Chemistry 330

Environmental Chemistry

Assignment Manual

Athabasca University

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CMID recycle symbol

Contents

Tutor-marked Assignment 1 (Units 2 and 3)

1. If atmospheric ozone were compressed into a single layer at STP it would only be 3 mm thick. Assuming the earth has a diameter of 12,000 km, calculate the mass of ozone in the atmosphere.

2. a. Give the chemical formula for CFC-152.

   b. The C–Cl bond strength in CFC-152 is 328 kJ mol^{-1}. What is the maximum wavelength of light required to cleave this C–Cl bond?

3. Stoke's Law describing partial sedimentation is given by

$$\text{Rate} = \frac{g d^2 (\Delta\rho)}{18\eta}$$

where g = 9.81 m s^{-2} is gravitational acceleration, $\Delta\rho$ is the density difference between particles and the air, air viscosity is $\eta = 1.76 \times 10^{-4}$ g cm^{-1} s^{-1} and d is the particle diameter in centimeters. You are a 170 cm tall worker at an incinerator with a smokestack that is 25 m high. The electrostatic precipitators accidentally malfunction at 1:30 p.m. and some soot escapes the smokestack.

   a. Calculate the weight (in grams) of one cubic centimetre of air at STP. Assume air as consisting of only 21% O_2 and 79% N_2.

   b. Use Stoke's Law to calculate the rate of settling of soot particles with a diameter of 20 µm. Assume the viscosity of air to be 175 g cm^{-1} s^{-1}.

   c. Assuming the air is still, will you be covered with any soot before you leave work at 4:00 p.m.?

4. A mining operation has a nickel ore with the following composition:

Cu	1.3%
Fe	2.2%
Ni	1.5%
S	11.3%

The plant processes 25,000 tonnes per day. Only 15% of the sulfur is released to the atmosphere and 40% of the sulfur is converted to H_2SO_4.

a. What mass (in tonnes) of nickel metal is produced each day?

b. What volume of SO_2 (in m^3 at STP) is released to the atmosphere each day?

c. What mass (in tonnes) of H_2SO_4 is produced each day?

5. The rate constant for the reaction below is $2.3 \times 10^{-12}e^{(-1450/T)}$ cm^3 $molecule^{-1}$ s^{-1}.

$$O_{3\,(g)} + NO_{(g)} \rightarrow O_{2\,(g)} + NO_{2\,(g)}$$

a. Write out the rate law for the reaction above.

b. Calculate the rate constant at 295 K, and the activation energy.

c. Calculate the initial rate of the reaction if the initial concentrations of O_3 and NO are 1.0 and 5.4 molecule cm^{-3}.

d. Calculate the ΔG^o_{295} for this reaction.

e. Use the above information to calculate the rate constant of the reverse reaction at 295 K.

$$O_{2\,(g)} + NO_{2\,(g)} \rightarrow O_{3\,(g)} + NO_{(g)}$$

Tutor-marked Assignment 2 (Units 4 and 5)

1. Approximately 250,000 tonnes of a trace atmospheric gas are made and destroyed every day. Its average atmospheric concentration is 73 ppb. What is the residence time of ozone in the atmosphere? (Hint: Total atmospheric weight is 5.1×10^{21} g.)

2. Based on the amount of heat generated per mole of $CO_{2\,(g)}$ emissions produced, which is the better fuel?
   a. Natural gas ($CH_{4\,(g)}$) $\Delta H_f^o = -250.0$ kJ mol^{-1}

   b. Gasoline (octane, $C_8H_{18\,(l)}$) $\Delta H_f^o = -74.8$ kJ mol^{-1}

3. A sample of permafrost contains methane that has 19% of the carbon-14 found in atmospheric methane. Carbon-14 has a half-life of 5730 y.

   a. How long ago did this sample of permafrost freeze?
   b. State whether methane released from melting permafrost would be considered negative or positive feedback. Explain.

4. A hot spring emits water that has a temperature of 41^o C and might be used as a source of geothermal power. Given that water has a specific heat capacity of 4.18 J C^{-1} g^{-1}, what minimum mass of water would be required to generate one kilowatt hour of electrical power if the discharge stream was 20^o C? (Hint: 1 kWh = 3.60×10^3 kJ)

5. The author of your textbook mentions that methanol can undergo a water gas shift reaction and therefore be used as a safe source of hydrogen for fuel cells. However, consider the use of methanol itself directly in a fuel cell by examining the following two half reactions.

$$CH_3OH_{(aq)} + H_2O_{(l)} \rightarrow CO_{2\,(g)} + 6e^- + 6H^+ \qquad E^o = 1.11\ V$$

$$O_{2\,(g)} + 4e^- + 4H^+ \rightarrow H_2O_{(l)} \qquad E^o = 1.23\ V$$

   a. Write the balanced chemical equation for the overall reaction of the proposed methanol fuel cell.
   b. What is the standard potential of this cell?
   c. Calculate the standard free energy of this cell. Will the reactants or products be favoured?

Tutor-marked Assignment 3 (Units 6 and 7)

1. Which mixture of the following mixtures is more toxic? Justify your answer.

PCDD	1,2,3,4,6,7,8-Cl_7	2,3,7,8-Cl_4	1,2,3,4,7,8-Cl_6
Mixture A	90.0%	2.0%	8.0%
Mixture B	86.0%	1.9%	12.1%

2. In ancient Rome wine was stored in lead vessels, which would make the wine taste sweeter. The lead would leach into the wine and react to form lead acetate, which is sweet but poisonous. Assume the wine in these vessels contained 1 ppm of lead. How much wine would an 80 kg person have to drink to exceed the 6 μg/kg maximum recommended daily lead intake?

3. PCBs can be dechlorinated by treatment with a stoichiometric amount of sodium metal in the so-called Wurtz reaction. The reaction removes chlorines and the remaining biphenyl rings couple to form an organic polymer.

   $$RCl_x + xNa \rightarrow R{-}R_x + xNaCl$$

   Using the Wurtz reaction, what weight of sodium (in kilograms) is required to fully dechlorinate a 108.0 L sample of Aroclor 1242 (42% chlorine by weight and density = 1.211 g mL^{-1})?

4. A toxic heavy metal has a whole body half-life of about 16 years.

   a. The ADI (RfD) of this metal for food is 2.3×10^{-3} mg kg^{-1} d^{-1}. What is the acceptable daily intake for a 75 kg person?
   b. What is the whole body level of this metal if ingestion were maintained at ADI?

5. Consider a lake containing 47 ppb concentration of parathion, which has a $\log K_{ow}$ = 3.8. The rate of parathion intake and output (including metabolizing the parathion) in a fish can be described by first-order kinetics.

   $$\text{Rate(intake)} = k_{in} \times [\text{parathion}]_{water}$$

   $$\text{Rate(output)} = k_{out} \times [\text{parathion}]_{fish}$$

   a. Assuming the body weight of a fish is 4% fat, what is the equilibrium concentration of parathion in the fish swimming in this lake?

   b. What is the relative size of k_{in} and k_{out}?

Tutor-marked Assignment 4 (Units 8, 9 and 10)

1. A water sample has a pH of 7.34 and a total Ca^{2+} concentration of 128 ppm.
   a. What are the molar concentrations of CO_3^{2-} and HCO_3^-?
   b. What volume of 2.614×10^{-2} M HCl is needed to titrate 1.00 L of this solution to pH 4.3?
   c. What is the total alkalinity of the water?

2. The COD of a water sample is 120 ppm.

   a. How many milligrams of O_2 per litre of water is this equivalent to?

   b. Calculate the value for the equivalent O_2 molarity.

   c. What volume (in mL) of 0.0054 M $Na_2Cr_2O_7$ would be required to titrate a 25 mL aliquot of this sewage water?

3. Water has a residence time of 35 minutes in the tank of a chlorination facility. The throughput is 2.3×10^3 m^3 of water per hour.

   a. Calculate the size of the tank needed.

   b. To achieve a chlorine concentration of 1.5 ppm, at what rate must Cl_2 be injected into the tank?

   c. If 0.72 ppm of Cl_2 is consumed by oxidizable substances in the water, what should the rate of Cl_2 injection be to maintain 1.5 ppm Cl_2 in the finished water?

4. A sewage treatment plant has a primary settling tank with the dimensions 5.0 m × 25.0 m × 45.0 m.

   a. If you require a residence time of 6 hours in this tank for settling, what will be the maximum treatment capacity (in litres per day) of the plant?

   b. Assume 10% by weight of the sewage (in part a) are solids removed in primary settling. What volume of oxygen (at STP) is required in the plant's activated sludge reactor to reduce the BOD from 800 ppm to 80 ppm per day?

5. To determine the cation-exchange capacity of soil one saturates a sample with ammonium cation to displace cations absorbed on the dry material. After a water wash the sample is treated with potassium chloride and the resulting displaced ammonium cation is measured in solution. If in the final step a 100 g soil sample is treated with 500 mol of KCl solution and the resulting solution is found to contain 0.321 M ammonium ion, what is the CEC of the sample?

Essay Assignment

Write a short essay of about 2000 words on one of the topics listed below. The essay should be typewritten and double-spaced on white 8.½" × 11" paper. Please look over the example essay assignment entitled *Bioaccumulation of Toxics in the Canadian Arctic: A Brief Review of Contaminant Sources, Transport Mechanisms and Contaminant Bioaccumulation Mechanisms in the Arctic Ecosystem* by Emily E. Barr. It will give you an idea of what is expected for this essay assignment. You will be graded on content, presentation, spelling and grammar. In some cases the topics are controversial and raise social and ethical questions. You may touch upon these questions in your essay, but you should concentrate on the *chemistry* of these topics. Your essay should accurately reflect the information that you have found in your literature search.

Students are expected to consult a number of books, articles, or both, to assist in the preparation of this essay. You may use some on-line sources, but these should be in the minority. All sources should be acknowledged and referenced in the appropriate consistent manner using either ACS[1] or APA[2] styles.

Before you go to your local university library or do an online search, please visit the Athabasca University library web pages (`http://library.athabascau.ca/`). There are some helpful features on this site and you should make yourself familiar with this resource before going on. As a start, we suggest you access the "Help Centre" from the AU library main page and pay particular attention to the section entitled "AU Library Guide to the Research Process." This will give you a good overall introduction. (The same page can be found directly at http://library.athabascau.ca/help/research/guide2research.html.) The AU library staff can assist you in carrying out searches or finding resources in your local area. You may also request to borrow materials from the library's collection. Staff can be contacted by e-mail (`library@athabascau.ca`) or by phone 1-800-788-9041 (ext. 6254). Students in Calgary please call (403) 263-6465 (ext. 6254) and students in Edmonton call (780) 421-8700 (ext. 6254). You can also fax requests (780) 675-6477 or contact the library by mail or in person.

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1. *The ACS Style Guide: A Manual for Authors and Editors.* Dodd, J.S., C. Brogan, M.C., Eds.; Washington, DC: American Chemical Society, 1986. (AU Call Number: QD 8.5.A187)

2. *Publication Manual of the American Psychological Association*, 5th ed. Washington, DC: American Psychological Association, 2001. (AU Call Number: BF 76.7 .P976 2001)

Notes on Essay Writing

1. When writing your essays, please follow the format instructions listed below.

2. Use white paper of standard size (8 ½ × 11 inches).

3. Type the essay or hand–write it clearly, in blue or black ink.

4. Write or type on one side of the page only.

5. Double space every line of the essay; use single spacing only for long quotations.

6. Leave one and one-half inch margins on all sides of every page.

7. Number the pages and place them in the correct order.

8. Fasten the pages together with a staple or paper clips.

9. Put your name, the title of the essay, the name and number of the course and the name of your tutor on a separate cover page.

10. For an acceptable format for footnotes and the bibliography, see the style used in the sample essay in this *Assignment Manual*.

11. Proof-read your essay carefully before submitting it.

12. Before sending your essay in the mail, make a copy to keep for yourself so that your work is not lost if the original should go astray, and attach a Tutor–marked Exercise Form.

Intellectual Indebtedness

Students enrolled in an Athabasca University course such as *Chemistry 330* are considered to be responsible scholars. As such, students are expected to adhere rigorously to principles of intellectual integrity.

Plagiarism is a form of intellectual dishonesty in which another person's work is presented as one's own. Be certain that whenever you use a secondary source in your course work and essay you reference your source in a consistent and logical manner. All direct quotes (quotations of any number of words from the original) and indirect quotes (paraphrased ideas) *must* be acknowledged. Failure to do so constitutes plagiarism, and as will other forms of academic misconduct, will be penalized. Depending on the specific nature of the infraction, penalties may take the form of rejection of the submitted work; expulsion from the examination, the course, or the program; or legal action.

Dutiful citation of quotes and paraphrased material does not mean you can write an essay assignment by stringing together a series of quotes. You should always try to summarize or describe someone else's ideas in your own words. When you present your own ideas or opinions in a paper, provide evidence or arguments to substantiate your position.

Note: All assignments submitted for credit in *Chemistry 330* must be original work prepared especially for this course. The use of work written for other courses, or by other students, both are considered cheating, and will be penalized as such.

Essay Topics

You may choose the topic for your essay from the list of suggested topics given below. If you wish to write about a topic outside this list, please contact your tutor to discuss and approve your proposed topic BEFORE researching and writing the essay.

1. The Use and Disposal of PCBs: An Updated Assessment of Health and Environmental Risk
2. Wood Smoke, Air Quality, Aesthetics and Human Health
3. El Niño and Changing Global Weather
4. Kuwait Oil Fires
5. Alberta's Swan Hills Hazardous Waste Treatment Centre
6. Sydney Tar Ponds
7. Irving Whale
8. Love Canal
9. Exxon Valdez Oil Spill
10. Minamata Bay Disaster
11. Skin Cancer in Australia
12. London Smog of 1952
13. Chernobyl and Three-Mile Island

Bioaccumulation of Toxics in the Canadian Arctic:

A Brief Review of Contaminant Sources, Transport Mechanisms and Contaminant Bioaccumulation Mechanisms in the Arctic Ecosystem

by

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for

Chemistry 330: Environmental Chemistry

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Bioaccumulation is defined as the accumulation of a chemical in an organism to a higher concentration than is present in an external source.[1] This term encompasses both bioconcentration (the partition process that transfers a chemical between the ambient water or atmospheric environment and an organism) and biomagnification (the transfer of a chemical to an organism from its food source). In recent years, bioaccumulation of toxics in the Canadian Arctic has become an issue of increasing concern. Until the mid 1970's the Canadian Arctic was considered to be a pristine environment, however, it has been confirmed that certain global climatic effects actually transport pollutants such as persistent organochlorines and heavy metals from more southerly locations to the Arctic, where they bioaccumulate in organisms and are magnified throughout the Arctic food web. This biomagnification is of great concern to the Inuit populations in the Canadian Arctic as they represent the highest level of the food chain and therefore suffer the most severe effects of bioaccumulation.

The sources of bioaccumulative pollutants in the Canadian Arctic vary with season and with region and are hard to accurately identify. There is extensive evidence to suggest that the primary sources are not point sources in the Arctic region itself, but a combination of several sources located in Europe, Asia and the tropics.[2] Meteorological studies of global circulation patterns indicate that the Arctic receives a nearly continuous flow of tropospheric air from lower latitudes.[3] The nature of the pollutants deposited indicate their origins are in developing countries (where the use of DDT and other environmentally detrimental pesticides are not controlled) and in Eurasia. An annual Siberian anticyclone transports contaminants to the Arctic from Eurasia in the winter season.

The mechanism of transportation of these pollutants to the Arctic is primarily what is termed 'global distillation'.[4]The toxins evaporate from soils and water systems and are dispersed throughout the global environment via long-range atmospheric transport. PCBs (polychlorinated biphenyls) and chlorinated pesticides have residence times in the atmosphere between 20 and 30 days[5], which is ample time for air to disperse throughout the northern hemisphere. When these volatile chemicals reach an environment where the temperature is cold enough to cause them to condense, they are deposited via sedimentation or precipitation. Thus the Canadian Arctic, which experiences some of the coldest temperatures in the world, acts as a major sink for volatile pollutants. Though termed global distillation, the mechanism is more like fractionation[6]; certain chemicals are concentrated at the latitude which provides a low enough temperature to cause them to condense. This latitude varies from chemical to chemical as their respective dew points vary, that is, increased volatility results in increased global mobility. The Arctic condenses chemicals with dew points between freezing and -50^{o}C; i.e. some PCBs, HCHs (hexachlorocyclohexanes), toxaphene and other pesticides such as chlordane.[4]

Contaminants such as heavy metals and less volatile organochlorines can also travel on windblown particles such as clays and aerosols.[2]These particles are also transported via long-range atmospheric transport to Arctic regions where sedimentation can occur. Contaminated soils are more abundant in the southern regions and thus, due to the concentration gradient of contaminated particles in the atmosphere, the net migration of contaminated particles will be south to north.

Pollutants that reach the Canadian Arctic are usually more concentrated due to the distillation effect. The Arctic regions of the earth occupy a much smaller fraction of the Earth's surface than the areas of pollutant origination. Also, the mechanism of removal of persistent organic pollutants from the atmosphere is through oxidation by the hydroxyl radical in the atmosphere. Hydroxyl levels are much lower in the Arctic regions than at lower latitudes because the hydroxyl radical is produced through photochemical reactions requiring solar radiation.[4] Thus, the rate of influx of these pollutants exceeds the Arctic atmosphere's capacity for their removal and accumulation results. Because the evaporation of these chemicals from soils and water systems in the source regions is a gradual process, levels of toxins in the Arctic may continue to rise for several decades despite large reductions in the usage of the chemicals in question.[4] For example, PCB concentrations in southern Canadian soil samples peaked in the early 1970s and have since declined whereas PCB concentrations in the Arctic are still rising. This temporal lag in Arctic contaminant concentrations is indicative of the gradual nature of evaporation and global dispersion of these pollutants. Recent global warming trends will only worsen the Arctic concentration of pollutants by causing faster evaporation and reducing the size of the region where the temperature is low enough to cause condensation.

Studies of bioconcentration mechanisms in the Canadian Arctic have focused primarily on the marine food chain. Transport of contaminants from the environment to the food chain is thought to occur through uptake of contaminants from surface waters by epontic algae and phytoplankton or by uptake of contaminants from sediments by bottom-dwelling organisms (such as zooplankton) in coastal and shallow shelf regions of the Arctic.[1] This is likely the major pathway for contaminants to enter the Arctic aquatic ecosystem. Induction of chemicals into the terrestrial ecosystem has also been investigated, though bioaccumulation is less severe in this system because of the smaller number of trophic levels in the food web. Studies of contaminant levels in lichen indicate that lichen accumulate atmospheric contaminants unselectively and thus contain similar concentrations of pollutants to those present in the atmosphere. Examination of contaminant concentrations in caribou populations* show substantially lower contaminant levels than those in marine mammals (due to the shorter food chain mentioned above) but the type and relative level of organochlorine concentrations were very similar. This similarity is one indication that long-range atmospheric transport is the source of the contamination rather than local point sources.

Though the rate of influx of contaminants into the Canadian Arctic ecosystem is much higher than the desired level for such an undeveloped region of the world, the level of contaminants in the Arctic waters is not substantially higher than in other parts of the world. Certain characteristics of the Arctic marine ecosystem, however, make bioaccumulation of these contaminants much more severe than in other regions. The long cold season in Arctic regions results in very short growing seasons for Arctic-dwelling organisms. This short growing season is responsible for very slow growth rates and longer life spans as compared to fauna in other regions of the world. Longer life spans provide longer tinic spans for bioaccumulation to occur and thus bioaccumulation factors (the numerical magnification of contaminant concentration) between trophic levels are as much as ten times higher in Arctic ecosystems than those in more southerly regions. Biomagnification factors for higher trophic level predators (such as seal, beluga, polar bear and human) are on the order of 10^7 for HCHs, toxaphene and chlordane and 10^9 for PCBs.[1]

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* Lichen is a major food source for caribou

The other major factor affecting the severity of bioaccumulation in Arctic ecosystems is the high fat content of Arctic mammals and fish that results from adaptation to a colder climate. The food-limited nature of the Arctic environment also promotes rapid utilization of concentrated organic matter by organisms which leads directly to the accumulation of organochlorines in lipid-rich tissues and metals in proteinaceous tissues.[8] Lipid soluble compounds such as organochlorines are further concentrated in organisms via natural seasonal cycles of lipid formation and storage. There is also evidence to suggest that cetaceans have a very low capacity for PCB metabolization and that over 60% of PCB residues in female cetaceans are passed on to their young during lactation.[7] These factors, combined with the characteristics of low diversity and dominance by large, long-lived species may cause Arctic ecosystems to be more susceptible to bioaccumulation than ecosystems in more temperate regions.

Biomagnification results in increasing contaminant concentrations with increasing trophic level. However, despite the relatively low diversity of the Arctic ecosystem, it is often difficult to identify trophic level of a species accurately. Thus, biomagnification is measured against $^{15}N/^{14}N$ ratio. This ratio increases from prey to predator because ^{14}N is preferentially excreted during metabolic processes.[9] This provides a continuous variable against which to measure bioaccumulation rather than requiring scientists to discern discrete trophic levels. Based on occurrence and potential toxicity, the contaminants of most concern for bioaccumulation in the Canadian Arctic are: PCBs, organochlorine pesticides such as DDT, chlordane, toxaphene and HCHs, mercury and lead.[10] The biomagnification potential in the Arctic is much greater for lipophilic contaminants (such as organochlorines) than heavy metals, but high levels of mercury and lead in the Arctic ecosystem are still cause for concern as they will be magnified to some extent. Molecules that bioaccumulate generally have the characteristics of a high molecular weight (between 100 and 350 g/g-mol relates to the highest bioaccumulation potential[1]), nonpolarity, low degree of ionization and high resistance to degradation (i.e. soil persistence on the order of years).

As mentioned earlier, organochlorines and PCBs bioconcentrate in fatty tissues due to high lipophilicity and resistance to biodegradation. Lipophilic compounds have low water solubilities and high fat or lipid solubilities. Lipophilicity is often measured using the 1-octonal to water partition coefficient, K_{ow}.* K_{ow} for bioaccumulative compounds usually ranges between 100 and 10 million.[1] Some compounds do not bioaccumulate appreciably themselves but their metabolic products are easily biomagnified compounds. An example of this is DDT, which is metabolized into a form of DDE that is a bioaccumulative toxin.

The focus of most attention to bioaccumulation in the Canadian Arctic is its effect on the health of aboriginal communities in the region. Inuit in the Canadian Arctic are one of several mammals that represent the highest trophic level and are thus most susceptible to the toxic effects of pollutant bioaccumulation. Along with the human population in the Arctic, sea mammals and polar bears also belong to the higher trophic levels in the ecosystem and are susceptible to adverse effects from bioaccumulation. There has been little research, however, on the effects of these toxins on humans and other mammals. The US Environmental Protection Agency (EPA)

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* K_{ow} = concentration in octanol / concentration in water for the compound distributed between two phases at equilibrium.

and the World Health Organization (WHO) have set reference levels for maximum blood concentrations of mercury and daily doses of organochlorides for no adverse effect. It is known that mercury accumulation can cause neurological damage in humans and mammals and that PCB exposure has adverse effects on fetal neural development and reproduction in humans, mammals, birds and fish.

Consumption of traditional foods such as muktuk (the surface fat and skin of whales) and ringed seal liver can expose Inuit to extremely high levels of organochlorines and mercury, respectively. Mercury concentrations in muscle and liver tissue of seals can exceed 0.5 μg/g and organochlorine concentrations[*] can be 1 - 5 μg/g in sea mammal blubber and 3 - 8 μg/g in polar bear fat.[5] Mercury concentrations in the blood of Canadian Inuit populations were 14.1 μg/l and 6.8 μg/l in adults and children, respectively. These levels, though much less than the low risk threshold set by the WHO at 200 μg/l,[11] far exceed levels measured in Quebec City, where 80% of the sample had a blood mercury concentration of less than 2 μg/l.

One of the most alarming effects of bioaccumulation is the transfer of accumulated contaminants from mother to child via lactation. A study of Northern Quebec Inuit women showed PCB levels in breast milk up to 6 - 10 times higher than levels in the general population. These concentrations indicate that the mothers' daily doses of organochlorines are approaching reference limits set by the US EPA. For example, the estimated daily dose of PCB #153 for these women is 0.04 μg/kg/day and the US EPA reference daily dose is 0.07 μg/kg/day.[12]

Recently, there has been pressure for world environmental agencies to propose guidelines for reducing airborne contamination responsible for bioaccumulation in the Arctic.[2] It is difficult, however, to predict interregional differences in contaminant concentrations in the Arctic and their effects on the health of humans and other mammals are not well established. Any management strategy introduced would have to be global in nature in order to be effective since temperate regions all over the globe are sources for contaminant deposition in the Arctic sink. There is also the paradox of aboriginal lifestyle: most of the DDT and pesticides released from tropical regions are being used to combat malaria in aboriginal populations in those regions. These pesticides are threatening the lifestyle of the Inuit in the Canadian Arctic by making it dangerous to consume traditional foods and continue their traditional role as hunter in the Arctic ecosystem.

Though contaminant releases are declining, the problem of bioaccumulation in the Canadian Arctic ecosystem will continue to grow for years to come. It has been established that toxics such as organochlorines and heavy metals are accumulating in the Canadian Arctic ecosystem and that the sources of these contaminants are located all over the world. The contaminants reach the Arctic through long-range atmospheric transport; a mechanism referred to as 'global distillation.' More research into long-term effects and the persistence of these contaminants is essential to develop effective global control strategies to prevent further damage to this very important ecosystem. As with most global environmental issues, the solution will be a complicated one and will likely require many years to implement. Hopefully, the solution will come before the ecosystem is irreversibly damaged and the traditional lifestyle of the Canadian Inuit ruined.

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[*] Concentration effects of planar organochlorides are thought to be additive.

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