PCBs AND OCPs IN SOIL SAMPLED ALONG THE LENA RIVER VALLEY, RUSSIA

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Abstract

The PCBs and OCPs levels were determined in background soil samples along the Lena River valley from the upper stream of the river in the Irkutsk Region in the south to the Arctic Ocean in the north. Soil samples were collected from 21 sites in the Lena River valley from Ust'-Kut (first big river port on the river located in the Irkutsk Region) to the delta of the river and cape of Neelova on the north during the expedition on ship "Moskovskiy 11" in summer of 2003 and from 2 sites in the previous study in 2001. It was found that the spatial distributions of PCBs, DDTs and HCHs in soil samples from background areas are wave-like. PCB levels (2.28-17.2 ng/cm^2) are higher in the south and north parts of the investigated distance and are lower in the middle part of the Lena River stream. DDT levels (0.11-3.04 ng/cm^2) are higher in upper and in half of middle stream of the river with decreasing in northern direction. The variation of HCH from the south to the north differs from PCB and DDT distribution. The HCH levels (0.14-11 ng/cm^2) distribute as convex arcs with elevation in middle parts of the Lena River.

Introduction

The Lena River is one of the largest in terms of the length and water effluent rivers in the world[1]. The length of the river comes to 4400 km. The Lena River takes its rise in west descents of the Baikal edge. The river passes from the south to the north practically the whole East Siberia (the Irkutsk Region and Republic Sakha (Yakutia)) and discharges into the Laptev sea of the Arctic Ocean where it forms a vast delta (30,000 km^2). The river streams in the area of deep-frozen soil. The Lena River streams in the areas of taiga and tundra. The Lena River flows in comparative strait valley before the confluence with the Vitim River. Then the valley widens up to 30 km. The square of the watershed of the Lena River is to 2430,000 km^2. Various industries of electric power, mining, oil and gas extracting and the industry of constructive materials are located in the watershed of the Lena River[1]. In addition the Lena River is the main water transport artery altogether with various concomitant companies in Yakutia. But there are no reports about location of the enterprises being considerable sources of POPs in the watershed of the Lena River. The first data on POPs in soil of the shore of the river in upper stream obtained in 2001 show background levels of PCBs for the region[2)].

The aim of the investigation was to present the distribution of PCBs and OCPs in background soil along the Lena River valley from the west shore of Lake Baikal in the Irkutsk Region in the south to the Arctic Ocean in the north.

Materials and Methods

Sample collection. Soil samples were collected from 21 sites in the Lena River valley from Ust'-Kut (first big river port on the river located in the Irkutsk Region) to the delta of the river and cape of Neelova on the north during the expedition on ship "Moskovskiy 11" in summer of 2003 (Figure 1). Soil samples were collected in inhabitant areas or in several kilometers from settlements. The soil was sampled to the bottom of the organic matter rich soil layer (A horizon) or up to deep-frozen layer of soil with a steel tube. The details of the soil sampling procedure are published previously [2)]. All samples were transported to the institute and stored at –30^{0}C prior to the analysis.

Sample extraction and analysis. Before analysis all samples of soil were dried at room temperature to constant weight and then the fraction <2 mm was used for the analysis. Samples were analyzed for 28 PCBs, including indicator PCBs (28, 52, 101/90, 138, 153, 180), *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDD, *p,p'*-DDE, α-HCH, γ-HCH at the laboratories of the Institute of Geochemistry in Irkutsk (Russia). Published analytical methods were used[2]. The POPs were analyzed using gas chromatography with a ^{63}Ni electron-capture detector (GC-ECD). The Hewlett – Packard 5890 series II GC was equipped with a 0.25 μm × 60 m DB-5 capillary column (J&W Scientific).

The concentrations were calculated normalized to the cross-sectional area of the area sampled. In addition results obtained in 2001[3)] for two samples collected in areas located upper stream from Ust'-Kut were used in the investigation.

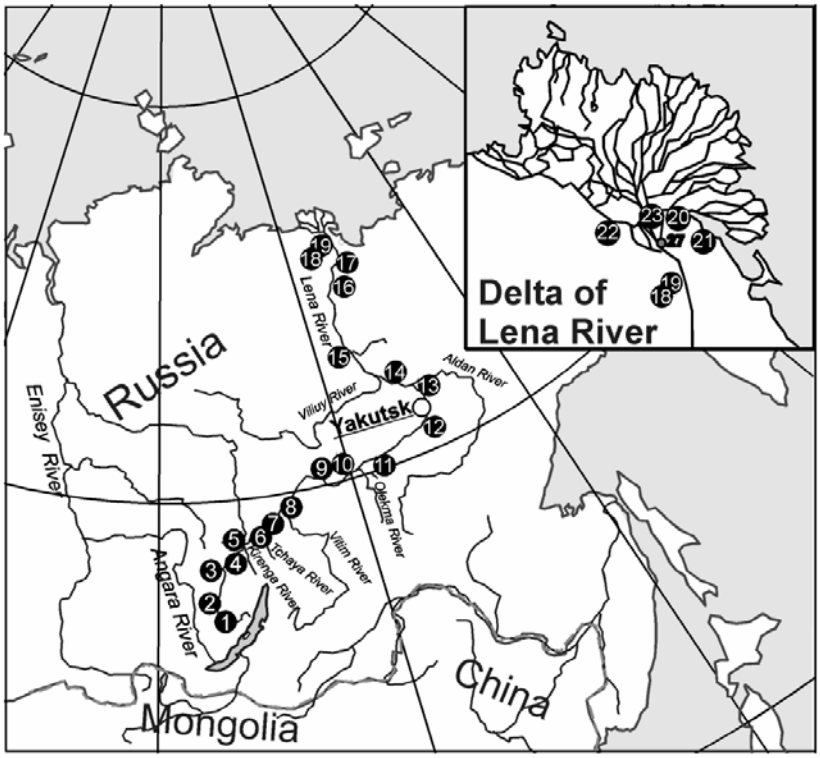

Figure 1. The scheme of soil sampling in the Lena River valley: 1. –Kachug settlement; 2. – Zhygalovo settlement; 3. – t. Ust'-Kut; 4. –Markovo settlement; 5. – 8 km upper stream from t. Kirensk; 6. –Tchaya River; 7. –Mutinskii rift; 8. –Rysinskii rift; 9 –Tchapaevo settlement; 10 –Biriuk Rver; 11. –Tuolbatchan River; 12. – Pokrovsk settlement ; 13 – 7 km upper of the inflow of the Aldan River in the Lena River; 14. –Viliuy River; 15. –Undiuliung River; 16. – 495 km; 17. –Kiusiur settlement; 18, 19. – 180 km, Tit-Ary settlement; 20. – Bykovskaya effluent; 21. –Neelova bay; 22. –Olenekskaya effluent; 23 –Samoylovskiy island.

Results and Discussion

The results are presented in Figures 2 and 3.

The mean levels of the organochlorine compounds in soil collected in the Lena River valley were 1.49 ng/g dry weight for total PCBs including 0.57 ng/g for 6 indicator PCBs, 0.24 ng/g for DDT and its metabolites, 0.37 ng/g for α- and γ-HCHs. Levels of PCBs and OCPs in soil don't exceed the Russian sanitary standard (0.06 mg/kg DW for PCB, 0.1 mg/kg DW for HCH and 0.1 mg/kg DW for DDT)[3)].

PCB. The concentration of the sum of all PCB congeners (ΣPCB) in soil expressed on square varied from 2.28 ng/cm^2 in the area of inflowing of the Undiuliung tributary into the Lena River (# 15 on the scheme of sampling sites) up to 17.2 ng/cm^2 in the area of t. Ust'-Kut (# 3) (Figure 2). It should be noted that soil sampled in upper stream of the Lena River in the area of Kachug (# 1) and Zhigalovo (# 2) (4.5-6.2 ng/cm^2) show lower total PCB levels than samples from t. Ust'-Kut . The sites # # 1 and 2 located in 250-350 km to north and north-west from t. Usol'e-Sibirskoe known as a highly contaminated with PCBs area[2)]. The polluted zone with PCB was more ready spread along the Angara River valley in direction of dominated winds (from the north-west to the south-east) but not in perpendicular directions (to the north or west). The PCB levels obtained for sites 1 and 2 were accounted in the previous study as one of background levels resulted from atmospheric transport. So, the PCB levels obtained for soil samples from Ust'-Kut are the result of local sources of PCB.

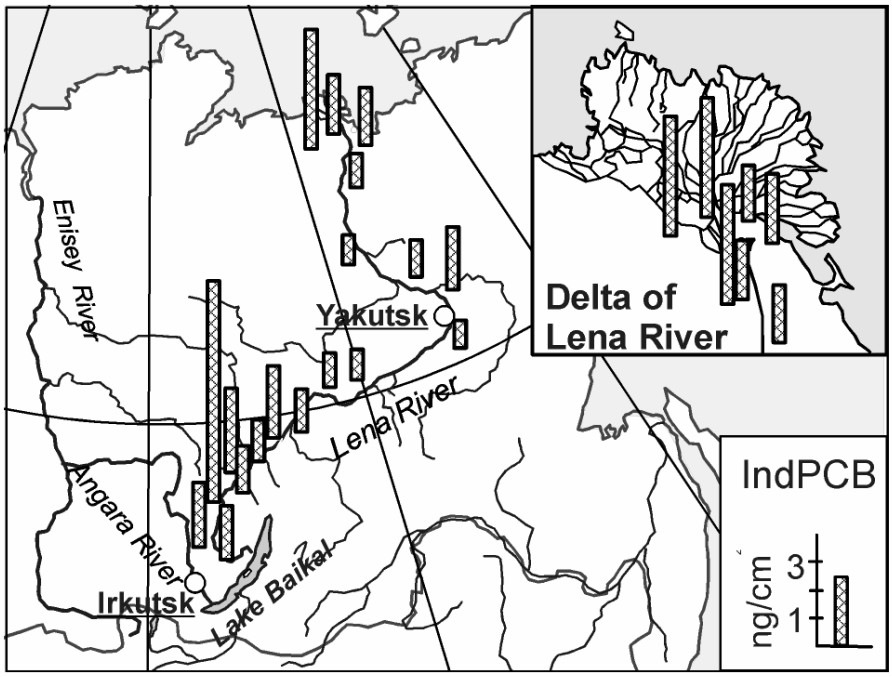

Figure 2. The distribution of indicator PCBs in soil from the Lena River valley (ng/cm^2).

The distribution of the sum of indicator PCBs (28, 52, 101/90, 138, 153, 180) in soil sampled in upper stream of the Lena River is a result of small local PCB sources and atmospheric transport of PCBs from industrial towns located in the Irkutsk Region and adjoining regions (Krasnoyarsk Region, Buryatia, Chita Region). The entrance of PCB in the direction to the north comes from atmospheric transport par excellence. The phenomenon is affirmed with the distribution of lower chlorinated and highly chlorinated congeners in soil samples (Figure. 3). Lower chlorinated congener levels increase from the south to the north in middle and lower stream of the Lena River. The same fate of lower chlorinated PCB congeners were found in the investigations of PCBs in Usol'e-Sibirskoe and in surrounding areas[2,4)] and can be explained by the effect of "grass hopping"[5)]. On the other hand the distribution of highly chlorinated congeners of PCB (for example PCB-180) can be also associated with small local sources.

DDT and its metabolites. The concentration of the sum of DDT and its metabolites in soil expressed on square varied from 0.11 ng/cm^2 in the area of upper stream from Yakutsk, the capital of Sakha Republic (Yakutia) (# 12 on the scheme of sampling sites) up to 3.04 ng/cm^2 in the area of t. Ust'-Kut (# 3) (Figure 4). The distribution of the sum of DDT and its metabolites along the Lena River valley were the same as for PCBs. The mean ratio DDE/DDT in soil samples was equal to 0.7.

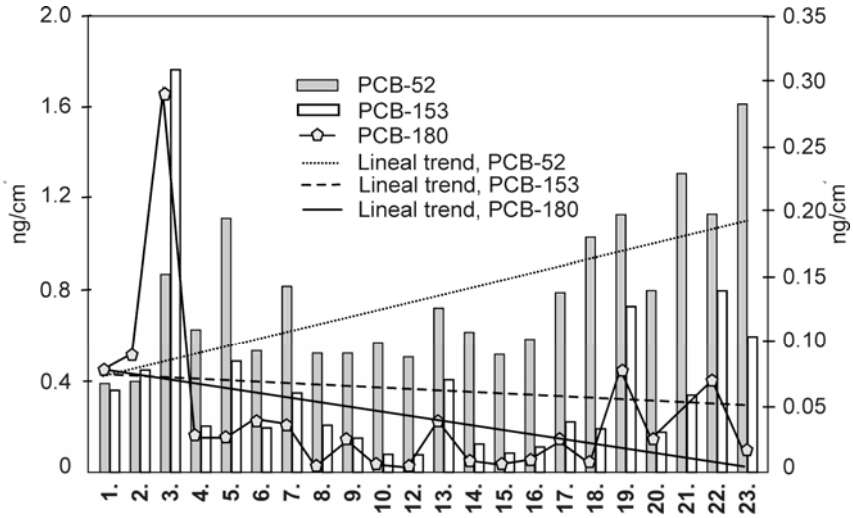

Figure 3. The distribution and trends of PCB-52, 153 and 180 in soil sampled along the Lena River valley (ng/cm^2).

HCH. The HCH levels in soil investigation varies from 0.14 in the site located closely to the delta (Tit-Ary, # 18-19) up to 11 ng/cm^2 in middle stream of the river (# 10) (Figure 5). The ratio α-HCH/γ-HCH were higher than 1 in all samples and varied from 1.5 up to 8.8 indicating the using of predominantly technical mixture of HCHs in the region in the past.

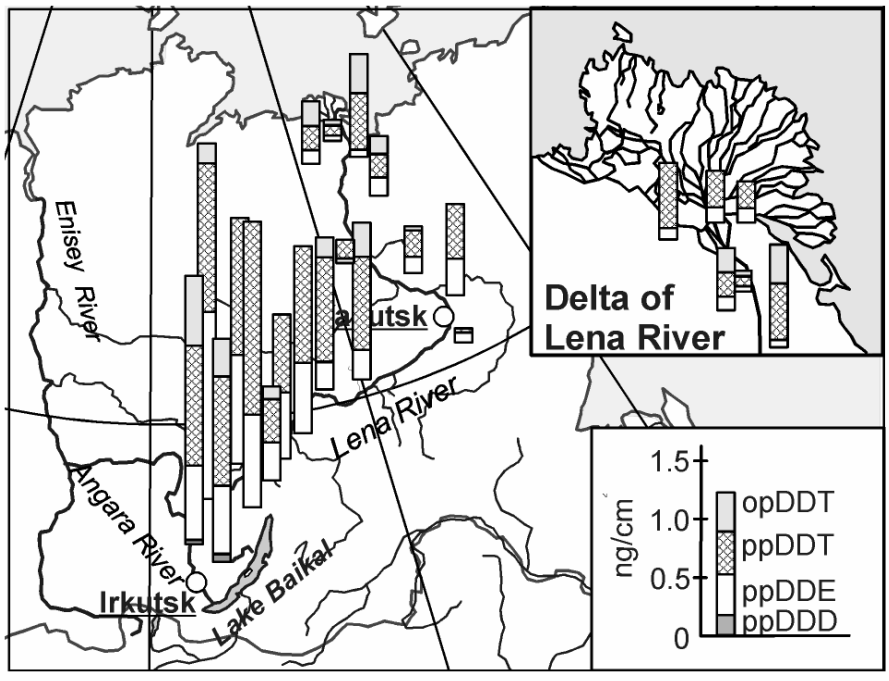

Figure 4. The spatial distribution of DDT and its metabolite in soil from the Lena River valley (ng/cm^2).

The spatial distributions of PCBs, DDTs and HCHs are wave-like. (Figure 6). The PCB levels are higher in the south and north parts of the investigated distance and are lower in the middle part of the Lena River stream. DDT levels are higher in upper and in half of middle stream of the river with decreasing in northern direction. The variation of HCH from the south to the north differs from PCB and DDT distribution. The HCH levels distribute as convex arcs with elevation in middle parts of the Lena River.

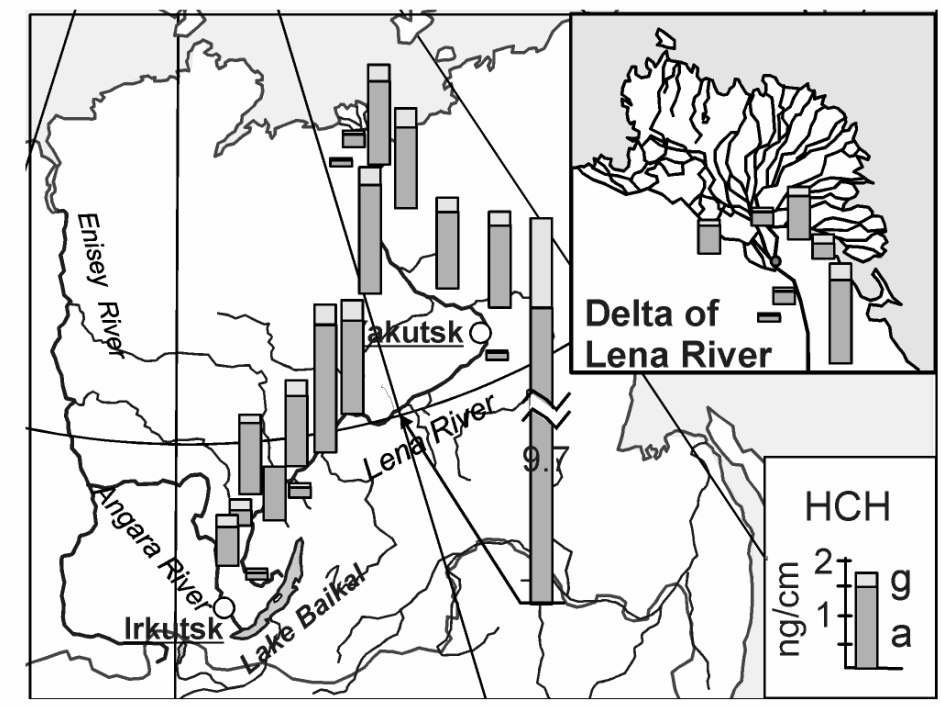

Figure 5. The spatial distribution of α and γ-HCH in soil from the Lena River valley (ng/cm^2).

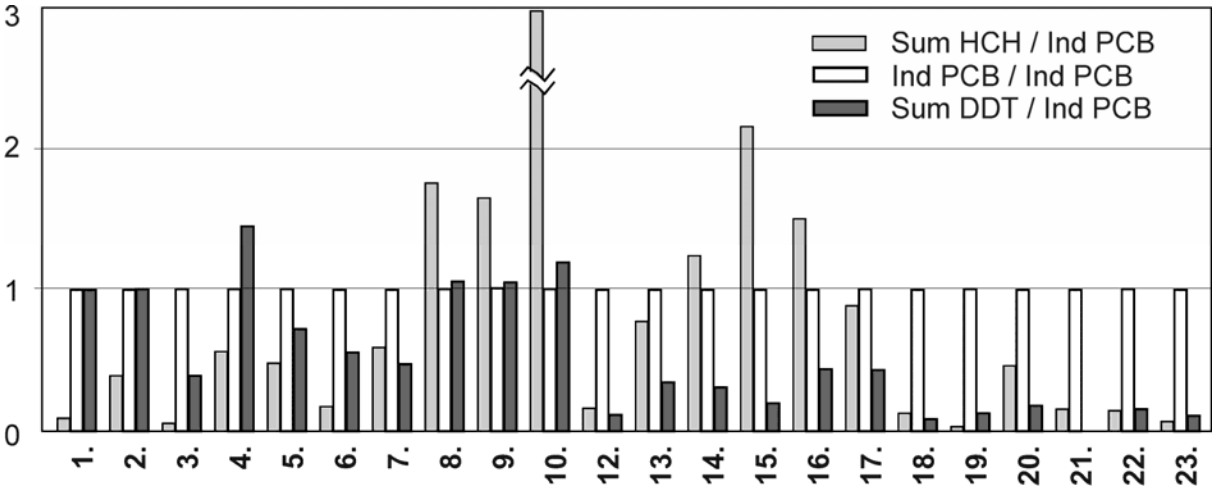

Figure 6. The relative distribution of sums of 6 indicator PCBs, HCHs, and DDT and its metabolites.

Acknowledgments

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