# An Assessment of the Metallic Iron Content from Steel Mill Scale – Essential Factor for Sustainability and Circular Economy

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**Abstract.** The aim of this paper is the assessment of the total and metallic iron contents from steel mill scale coming from the technological flow of the steel rolling and from the Crişeni landfill (Sălaj County, Romania). The ten steel mill scale samples were collected from the technological flow of the steel rolling and the ten steel mill scale samples were collected from the Crişeni landfill. The determination of the total and metallic iron in the steel mill scale samples was achieved by using a spectrometer based on X-ray fluorescence. There were analyzed ten samples from the technological flow of the steel rolling and ten samples from the landfill. The metallic iron content from the ten samples coming from the technological flow of the steel rolling, varies from 64.4 (sample 8) to 72.7 (sample 7). The metallic iron content from the ten samples coming from the landfill, varies from 58.7 (sample 4) to 63.2 (sample 9). The results obtained show that the steel mill scale is a significant source of the metallic iron. The reuse of the metallic iron content, as a raw materials or auxiliary materials, would contribute to sustainability and circular economy in the iron and steel industry.

**Keywords:** Metallic iron · Steel mill scale · Metallurgical wastes management · Sustainability · Reuse · Closed - loop system · Circular economy

## 1 Introduction

Mill scale is considered a by-product of the steelmaking, which comes from the rolling mill in the steel hot rolling process. Mill scale it is a valuable metallurgical raw material for iron making, steelmaking, and construction industries because it contains valuable metallic fractions. The annual quantity of the oily sludge and mill scales, generated in Europe, it is approximately 500,000 tones/yr. From this quantity, more than 30% is not valorized. Due to this fact, significant quantities of valuable metallic minerals are lost forever. In the world, the quantity of the steelmaking by-products, such as dust and mill scale represent approximately 5 million tons [1–9].

The main characteristic of the circular economy is the redesign of the industrial processes, so that the materials constantly circulate in a "closed-loop system", which assures that the waste generation is minimized [10].


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A circular economy enables economic growth in a sustainable manner and at the same time encourages environmental protection and social prosperity.

The European Commission has estimated that manufacturing sector from the European Union (EU) would gain an additional 600 billion Euros each year, if the transition to a circular economy would be accomplish. At first, the circular economy concept was based on the 3R principle (reduce, reuse, recycle), while more recently it was expanded to the 6R principle (reuse, recycle, redesign, remanufacture, reduce, recover) [11–13].

Sustainable development in the steel industry, involves [14, 15]:

- recovery and reuse the metallic iron contents from the wastes;
- recovery and reuse the valuable components from the wastes;
- conserving the natural resources such as iron ore, coal, dolomite, magnesite etc.;
- minimizing the quantity of wastes landfilled;
- increasing the degree of the metallurgical wastes recycling;
- minimizing the quantity of hazardous wastes;
- minimizing the emissions.

The purpose of the paper is the assessment of the total and metallic iron contents from steel mill scale, in order to improve the management of metallurgical wastes, for sustainability and circular economy in the steel industry.

The objectives of the paper are:

– the assessment of the total iron contents from steel mill scale (from landfill Crişeni);
– the assessment of the metallic iron contents from steel mill scale (from landfill Crişeni);
– the assessment of the total iron contents from steel mill scale (coming from the technological flow of the steel rolling);
– the assessment of the metallic iron contents from steel mill scale (coming from the technological flow of the steel rolling);
– improving the metallurgical wastes management from landfill;
– improving the metallurgical wastes management, coming from the technological flow of the steel rolling;
– reuse of the iron from this waste (as a raw material or as an auxiliary material) for closed - loop system and for sustainability and circular economy in the iron and steel industry.

## 2 Materials and Methods

The ten mill scale samples were collected from the technological flow of the steel rolling (metallurgical plant, Sălaj County, Romania) and the ten steel mill scale samples were collected from the Crişeni landfill. The mill scale landfilled to the landfill, comes from the different cooling and cleaning operations taking place in the rolling process. The steel mill scale samples were collected from ten points to the edge of the landfill.

There were analyzed ten samples from the technological flow of the steel rolling and ten samples from the landfill. The determination of the total and metallic iron in the steel mill scale samples was achieved by using a spectrometer (Niton type) based on (XRF) X-ray fluorescence. The chemical composition of the metallic iron from steel mill scale samples was determined in compliance with the methodology described in the references [15–17].

## 3 Results and Discussions

In the Fig. 1 are presented the changes in the percentage concentrations of the total and metallic iron in the steel mill scale samples from landfill.

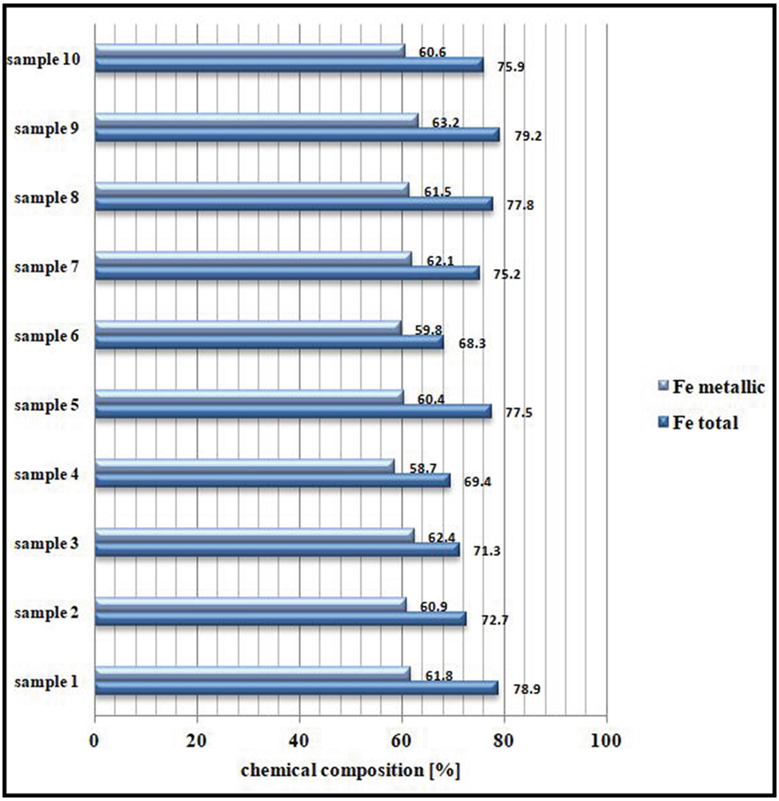


**Fig. 1.** Changes in the level of total and metallic iron of the steel mill scale from landfill.

From the analysis of the data presented in the Fig. 1 it results that:

- the concentrations of the total and metallic iron in all ten steel mill scale samples, are significant;
- the percentage concentration of the total and metallic iron, from the ten steel mill scale samples varies from one sample to another;
- the ten steel mill scale samples have variable concentrations of the total iron, between 68.3 (sample 6) to 79.2 (sample 9);

- the metallic iron content from the ten steel mill scale samples, varies from 58.7 (sample 4) to 63.2 (sample 9);
- the reuse of the iron content from this waste, as a source of raw material or as a source of auxiliary material, in the technological process from which it comes, would contribute towards a closed - loop system for the steelmaking industry.

In the Fig. 2 are presented the changes in the percentage concentrations of the total and metallic iron in the steel mill scale samples coming from the technological flow of the steel rolling.

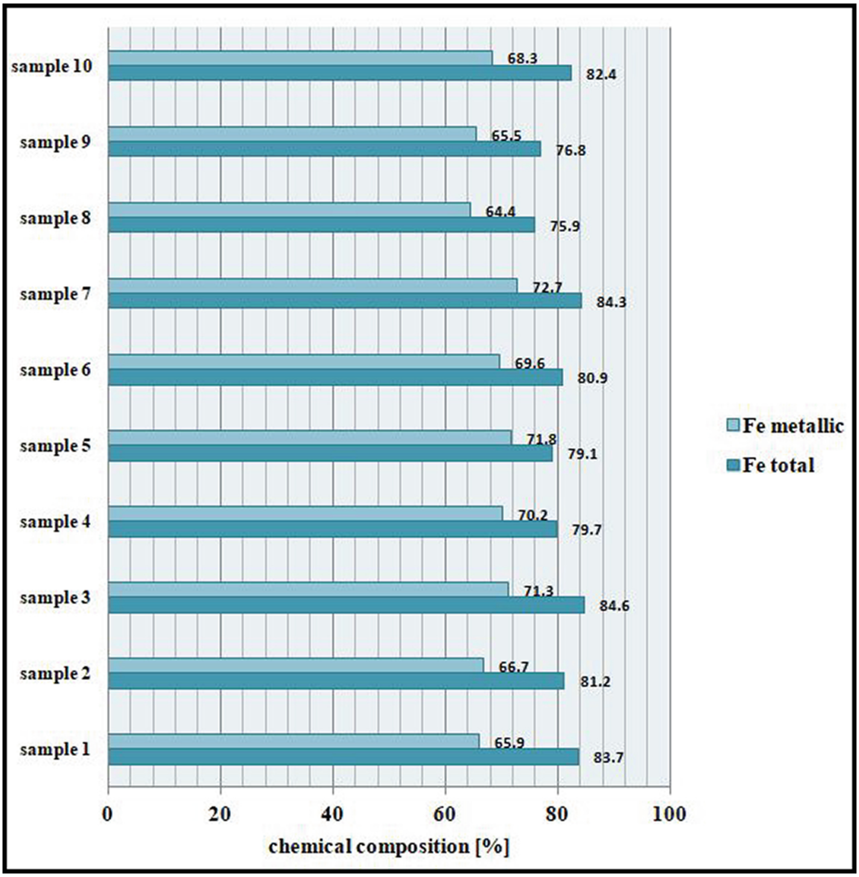


**Fig. 2.** Changes in the level of total and metallic iron of the steel mill scale coming from the technological flow of the steel rolling.

From the analysis of the data presented in the Fig. 2 it results that:

- the concentrations of the total and metallic iron in all ten steel mill scale samples, coming from the technological flow of the steel rolling, are significant;

– the percentage concentration of the total and metallic iron, from the ten steel mill scale samples varies from one sample to another;
– the ten steel mill scale samples have variable concentrations of the total iron, between 75.9 (sample 8) to 84.6 (sample 3);
– the metallic iron content from the ten steel mill scale samples, coming from the technological flow of the steel rolling, varies from 64.4 (sample 8) to 72.7 (sample 7);
– the reuse of the metallic iron content from this waste, as a raw material or as an auxiliary material (to the steelmaking in the EAF), would contribute to sustainability and circular economy in the iron and steel industry.

Figure 3 shows the average percentage concentrations of the total and metallic iron in the ten steel mill scale samples (from landfill) and in the ten steel mill scale samples (coming from the technological flow of the steel rolling).

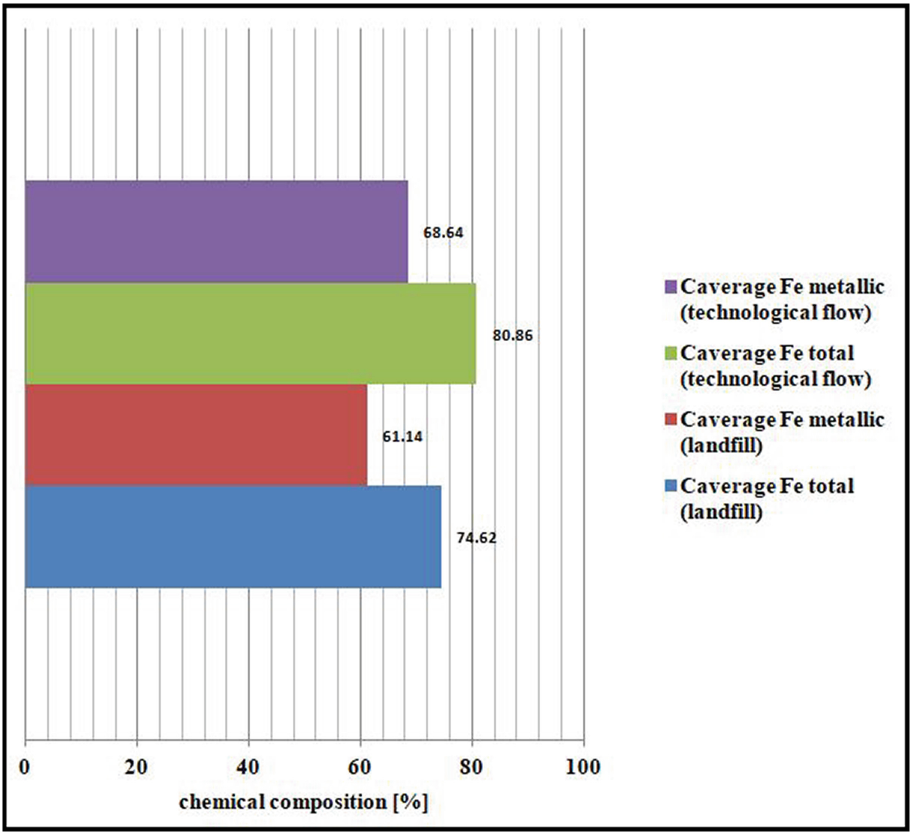


**Fig. 3.** Average concentrations of the total and metallic iron in the steel mill scale samples (from landfill) and in steel mill scale samples (coming from the technological flow of the steel rolling).

From the analysis of the data presented in the Fig. 3 it results that:

- the average concentrations of the total and metallic iron, in the steel mill scale samples, coming from the technological flow of the steel rolling and from the landfill, are significant;
- the landfill Crişeni is a significant source of iron;
- the reuse of iron, as a raw material, in the steelmaking process or in the other technological process, may be considered a positive economic factor would contribute to sustainability and circular economy.

## 4 Conclusions

For sustainability and circular economy in the steel industry, in a first stage, it is necessary, to assess the total and metallic iron from landfill wastes and from technological flow.

From the analysis of the obtained results, regarding the assessment of the metallic iron content from steel mill scale, it results that:

- the steel mill scale is a significant source of the metallic iron;
- the metallic iron content from the ten samples coming from the technological flow of the steel rolling, varies from 64.4 (sample 8) to 72.7 (sample 7);
- the metallic iron content from the ten samples coming from the landfill, varies from 58.7 (sample 4) to 63.2 (sample 9).

Without an assessment of the total and metallic iron content from steel mill scale, followed by reuse in the steel industry or in the other technological processes, this resource is lost forever. The reuse of the metallic iron from this waste, as a raw material or as an auxiliary material to the steelmaking in the electric arc furnace, would contribute to sustainability and circular economy in the iron and steel industry.

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