Module C.ii.

Analytical Methods for Measuring Lead in Paint

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Outline

- Reasons for analysing the lead content of paint
- New paint: Options for laboratory analysis of total lead content
- Existing painted surface: Options for analysis of lead content
- Using lead paint analyses to investigate the market for new paints
- Summary, References and Contacts

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Reasons for analysing the lead content of paint

New paint for sale:

- Assess the availability of lead-containing paint in the market and the need for better government regulation and enforcement
- Provide consumers with information so they can choose non-lead paint and can push for government controls on lead paint
- Draw attention to companies that produce lead-containing paint and encourage them to reformulate their products voluntarily

Existing paint on structures:

- Assess potential sources of exposure to lead from existing paint on structures, e.g. in homes, schools and playgrounds, and the possible need for mitigation measures

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Optional methods for measuring lead in paint

New paint prior to use:

1. Laboratory analysis (three methods)
2. High definition portable X-ray fluorescence analysis (HDXRF)

Existing painted surface:

1. Laboratory analysis (three methods)
2. Portable X-ray fluorescence (XRF) analysis (on-site)
3. Chemical test kits (on-site)

The choice of method depends on several factors e.g. the level of accuracy required, the substrate to be tested (new paint or painted surface), the analytical equipment, and the cost.

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Measurement units for test results

Choice of analytical method and measurement unit depends on the reason for the analysis

New paint

Lead paint formulations and regulatory standards for lead in new paint are usually expressed as a percentage (%) or as parts per million (ppm), though some regulatory standards use milligrams per kilogram (mg/kg)

- Laboratory analysis: lead content can be reported in ppm, % or mg/kg
- HDXRF: lead content can be reported in ppm
- 100 ppm = 0.01% = 100 µg/g = 100 mg/kg

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Measurement units for test results

Existing painted surface

Analysis of lead in paint on an existing painted surface may also be reported as the amount of lead per unit area: mg/cm^2. There is no mathematical equivalence between ppm and mg/cm^2

- Laboratory analysis: lead content can be reported in ppm, %, mg/kg or amount per unit area (mg/cm^2)
- Portable XRF analysis (on-site): lead content is reported as mg/cm^2
- Chemical test kits (on-site): lead content is reported as a colour change when the concentration is above a specific threshold

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New paint: Measuring total lead content is preferred over soluble lead content

- Total lead measured by extracting all the lead present in the paint
- Almost all national regulatory standards use total lead content
- Promotes harmonization for exports to countries with total lead standards for products
- Cheap, routine laboratory methods are available and many laboratories can do the measurements
- Provides a more predictable test for manufacturers who have test results from ingredients

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New paint: Measuring total lead content is preferred over soluble lead content

- Soluble lead (migratable lead) content is assumed to simulate the uptake of lead from the gut when lead paint chips or coated objects are swallowed.
- BUT:
  - there is no scientific basis to support this assumption
  - does not take account of exposure of lead in dust from deteriorating paint and does not provide the best measure of potential health risks
- More expensive, more complicated laboratory method is needed
- Technical modifications to paint can hide dangerous lead content, e.g. paint shown to have 13 000 ppm total lead content not detected by soluble lead test (ref 1)

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New paint: Options for laboratory analysis of total lead content

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Laboratory analysis: Three options

Three commonly used methods are (in order of higher to lower limit of detection):

1. Flame Atomic Absorption Spectrometry (FAAS)
2. Graphite Furnace Atomic Absorption Spectrometry (GFAAS)
3. Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

Method 1: Flame Atomic Absorption Spectrometry (FAAS)

- Relatively easy to use and moderate cost
- Needs special gases
- Can be fitted with auto-sampler so multiple samples can be processed
- Limit of detection depends on sample preparation and method used

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Method 2: Graphite Furnace Atomic Absorption Spectrometry (GFAAS)

- Requires skilled laboratory technician
- Needs special gases
- Can analyze very small samples
- Can be fitted with auto-sampler so large number of samples can be run

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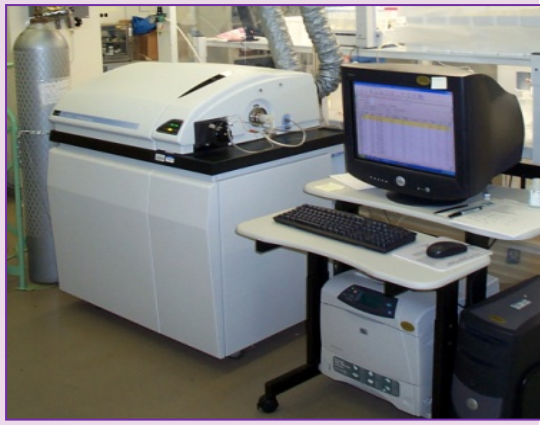
Method 3: Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

- Expensive, with high running costs
  - More economical if used for large sample runs
- Requires highly-skilled laboratory technician
- Very low limit of detection
- Can measure multiple elements from a small sample
- Can determine isotope ratio, which may help to identify the source of the lead



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Laboratory analysis: Quality considerations

- Trained personnel and good quality assurance procedures are essential to ensure accuracy and reliability of results
- Laboratory should participate in a proficiency-testing scheme, e.g. the Environmental Lead Proficiency Analytical Testing (ELPAT) program (ref 2)
- International standards exist for sample preparation and analysis (see following slides)

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International standards for sample preparation

- **ISO 1513**, Paints and varnishes - Examination and preparation of test samples (ref 3)
- **ASTM E1645-01**, Practice for Preparation of Dried Paint Samples by Hotplate or Microwave Digestion for Subsequent Lead Analysis (ref 4)
- **ASTM E1979-12**, Practice for Ultrasonic Extraction of Paint, Dust, Soil, and Air Samples for Subsequent Determination of Lead (ref 5)

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International standards for test methods

- **ISO 6503**, Paints and varnishes - Determination of total lead - flame atomic absorption spectrometric method (for measurement of lead concentration of 0.01% to 2.0%) (ref 6)
- **ASTM D3335-85a(2014),** Standard test method for low concentrations of lead, cadmium, and cobalt in paint by atomic absorption spectroscopy (for measurement of lead concentration of 0.01% to 5.0%) (ref 7)
- **ASTM E1613-12**, Standard Test Method for Determination of Lead by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Flame Atomic Absorption Spectrometry (FAAS), or Graphite Furnace Atomic Absorption Spectrometry (GFAAS) Techniques (measurement of lead concentration differs according to analytical technique) (ref 8)

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Considerations when choosing a laboratory

- Laboratory's experience in lead paint analysis
- Accreditation through a recognized proficiency testing scheme
- Analytical methods used (e.g. FAAS, GFAAS, ICP-AES)
- Limit of detection
- Costs per sample, including any shipping costs
- Specific sample requirements that the chosen laboratory may have
- Turn-around time

High-definition portable X-ray fluorescence analysis

- New technology that can measure very low concentrations of lead
- Lead concentration can be reported as ppm
- Suitable for compliance testing of new paints
- Samples should prepared on a metal free homogeneous substrate, e.g. wood
- But: very few models available, expensive to buy

(For information on standard portable XRF see later slides)

Existing painted surface: Options for off-site and on-site analysis of lead content

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Painted surfaces: Options for measuring lead content

1. Laboratory analysis (off-site)

2. Portable X-ray fluorescence (XRF) analysis (on-site)

3. Chemical test kits (on-site)

Option 1: Laboratory analysis for existing painted surfaces

- Samples should be taken by trained personnel to ensure samples are adequate
- When taking a paint chip sample from a painted surface:
  - paint must be removed from the underlying material, i.e. it is necessary to damage the painted surface
  - it is important to remove a precisely-measured area of paint
- Paint sample must be prepared (e.g. by acid digestion) before analysis
- Laboratory analysis takes additional time compared to on-site analysis
- See previous slides on new paint for information on laboratory test methods, standards, and considerations for choosing a laboratory

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Option 2: Portable XRF

- Uses a radiation source or x-ray tube to detect and measure lead (radiation and x-ray safety precautions should be followed)
- Should be used by a trained operator to ensure reliable results
- Not all XRF devices are suitable for measuring lead in paint – check before using
- Equipment is relatively expensive but is more practicable for measuring a large number of surfaces than laboratory analysis

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Option 2: Portable XRF (continued)

- Tested surface does not need to be damaged
- Results are available immediately
- Good accuracy when used by a trained operator, though there is a larger margin of error than with laboratory methods
- Can only be used on smooth, flat surfaces
- Suitable for dry paint but not wet paint

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Option 3: Chemical test kits

- Qualitative test for lead paint on walls or other surfaces
- Relies on a colour change to indicate the presence of lead above a specified concentration, e.g. 5000 ppm
- Test gives rapid results
- Note: Some kits have a high rate of false positives or false negatives

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Option 3: Chemical test kits (continued)

- Two types of chemical test kits:

  1. Swab impregnated with reagents – wiped against painted surface, and colour changes after seconds to minutes

  2. Test-tube with reagents – place paint chip in tube to mix with reagent

- Only tests the exposed layer (to test underlying layers of paint, score or scrape off the surface paint)

- Special procedure may be needed for certain surfaces, e.g. plaster

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Using lead paint analyses to investigate the paint market

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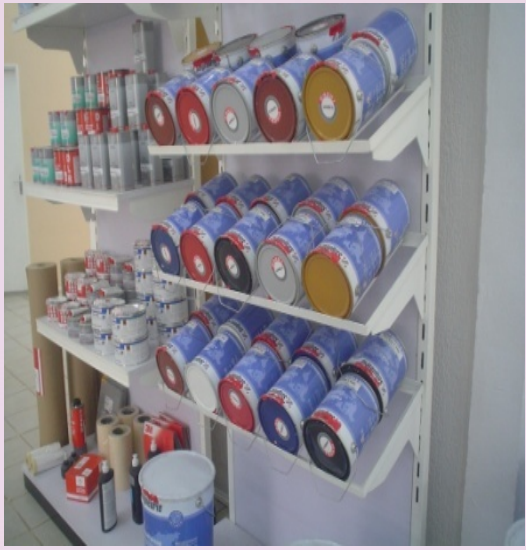
Conducting a market survey of lead content in new paint for sale

- Provides information about the extent of the problem that lead paint presents in a country and the need for regulatory or enforcement measures.
- Important to ensure that tested products are representative of all major brands and include a range of colors:
  - brightly colored paints, e.g. yellow, red, orange, green, typically contain the highest levels of lead
  - include low-lead colours such as white in the range
- Useful to link data about lead content of paints to information about the manufacturers selling paint on the national market



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Linking analytical data to paint market information

- Relevant information includes:
  - available brands on the market, both locally-produced and imported products
  - size of manufacturer and relative sales volume
  - information on paint-can labels about ingredients, hazard warnings about lead, or statements indicating low lead content

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Linking analytical data to paint market information (continued)

- This information can be used:
  - as evidence when enacting and enforcing regulations on production, export / import, sales and use of paint with added lead
  - to show the need to include a labeling requirement in the regulation
  - in outreach to industry stakeholders for dialogue about regulatory controls on lead paint
- More information is available
  - More detail on how to conduct a market survey is found in a 2013 UNEP/IPEN report (ref 9)
  - See Module F of the toolkit for paint study results in developing countries

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Summary

- Choice of analytical method to measure lead in paint depends on many factors, such as the reason for analysis, number of samples, cost limitations, need for precise measurement, etc
- For new paint, three good laboratory methods are available that vary in cost and level of detection
- For existing painted surfaces, measurement methods include off-site laboratory analyses plus two on-site tests that vary in cost and accuracy
- Market surveys of new paints for sale are used to determine the availability of lead paint and can provide evidence to justify regulation and to monitor compliance

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References

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3. ASTM D3335-85a (2014), Standard Test Method for Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy, ASTM International, West Conshohocken, PA (http://www.astm.org/Standards/D3335.htm, accessed 25 July 2017)

4. ASTM E1613-12, Standard Test Method for Determination of Lead by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Flame Atomic Absorption Spectrometry (FAAS), or Graphite Furnace Atomic Absorption Spectrometry (GFAAS) Techniques, ASTM International, West Conshohocken, PA (http://www.astm.org/Standards/E1613.htm, accessed 25 July 2017)

5. ASTM E1645-01 (2007), Standard Practice for Preparation of Dried Paint Samples by Hotplate or Microwave Digestion for Subsequent Lead Analysis, ASTM International, West Conshohocken, PA (http://www.astm.org/Standards/E1645.htm, accessed 25 July 2017)

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6. ASTM E1979-12, Standard Practice for Ultrasonic Extraction of Paint, Dust, Soil, and Air Samples for Subsequent Determination of Lead, ASTM International, West Conshohocken, PA (http://www.astm.org/Standards/E1979.htm, accessed 25 July 2017)

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9. Lead in Enamel Decorative Paint: National Paint Testing Results: A Nine Country Study (method described in pages 36-38). Nairobi: United Nations Environment Programme; 2013 (http://www.unep.org/chemicalsandwaste/sites/unep.org.chemicalsandwaste/files/publications/Lead_in_Enamel_decorative_paints.pdf, accessed 25 July 2017)

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Additional information

Brief guide to analytical methods for measuring lead in paint (available in Chinese, English, French and Spanish). Geneva: World Health Organization; 2011 (http://www.who.int/ipcs/assessment/public_health/lead/en, accessed 25 July 2017).

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Point of Contact

Joanna Tempowski
Department of Public Health, Environmental and Social Determinants of Health
World Health Organization
20 Avenue Appia
1211-Geneva 27
Switzerland
Email: tempowskij@who.int

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