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Inorganic & Organic Certified Reference Materials

Your Science is Our Passion.™

Contamination, Adulteration and Counterfeiting: An Examination of Sources and Concentrations of Heavy Metals Present in Food, Spices, Beverages and Drinking Water

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Heavy Metals Routes of Exposure

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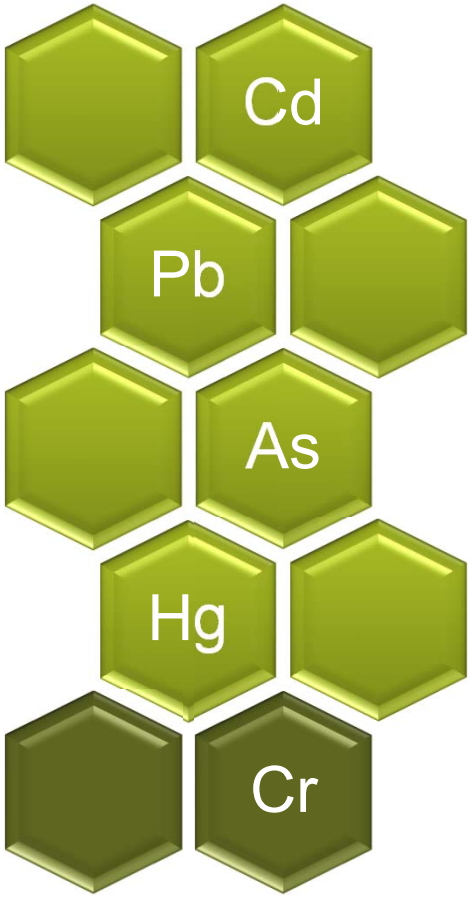

Injection

- Drugs & Pharmaceutical
- Accidental Exposure

Inhalation

- Air Quality: Indoor & Outdoor
- Drugs & Pharmaceutical
- Smoking

Transdermal

- Cosmetics, Health & Beauty Products
- Drugs & Pharmaceuticals
- Accidental Exposure

Ingestion

- Food
- Water
- Drugs & Pharmaceuticals
- Accidental Exposure

Dust

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	Known Oxidation States										
		-3	-2	-1	0	1	2	3	4	5	6
As		X	x	x	X	x	x	X	x	X	
Cd			x		X	x	X				
Hg			x		X	X	X				
Pb	x		x	x	X	x	X	x	X		
Cr	x		x	x	X	x	x	X	x	x	X

- Contamination by particles by charge transfer from friction
  - *Openi container – skin, hair, h*
  - *Tribo*

Extreme Positive Charge

Extreme Negative Charge

Wool | Lead | Heavy Metals | Human Hair | Paper | Cotton | Wood | Rubber | Polyester & Rayon | PS | Tape | PU | PE | PP | PVC | Silicon | Teflon | Silicone Rubber

Sources

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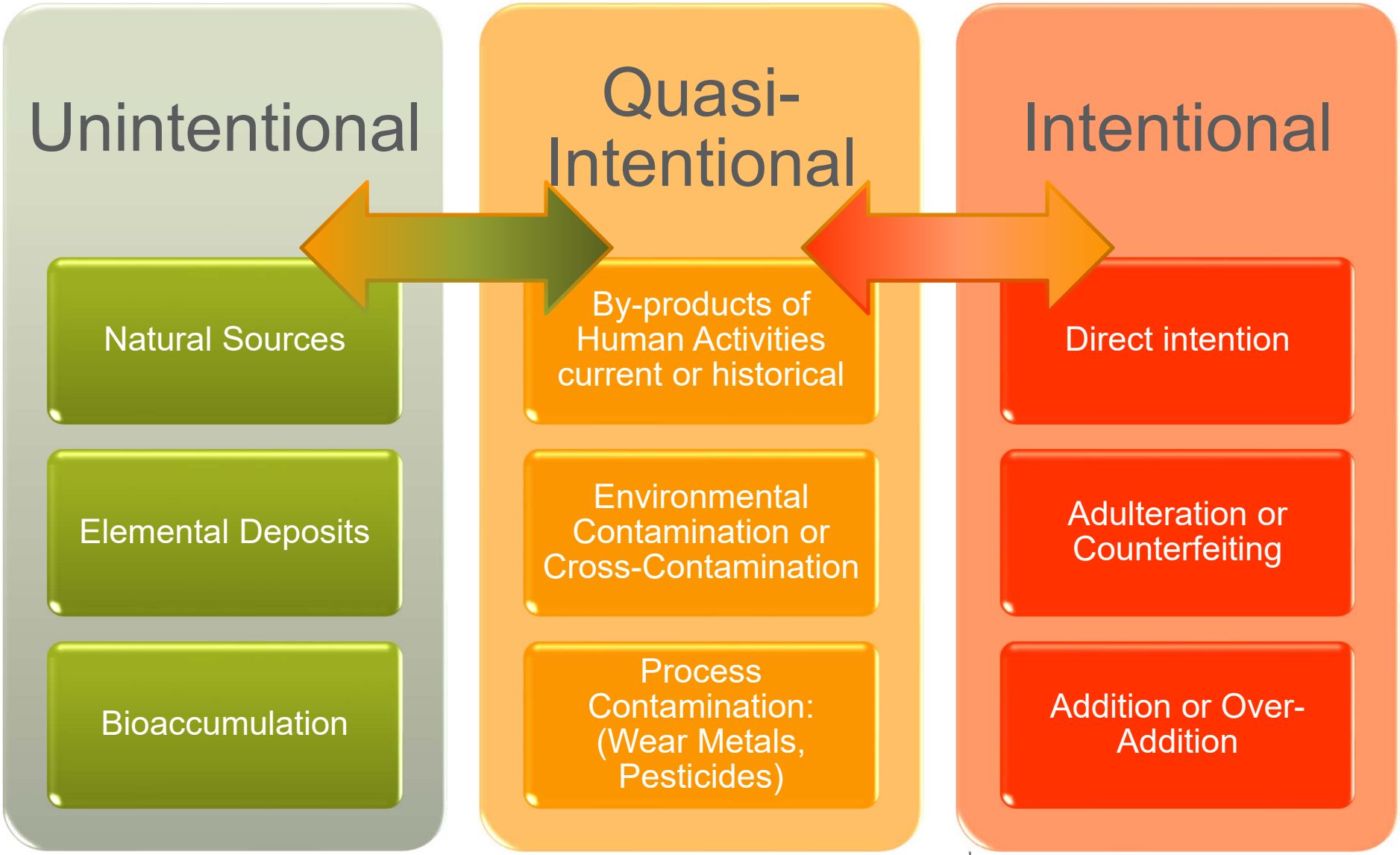

Heavy Metal Limits - Adults

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	FDA Bottled Water	EPA Drinking water	WHO Drinking water	EPA	FDA	WHO/ JECFA	ATSDR	NSF/ANSI 173	CNHP (2008)	AHPA (2012)	USP <2232>
	Action Level (ug/L)	Action Level MDL (ug/L)	Action Level (ug/L)	Oral Rfd (ug/day)	PTTDI (ug/day)	PTDI (ug/day)	Oral MRL (ug/day)	Finished Product (ug/day)	Oral Finished Product (ug/day)	Oral Finished Product (ug/day)	Oral Finished Product (ug/day)
As (Total)	**10**	**-**	**10**	**21 (chronic)**	**-**	**150**	**21 (chronic)**	**10**	**9.8**	**-**	
As (Inorg)	**-**	**10**	**-**	**-**	**130**	**-**	**-**	**-**	**-**	**10**	**15**
Cd	**5**	**5**	**3**	**70**	**?**	**70**	**14**	**6**	**6.3**	**4.1**	**5**
Hg (Total)	**2**	**2**		**-**	**-**	**-**	**-**	**20**	**20.3**		**15**
Hg (MeHg)	**-**	**-**	**-**	**7**	**-**	**16**	**21**	**-**	**-**	**2**	**2**
Hg (Inorg)	**-**	**-**	**6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Pb	**5**	**15**	**10**	**-**	**6 or 75 ug**	**250**	**-**	**20**	**20.3**	**6**	**10**

- Lead
  - FDA: 75 ug/day adults; 6 ug/day children
  - *California Prop 65: 0.5 ug/day; naturally occurring up to 1 ug more per 100 mg*

Heavy Metal Sources

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Natural Sources

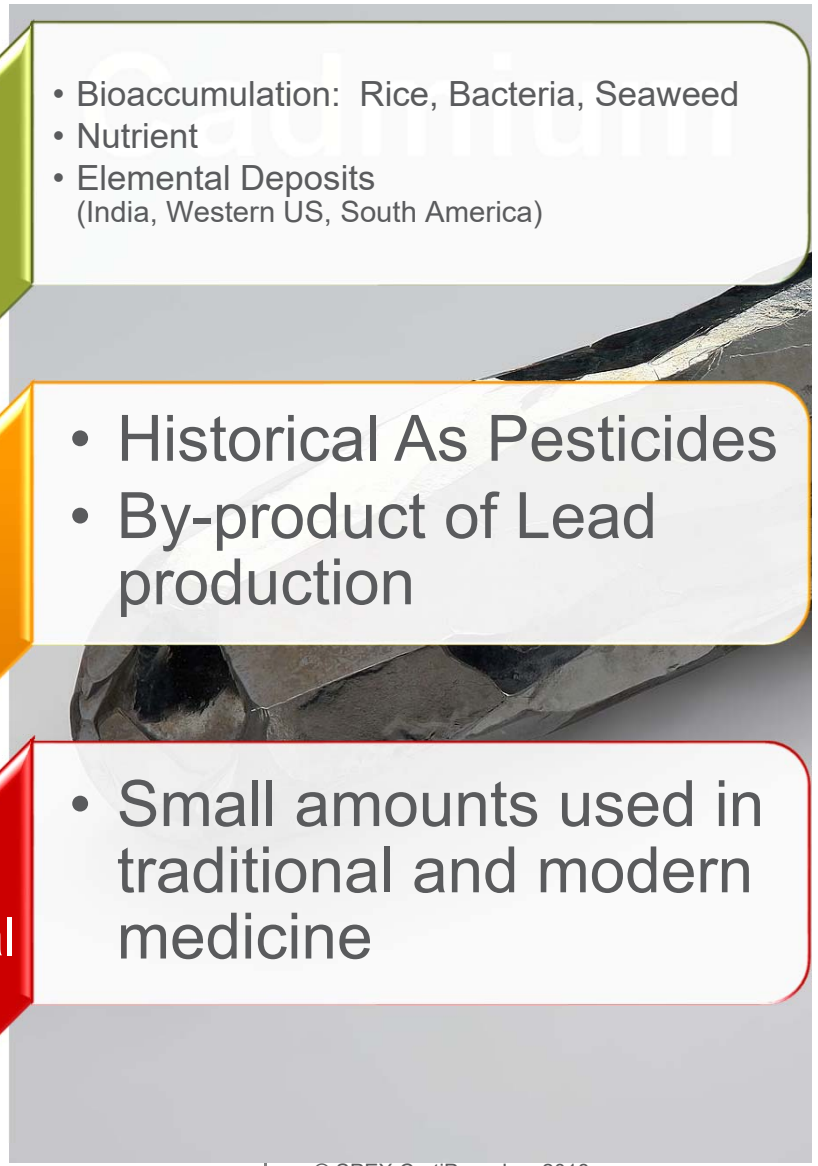
- Found in fertilizer
- Bioaccumulation orga ats and seafood

By-Products

- Colorants
- Stabilizer: Glass & Pl ic
- Coatings Iron & Steel
- By-product of Zinc pr

Intentional

- Colorants for counterf ting
- Illegal use as stabilize colorant



Natural Sources

- Bioaccumulation: Rice, Bacteria, Seaweed
- Nutrient
- Elemental Deposits (India, Western US, South America)

By-Products

- Historical As Pesticides
- By-product of Lead production

Intentional

- Small amounts used in traditional and modern medicine

Heavy Metal Sources

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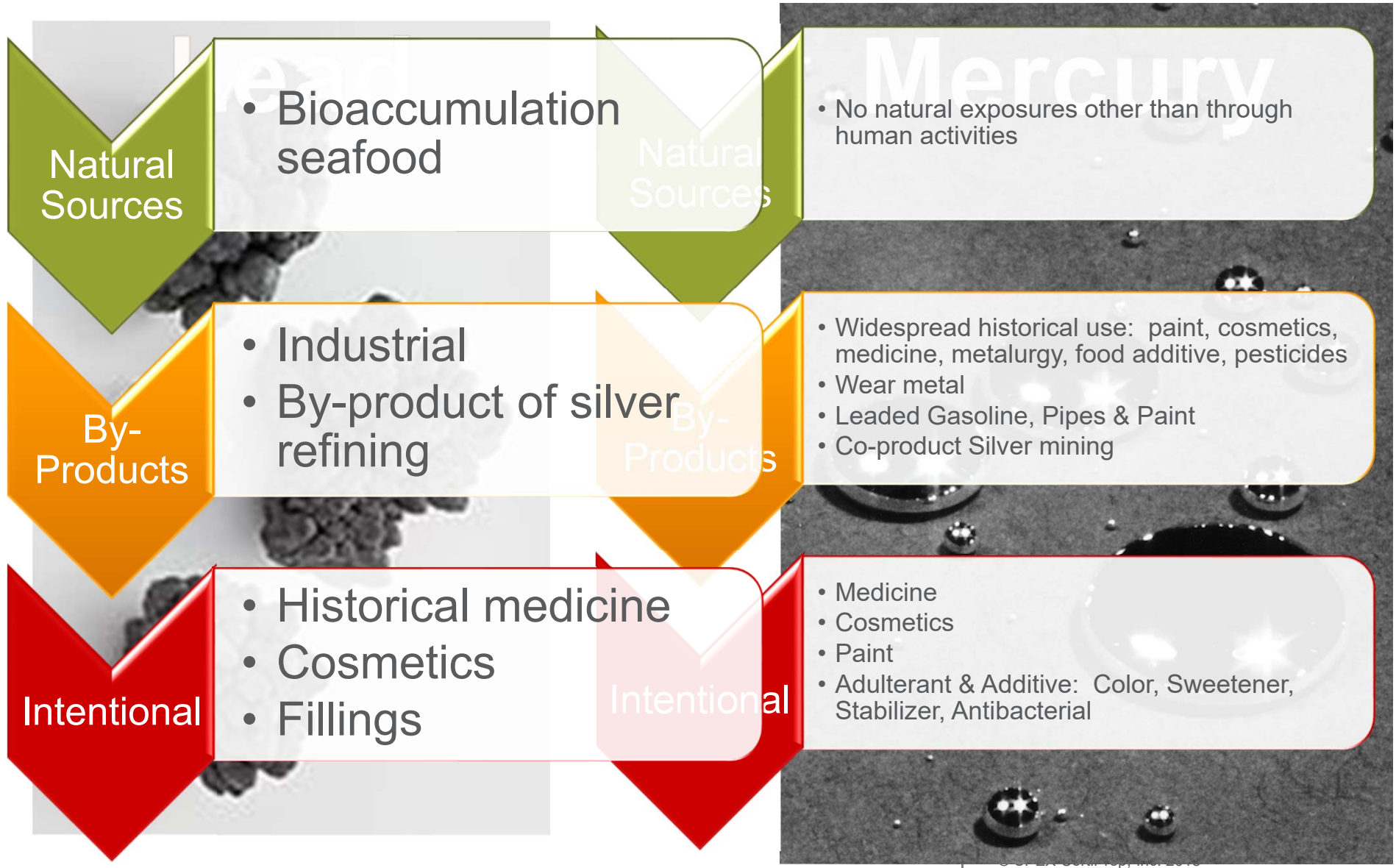

Natural Sources

- Bioaccumulation seafood

- No natural exposures other than through human activities

By-Products

- Industrial
- By-product of silver refining

- Widespread historical use: paint, cosmetics, medicine, metalurgy, food additive, pesticides
- Wear metal
- Leaded Gasoline, Pipes & Paint
- Co-product Silver mining

Intentional

- Historical medicine
- Cosmetics
- Fillings

- Medicine
- Cosmetics
- Paint
- Adulterant & Additive: Color, Sweetener, Stabilizer, Antibacterial

Two Cases of Natural Sources/By-Products

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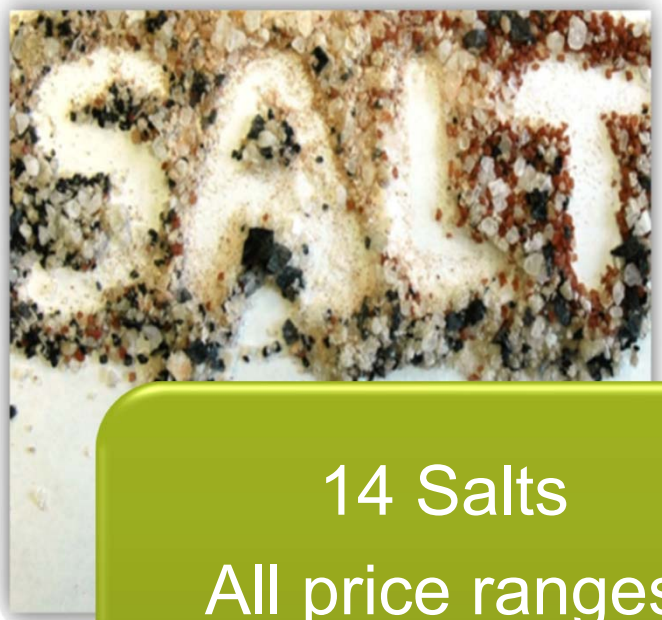

14 Salts

All price ranges

Gourmet to Laboratory

Dissolved

ICP-MS

13 Ca Supplements

All price ranges

Natural and Formulated

Dissolved

ICP-MS

Gourmet Salts

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ug/1 tsp (6 gm)	Finished Product limit (ug)	Daily Limit (ug)	Cyprus Black	Sel Gris	Kai Black	Himalyan	Fumee Sel Oak
Pb (in 1 tsp)	10	75	5.46	8.04	5.28	5.64	6.6
% Daily limit			7.28	10.72	7.04	7.52	8.8

Hg	0.12	0.01	0	0.16	0.11	0.07	0.07	0.04	0.12	0.18	0	0.04	0	0
Pb	0.91	0.56	1.34	0.47	0.88	0.51	0.94	0.46	0.4	0.58	1.1	0.46	0.44	0.39

Calcium Supplements

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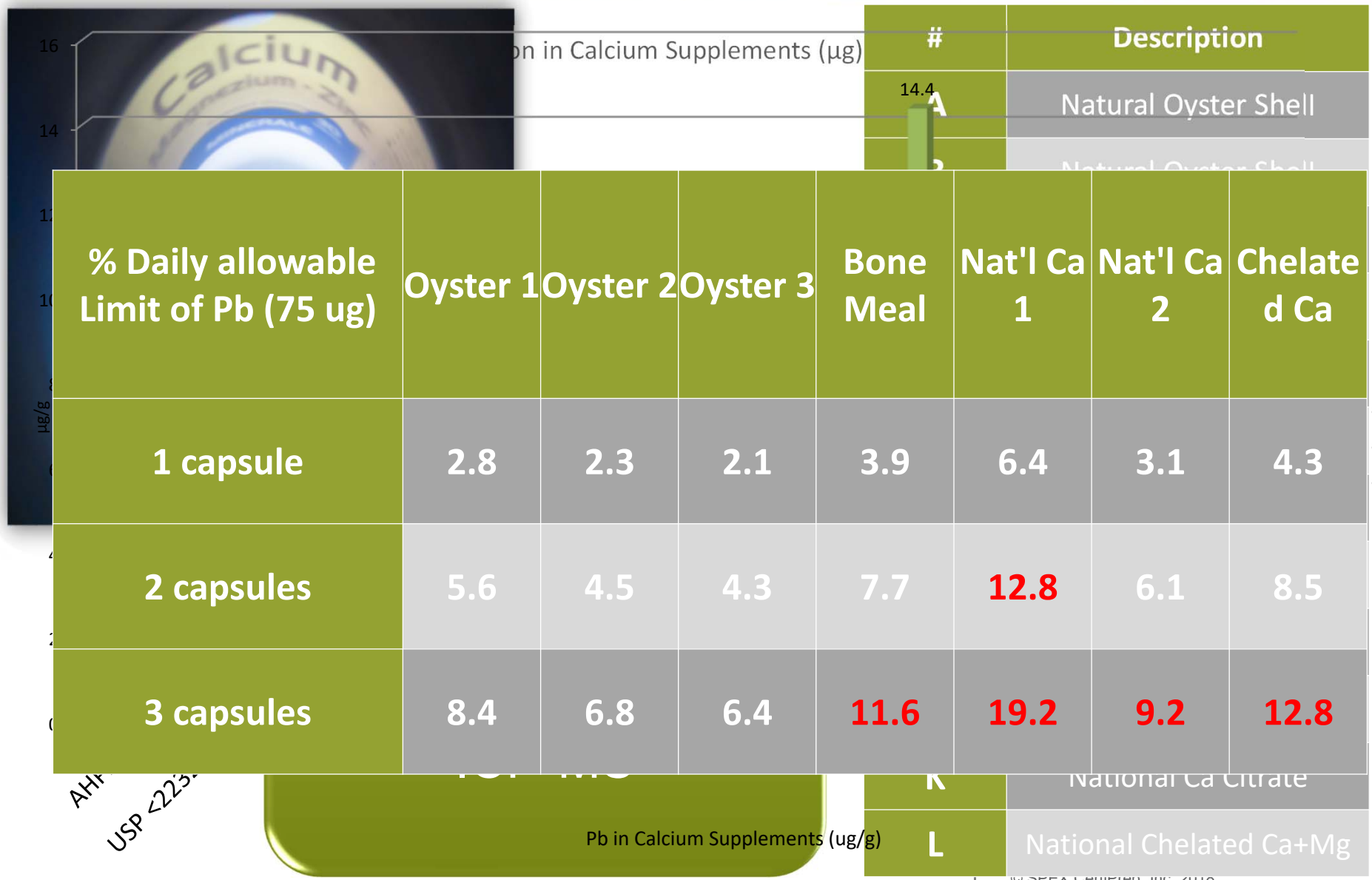
% Daily allowable Limit of Pb (75 ug)	Oyster 1	Oyster 2	Oyster 3	Bone Meal	Nat'l Ca 1	Nat'l Ca 2	Chelated Ca
1 capsule	2.8	2.3	2.1	3.9	6.4	3.1	4.3
2 capsules	5.6	4.5	4.3	7.7	12.8	6.1	8.5
3 capsules	8.4	6.8	6.4	11.6	19.2	9.2	12.8



#	Description
A	Natural Oyster Shell
K	National Ca Citrate
L	National Chelated Ca+Mg

Three Cases of Bioaccumulation/By-Products

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4 Types: Tuna, Marlin, Swordfish, Salmon

All price ranges

Farm to Wild

Digested

ICP-MS

7 Samples

All price ranges

Dark, Milk & Liquor

Digested

ICP-MS

19 Samples

All price ranges

Oils, Concentrates, Pills

Digested

ICP-MS

Mercury in Fish

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Fish	Hg in 4 oz serving (ug)	% of Week Limit (7 ug of MeHg) EPA in Serving
Wild Alaska Salmon	5.1	72.86%
Farm Raised Salmon	4.9	70.00%
Black Peal Salmon	3.5	50.00%
Fresh Tuna	6.1	87.14%
Frozen Tuna	21.8	311.43%
Swordfish Steaks	110.8	1582.86%
Marlin Steaks	329.1	4701.43%

Heavy Metals in Chocolate

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Toxic met  **late (in µg, per 40 g serving)**

	Dark 1	Dark 2	Dark 3	Milk 1	Daily Limit	Product Limit	% Daily Limit Highest Result
As	0.39	0.98	2	0.4	21	10	4.7
Cd	3	3.8	5.3	0.9	70	6	7.6
Hg	2	0.1	<0.04	4	7*	20	? 50%
Pb	3	2.8	0.87	1	75 or 6	20	4% adult or 50% child

Dark, Milk & Liquor
Digested
ICP-MS

Hemp Oils/Supplements: µg/ 28 g dose

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#	As	Cd	Pb
1	0.5	0.0	1.9
2	0.7	0.2	1.4
3	0.6	0.1	1.3
5	0.8	0.4	0.9
6	0.9	0.4	1.9
7	1.1	0.4	**3.8**
10	0.7	0.3	2.5
12	0.7	0.2	1.0
13	0.7	0.4	1.4
14	0.8	0.0	2.7
15	0.0	**0.7**	0.6
16	0.6	**0.7**	1.8
17	0.9	0.2	1.2
18	0.8	0.0	0.4
19	1.0	0.0	1.5
11C	0.6	**0.7**	2.5
4C	0.6	0.3	1.8
8E	1.2	0.2	1.8
9E	**3.8**	0.1	0.4

Hemp Oils:
Pb (µg/ 28 g Daily Dose)

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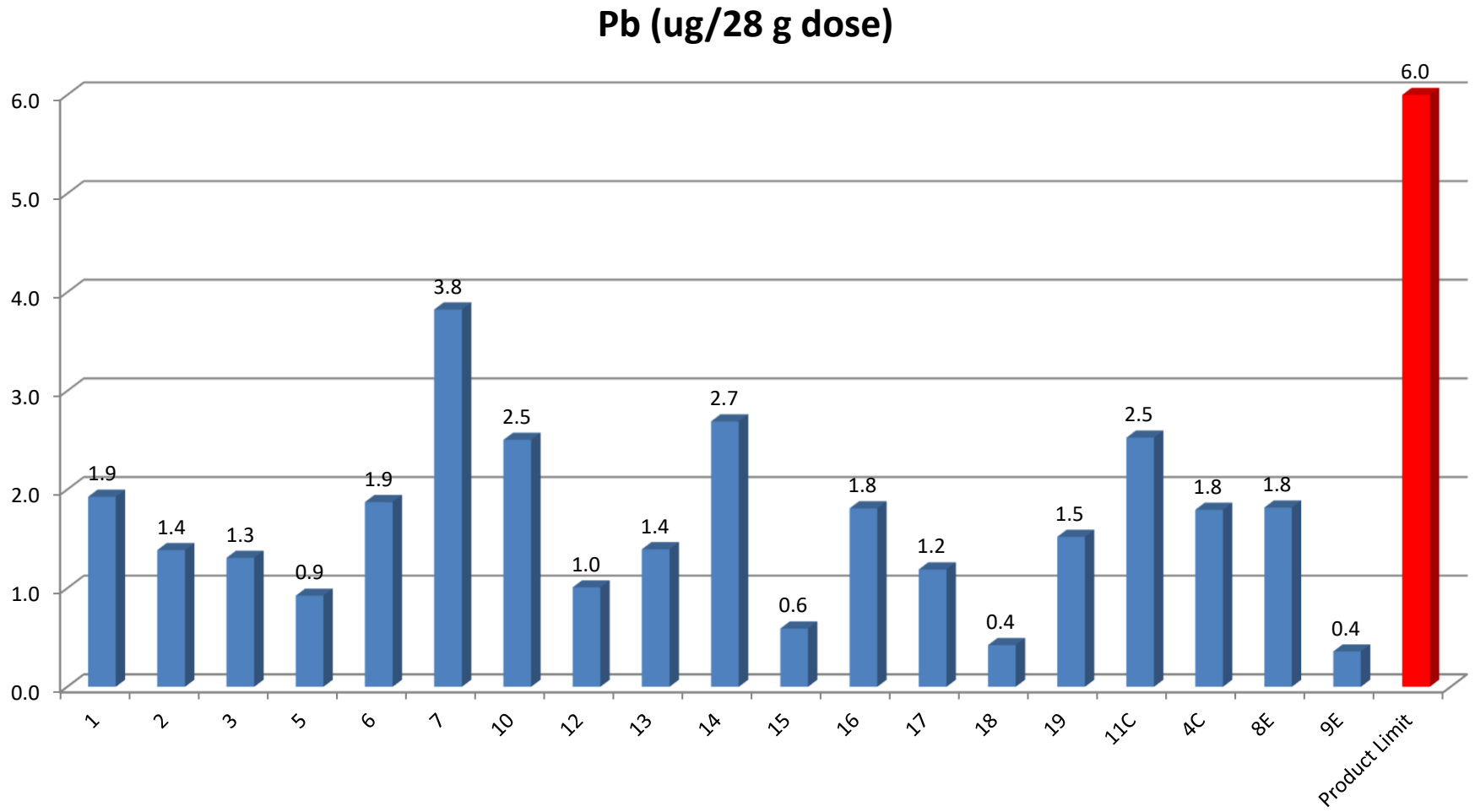

A Case Study of Environmental Contamination/By-Products

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13 Alcoholic Ciders

All price ranges

American & European

Digested

ICP-MS

Pb in Cider

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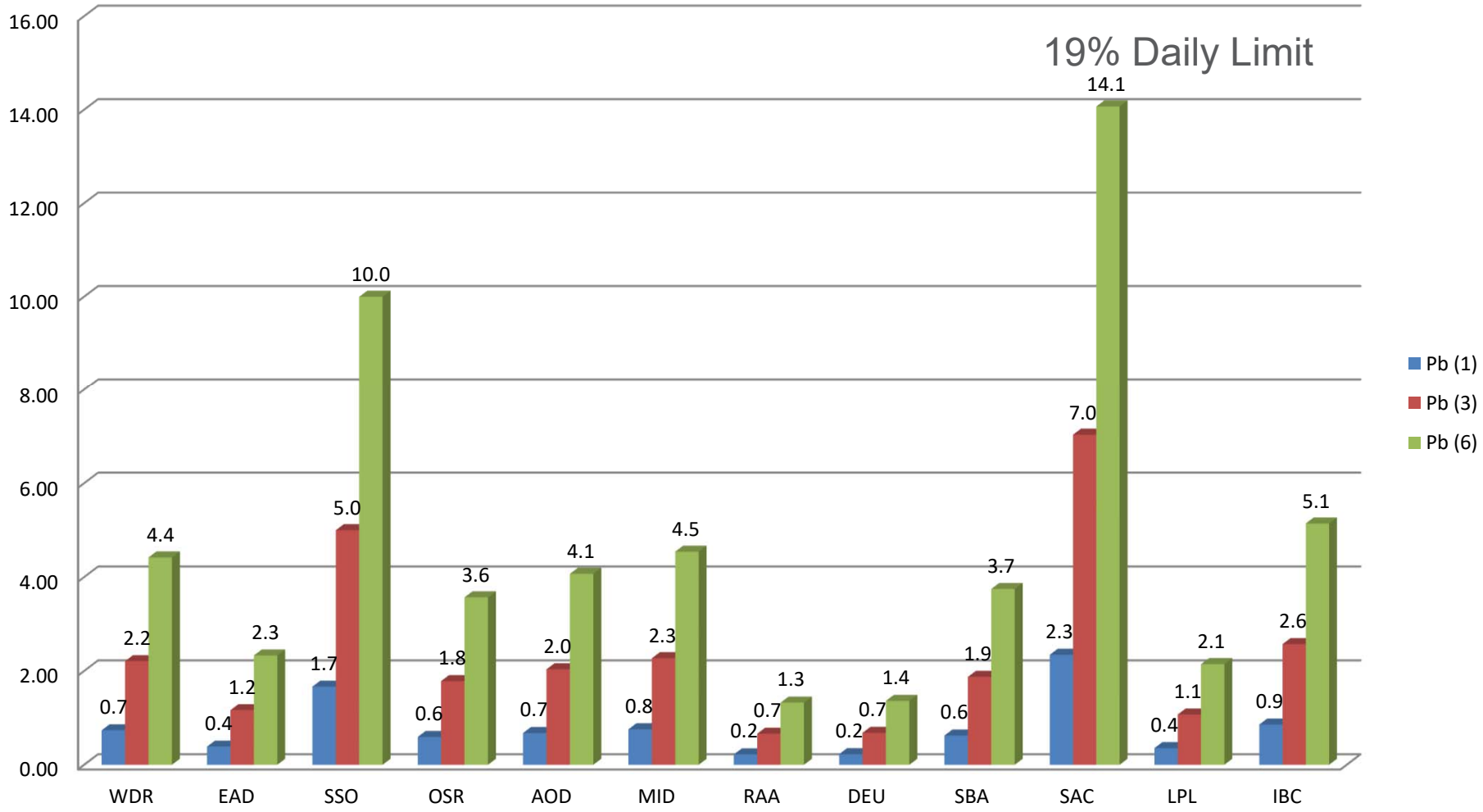
Pb (µg) in multiple 12 oz servings



As in Cider

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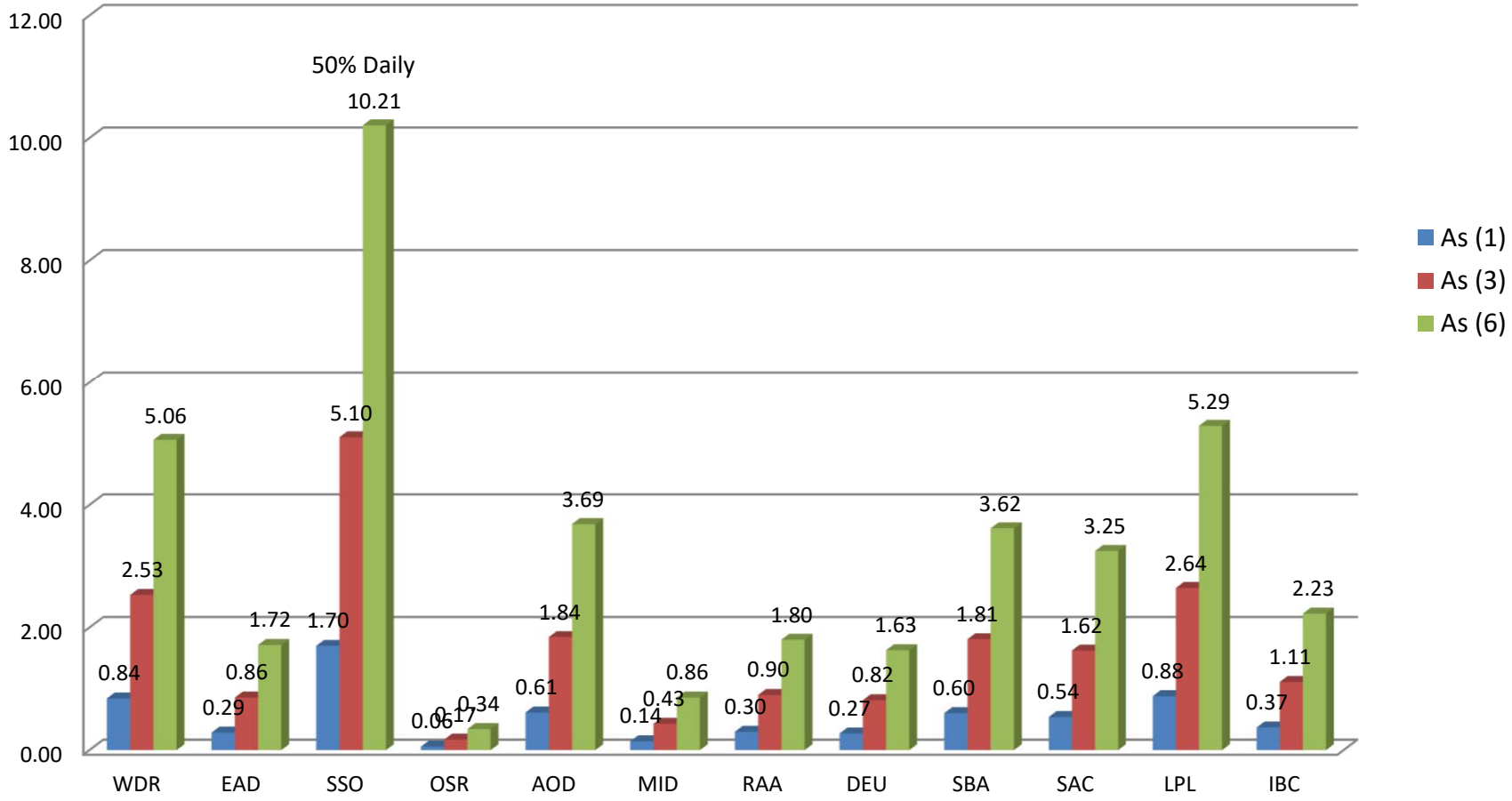
As (µg) in multiple 12 oz servings



A Case of Adulteration, Counterfeiting & By-Products

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7 Spice Groups & Products

BP, RP, Cinn, Ginger, Cumin, Mustard, Turmeric

All price ranges

Whole & Ground

Digested

ICP-MS

Spice Samples

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- 8 Spice Groups & Products

  (Supplements, Teas, Sauces & Condiments)
  - *Black Pepper*
  - *Red Pepper: Spice, Hot Sauce, Chili Powder*
  - *Cinnamon: Spice, Supplement, Tea*
  - *Ginger: Spice, Supplement, Tea*
  - *Cumin: Spice, Curry Powder*
  - *Mustard Seed: Spice, Condiment*
  - *Turmeric: Spice, Supplement*
  - *Salt: Gourmet, Table & NaCl*
- Whole & Ground Spices
- Range of Prices:
  - *Dollar store*
  - *Farmer's Market*
  - *Grocery*
  - *Retail Chain*
  - *Name Brand*
  - *Organic*

Common Ground Spice Adulterants

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Sawdust or
Bran Powder

Sand or
Silica

Starch or
Flour

Salts:
Na, Mg

Chalk or
Talc

Charcoal

Brick Powder

Illegal Dyes:
Pb, Azodyes,
Metanil Yellow

Illegal
Preservatives

Illegal
Pesticides

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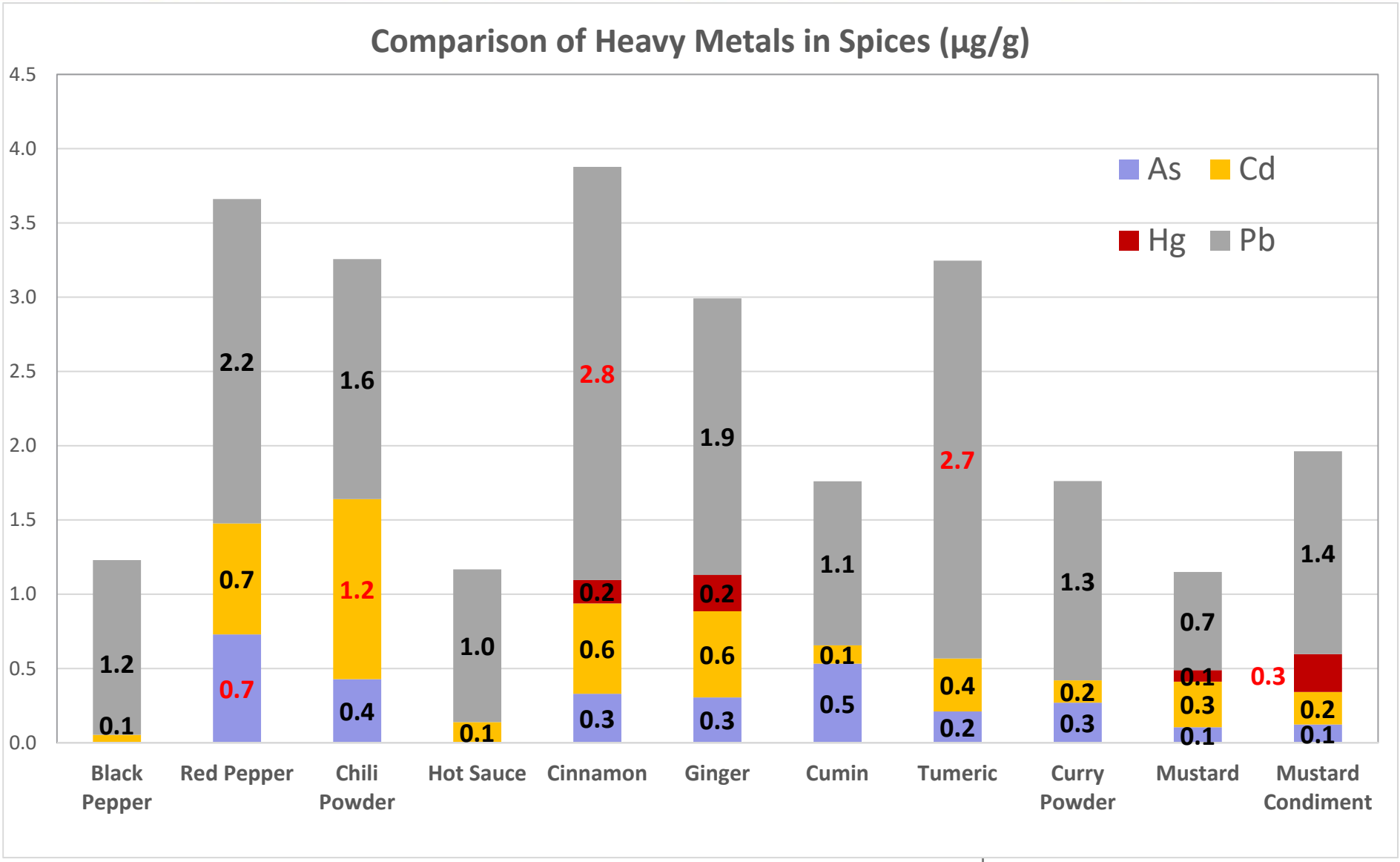

Heavy Metals in Hot Sauce (ug/serving)

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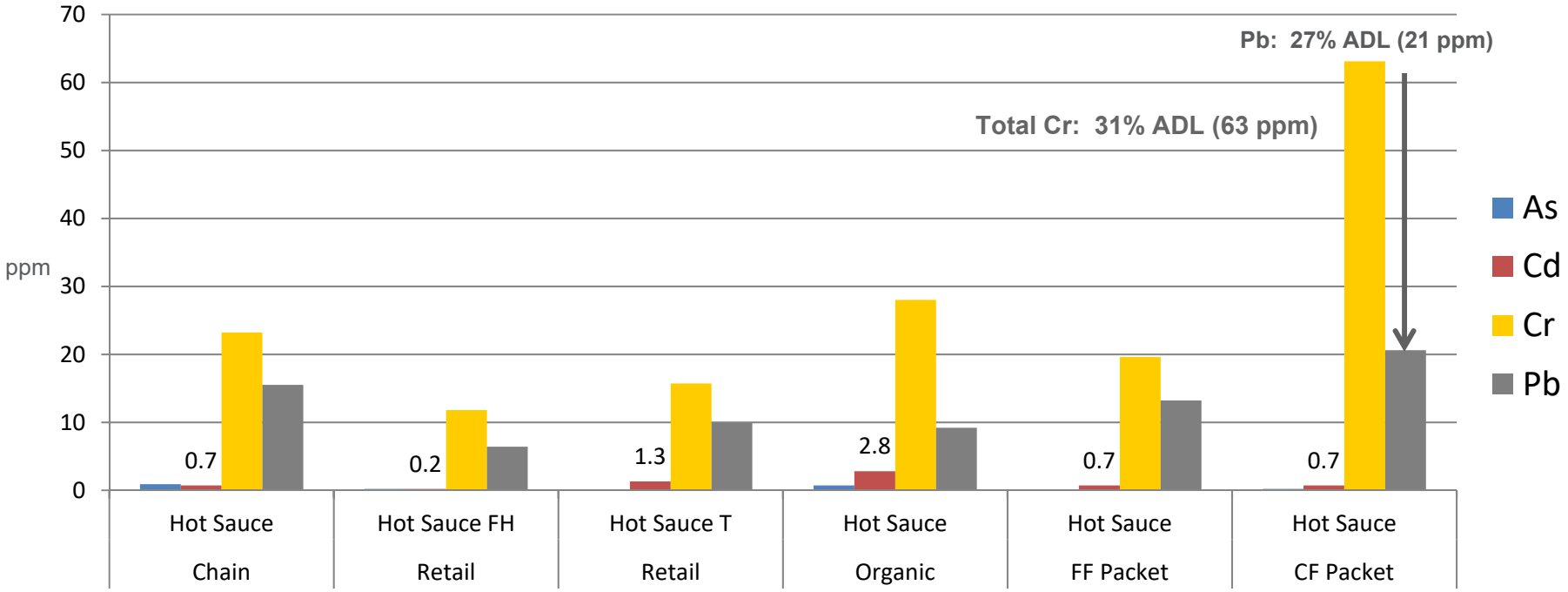

- Packet – 10 g
- Average Use: 1-2 packets (20 g)
- Pb levels, Total Cr level increase to about 30% ADL
- Ingredients:

  Water, Salt, Food Starch, Cayenne Pepper, Vinegar, Spices, Colorings & Preservative

A Case of By-Products & Intentional Contamination

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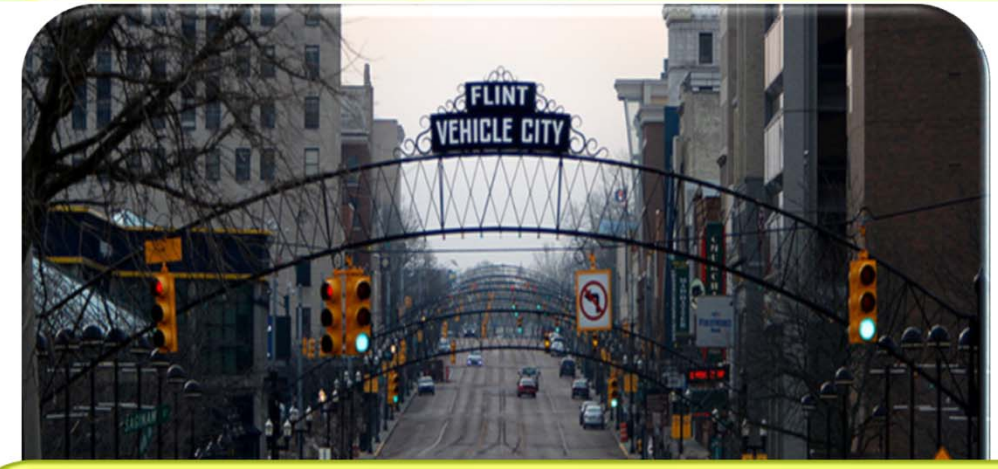

Flint, Michigan
Lead in Drinking Water
2014-2016

Flint & Water

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2014	April 2014	2014- 2015	2016

Comparison of Established Regulatory Limits for Lead in Water and Results from Flint Michigan Water Samples

Source	FDA	EPA	EU/WHO	Cited References	Detroit Lake Huron	Flint	Flint	Flint	EPA
Form	Bottled Water	Drinking Water Action Level	Drinking Water Action Level	Concentration of Concern for Lead exposure	90th Percentile Results	90th Percentile Results	High Result (VT Sample)	Highest Recorded Sample	Designation for Toxic Waste Concentration
Pb (µg/L)	5	15	10	5	2.3	27	158	13000	5000

Contamination measured by the 90th percentile level of lead exposure
90% of homes below that threshold and 10% above it.

The action level for drinking water is 15 µg/L

Flint isn't the only problem

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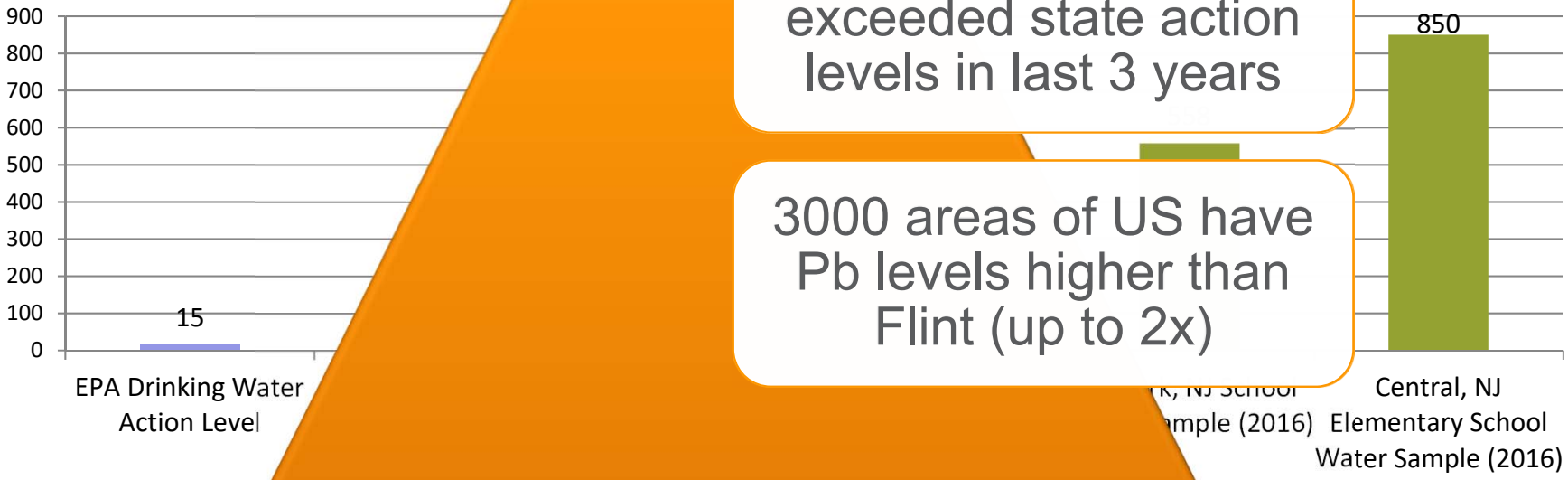
- At end of Flint = Newark, NJ Pb in s
- Another NJ elementary school ha

Only 9 states routinely report safe Pb levels in water

41 States have exceeded state action levels in last 3 years

3000 areas of US have Pb levels higher than Flint (up to 2x)



Comparison of Lead Levels Found in Flint Water Samples and NJ School Water Sources in 2015-2016 (µg/L)

Exposure

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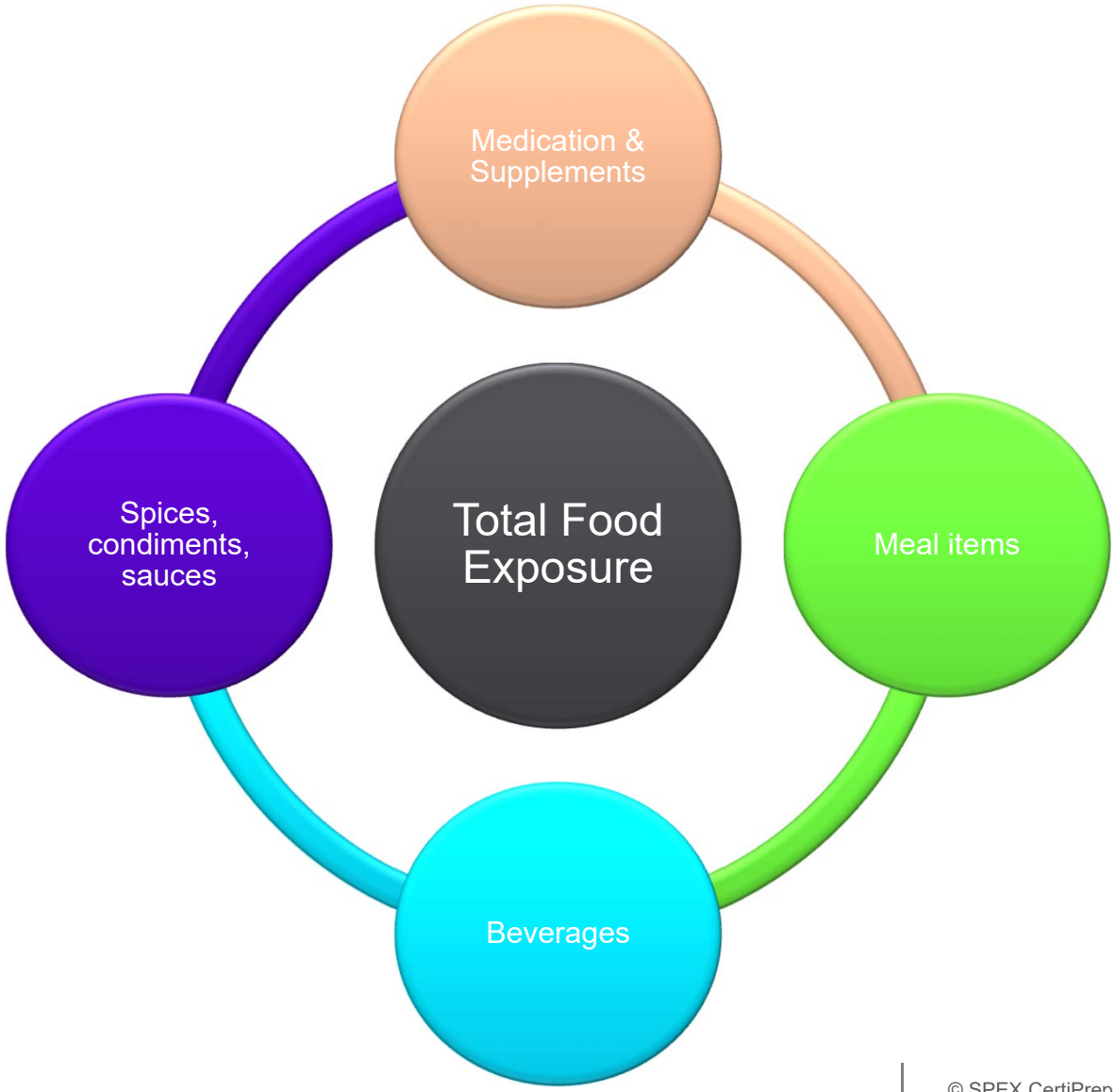

Most Dangerous Meal

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- Individual products not necessarily the danger
- Combined Daily Exposure





	As	Cd	Hg	Pb
Rx	5.600	10.133	0.831	24.290
Breakfast	1.368	3.464	0.210	3.252
Lunch	4.246	5.594	0.340	23.380
Dinner	15.058	61.114	332.114	14.864
Snacks	2.492	4.388	2.000	3.084
Drinks	5.304	0.000	0.000	61.000
Total	**34.068**	**84.693**	**335.495**	**129.870**
Daily Limit	**21.0**	**70.0**	**7.0**	**75.0**

Toxic food components (ug)

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Supplements		As	Cd	Hg	Pb
Hemp dose	2 tsp	3.800	0.700	0.000	3.800
Ca Dose	3 capsules				19.200
Multivitamin	Dose	1.800	9.433	0.831	1.290
Total		5.600	10.133	0.831	24.290
Breakfast		As	Cd	Hg	Pb
Milk	8 oz glass	0.000	0.023	0.000	0.068
Coffee	8 oz cup	0.000	0.023	0.000	0.000
French Toast	2 slices	0.614	2.614	0.010	0.100
Cinnamon	sprinkle 1 g	0.300	0.600	0.200	2.800
Bacon	2 slices	0.000	0.114	0.000	0.057
Apple Juice	8 oz glass	0.454	0.091	0.000	0.227
Total		1.368	3.464	0.210	3.252
Lunch		As	Cd	Hg	Pb
Chinese Carryout	1 serving	4.046	4.760	0.340	0.340
Hot Sauce	2 packets	0.200	0.700	0.000	21.000
Beer	2 beers	0.000	0.134	0.000	2.040
Total		4.246	5.594	0.340	23.380
Snacks		As	Cd	Hg	Pb
Chocolate Bar	1 bar	0.980	3.800	2.000	3.000
Granola Bar	1 bar	1.512	0.588	0.000	0.084
Total		2.492	4.388	2.000	3.084
Drinks		As	Cd	Hg	Pb
Water	2L				54.000
Ciders	3 Ciders	5.100	0.000	0.000	7.000
Soda	2 sodas	0.204	0.000	0.000	0.000
Total		5.304	0.000	0.000	61.000
Dinner		As	Cd	Hg	Pb
Salad	228	4.560	15.504	0.000	1.368
Spinach	1/2 c	0.034	20.862	0.034	0.456
Rice	1/2 c	7.524	0.798	0.000	0.000
Marlin Steak	4 oz	0.000	19.380	329.000	2.850
Salt	tsp	0.600	0.600	1.080	6.000
Wine	glass	1.360	0.170	0.000	1.190
Chocolate Bar	bar	0.980	3.800	2.000	3.000
Total		15.058	61.114	332.114	14.864

Data from FDA TDS & SPEX & Independent Studies; simulates worse case senario for the study products and average for TDS

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Thank You!

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