

E-waste: the Unintended Consequence of our Digital Revolution



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 2. Occupational Cancer Research Centre & Dalla Lana
 3. Environment & Climate Change Canada
 4. Indiana University
 5. RECETOX, Masaryk University
- 

No conflict of interest

MARCH 14, 2018



About a quarter of U.S. adults say they are 'almost constantly' online

BY ANDREW PERRIN AND JINGJING JIANG



(Volkan Furuncu/Anadolu Agency/Getty Images)

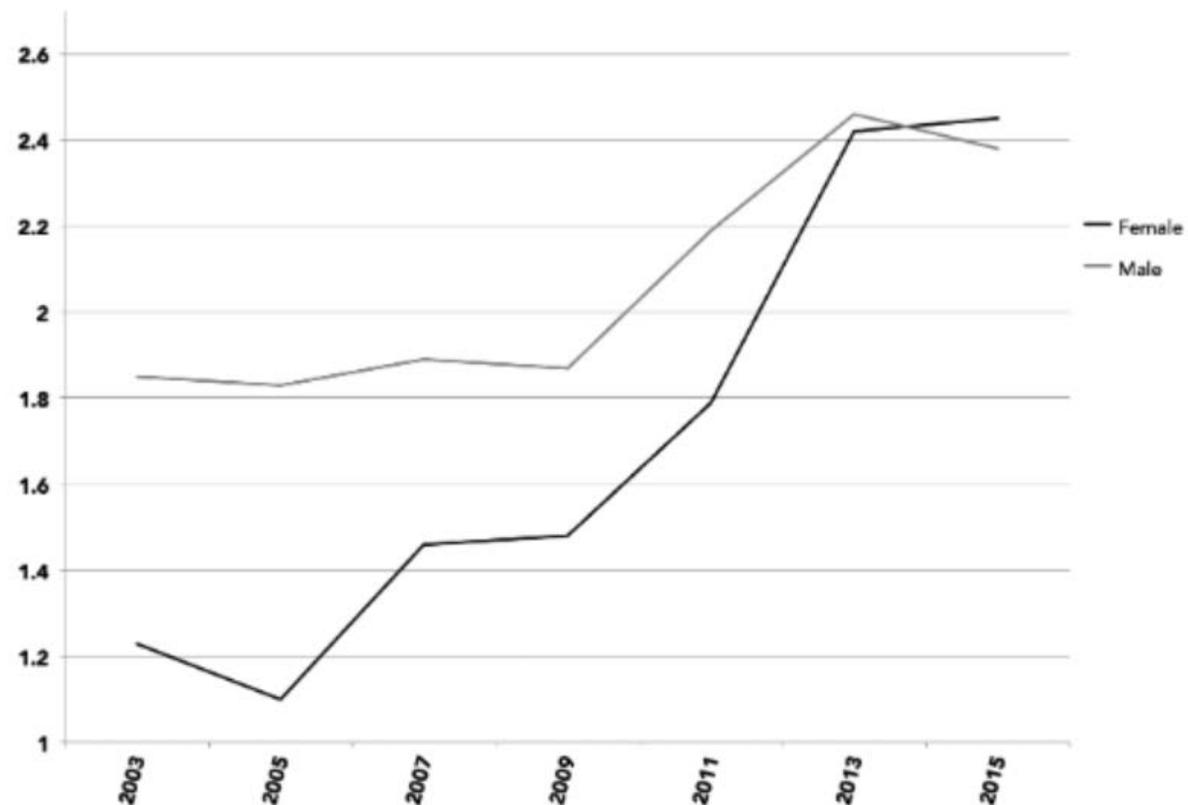


Figure C.3. Hours spent on electronic devices per day by 9th to 12th graders, by sex. Youth Risk Behavior Surveillance System, 2003–2015.

<http://www.pewresearch.org/fact-tank/2018/03/14/about-a-quarter-of-americans-report-going-online-almost-constantly/>

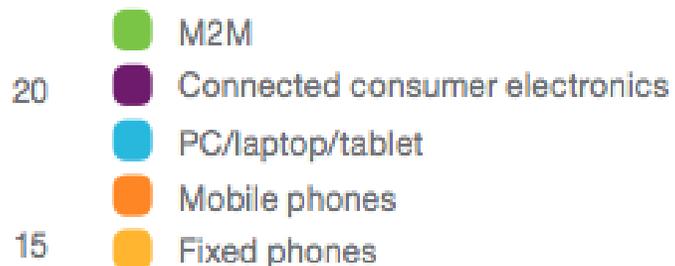
Twenge J 2017. iGen. Why today's super-connected kids are growing up less rebellious, more tolerant, less happy- and completely unprepared for adulthood.

<http://d1hbl61hovme3a.cloudfront.net/igen-appendix.pdf>

E-Waste – The Growing Mountain

Connected devices (billions)

25



10

5

0

2010

2011

2012

2013

2014

2015

2016

2017

2018

2019

2020

Examples of M2M: connected cars, machines and utility meters

Examples of consumer electronic (CE) devices networked TVs, digital media boxes, Blu-ray players, etc

Not included: passive sensors and RFID tags

Proposition

E-waste is a major unintended consequence of the digital revolution and e-waste workers are vulnerable to those consequences;

We are predisposed to adopt new technologies, and externalize the negative impacts.



Canada in 2016:

- 1,898 motor vehicle fatalities (2% increase from 2015, 5.2 per 100,000 population)
- 10,322 serious injuries (4% decrease from 2015)
- 72,039 impaired driving incidents (201 per 100,000)

Canadian Association of Chiefs of Police, data from Canadian Motor Vehicle Traffic Collision Statistics, 2016

https://www.cacp.ca/index.html?asst_id=1626

Outline



1. How much?
2. How is it handled?
3. Results from our studies
4. Solutions?

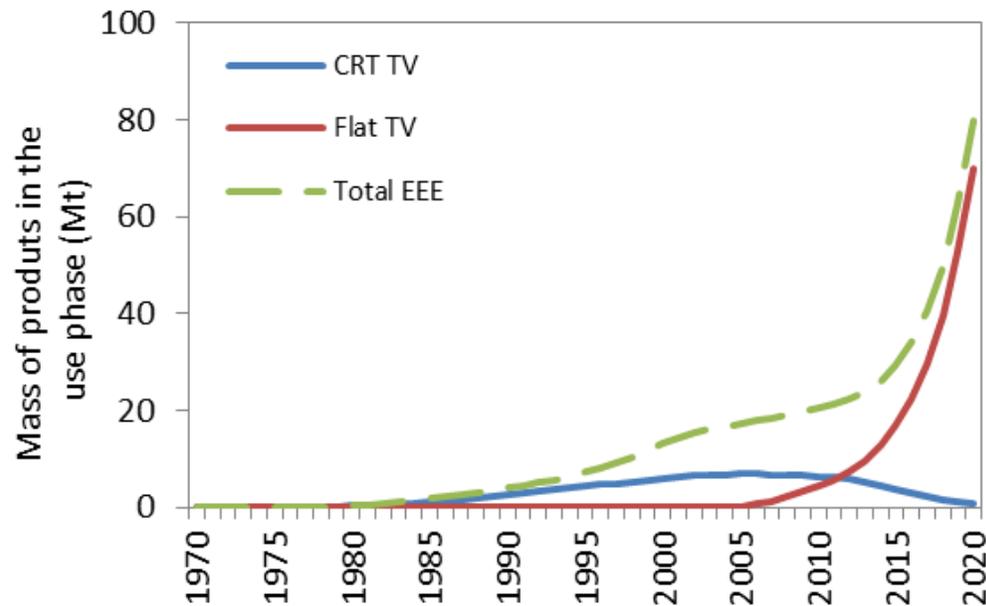
Outline



1. How much? – highly uncertain
2. How is it handled?
3. Results from our Ontario study
4. Solutions?

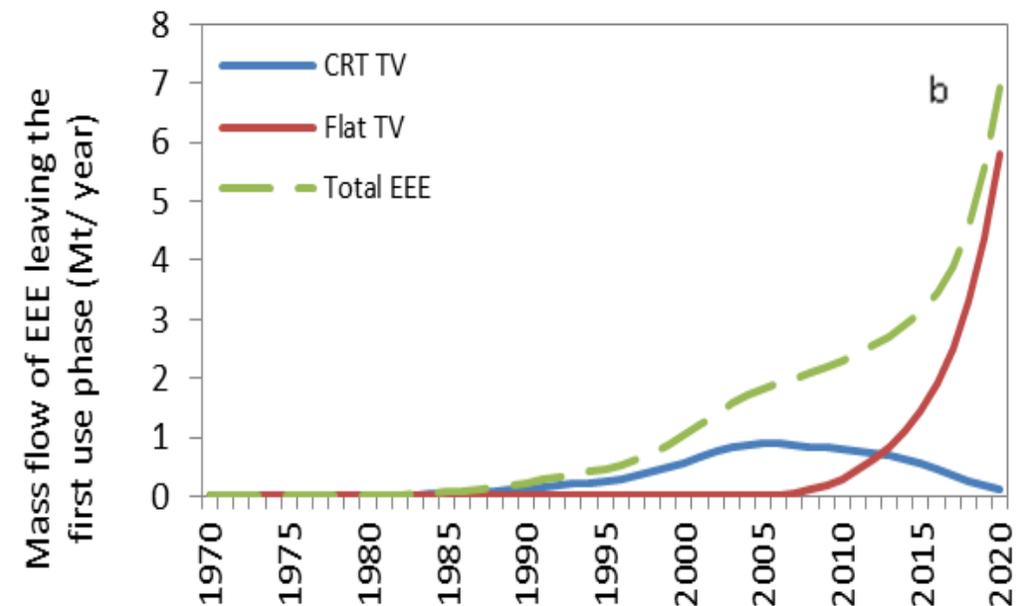
In-use

- 60 million tonnes from 1970-2014



Leaving 1st Life

- 35 million tonnes 1970-2014
 - 2nd use (reuse), storage, landfill, recycling

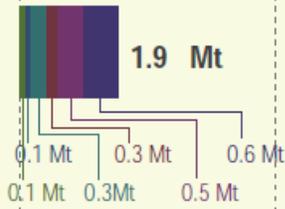


Global E-Waste Generation in 2014

1.7 kg/inh.

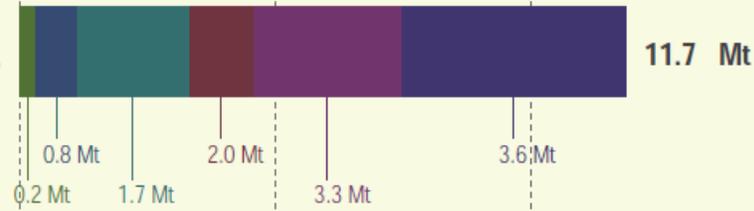


Africa



12.2 kg/inh.

Americas

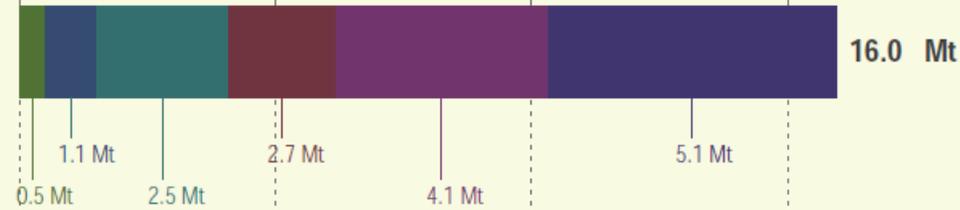


8.5 kg/inh for digital devices

3.7 kg/inh.

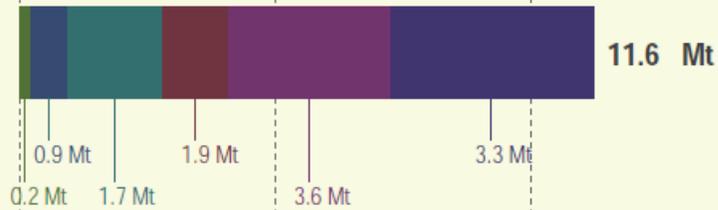


Asia



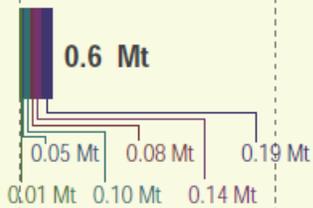
15.6 kg/inh.

Europe



15.2 kg/inh.

Oceania



Numbers under bars for: Lamps, small IT, screens, temp exchange eq., large equipment, small equipment

Baldé et al. 2015. The global e-waste monitor – 2014. United Nations University, IAS-SCYCLE, Bonn, Germany.

E-Waste: How Much?

41.8 million tonnes
globally in 2014 (Baldé et al.
2015)



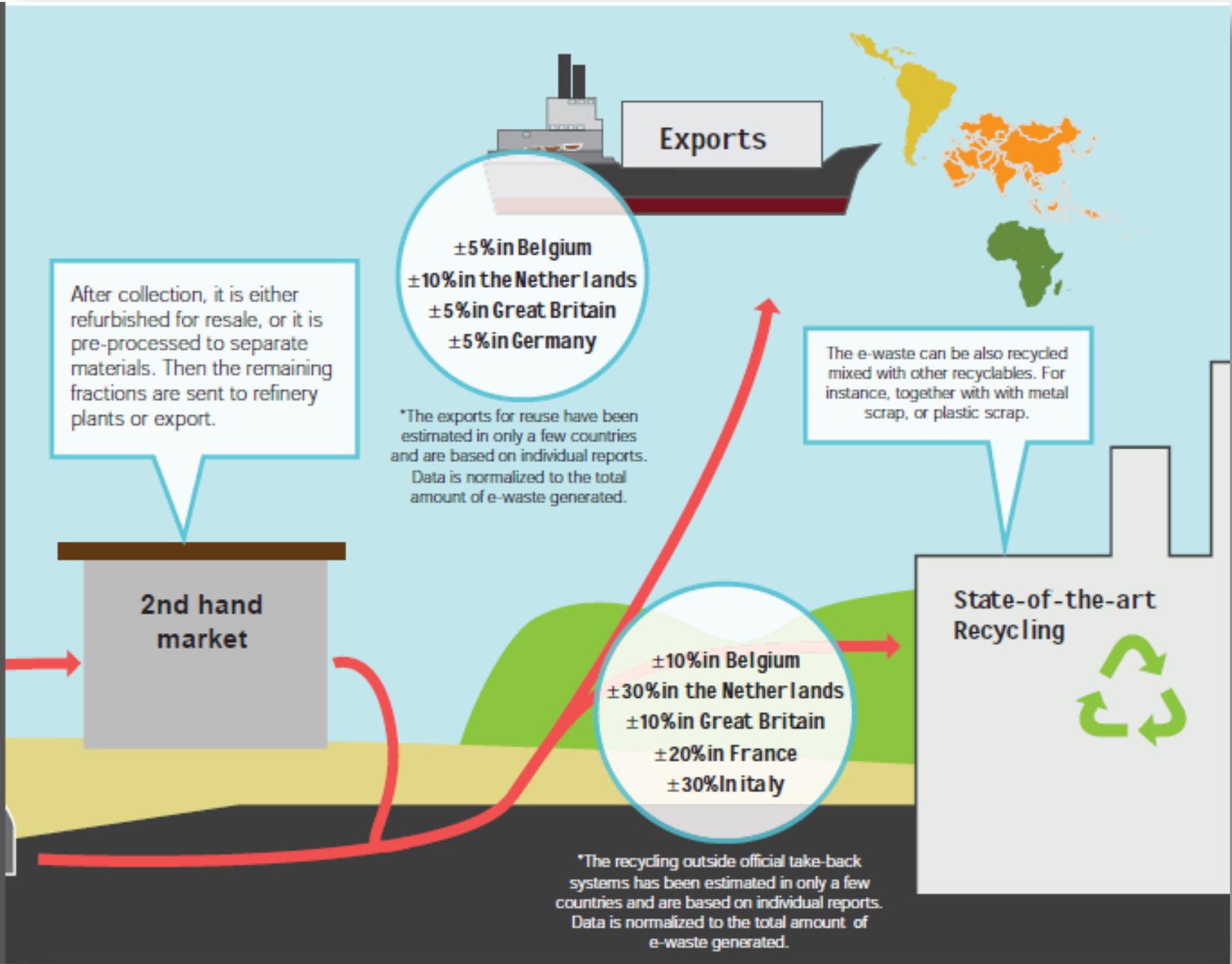
<https://pubs.acs.org/cen/news/88/i09/8809news2.html>

400 million tonnes human
biomass (Vaclav Smil)

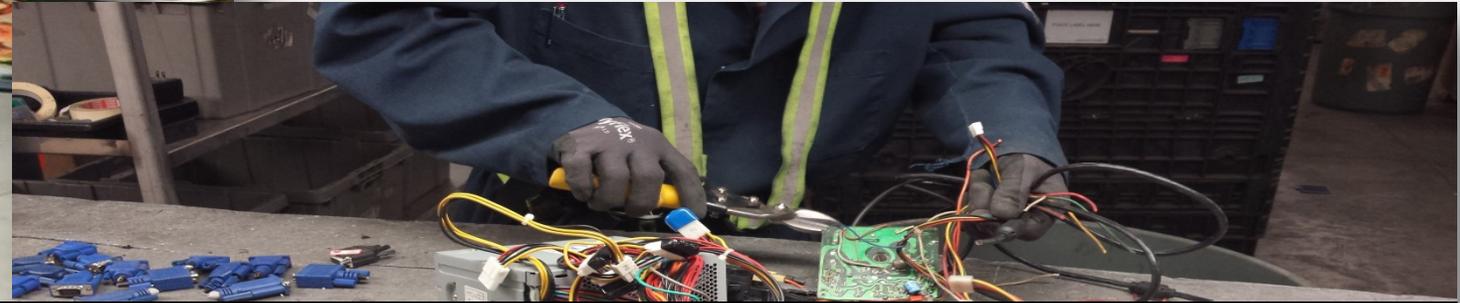


<http://i.imgur.com/etPtdcl.jpg>

Where does e-waste go?



~12% in Canada & US for formal recycling

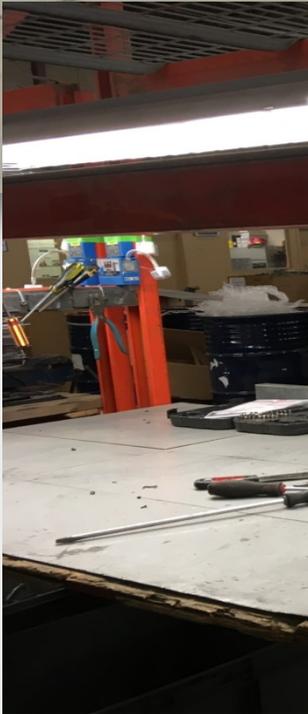


75,702 tonnes collected in Ontario in 2012

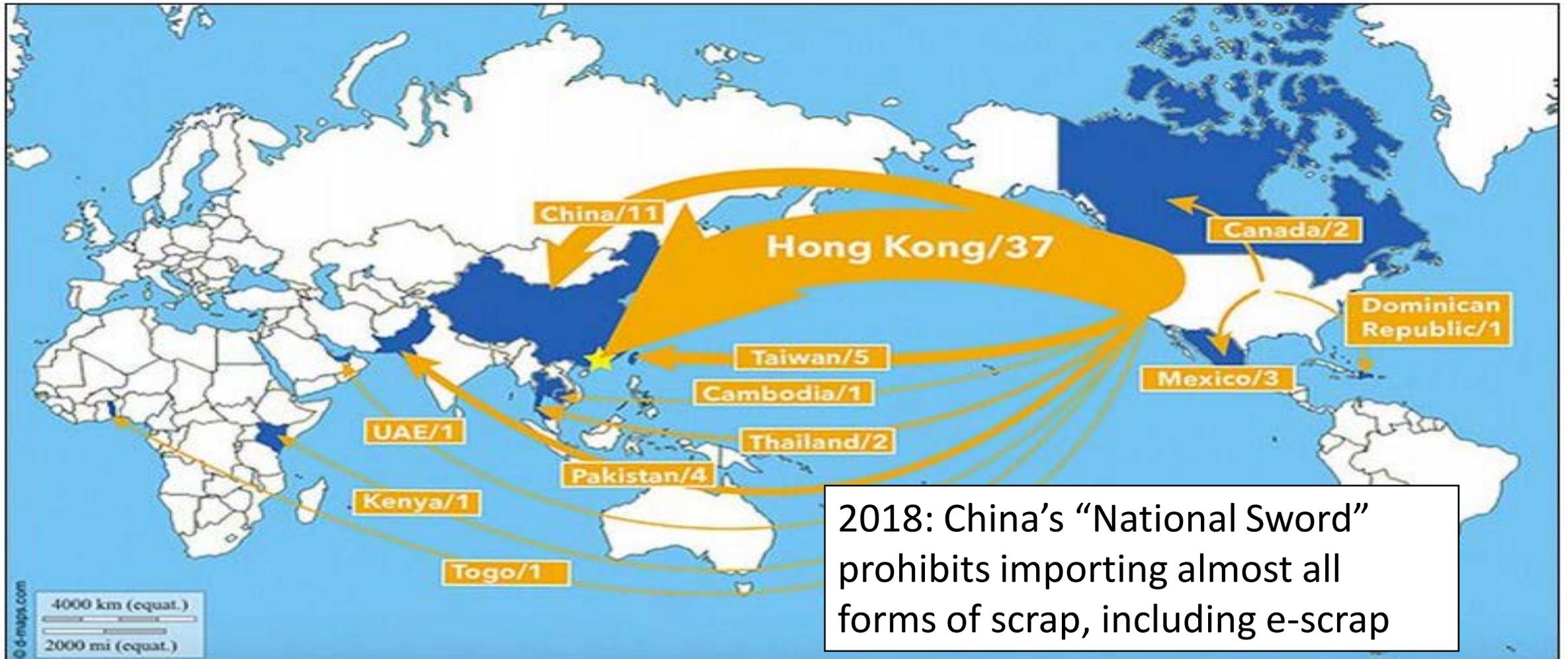
The WEEE Report. Waste Electrical and Electronic Equipment Reuse and Recycling in Canada – 2013.
CM Consulting, Peterborough, Ontario

71,300 tonnes processed in Canada in 2015

(Statistics Canada, 2016)



Photo's courtesy Labrèche & Gravel



A map shows the destinations of the electronic products tagged with trackers in the e-Trash Transparency Project. (Map: Basel Action Network)

Basel Action Network: 205 GPS trackers on US e-waste, 2016

<http://wiki.ban.org/images/1/12/ScamRecyclingReport-web.pdf>

India's e-waste burden

The country's IT prowess attracts global business, but it also generates huge amounts of electronic waste often scavenged by children in dangerous conditions



▲ Brigade Road, Bangalore. The city produces around 20,000 tonnes of e-waste per year and the figure's rising.
Photograph: 19697.000000/Getty Images

Bangalore:
20,000 tonnes e-waste annually,
rising at 20% per year

Outline



1. How much?
2. How is it handled?
3. Results from our Ontario study
4. Solutions?

Guiyu, China



Photos courtesy Iryna Labunska,
Greenpeace UK
Labunska et al. 2013, 2014, 2015



Photo's courtesy Iryna Labunska, Greenpeace UK
Labunska et al. 2013, 2014, 2015

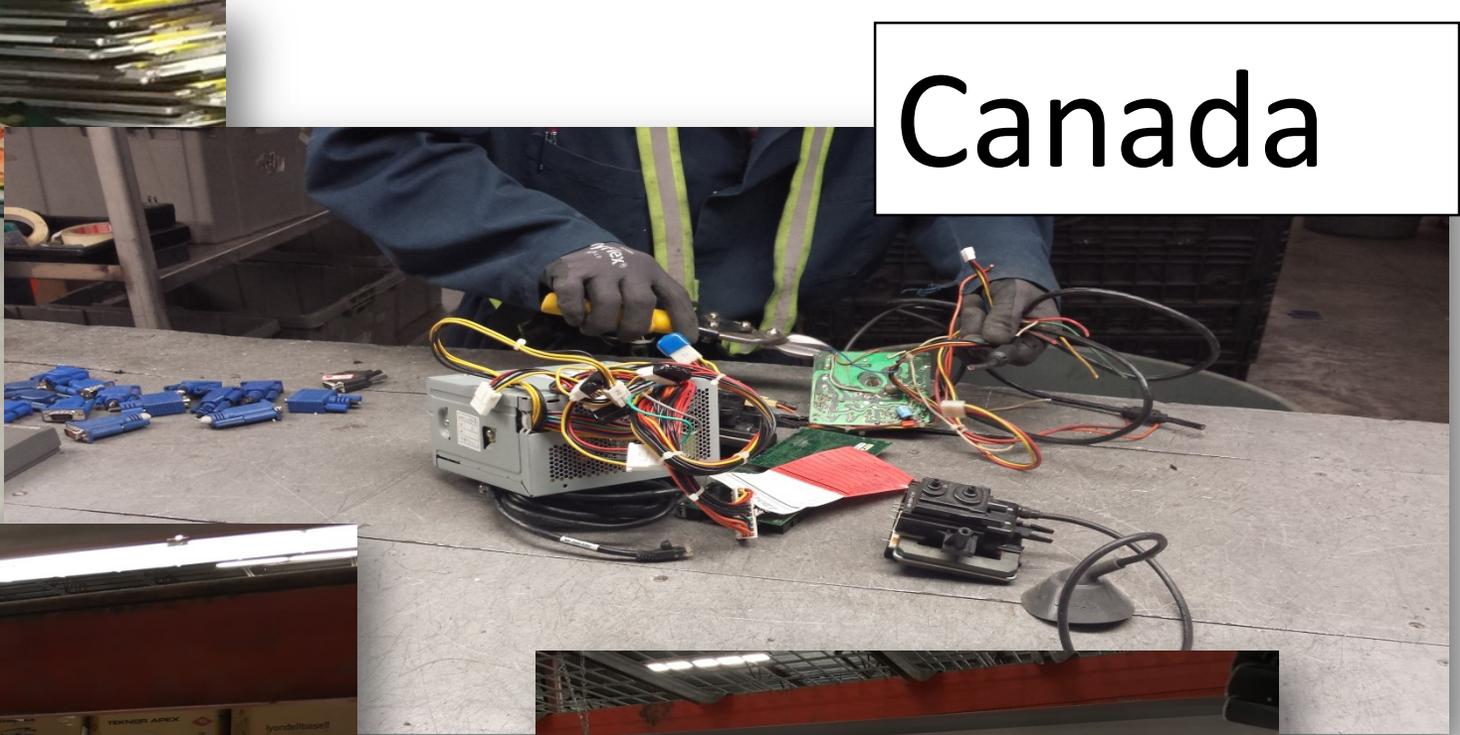
Dhaka, Bangladesh



Photos courtesy Prof. Ishtiaque Ahmed,
University of Toronto

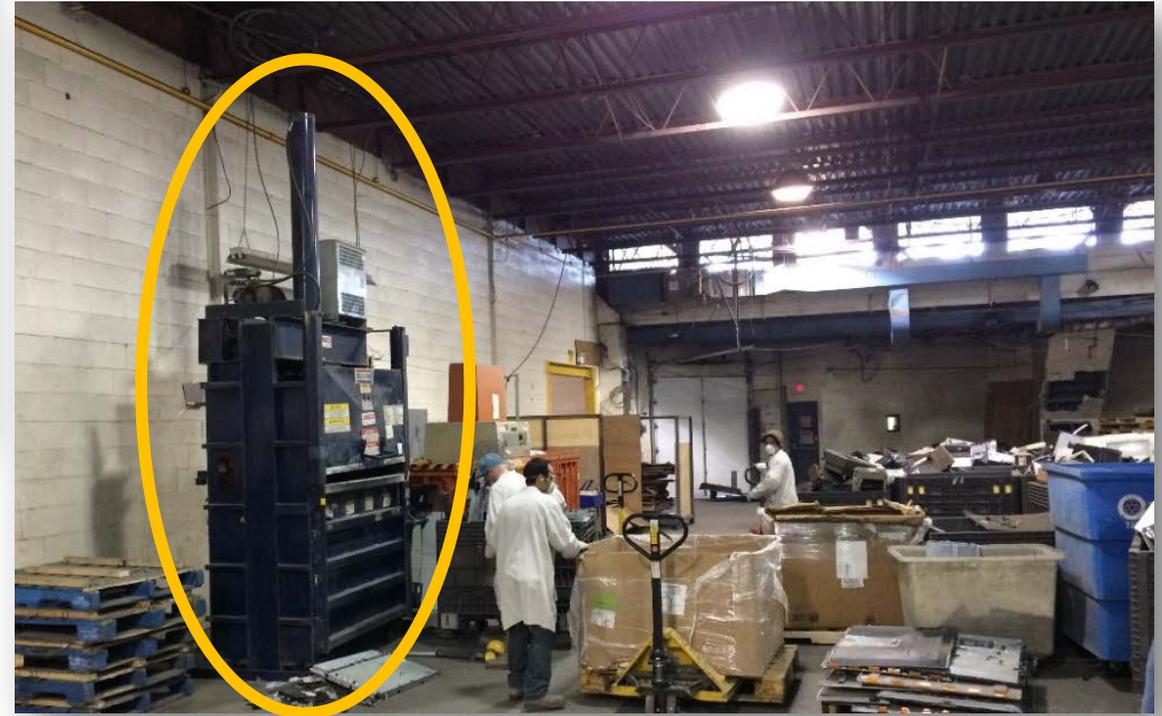


Canada



Photo's courtesy Labrèche & Gravel

Ontario Facility



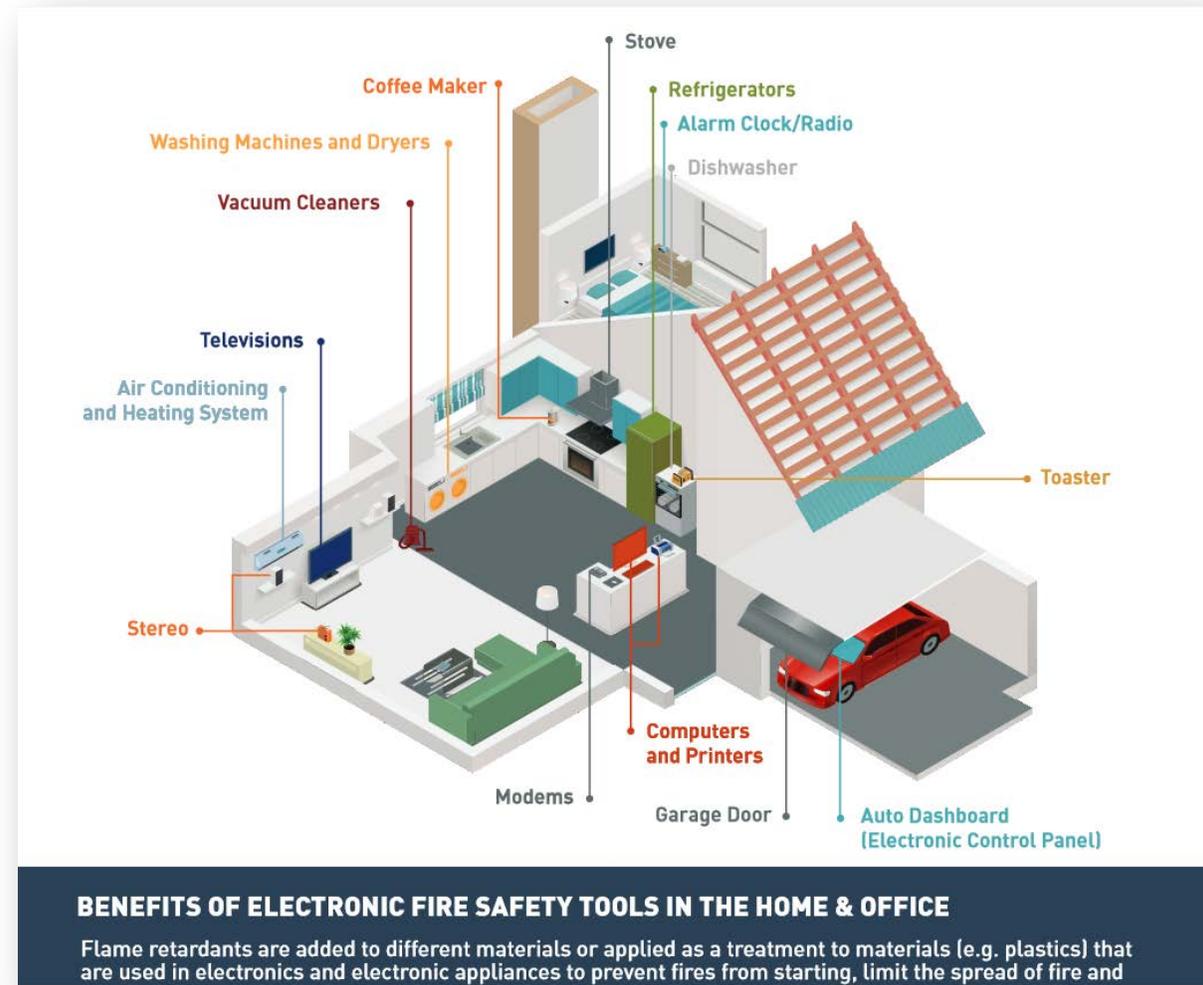
Outline



1. How much?
2. How is it handled?
3. Results from our Ontario study
 - Flame retardants
4. Solutions?

Flame retardants

- Chemicals added to materials to meet flammability std's
- Added to e-devices with a plug, battery or chip

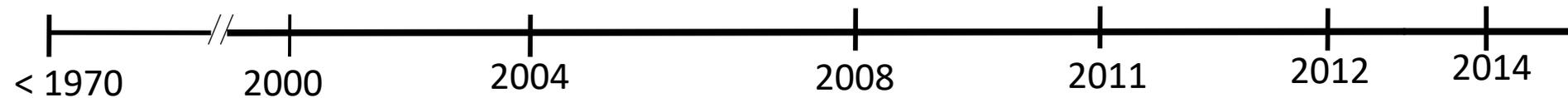


Diamond et al. 2015. Exploring the planetary boundary for chemical pollution.
Environment International 78:8-15.

Flame Retardants Restrictions

BFRs added
consumer
products

Detection of
PBDEs in
breast milk



PENTA and OCTA
Voluntary
agreement to stop
production
in US 2004

PENTA and OCTA
ban on
production &
new uses in US
2008

TCPD proposed
restricted in
Canada 2018

TCEP restricted
in Canada
2014

PENTA & OCTA
new uses banned
in Canada 2009

DECA proposed
banned in
Canada 2013;
Final PBDE reg
2017

What's
replacing
them?

47 FRs in
Ontario
E-waste dust

Compound
Penta-BDE
Octa-BDE
Deca-BDE
decabromodiphenylethane
tetrabromo- <i>p</i> -xylene
1,2,3
2,3,4
Hexa
1,2-b
2-eth
di-(2
allyl
2-br
2,3-d
6"-m
4"-methoxy-2,2',4,6,6'-pentabromodiphenoxy benzene
2,4,6-tris(2,4,6-tribromophenoxy)-1,3,5-triazine
Octabromotrimethylphenylindane
Pentabromotoluene
2,4,6-tribromophenol
Dechlorane Plus®
1,2,3,4,7,7'-hexachloro-5-phenyl-2-norbornene (also called Dec604-0)
Dechlorane Plus® mono adduct (also called DPMA)
1,3-Dechlorane Plus® mono adduct
Kepon® (also called chlordecone)
Mirex (also known as Dechlorane)
chlordane plus
Dechlorane 601
Dechlorane 602
Dechlorane 603
Dechlorane 604
Dec604 Component B (Dec604-3)
Cl ₁₁ Dechlorane Plus®
Cl ₁₀ Dechlorane Plus®
tris(2-chloroethyl) phosphate
tris(1-chloro-2-propyl) phosphate
tris(1,3-dichloro-2-propyl) phosphate
triethyl phosphate
tri-isopropyl phosphate
tripropyl phosphate
tri- <i>n</i> -butyl phosphate
tripentyl phosphate
triphenyl phosphate
2-ethylhexyl-diphenyl phosphate
tri- <i>o</i> -tolyl phosphate (also called tri- <i>o</i> -cresyl phosphate)
tris(2,3-dibromopropyl) phosphate
tris(4- <i>tert</i> -butylphenyl) phosphate

Reasons for the Restrictions?

- **PBDEs**

- Endocrine disruption through the thyroid system
- Neurobehavioural effects, decrease IQ (National Academies of Science 2017)
- Cryptorchidism (Goodyer et al. 2017)

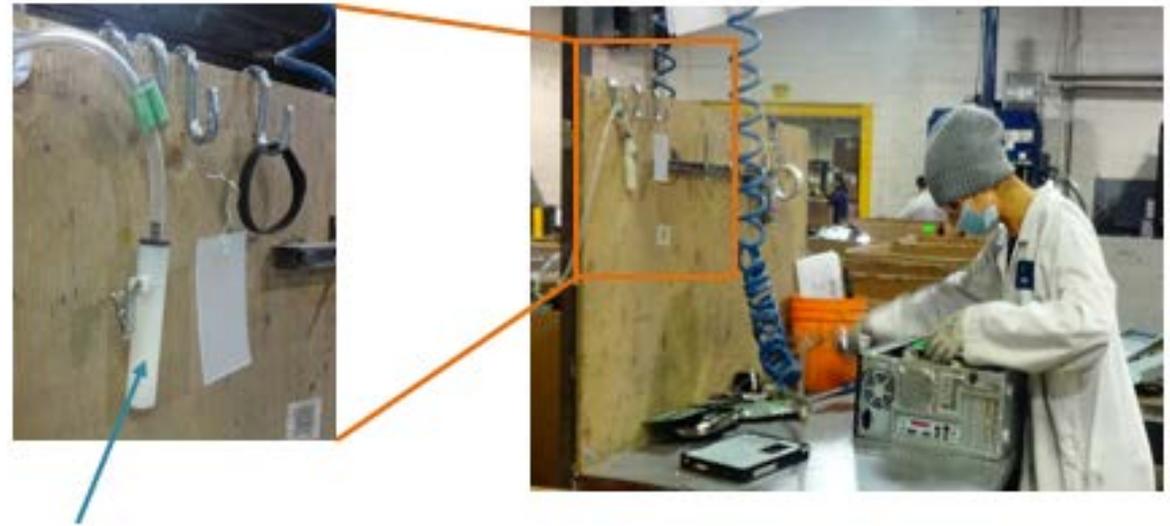
- **Organophosphate esters**

- Reproductive impairment (Carignan et al. 2017, 2018, Meeker et al. 2013)
- Developmental toxicity (decreased IQ, working memory) (Castorina et al. 2017)
- Papillary thyroid cancer (Hoffman et al. 2017)

Sampling Flame Retardants in Ontario E-Waste Facility



Sampling Strategy



OVS sampler
(a GFF and a PUF/ XAD-2/PUF sandwich)

- February 2017
- Five sampling days over two weeks
- 24 hour samples, with equipment deployed in the early mornings (prior to day shift)
- Facility operated 16 hours per day (2 shifts)
- All stationary samples

Sampling Flame Retardants in Ontario E-Waste Facility



Active air sampling train
(a GFF and a PUF/XAD-2/PUF sandwich)

Dust samples



Collected dust from floor, bench tops, and sorted-waste bins using defined method (Harrad *et al.*, 2008).

Air samples



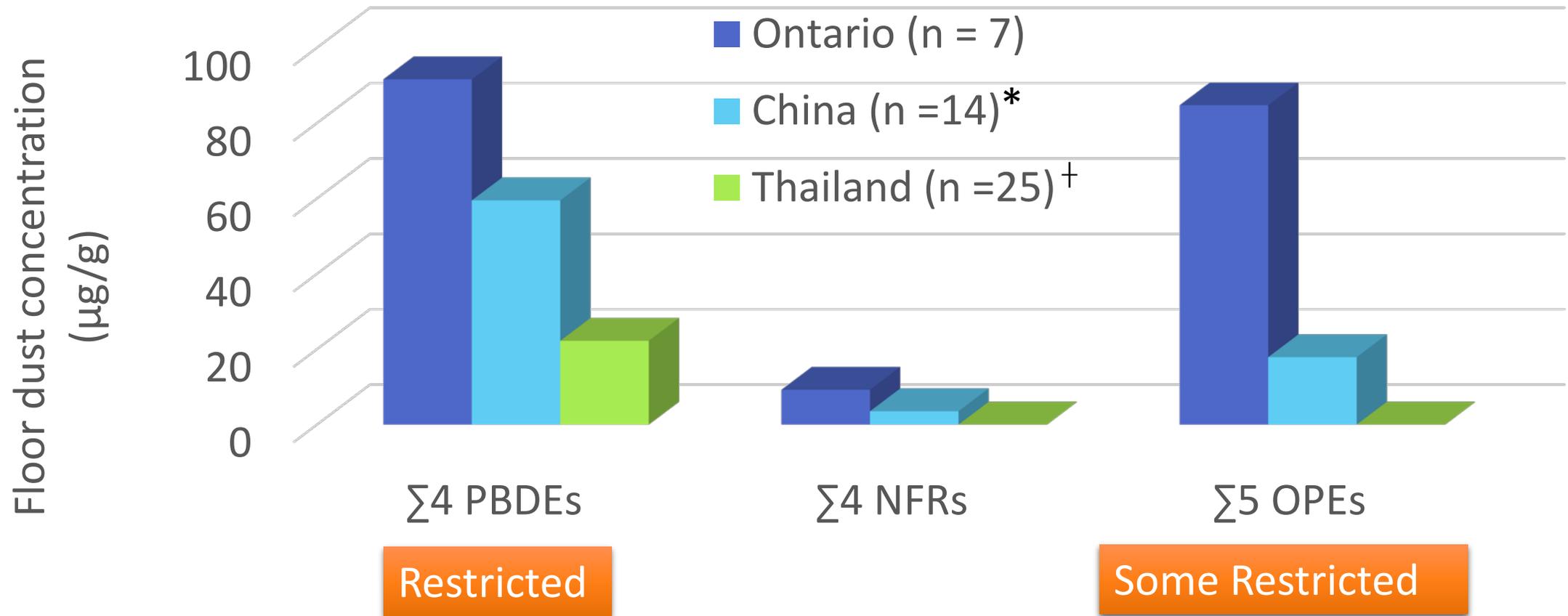
Co-deployed active and passive samplers at the workbenches and central work area.

Size segregated air samples



Deployed Micro-orifice Uniform Deposition Impactor (MOUDI).

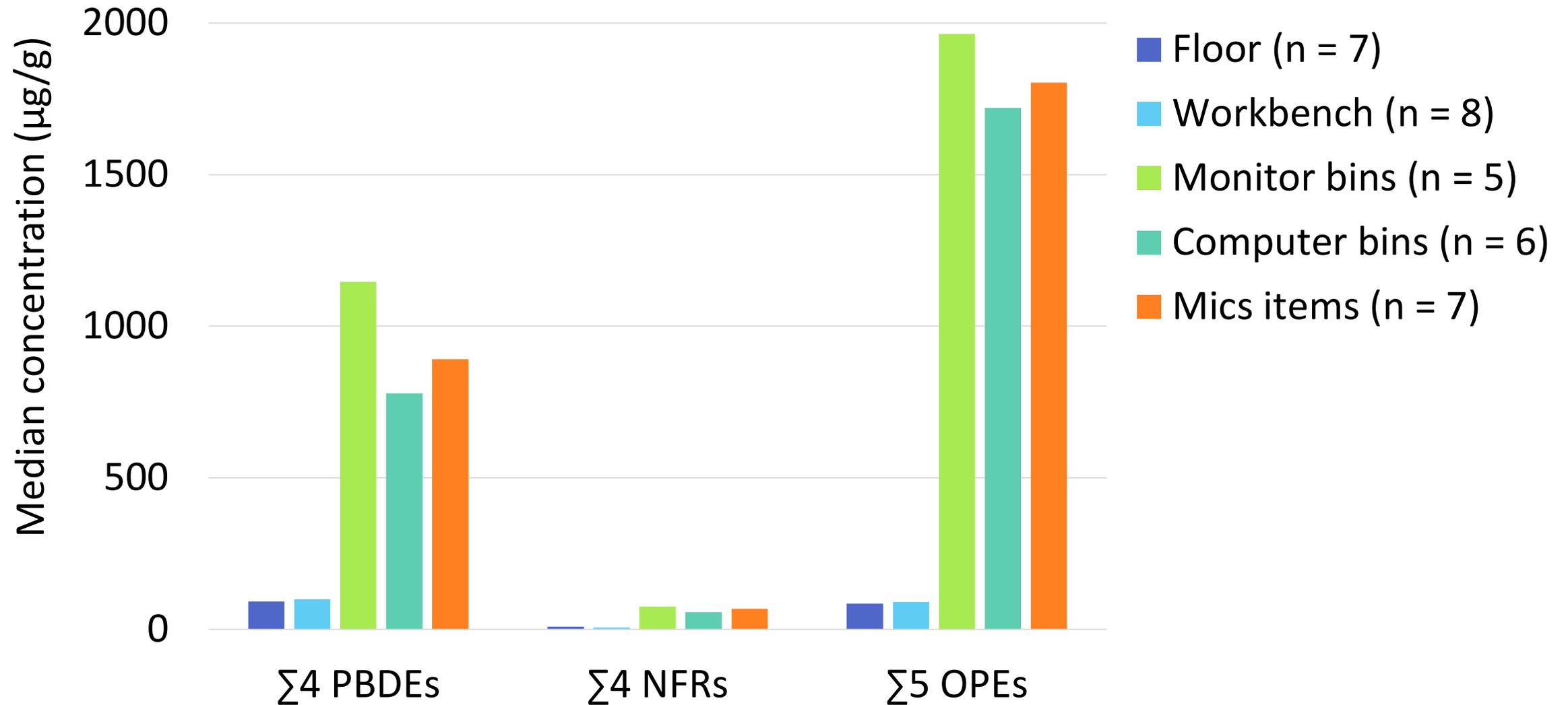
FRs in Dust – Canada & International Comparison



*Zheng *et al.*, 2015. *Environment International*, 78, 1-7.

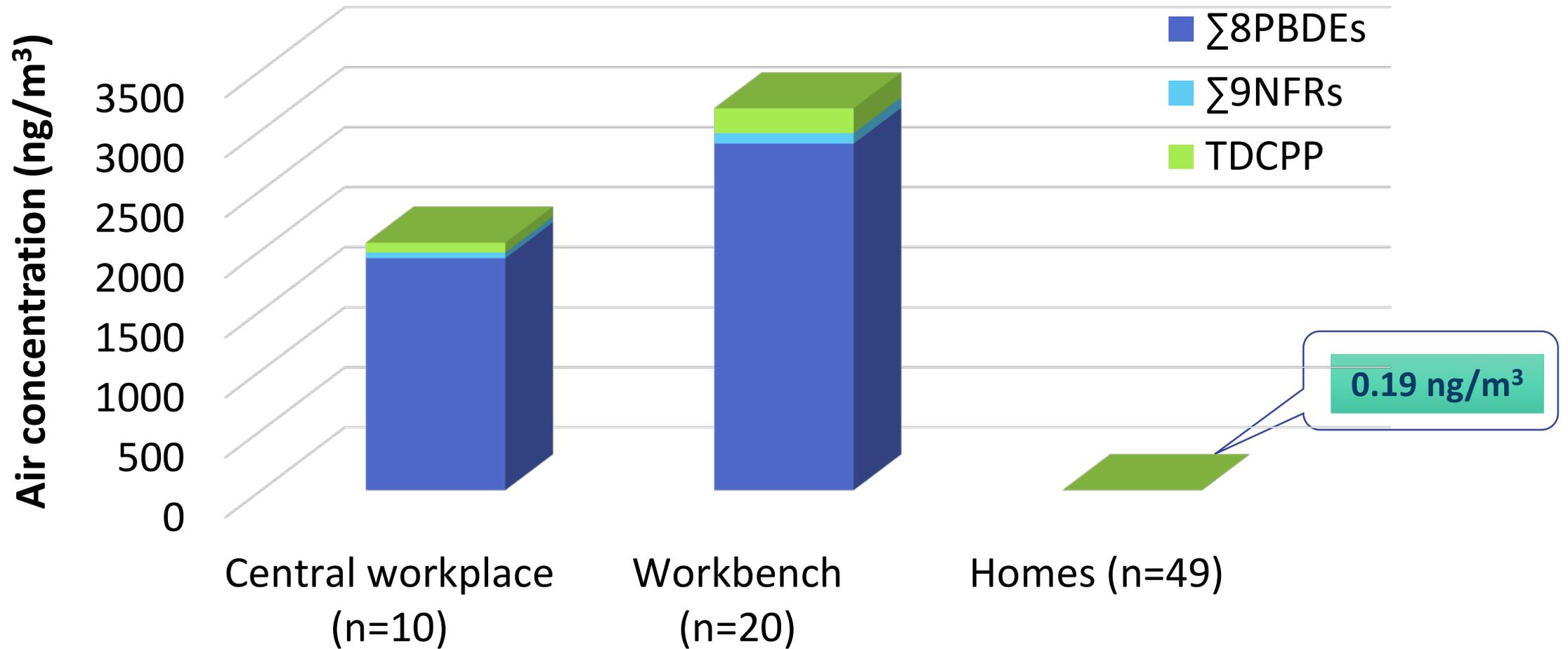
†Muenhor *et al.*, 2010. *Environment International*, 36(7), 690-698.

FRs in Dust – Comparison of Locations in Facility



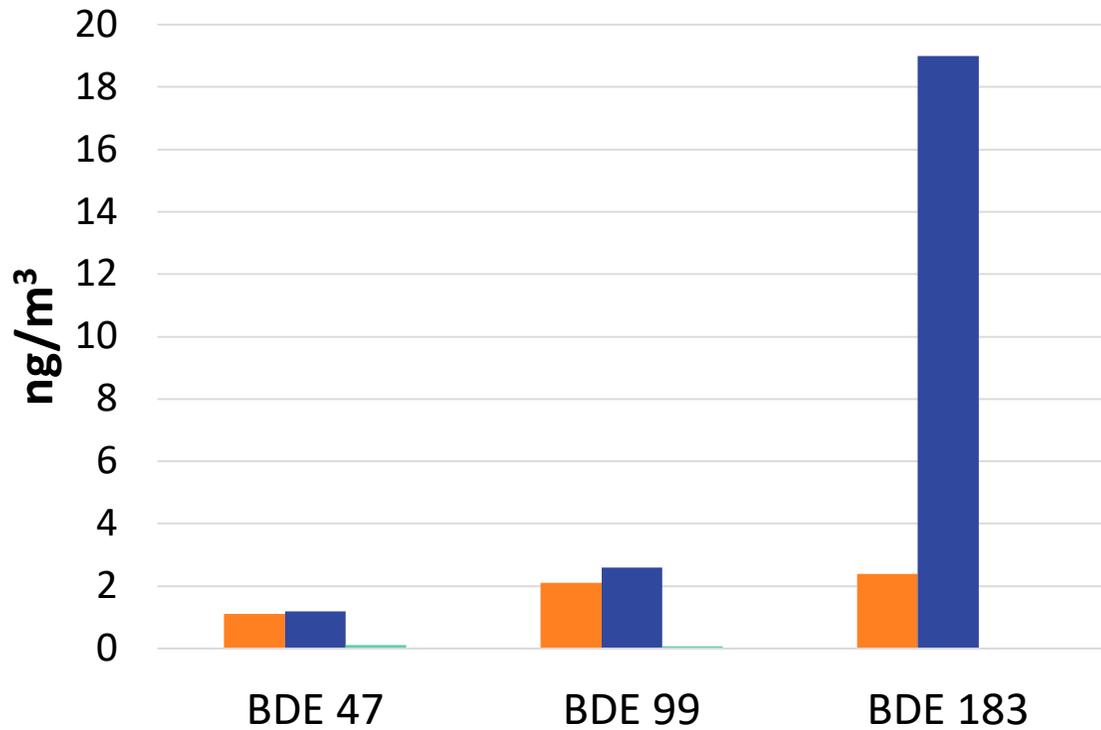
FRs in Air

(Silicone Rubber Passive Air Samplers)

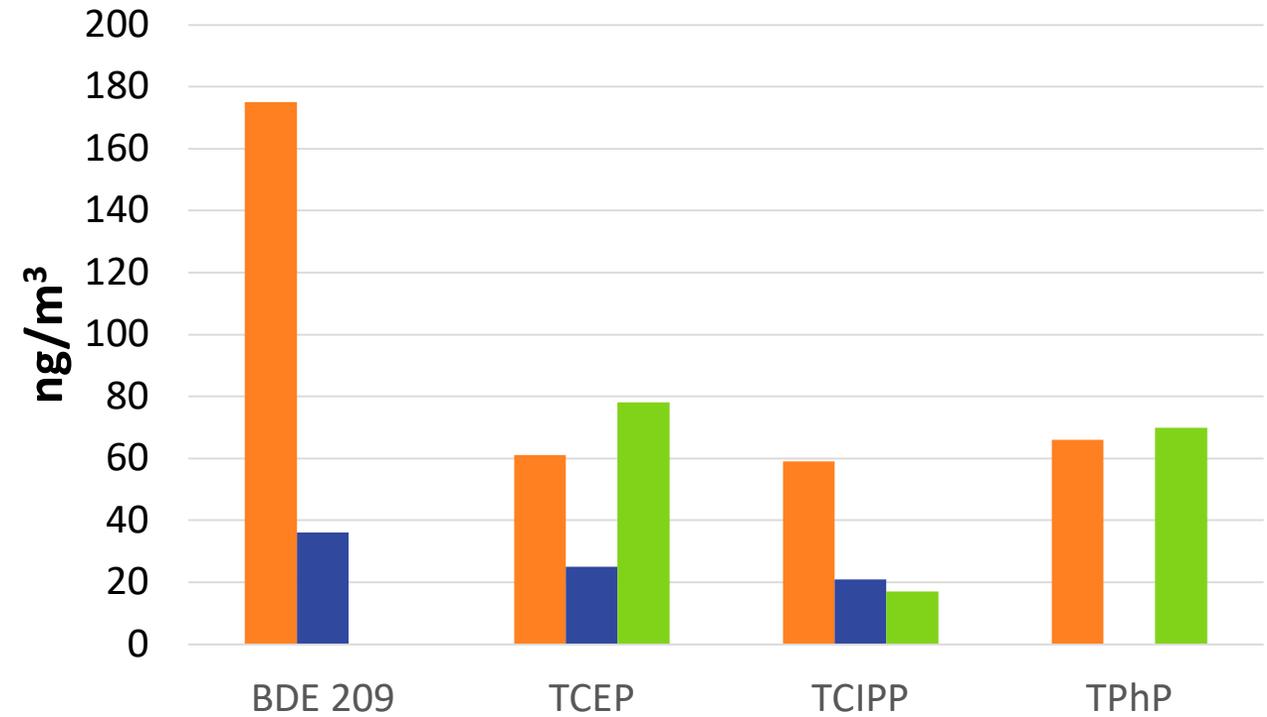


Comparison of Air Concentrations

Stationary Active Samplers

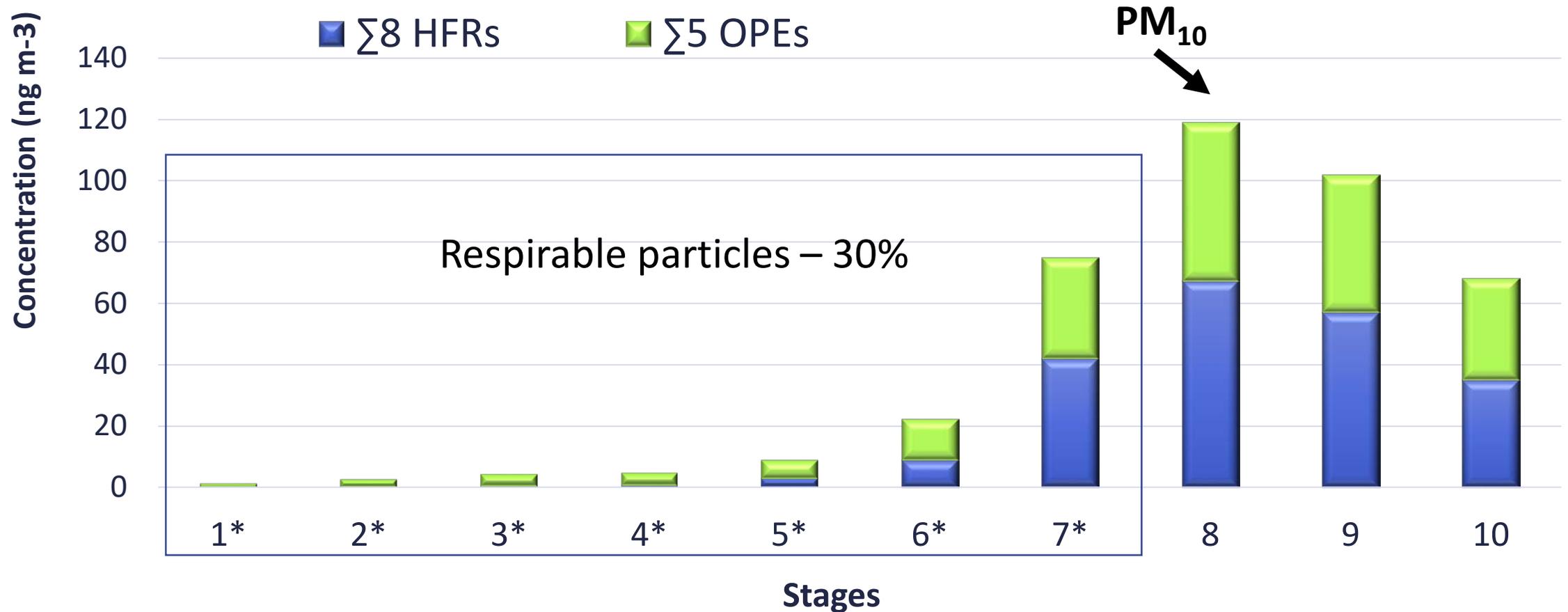


Canada Sweden Vietnam
(Sjödín et al., 2001) (Tue et al., 2013)



Canada Sweden Finland
(Sjödín et al., 2001) (Mäkinen et al., 2009)

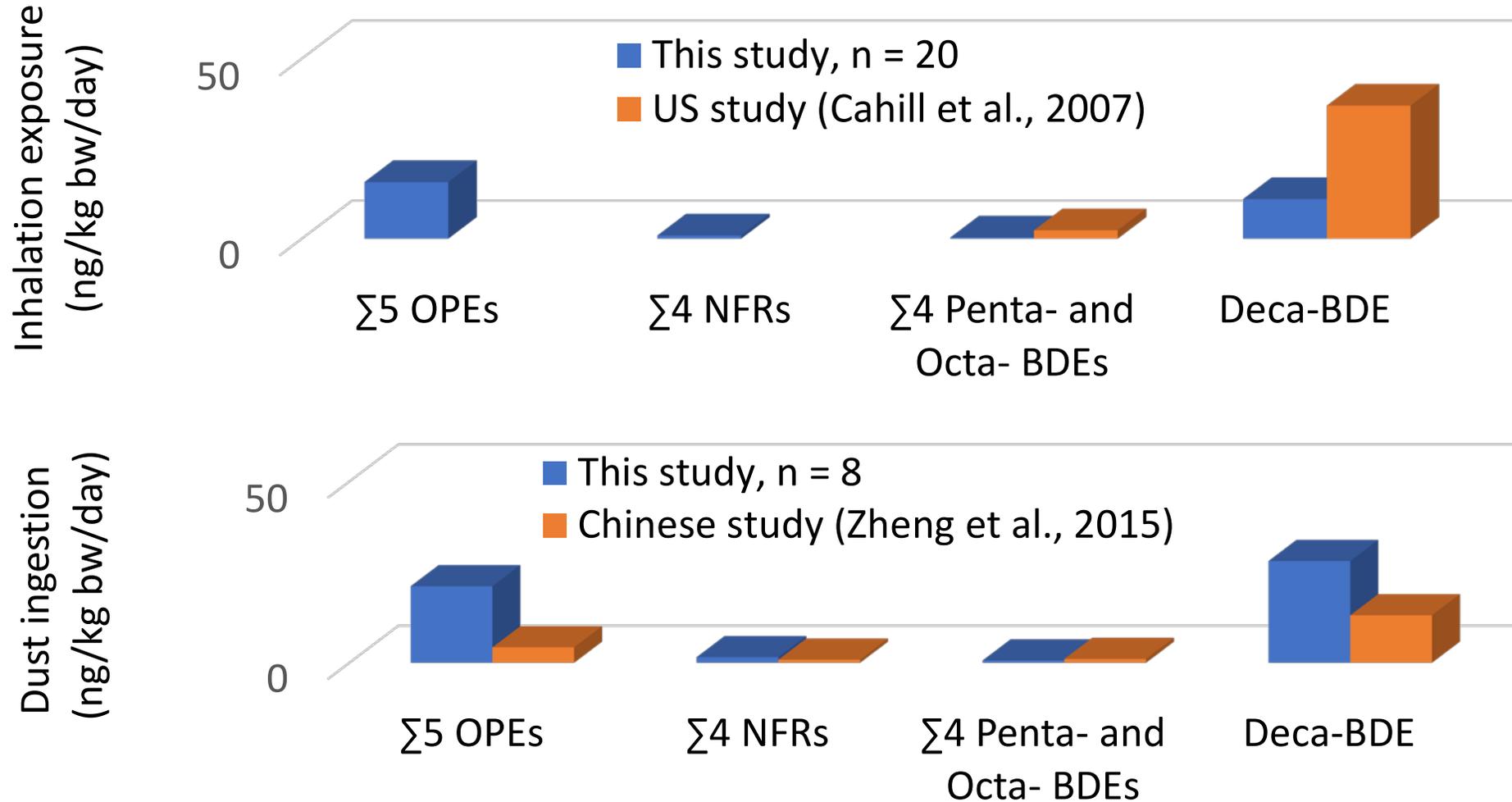
Size-Segregated Air Particles (0.1-18 μ m)



Exposure Estimates for male workers (ng/kg bw/day, median values)

	$\Sigma 4$ PBDEs	$\Sigma 4$ NFRs	$\Sigma 5$ OPEs	Total 13 FRs
Inhalation	11	0.8	16	28
Dust ingestion	29	1.5	21	52
TOTAL	40	2.3	37	80

Exposure – Comparison with Other Estimates



Ontario Occupational Health Regulations

- Limits for lead, mercury, copper, cadmium
- Only flame retardant limit for TPhP (3 mg m^{-3} , from 1961)
- Where personal protective equipment is used, must be in good working condition

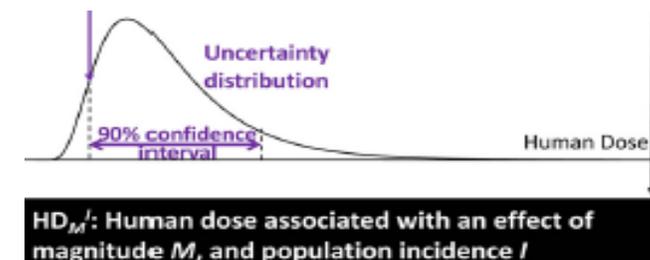
Concern about exposures?

	E-waste Estimated Exposure, 95 th Percentile	RfD*
BDE-47	0.3	255
BDE-209	72	2,300
TDCiPP	58.5	24,500
TCEP	11	17,900
TPhP	26.4 (2.3E-5 mg m ⁻³)	3 mg m ⁻³

ng/kg bw/day

Chiu W et al. 2018. Beyond the RfD.... *Environ Health Perspect*

<https://doi.org/10.1289/EHP3368>



Outline



1. How much?
2. How is it handled?
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Solutions for dealing with E-waste



Rittel, H.W.J. & Webber M.M. 1973. Dilemmas in a General Theory of Planning. *Policy Sci* 4: 155-169, <http://socialmarketing.blogs.com/.a/6a00d8341c595f53ef017d3bc64ca9970c-pi>

Legislative Complexity

	Waste	Chemical Management	Occupational Health & Safety
International	Basel Convention, USMCA? Import-export controls, substance content restrictions	Stockholm Convention Persistent Organic Pollutants	
Federal	Industry: Electronic Product Stewardship Canada; Electronic Products Recycling Association	Canadian Environmental Protection Act Chemical Management Plan	
Provincial	<i>Waste Diversion Act</i> Extended producer responsibility, intra-provincial movement, licence waste treatment Ontario Electronic Stewardship	Specific regulations that don't pertain to e-waste	Occupational Health & Safety Act
Municipal	Waste management services Landfills, direction on recycling & disposal	Landfill bans	

Basel Convention | Rotterdam Convention | Stockholm Convention | Synergies



BASEL CONVENTION
 Controlling transboundary movements of hazardous wastes and their disposal

[HOME](#) | [THE CONVENTION](#) | [PROCEDURES](#) | [IMPLEMENTATION](#) | [COUNTRIES](#) | [PARTNERS](#)

You are here: [Basel Convention](#) > [Implementation](#) > [Partnership Programme](#) > [PACE](#) > Overview | [Log](#)

Partnership Programme

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- [Decisions](#)
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- [PACE](#)
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PACE

- [Overview](#)
- [Decisions](#)
- [Progress Reports](#)
- [Terms of Reference](#)
- [List of Fact Sheets](#)
- [PACE Guidance Document](#)

Partnership for Action on Computing Equipment (PACE)



Computing equipment has improved the lives of people everywhere. As global use expands, society everywhere faces new challenges from the impacts of the entire life-cycle of computing equipment. According to United Nations Environment Programme, some 20 to 50 million metric tonnes of e-waste are generated worldwide every year, comprising more than 5% of all municipal solid waste.

In 2006, the eighth meeting of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal adopted the Nairobi Declaration on the Environmentally Sound Management of Electrical and Electronic Waste which called for more structured and enhanced efforts towards achieving global solutions for management of e-waste problems and among others encouraged Parties to develop further partnerships targeting e-waste.

Partnership Programme

- [Overview](#)
- [Decisions](#)
- [MPPI](#)
- [PACE](#)
- [Other Partnerships](#)

MPPI

- [Overview](#)
- [Decisions](#)

Mobile Phone Partnership Initiative (MPPI)

The use of mobile phones has grown exponentially from the first few users in the 1970s, to 1.76 billion in 2004, more than 3 billion in 2008, and almost 6 billion mobile-cellular subscriptions in 2011. Sooner or later, these phones will be discarded, whole or in parts. In average, the first owner will generally replace their mobile phone within two years.

The total mass of all mobile phones produced worldwide is tens of thousands of tonnes per year, and accessories represent tens of thousands of tonnes more. Also, the fastest-growing markets for new and used mobile phones are in many developing countries. The result of that growth is waste when such phones reach the end of their lives. The issue of wastes from discarded mobile phones is, therefore, a significant one due to their sheer quantity globally and the possibility of pollution as well as the loss of valuable resources.



BAN Together to protect people & the planet

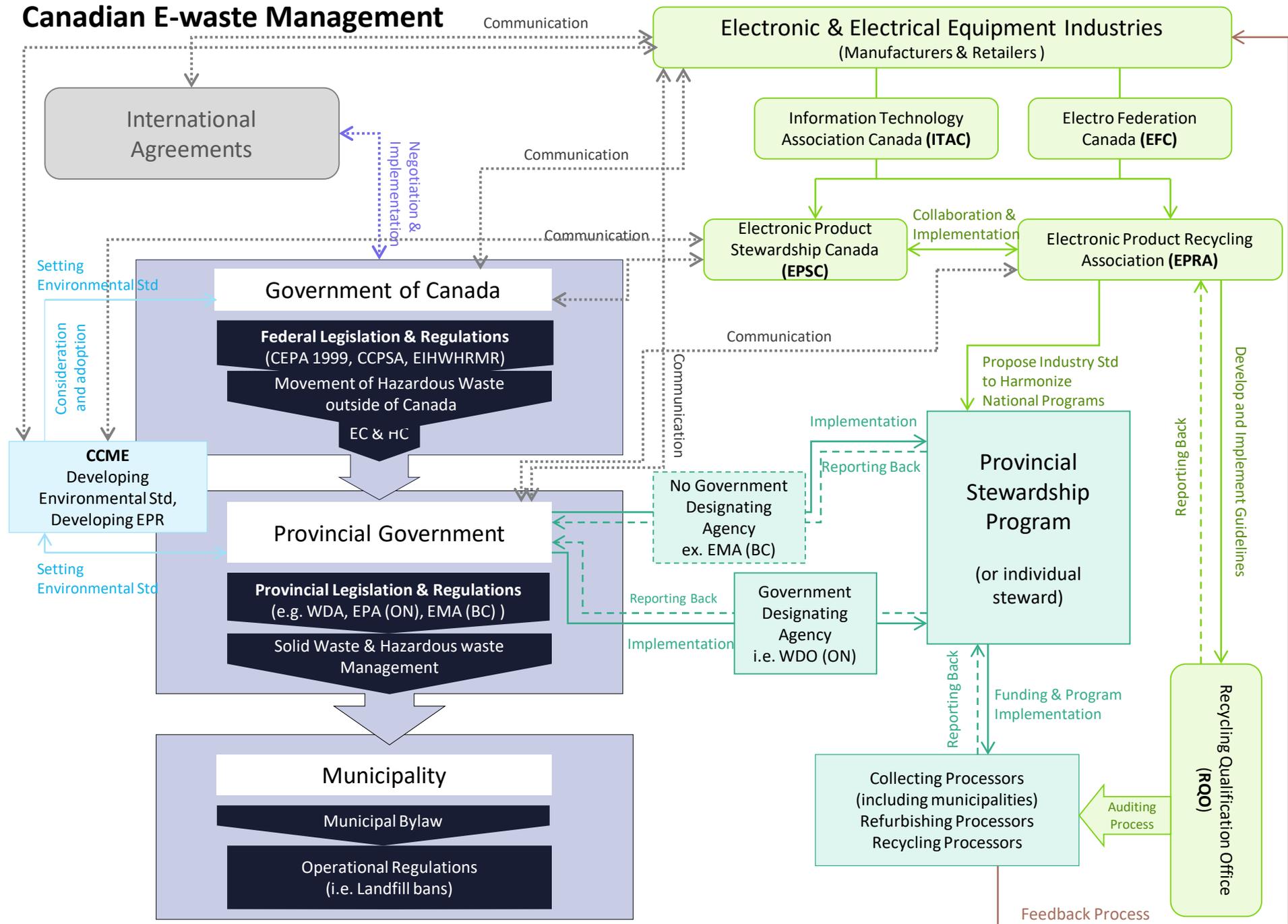
GIVE TODAY

Safeguarding people & the planet
from toxic waste trade

What We Do



Canadian E-waste Management



MARCH 14, 2018



About a quarter of U.S. adults say they are 'almost constantly' online

BY ANDREW PERRIN AND JINGJING JIANG



(Volkan Furuncu/Anadolu Agency/Getty Images)

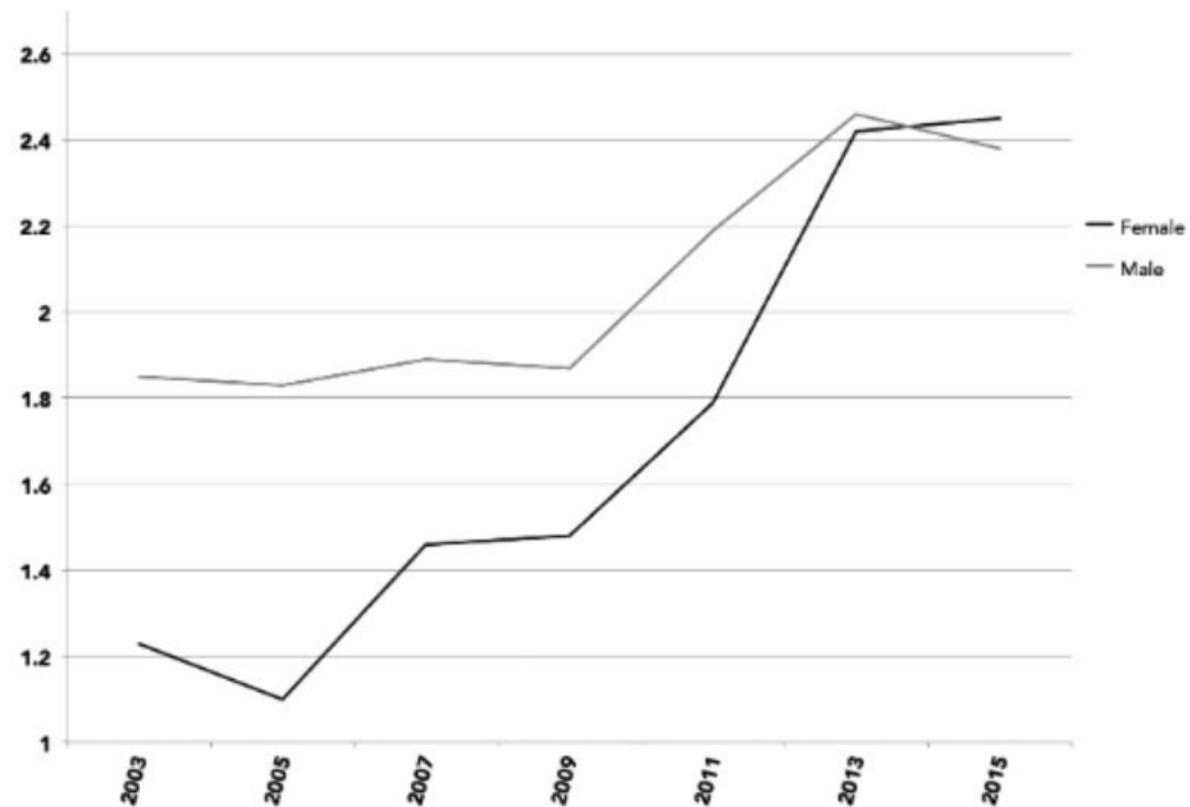


Figure C.3. Hours spent on electronic devices per day by 9th to 12th graders, by sex. Youth Risk Behavior Surveillance System, 2003–2015.

<http://www.pewresearch.org/fact-tank/2018/03/14/about-a-quarter-of-americans-report-going-online-almost-constantly/>

Twenge J 2017. iGen. Why today's super-connected kids are growing up less rebellious, more tolerant, less happy- and completely unprepared for adulthood.

<http://d1hbl61hovme3a.cloudfront.net/igen-appendix.pdf>

Dramatic decline in self-liking and rise in depressive symptoms that coincide with widespread use of Smart Phones

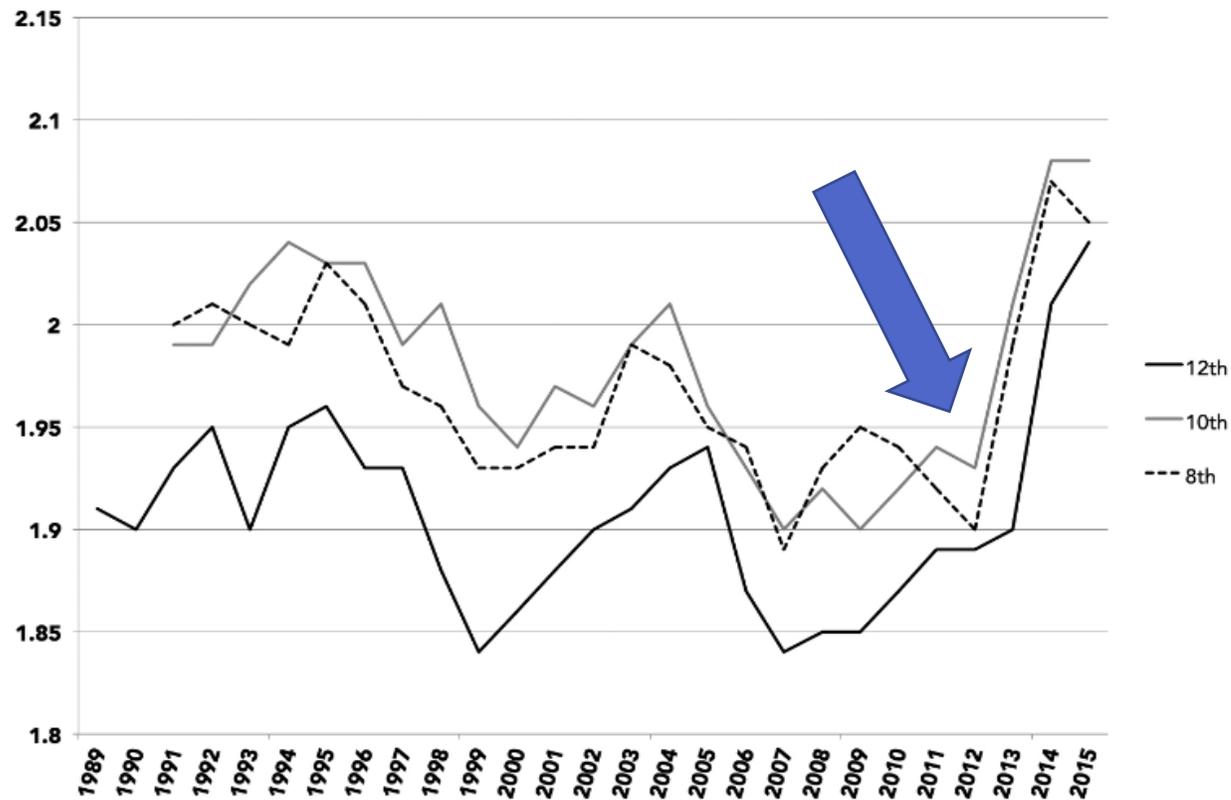


Figure F.3. Depressive symptoms among 8th, 10th, and 12th graders. Monitoring the Future, 1989–2015.

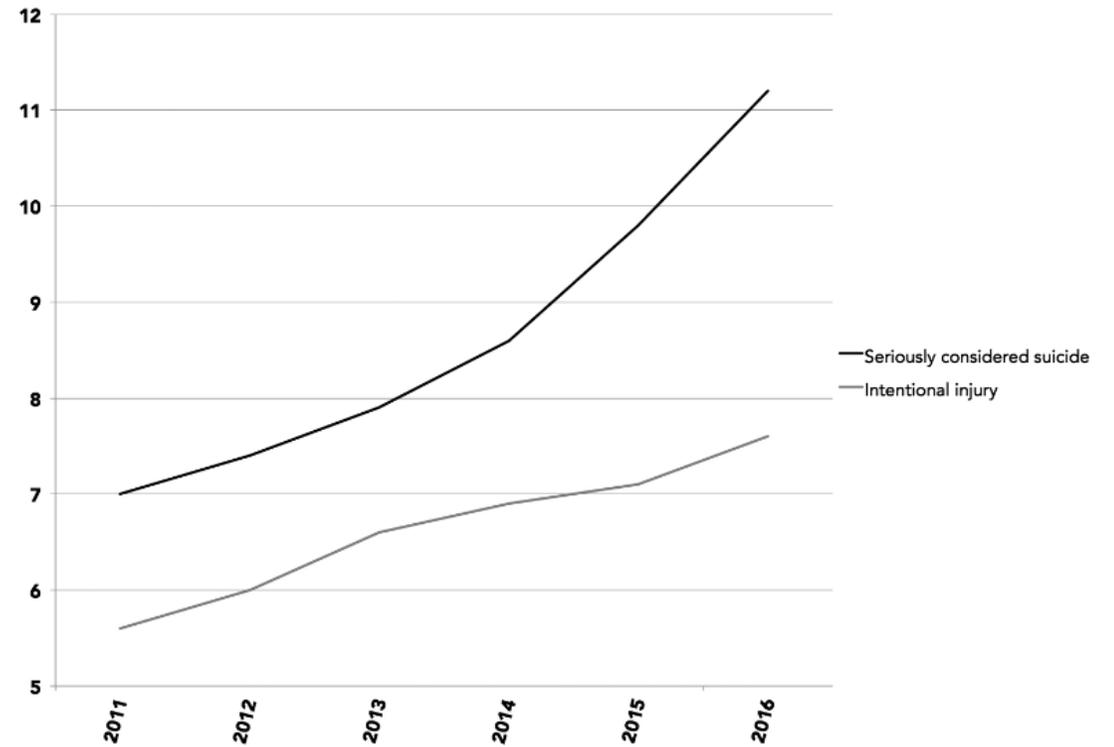


Figure F.10. Percentage of undergraduate college students who seriously considered suicide or who intentionally injured themselves in the last twelve months, 2011–2016. American College Health Association survey of approximately 400,000 students on about 100 campuses.

Summary

- E-waste is a major unintended consequence of the digital revolution;
- We are predisposed to adopt new technologies, and to externalize the negative impacts;
- E-waste handlers are most vulnerable
- to adverse impacts
- Solutions



Acknowledgements



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Cancer Care Ontario
Action Cancer Ontario

 **Canadian
Cancer
Society** **Société
canadienne
du cancer**

 **Ontario**
Ministry of Labour
Ministère du Travail