Quality Control

XRF Results versus Laboratory Testing

RMS Quality Control Team

24 October 2023

Objectives

We used on XRF to screen >1000 items, but are our results accurate?

Across RMS Product Categories (toys, spices, cosmetics etc.):

- Evaluate XRF testing results with an independent XRF in New York
- Compare XRF readings with laboratory testing results
- Provide laboratory testing data for products reference values below XRF detection limits (e.g., staple food products like flour).

Methdology

- Over 1,000 samples shipped to New York
- Over 1,100 XRF readings made, often multiple readings on same item
  - Comparison to field XRFs – used range of 70% to 130% of NY XRF (and lab)
  - Anomalous results required more in depth look as to why…
  - Submission of selected samples to lab
- 356 samples submitted for laboratory testing for total lead
  - Majority to CET in Connecticut, in addition to labs in Georgia and the Philippines due to import/export issues with perishables

What Does This Look like?

Bangladesh	Toy - Plastic/Rubber	Several toy, plastic	7/21/2022	08RAJ015	1,814	ND<4	ND<4	ND<4	1,239	428	ND<4	1,810	average representing composite sent to lab = ND<4/sq. rt. of 2	2.8	ND<0.50	composite of plastics submitted to lab (CET) for total lead
Bangladesh						Car1, purple portion Test All - plastics NY XRF#1	Car1, orange bot. portion Test All - plastics NY XRF#2	Car1, red hub cap Test All - plastics NY XRF#3	Car3, blue bot. atop int. gear box Test All - plastics NY XRF#4	Car2, blue bot. atop int. gear box Test All - plastics NY XRF#5	Car3, blue bot. only Test All - plastics NY XRF#6	int. gear box Test All - plastics NY XRF#7				
Bangladesh	Toy - Plastic/Rubber	Car, toy plastic	7/28/2022	08BAR047	755	27	240	2,454					average representing composite sent to lab	134	150	composite pink/black submitted to lab (CET) for total lead
Bangladesh						pink top of car Test All - plastics NY XRF#11	black bottom itself Test All - plastics NY XRF#12	black bottom atop gear box Test All - plastics NY XRF#13								
Bangladesh	Toy - Plastic/Rubber	Car, toy	7/28/2022	08BAR016	13											

What Does This Look like?

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Tunisia	Spices	Cumin	5/21/2023	23TAT094	ND<2/sq. rt. of 2	1.4	2.73	submitted to lab (Multitest, Georgia) for total lead
Bangladesh	Spices	Turmeric	7/19/2022	08KHU067	Average of all XRF readings	3	2.8	submitted to lab (CET) for total lead
Armenia	Spices	Paprika	7/10/22	15VAG018	singular reading	4	2.80	tested by Georgian lab for total lead
Nigeria	Spices	Anise Seed (Powder)	11/14/2022	24LAG051	ND<3/sq. rt. of 2	2.1	3.1	submitted to lab (CET) for total lead
Nigeria	Spices	Ginger (Powder)	11/14/2022	24LAG003	ND<4/sq. rt. of 2	2.8	4.1	submitted to lab (CET) for total lead
Kenya	Spices	Chili powder	11/21/2022	22NBI002	lowest ND = ND<4/sq. rt. of 2	2.8	5.1	sent to CET for total lead analysis
Vietnam	Spices	Ginger powder	7/24/2022	29NAD010	average of all readings	9	9.8	submitted to lab (CET) for total lead
Armenia	Spices	Coriander	7/10/22	15VAG009	singular reading	12	10.95	tested by Georgian lab for total lead
Pakistan	Spices	Pakistani spices blend (Garam Masala)	12/15/2022	26KAR032	single XRF reading	160	13.04	submitted to lab (Multitest, Georgia) for total lead
Tajikistan	Spices	Spice "Turmeric"	8/12/2022	11KHU069	average of all XRF readings	72	66	submitted to lab (CET) for total lead
Tajikistan	Spices	Spice "Turmeric No. 1"	8/11/2022	11KUL005	average of all XRF readings	262	220	submitted to lab (CET) for total lead
Tajikistan	Spices	Spice "Turmeric"	8/25/2022	11BOK136	average of all XRF readings	393	320	submitted to lab (CET) for total lead

Key Findings

- Lead concentrations measured with a portable XRF were very comparable to lead concentrations determined by laboratory analysis across all screened items with lead concentrations in the low to high range (e.g., >5 to <30,000 ppm) based on a comparison of 353 samples submitted for laboratory testing for comparison to corresponding XRF readings. See graphs in following slides…

- Detection limits of the XRF (generally <3 or 4 ppm) and the reporting limit for laboratories (0.2 to 0.5 ppm) made comparison at the <5 ppm range difficult.

- In the limited number of samples with lead concentrations in the very high (e.g., >30,000 ppm or 3%), the XRF significantly overestimated the lead concentration in those samples, although there were only a limited number of samples in this range; e.g., pure lead on XRF vs. 30% in lab…
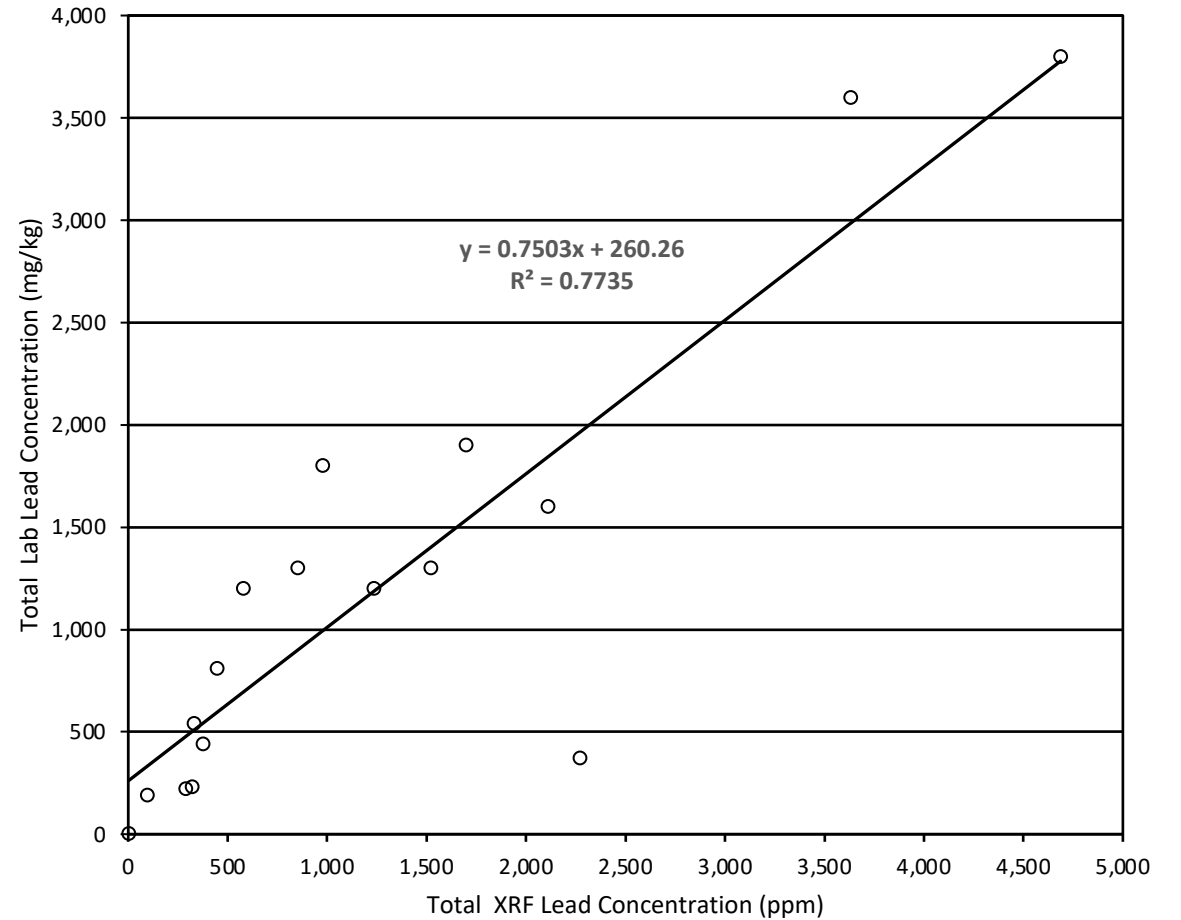
Key Findings

- Heterogeneous samples (e.g., with multiple colors or materials) or items containing internal metal parts (e.g., gear boxes, batteries, wires in toys; decorative portions on ceramics) proved a challenge to screen with an XRF.
- Lastly, the XRF underestimated the concentration of lead in thinly painted toys relative to scraped samples of paint submitted for laboratory testing.
  - In one case, it was the plastic beneath the paint that contained lead by XRF (not the paint)
- XRF used for Tajikistan and Kazakhstan samples had issues causing most of the data to be expunged...

- **Overall, the XRF results proved to be an excellent screening tool for elevated total lead in products ranging from spices to plastics, and at levels at or below the majority of reference standards (e.g., >5 ppm) with the exception of foods and cosmetics.**

XRF vs. Lab

XRF vs. Laboratory Comparison
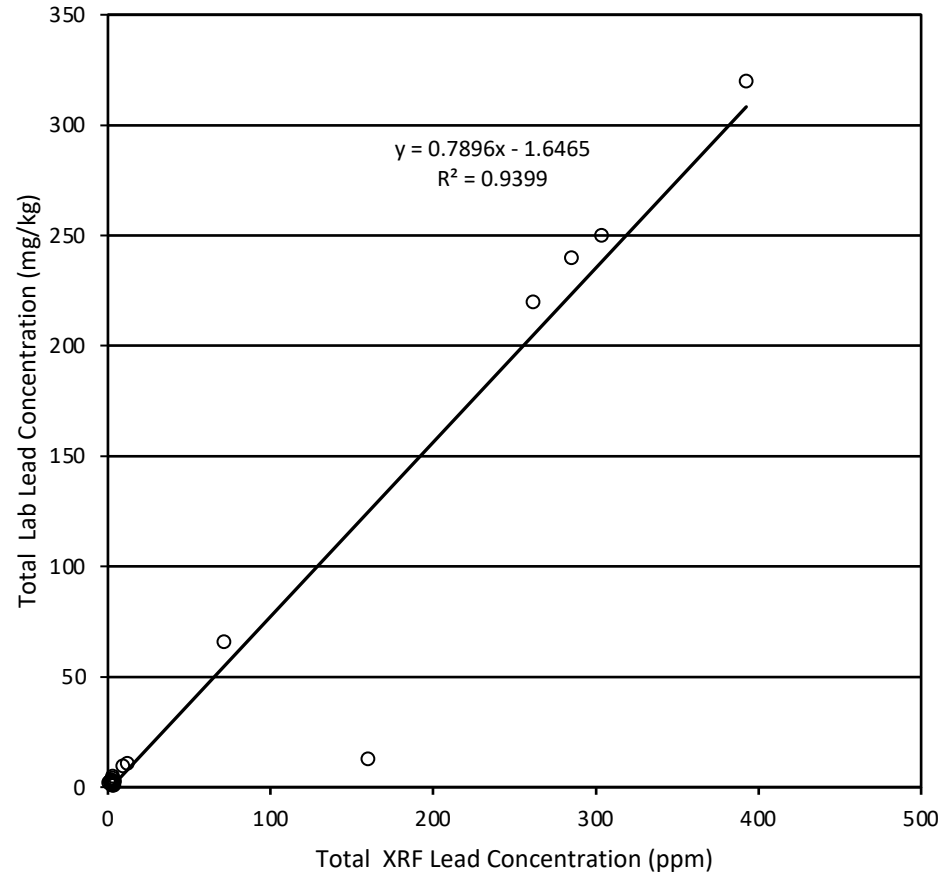Total Lead in Plastic Toys

$y = 1.0629x + 8.2399$
$R^2 = 0.9597$
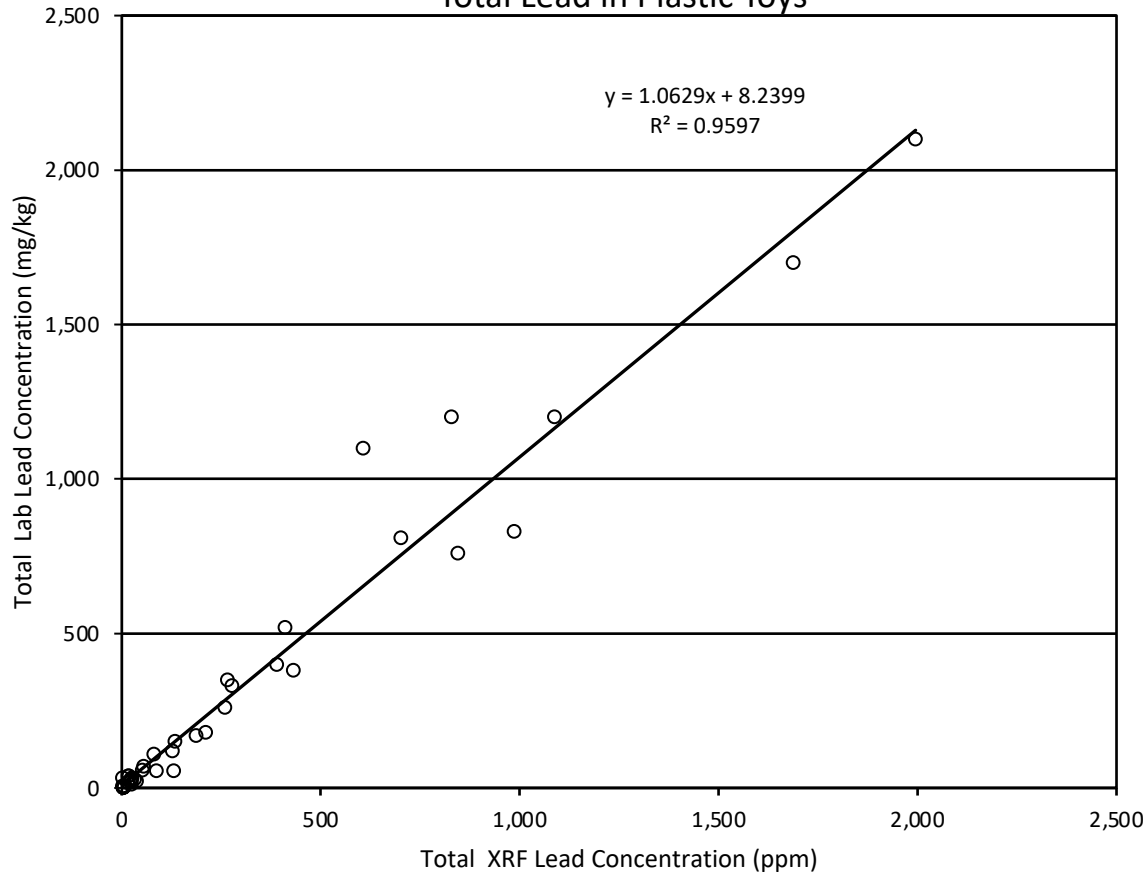
XRF vs. Laboratory Comparison
Total Lead in Plastic Foodware

$y = 0.7503x + 260.26$
$R^2 = 0.7735$

XRF vs. Lab

XRF vs. Laboratory Comparison
Total Lead in Spices

$y = 0.7896x - 1.6465$
$R^2 = 0.9399$

Total Lab Lead Concentration (mg/kg)

Total XRF Lead Concentration (ppm)

XRF vs. Laboratory Comparison
Total Lead in Cosmetics

$y = 0.7819x + 11.912$
$R^2 = 0.7754$

Total Lab Lead Concentration (mg/kg)

Total XRF Lead Concentration (ppm)
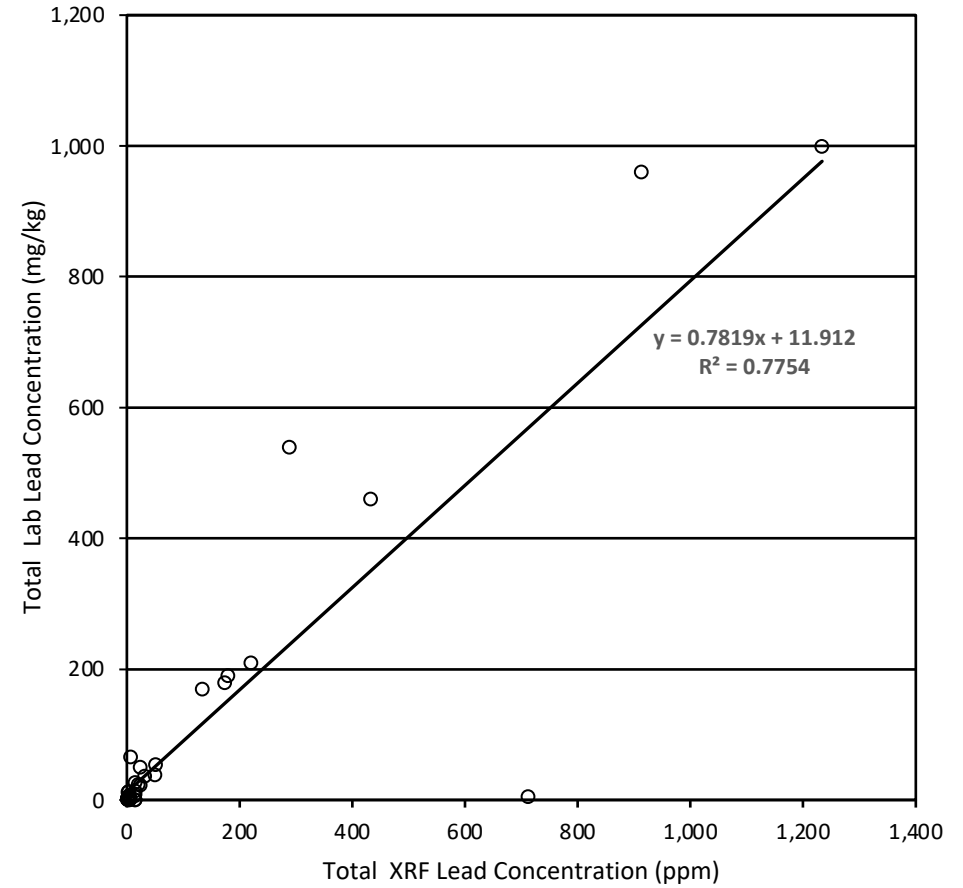
Heterogeneous toy samples from Kyrgyzstan.

Metal interior to a plastic toy from Azerbaijan.