ACCUMULATION OF PERSISTENT ORGANIC POLLUTANTS IN SOILS IN AND AROUND DUMPSITES AND SEWAGE EFFLUENTS IN THE CANADIAN NORTH

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Introduction

Persistent organic pollutants (POPs) such as hexachlorocyclohexane (HCHs), aldrin, chlordane, DDT compounds, dieldrin, hexachlorobenzene (HCB), pentachlorobenzene and endosulfan II are Canada's legacy environmental contaminants. In addition, due to their persistence and semi-volatility, POPs are transported to remote marine environments by atmospheric transport[1]. Of particular concern is the deposition of chlorinated hydrocarbons transported from continental areas to polar regions[2-3]. Mainly, POPs released to the environment can travel through air and water to regions far distant from their original sources. POPs can concentrate in living organisms, including humans, wildlife to levels with the potential to injure the environment even in regions far from where they are used or released. POPs do not break down easily and they accumulate in the fatty tissue of fish and animals. They tend to biomagnify, so that their concentration increase with trophic level[4].

Most persistent organic pollutants (POPs) continue to be transported in the atmosphere from distant sources in the southern United States, Mexico, Central America, Eastern Europe and Asia. The Canadian North (north of parallel 60) is remote, polar regions with a perennial frozen sea. The North appears to have a greater capacity for storage of POPs as compared to other regions; therefore, once POPs enter the North, they are readily incorporated within biological systems[5-6]. In Canada's far northern communities, mass balances are needed to indicate the sources, transfers and accumulation of the various POPs in air, water and soil[7]. At present, there are no reported studies quantifying the distribution of POPs in landfill soils and the mechanism of leaching of POPs from such sites. In the present study, we examine profiles of POPs in soil samples collected in impacted sites near three major communities in the Canadian North and in background locations[7]. The sites selected were assessed to be impacted by landfill leachate (landfills and dumpsites) and wastewater effluents. The aim was also to identify local sources of POPs distinct from long-range atmospheric deposition.

Materials and methods

A sampling trip was made to three northern Canadian locations (Yellowknife "YELL", Iqaluit "IQA", and Cambridge Bay "CAM"). Twenty four soil samples (YELL=3, IQA=15, CAM=6) were collected (with depths of 0-20 cm below surface). Details of the sampling locations are shown in Figure 1. Multiple samples were collected at both the Iqaluit and Yellowknife landfills. The dumpsite in Cambridge Bay was also collected for comparison purposes. YELL and IQA samples were drawn from town locations, including close to wastewater effluent discharge areas. Most sites sampled contained sewage effluent or leachate discharged into the water body nearest each site. Hand trowels were used for soil collection. Samples were refrigerated at 4°C until analysis.

Totally organochlorine pesticides (OCPs) such as pentachlorobenzene, hexachlorobenzene (HCB), hexachlorohexane isomers such as (α-HCH, β-HCH, γ-HCH(Lindane), δ-HCH), chlordane compounds such as (α-chlordane, γ-chlordane, cis-nonachlor and trans-nonachlor), cyclodienes such as (aldrin and dieldrin), endosulfan II and DDT compounds such as o,p' and p,p'-DDE, DDD and DDT were analyzed using gas chromatography-electron capture detector. The soil samples were extracted and analyzed was described elsewhere[8]. Briefly, soil was extracted with dichloromethane using Soxhlet extractor for sixteen hours. The extract was cleaned using alumina-silica gel column chromatography. After concentration, the extract was cleaned again using size exclusion chromatography (Phenomenex Co., 100Å column) to remove biogenic materials. OCPs were analyzed using gas chromatography with ^{63}Ni μ-electron capture detector (GC/μ ECD).

Quality assurance/quality control (QA/QC) proceduresincluded analyses of duplicates, standard reference materials, and spiked internal standards. In the POPs analyses, internal standards were added at the beginning of the procedure and carried through the extraction, cleanup, and instrumental analysis steps to determine recovery. The following specific quality assurance steps were used to ensure measurement accuracy and precision: one procedural blank, one matrix spike, one duplicate spike and one standard reference material were run with each batch of not more than 20 samples. In the blank analysis, pentachlorobenzene and aldrin, α-HCH, dieldrin and HCB were detected at 0.001, 0.002, 0.05 and 0.003 ng/g dry weight, respectively.

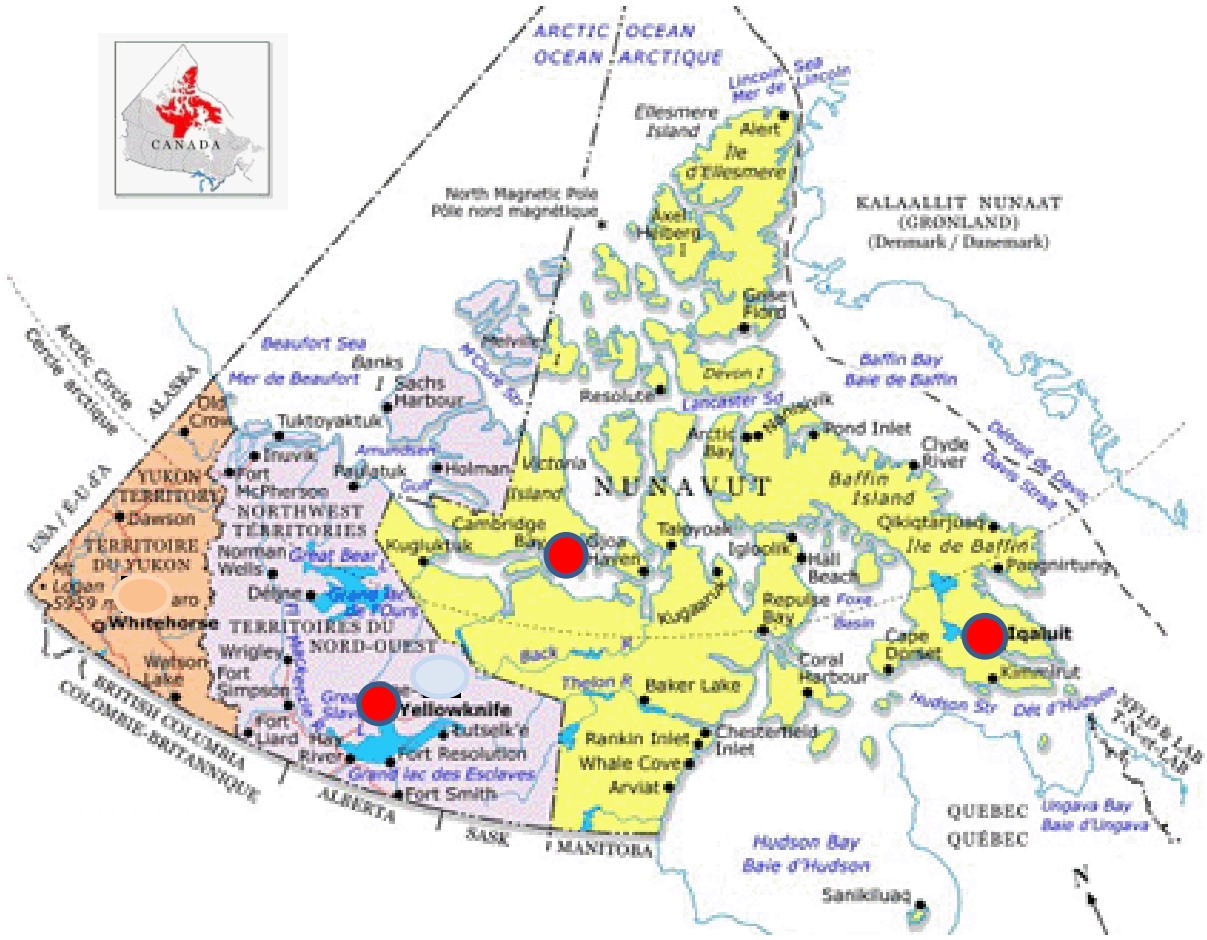

Figure 1. The map showing sampling locations.

Results and discussion:

The concentrations of the POPs measured in the soil samples of the disposal sites selected for this study are reported in Table 1. The overall highest total POPs concentrations measured in the soil samples from the major landfill sites and vicinity areas were those from Iqaluit (0.03-453 ng/g dry weight) followed by samples from Yellowknife (5.3-8.0 ng/g dry weight) and Cambridge Bay (0.17-8.5 ng/g dry weight). These levels were significantly higher than what was measured in corresponding background locations; IQA-2 = 0.1 ng/g. The background sample sites were chosen to be representative of clean and undisturbed soils. The large difference in concentrations observed between the landfill and background soil samples suggest POPs deposition into these landfills from materials discarded within. The levels measured in background soil samples are assumed to reflect deposition from atmospheric transport. There were huge variations between the lowest and highest concentration measured in the soil samples within each of the landfills that could be attributed to multiple factors including the historical movement of material within each site and the drainage characteristics of the site[7].

Yellowknife: Among the three samples, DDT and its metabolites were higher in two locations (YELL-01 and YELL-02), while HCHs were slightly higher than DDT in YELL-04. Among the HCHs β-HCH were major contributor in three soil samples (Figure 2). While, p,p'-DDD was higher in two soil samples (YELL-01 and YELL-04) and p,p'-DDT was major contributor in YELL-02. Contamination profiles of pentachlorobenzene, chlordanes, aldrin, dieldrin and endosulfan II is minimal and twice the concentration of those observed in the blank samples (blank data not shown).

Iqaluit: Maximum POPs concentration was noticed in the IQA-14 sample, which is similar to the concentrations of PCBs observed in another study[9] (Table 1). Interestingly, the adjacent sample (IQA-15) also contained 10 times lower concentration than IQA-14, however, significantly higher concentrations than rest of the 13 samples. Not only the DDT but also all other POPs such as pentachlorobenzene, HCB, HCHs, chlordanes, aldrin, dieldrin and endosulfan II were also detected at considerable levels in these particular two samples. When compared to the HCH composition, α-HCH was greater than the samples collected from YELL and CAM which showed greater β-HCH composition. Among DDTs p,p'-DDD and DDT comprise equal contribution than the DDE (Figure 2).

Cambridge Bay: Among the six samples collected, CAM-08 showed the levels equal to the blank, however, the rest of the samples contained levels similar to all samples collected from YELL. Indeed, the composition of HCHs, chlordanes and DDTs in CAM samples wereslightly different than other two communities[10] (Figure 2).

Table 1. Concentration (ng/g dry weight) of pesticides in soils from Canadian Arctic.

Location	IQA-1	IQA-2	IQA-3	IQA-4	IQA-5	IQA-6	IQA-7	IQA-8	IQA-9	IQA-12	IQA-13	IQA-14
Pentachlorobenzene	0.0024	0.016	<0.0003	0.0029	0.024	0.080	<0.0003	0.0029	0.00030	<0.0003	0.017	3.4
HCB	0.0040	0.0038	0.0018	0.11	0.10	3.2	12	0.014	0.0030	0.0020	0.0025	5.5
Sum HCH	0.0030	0.027	0.098	0.080	0.033	0.14	1.9	0.42	0.073	0.0057	0.14	19
Sum Chlordanes	0.0019	0.0018	0.0067	0.31	0.24	0.38	0.066	0.0072	0.0025	0.0028	0.0075	6.6
Aldrin	<0.001	<0.001	0.0059	0.010	0.0068	0.015	0.0080	<0.001	<0.001	<0.001	0.0053	0.54
Dieldrin	0.0033	0.030	0.0028	0.0081	0.11	0.016	<0.002	0.010	0.0043	0.0024	0.0049	58
endosulfan II	<0.002	<0.002	<0.002	<0.002	<0.002	0.017	0.015	0.20	0.011	<0.002	<0.002	0.60
Sum DDT	0.053	0.023	0.034	3.6	1.01	2.5	0.73	0.070	0.016	0.019	0.025	359
Sum Pesticides	**0.068**	**0.10**	**0.15**	**4.2**	**1.5**	**6.4**	**15**	**0.72**	**0.11**	**0.032**	**0.20**	**453**

Table 1. Continues.,

Location	IQA-15	IQA-16	IQA-17	YELL-01	YELL-02	YELL-04	CAM-01	CAM-02	CAM-04	CAM-06	CAM-07	CAM-08
Pentachlorobenzene	0.046	0.011	0.039	0.0038	0.062	0.011	0.056	0.13	0.031	0.038	0.016	0.021
HCB	0.079	<0.001	0.036	0.11	0.88	0.11	0.32	3.2	0.21	0.013	0.089	0.0086
Sum HCH	0.86	0.86	0.030	0.030	0.090	4.3	<0.002	0.20	0.15	1.2	0.31	0.082
Sum Chlordanes	1.8	0.040	0.010	0.094	0.11	0.072	0.23	0.35	0.26	0.045	0.22	0.0063
Aldrin	0.019	0.025	<0.001	0.0013	0.0015	<0.001	0.0020	0.028	0.0097	0.022	0.028	<0.001
Dieldrin	0.041	0.013	0.013	0.044	0.12	0.012	0.086	0.13	0.20	0.024	0.078	0.013
endosulfan II	0.52	0.0029	<0.002	0.010	0.078	0.0088	0.052	0.11	0.11	0.015	0.11	0.0069
Sum DDT	50	1.2	0.46	5.0	4.1	3.5	1.08	4.4	1.2	0.23	6.8	0.030
Sum Pesticides	**53**	**2.2**	**0.59**	**5.3**	**5.5**	**8.0**	**1.8**	**8.5**	**2.2**	**1.5**	**7.6**	**0.17**

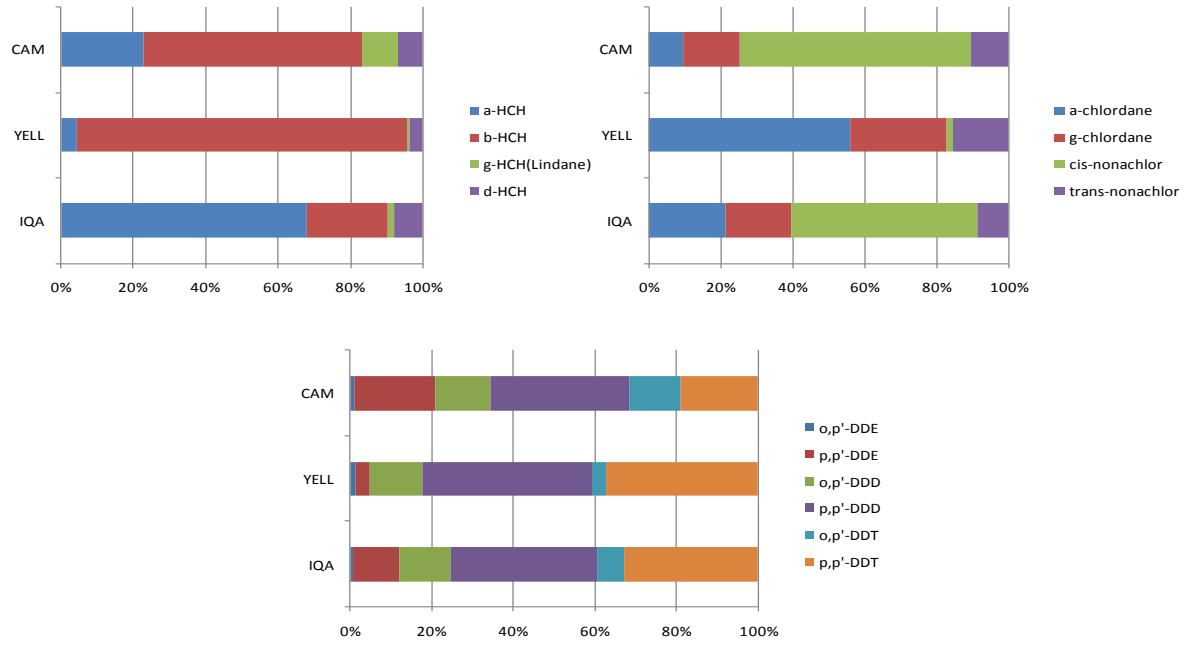

Figure 2. Compositions of HCHs, chlordane compounds and DDT metabolites in Soils from the Canadian North.

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