

Review

PLANNING AND IMPLEMENTATION OF MINING WASTE SAMPLING: STANDARDS AND LEGAL REGULATIONS

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Abstract

In this paper, the mining waste sampling process was analyzed with the aim of obtaining a representative sample, which is crucial for reliable laboratory analysis. A special emphasis is placed on drawing up a sampling plan in accordance with relevant standards, such as SRPS EN 14899:2012, SRPS CEN/TR 16365:2013, and the CEN/TR 15310:2009 series, which provide a methodological framework and practical guidelines for sampling in different conditions. Also, the legal regulations in the Republic of Serbia governing the field of mining waste management, including obligations related to classification, testing, disposal, and monitoring of waste, are presented. It was concluded that the proper application of standards and regulations enables efficient management of mining waste, reduction of negative impacts on the environment and contribution to the sustainable development of the mining sector.

Keywords: mining waste, sampling plan, representative sample, standards, legislation, environmental protection.

INTRODUCTION

Mining waste represents a significant source of potential environmental pollution, due to the presence of harmful substances that can negatively affect soil, water resources, and air. In this context, developing sustainable approaches to the management of mining waste is becoming one of the key challenges of the modern mining industry. Sustainable management implies the integration of environmental, economic, and social aspects in order to minimize negative impacts and optimize the use of resources. Management of mining waste involves a series of activities, including its characterization, assessment of potential environmental impacts, and the application of appropriate remediation and control measures [1,2].

The Law on Mining and Geological Research [3] regulates resource exploitation, mining waste management, the construction and use of mining facilities, and the rehabilitation and supervision of these activities. This law stipulates that mining waste must be managed in a way that does not endanger human health and the environment, i.e. the law requires that mining

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waste must be properly classified and recorded, the operator must develop a mining waste management plan, waste disposal must be carried out in a technically and ecologically safe manner, measures to prevent water, soil and air pollution must be applied, mandatory monitoring of landfills and tailings and after the closure of the mine, the operator is obliged to carry out rehabilitation and reclamation of the area.

In the legislation of the Republic of Serbia, the Regulation on the conditions and procedure for issuing a permit for waste management, as well as criteria, characterization, classification, and reporting on mining waste [4] regulates in more detail the conditions and procedure for issuing a permit for waste management, as well as criteria, characterization, classification, and reporting on mining waste. According to this regulation, companies or other legal entities and entrepreneurs that manage waste generated during geological research, exploitation, preparation, and storage of mineral raw materials are obliged to harmonize their operations with the provisions of this regulation.

The Rulebook on Categories, Testing and Classification of Waste [5] prescribes the classification and testing of waste, including the catalogue of waste, categories, and lists of hazardous waste, its characteristics and components, as well as methods of disposal and reuse. It also defines limit values, test parameters and the content of the waste report.

One of the first and basic steps in the characterization of any raw material, including mining waste, is the implementation of the sampling process, in accordance with the basic principles of sampling theory, with the aim of obtaining representative samples. Obtaining a representative sample of mining waste for environmental impact assessment requires a detailed sampling plan. The sampling plan must be done according to standard methods and according to legal regulations. Mandatory standards for drawing up a sampling plan are SRPS EN 14899:2012, which is used as the basic framework for drawing up the plan, followed by the technical report SRPS CEN/TR 16365:2013, the series of standards CEN/TR 15310:2009, and other supporting standards [6–14].

Preparation of a sampling plan according to standard methods

Mining waste represents a significant ecological and technical challenge due to its non-homogeneity and potential impact on the environment. In order to obtain a representative sample, a sampling plan should be prepared according to standard methods and legal regulations. The sampling plan describes the method of collecting the laboratory sample necessary to fulfil the objective of the test program and obtain a representative sample. Mining waste sampling is carried out for the purpose of characterizing the waste, assessing the risk of creating acid rock drainage (ARD), acid mine drainage (AMD), and checking compliance with the limit values for waste disposal.

Standard SRPS EN 14899:2012 (Characterization of waste – Sampling of waste materials – Framework for the preparation and application of a Sampling Plan) determines the procedural steps that need to be taken in the preparation of the sampling plan [6]. This standard is an umbrella European standard that defines the framework for preparing a waste sampling plan. He does not give fixed procedures, but lays down a procedural logic for sampling to be proper and scientifically validated. The key elements of this standard are: defining the sampling objective (Testing Programme). According to him, the sampling plan must be documented and

contain the identification of the population, a sampling strategy that involves determining the number of increments and sampling locations that can be random, systematic or stratified, and a systematic approach that involves determining the required mass of the sample based on grain size. Also, the sampling plan must contain technical instructions (Sampling Operations) that describe in detail which tool is used, which container to use in order to prevent contamination of the sample during transport, and the system for marking the sample taken (date, place, depth of sampling, etc.), Figure 1. According to this standard, sampling is considered complete only when the sampling record is filled out. Any deviation from the plan in the field must be noted, because it directly affects the reliability of the laboratory result.

The principles or basic rules set out in this standard provide a framework that the project manager can use to: develop standardized sampling plans for use in regular or routine circumstances; include specific sampling requirements under European and national legislation; design and develop a sampling plan for case-by-case use. Sometimes more than one sampling plan may be needed to meet all the requirements of the test program. A sampling plan provides the sampler with detailed instructions on how to perform the sampling.

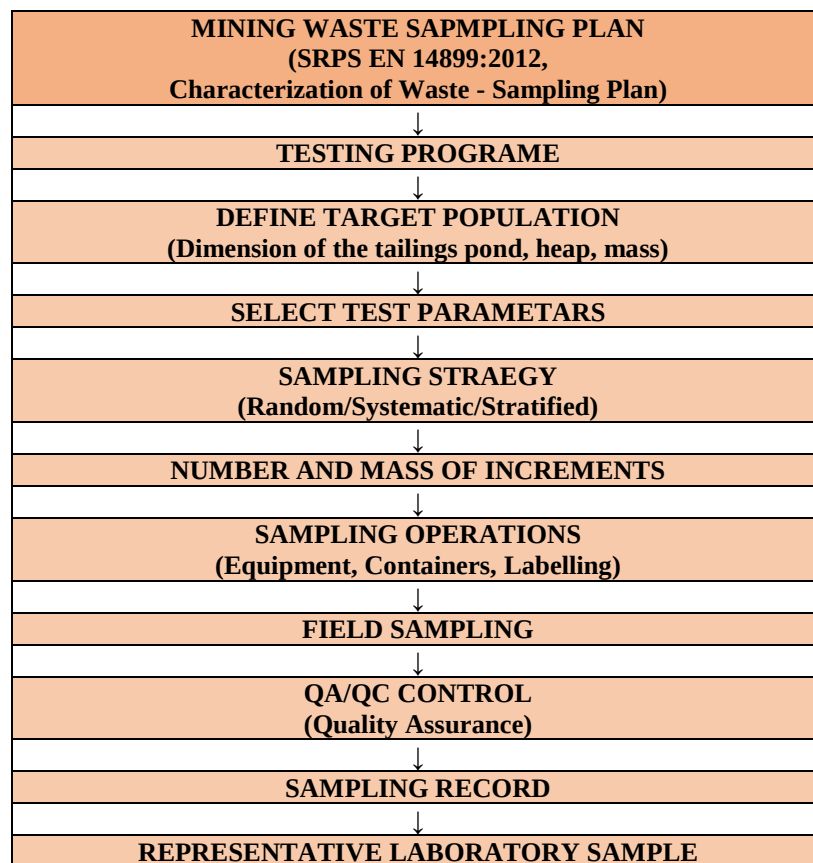


Figure 1 Mining waste sampling plan

The sampling plan according to this standard must contain: testing objective, population definition (determining the exact dimensions of the tailings pond (X, Y, Z coordinates) and estimation of total mass), selection of parameters, sampling strategy, mass and number of increments, technical requirements, and quality assurance (QA/QC).

SRPS EN 14899:2012 is used as a basic framework for mining waste sampling, but is rarely used independently. Since mining waste is very specific, a special technical report SRPS CEN/TR 16365:2013, Waste characterization – Sampling of waste from the extractive industry, was developed, which directly follows EN 14899:2012. This technical report provides additional specific information on extractive waste sampling and testing to support the development of suitable sampling plans. This additional guidance for the application of EN 14899:2012 is necessary because extractive waste is significantly different from other types of waste, and the existing sampling scenario given in technical reports CEN/TR 15310-1 to 5. This document should be used together with EN 14899:2012 and CEN/TR 15310-1 to 5 [7].

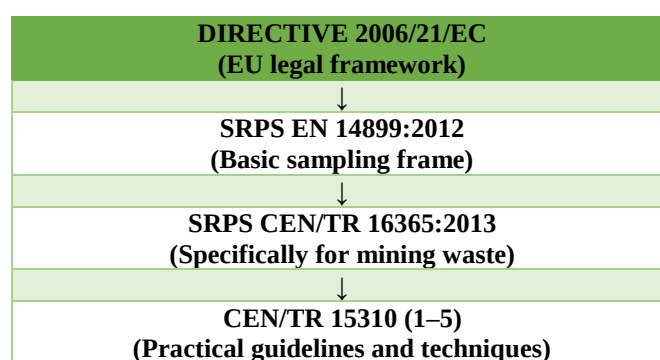


Figure 2 Hierarchy of standards for creating a mining waste sampling plan

Preparation of technical reports

The technical report SRPS CEN/TR 16365:2013 uses the logic of EN 14899:2012, but is adapted to challenges such as huge amounts of material and its great heterogeneity. This document provides guidance and specific information for designing and implementing a waste sampling program for mining and quarrying waste. The purpose of this technical notice is to support the development of adequate sampling plans to characterize the waste in accordance with regulatory requirements, operational control, or mine closure plans. The standard focuses on obtaining samples to be representative of the entire mass of waste, which is crucial for assessing potential environmental hazards, such as acid drainage or the presence of heavy metals.

Technical report CEN/TR 16365:2013 does not prescribe one universal method, but offers a framework for creating a Sampling Plan that depends on the phase of the mining project. If the mine is in the exploration phase, then the focus is on cores and analysis of the potential for acid generation (ABA tests). If the mine is in the operational phase, sampling is done directly from strips, from trucks, or from active disposal sites (tailings) to monitor waste variability. If the mine is in the closure phase, methods focus on surface layers and deep drilling to assess long-term stability and reclamation.

According to this technical report, the sample size is determined based on the maximum particle size (granulation) to ensure representativeness, and incremental sampling is recommended, *i.e.*, taking several small "portions" (increments) that are combined into a composite sample.

CEN/TR 16365:2013 is part of a wider package of documents developed for the implementation of Directive 2006/21/EC (known as the Mining Waste Directive) and which represents the key legal act of the EU that regulates the management of waste from the extractive industry [8]. The main objective of the directive is the prevention or reduction of harmful effects on the environment and human health resulting from the management of waste from mining, exploration, extraction, and storage of mineral resources [9].

CEN/TR 15310:2009 is a series of five technical reports (Technical Reports) issued by the European Committee for Standardization (CEN) under the umbrella title "Characterization of waste - Sampling of waste materials". These documents complement SRPS EN 14899:2012 and provide detailed guidance and tools for the practical application of sampling plans in a variety of conditions.

The CEN/TR 15310:2009 series is divided into five specific units:

1. SRPS CEN/TR 15310-1:2009, Waste characterization – Waste sampling – Part 1: Guidelines for the selection and application of sampling criteria under different conditions. This section covers the statistical principles of sampling and helps determine the number and size of samples to achieve the desired precision and reliability. The report shows methods that help in planning sampling in different conditions, but does not provide universal instructions; it provides guidelines for choosing the amount and method of sampling for maximum reliability of the results [10].
2. SRPS CEN/TR 15310-2:2009, Waste characterization – Waste sampling – Part 2: Guidelines for sampling techniques. This section provides practical guidance for sampling different types of waste (solid, liquid, and sludge). This technical report provides information that enables the selection and preparation of equipment and apparatus used for taking samples that can be found in various locations [11].
3. SRPS CEN/TR 15310-3:2009, Waste characterization – Waste sampling – Part 3: Guidelines for field subsampling procedures. It addresses methods for reducing the primary sample to a transportable size while preserving representativeness. It describes procedures in accordance with good practice, with the possibility of applying other appropriate methods [12].
4. SRPS CEN/TR 15310-4:2009, Characterization of waste – Sampling of waste – Part 4: Guidelines for procedures for packaging, storage, protection, transport and delivery of samples. It focuses on preserving sample integrity from sample collection to the laboratory. It describes the procedures for packaging, protection, short-term storage, and transportation of solid and liquid waste samples, with the application of appropriate standards and good practices. When possible and suitable for field application, requirements related to specific storage conditions and protection methods should be selected from the appropriate analytical standard in cooperation with the testing laboratory [13].
5. SRPS CEN/TR 15310-5:2009, Characterization of waste – Sampling of waste – Part 5: Guidelines for drawing up a sampling plan. This technical report contains instructions for documenting the sampling process and developing a sampling plan. It helps with the choice of location and methods, but only provides guidelines based on statistical approaches, in order to achieve reliable results. Due to the variety of waste types, objectives, and sampling techniques, this document does not provide definitive guidance. Only statistical approaches

and statistical methods are given, which are used to determine the sample and the method of collection, to achieve maximum reliability for further testing methods [14].

These reports are of critical importance to laboratories and waste management companies, as they provide a uniform approach necessary for legal compliance and environmental protection. The procedures shown in these documents are in accordance with current good practice.

CONCLUSION

This paper examines the sampling of mining waste as a critical step in its characterization and subsequent management. Due to the pronounced heterogeneity of mining waste, sampling represents a complex process that requires careful planning and the application of appropriate methodologies to ensure sample representativeness. The reliability of laboratory results is directly dependent on the quality of sampling, further emphasizing the importance of a well-designed sampling plan.

Standards such as SRPS EN 14899, SRPS CEN/TR 16365, and the CEN/TR 15310 series provide a comprehensive methodological framework and practical guidance for planning and implementing sampling under various conditions. Their application enables a systematic approach, encompassing the definition of sampling objectives, selection of appropriate strategies, and proper handling, processing, and transport of samples, thereby ensuring the reliability and comparability of results.

In addition to technical considerations, this paper also reviews the legislative framework in the Republic of Serbia governing mining waste management. These regulations clearly define the obligations of operators regarding waste classification, monitoring, safe disposal, and site remediation following the cessation of mining activities. Compliance with these legal requirements, alongside adherence to established standards, forms the foundation of responsible mining waste management.

Based on the presented analysis, it can be concluded that an integrated approach – combining regulatory compliance, standard application, and sound engineering practices – is essential for effective mining waste management. Such an approach contributes to minimizing environmental impacts, conserving natural resources, and supporting the sustainable development of the mining sector.

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