IOP Conference Series: Earth and
Environmental Science

PAPER • **OPEN ACCESS**

Migratory birds are the source of highly toxic organic pollutants for indigenous people in the Russian Arctic

To cite this article: A A Pesiakova *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **107** 012088

IOP Conf. Series: Earth and Environmental Science **107** (2018) 012088 doi:10.1088/1755-1315/107/1/012088

Migratory birds are the source of highly toxic organic pollutants for indigenous people in the Russian Arctic

A A Pesiakova, E V Gusakova, A N Trofimova and T Yu Sorokina

Northern (Arctic) Federal University, Severnaya Dvina Emb. 17, Arkhangelsk, 163002, Russia

E-mail: helengusakova@gmail.com

Abstract. Polychlorinated biphenyls are highly toxic organic contaminants. Due to their chemical properties they had wide application in industry and agriculture in the 20th century. In 2001 the production of PCBs has been prohibited almost worldwide. Environmental contamination has been found in soils, water, and air where there were PCB production sites. They have been detected in fish, birds and animals of migratory species, retaining transboarding transfer. Several migratory species of birds (Taiga bean goose, greater white-fronted goose, lesser white fronted goose and barnacle goose) are a diet for indigenous people. PCBs accumulating in the human body affect all systems and organs. This article reviews the contribution of migratory bird species in transboarding transfer of highly toxic contaminants in the Nenets Autonomous Area, Kolguev island (Russian Arctic).

1. Introduction

PCBs (polychlorinated biphenyls) are highly toxic organic contaminants, accumulating in the fat of animals and humans, affecting skin, immune systems, and body organs (liver, respiratory tract). Consequences from PCBs exposure are headaches, depression, tiredness, amnesia, reproduction failure, transformation of microbiota, liver and kidney impairments and cancer [1, 2, 3, 4]. Serious genetic disruptions occur through cytochrome P450 mediated transformation [5].

Polychlorinated biphenyls are chemically stable, low water soluble, non-flammable, electrically insulating [6]. Due to their properties PCBs have a versatile use in industry: electrical capacitors and transformers, rubber/resin production, hydraulic fluids, lubricants, plasticizers, and surface coatings [7].

Severe environmental contamination has been established in areas located in neighborhoods with former PCB production. Major producers were the US, UK, Germany, France, Japan, Italy, USSR and Czechoslovakia. In 2001 the majority of countries in the world signed the Stockholm Convention on Persistent Organic Pollutants, which prohibited the production and utilization of persistent organic pollutants. It is over 10 years since PCB production was stopped, however its accumulation has been found in samples of air, soil, ice, water, sediments, plankton, birds, fish, and mammals [8, 9]. Biphenyls pass through biomagnification in trophic chains and tend to retain transboarding transfer with migratory species (birds, fishes, mammals). For the indigenous people living in the Russian Arctic, migratory animals are a basic part of their diet. For example, in Bugrino (Kolguev island, Nenets Autonomous Area) local people eat approximately 65.3 geese per capita in a year. Increased amounts of PCBs in their blood is a result of their eating habits. Humans, as top trophic members, tend to accumulate highly toxic organic pollutants over the life span. The authors' goal is to analyze risks for indigenous people from PCB transboarding transfer with migratory birds

2. A pathway of PCB transfer to the Russian Arctic

Generally, the diet of the indigenous people from Bugrino village (Kolguev, NAA) consists of migratory birds. Bugrino inhabitants were asked about the most valuable migratory birds species that are caught in the territory and used as a food. Based on the talk with the Department of Natural Resources, Ecology and Agroindustrial Complex of Nenents Autonomous Area, it was found that in the spring and autumn period, the local population catches mainly members of the *Anatidae* family, such species as the Taiga Bean-Goose (*Anser fabalis*), Greater White-fronted Goose (*Anser albifrons*), Lesser White-fronted Goose (*Anser erythropus*), Barnacle Goose (*Branta leucopsis*) as well as the eggs of these species and eggs of the Tundra Swan (*Cygnus columbianus columbianus*) and Long-tailed Duck (*Clangula hyemalis*), all of which could be potential sources of the various PCBs for humans in the Russian north. In avian species, PCB bioaccumulation is related to many factors, such as sex and age of the bird, but the most important factors are diet and residence time in PCB-contaminated areas.

2.1. Migratory pathways of commercially valuable birds

The Taiga Bean-Goose (*Anser fabalis*) and Greater White-fronted goose (*Anser albifrons*) have similarities in many behavior parameters. They are both fully migratory species that have breeding grounds in the high Arctic region. They breed in the spring on areas near lakes, pools, rivers and streams [10]. Their wintering grounds in Europe (mostly in Germany and the Netherlands) [10, 11]. Both of them are herbivorous species. Their diet consists of herbs, grasses, mosses and sedges, and is complemented during the breeding season by berries (e.g. from *Empetrum* or *Vaccinium spp.*). During winter the Taiga Bean-Goose feeds predominantly on agricultural lands taking grain, beans, potatoes and sprouting winter cereal crops. The Greater White-fronted Goose prefers agricultural grains (e.g. corn, oats, wheat, rice and barley, potatoes and sprouting cereals) [10, 11, 12].

The Lesser white-fronted goose (*Anser erythropus*) is also a strongly migratory species; it breeds in the northern Russian region, on the Taimyr Peninsula, to the west and east of the Pechora river and Yamal and Gydan peninsulas. But this species has a different migratory pattern because it winters mainly around the Black and Caspian Seas, in Azerbaijan, Iraq and Uzbekistan [11]. This species is herbivorous, feeding on roots, stems, and leaves and completes its diet with agricultural grains during the winter [12].

The Barnacle goose (*Branta leucopsis*) breeds in the Arctic tundra and winters in the Netherlands and the North of Germany [11, 13]. The diet of this species consists of stems, grasses, sedges, aquatic plants, herbs and shrubs, but in winter it is also completed with agricultural grains and vegetables [10, 11, 12].

Such species as the Tundra swan (*Cygnus columbianus columbianus*) and the Long-tailed Duck (*Clangula hyemalis*) are not included in the indigenous peoples' rations, but the eggs of these species mainly contribute to the diet of the people during the spring. It is known that by laying eggs birds remove some PCBs from their bodies. Therefore, by consuming this product indigenous peoples also can get a large amount of the highly toxic substances. The Tundra Swan and Long-tailed Duck are also migratory species that can transport the PCBs from the contaminated areas to the Arctic region during seasonal migrations. Compared to the previously discussed members from the *Anatidae* family, these two species show a preference for marine foods as well as for plant feedstock. In this case we suggest there is evidence of PCBs bioaccumulation, along with the biomagnification of PCBs via the trophic chain. Due to the consumption of marine and fresh water invertebrates and fish, these birds have a higher chance of obtaining larger amounts of PCBs compared to herbivorous birds.

The Long-tailed Duck (*Clangula hyemalis*) is a species that has a circumpolar range and breeds in the North of Russia. It winters mainly in Germany, Lithuania and Sweden. This species' diet consists of animal matter such as crustaceans, molluscs, and some other marine invertebrates and fish, but it also takes freshwater insects and their larvae and some plant materials such as algae and grasses.

The Tundra Swan (*Cygnus columbianus columbianus*) migrates on a narrow front between its Arctic breeding and European wintering grounds. Its wintering occurs mostly in the Netherlands and the United Kingdom [10, 11, 13]. Food preferences of this species include estuarine invertebrates such as molluscs, amphipods and polycheate worms, as well as herbaceous tundra vegetation; but during the winter its diet is completed with agricultural grain and vegetables (e.g. potatoes and sugar beets) [10, 11].

Migratory pathways and PCB contaminated areas are represented on figure 1.

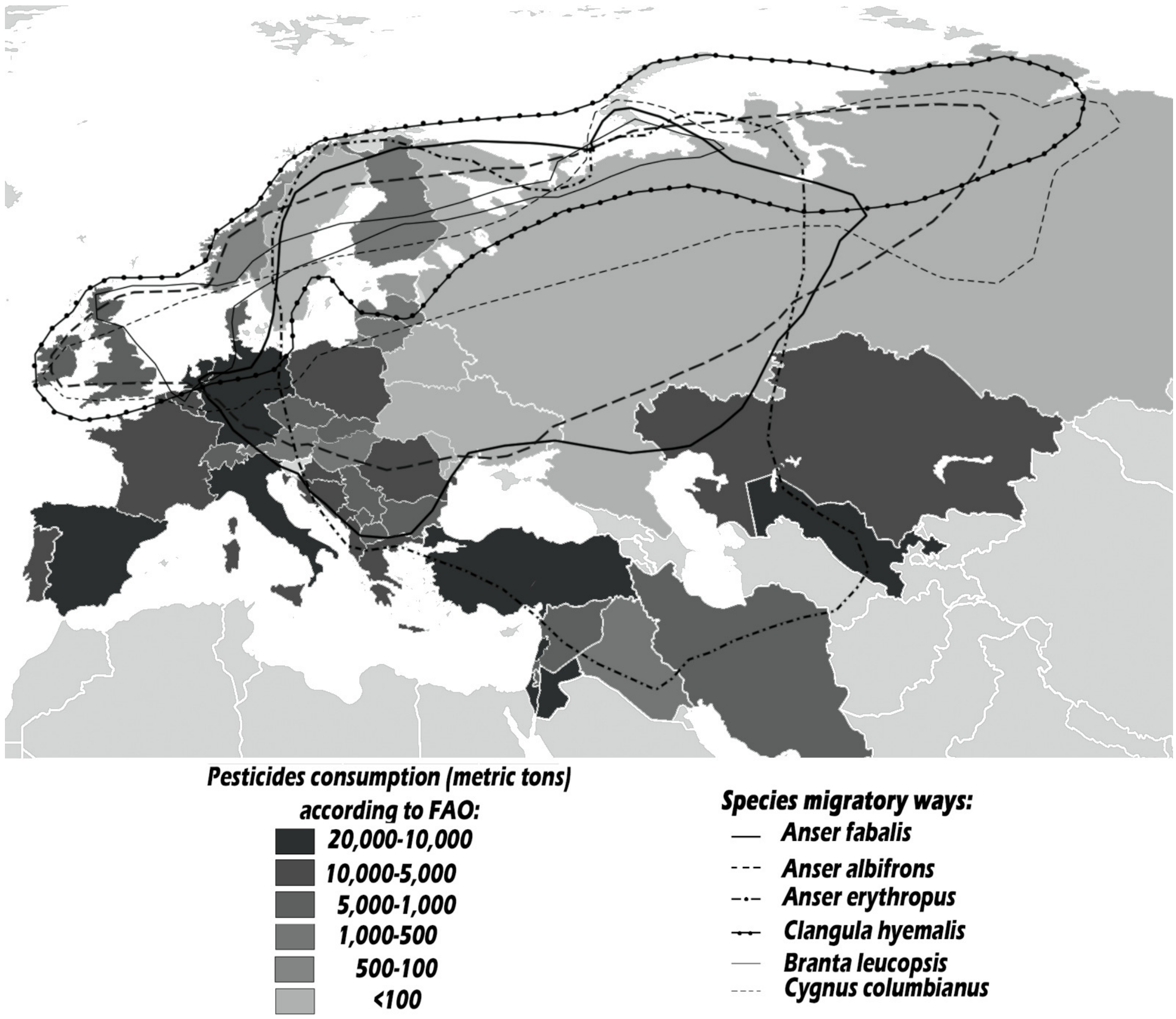

Figure 1. Migratory birds' pathways and pesticides consumption according to the Food and Agriculture Organization of the United Nations.

Based on the study of migratory ways and diet of the bird species that contribute a lot to the diet of the indigenous people of the Russian north we identified some key regions that can be potentially associated with the spread of PCBs.

2.2. Potential sources of PCBs: agriculture

Industrial application of PCBs is worldwide, particularly in electrical industry . There is a long history of PCBs use in agriculture. Many of these highly toxic substances were used as pesticides and insecticides in the USA, Europe and the territory of the Soviet Union. The major producers of the PCBs were Monsanto (USA, UK) and Mitsubisi-Monsanto (Japan), Bayer (Germany), Prodelec (France), Caffaro (Italy), Sovol (USSR) and Chemko (Czechoslavakia).

Annually, approximately 2 million tons of pesticides were used worldwide in agriculture, water disinfection and wood preservation until 2001. The chlorine organic chemical heptachlor was used as an insecticide and for etching of corn and sugar beet seeds [14]. Toxaphene was used to control sugar beet and pea pests and to treat cotton and soybean crops. Hexachlorobenzene (HCB) was used as a seed dresser to combat diseases of wheat, rye, buckwheat, soybean and other cereal crops [15]. According to Eurostast data, at the peak of pesticide use (fungicides, herbicides, insecticides and other pesticides) the largest users of these substances in Europe were the Netherlands (9.4 kg/ha), Portugal (5.3 kg/ha), France (4.6 kg/ha),Italy (4 kg/ha), Greece (2.8 kg/ha), Germany (2.5 kg/ha), Jordan (1.4 kg/ha), Czech Republic (1.3 kg/ha) and Iraq (0.1kg/ha).

Despite of the fact that most PCB-containing pesticides were prohibited due to their high toxicity to living organisms and low rate of biodegradation, in some countries the production and use of PCBs (e.g. Dichlorodiphenyltrichloroethane or DDT) still exists (for instance in China, India and Australia and there is a reserve of these substances in many countries) and the contamination of the environment by these substances is still very high. In the Soviet Union even after its prohibition, DDT was used in Uzbekistan as a remedy against the spread of malaria. The soil in Uzbekistan is still full of chlorine and other chemicals from the DDT used in cotton production in the Soviet period, which continues to contaminate farmland [15, 16].

The most dangerous aspect of using pesticides is that only 0.1 to 1% of these substances reach the target area of plants, while 99% of them transfer to the soil, water, air and to agricultural products. The PCBs due to their physical and chemical features are actively accumulating in sediments and biota. They actively accumulate in organisms and multiply their concentration during bird migration via the trophic chain, and as a result, concentration in the final members of the chain increases dramatically. For instance DDT is known to have the following pattern of biomagnification: sediments – 0.014 mg/kg, invertebrates – 0.41 mg/kg, fish – 3 to 6 mg/kg depending on the size, sex, physiological features and specifics of metabolism of different species and their food preferences, lipids of marine fish-eating birds – up to 200 mg/kg [15, 16].

3. Conclusions

Taking into accountmigration routes and diet preferences of the commercial bird species of the NAA, we can suggest that it is a possible way of PCB transport from PCB-contaminated areas of Europe and East Asia. Most of the studied species are herbivorous and winter in the territory of the Netherlands, Germany and Uzbekistan, predominantly on agricultural land (pastures, arable fields, rice-paddies, damp steppe grasslands). Previously these countries actively produced and used various chlorine organic pesticides in agriculture and due to the PCB’s slow degradation rate and its ability to be preserved in the environment, these areas still can be a potential source of persistent organic pollution. Biomonitoring analysis will help assess and minimize risks for the population from pollution. We suggest developing a National biomonitoring system of indigenous people exposed to highly toxic organic pollutants, conducted by official authorities in Russia.

Acknowledgements

The work was supported by the Contract from 14th of March 2017 No. 14.Y26.31.0009 "About the Governmental Grant of Russian Federation for state support of scientific research, conducted under the guidance of leading scientists, in Russian educational organizations of higher education, scientific institutions, coordinated by Federal Agency of Scientific Organizations, and State Scientific Centers of Russian Federation, in terms of the subprogram "Institutional development of the research sector" from the state program of Russian Federation "Development of Science and Technology" for 2013-2020.

IOP Conf. Series: Earth and Environmental Science **107** (2018) 012088 doi:10.1088/1755-1315/107/1/012088

References

[1] *Environment Canada. Meeting Background Report* 1985 vol IV Prepared for International Experts Meeting on Persistent Organic Pollutants Towards Global Action, Vancouver, Canada, June

[2] Agency for Toxic Substances and Disease Registry (ATSDR) 1997 *"ToxFAQs: Polychlorinated Biphenyls"* URL: http://atsdr1.atsdr.cdc.gov:8080/tfacts17.html, Atlanta, Gerogia, USA,

[3] International Agency for Research on Cancer (IARC). *IARC Monographs*, Supplement 7. URL: http://193.51.164.11/htdocs/Monographs/Suppl7/PolychlorinatedBiphenyls.html, Lyon, France, 1987

[4] *Memorandum of State Committee for Environmental Protection of RF N165*, 13th April, 1999.

[5] Mills R A, Mills C D, Dannan G A, Guengerich F P and Aust S D 1985 *Toxicol. Appi. Pharmat* **78** 96–104

[6] Tanabe S 1988 *Environ. Po. Nut.* **50** 5–28

[7] *Guidelines for Identification of PCBs and Materials Containing PCBs* United Nations Environment Programme. UNEP First Issue Geneva, Switzerland, August 1999

[8] Waid J S 1987 *PCBs and the Environment* vol Z-III (FL:CRC Press, Boca Raton)

[9] Grimm F, Hu D, Kania-Korwel I, Lehmler H, Ludewig G, Hornbuckle K and Robertson L. 2015 *Critical Reviews in Toxicology* **45** 245–272

[10] del Hoyo J, Elliot A and Sargatal J 1992 *Handbook of the Birds of the World* 1: Ostrich to Ducks (Spain: Lynx Edicions)

[11] Kear J 2005 *Ducks, geese and swans 1: general chapters; species accounts (Anhima to Salvadorina)* (Oxford: Oxford University Press)

[12] Johnsgard P A 1978 *Ducks, geese and swans of the World* (Lincoln: University of Nebraska Press)

[13] Madge S and Burn H 1988 *Wildfowl* (London: Christopher Helm)

[14] Borlakoglu J T and Haegele K D 1991 *Comparative Biochemistry and Physiology Part C: Comparative Pharmacology* **100**(3) 327–338

[15] Moiseenko T I 2009 *Aquatic ecotoxicology: fundamental and applied aspects* (Moscow: Science) p 400

[16] Barron M G, Galbraith H and Beltman D 1995 *Comparative Biochemistry and Physiology Part C: Pharmacology, Toxicology and Endocrinology* **112**(1) 1–14