NICHOLAS SCHOOL OF THE ENVIRONMENT AND EARTH SCIENCES
DUKE UNIVERSITY

February 14, 2006

To Whom It May Concern:

My name is Heather Stapleton, assistant professor of environmental chemistry within the Nicholas School of the Environment and Earth Sciences at Duke University (Durham, NC, USA). For the past seven years I have been investigating the fate, transport and metabolism of brominated flame retardants, and specifically, polybrominated diphenyl ethers (PBDEs), in the environment. In 2003 I received my Ph.D. from the University of Maryland based on a dissertation which examined the uptake and metabolism of PBDEs in fish. Currently I have more than a dozen peer-reviewed papers published on PBDEs with two more currently in review with leading environmental scientific journals. Given this background, I consider myself to be one of the leading experts on PBDE fate and transport in the environment.

With this letter I would like to give you a brief overview of some of the more pressing issues regarding the use of PBDEs, and specifically the issues surrounding the fate of the commercial flame retardant mixture known as Decabromodiphenyl Ether, or DecaBDE. These issues include the bioaccumulation and breakdown potential of the primary component of this mixture, BDE 209. Here are a few of the key points:

1. Human accumulation of BDE 209
2. Bioaccumulation of BDE 209 in food webs
3. Potential for debromination of BDE 209 in the environment

Human Accumulation of BDE 209: BDE 209 has been detected in human tissues (breast milk and serum) in several different studies (1-3) suggesting it can accumulate in people and is bioavailable, contrary to industrial claims. Due to the fact that house dust has been found to contain some of the most concentrated levels of BDE 209 ever measured, there is some concern that children may be receiving elevated exposure to BDE 209 that is greater than adults. In fact, the only study to examine BDE 209 in children found that BDE 209 was present in serum and at levels that were two orders of magnitude greater than levels measured in adults (3). Thus, there may be concern about children's exposure to DecaBDE in indoor environments.

Bioaccumulation of BDE 209 in Food Webs: Generally speaking, the terms bioaccumulation and biomagnifications indicate that the concentration of a chemical is higher in the animal than it is in their food sources, or in the cases of aquatic environments, higher than the concentration found in the water. Recent studies have detected BDE 209 in a variety of fish, rodent, bird and mammal species, suggesting it is

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bioaccumulative (4-8). However, it is often difficult to estimate the bioaccumulation potential unless the prey items or food sources have been measured for BDE 209 as well. One study conducted on the food web of Lake Winnipeg in Canada has found evidence to suggest significant bioaccumulation of BDE 209 does occur (9). In this study, the authors calculated biomagnification factors (BMF) for several predator/prey species that had been measured for BDE 209. A BMF is defined as the concentration of a chemical in a predator divided by the concentration of a chemical in its food source/prey. The calculated BMFs for several fish species in Lake Winnipeg ranged from <1 up to 34. This suggests, for example, that some fish had levels of BDE 209 in their tissues that were 34 times greater than the levels in their known food sources, implying bioaccumulation. Furthermore, BDE 209 has been detected and measured in wildlife at levels as high as 12,200 ppb (5) and in some cases it is the primary PBDE congener present in wildlife tissues (4,6). Furthermore, the levels measured in wildlife (bears, foxes, birds, etc.) suggest that accumulation of BDE 209 is occurring at greater rates in terrestrial environments relative to aquatic environments (4,6). Based on this evidence, BDE 209 is believed to be bioaccumulative.

Due to very low water solubility, exact measurements of bioconcentration factors (BCFs) have been difficult to measure/estimate because they rely upon measuring BDE 209 in aqueous systems. However, the estimated Log K_{ow} values for BDE 209 range from 6.3 to 9.7 (European Commission, 2002; European Chemicals Bureau, 2004) which does classify this compound as bioaccumulative according to the Organisation for Economic Co-operation and Development (OECD) guidelines, which states that in the absence of BCF measurements, a substance is bioaccumulative when the logarithm of its octanol-water partition coefficient is equal to or greater than 5.

Potential for Debromination of BDE 209 in the Environment: An additional concern regarding the use and fate of decaBDE is the potential for this compound to breakdown via a mechanism known as debromination. Debromination of BDE 209 indicates that the congener is successively losing bromine atoms from the molecule, creating a smaller, more persistent, more bioaccumulative, and potentially a more toxic compound. Studies have indicated that PBDE congeners with 4 to 7 bromine atoms have greater rates of accumulation, larger BMF values and longer half-lives in tissues that the fully brominated (10 bromine atoms) BDE 209 congener (10-12). Due to the high use and distribution, environmental debromination of BDE 209 may be of concern and lead to greater exposure to lower brominated PBDE congeners. In laboratory studies debromination of BDE 209 has been found to occur from both exposure to UV light and sunlight (13-15), by bacteria (16,17) and by endogenous metabolism in fish (18,19). The potential for photolytic debromination and exposure to lower brominated congeners in people is of real concern given the abundance of BDE 209 measured and detected in house dust. Furthermore, BDE 209 is found at relatively large abundance in biosolids and sewage sludge (20-23) which are often land applied as a recycling strategy and receive significant sunlight exposure.

The extent of debromination varies depending on the mechanism involved, and in the case of photolysis, the intensity of the light. Photolytic studies using UV lamps have

shown that BDE 209 can debrominate down to tri, tetra-, penta- and hexaBDE congeners (13-15). The extent to which this compound will break down under environmentally relevant conditions is difficult to assess. In one of my own research studies we investigated the debromination potential of BDE 209 in house dust following exposure to natural sunlight. BDE 209 debrominated with a half-life of approximately 200 hours and formation of PBDE congeners with 7 to 9 bromine atoms was observed. This study is currently in review with the journal Environmental Science & Technology. In a fish exposure study we examined the capability of carp to debrominate BDE 209 via metabolism. Following exposure, carp were observed to accumulate one pentaBDE, three hexaBDE, two heptaBDE and one octaBDE congeners as a result of debromination, although the concentrations of these less brominated congeners represented about 1% of the BDE 209 exposure (18). The ability of other species to debrominate BDE 209 is unknown. Exposure studies using rats have found that BDE 209 is metabolized via a combination of debromination and oxidative pathways leading to accumulation of hydroxylated (OH-BDEs) and methoxylated (MeO-BDE) congeners which are also of toxicological concern (24,25).

Given these issues, I would support a ban on the use of the flame retardant mixture known as decaBDE if suitable alternatives can be found. While I acknowledge and appreciate the need for flame retardant chemicals in our products, I think it is also important to reduce exposure to potentially bioaccumulative and toxic chemicals. This is particularly important for reducing exposure to children who are in sensitive developmental stages. With the high levels of BDE 209 measured in indoor environments (i.e. indoor air and dust), children's exposure to this chemical may be significantly higher than most adults.

If there are any further questions regarding the statements written herein I can be reached at the contact information below. I am also willing to testify before a board of review on this issue if need be.

Thank you,

Heather Stapleton

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PROFESSOR
Deptartment of Environmental Chemistry

14 Feb. 07

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Science based view on DecaBDE

As I understand the Canadian government has announced their intention to ban PentaBDE and OctaBDE, as EU has. The EU decision was based on some extensive environmental and health risk assessments. I fully agree with the action taken by EU. Despite rather extensive data regarding DecaBDE, no action was taken to regulate the use of DecaBDE at that time. I like to point out a few scientific facts that must be considered by the Canadian government when approaching the question if DecaBDE meets the criteria for "*virtual elimination*", i.e. persistance, bioacuumulation, and toxicity.

First I like to discuss DecaBDE as the perbrominated diphenyl ether 2,2',3,3',4,4',5,5',6,6'-decaBDE (BDE-209) since the major species in the DecaBDE product is this particular compound. Still it has to be acknowledged that the DecaBDE product contains minor amounts of nonaBDE and traces of octaBDE congeners.

Several scientific peer reviewed articles have shown long range transport of BDE-209 to geographical areas far away from DecaBDE production sites and use. Even though BDE-209 is readily undergoing photolysis leading to lower brominated diphenyl ethers and to polybrominated dibenzofurans ("dioxins") and reductive reactions to lower brominated diphenyl ethers, BDE-209 is stable enough to undergo long-range transport. The extensive distribution of BDE-209 in the environment has lead to its identification in a very large number of wildlife species and in humans around the world.

The kinetics of BDE-209 is interesting and different from most other environmental pollutants I am aware of. BDE-209 has a short half life in humans, rats and grey seal. In contrast, the very high concentrations determined in some birds of prey are showing a very different behavior in these birds. Most recently birds of prey sampled in China has shown BDE-209 concentrations above 10.000 ppb (to compare with typical North Amarican human levels of 10-100 ppb and European concentrations of 1-10). Aquatic wildlife seems to contain low concentrations of BDE-209. *It is evident that BDE-209 is bioaccumulating in terrestrial birds of prey (e.g. Peregrine falcons, Buzzard and Kestrels).* Some occasionally high levels of BDE-209, e.g. in humans, are related to recent exposure to DecaBDE. It is still notable that the human levels may be several hundred ppb.

In mammals, including humans, and in fish data show formation of lower brominated diphenyl ethers as a result of BDE-209 metabolism. Most likely a number of other hitherto non-identified hydroxylated metabolites are also formed. Indications of their presence have been published. BDE-209 is undergoing microbial

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debromination to lower brominated congeners, shown to be persistent, bioaccumulative, and toxic.

Data showing the neurodevelopmental health effects are intriguing and must be taken seriously. Since BDE-209 is forming lower brominated diphenyl ethers the health effects of these PBDEs must be considered. The environment and health risk assessments for PentaBDE and OctaBDE become important documents for this assessment.

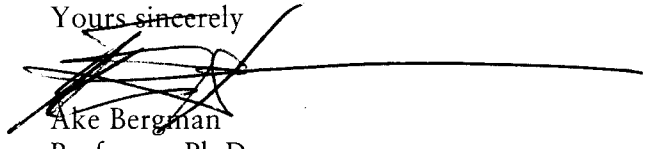
DecaBDE (BDE-209) is fulfilling, to the best of my understanding, the criteria of a persistent organic pollutant (POP) (according to the Stockholm convention). My conclusion is that BDE-209 (DecaBDE) needs to be regulated. If it is not done we will have to expect environmental effects to be observed in wildlife with the highest exposure, and possibly in humans with high exposure.

As far as I understand there are alternatives for DecaBDE but I am not going into any further discussion on that matter.

I have not included any references to the appropriate scientific articles above. This can of course be done if there is a request for this. Most likely these articles are included in any up-to-date review of the literature.

I regard this issue of such importance that I am willing to testify at a board of review hearing regarding the POP characteristics of DecaBDE (BDE-209), if I am asked to do so.

Yours sincerely



Åke Bergman
Professor, Ph.D.
Chair of in Environmental Chemistry
A short CV follows on the next few pages

Åke Bergman Curriculum vitae

Name: Bergman, Bengt Åke Lennart (born 1950)

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E-mail: ake.bergman@mk.su.se; Web: www.mk.su.se

Education/Academic Training, Degrees and Academic Positions

1974-12-23	BS at Stockholm University
1980-05-27	Ph.D. in Organic Chemistry, Stockholm University
1983-09-15	Docent (Associate professor) in Organic Chemistry at Stockholm University
1993-11-01	Professor in Environmental Chemistry, Chair of Environmental Chemistry, Stockholm University

Appointments

750101-830930	Research. assistant at the Unit of Organic Chemistry, Wallenberg laboratory, SU.
810801-820731	Research associate, Dept. of Biochemistry, North Dakota, State University, Fargo, ND, USA.
831001-860630	Researcher at Unit of Organic Chemistry, Wallenberg laboratory, SU (40%).
860701-870630	Researcher at the Special Analytical Laboratory, Swedish EPA (60%).
870701-931101	University lecturer in miljökemisk syntes at the Unit of Environmental Chemistry, SU
900301-920630	Acting professor in Kemisk Miljöanalys at Unit of Environmental Chemistry, SU
900701-	Head of the Unit of Environmental Chemistry, SU, 940920.
920701-931030	Acting professor in Environmental Chemistry at the Unit of Environmental Chemistry, SU. Prefekt (Head of the unit)
931101	Professor, Chair of Environmental Chemistry at Stockholm University. Prefekt (Head of the department)#

Research orientation

My present research activities are best seen as presented at our website (www.miljokemi.su.se). In breif, my research projects in the field of organic environmental chemistry include *i:* synthesis of standard and test compounds of environmental concern, including metabolites of these compounds and radiolabelled substances; *ii:* development of analytical methods for and analysis of organic substances in environmental samples (primarily in biota); *iii:* exposure assessments in humans and wildlife; *iv:* metabolism studies (kinetics) of

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The status of the Unit of Environmental Chemistry was changed to Department of Environmental Chemistry in September, 1994

environmental pollutants; *v:* development of a new operational concept of persistency; and *vi:* contributions to risk assessment of chemicals.

International Committee/Board member

International Advisory Committee for the dioxin series of symposia, from 1996 – 2002
Editorial board of "Impact of Endocrine Disrupters on Human Health and Wildlife, 1996/1997, (EU, EEA, WHO, OECD and three national EPA, CEFIC/EMSG).
Steering group on Endocrine disrupters, IPCS/OECD, WHO, Pan American Health Organisation/ AMRO 1998-
National representative in Federation of European Chemical Societies (FECS), Division on Chemistry and the Environment, 1998 – Name changed to EuCheMS 2004
International Advisory Committee for BFR workshops 2003-

National Committee/Board member
Research committees at the Swedish EPA (1990-1998)
Institute of Applied Environmental Research (ITM), Stockholm University, 1992-; Chairman 1995-1998, 1999-2001.
The Swedish Chemicals Policy Committee 1996/1997, Expert group
Expert panel for STFI, 1997-
Expert panel for NCC, 1998- 2001
Expert board for the Swedish Food Administration, 1998-
The Royal Swedish Academy of Sciences, The Environmental Committee, 2000-2002; 2003-2005.
Board Member of the Foundation for Strategic Environmental Research - MISTRA, 2000-2001; 2002-2003; 2004-2005
Member of the Scientific Advisory Board for the Swedish Society for Risk Sciences, 2000-
Chairman of the committee for environmentally related toxicology, KMRT, FORMAS, 2001-2003.
Appointed by the Swedish government as a member of the Environmental Advisory Council, 2002-2007
Appointed by the Swedish government as a member of the board of the Chemicals Inspectorate, 2005-

Stockholm University Committee/Board member
Member of the Stockholm University Institute for Applied Environmental Research (ITM) board from 1992-2001, and as ITM board chairman 1996-2001.
Deputy member of the Natural Science Faculty board 1994-2002.
Chairman of the Environmental Science drafting committee 2002-2005; 2006-
Member of the "tjänsteförslagsnämnen" within the Chemistry section at Stockholm University

Other activities
Co-ordinator of the 4th framework EU programme "Risk of Endocrine Contaminants" 1996-1999.
Main co-organiser of the 18th Symposium on Halogenated Environmental Organic Pollutants in Stockholm, August 17-21, 1998

Government expert on brominated flame retardants on a one week tour to the US (Washington, Chicago and San Francisco together with the State Secretary of the Environment, Ministry of the Environment, Sweden (June 28-July 2, 1999).
Swedish participant in the start up of the STINT program for bilateral cooperation between Mexico and Sweden, 2000
Chairman of "The Second International Workshop on Brominated Flame Retardants", Stockholm May 14-16, 2001

Reviewer of scientific articles for
Ambio; Analytical Chemistry; Chemosphere; Environment and Health Perspectives; Environmental Science and Technology; Journal of Chromatography; Rapid Communications in Mass Spectrometry; Toxicological and Environmental Research; Environmental Pollution and occasionally other scientific journals.

Professional Associations (International and National Societies)
American Chemical Society (ACS)
International Society for the Study of Xenobiotics (ISSX)
International Isotope Society (IIS)
Society of Environmental Toxicology and Chemistry (SETAC)
Swedish Chemical Society
Swedish Society for Toxicology

Awards
Stipend from The Swedish Union of Clerical and Technical Employees in Industry (SIF), 1997
Research Stipend from the King Carl XVI Gustafs jubileumsfond, 1998
Travel stipend from Stockholm University 1999
Awarded the *Honoris causa* degree at University of Latvia, 2002.
Award recognizing the contribution of A. Bergman and B. Jansson in the field of BFR research "The Ake Bergman & Bo Jansson BFR Student Presentation Award" ("Award recognizing the contribution of A. Bergman and B. Janssonin the field of BFR research") at the International BFR workshop 2004, Toronto.
Travel stipend from Stockholm University 2007

Teacher of undergraduate courses
Environmental Chemistry and Organic Environmental Chemistry, respectively, at Stockholm University.
Regular lecturer at university courses at Uppsala University
Lecturer at post-graduate courses
In charge of a program for environmental science education (3 or 4 years of studies) at Stockholm University, Faculty of Natural Sciences, starting August 2004.
In charge of the department participation for the development of the master program "Swedish School of Environmental Chemistry" SSEC offered as a joint program between Department of Environmental Chemistry, Stockholm University and Department of Chemistry/Environmental Chemistry, Umeå University, starting August 2006 (www.mk.su.se).

Degrees completed under my supervision
Main supervisor for 16 doctorate degrees: Eva Jakobsson (1994); Anders Olsson (1999); Andreas Sjödin (2000), Karlis Valters (2001), Maria Söderström (2002), Christina Larsson (2002), Göran Marsh (2003), Maria Athanasiadou (2003), Johan Eriksson (2004), Sara Rahm (2004), Tina Malmberg (2004), Kaj Thuresson (2005),

Britta Fängström (2005); Lotta Hofvader (2006); Karin Norström (2006); Jana Weiss (2006)

Assistant supervisor for the doctorate degree of: Eva Klasson Wehler (1989); Lillemor Asplund (1994), Henrik Kylin (1994), Daiva Guvenius-Meironyté (2002)

Opponent for doctoral degree ***(Respondent names given below)***
Ulrika Nilsson, Stockholm University (1992)
Martine Lans, Wageningen Agricultural University, Wageningen, The Netherlands (1995)
Lars-Ove Kjeller, Umeå University (1998)
Hermes Licea Pérez, Stockholm University (2000)
Ilonka Meerts, Wageningen University, Wageningen, The Netherlands (2001).
Monica Waldebäck, Uppsala University (2005)

Doctoral degree committees
Frequently appointed; Not specified.

Publications (please see www.miljokemi.su.se under my name)
Up till now I have published approximately 200 original scientific articles in peer reviewed international journals and approx. 100 peer reviewed extended abstracts (4-6 pages) for presentations at international symposia, preferentially the Dioxin symposium series. I have published an additional number of short abstracts (1 page or less) for presentations at national and international symposia. The latter have not been listed among the "Publications".
Book chapters, popular scientific publications, compendium for teaching, scientific policy documents and debate articles have also been written by me.
Part of several newspaper, radio and television interviews and/or discussions.

Invited speaker and session organizer
List available upon request.

Research grants
List available upon request.
Financial support for the research I am doing is coming from Sweden (the Research Council Formas, MISTRA, SEPA), Nordic Council of Ministers, EU R&D and US granting bodies.