UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Raw Materials and Sustainable Industry

2526-1-F7603Q023-F7603Q02301

Aims

Solid waste, either civil or industrial, represents a multifaceted problem since the volume of waste produced increases exponentially with time, often represents a hazard for the environment and human health, and potential precious raw materials are abandoned forever. This module, after introducing basic concepts of mineralogy and related characterization techniques, through the presentation of some case studies aims at demonstrating how what commonly considered a waste, or even a toxic waste, can actually be recycled as secondary raw material in a sustainable way in a perspective of circular economy.

The students are invited to consult the syllabus of the entire course for details regarding learning- and skill-related objectives.

Contents

• Introduction to minerals and mineral resources.
• Introduction to material characterization techniques.
• Thermal deactivation of asbestos cement and recycling.
• Rare earth elements for green technologies.
• From waste to secondary raw materials.

Detailed program

Introduction to minerals and mineral resources
• raw materials for the ceramic industry;
• cement minerals;

• common inorganic fillers.

Introduction to material characterization techniques
• X-ray powder diffraction (XRPD);
• X-ray fluorescence analysis (XRF);
• scanning (SEM) and transmission electron microscopy (TEM);
• inductively coupled plasma absorption emission spectroscopy (ICP-AES);
• mechanical tests;
• leaching tests.

Thermal deactivation of asbestos cement and recycling
• asbestos minerals, toxicity, applications and banning;
• asbestos in the built environment;
• current strategies of asbestos remediation;
• smart strategies of asbestos detoxification;
• recycling deactivated asbestos cement in several industrial applications;
• cost-benefits analysis and life cycle assessment of asbestos deactivation and recycling;
• ecotoxicological tests on deactivated asbestos cement.

Rare earth elements for green technologies
• technological applications;
• REE ore minerals;
• the contribution of mineralogy to REE exploration, exploitation, beneficiation and recycling.

From waste to secondary raw materials
• red muds from the alumina production: the case of red mud from Portovesme (Sardinia, Italy);
• from high-volume industrial waste to new ceramic material: the case of red gypsum muds in the TiO2 industry;
• flotation sludges from precious metal recovery processes: from waste to secondary raw material in ceramics;
• stearate from the metal wire industry: recycling in ceramics, mortar and polymers.

Prerequisites

• Basic knowledge of inorganic chemistry.
• Basic knowledge of solid-state physics.

Teaching form

2 CFU of mixed didactics in the classroom (20 hours):
• 6 two-hour lectures, in person, Delivered Didactics;
• 2 two-hour practical sessions (quiz), in person, Interactive Teaching;
• 2 two-hour practical sessions with seminars, visits to laboratories (virtually or in person), Interactive Teaching.

Attendance to lectures and interactive exercises is highly recommended.

Textbook and teaching resource

• Lecture notes provided by the lecturer.
• Research articles and book chapters provided by the lecturer.
• On-line material.

Semester

II semester (March - June)

Assessment method

At the end of this module, an online multiple choice (true/false) test needs to be passed.

The final oral exam for the laboratory course as a whole comprises the discussion of various topics covered in the three modules, with an emphasis also on the connections between concepts and tools, such as to arrive at a critical evaluation of the laboratory course topics as a whole.

The final score will be between 18/30 and 30/30 *cum laude*, based on the overall assessment considering the following criteria:
(1) knowledge and understanding;
(2) ability to connect different concepts;
(3) autonomy of analysis and judgment;
(4) ability to correctly use scientific language.

Office hours

Always, after scheduling an appointment *via* phone or e-mail.

Sustainable Development Goals

QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION