Agricultural Plastics Recycling Pilot Project

Summary Report

Recycling Council of Alberta

September 2009

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1 Introduction

In 2007, the Recycling Council of Alberta (RCA) established a working group with representatives from the Alberta Plastics Recycling Association (APRA), the plastic manufacturing sector, retailers, recycling project operators, Alberta Agriculture, Alberta Environment, and recyclers to look at options for agricultural plastic waste.

The use of plastic materials in agriculture has been a factor in growth of productivity and capacity / scale. At the same time, agricultural plastics in the form of baler twine, bale wrap, silage wrap and feed bags of various sizes are a problematic waste for farmers and agricultural businesses, and their use is continuing to increase. APRA has calculated that polypropylene (twine and cord) sold in the Alberta in 2007 is in range of 9.5 – 11 million lbs. (4300 – 5000 tonnes) and the polyethylene material (sheet materials like silage bags and cover) is somewhat less at 6.5 -8.7 million lbs. (3000 – 4000 tonnes), although that number is expected to grow as grain storage bags gain popularity and continue to replace buildings in application. Although not captured in the above numbers, polypropylene is also used extensively in the manufacture of bulk bags, feed sacks and lumber wrap.

The use of plastic in agriculture is ubiquitous, yet the question remains “is there a cost”?

- Those involved in agronomy are generally well-informed about sustainable production – indeed to have an inherent understanding of its implications as nature’s cycles are combined with various inputs to create the bountiful crops we typically enjoy.
- As economics recognizes, and eventually moves to full cost accounting; however difficult, the true cost of plastic use, disposal / recycling must be considered.

So what is full cost accounting and how does it apply to agricultural plastics? Full cost accounting is a system where we must account for costs to natural and social systems as well as economic ones; a concept that meshes well with sustainability. In a review of the issues surrounding the use of agricultural plastics, there are costs that are not recognized in the system used today where plastics are burned on site, disposed of by burying in landfills or backyard pits, or left in the environment as litter.

2 Current Plastic Disposal Methods & Drivers of Change

2.1 Burning on Site

Burning on site is anecdotally thought to be the predominate means of disposal today, yet research shows that harmful compounds are released from burning plastic at low to moderate temperatures. These compounds create a health hazard when inhaled and after they fall to the ground, typically within 500 meters of the burn site, contaminating soil. Some, including dioxins and furans, accumulate in soil and bio-accumulate in fat as they move up the food chain. (See Appendix for additional information.)

The Alberta Livestock and Meat Strategy (ALMS) focuses on On Farm Food Safety and Source Verification as marketing tools; surely it is in our interest as livestock producers individually and collectively to prevent this hazard. Do we know normal background levels of these chemicals in soil and meat? What are current levels? Abnormal levels could make marketing livestock impossible and may require soil remediation/removal - terrifying concepts but costs that are not included in current decisions to burn. For this reason alone it is imperative that burning stop; if it is not acceptable, people must be educated to use alternate means of disposal, and those alternate methods made easily accessible to them.

2.2 Landfill

Landfill currently costs in the order of $50/tonne on average in Alberta, with many sites charging tipping fees that are considerably higher, and prices likely to continue to rise in the future. In addition, landfills may prohibit or limit the disposal of some agricultural plastics, in particular twine, because of the handling challenges it presents and potential damage to equipment.

2.3 Burying on Site

Burying on site occurs in situations where farmers feel they have no other alternative, or that alternatives are inconvenient.

2.4 Recycling

Recycling avoids the cost of landfill. Plastic is a valuable commodity ($2-300 per ton clean and pure in 2008), and clean used plastics can be recycled to resin. To do so, industry must have capability and capacity to deal with the materials and volumes generated. Alberta has significant industrial plastic producers (e.g., Nova) and post industrial processors (e.g. NPI). Post-consumer industry exists for HDPE and PET, while the Beverage Container Recycling System is supported by a recycling fee that provides an incentive to stimulate recycling. There is little industry capacity to handle used agricultural plastic at this time; thus a pilot program was conducted to gain insight into the amount, type and quality of used agricultural plastic available, and the capability of industry to utilize it.

Shipment to China for recycling is done currently with small volumes, however, this should not be seen as a long term solution, as agricultural contaminants like manure or feed can spread plant or animal disease or introduce new species. Because of this, limitations on exports to other countries is a significant risk.

3 Agricultural Plastic Recycling Pilot

As part of its research efforts, the working group established a pilot project on recycling of agricultural plastics. Before a recycling solution can be advocated problems associated with collection, shipment and recycling must be understood and solved. The goal of the agricultural plastics pilot program was to facilitate a recycling solution to conserve a plastic resource that is currently lost and in the process reduce the air pollution that results from open burning of the material. Assessments in communities across the province were made as agricultural profiles and climates differ significantly.

3.1 The Project:

a. Short-term collection programs (approximately 2 months) for baler twine and silage plastic / wrap were established in the Lethbridge and St. Paul / Smoky Lake (Evergreen Regional Waste Management Commission) areas, as well as continuation of work already underway in Mountain View County. Weight of materials received was tracked along with quality, handling and storage challenges with notation of the effectiveness of sorting, cleanliness, contamination etc.
b. A second component of the trial addressed handling and processing of the material in preparation for shipment to a recycler. The product was baled at public or private recycling facilities in the collection area; however this entailed significant manual handling for transport to the central location from collection sites.
c. A third component of the project was communication with the recyclers to understand issues that arose when dealing with agricultural plastics.
d. The final component is to make recommendations as to how the project can be sustained and developed into a province wide recycling program for agricultural plastics.

The pilot projects were conducted in three representative districts across the province and focused on polyethylene film (bale wrap and silage plastic) and polypropylene (baler) twine. Some net wrap was collected – it is of unknown (mixed) resin types.

Details and outcomes of the three pilot districts follow:

3.1.1 Evergreen Regional Management Services Commission (Counties of St. Paul and Smoky Lake)

- Contact: Dennis Bergheim
- Predominantly mixed farming with moderate scale livestock enterprises. These counties are representative of the northeast; the geographic spread of collection sites was large as the entire region wished to participate.
- Twine was collected in barrel-sized bags, silage plastic in piles, preferably folded and stacked although this was not always the case. Miscommunication at Smoky Lake resulted in plastic added to accumulated piles; an estimate of collected amounts was made and it was manually sorted from the pile.

  Smoky Lake and Bellis transfer stations had anticipated agricultural plastic recycling and had stockpiled mixed plastics over several years. At Bellis, it is estimated the pile contained 25 cubic meters. At Smoky Lake, two small piles had been re-piled with heavy machinery into a single pile estimated at 125 cubic meters, perhaps 100 tonnes.
- All pilot materials were delivered to St. Paul Abilities for baling, largely by with a pickup and trailer. A 30 cubic yard bin of twine collected prior to the pilot project was also hauled for baling but was so entangled baling was impossible. It was landfilled as were the remainder of the piles.
- Baled samples were delivered to Merlin Plastics in Calgary.
- Volumes:

	film	**twine**
Elk Point	1100 kg	200 kg
Mallaig	400 kg	700 kg
Evergreen Regional	100 kg	200 kg
Smoky Lake	3200 kg	4000 kg
Bellis	500 kg	800 kg
Totals	**5300 kg**	**5900 kg**

3.1.2 Mountain View Regional Waste Management Commission (includes Town of Olds and Rocky View County)

- Contacts: Neil Kivell (Olds) and Joanne Walroth (Rocky View)
- Commission jurisdiction represents central geography and mixed farming enterprises
- They have had positive experience collecting agricultural plastics over several years. Although agricultural plastic is collected throughout the year, an advertising campaign is run through the fall and winter to make producers aware of the program and requirements. In 2008, 6 mm clear poly bags were made available for twine with the result that the material was cleaner and easier to handle than that from previous years. In addition, a County-sponsored program offering $100 for a minimum of 100 kgs ran from April 18 to June 20, 2008. This program collected 19.3 tonnes from 76 participants and of the $7600 payout, $2100 was donated to local 4-H Clubs.
- Volumes:
  - From January 1 to June 30, 2008 Mountain View County collected a total of 21.4 tonnes of mixed polypropylene and polyethylene ag plastic, estimated to be 40% polypropylene and 60% polyethylene.
  - There are approximately 1800 farms in Rocky View County. Farms that have delivered plastic in prior years averaged about 200 kg per farm. It is thus estimated that there are at least 360 tonnes of readily collectable ag plastic per year in the county.
- Mountain View collects and bales plastic at the Olds transfer site, puts it in containers and ships it to China for recycling through Canadian Recycling at a cost to the commission of $380/container.

3.1.3 County of Lethbridge (Iron Springs Transfer Station)

- Contact: Les Wieland
- This is a southern location with good representation of the large scale feedlot industry. There are 60,000(?) head of cattle within a five mile radius of Iron Springs. We are told each feedlot will have a pick up truck box of twine on a daily basis over winter! The pilot collection began in June when the winter feeding season was finished, thus volume is low. Twine was collected in bags; either barrel sized plastic bags or mini bulk bags. Silage plastic was collected in a 40 cubic yard container to prevent wind scatter.
- Volumes:
  - Silage wrap 3000 lbs (1.4 tonnes)

  - Twine 2000 lbs (0.9 tonnes)
- There is pressure from farmers, especially younger ones, to continue the program. Burn pits are the common method of disposal and are understood to be a poor management practice, but no reasonable alternative exists.
- Plastic was transported to Lethbridge and baled by GPS for this pilot, where is remains as the original recycler destined to receive the material is no longer in business. He is not interested in large volumes as his excess capacity is limited.

3.2 Recyclers

Resin values of up to $300 per ton in the summer of 2008 created significant interest. Lower values in 2009 are less attractive, plastics having zero value as of July 2009.

Used plastic is a low value substance which recyclers view as a potential resource, but are uncertain of their ability to process and the cost to do so. Washing equipment for processing large volumes used plastic is not available locally, freight to Vancouver is a cost factor and capacity there is limited. All recyclers wanted the plastic delivered to their sites at no cost to them. Purity of the resin type is also a concern for true recycling as impurities decrease the value significantly. The exception to this is Pnewko, who ships the plastic to the US where it is made into railroad ties of mixed resin types.

China is a significant market for used plastics and there is a possible market for twine in the USA ; however, agricultural contaminants make international shipments vulnerable to trade policy and plant / animal disease issues.

Since the pilot was completed, a potential market for agricultural film has emerged in Southern Alberta. This market currently accepts film at its door with no compensation, and can handle the level of contamination present in this material.

4 Pilot Study Conclusions

4.1 Lessons learned that apply to collection sites

1. Used plastics must be **sorted at source** by resin type. Mixed resin types have much lower value.

2. **Minimal contamination** is important. Dirt and manure add significant weight to films. Straw or hay stuck to twine are difficult for recyclers to separate.

3. **Ease of handling** at collection sites .Twine must be bagged to prevent tangling and in sizes that can be easily handled. Bagging should occur in units < 1 cubic metre, such as barrel-size bags or minibulk bags. Film must be rolled or folded to minimize tangling for handling for transport. Large roll-off bins are not efficient for collection.

4. **Manual handling is inefficient,** as is transportation, where used plastic is moved to central sites for baling as the material is of low density and difficult to handle with machines. Options are: accumulation on site with periodic baling or the use of bins / bags for accumulation which can be handled mechanically when full.

5. **Generators are willing** to bring used plastics to landfills for recycling. Many are asking for the pilot to be continued or expanded.

6. **Education** is key. Results in the MD of Mountain View suggest that producers will collect the material, keeping it as clean as possible, and deliver it seasonally.

7. **Site variability is great**. Wind in the south necessitates a storage method that avoids litter. Winter temperatures combined with thaws in the north freeze bags / film to the ground (and would also do so into bins). Seasonality of processing must be considered. Pole sheds or equivalent covers may be required in some areas.

4.2 Market Conclusions

What have we learned:

- Entrepreneurs have shown interest in agricultural plastics for recycling, however, they must be able to cover costs and generate profit to do so. In addition, post-industrial plastics processors are looking at post-consumer sources to increase their supply base.
  - A viable recycling industry must have an economy of scale. A recently established wash plant required 1500 tonnes to start and had a capacity of 3000 tonnes per year.
- The resins are potentially valuable materials.
  - Material that is clean had a value of ~$2-300 per tonne in 2008.

Mixed and contaminated material has no value - some companies will accept limited amounts of it FOB their site. This material may have limited application for railroad ties and curbs.

In order for viable collection of agricultural plastics, there must be a market for the material, including local and regional infrastructure that can handle and process the volumes collected.

4.3 Issues to deal with / possible solutions

1. Reliable recyclers with capacity and demand are required; there must be an economic incentive throughout economic cycles.
2. Cleanliness of materials for recycling: Dirt and mud clean off ag plastics with little problem, although they add significantly to weight and handling cost. Straw and hay mixed into twine are difficult to remove with present cleaning equipment.
3. Net Wrap which has replaced a portion of the twine market may be of unknown resin types which make recycling difficult. It devalues twine if mixed with it as mixed resins have less value.
4. Twine must be bagged for handling. Truckloads of time and mixed materials become inseparable and cannot be handled even with machinery.
5. Transport: to haul economically, weight must be near truck capacity thus compaction is required. Estimated production of a portable baler unit is 2 bales per hour at a cost of 10 cents per pound.

4.4 Overall Conclusions

Prerequisites and relative stakeholder roles for a viable agricultural plastics recycling system include:

1. Industry:
   - supplies agriculture with plastic of known resin types, preferably not mixtures
   - provides funding through stewardship program
2. Agriculture /farms /feedlots:
   - sort plastic by resin type
   - keep plastics as clean as possible for recycling
   - deliver used plastics to collection sites
3. Collection facilities:
   - separate resin types and prevent wind scatter

- compact collected material to minimize transportation cost

4. Regional Facilities / Industry:
   - clean plastics contaminated with dirt, hay /straw
   - process cleaned plastic into resin for industry use

5 Recommendations

5.1 Requirements of a provincial program

- Protocols for collection, compaction and shipping
- Education of generators, including early site inspections, so protocols are met
- Access to required equipment for compaction and loading / shipping
- Processing equipment and technology to clean recycle material and process it into a saleable bead or granule
- Processing should be regional and within Canada to avoid potential constraints on shipment, yet economies of scale require a large collection area.
- An end use for the material.

5.2 Recommendations

1. The development of local / regional recycling capability.
   - Avoidance of possible barriers to shipment across international borders due to agricultural contaminants necessitates
   - Reduction of freight and handling costs
   - Alberta should be seen as a leader in sustainability, programs are under development elsewhere in Canada and internationally. A recycling industry would complement existing industry in the province and minimize shipping costs.

2. A program to establish an economic incentive for recycling throughout an economic cycle is required. This should cover costs of transport, handling and perhaps some processing at times of low resin value but may create an income stream at times of high resin value. This may take the form of a recycling charge at time of purchase as with other Alberta stewardship programs.

Appendix

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COUNCIL OF EUROPE CONSEIL DE L'EUROPE

DIOXIN CONTAMINATION IN FOODSTUFFS

Report prepared by Jean-François Narbonne, rapporteur for the Committee of Experts on nutrition, food safety and consumer health

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PREFACE

THE COUNCIL OF EUROPE

The Council of Europe is a political organisation which was founded on 5 May 1949 by ten European countries in order to promote greater unity between its members. It now numbers 41 member States[1].

The main aims of the Organisation are to reinforce democracy, human rights and the rule of law and to develop common responses to political, social, cultural and legal challenges in its member States. Since 1989 the Council of Europe has integrated most of the countries of central and eastern Europe into its structures and supported them in their efforts to implement and consolidate their political, legal and administrative reforms.

The work of the Council of Europe has led, to date, to the adoption of over 170 European conventions and agreements, which create the basis for a "common legal space" in Europe. They include the European Convention on Human Rights (1950), the European Cultural Convention (1954), the European Social Charter (1961), the European Convention on the Prevention of Torture (1987) and the Convention on Human Rights and Bioethics (1997). Numerous recommendations and resolutions of the Committee of Ministers propose policy guidelines for national governments.

The Council of Europe has its permanent headquarters in Strasbourg (France). By Statute, it has two constituent organs: the Committee of Ministers, composed of the Ministers of Foreign Affairs of the 41 member States, and the Parliamentary Assembly, comprising delegations from the 41 national parliaments. The Congress of Local and Regional Authorities of Europe represents the entities of local and regional self-government within the member States. These bodies and the intergovernmental committees are served by a multinational European Secretariat.

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1 Albania, Andorra, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, The Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, "the former Yugoslav Republic of Macedonia", Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland.

PARTIAL AGREEMENT IN THE SOCIAL AND PUBLIC HEALTH FIELD

The Council of Europe has a vast range of activities since only questions of defence are excluded from its competence.

Where a lesser number of member states of the Council of Europe wish to engage in some action in which not all their European partners desire to join, they can conclude a 'Partial Agreement' which is binding on themselves alone.

The Partial Agreement in the social and public health field was concluded on this basis in 1959. At present, the Partial Agreement in the public health field has 18 member states[2].

The principal areas of activity include:

- protection of public health and especially the health of the consumer
- rehabilitation and integration of people with disabilities.

The activities are entrusted to Committees of experts, which are responsible to a Steering committee for each area.

The work of these Partial Agreement committees occasionally results in the elaboration of conventions or agreements, but the more usual outcome is the drawing-up of recommendations to member states in the form of resolutions adopted by the Committee of Ministers. The resolutions should be considered as statements of policy for national policy-makers. Governments have actively participated in their formulation: the delegates to the Partial Agreement committees are both experts in the field in question and responsible for the implementation of government policy in their national ministries.

[2] Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland.

This procedure provides for considerable flexibility in that any state may reserve its position on a given point without thereby preventing the others from going ahead with what they consider appropriate. Another advantage is that the resolutions are readily susceptible to amendment should the need arise. Governments are furthermore called upon periodically to report on the implementation of the recommended measures.

A less formal procedure is the publication of general guidelines intended to serve as a model for member States. Each government can interpret these guidelines in accordance with its own law and practice in the matter.

Furthermore, scientific reports aimed at informing both governments and experts in the field are published on specific questions of current concern.

Bodies of the Partial Agreement in the social and public health field enjoy close co-operation with equivalent bodies in other international institutions. Contact is also maintained with international non-governmental organisations (INGOs) and industry, working in similar or related fields.

DIOXIN CONTAMINATION IN FOODSTUFFS

Dioxins can be found as contaminants in almost every part of the environment and therefore present an obvious public health concern. The present report outlines the health hazards posed by dioxins and evaluates human exposure to and intake of dioxins from foodstuffs. It also sets out recommendations for relevant source-directed measures for reducing the contamination of food by dioxins and gives guidance on risk management in foods.

1. INTRODUCTION

Polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) are halogenated aromatics compounds that have been identified as contaminants in almost every component of the global ecosystem including the air, aquatic and marine sediments, fish, wildlife and human adipose tissue, milk and blood. PCDDs and PCDFs are industrial by-products that are formed during the production of chlorinated phenols and their derived products and other chlorinated compounds. These contaminants have also been identified as by-products from the combustion of municipal and industrial waste, petrol, wood, coal and numerous other combustion processes. Lastly, PCDDs and PCDFs are formed during the bleaching of wood and pulp paper, and during metal-producing and metal-recycling processes. The structures of individual PCDD and PCDF congeners differ by their degree of chlorination and the ring substitution patterns. There are 135 individual PCDFs and 75 individual PCDDs. The composition of the PCDD and PCDF by-products are highly variable dependent on their source. However, quantitative analysis of PCDDs/PCDFs in environmental matrix requires a number of different procedures in order to prepare concentrated and cleaned extracts before analysis by gas chromatography combined with mass spectrometry technique. Such analysis is expensive and is a limiting factor for monitoring programmes.

2. HAZARD CHARACTERISATION

Concern over dioxins arose initially because one particular congener, 2,3,7,8-TCDD, was found to be extremely toxic to some types of laboratory animals. Toxic potency has been demonstrated to be associated with the number and position of chlorine atoms, since congeners lacking chlorines in the four lateral positions, as well as those having chlorines in addition to those in the 2,3,7 and 8 positions, have been shown to be less toxic than TCDD. In addition, congeners chlorinated in the lateral positions have been found to accumulate preferentially in animal tissues and have been implicated in the human poisoning incidents. As a result of toxic potency, widespread distribution, persistency and potential for bioaccumulation of congener mixtures available for human exposure, dioxin risk assessment requires a number of analytical, toxicological and epidemiological data.

2.1. Toxicokinetics

The toxicokinetic of PCDDs/PCDFs is related to their characteristics in terms of lipophilicity and susceptibility to CYP dependent metabolism. Absorption of PCDDs and PCDFs after oral administration is dependent on the vehicle used but remains very high (ranging from 60 to 90%), both in experimental animals and humans. However, elimination is much slower in man (T1/2 about 7 years for TCDD in man compared to a few weeks in rodents). Congeners with few chlorine atoms are usually metabolised and eliminated faster than higher chlorinated ones. The body burden in animals and humans can be easily estimated by measurements in tissues and plasma lipids.

2.2. Toxicity in experimental animals

The acute LD_{50} of TCDD varies over 5000-fold range between Guinea pig (most sensitive) and Hamster. Among PCDDS and PCDFs, 2,3,7,8-TCDD exhibits the higher toxic potency. Toxicological effects of PCDDs have been found dose-related and thus are relevant to risk assessment for man:

1) induction of hepatic monooxygenases,
2) effects on components and functions of the immune system,
3) reproductive and developmental toxicity,
4) organ toxicity,
5) effects on hormone systems,
6) effects on the central nervous system
7) carcinogenicity.

For carcinogenicity, TCDD is regarded as a promotor and is not genotoxic. Therefore, a classic approach via NOAEL and safety factors seems adequate for risk assessment.

2.3. Tolerable Daily Intake (TDI)

European governments have developed a range of TDIs depending on the toxicological endpoints observed and the safety factors applied at the endpoint. In 1990 the WHO recommended a TDI of 10 pg I-TEQ/kg bw/day. This TDI was based on carcinogenic effect in rat (NOAEL 10 ng I-TEQ/kg/day and safety factor of 1000) and on primate reproductive performance (NOAEL of 1 ng I-TEQ/kg/day and safety factor of 100). The UK and Belgium have adopted the WHO recommendation of 10 pg I-TEQ/kg/day. Sweden, Norway and Finland have adopted a TDI of 5 pg I-TEQ/kg/day using a safety factor of 200. The Netherlands adopted, in 1982, a TDI of 4 pg I-TEQ/kg/day with a safety factor of 250 and recommended recently to reduce the TDI to 1 pg I-TEQ/kg/day. In France, safety factors of 50-1000 have been applied to obtain TDIs in the range of 1-10 pg I-TEQ/kg/day. In Germany, a similar range of TDIs was obtained using safety factors of 100-1000, 1 pg I-TEQ/kg/day being regarded as a non-statutory precautionary TDI, and 10 pg I-TEQ/kg/day as a preventive or intervention TDI. The American Environmental Protection Agency (EPA) has proposed a virtual safe dose of 0.006 pg/kg/day, corresponding to an acceptable lifetime tumour risk of 10^{-6}. In Japan, the TDI was recently reduced to 5 pg I-TEQ/kg/day. In the light of current scientific knowledge, it can be generally assumed that an exposure lower than 1 pg I-TEQ/kg/day does not present adverse human health implications. The 1998 WHO-consultation recommended that every effort should be made to reduce exposure to the lower end of the advised range of 1-4 pg TEQ/kg bw/day.

2.4. Effects on Humans

Health effects such as chloracne have been identified as an effect of dioxins in humans. Epidemiological data on dioxins have been collected through studies on victims of accidents, occupational exposure and on veterans who were engaged in herbicide scattering operations in the Vietnam war. Records of poisoning of humans by furans include cases of cooking oil contamination in Japan and Taiwan.

In February 1997 the IARC classified 2,3,7,8-TCDD as a «known» human carcinogen, but continues to regard other PCDDs/PCDFs as «not classifiable» despite a similar mode of action to 2,3,7,8-TCDD. Other effects than carcinogenicity have been studied in humans as discussed in a recent Toxicology Forum in Berlin (1996). The following acute effects have been observed: chloracne, porphyria cutanea, liver dysfunctions, respiratory and neurological disorders, increased diabetes susceptibility, and changes in lipids parameters in blood. Recent epidemiological studies have focused on the anti-oestrogenic effect and subtle developmental effects in infants and children. However, since confounding factors may have been present, any or all of the effects observed cannot be ascribed specifically to dioxine exposure.

Most of the comparisons between human and animal dioxin toxicity refer to the mechanism of action based on binding to Ah receptor. Activation of the Ah receptor can result in endocrine and paracrine disturbances and alterations in cell functions, including growth and differentiation. Some of these effects have been observed both in humans and animals, indicating the existence of common mechanisms of action. However, the human Ah receptor has a lower affinity for TCDD binding than rodents, suggesting that humans may be one order of magnitude less sensitive to TCDD than mice and rats. It has been demonstrated that the induction of CYPIA1 in human lymphocytes by TCDD falls into a bimodal distribution with high responders and low responders. A high inducibility phenotype for CYPIA1 induction may be associated with increased susceptibility to lung cancer. Moreover, Ah receptor mediated CYP1A induction can be obtained without ligand binding. These points are very important for the choice of safety factor in TDI calculation.

2.5. Toxic Equivalent Factors

Although there are extensive data on the toxicity of 2,3,7,8-TCDD, toxicological information on the other 209 compounds in the family is much more sparse. In order to help in the toxicological evaluation of complex mixtures, a concept of toxic equivalent factors (TEFs) has been developed, taking in account the mechanism of action of PCDDs and PCDFs. Although 2,3,7,8- TCDD is the most potent congener able to bind Ah receptor, other compounds that interact with this receptor result in similar effects, albeit at higher doses. These relative potencies are expressed as TEFs. After examining the relative potency of different PCDDs and PCDFs for a variety of end points both *in vitro* and *in vivo*, such as cancer, reproductive effects, body weight loss, cell transformation, immunotoxicity and Ah receptor binding, a set of TEFs has been developed. In 1988 a NATO/CCMS sub-committee proposed a new set called International TEFs adopted by several regulatory agencies in North America and Europe. The TEF models contain many sources of uncertainties related to a lack of scientific data on congeners, differences in toxicokinetics and metabolism, the interaction between congeners, and to variations between species and individuals. TEF values for human beings and mammals were revised by the WHO in 1997. At the present time, the TEFs can be regarded as an interim procedure to be improved.

2.6. Coplanar PCBs

The toxicity of coplanar PCBs follows a similar mechanism to that of dioxins and attention must be given to their risks to human health. While some correlation can be found between the presence of PCDDs/PCDFs and PCBs in animal fat, coplanar congeners are minors in PCBs mixtures and non coplanar PCBs exhibit higher toxicity than coplanar congeners in some toxicological end points (effects on thyroxin transport and on brain development). If coplanar PCBs can be associated to PCDDs/PCDFs for AhR dependent toxicological effects, these congeners should not be only considered for risk evaluation of PCBs. Moreover, differences in the origin of the contamination between PCBs and PCDDs/PCDFs lead to differences in risk management.

3. EXPOSURE EVALUATION

3.1. Analytical aspects

Over the past three decades the analytical technology involved in the determination of chlorinated PCDDs and PCDFs has evolved following advances in the science of both isolating the analyses as well as identifying and measuring them. In the course of this evolution, the techniques of mass spectrometry have been the primary driving force. However, analytical methodology for dioxin samples from the environment and foodstuffs remain difficult and costly, limiting the quantity and significance of the data available.

PCDDs and PCDFs have been identified in extracts of samples from the environment and the composition of these analyses depend on their origins and inputs from nearby sources. The congener distribution for most atmospheric samples resembles the typical combustion pattern for these compounds. Octa and hepta-CDDs are dominant in PCDD profiles, and tetra and penta-CDFs are dominant among PCDFs. Similar patterns have been detected in plant extracts. In contrast, only 2,3,7,8 substituted PCDDs and PCDFs are currently detected in animal samples, while OCDD often remains the dominant congener. In 1990, municipal incinerators appeared to be the major source of dioxins in the atmosphere (from 47% in Germany to 82% in the Netherlands). In the past decades, the manufacture of polychlorinated aromatic chemicals has probably been the major source. Maximum air emission from combustion sources was evaluated from 926 g I-TEQ/year in West Germany (1990) to 3870 g I-TEQ/year in the U.K. (1989). Dioxins and furans are almost insoluble in water and therefore strongly adsorbed to soil and organic matter where they persist for many years due to their chemical stability and resistance to biodegradation. These compounds are thus available for biological absorption, and first of all for organisms containing significant amounts of fat. Therefore, PCDDs and PCDFs can contaminate food destined to human consumption and they are more likely to be present in fatty foods such as meat, fish and dairy products, rather than fruit, vegetables and drinking water.

3.2. Intake data

Human exposure to PCDDs and PCDFs is possible by several routes. Intake by inhalation and by ingestion of contaminated particles is minor compared to the contribution from contaminated foodstuffs. The data used here for food intake calculations are from various surveys carried out by official bodies from different countries. The majority of the studies has been conducted on cow's milk and dairy products, fish and meat products. Other foodstuffs investigated in some countries yield the relative contributions of major food types for the estimation of the total dietary intake of dioxins and furans. The major route of food contamination seems to be the ingestion of contaminated herbage (with any adhering soil) and feed by cattle leading to the contamination of milk, meat and derivative products. The concentrations in milk and dairy products range from 0.4 to 27 pg I-TEQ/g fat. The mean level of contamination in milk from retail samples is situated between 0.4 and 2 pg I-TEQ/g fat. The mean content in samples from contaminated farms ranges from 3 to 27 pg TEQ/g fat. PCDD and PCDF intake from milk and dairy products is between 25 and 45% of the total intake. Similarly, meat and meat products (including eggs and fat) provide nearly 25% of the total intake. Fish has been reported in the literature to be a major dietary source of dioxins and furans for the populations around the Baltic (up to 60%). As indicated previously, PCDD and PCDF contents in vegetables, cereals and fruit are very low as can be expected for non-fatty foodstuffs. However, cereal products containing significant quantities of added fat may contain appreciable levels of PCDDs and PCDFs. Thus the contribution of vegetables is nearly 5% to the total intake, while in countries which usually consume significant quantities of biscuits and cakes cereal products can contribute up to 15% of the total intake. Thus the total intake in European countries is in the range of 70 to 350 pg I-TEQ/person/day. A total diet study in the UK reported a mean estimated dietary intake of 125 pg I-TEQ/day, and a calculation from the Netherlands showed that the 99 percentile of the adult population had a dioxin intake below 150 pg TEQ/day. Based on the intake data available from European countries, it can be estimated that the intake of PCDDs/PCDFs in pg I-TEQ/kg/day ranges from 1 to 5 for adults (70 kg) and from 3 to 12 for infants (13 kg).

Levels of PCDDs and PCDFs in human milk have been reported from different countries. In Europe, the values range from 9 to 67 pg I-TEQ/g fat. Accordingly, the intake of PCDDs and PCDFs by breast-fed infants has been estimated to vary from 27 to 418 pg I-TEQ/kg /day.

4. RISK MANAGEMENT AND RECOMMENDATIONS

4.1. Recommendations for emission-reducing measures

The currently estimated food intake of TCDD equivalents by adults is lower than the WHO TDI, but higher than the guideline level. Since PCDDs and PCDFs are known to be persistent in the environment, their levels tend to increase as a result of continuous release. Therefore, the introduction of these compounds into the environment should be reduced. Accordingly, the following emission-reducing measures are recommended.

Incinerators: Emission of PCDDs and PCDs by all kinds of incinerators (including municipal solid waste incinerators) should be limited to a maximum of 0.1 ng I-TEQ/Nm^3

Metal industry: Emission from metal-producing and metal-recycling industries should be minimised by optimisation of technical procedures and equipment.

Motor vehicles: The use of halogenated scavengers in petrol should be phased out as soon as possible.

Chlorine-containing chemicals: Production and use of chlorine-containing chemicals such as certain pesticides and wood preservatives should be reduced in combination with the reduction of the contamination of these products by dioxins and PCBs.

Pulp and paper industries: Bleaching processes other than involving chlorine treatment should be adopted to minimise the presence of PCDDs and PCDFs in pulp and paper products and effluent waste. For materials in contact with food the maximum level should be reduced as much as possible.

Fireproofing substances: The use of PCB as fireproofing substances should be re-examined

Other sources: Since the origin of a large fraction of PCDDs and PCDFs is not known, every effort should be made to identify other sources of contamination pathways, in order to take appropriate measures.

4.2. Recommendations for risk management in foods

1) Emission-reducing measures are recommended as the best way for risk-management.

2) Main dietary intake of PCDDs and PCDFs is from milk and dairy products due to the considerable consumption of these foodstuffs,

particularly by children. Thus standards in milk and dairy products should be recommended:

- Levels lower than 1 pg I-TEQ/g fat are a desirable target achievable after reduction of PCDD pollution in the environment.
- Levels higher than 5 pg I-TEQ/g fat must lead to the consideration of a ban on trade of affected milk and dairy products (fat content higher than 2%).

3) National and international monitoring of the levels of contamination in both milk and dairy products as well as in fat from meat, fish, seafood and eggs is recommended.

4) Monitoring of dioxins in human milk and blood is recommended as a way of obtaining information on the level of human intake of these contaminants from foodstuffs.

4.3. General recommendation on further data

Generally, further epidemiological and toxicological data are expected to contribute to the clarification of the effects of dioxines on consumer health.

SELECTED LIST OF PUBLICATIONS

Nitrates and nitrites in foodstuffs (1993) ISBN 92-871-2425-6

Contaminants in food (Resolution AP (93) 3)

Lead in food (1994) ISBN 92-871-2573-2

Cadmium in food (1995) ISBN 92-871-2878-2

Mercury in food (1995) ISBN 92-871-2880-4

Lead, cadmium and mercury in food: Assessment of dietary intakes and summary of heavy metals in foodstuffs (1994) ISBN 92-871-2620-8

Health aspects of nitrates and its metabolites (particularly nitrite) Proceedings of International Workshop, Bilthoven (NL) 8-10 November 1994, ISBN 92-871-2792-1

Up in Smoke:
Household Garbage Burning

NORTHERN C.A.R.E

Northern Alberta Recycling Workshop and Trade Fair

Slave Lake, Alberta

September 10-12, 2003

Markus Kellerhals - Environment Canada, Prairie and Northern Region

Environment Canada Environnement Canada

What is "Backyard Household Garbage Burning" ?

- Residential burning of:
  - all types of domestic waste (paper, plastic, construction debris
  - agricultural packaging or other commercial wastes
- typically in a 45 gallon drums ("Barrel Burning") and also in woodstoves, open pits and fireplaces.

Defining the extent of Household Garbage Burning

- "A family tradition"
- Prevalent, especially in rural areas:
  - 28% of residents of rural NE-Minn + NW-Wisc (Western Lake Superior Sanitary District, Jan. 2000)
  - 24% of residents of rural Ontario (Environics for Environment Canada Mar 2001)

Prevalence in Ontario

- Survey of rural residents (March 2001)
  - **24%** burn garbage on their property in open pits, woodstoves, burn barrels, and fireplaces;
  - **76%** of those who burn reported burning garbage at home once a week
  - common reasons for burning garbage - “convenience”, “reducing landfill use”

Household Garbage Disposal and Burning

ONTARIO SURVEY

Prepared for
Environment Canada

Prepared by
Environics Research Group

ENVIRONICS

March 2001

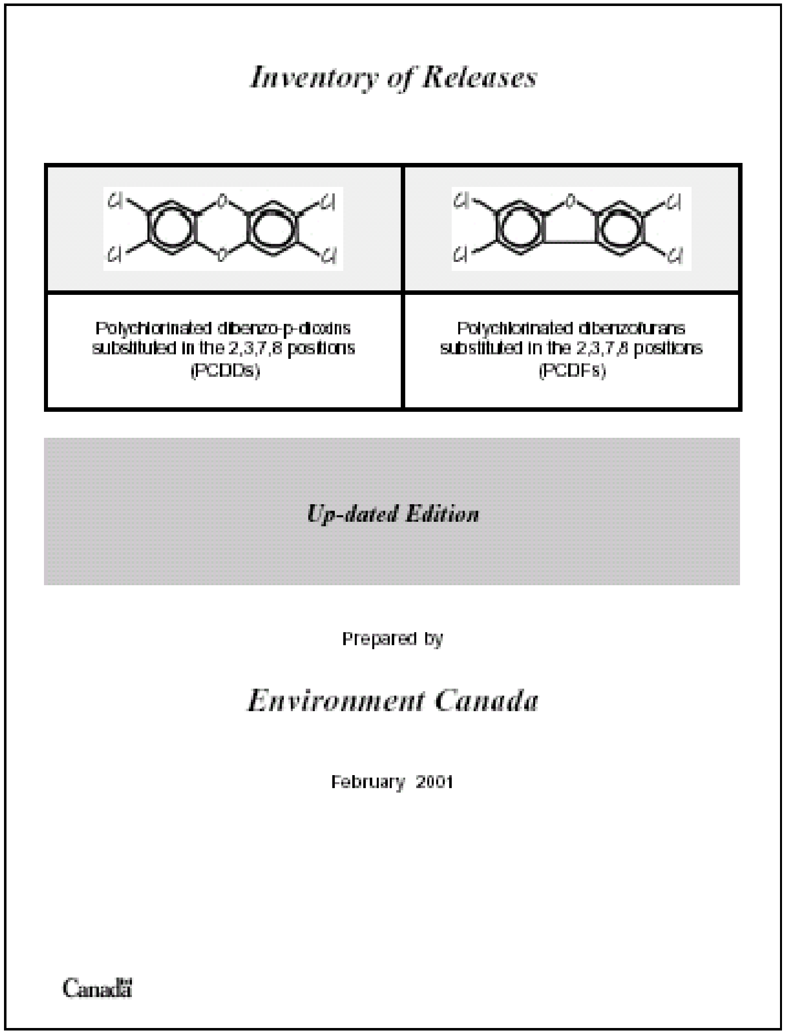
Environment Canada Environnement Canada

Environmental Issues with Burning Garbage

- Air Pollution
  - **emission of toxic pollutants**
  - odours
  - reduced visibility
  - soiling
- Ash Disposal
  - potential for leaching into groundwater
  - potential for dispersal by wind
- Fire Hazard

Air Pollutants from Burning Garbage

- **Dioxins and Furans**
- Polyaromatic Hydrocarbons (PAHs)
- Fine Particulate Matter (PM_{10}, $PM_{2.5}$)
- Volatile Organic Compounds (e.g. benzene, styrene)
- Metals
- Nitrogen Oxides and Carbon Monoxide


Inventory of Releases

Polychlorinated dibenzo-p-dioxins substituted in the 2,3,7,8 positions (PCDDs)	Polychlorinated dibenzofurans substituted in the 2,3,7,8 positions (PCDFs)

Up-dated Edition

Prepared by

Environment Canada

February 2001

Canada

- **Emissions From Backyard Burn Barrels:**
- 12 % of quantifiable annual Dioxin/Furan releases
- Likely largest remaining single source of anthropogenic dioxins

http://www2.ec.gc.ca/dioxin/download/inventory.pdf

Environment Canada Environnement Canada

Dioxin/furan emissions inventory due to “barrel burning”

- Alberta
  - 1.4 - 2.8 g ITEQ/y (Feb 2003, CCME)
  - 2nd largest source after residential/agricultural fuel combustion
- US
  - largest source of dioxins/furans in 2002

Dioxins - formation in burning garbage

- low temperature and oxygen poor combustion conditions in burn barrels favour formation of dioxins and other pollutants
- chlorine content of most waste is high enough to favour dioxin formation

Dioxins - formation in burning garbage

- Burning garbage in a backyard barrel releases many thousands more dioxins and furans that the same amount of garbage burned in a properly controlled municipal waste incinerator.
    - EPA study - barrel burning garbage from 2 - 40 households produces same amount of dioxins as a modern 200 t/day incinerator (40,000-120,000 households)

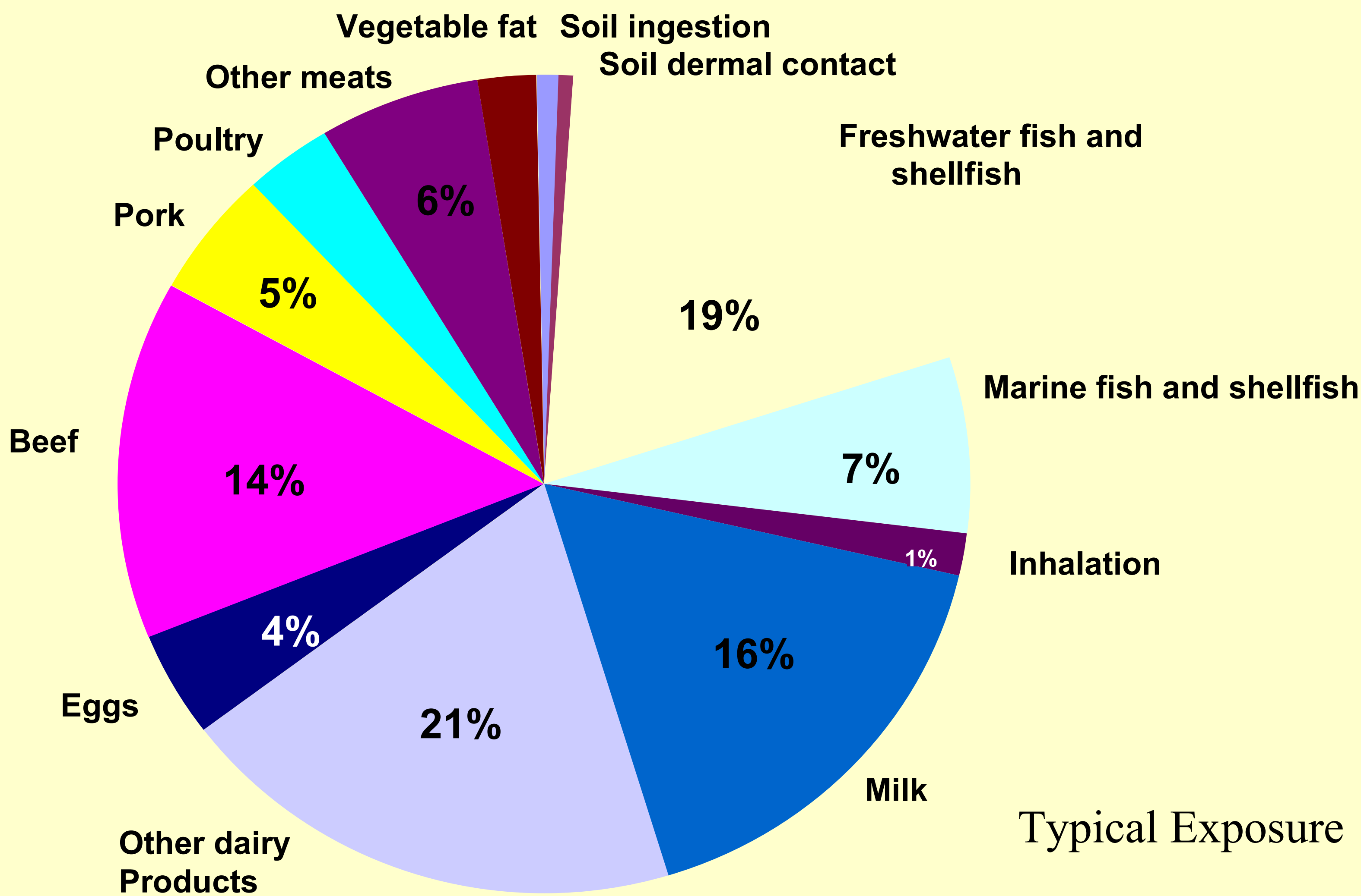
Dioxins -why a problem ?

- Persist and accumulate in biological tissues
- Exposure linked to many health concerns, including: cancer, disruption of endocrine function, developmental problems, endometriosis, cardiovascular disease, diabetes.

Dioxins -why a problem ?

- Dioxins can be transported long distance in the atmosphere hence they can be a problem both locally (near emission sources) and globally (remote areas such as the Arctic)
  - NACEC study on sources of dioxins in Nunavut - sources in southern Canada, Mexico, US all had significant impact in Nunavut

How people are exposed to dioxins and furans



Environment Canada Environnement Canada

Addressing the Issue

- There is no “technological” solution for backyard burning
- Thus the desired goal is reduction and ultimately elimination of backyard trash burning

Addressing the Issue

- Education
  - decision makers need to be informed about issues
  - public (“burners” and “non-burners”) need to be engaged
- Infrastructure (viable alternatives to burning)
  - barriers to recycling in rural and small/urban areas
- Regulation/Enforcement
  - based on Ontario survey a proportion of “burners” would only stop if forced to do so
  - often in municipal/county level jurisdiction

Alternatives to Backyard Garbage Burning

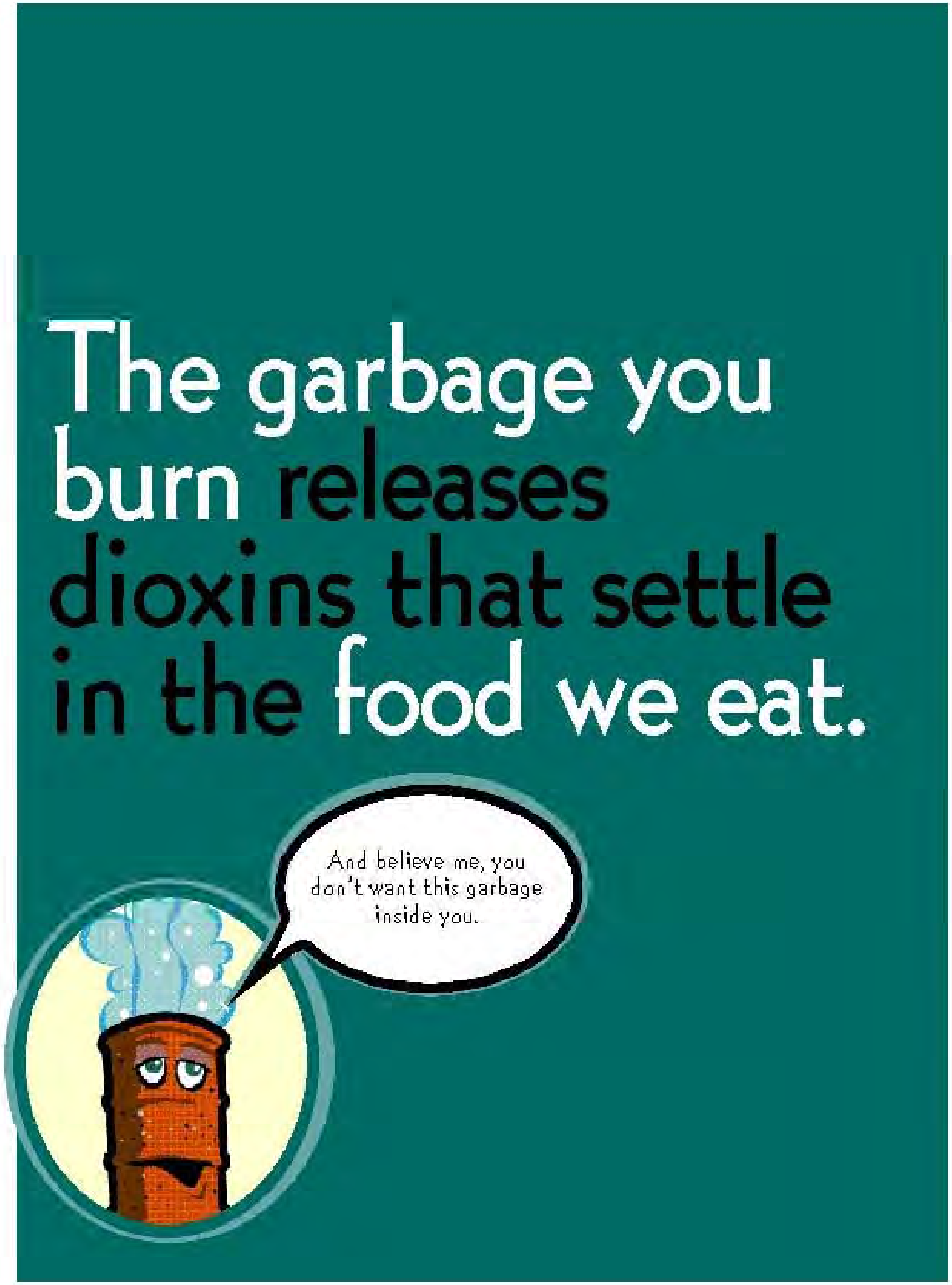
- Buy Smart. Look for items with less packaging
- Seek out local recycling options for recyclable waste
- Compost organic waste such as food scraps, leaves, and grass
- Use the nearest garbage landfill or depot for remaining waste

Reducing Household Garbage Burning in Lake Superior Region

- Strategy
  - developed by the Great Lakes Binational Toxics Strategy (BTS) Dioxins/Furans Working Group, Burn Barrel Subgroup.
- Change behavior of individuals via:
  - **Education** - of local decision makers and the public
  - **Infrastructure -** garbage disposal/recycle
  - **Regulations/Enforcement**

Ontario Lake Superior Region Project

- EcoSuperior's activities, sponsored by Environment Canada over 2003 included TV and radio information ads, meetings with municipal leaders, tax bill inserts to municipalities, tags for woodstove retailers, information for campgrounds, posters etc..
- website **www.ecosuperior.com**
- consistent messages being developed for US. and Canada, through the Great Lakes BTS.

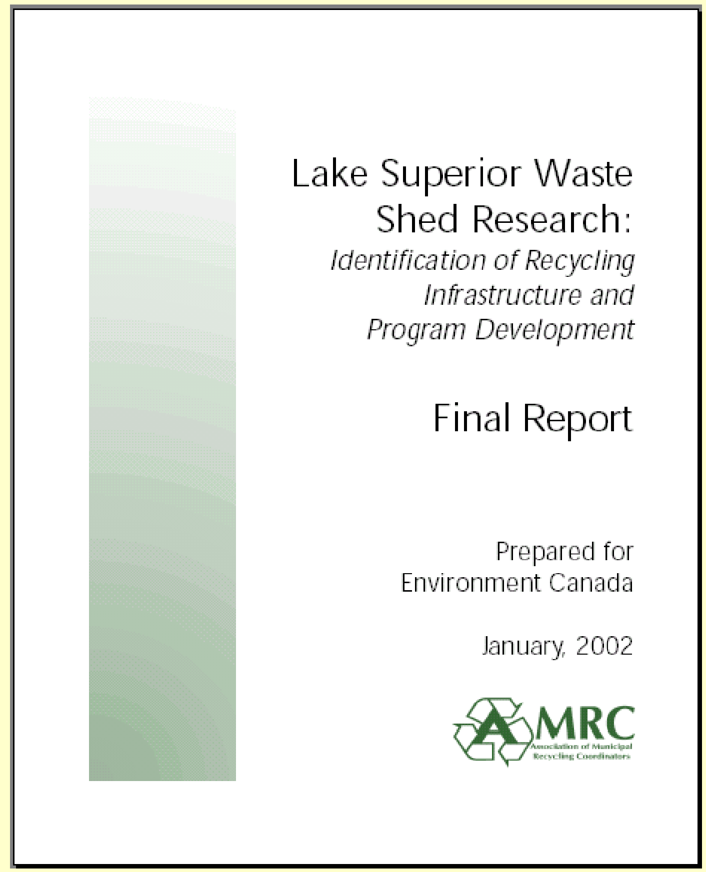


WLSSD, Minn, 2001

- Environment Canada, 2002
- (for Lake Superior area)

Lake Superior Waste Shed Research: Identification of Recycling Infrastructure and Program Development

- by Association of Municipal Recycling Coordinators of Ontario (AMRC)
- 34 municipalities contacted


Lake Superior Waste Shed Research:
Identification of Recycling Infrastructure and Program Development

Final Report

Prepared for Environment Canada

January, 2002

AMRC

Environment Canada Environnement Canada

Web Resources

- **www.openburning.org** - site for Great Lakes program
- **http://wlapwww.gov.bc.ca/air/particulates/bbsgiyea.html** - BC government site - includes link to a "model bylaw"
- **http://www.c3.org/chlorine_issues/understanding_dioxin/trash_burning.html** - pamphlet from Chlorine Chemistry Council
- **http://www.health.state.ny.us/nysdoh/environ/trash.htm** - NY State Department of Health
- **http://www.deq.state.id.us/air/smoke/Residential_Burning.htm** - Idaho Department of the Environment