GREEN TREATMENTS & THEIR ASSESSMENT: OBJECTS

INSTRUCTIONAL INFORMATION

The following module template has been developed as part of Work Package 7 of the EU-funded GoGreen project. The module is designed in a skeletal format to allow for broad adaptation to a wide range of existing curricula and professional development schemes. To enhance flexibility, the module is divided into theme blocks with suggested content, assessments, and activities. The template has been constructed to serve as foundational material for curriculum development or course integration.

INTENDED AUDIENCE

This module may be adapted for the instruction of conservation and conservation science learners at the undergraduate, postgraduate, and professional level with a focus on metals and glass objects. The activities and assessments of this module are developed for a group audience.

MODULE DELIVERY

This module is best suited for in-person, practical instruction. Content in this module will be delivered using a case study. Throughout the module learners will:

- Conduct tests on their case study using various cleaning and stabilization materials and methods
- Observe and record the effects of the different materials and methods
- Utilize analytical techniques and simple-assessment approaches to assess, compare, and evaluate the effectiveness of cleaning and stabilization methods

PRE-REQUISITE KNOWLEDGE

Prior to the module, learners should be prepped with the following skills and knowledge which may be acquired from previous coursework or through complementary GoGreen modules:

1. Knowledge of the foundational principles for object conservation and the chemical and physical attributes associated with the deterioration of objects both from a material science perspective and a conservation perspective.
2. Awareness of polices, frameworks, and methodologies within the cultural heritage sector that may be applied to the remedial conservation of objects. Supported by the GoGreen module ***Leadership in Green Conservation***
3. Knowledge of the GoGreen definition for green conservation and green parameters, and the Green Decision-Making Model (DMM). Supported by the GoGreen module ***Leadership in Green Conservation***
4. Knowledge of the tools and frameworks used for understanding object stability and risks to make informed green decisions. Supported by the GoGreen module ***Determining Material Sensitivities and Green Decision-Making***

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MISSION STATEMENT

To empower students and professionals to make informed green(er) choices in their personal practice by integrating tools, metrics, and guidelines for selecting and evaluating materials and methods for the remedial conservation of objects.

DESCRIPTION

Green Treatment and Their Assessment: Objects explores the green frameworks, tools, and guidelines relevant for the selection and application of green(er) materials and methods for the conservation of objects. The content emphasizes conservation methods for the cleaning of metals, and stabilization of metal and glass objects developed within the GoGreen project and broader EU-funded Green Cluster. The content emphasizes efficacy, safety, and ethical considerations of these materials and methods, and demonstrates how the frameworks and tools may be applied to other remedial conservation practices.

Content is delivered through practical, case study-based learning, supporting student-centred development of both theoretical and practical skills. Learners are encouraged to apply green thinking to their own conservation practice or a selected case study, reflecting on the practicalities, challenges, and limitations of sustainable approaches in real-world contexts.

LEARNING GOALS AND OUTCOMES

Main Goal Provide conservation researchers and conservators with the knowledge and practical tools needed for the development, assessment and use of green(er) approaches for the conservation of objects

Subsidiary Goals

- Develop an understanding of tools, metrics, and guidelines that inform green(er) decision-making for the conservation of objects
- Examine new materials and techniques used for the remedial conservation of objects and their comparative performance against commonly used materials in terms of the green parameters
- Evaluate the efficacy of cleaning and stabilization practices utilizing new techniques and technologies from the GoGreen project
- Develop practical knowledge of cleaning and stabilization approaches through the application of assessment strategies and the green parameters.

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By the end of this module,

Learning Outcomes

1. *(**Evaluation**)* Evaluate the 'greenness' of materials used in the cleaning and stabilization of objects by applying the *Green Parameters and Frameworks:* (1) Globally Harmonized System (GHS), (2) Life-Cycle Assessment (LCA), (3) Safe and Sustainable by Design principles, and (4) Guidelines.
2. *(**Comparison**)* Compare cleaning and stabilization strategies used in the remedial conservation of objects, considering their impact through a holistic approach aligned with the green parameters.
3. *(**Assessment**)* Gain knowledge of new analytical techniques and simple assessment approaches to assess treated surfaces to compare and evaluate different applications and materials for the cleaning and stabilization of objects.
4. *(**Reflection**)* Demonstrate theoretical and practical competency in reflecting on the selection and application of green(er) cleaning and stabilization methods for object conservation by discussing the processes, decisions, and outcomes involved in their application on a case study.

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RECOMMEND READINGS

Visit the GoGreen Zenodo for the full module bibliography

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Glass

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GREEN TREATMENTS AND THEIR ASSESSMENT: OBJECTS

THEME	TOPICS	DESCRIPTION	LEARNING OUTCOMES	ACTIVITIES + ASSESSMENTS
Foundation and Tools for the Green Conservation of Objects	*Green Frameworks and Tools for Sustainable Decision-Making (1)*	Introduces green conservation, the green frameworks, and practical tools for sustainable decision-making in object conservation.	Evaluate the 'greenness' of materials used in the cleaning and stabilisation of objects by applying the Green Parameters and Frameworks: (1) Globally Harmonized System (GHS), (2) Life-Cycle Assessment (LCA), (3) Safe and Sustainable by Design principles, and (4) Relevant Guidelines.	**Activity/Assessment:** Using relevant green frameworks and tools, evaluate the 'greenness' of a conservation material commonly used within personal context and present findings. **Activity/Assessment:** Choose and use a tool for green(er) decision-making on a provided case study for the remedial conservation of objects. Consider the appropriateness of the treatment using a holistic approach aligned with the green parameters.
Green Treatments for Metals	*Materials and Methods for Cleaning (2) and Stabilisation (3)*	Explores green(er) advancements in the materials and methods for cleaning and stabilising metals, and how they compare to traditional approaches.	Compare cleaning and stabilisation strategies used in the remedial conservation of objects, considering their impact through a holistic approach aligned with the green parameters.	**Activity:** Investigate 1-2 newly identified materials and methods for the cleaning and stabilisation of metals and create a concise properties profile that includes the key physical/functional properties, toxicity and hazard metrics, and LCA considerations. Exchange with fellow students to identify how chosen materials and methods compare against commonly used benchmark treatments.
	Practical Application of Cleaning (4) and Stabilisation (5) Materials and Methods	Practical focused on the application of new materials and methods highlighted in the Green Cluster and on-going innovations for the remedial conservation of metals. Utilises suggested module delivery for instruction.		**Activity:** *Apply a chosen material or method identified in previous activity on a case study. Exchange with fellow students and identify how materials and methods compare against commonly used approaches. Consider effective communication strategies for presenting the full profile to broader class, for example such as star diagrams.*
Green Treatments for Glass	*Materials and Methods for Stabilisation (6)*	Explores green(er) advancements in the materials and methods for the stabilisation of glass and how they compare to traditional approaches. .	Compare cleaning and stabilisation strategies used in the remedial conservation of objects, considering their impact through a holistic approach aligned with the green parameters.	**Activity:** Investigate 1-2 newly identified materials and methods for the stabilisation of glass objects and create a concise properties profile that include the key /functional physical properties, toxicity and hazard metrics, and LCA considerations. Exchange with fellow students to identify how chosen materials and methods compare against commonly used benchmark treatments.
	Practical Application of Stabilisation Materials and Methods for Glass (7)	Practical session focused on the application of new materials and methods highlighted in the Green Cluster and on-going innovations for the remedial conservation of glass objects. Utilises suggested module delivery for instruction.		***Activity:*** *Apply a chosen material or method identified in previous activity on a case study. Exchange with fellow students and identify how materials and methods compare against commonly used approaches. Consider effective communication strategies for presenting the full profile to broader class, for example such as star diagrams.*

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GREEN TREATMENTS AND THEIR ASSESSMENT: OBJECTS				
THEME	TOPICS	DESCRIPTION	LEARNING OUTCOMES	ACTIVITIES + ASSESSMENTS
Testing and Monitoring of Treated Surfaces	*Introduction to Assessment Techniques for the Evaluation of Cleaning and Stabilisation Strategies (8)*	Introduces new analytical techniques and simple assessment methods developed for the evaluation of cleaning and stabilisation methods.	Gain knowledge of new analytical techniques and simple assessment approaches to evaluate treated surfaces and compare the effectiveness of different materials and applications for the cleaning and stabilisation of objects.	**Activity/Assessment:** Present on a specific key risk, benefit, or limitation of 1 to 2 analytical techniques or simple assessment methods. **Activity:** Explore when and how new analytical techniques can be applied using green parameters and assess their added value in treatment or research. Reflect on how these techniques and methods can become part of your own conservation toolbox.
	Practical Application of Assessment Techniques (9)	Practical session focused on the application of assessment techniques highlighted in the Green Cluster and on-going research. Utilises suggested module delivery for instruction.		**Activity:** Apply available monitoring and assessment techniques onto case studies to evaluate the efficacy of materials and methods. Expand the properties profile created in earlier activities to include the efficacy of the materials and application methods. **Assessment:** Present full properties profile using visual communications strategies.
Conservation Practice	*Putting into Practice (10)*	Provides learners with the opportunity to apply new knowledge to personal context by integrating green(er) thinking into existing conservation practice or on a case study and assessing the practicalities and limitations.	Demonstrate theoretical and practical competence in reflecting on the selection and application of green(er) cleaning and stabilisation methods for object conservation by analysing the processes, decisions, and outcomes within a case study.	**Activity/Assessment:** Present on a case study **i**dentifying strategies for integrating green(er) strategies in one's professional practice. Analyse the practicality and limitations of suggested strategies in real world contexts. **Activity/Assessment**: Create a mood board for a personal mission statement. **Activity: Group discussion** How can different stakeholders contribute to greener decision-making within the complexities of cultural heritage conservation?

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DISCLAIMER

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AUTHORS AND CONTRIBUTORS

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Additionally, we would like to thank the broader conservation community for collaborating in the development of the module templates through inputs and feedback via workshops, surveys, and focus groups. For more details on the list of contributors see the project deliverable 7.1 report.

1. Green Frameworks and Tools for Sustainable Decision-Making in Object Conservation

Authors: Gwendoline Fife, Julia Wagner, Edith Joseph, Sky-Lyn Munoz

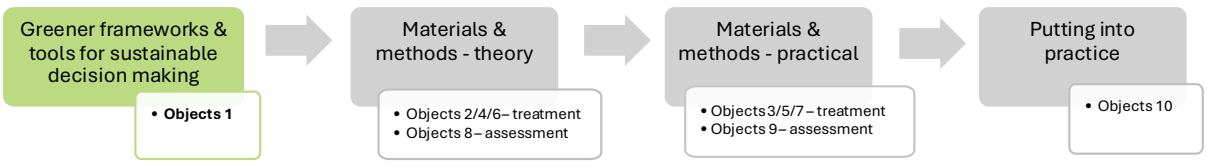
This session introduces the definition of green conservation and parameters defined by GoGreen and explores frameworks, tools, and guidelines for green decision making in the conservation of metal and glass objects. This module can also be adapted to other specialisations.

Key Concept 1	***LCA and Hazard Assessments***
Key Concept 2	***Safe and Sustainable by design***
Key Concept 3	***Green Conservation Definition and Parameters***
Key Concept 4	***Sustainable Decision-Making (applying parameters in practice)***

OBJECTIVES

Objective 1	Familiarity with the definition of green conservation, 14 green parameters and the decision-making model developed in GoGreen.
Objective 2	Awareness of the supporting frameworks and tools for the implementation of green conservation (according to definition, parameters and decision-making model).
Objective 3	To apply green conservation frameworks to an example of decision-making in an assessment for an interventive treatment and/or in the preventive conservation of an object.
Objective 4	To develop the technical language and general communication skills (verbal and written) to discuss the rationale behind conservation decisions.

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

Green conservation summary report. Fife, G. R., Wagner, J., Goncalves, B., Southwick, C., & Keune, K. (2025). Zenodo. https://doi.org/10.5281/zenodo.16980962)

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Practitioner-tested Decision Model, Taylor, J. (available on GoGreen Zenodo)

Frameworks & guidelines: Sustainability, Sustainability development goals, Globally Harmonized System (GHS), Life-Cycle Assessments (LCA), (LCC), (3) Safe and Sustainable by Design principles, green heritage science, BIZOT

Tools: GoGreen DSA, STiCH, HERiE, GCC calculator, Our Collections Matter.

SESSION OUTLINE (total 2 hours)

Introduction (60 minutes)

- Introduce the green conservation definition and explore the 14 green parameters developed in GoGreen (from a sustainability perspective and with an LCA-based approach);
- Explore decision-making according to parameter impact categories and specific context;
- Examine metrics and frameworks for assessments: Life cycle assessments; Safe and sustainable by design (discusses circular economy, energy consumption, health and safety); Globally harmonized system (GHS); principles of green chemistry and green heritage science

Tools (60 minutes)

- Tools supporting sustainable decision-making:
    - GoGreen Digital Support App (DSA): prototype app developed within GoGreen which aims to provide metrics for conservation treatments based on the GoGreen green parameters;
    - GoGreen DMM (decision-making model);
    - GHS hazard databases (e.g. ECHA) and GHS-based approaches (e.g. Chem21);
    - STiCH: utilizes an LCA approach to provide carbon footprint data for commonly used conservation materials;
    - GCC calculator;
    - HERIe;
    - Our Collections Matter (toolkits https://ocm.iccrom.org/);
    - Other treatment specific assessment tools aligned with parameters (safe efficacy)

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- Guidelines
  - 12 principles of Green Chemistry
  - Conservation ethics guidelines (ICCROM, E.C.C.O, ICOM, ICON, AIC guidelines for conservation practices)
  - BIZOT

Activity (2-3hr session)

Individual activity (or in pairs): Using relevant green frameworks and tools, evaluate the 'greenness' of 2 options in an interventive conservation treatment they have recently carried out on glass or metals (cleaning or stabilization treatments) or a preventive approach (e.g. digital accessibility vs travelling for exhibition). Choose and use tool(s) for the green(er) decision-making. Consider the appropriateness of the treatment using a holistic approach aligned with the green parameters.

***Group activity*:** Each individual (or group of two) presents a 10-minute summary of their specific assessment of the green parameters to compare the potential treatment/approach options holistically. They can also potentially provide a rationale for focussing on a specific impact category (i.e. hazards/energy/resources) alongside professional parameters.

Group discussion: What was found particularly challenging/what were the encountered barriers? Is there general in agreement among colleagues' choices? If not, why not (how much does the context/comparative nature/regional focus/specific or personal factors impact the decision?)

Summary / wrap-up (5–10 minutes)

Summary of main points from group discussion.

METHODOLOGY

Delivery format Blended approach. The session will comprise an initial lecture with PowerPoint presentation, then practical exercises, followed by discussions.

Activities / Exercises / Assessments

By the end of the activity, learners will:

- Have a basic knowledge and understanding of the frameworks and tools for assessing sustainable decision-making in the conservation of objects.
- Apply decision-making and sustainability frameworks and tools to assess their approaches and choices in real-world conservation contexts.

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- Collaborate and communicate findings effectively through discussion and analysis of comparative profiles.

Materials:

- Computer for digital documentation and sharing (if possible, using assessment tool data for displaying results),.
- Reference data (e.g. toxicity/hazard metrics, and LCA information from above tools and databases),
- Video projector.

Tasks:

- Application of decision-making tools to assess approaches and choices,
- Compile material profiles (where relevant) related to the impact categories (e.g. hazard metrics, energy, resources, cultural heritage),
- Reflection on priorities when selecting green(er) alternatives.
- Discuss findings with peers and assess practical applicability in conservation contexts.

Questions:

- What was found particularly challenging/what were the encountered barriers?
- Is there general agreement among colleagues' choices? If not, why not (how much does the context/comparative nature/regional focus/specific or personal factors impact the decision?)
- How do factors like accessibility, cost, material compatibility, and limitations affect the choices?

Discussion and Analysis:

- As a group discuss findings, compare comparative profiles, and reflect on the practical applicability and compromises in real-world conservation contexts.

Facilitator Notes

Prepare some case studies in advance in case examples are needed.
Webinar links from GoGreen: https://www.youtube.com/@GoGreenConservation

ADDITIONAL RESOURCES

- STiCH Access Link: https://stich.culturalheritage.org/
- Starters Manual (see **Appendix 1.1**)
- Green Conservation Summary Report
- DSA APP
- Safety Information: Globally Harmonized System of Classification and Labelling of Chemicals, ACS
  Access Link: https://youtu.be/xtacgd3RXWo?feature=shared

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- Safe and sustainable by design: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/chemicals-and-advanced-materials/safe-and-sustainable-design_en

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APPENDIX 1.1

Starters Guide to Using the 14 Green Parameters

Gwendoline Fife, Momoko Okuyama, Julia Wagner[1]

As a conservator, you hold a uniquely positive and powerful role: preserving human history while supporting a sustainable future. However, navigating the complexities of the climate crisis in your daily practice can feel overwhelming. The good news is that you do not need to be perfect, and you do not need to do everything at once. The green conservation framework is designed to be an encouraging, practical compass rather than an administrative burden.

To help you integrate sustainability into your work, the GoGreen project identified 14 Green Parameters for conservation grouped into four big-picture areas: Health and Environment (toxicity), Climate Change (energy), Resources (waste and water), and Cultural Heritage (professional efficacy and ethics). The parameters encourage you to weigh these environmental factors holistically alongside the safety and needs of the artwork (Parameters G9–G14), ensuring your preservation goals are never compromised[2].

For instance, the green parameters can be put into practice through two activities: **collecting comparative data and information** on the parameters e.g. for different suitable materials, equipment and treatment approaches; and **examining this information for assessing** selections, decision-making and potential advocacy from a holistic sustainability perspective.

To familiarize yourself with the parameters, you may find it easiest to begin with a comparison between two intervention options that achieve the same conservation goals.

Here is a starter's guide to using them with balance, nuance, and positivity.

1. Start Where You Are (And Start Small) You do not need to overhaul your entire studio overnight. Begin simply by pausing to reflect on a current activity. For a practicing conservator, the most direct and empowering point of leverage is often right at the bench with your material selection. Look at Parameters G1 and G2 (Toxicity and hazards). Can you swap a highly hazardous, petroleum-based solvent for a safer alternative? While the carbon footprint of conservation materials might only make up

[1] Google Notebook (off-line AI tool) helped generate this document based solely on original source material developed in the GoGreen project.

[2] A full description of these parameters can be found on the GoGreen website, on GoGreen's Zenodo page and in Fife, G. R., Turrina, A., Wagner, J., Del Curto, D., Southwick, C., & Keune, K. (2025). *Defining Green in the Conservation of Cultural Heritage*. [Manuscript accepted for publication by Studies in Conservation]. https://doi.org/10.1080/00393630.2026.2653274

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1% of an activity's total impact, choosing less toxic materials drastically improves your immediate health and local environment, turning climate anxiety into positive, tangible action.

2. Embrace Nuance and Balance A crucial secret to green conservation is acknowledging that "100% green" simply does not exist. Sustainability is always a comparative, consultative process full of trade-offs. You might find a bio-based material that is great for reducing impacts on the environment, but it might take a relatively excessive amount to achieve the preservation goals. Because this is a cyclical process, if a greener option isn't viable today due to budget or time constraints (Parameter G13), simply note the barrier and try again on the next project.

3. Look Up From the Bench to the Bigger Picture While your bench work is vital, the parameters also help you map your influence onto larger systems. Energy consumption for indoor climate control (Parameter G3) is one of the sector's biggest impacts. You can leverage your specialized knowledge to advocate for greener institutional policies. For example, by using your understanding of material stability, you can confidently advise curators or registrars to widen evidence-based relative humidity tolerances for museum loans, or advocate for microclimate boxes instead of room/building-level climate control. This shifts your influence from the operational level (the bench) to the strategic level, massively reducing your institution's HVAC energy burden.

Ultimately, using the 14 parameters aligns with a scientific attitude—a willingness to ask questions, test new empirical evidence, and openly communicate with your peers. By integrating these nuanced reflections into your daily routine, you actively drive the conservation profession toward a resilient and greener future.

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2. Green Treatments for Metals: Materials and Methods for Cleaning

Authors: Sky-Lyn Munoz, Qing Wu, Edith Joseph

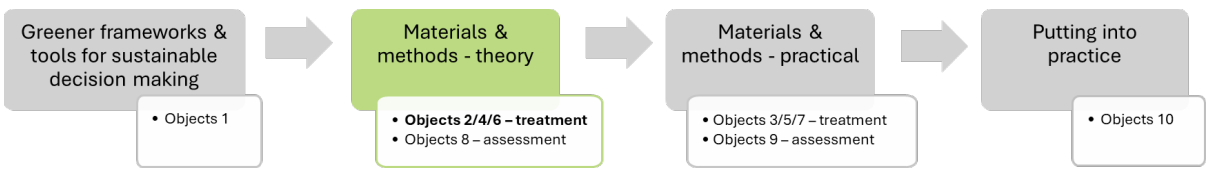
This session introduces current advancements in greener treatment methods for the cleaning of metals, presenting sustainable strategies for historical metal conservation. It explores the use of bio-sourced microbial metabolites, greener complexing agents, and nonwoven microfibre- and gel-based delivery systems as alternatives to traditional, hazardous cleaning methods. Case studies are included to demonstrate practical applications and to compare greener approaches with conventional protocols.

Key Concept 1	**Cleaning traditional methods (including abrasive, chemical and electrochemical)**
Key Concept 2	**Complexation using bio-degradable agents (including EDDS, DFO, saponin, and cysteine)**
Key Concept 3	**Controlled cleaning using hydrogels, especially flexible gel systems for localised cleaning**
Key Concept 4	**Use of deep eutectic solvents and nonwoven microfibres for extended and controlled cleaning applications**

OBJECTIVES

Objective 1	Recognise the possible impacts of traditional cleaning approaches for metals
Objective 2	Gain knowledge of greener strategies developed in GoGreen and their cleaning mechanisms.
Objective 3	Demonstrate microbial-based stabilization procedures using case-study presentation (PowerPoint)
Objective 4	Evaluate the applicability of bio-based treatments in real conservation contexts, including sustainability considerations

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

- Basic understanding of corrosion processes in metals (silver, copper and iron alloys)
- Familiarity with common conservation cleaning approaches
- Introductory awareness of sustainability frameworks in conservation practice (recommended)

SESSION OUTLINE (total 2 hours)

1. Overview of traditional cleaning approaches and their limitations (15 minutes)
   - Abrasive, chemical, and electrochemical cleaning methods
   - Benchmark methods used in conservation practice

Metal type	First benchmark	Second benchmark
Silver (lightly tarnished)	Hagerty silver polish cloth	Thin $CaCO_3$ slurry
Silver (strongly tarnished)	Slurry made from lab-grade $CaCO_3$ powder in deionized water/1 % Triton X100	Hagerty silver polish or silver dips
Copper	0.5 M EDTA solution of pH 10	Slurry made from $CaCO_3$ or Silitin N82 in paraffin oil or Shellsol T
Brass	0.03 M EDTA solution of pH 10	
Iron/steel	Fine steel wool (00000 quality); fine Al_2O_3 particles mixed paraffin oil or Shellsol T	5% w/v EDTA solution, not pH adjusted

   - Discussion of environmental, health, and safety concerns

2. Presentation of green(er) cleaning strategies developed in GoGreen (60 minutes)
   - Biodegradable complexing agents (EDDS, DFO, cysteine, saponin) and their cleaning mechanisms
   - Controlled and localised cleaning using flexible hydrogel systems (e.g., XKA gels)
   - Introduction of deep eutectic solvents and nonwoven microfibre / electrospun delivery systems
   - Review case studies

3. Evaluation and comparison against benchmark (40 minutes + to be completed in following sessions about practical application)
   - Discussion of the advantages and disadvantages of each cleaning protocol
   - Completion of concise properties profile sheets.

Case Study / Example

- Presentation of examples where greener metal cleaning methods have been applied
- Presentation of examples where greener cleaning approaches are compared to traditional ones

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Summary / Wrap-Up (5–10 minutes)

Recap of key points

- main advantages of bio-based cleaning compared to traditional treatments
- The relevance of delivery systems (gels, microfibres, DES) for controlled cleaning

Discussion prompts

- What barriers exist to wider adoption of greener methods?
- What are the current limitations or risks of bio-based conservation methods?
- Are there cases where green(er) approaches may not be applicable? Why? (e.g. lack of availability)
- Discussion on scalability and practical implementation in museum contexts

METHODOLOGY

Delivery Format The session is delivered through a blended approach combining lecture-based presentations and guided discussion. Participant questions and feedback are addressed throughout and at the end of the session.

Activities / Exercises / Assessments

Activity 1: Theory Session

- Presentation of current challenges in traditional conservation of historical metals, highlighting limitations of conventional methods
- Introduction of greener cleaning methods for silver, copper and iron alloys,

Purpose: build conceptual understanding of sustainable alternatives in metal cleaning

Activity 2: Discussion and Evaluation

- Group discussion based on presented case studies and theoretical content
- Address participant questions and clarify scientific principles
- Collect feedback on applicability, challenges, and sustainability perception in practice

Purpose: reinforce knowledge transfer and encourage critical reflection

Duration: 1.5-2hours

Materials required: Presentation slides, online evaluation forms, QR code for feedback collection. **Appendix 2.1** (alternative: printed evaluation forms).

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Facilitator Notes

General Guidance:

- Keep the session interactive, encouraging questions and discussions.
- Emphasise the connection between green conservation frameworks discussed in previous sessions or that can be learned from taking the GoGreen module *Leadership in Green Conservation*
- Remind participants that "green does not necessarily mean new"—some green(er) alternatives build on established methods.

Recommended Discussion Points:

- What factors most influence the choice of cleaning approaches (e.g., safety, environmental impact, corrosion type)?
- What are the principles behind the greener cleaning approaches developed in the GoGreen project. Participants should be encouraged to ask questions to clarify the concepts before moving to the practical activities.

Resources Required:

- PowerPoint slides with key concepts and visual examples.
- Worksheets or digital templates (Padlet) for the activity.
- Reference data (e.g., physical properties, toxicity/hazard metrics, and LCA information).
- Reference bibliography for participants to consult.
- Whiteboard or interactive whiteboard/projector for group discussion notes.

Tips for Facilitator:

- Use real examples where possible to make concepts concrete.
- Tailor the concepts to participants' backgrounds (e.g., conservators, heritage scientists).
- Reserve sufficient time for evaluation and feedback
- A follow-up reminder email is recommended

ADDITIONAL RESOURCES

- GoGreen Deliverable 3.2: Benchmark performances of cleaning methods
- Literature on biodegradable complexing agents (EDDS, DFO) in conservation
- Research on gel-based delivery systems for metal cleaning
- Studies on deep eutectic solvents in cultural heritage conservation
- Publications on electrospun microfibres and controlled cleaning applications

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APPENDIX 2.1 Concise Properties Profile Template (Pre-Monitoring Version)

Materials & Methods Sessions (Metals Cleaning / Metals Stabilisation / Glass Stabilisation)

Group: _____ **Date:** _____
Material / Method: _____
Object / Surface Type: ☐ Metal ☐ Glass
Metal/Glass type (if known): _____
Target issue (tarnish/corrosion/leaching/chlorides/etc.): _____
Benchmark method for comparison: _____

1) Treatment Description

Treatment category: ☐ Cleaning ☐ Stabilisation ☐ Coating/Consolidation
Active component(s): _____
Delivery system: ☐ Liquid ☐ Gel ☐ Microfibre ☐ Immersion ☐ Spray ☐ Other: _____
Typical working conditions (pH, concentration, time): _____

2) Physical / Functional Properties

Property	*Notes / Expected Values*
Solubility / miscibility	
pH range	
Stability / storage	
Selectivity / mechanism	
Ease of application	☐ Easy ☐ Moderate ☐ Difficult
Residue risk (expected)	☐ Low ☐ Med ☐ High
Compatibility with mixed materials	☐ Good ☐ Uncertain ☐ Poor

3) Toxicity & Hazard Metrics (GHS / SDS-Based)

Known GHS classification: ☐ Yes ☐ No
Main risks: ☐ Irritant ☐ Corrosive ☐ Toxic ☐ Sensitiser ☐ Flammable ☐ Other: _____
Human health risk: ☐ Low ☐ Med ☐ High
Environmental hazard risk: ☐ Low ☐ Med ☐ High
PPE required: ☐ Gloves ☐ Goggles ☐ Mask/Respirator ☐ Ventilation

4) Sustainability / LCA Considerations (Estimated if needed)

Indicator	Low	Med	High
Renewable / bio-based origin	☐	☐	☐
Biodegradability potential	☐	☐	☐
Expected waste volume	☐	☐	☐
Solvent/VOC contribution	☐	☐	☐
Energy/resource demand	☐	☐	☐
Availability / sourcing burden	☐	☐	☐

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Main sustainability advantage: _____
Main sustainability concern/trade-off: _____

5) Expected Performance (Pre-Test Prediction)

Expected effectiveness: ☐ Low ☐ Med ☐ High
Key expected benefit: _____
Key expected limitation / risk: _____

6) Benchmark Comparison (Quick Rating)

Category	Green(er) Method	Benchmark
Safety	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Sustainability	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Expected efficacy	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Practical feasibility	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse

7) Notes / Sources

Data sources used: ☐ SDS ☐ GoGreen deliverable ☐ Paper ☐ Lecture notes ☐ Other: _____

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3. Green Treatments for Metals: Practical Application for Cleaning

Authors: Patrycja Petrasz, Edith Joseph

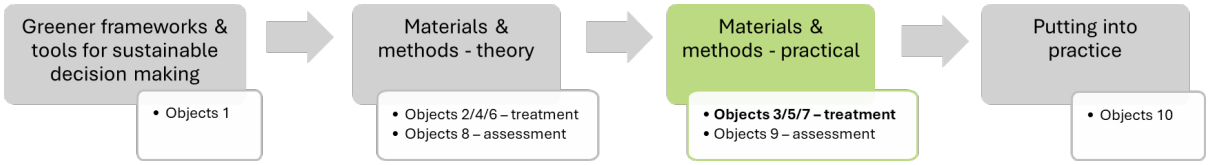
This practical session presents greener approaches for the cleaning of historic and artistic metal objects, based on the biodegradable materials and protocols developed within the GoGreen project. Participants will test and evaluate sustainable cleaning systems on prepared metal coupons (silver, brass, and steel) or on sacrificial objects brought to the workshop. The session focuses on complexation-based cleaning using EDDS, DFO, and saponite for brass and steel, and cysteine for silver tarnish removal. Different application and delivery systems will be demonstrated and applied, including flexible hydrogels, electrospun mats as loading matrices, and immersion cleaning for silver. The session is strongly hands-on and encourages participants to assess effectiveness, usability, and practical limitations of each greener method.

Key Concept 1	**Corrosion mechanisms of silver, copper, iron, and their alloys**
Key Concept 2	**Sustainable principles in metal conservation and greener cleaning strategies**
Key Concept 3	**Future conservation practice**
Key Concept 4	**Practical experience**

OBJECTIVES

Objective 1	Introduce greener strategies for historical metal artifacts, developed withing GoGreen project
Objective 2	Gain practical experience in applying bio-based cleaning treatments using mock-ups and sacrificial objects
Objective 3	Evaluate treatment effectiveness and reflect on sustainability, feasibility, and limitations for real-world conservation practice

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

- PowerPoint: GoGreen greener cleaning strategies for metal conservation (previous session)
- Safety sheet for EDDS, DFO, saponin, and cysteine solutions
- If available, physical or visual examples of treated case studies illustrating greener cleaning methods.
- short video introducing electrospun mats and flexible gels (optional)
- Short handout on corrosion products and cleaning mechanisms (optional)

SESSION OUTLINE

Health and Safety (10–15 minutes)

- Highlight appropriate PPE and safe handling procedures
- Good laboratory practice and contamination prevention
- Waste management and disposal aligned with green principles
- Practical precautions for immersion methods and gel use

Demonstration (20–30 minutes) – optional

- Step-by-step demonstration of:
    - Cysteine swabbing and cysteine gel application on silver coupons
    - Setting up immersion test for silver coupons
    - Application of EDDS/DFO/saponin using gels and electrospun mats
- Visual evaluation of cleaning effectiveness and controlled removal

Practical Session (4 hours)

- Participants apply methods on prepared coupons or sacrificial objects
- Documentation encouraged (before/after photos, contact time, observations)
- Compare results between delivery systems and cleaning agents

Final Discussion / Evaluation (15–30 minutes)

- Compare observed outcomes and challenges
- Discuss advantages and limitations of each method
- Collect structured feedback from participants

Case Study / Example

During the workshop, participants will work with prepared silver, brass, and steel coupons exhibiting typical corrosion layers. Participants will compare results between delivery systems and document surface appearance changes.
This is a case study submitted by a participant after the workshop, including photos of a sterling silver object during (left) and after (right) treatment with cysteine gels and swabbing with cysteine solutions of different concentrations.

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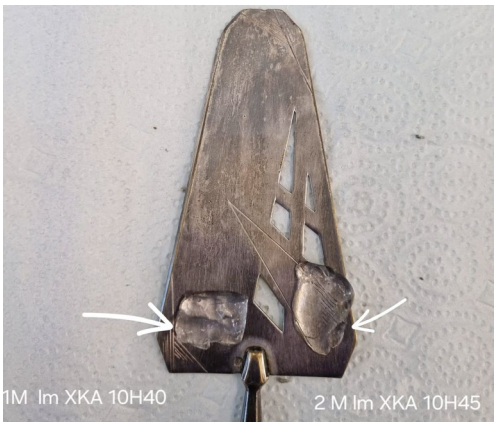

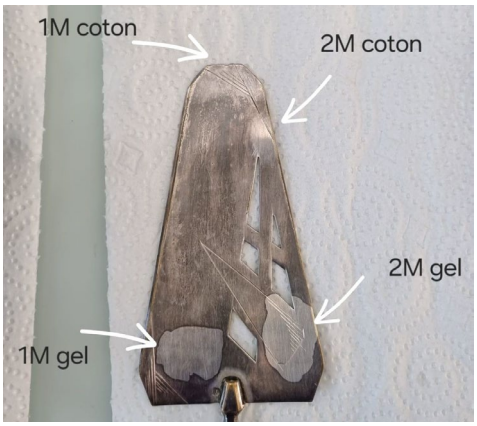

Summary / Wrap-Up (5–10 minutes)

The wrap-up may include answers, tips, and highlights gathered from participants during their application of the greener protocols.
Discussion prompts may include :

- Which method produced the best cleaning effect with minimal surface disruption?
- How did delivery systems influence control and residue management?
- Which protocol seems most feasible for real conservation practice?
- What practical improvements could be made to increase usability?

METHODOLOGY

Delivery Format This session is a practical session where materials are provided to participants and the facilitator demonstrates each method step-by-step. Participants then carry out the treatments under guided supervision. Questions are addressed continuously throughout the practical work, and results are discussed collectively during the final evaluation.

Activities / Exercises / Assessments

Activity 1: Silver cleaning using cysteine solutions and cysteine-incorporated gels

Purpose: To demonstrate the removal of silver tarnish using biodegradable cysteine-based cleaning systems in both immersion and gel application, and to allow participants to practice the cleaning procedure on silver coupons.

Duration: 120 minutes

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Materials required: Silver coupons, sacrificial objects brought by the participants, cysteine solution, cysteine-based gels, glass vials (for immersion), glass petri dishes, beakers, pipettes, cotton swabs, deionized water, tweezers, gloves, blotting paper.

Activity 2: Cleaning of Brass and Steel Using EDDS, DFO, and Saponin

Purpose: To demonstrate the application of greener chelating agents for the cleaning of brass and steel objects using gels and ES mats. Participants apply the cleaning methods to prepared samples.

Duration: 120 minutes

Materials required: Brass and steel coupons, EDDS solution, DFO solution, sapoline solution, hydrogels, ES mats, glass slides, cotton swabs, deionized water, cleaning tools, gloves, blotting paper.

Activity 3: Feedback and Discussion

- Reviewed outcomes of practical sessions, addressed questions, and discussed challenges and observations.
- Collected participant feedback to evaluate learning and reinforce knowledge transfer, including sustainability considerations and real-world applicability.

Duration:30 minutes- 1hour

Materials required: Evaluation forms- online, QR code.

Facilitator Notes

- Before the session, the facilitator should prepare metal coupons (silver, brass, and steel), cleaning solutions (EDDS, DFO, sapoline, and cysteine), hydrogels, electrospun mats, and the necessary laboratory tools and post-cleaning materials.
- *Optional, the facilitator should first demonstrate the cleaning procedure step by step before allowing participants to perform the treatments themselves.*
- Particular attention should be paid to explaining the preparation and application of gels and electrospun mats, as well as the immersion cleaning method used for silver.
- The facilitator should monitor the participants during the exercises to ensure correct handling of materials and safe laboratory practices, as well as answer questions from the participants.
- In the end of practical activities, the facilitator should guide a discussion on the observed cleaning effects, encouraging participants to compare the results obtained with different materials and application methods.

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- Key points regarding the advantages and limitations of the greener cleaning approaches should be highlighted, including ethical considerations, scalability, long-term effectiveness, and institutional feasibility.
- The facilitator conclude with a structured wrap-up discussion and ensure all feedback forms are completed.

ADDITIONAL RESOURCES

- GoGreen project case studies and treatment reports
- Reference images of corrosion morphologies and expected cleaning outcomes
- Laboratory protocol sheet for solutions and gels preparation
- Waste disposal and sustainability guidance for conservation laboratories

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4.Green Treatments for Metals: Materials and Methods for Stabilisation

Authors: Patrycja Petrasz, Edith Joseph

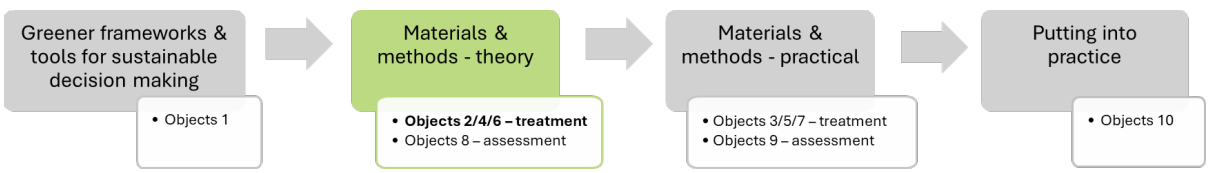
This session introduces current advancements in greener treatment methods for the stabilization of archaeological metals, focusing on copper and iron objects. It explores sustainable conservation strategies based on bio-sourced microbial processes and gel-based delivery systems as alternatives to conventional chemical treatments. The session is designed for conservators and students in cultural heritage conservation who wish to integrate environmentally responsible practices into metal preservation.

Key Concept 1	**Limitations of conventional conservation methods for archaeological metals and their long-term effects.**
Key Concept 2	**Meyerozyma immersion-based stabilization as a sustainable approach for archaeological iron corrosion treatment.**
Key Concept 3	**Fungal metabolites-driven formation of protective passivation layers on iron and copper alloys.**
Key Concept 4	**Controlled stabilization using microorganisms embedded in hydrogel systems.**

OBJECTIVES

Objective 1	Recognise the environmental and material impacts of traditional conservation approaches for archaeological metals
Objective 2	Understand greener stabilization strategies for copper and iron artifacts developed within the GoGreen project
Objective 3	Demonstrate microbial-based stabilization procedures using case-study presentation (PowerPoint)
Objective 4	Evaluate the applicability of bio-based treatments in real conservation contexts, including sustainability considerations

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

- Basic understanding of corrosion processes in metals (copper and iron alloys)
- Familiarity with common conservation stabilization approaches
- Introductory awareness of sustainability frameworks in conservation practice (recommended)

SESSION OUTLINE (total 2 hours)

1. Overview of current challenges in traditional conservation of archaeological metals (15 minutes)

2. Presentation of microbial and bio-based alternative strategies: (60 minutes)
    - Hydrogels / immersion systems enriched with *Meyerozyma* sp. (biosorption + iron reduction for chloride extraction and transformation of corrosion products)
    - Hydrogels enriched with *Pleurotus ostreatus* (conversion of reactive iron corrosion products)
    - Hydrogels enriched with *Beauveria bassiana* (biopassivation of copper corrosion products)
    - Review case studies

3. Evaluation and comparison against benchmark (40 minutes, to be completed in following sessions about practical application)
    - Discussion of the advantages and disadvantages of each cleaning protocol
    - Completion of concise properties profile sheets.

Case study / example

- Presentation of examples where greener metal stabilization methods have been applied
- Presentation of examples where greener stabilization approaches are compared to traditional ones

Summary / Wrap-Up (5–10 minutes)

- What are the main advantages of microbial stabilization compared to traditional treatments?
- What are the current limitations or risks of bio-based conservation methods?
- Discussion on scalability and practical implementation in museum contexts

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METHODOLOGY

Delivery Format The session is delivered through a blended approach combining lecture-based presentations and guided discussion. Participant questions and feedback are addressed throughout and at the end of the session.

Activities / Exercises / Assessments

Activity 1: Theory Session

- Presentation of current challenges in traditional conservation of archaeological metals, highlighting limitations of conventional methods
- Introduction of microbial-based alternatives for iron and copper stabilization, explaining biosorption, iron reduction, and biopassivation mechanisms

Purpose: build conceptual understanding of sustainable alternatives in metal conservation

Activity 2: Feedback and Discussion

- Group discussion based on presented case studies and theoretical content
- Address participant questions and clarify scientific principles
- Collect feedback on applicability, challenges, and sustainability perception in practice

Purpose: reinforce knowledge transfer and encourage critical reflection

Duration: 1.5-2 hours

Materials required: Presentation slides, online evaluation forms, QR code for feedback collection. (alternative : printed evaluation forms)

Facilitator Notes

- Before the session, the facilitator should prepare all presentation materials and, if available, physical or visual examples of treated metal coupons illustrating microbial stabilization methods.
- During the theoretical session, the facilitator should clearly explain the limitations of conventional conservation approaches and introduce the scientific principles behind microbial stabilization, including biosorption, iron reduction, and biopassivation. Participants should be encouraged to engage actively and ask questions throughout the presentation.
- At the end of the session, the facilitator should lead a structured discussion summarizing key learning outcomes, addressing remaining questions, and collecting participant feedback to evaluate the effectiveness of the training and its relevance to sustainable conservation practice.

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ADDITIONAL RESOURCES

- GoGreen Project documentation and publications
- Recent studies on microbial corrosion control in conservation science
- Hydrogel-based delivery systems in cultural heritage conservation
- Case studies on bio-based stabilization of archaeological metals

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APPENDIX 4.1 Concise Properties Profile Template (Pre-Monitoring Version)

Materials & Methods Sessions (Metals Cleaning / Metals Stabilisation / Glass Stabilisation)

Group: _____ **Date:** _____
Material / Method: _____
Object / Surface Type: ☐ Metal ☐ Glass
Metal/Glass type (if known): _____
Target issue (tarnish/corrosion/leaching/chlorides/etc.): _____
Benchmark method for comparison: _____

1) Treatment Description

Treatment category: ☐ Cleaning ☐ Stabilisation ☐ Coating/Consolidation
Active component(s): _____
Delivery system: ☐ Liquid ☐ Gel ☐ Microfibre ☐ Immersion ☐ Spray ☐ Other: _____
Typical working conditions (pH, concentration, time): _____

2) Physical / Functional Properties

Property	*Notes / Expected Values*
Solubility / miscibility	
pH range	
Stability / storage	
Selectivity / mechanism	
Ease of application	☐ Easy ☐ Moderate ☐ Difficult
Residue risk (expected)	☐ Low ☐ Med ☐ High
Compatibility with mixed materials	☐ Good ☐ Uncertain ☐ Poor

3) Toxicity & Hazard Metrics (GHS / SDS-Based)

Known GHS classification: ☐ Yes ☐ No
Main risks: ☐ Irritant ☐ Corrosive ☐ Toxic ☐ Sensitiser ☐ Flammable ☐ Other: _____
Human health risk: ☐ Low ☐ Med ☐ High
Environmental hazard risk: ☐ Low ☐ Med ☐ High
PPE required: ☐ Gloves ☐ Goggles ☐ Mask/Respirator ☐ Ventilation

4) Sustainability / LCA Considerations (Estimated if needed)

Indicator	Low	Med	High
Renewable / bio-based origin	☐	☐	☐
Biodegradability potential	☐	☐	☐
Expected waste volume	☐	☐	☐
Solvent/VOC contribution	☐	☐	☐
Energy/resource demand	☐	☐	☐
Availability / sourcing burden	☐	☐	☐

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Main sustainability advantage: _____

Main sustainability concern/trade-off: _____

5) Expected Performance (Pre-Test Prediction)

Expected effectiveness: ☐ Low ☐ Med ☐ High

Key expected benefit: _____

Key expected limitation / risk: _____

6) Benchmark Comparison (Quick Rating)

Category	Green(er) Method	Benchmark
Safety	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Sustainability	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Expected efficacy	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Practical feasibility	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse

7) Notes / Sources

Data sources used: ☐ SDS ☐ GoGreen deliverable ☐ Paper ☐ Lecture notes ☐ Other: _____

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5. Green Treatments for Metals: Practical Application for Stabilisation

Lead author: Patrycja Petrasz

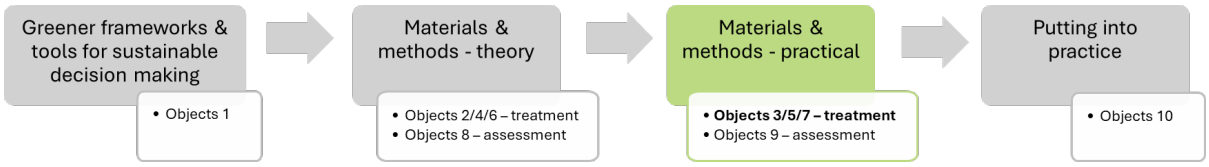
This practical session introduces greener treatment methods for the stabilisation of archaeological metals, with a focus on copper alloys and iron objects. It presents sustainable alternatives to traditional stabilisation approaches by using bio-sourced microbial processes and gel delivery systems. Participants will undertake guided practical exercises using fungal-based treatments (*Beauveria bassiana, Pleurotus ostreatus*) and immersion stabilisation using *Meyerozyma* sp. Case studies and mock-ups will be used to demonstrate treatment procedures, expected outcomes, and challenges in real conservation scenarios.

Key Concept 1	**Archaeological copper and iron corrosion**
Key Concept 2	**Sustainable principles in metals conservation and greener stabilization strategies**
Key Concept 3	**Future conservation practice**
Key Concept 4	**Practical experience**

OBJECTIVES

Objective 1	Introduce greener strategies for archaeological copper and iron artifacts, developed withing GoGreen project
Objective 2	Gain practical experience in applying microbial-based stabilisation treatments using mock-ups and sacrificial objects
Objective 3	Evaluate treatment effectiveness and reflect on sustainability, feasibility, and limitations for real-world conservation practice

Module placement in green treatments learning trajectory



PREPARATORY MATERIALS

- PowerPoint slides on sustainable approaches for metals stabilization (previous session)
- Safety sheet / lab protocol for handling biological materials and gels

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- if available, physical or visual examples of treated case studies illustrating microbial stabilization methods.
- *short video introducing immersion and gel treatments (optional)*
- *Short handout on microbial treatments for archaeological metals (optional)*

SESSION OUTLINE (total 6- 8 hours)

Health and safety (10–15 minutes)
- Safe handling of microbial cultures and fungal biomass
- PPE requirements: gloves, lab coats, eye protection
- Good laboratory practice and contamination prevention
- Waste management and disposal aligned with green principles
- Safe use of ethanol and post-treatment cleaning materials

Demonstration *(20–30 min)- optional*
- *Step-by-step demonstration of:*
  - *Preparation of biopolymer gels*
  - *Incorporation of fungal biomass into gel systems*
  - *Application strategies for copper coupons and objects*
  - *Immersion treatment workflow for iron samples*
- *Visual evaluation of treatment coverage and application thickness*
- *Documentation methods: photographs, notes, treatment parameters*

Practical session Copper - part 1 (1 hour)
- Preparation of hydrogels amended with *Beauveria bassiana*
- Discussion of how fungal metabolites contribute to passivation layers
- Preparation of workstations and sample documentation

Practical session Copper- part 2 (2 hours)
- Application of *Beauveria bassiana* hydrogel treatment on:
  - Copper coupons
  - Sacrificial objects / mock-ups
  - Participant-provided artefacts (if applicable)
- Observation of reaction behaviour and gel interaction with corrosion layers
- Recording key parameters:
  - Gel thickness and coverage
  - Exposure time
  - Surface condition and corrosion morphology
  - Handling challenges and treatment limitations

Practical session Iron - part 3 (3 hours)
- Removal of iron objects from immersion stabilisation using *Meyerozyma* sp.
  - Chloride extraction processes
  - Conversion of reactive corrosion products

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- Preparation and application of hydrogels amended with *Pleurotus ostreatus* on iron coupons

Final Discussion / Evaluation (15–30 minutes)

- Observation and comparison of outcomes across sample types
- Documentation of :
  - Visual change in corrosion products
  - Surface condition before/after
  - Practical challenges (uneven surfaces, adhesion, drying)
- Discussion on advantages and limitations of each method
- structured feedback from participants.

Case Study / Example

Participants will work with copper and iron coupons and sacrificial archaeological-style mock-ups exhibiting common corrosion morphologies. Where possible, participants may also apply treatments to small archaeological objects brought from their institutions. Case studies from the GoGreen project will be used to demonstrate treatment objectives, expected stabilisation effects, and long-term conservation relevance.

Summary / Wrap-Up (5–10 minutes)

- What differences were observed between copper and iron stabilisation behaviour?
- Which parameters seemed most critical for treatment success?
- What limitations might prevent these methods from being adopted in routine practice?
- How do microbial and gel-based methods align with greener conservation goals?
- What additional monitoring or research would be needed before wider implementation?

METHODOLOGY

Delivery Format

- step-by-step demonstrations by the facilitator (optional)
- participant-led practical exercises using prepared materials and sample objects
- group reflection and structured discussion after each activity

Activities / Exercises / Assessments

Activity 1: Copper biopassivation

- Prepared hydrogels amended with *Beauveria bassiana*

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- Application on copper coupons and participant's samples
- Observation of surface response and discussion of effectiveness

Duration: 3- 4 hours
Material required: gloves, spatulas, beakers, deionized water, biopolymer- based gel, fungal active biomass, ethanol, cylinder, petri dishes, boxes with lids (for larger objects), paper towels, parafilm, scissors.

Activity 2: Iron stabilization

- Removal of iron objects from the immersion *Meyerozyma sp*. Treatment
- Preparation of hydrogel amended with Pleurotus ostreatus
- Application on iron coupons and observation of treatment behaviour

Duration: 3- 4 hours
Materials required: gloves, ethanol, paper

Activity 3: Feedback and Discussion

- Reviewed outcomes of practical sessions, addressed questions, and discussed challenges and observations.
- Collected participant feedback to evaluate learning and reinforce knowledge transfer, including sustainability considerations and real-world applicability.

Duration:30 minutes- 1hour
Materials required: Evaluation forms- online, QR code

Facilitator Notes

- Prepare all materials in advance: copper and iron coupons, mock-ups, immersion solutions, microbial treatments (*Meyerozyma* sp., *Beauveria bassiana, Pleurotus ostreatus*), gels, and lab tools.
- Ensure all demonstration materials and presentation slides are ready before the session begins.
- *Optional, begin each practical block with a step-by-step demonstration, including correct gel preparation, incorporation of microbial biomass, and controlled application methods.*
- Encourage participants to document each step (coverage, thickness, contact time, drying conditions, and surface response).
- Monitor participants for safe handling of biological materials and ensure correct waste disposal aligned with sustainable practice.
- After each activity, guide a short reflection discussion to compare results across samples and identify key influencing variables.

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- Highlight advantages and limitations of microbial stabilisation, including ethical considerations, scalability, long-term effectiveness, and institutional feasibility.
- Conclude with a structured wrap-up discussion and ensure all feedback forms are completed.

ADDITIONAL RESOURCES

- GoGreen project case studies and treatment reports
- Reference images of corrosion morphologies and expected stabilisation outcomes
- Laboratory protocol sheet for microbial gel preparation and immersion treatments
- Waste disposal and sustainability guidance for conservation laboratories

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6. Greener Materials and Methods for Glass Stabilisation

Author: Roberta Zanini

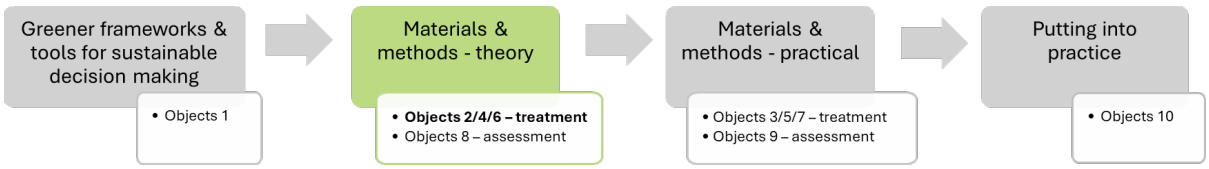
This session introduces green(er) advancements in the materials and methods for the stabilisation of glass and how they compare to traditional approaches. The session is dedicated to glass conservators and students of restoration and conservation of cultural heritage.

Key Concept 1	**Glass corrosion**
Key Concept 2	**Sustainable principles in conservation**
Key Concept 3	**Archaeo-inspiration for greener solutions in glass conservation**
Key Concept 4	**Role of nanomaterials in glass conservation**

OBJECTIVES

Objective 1	Understanding the glass corrosion mechanisms from a chemical point of view
Objective 2	Learning the limitations of the traditional methods in terms of glass conservation and sustainability
Objective 3	Achieving the sustainable impact of the novel and greener method

Module placement in green treatments learning trajectory



SESSION OUTLINE (2 hours)

Glass (its structure and different compositions of historical glass) (15 minutes)

Corrosion mechanism of glass (15 minutes)

Overview of traditional methods for glass conservation (20 minutes)

- Natural
- Polymers
- Synthetic

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Limitations of traditional methods (20 minutes)

- In long-term glass conservation
- In green conservation

Green(er) advancements in the materials and methods for the stabilisation of glass (30 minutes)

- Nano-silica as glass corrosion products
- Its properties in glass stabilisation
- Synthesis of nano-silica
- Greener protocol for preparing mesoporous nano-silica
- Its application on glass and the impact on green conservation

Round table discussion (20 minutes)

Case Study / Example

- Presentation of examples where greener metal cleaning methods have been applied
- Presentation of examples where greener cleaning approaches are compared to traditional ones

METHODOLOGY

Delivery Format Lecture with PowerPoint presentations and follow-up group discussion

Activities / Exercises / Assessments

The instructor presents the topics, and at the end, there will be a discussion to verify that the key concepts are fully understood, both in terms of long-term glass conservation purposes and for green conservation evolution.

Facilitator Notes

Ask conservators for feedback on their personal experience with materials and resources during practical activities, and on the general sustainability problems they encounter.

Resources Required:

- PowerPoint slides with key concepts and visual examples.
- Worksheets or digital templates (Padlet) for the activity
- Reference bibliography for participants to consult.
- Whiteboard or interactive whiteboard/projector for group discussion notes.

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7. Practical Session: Greener Materials for Glass Stabilisation

Lead author: Roberta Zanini

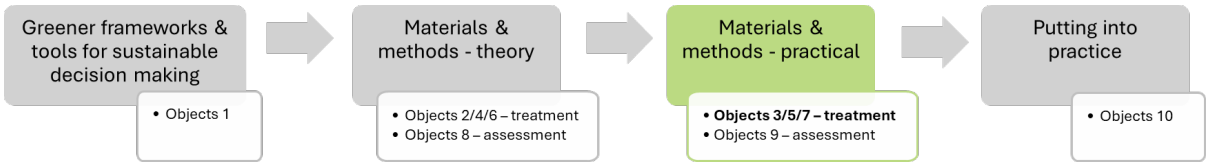
This practical session presents a greener approach for glass conservation and restoration. After a theoretical introduction on fundamental concepts, the practical session will be primarily focused on mesoporous silica nanoparticles (MSNs) as a green stabilisation method for glass, highlighting all the steps and challenges that conservators may face.

Key Concept 1	**Glass corrosion**
Key Concept 2	**Sustainable principles in conservation**
Key Concept 3	**Future conservation practice**
Key Concept 4	**Practical experience**

OBJECTIVES

Objective 1	Understand various methods for the stabilisation of glass
Objective 2	Gain practical experience in handling and applying mesoporous silica nanoparticles (MSNs)

Module placement in green treatments learning trajectory



PREPARATORY MATERIAL

Zanini, Roberta, et al. "A review of glass corrosion: the unique contribution of studying ancient glass to validate glass alteration models." *npj Materials Degradation* 7.1 (2023): 38.

Centenaro, Stefano, et al. "Consolidation and coating treatments for glass in the cultural heritage field: a review." *Journal of Cultural Heritage* 64 (2023): 132-143.

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SESSION OUTLINE (2.5 hours)

Introduction (10 minutes)

Theoretical Introduction (30 minutes)

- What mesoporous silica nanoparticles (MSNs) are:
  - Key properties
- Why MSNs are considered a greener stabilisation material
  - Discuss their synthesis as well as their impact on human and environmental health and well-being
    - Additional Resource: Green Synthesis Protocol (video)
- How MSNs interact with glass surfaces
- Application strategies for MSN
- Main variables that affect treatment success:
  - Concentration
  - Application method
  - Surface preparation
  - Drying conditions
  - State of deterioration

Health and Safety (5 minutes)

- Highlight propery ppe; material use and disposal

Demonstration (15 minutes)

- Before participants begin demonstrate application method for MSN and how to visually evaluate application coverage
- Practical – refer to facilitator notes on how to conduct
- Remind participants to document each step such as : spray count, distance of application, drying time. Compare behaviour across different types of glass. Note any challenges such as pooling, uneven coverage, or absorption variations

Greener Approaches and MSNs (25 minutes)

- Key properties and benefits
- Green synthesis protocol (video?)
- Stabilisation treatment

Practical session (50 minutes)

Final discussion (15 minutes)

Case Study / Example

During the workshop, participants will work with a practical example of altered historical glass exhibiting different sizes, shapes, and surface morphologies. The case

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study will focus on the application of MSN loaded with calcium ions as a green stabilisation method.

METHODOLOGY

Delivery Format Lecture with PowerPoint presentation of the theoretical key-concepts, then a practical session where materials are provided to the participants and the lecturer demonstrates step by step with also a presentation to ensure the correct execution.

Activities / Exercises / Assessments

Participants will practice applying stabilisation materisl to glass. This session will focus on GoGreen stablisation technique applying MSNs to altered glass samples under guided supervision.

Guide for Practical Session:

1) Before applying the material, conservators will clean the glass surfaces following their usual conservation procedures. Encourage participants to utilise greener cleaning methods.
2) The lecturer will then show visual examples of different application procedures, including number of sprays, concentrations, and characterisation results to highlight relevant parameters.

For the practical session the participants will be provided with the following material:

- Altered glass with different size and morphology:
  - Glass slides (small, flat surface)
  - Glass tiles (big, near-flat surface)
  - Glass chunks (different sizes and shapes)
- 20 mL of MSN-NH_2 in a concentration of 1 mg/mL
- Spray nebuliser
- Gloves

Facilitator Notes *

Recommended Discussion Points/Reflection Questions:

1) Differences in application success across samples
   Effects of Spray number
2) Challenges encountered and possible solutions
3) Appearance before vs. After treatment
4) How msn-based stabilisation aligns with greener conservation goals

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8. Introduction to Assessment Techniques for the Evaluation of Cleaning Strategies and Stabilisation Treatments

Author: Loic Bertrand

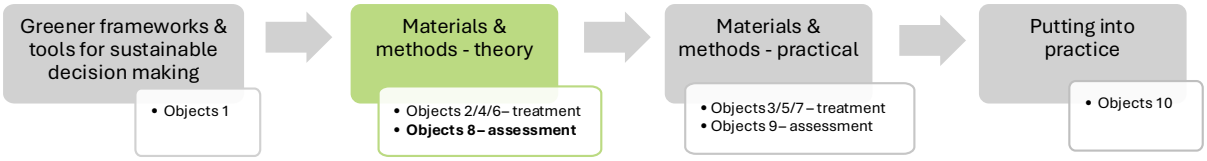
This session introduces the most current assessment and monitoring techniques used to analyse the impact, effectiveness and risks of conservation treatments applied to the surfaces of heritage objects. It explores the specific aspects of studying green treatments, particularly those based on bio-based materials. Several case studies are presented to illustrate the various methods. Commonly available methods are presented. An introduction is provided to an advanced method used in research to better interpret the local impact of treatments guiding their efficacy.

Key Concept 1	**Analytical methods should be applied within a carefully designed analytical sequence, with each technique selected to maximise the expected information obtained.**
Key Concept 2	**When analysing cultural heritage objects, non-invasive and non-destructive techniques should be prioritised whenever possible to preserve the integrity of the material.**
Key Concept 3	**The assessment of green conservation treatments often requires tailored analytical strategies, particularly for complex systems containing both organic and inorganic compounds.**
Key Concept 4	**A thorough review of the scientific literature, together with exchanges with experts, is essential for designing an appropriate analytical protocol and selecting the most relevant techniques.**

OBJECTIVES

Objective 1	Apply monitoring and assessment techniques to evaluate the efficacy of conservation cleaning and stabilisation treatments.
Objective 2	Identify treatment-related surface changes (residue, corrosion reactivation, texture changes, gloss/colour shift).
Objective 3	Expand the materials properties profile developed in earlier session (*Green Frameworks and Tools for Sustainable Decision-Making)* to include performance and monitoring outcomes.
Objective 4	Compare green(er) approaches with benchmark traditional methods using measurable assessment criteria.

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

- Chemical Analysis in Cultural Heritage, Luigia Sabbatini and Inez Dorothé van der Werf, De Gruyter, 2020.
- Analytical Chemistry for Cultural Heritage, Rocco Mazzeo, Springer International Publishing, 2017.
- Analytical Chemistry in Archaeology, Mark Pollard et al., Cambridge University Press, 2026.

SESSION OUTLINE (total 2-2.5 hours)

Introduction (15 minutes)

- General terminology in analytical assessment
- Specificities of assessing green conservation treatments:
  - Heterogenous systems combining organic and inorganic compounds
  - Biobased materials that may be particularly complex at the molecular level
  - Material preciousness and constraints associated with cultural heritage objects

2. Overview of conventional analytical methods in heritage science and associated sample preparation techniques (1 hour)

- Introduction
- Morphological analysis: photography, optical microscopy, scanning electron microscopy (SEM), profilometry, X-ray micro-computed tomography (µCT)
- Elemental analysis: X-ray fluorescence (XRF), SEM coupled with energy-dispersive X-ray spectroscopy (SEM-EDS)
- Molecular and chemical characterization: mid-infrared spectroscopy (FTIR), Raman spectroscopy
- Structural (crystalline) analysis: X-ray diffraction (XRD)
- Molecular identification: mass spectrometry

3. Analysing results from the literature (30 minutes)

- Critical reading of "Materials and Methods" sections of articles
- Evaluation of analytical choices and methodological transparency.
- Example on a case study

4. Exercise on monitoring plan (15 minutes)

Participants work in groups to answer which analytical methods would be most useful for evaluating:

- cleaning efficacy?
- residues?
- corrosion reactivation?
- surface damage?
- sustainability claims?

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Case Study / Example

Study performed by P. Petrasz *et al.* on the X-ray micro-computed tomography assessment of biobased treatment of metallic artefact (article to be published).

Summary / Wrap-Up (5–10 minutes)

- Can analytical methods damage samples? Is it an issue?
- How to combine methods for very heterogenous samples?
- How complex is the analysis of analytical data?
- What challenges do conservators face in practice? Is the situation the same among professionals? And on an international scale?

METHODOLOGY

Delivery Format The session is delivered through a lecture-based presentation, followed by an exercise guiding discussion with the trainer. Participant questions and feedback are addressed throughout and at the end of the session.

Activities / Exercises / Assessments

Activity 1: Learn from published examples (30 minutes)

Based on the reading of the Materials and Methods section of an article, explain the strategy followed and discuss the choices made in terms of analytical protocols and parameters.

- Critical analysis
- Identification of the rationale behind technique selection and sequence
- Assessment of methodological coherence and complementarity of techniques

Activity 2: Designing a Monitoring and Assessment Plan for a Green Treatment (15–20 minutes)

Participants work in small groups to design a monitoring and assessment strategy for a conservation treatment scenario involving a green cleaning or stabilisation method.

Example Scenarios

- Evaluation of a metal object cleaned with EDDS or DFO.
- Assessment of a gel-based stabilization treatment on archaeological copper or iron.
- Assessment of a greener consolidation treatment on glass.
- Comparison of a bio-based treatment and a conventional benchmark method.

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Tasks

Each group should identify:

1. **What questions need to be answered?**
    - Was the treatment effective?
    - Were residues left on the surface?
    - Has the treatment altered the surface?
    - Is there evidence of improved stability?
    - Are there sustainability-related benefits or trade-offs?

2. **Which assessment methods would be most appropriate?**
    - Photography
    - Optical microscopy
    - SEM/EDS
    - XRF
    - FTIR
    - Raman spectroscopy
    - Profilometry
    - Other methods as appropriate

3. **When should measurements be taken?**
    - Before treatment
    - During treatment
    - Immediately after treatment
    - During long-term monitoring

4. **What practical constraints must be considered?**
    - Access to equipment
    - Cost and time
    - Sampling restrictions
    - Non-invasive requirements
    - Sustainability considerations associated with analytical testing

Output

Each group prepares a simple monitoring plan showing:

- Objectives of the assessment
- Analytical methods selected
- Sequence of measurements
- Expected information from each method
- Potential limitations

Each group should submit a one-page Monitoring Plan Worksheet. The worksheet will be revisited during Session 9, where participants will compare their proposed monitoring strategy with the methods actually applied during practical evaluation.

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Facilitator Notes

General Guidance

- Emphasise the breadth of available analytical methods and the importance of accessing expertise, not only instrumentation.
- Highlight that reliable results are typically obtained through the combination of multiple complementary techniques, rather than relying on a single “magic” method.
- Stress the inherent complexity of analysing treated heritage objects, particularly heterogeneous and altered materials.
- Encourage rigorous and consistent documentation of all analytical procedures, including experimental conditions and limitations.
- Propose a decision-tree approach to guide the selection and sequencing of analytical methods.

Recommended Discussion Points

- What are the main advantages and limitations of each analytical technique presented?
- To what extent can these techniques realistically be used:
  - in imaging mode?
  - in a conservation studio?
  - in a research laboratory environment?
- What are the main challenges associated with sample preparation for each method?
- What are the difficulties involved in processing and interpreting the collected data?
- How should analytical data be organised, stored, and managed over time?
- How should negative, ambiguous, or inconclusive results be interpreted and reported?

Timing Suggestions

- Prioritise the most accessible and widely applicable methods in the core presentation.
- Maintain a clear, structured progression when introducing analytical techniques (e.g., by type of information obtained or scale of analysis).
- During the exercise, direct students to the most relevant sections of the article to focus their critical reading and avoid information overload.

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9. Practical Application of Assessment Techniques

Authors: Edith Joseph (adapted from GoGreen contributors:
Qing Wu, Roberta Zanini, Patrycja Petrasz)

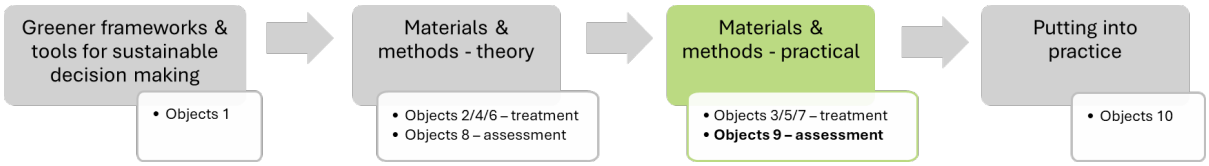
This session introduces practical assessment and monitoring techniques used to evaluate the effectiveness and risks of conservation treatments applied to heritage surfaces. Building on Session 8 (Introduction to Assessment Techniques) and previous sessions on *Green Treatments for Metals (sessions 2-5) and Green Treatments for Glass (sessions 6-7),* participants will apply selected monitoring tools and assessment methods to evaluate treatment performance and sustainability. The session supports evidence-based decision-making by expanding the previously developed properties profiles to include efficacy, surface impact, and treatment performance metrics. For simplicity, the practical activities in this session are demonstrated using metal cleaning; however, the same assessment framework and monitoring approach can be directly applied to metal and glass stabilization treatments.

Key Concept 1	**Assessment of cleaning/stabilisation efficacy must include both visual outcomes and scientific monitoring indicators.**
Key Concept 2	**Monitoring techniques can reveal hidden risks such as residues, micro-surface alteration, or accelerated corrosion.**
Key Concept 3	**Evaluation of green(er) treatments requires both sustainability metrics and performance validation.**
Key Concept 4	**Standardised documentation supports comparison, repeatability, and responsible conservation decision-making.**

OBJECTIVES

Objective 1	Apply monitoring and assessment techniques to evaluate the efficacy of conservation cleaning and stabilisation treatments.
Objective 2	Identify treatment-related surface changes (residue, corrosion reactivation, texture changes, gloss/colour shift).
Objective 3	Expand the materials properties profile developed in earlier session (*Green Frameworks and Tools for Sustainable Decision-Making)* to include performance and monitoring outcomes.
Objective 4	Compare green(er) approaches with benchmark traditional methods using measurable assessment criteria.

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

- Understanding of corrosion and deterioration processes in metals
- Familiarity with treatment approaches presented in earlier sessions (complexation (EDDS, DFO, cysteine), gels, surfactants (saponin), Deep Eutectic Solvents)
- Basic knowledge of sustainability parameters (toxicity, hazard, LCA indicators)

SESSION OUTLINE (total 2 hours)

Activity 1: Revisiting the Monitoring Plans (10 minutes)
Participants review the monitoring plans developed in Session 8 and discuss:

- Which methods are available today?
- Which methods are missing?
- What compromises are necessary in a real conservation setting?
- Which measurements will provide the most useful information?

Activity 2: Apply Monitoring Techniques to Case Studies (45–60 minutes)
Participants work in small groups rotating through treated sample sets.
Sample types (suggested):

- Metal coupons treated with: EDDS, DFO, cysteine, saponin, EDTA benchmark, $CaCO_3$ slurry benchmark
- Gel-treated vs liquid-treated areas (e.g., flexible hydrogel system vs immersion/swabbing)

Tasks:

- Conduct structured before/after observation
- Identify and record:
  - cleaning effectiveness
  - surface changes (scratches, etching, residue films, discolouration)
  - evidence of incomplete cleaning or uneven treatment
  - potential corrosion reactivation indicators
- Document using worksheets (template in annex B) and images

Purpose:
To build hands-on competence with monitoring methods and highlight differences between treatment approaches.

Activity 3: Expand the Green Properties Profile Using Monitoring Data (25–30 minutes)
This activity directly builds on the earlier exercise.
Each group updates their previously created “properties profile” profile (annex A in session 2) to include:

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A. Efficacy Metrics

- level of tarnish/corrosion removal
- uniformity of cleaning
- time efficiency
- need for mechanical assistance

B. Surface Impact Metrics

- abrasiveness / surface alteration risk
- residue risk
- risk of microstructural change (etching, dulling, pitting)

C. Practical Use Criteria

- ease of application
- scalability in museum contexts
- compatibility with mixed-material objects

D. Sustainability Confirmation / Trade-offs

- did greener method require more time, energy, or repeat applications?
- did delivery systems reduce chemical volume and waste?
- did safer chemistry still provide acceptable results?

Output:
Expanded full profile including physical properties + toxicity/hazard + LCA + performance.

Activity 4: Group Exchange and Comparison (10–15 minutes)
Groups share results and compare profiles across methods.
Discussion prompts:

- Which method provided the best balance of performance and sustainability?
- Were there any unexpected residues or surface risks?
- Did gel or microfibre delivery improve control compared to liquid cleaning?
- Where did benchmark methods outperform green methods, and why?
- Did the monitoring results change your perception of which treatment was the most sustainable?

Case Study / Example

Glass treatment assessment: MSNs loaded with salts fluorescent under UV light will be also deposited to verify the homogenous deposition of the silica-based treatment for glass.

Summary / Wrap-Up (5–10 minutes)

- Recap: monitoring as essential for responsible treatment selection
- Link results to long-term conservation stability
- Instructions for assessment deliverable

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METHODOLOGY

Delivery Format This session is delivered as a guided practical workshop with short demonstrations, group-based analysis, and facilitated discussion. Participants apply monitoring tools directly to treated case studies and interpret results using structured templates.

Activities / Exercises / Assessments

Activity 1: Revisiting the Monitoring Plans
Participants review the monitoring plans developed in Session 8.
Purpose: To connect theoretical analytical design with practical conservation constraints.
Duration: 10 minutes

Activity 2: Practical Application of Assessment Tools
Participants rotate through treated surface stations and apply monitoring techniques (visual, microscopy, documentation, simple residue or surface testing where available).
Purpose: build competence in assessing treatment outcomes and risks.
Duration: 45–60 minutes

Activity 3: Monitoring-Based Expansion of the Properties Profile
Participants integrate monitoring results into their sustainability-based properties profile developed earlier.
Purpose: connect green metrics with real treatment performance.
Duration: 25–30 minutes

Activity 4 Assessment: Visual Presentation of Full Properties Profile
Participants present their final expanded profile using a clear visual communication format:

- comparison matrix
- infographic
- poster slide
- short PowerPoint summary

Required components:

- physical properties
- toxicity/hazard metrics
- LCA considerations
- monitoring results and efficacy outcomes
- final evaluation and recommendation

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Materials Required

- Treated case study samples (metals, glass)
- Handheld microscope / digital microscope (if available)
- Documentation tools (camera/phone, light source)
- pH strips, conductivity meter (optional)
- Cotton swabs, deionised water, gloves
- Worksheets / digital templates for recording results
- Reference data: SDS extracts, hazard pictograms, benchmark method summaries

PowerPoint slides and printed instruction sheets

Facilitator Notes

General guidance

- Emphasise that sustainability evaluation must be evidence-based: “green” is not automatically safer or more effective.
- Encourage careful documentation and consistent observation conditions (lighting, magnification, scale).
- Reinforce cross-material thinking: methods that work on metals may behave differently on glass for example.

Recommended Discussion Points

- What monitoring technique gave the most useful information?
- How do you define “successful treatment” beyond visual appearance?
- Do green delivery systems reduce overall risk even if chemistry is similar?
- What indicators suggest long-term instability may still occur?

Timing Suggestions

- Keep demonstrations short and prioritise hands-on work.
- Use structured worksheets to prevent groups from losing time.
- Reserve final time for profile comparison and reflection.

ADDITIONAL RESOURCES

- GoGreen Deliverables 3.2 and 4.2: Benchmark performances of cleaning/stabilization methods
- Literature on monitoring techniques for conservation cleaning evaluation
- Research on residues and surface change detection after gel-based cleaning
- Studies on assessment of biodegradable chelators (EDDS, DFO)

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Appendix 9.1: Worksheet template – Expanded Properties Profile Worksheet (Monitoring + Sustainability)

Group: _____ Date: _____ Sample ID: _____
Material/Method Tested: _____
Benchmark Method: _____
Surface Type: ☐ Metal ☐ Glass Type/Alloy (if known): _____
Corrosion/Alteration Type: _____

1) Treatment Description

Active agent: _____ Delivery: ☐ Liquid ☐ Gel ☐ Microfibre ☐ DES ☐ Other: _____
Application method: ☐ Swab ☐ Immersion ☐ Poultice ☐ Local gel ☐ Other: _____
Concentration: _____ Time: _____ Rinsing/clearance: _____
Waste generated (est.): ☐ Low ☐ Med ☐ High

2) Physical / Functional Properties (quick notes)

pH (if known): _____ Solubility/miscibility: _____
Selectivity (target): _____
Handling / control: ☐ Easy ☐ Moderate ☐ Difficult
Residue risk (expected): ☐ Low ☐ Med ☐ High
Compatibility with mixed materials: ☐ Good ☐ Uncertain ☐ Poor

3) Toxicity & Hazard Profile

GHS hazards known? ☐ Yes ☐ No Key risks:
_____
Human health risk: ☐ Low ☐ Med ☐ High
Environmental risk: ☐ Low ☐ Med ☐ High
Disposal concern: ☐ Low ☐ Med ☐ High
PPE needed: ☐ Gloves ☐ Goggles ☐ Mask/Respirator ☐ Ventilation required

4) LCA / Sustainability Indicators (estimate if needed)

Indicator	*Low*	*Med*	*High*
Renewable / bio-based origin	☐	☐	☐
Biodegradability potential	☐	☐	☐
Energy intensity of production	☐	☐	☐

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Indicator	*Low*	*Med*	*High*
Waste volume produced	☐	☐	☐
Water demand	☐	☐	☐
Solvent/VOC contribution	☐	☐	☐
Availability / sourcing burden	☐	☐	☐

Main sustainability advantage: _____
Main sustainability concern/trade-off: _____

5) Monitoring Methods Used (tick)

☐ Before/after photos ☐ Visual inspection ☐ Microscope ☐ Colour check ☐ Gloss check
☐ pH test ☐ Conductivity test ☐ Swab residue test ☐ Other: _____

6**) Efficacy Results (Score 1–5)** ***(1 = poor, 5 = excellent)***

Criterion	*Score*	*Notes*
Corrosion/tarnish removal	1 2 3 4 5	
Uniformity of cleaning	1 2 3 4 5	
Control/localisation	1 2 3 4 5	
Time efficiency	1 2 3 4 5	
Need for mechanical action	1 2 3 4 5	
Aesthetic outcome	1 2 3 4 5	

7) Surface Impact / Risks (tick + note)

☐ Scratching/abrasion ☐ Dulling/gloss loss ☐ Colour shift ☐ Etching/pitting
☐ Residue/film ☐ Uneven reaction ☐ Corrosion reactivation signs ☐ None observed

Evidence/notes (microscopy, swab, photos):

_____
_____
_____
_____
_____
_____

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_____
_____
_____
_____
_____

Ease of clearance/rinsing: ☐ Easy ☐ Moderate ☐ Difficult
Residue risk after treatment: ☐ Low ☐ Med ☐ High

8) Comparison with Benchmark

Category	*Green(er)*	*Benchmark*
Effectiveness	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Surface safety	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Sustainability	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse
Practical usability	☐ Better ☐ Same ☐ Worse	☐ Better ☐ Same ☐ Worse

Overall winner: ☐ Green(er) ☐ Benchmark ☐ Comparable
Reason (1 sentence): _____

9) Final Recommendation

Recommend? ☐ Yes ☐ No ☐ Yes, with limitations
Limitations / conditions: _____

Next steps / further testing needed: _____

10) References / Data Source

☐ SDS ☐ Paper ☐ GoGreen Deliverable ☐ Lecture notes ☐ Other: _____

Assessment Output (tick)

☐ Poster slide ☐ Infographic ☐ Matrix chart ☐ Short presentation (3–5 slides)

Attach: ☐ Before/after images ☐ Scoring summary ☐ Sustainability indicators

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10. Green Treatment for Objects and Their Assessment: Putting into Practice

Author: Edith Joseph

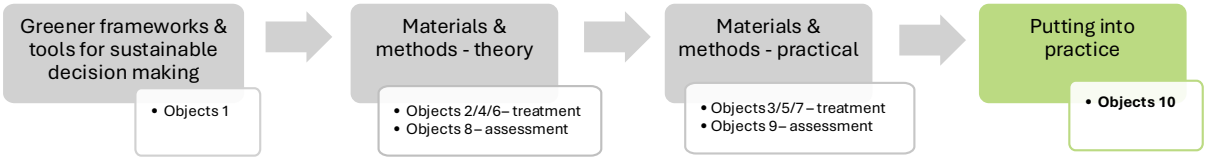
The aim of this concluding session is to consolidate and apply the knowledge, tools and methodologies introduced throughout the previous sessions on metals and glass conservation. Participants will work collaboratively on practical case studies involving conservation treatment options for metal and/or glass objects. Through structured sustainability assessment exercises, they will compare traditional and greener treatment approaches, evaluate their effectiveness, and justify their decisions using the frameworks introduced in Session 1 and progressively developed throughout Sessions 2–9. The session focuses on translating sustainability concepts into practical conservation decision-making by integrating technical, ethical, environmental and feasibility considerations into treatment planning.

Key Concept 1	**Sustainability assessment as an integral part of conservation decision-making.**
Key Concept 2	**Balancing conservation effectiveness with environmental and ethical responsibility.**
Key Concept 3	**Comparative evaluation of traditional and greener treatment approaches.**
Key Concept 4	**Collaborative and reflective professional decision-making.**

OBJECTIVES

Objective 1	Be able to apply sustainability assessment tools and green conservation frameworks to real conservation treatment scenarios involving metal and/or glass objects.
Objective 2	Be able to compare and evaluate traditional and greener treatment options according to conservation effectiveness, environmental impact, practitioner safety, feasibility and ethical considerations.
Objective 3	Be able to work collaboratively in groups to develop and justify conservation treatment decisions using structured assessment frameworks.
Objective 4	Be able to critically reflect on the opportunities and limitations of greener conservation approaches in professional practice.

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

Preparation

Select one or more metal and/or glass objects representing different conservation challenges. Objects may include:

- Corroded archaeological metals
- Tarnished historic silver, iron or copper alloys
- Glass objects exhibiting instability, weathering or surface deterioration
- Previously treated objects requiring reassessment

Objects could ideally present several possible treatment approaches to encourage comparative discussion.
Depending on participant numbers and available resources, participants may work individually, in pairs or in groups of three to four.

Selection of treatment options and assessment materials

Prepare a range of treatment options for comparison, including:
Metals

- Traditional solvent cleaning systems
- Mechanical cleaning options
- Chelating systems
- Greener solvent alternatives
- Low-toxicity corrosion inhibitors
- Alternative coating systems

Glass

- Traditional consolidants or stabilisation systems
- Alternative greener consolidants
- Cleaning systems with reduced toxicity
- Environmental control approaches
- Preventive conservation alternatives

Include relevant documentation for:

- Hazard assessment
- Environmental impact
- Resource consumption
- Waste generation
- Practitioner safety
- Long-term stability and retreatability

Preparation of sustainability assessment templates

Prepare or adapt worksheets and diagrams for:

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- StiCH or DSA assessment exercises
- Comparative treatment matrices
- Risk-benefit analysis
- Ethical decision-making frameworks
- Environmental impact scoring
- Group presentation summaries
-

Digital or printed documentation may be used depending on local conditions and available infrastructure.

Preparation of practical workstations

Prepare:

- Workstations for examination and testing
- Documentation equipment
- Microscopes and UV lamps if available
- PPE and waste-management systems
- Samples or mock-ups if treatment testing is included

Facilitator preparation

Facilitators should review previous sessions carefully in order to:

- Reconnect participants with previously introduced tools and concepts
- Ensure continuity between material-specific sessions and this capstone exercise
- Prepare guiding questions encouraging critical discussion
- Identify possible treatment pathways for each object.

SESSION OUTLINE (total 3-4 hours)

The session is designed as a concluding practical workshop lasting approximately 3 hours, combining group discussion, sustainability assessment exercises, comparative treatment planning and presentation of results.

Session 1: Object Examination and Problem Definition (30 min)

Participants examine the assigned objects and identify:

- Conservation problems
- Material-specific risks
- Historical and ethical considerations
- Desired treatment outcomes
- Constraints affecting decision-making

Groups define the scope of the conservation challenge and identify possible intervention strategies.

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Session 2: Comparative Treatment Planning (30 minutes)
Participants identify and compare multiple treatment scenarios, including:

- Traditional approaches
- Greener alternatives
- Minimal intervention options
- Preventive conservation approaches

Using sustainability frameworks, participants assess:

- Effectiveness
- Risks to the object
- Practitioner safety
- Environmental impact
- Resource use
- Feasibility and accessibility
- Long-term implications

Session 3: Sustainability Assessment Workshop (60 minutes)
Participants complete structured sustainability assessments of selected treatment options using the tools introduced earlier in the module.
Activities may include:

- Completing comparative matrices
- Scoring treatment options
- Risk-benefit analysis
- Waste and energy evaluation
- Hazard assessment
- Ethical analysis
- Group discussion

Where practical testing is included (additional 1 hour), participants may also:

- Conduct limited treatment tests
- Evaluate treatment effectiveness visually and microscopically
- Compare traditional and greener treatment systems
- Assess ease of application and practitioner comfort

Session 4: Group Presentations and Comparative Discussion (35 minutes)
Each group presents:

- Their selected treatment approach
- The reasoning behind their decisions
- Comparative evaluation of alternatives
- Environmental and ethical considerations
- Anticipated limitations and risks

The wider group discusses:

- Differences between decision-making approaches
- Trade-offs between effectiveness and sustainability
- Feasibility in professional practice
- Areas where greener approaches remain limited

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Session 5: Final Reflection and Wrap-Up (10 minutes)
Participants reflect on:

- How sustainability assessment tools influenced decision-making
- Which criteria proved most difficult to balance
- How they may integrate these approaches into future practice
- Remaining challenges in green conservation for objects

Session 6: Cleaning Up and Waste Management (10 minutes)
Dedicated discussion and demonstration of:

- Waste segregation
- Solvent disposal
- Reuse and reduction strategies
- Sustainable laboratory practice

Case Study / Example

Possible case studies may include:

- Comparison of corrosion stabilisation systems for archaeological iron
- Assessment of traditional versus greener coating systems for copper alloys
- Evaluation of cleaning systems for tarnished silver objects
- Comparative stabilisation strategies for unstable glass objects

The selected case study should encourage participants to compare several valid treatment options rather than identify a single "correct" answer.

Summary / Wrap-Up (5–10 minutes)

At the end of this session, participants reflect collectively on the role of sustainability assessment in conservation practice. Discussion prompts may include:

- Which sustainability criteria most strongly influenced your treatment decision?
- Were greener alternatives always the preferred option?
- How should conservators balance practitioner safety, object preservation and environmental concerns?
- Which limitations currently prevent wider adoption of greener approaches?
- How can sustainability assessment tools support communication with institutions and stakeholders?

This final reflection allows participants to revisit the key concepts introduced throughout the module and consolidate their understanding of sustainable conservation decision-making.

METHODOLOGY

Delivery Format This session combines:

- Practical object-based analysis
- Group discussion and collaborative decision-making

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- Comparative assessment exercises
- Structured sustainability evaluation
- Reflective discussion and presentation

The session emphasises active participation and critical reflection.

The session begins with a short recap presentation reconnecting participants with the sustainability frameworks and treatment methodologies introduced earlier in the course.

Participants then work in groups on practical case studies involving metal and/or glass objects. They examine the objects, define conservation priorities and compare several possible treatment approaches.

Using the sustainability assessment frameworks presented in Session 1 and progressively developed through Sessions 2–9, participants evaluate each option according to conservation effectiveness, environmental impact, practitioner safety, resource use, feasibility and ethical considerations.

Groups present and justify their final decisions to the wider class, allowing comparative discussion and reflection on different professional approaches.

Where possible, the workshop should take place directly in front of the objects or within a practical conservation environment to encourage engagement with real conservation challenges.

Activities / Exercises / Assessments

1. Object Examination and Definition of Conservation Goals (Activity, 30 minutes)

Materials/tools
Objects, examination lighting, UV lamp, microscope if available, documentation sheets, cameras.
Description
Participants examine the assigned object(s) and identify:

- Material-specific deterioration
- Risks and vulnerabilities
- Ethical considerations
- Desired treatment outcomes
- Areas requiring further assessment

Groups discuss and define realistic conservation goals.

2. Comparative Treatment Planning (Activity, 30 minutes)

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Materials/tools
Course literature, sustainability assessment frameworks, treatment documentation, hazard information sheets, comparative assessment templates.
Description
Participants identify possible treatment approaches and compare:

- Traditional systems
- Greener alternatives
- Preventive conservation options
- Minimal intervention strategies

Participants discuss advantages, limitations and practical implications before selecting options for deeper assessment.

3. Sustainability Assessment Workshop (Activity, 60 minutes)

Materials/tools
Assessment templates, decision-making matrices, treatment samples if applicable, PPE, microscopes, documentation materials.
Description
Participants perform structured sustainability assessments of selected treatment options.
Assessment criteria may include:

- Conservation effectiveness
- Risks to the object
- Practitioner health and safety
- Environmental impact
- Waste generation
- Resource and energy consumption
- Feasibility and accessibility
- Long-term stability and retreatability

Where practical treatment testing is included (+ 1 hour), participants compare traditional and greener approaches and document observations.
Participants complete comparative matrices and formulate a proposed treatment strategy.

4. Group Presentations and Comparative Discussion (Activity, 35 minutes)

Materials/tools
Presentation sheets, whiteboard or projector, documentation images.
Description
Groups present and justify their treatment decisions.
Presentations should include:

- Selected treatment approach
- Alternative options considered
- Sustainability assessment results
- Risks and limitations

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- Ethical considerations
- Justification for final decisions

The wider group discusses similarities and differences between approaches and reflects on the complexity of sustainable conservation decision-making.

5. Final Reflection and Action Planning (Activity, 10 minutes)
Materials/tools
Reflection sheets or action-plan templates.
Description
Participants reflect individually or in groups on:

- Lessons learned
- Challenges encountered
- Areas for future development
- How sustainability assessment may influence their professional practice.

Facilitator Notes

When selecting case studies and treatment options, facilitators should ensure that:

- Multiple valid treatment approaches are possible
- Environmental and ethical trade-offs are visible
- Discussions remain open and critical rather than solution-driven
- Participants are encouraged to justify decisions rather than identify a single correct answer

Where resources are limited, groups may work on the same object while comparing different treatment strategies.

Facilitators should adapt examples and benchmark methods to local professional practices and available materials.

General Guidance

- Encourage discussion and collaborative reflection throughout the session.
- Remind participants that sustainability assessment is intended to support—not replace—professional judgement.
- Emphasise that greener approaches are not automatically preferable if they compromise conservation quality or long-term stability.
- Highlight the importance of practitioner safety and feasibility alongside environmental considerations.
- Encourage participants to revisit concepts introduced in previous sessions.
- Ensure that all materials and waste containers remain clearly labelled.
- Use the final discussion to connect technical decision-making with broader professional responsibilities.

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ADDITIONAL RESOURCES

- Sustainability assessment worksheets (StiCH, DSA or equivalent)
- Comparative treatment matrices
- Risk-benefit analysis templates
- Hazard and environmental impact guidance sheets
- Documentation templates for practical exercises
- Relevant literature from Sessions 1–9
- Waste-management and laboratory sustainability guidelines

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