercury concentrations in surface bottom sediments. As in other Arctic seas, mercury concentrations depended on the granulometric composition of the bottom sediments.

There was no anthropogenic mercury pollution of the sediments, but it is likely that some part of it entering together with the water of the Lena River and accumulating in the shallow part of the Laptev Sea may be of anthropogenic origin.

Acknowledgements

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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