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Environmental Impact of Ecotoxicant H_2S and SO_2 Compounds Formed at the Baku Steel Smelting Plant on the Lithosphere

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Abstract

In many literature sources, the reasons for the formation and emission of harmful substances in the Primary and Secondary Steel Melting production areas are often not analyzed in detail. Based on the information provided in some literature, we conducted ecological research and explanations regarding the reasons for the formation of H_2S and SO_2 gases, considered ecotoxicants, in the atmospheric air and wastewater at the Secondary Steel Melting Plant. The causes of the formation of H_2S and SO_2 compounds in Secondary Steel Melting production were studied, and their ecological scientific explanations were justified. As is known, after some time, every waste leads to pollution in the lithosphere, hydrosphere, and atmosphere, which ultimately has negative impacts on the biosphere, especially on human health. In this regard, our scientific research focused on providing ecological scientific explanations for the reasons for the formation of each harmful substance at the Secondary Steel Melting Plant, which is one of the most important issues.

Keywords: Ecotoxicant, Steel Melting, Ecological Analysis, Electric Arc Furnace, Working Zone, Maximum Allowable Concentration.

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Introduction

As is known from many technical literature sources, the Secondary Steel Melting Plant is significant both ecologically and economically. In the metallurgical industry, steel melting initially results in the release of more harmful substances into the atmosphere, leading to higher consumption of energy resources and natural ore reserves. However, it should be noted that less natural ore is used in relation to Secondary Steel Melting. Despite this, at the Secondary Steel Melting Plant, many waste materials, especially with wastewater, are released into the atmosphere as harmful substances. The number of harmful substances emitted into the atmosphere is significantly lower compared to primary steel melting.

According to modern ecological requirements, environmental protection is one of the most important ecological demands of the day. One of the main causes of environmental pollution is the melting of old, unusable metal waste. As mentioned earlier, despite the advantages of the Secondary Steel Melting sector over the Primary Steel Melting sector, this industry is also considered one of the major sources that pollute the environment in various directions. In many cases, the melting of alloys in the Secondary Steel Melting sector leads to poor-quality metal alloys. One of these factors is the presence of mercury compounds in the alloys, which have toxic effects on the human body and can even result in death. Another factor is the presence of tungsten-containing metal waste, which requires very high temperatures and additional costs during melting. Therefore, these types of metal waste are considered unusable waste.

It can be noted that when using reagents containing sodium compounds, the reaction with water leads to the formation of hydrogen and combustible flames, which negatively affects the quality of the metal alloy. Additionally, according to the information provided by the enterprise, research has shown that excessive use of certain reagents results in the production of low-quality alloys. Despite these factors, it should be emphasized that the materials obtained at the Secondary

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Steel Melting Plant play a crucial role in the construction industry, particularly in the production of special reinforcement and equipment. The concentrations of H_2S and SO_2 compounds present in both the wastewater generated in the Baku Steel Melting Plant's Electric Arc Furnace (EAF) and related production areas, as well as those released into the atmosphere, were measured using a Drager Tubes LLG gas detector, a highly sensitive mobile device [1-5].

Experimental Part

During the ecological research conducted at the Baku Steel Melting Plant, the actual concentrations of H_2S and SO_2 gases in the air were determined within the area of the Electric Arc Steel Melting Furnace (EAF) and its surroundings, along with other ecotoxicant substances. The determination of the concentrations of ecotoxicant substances in the air was carried out using glass indicator tubes. The analyses were repeated several times on different days to refine the average values. Measurements were conducted at distances of 10–50 meters from the Electric Arc Steel Melting Furnace (EAF) area of the plant. Due to the plant's ventilation system, the results of these analyses showed some variations. Therefore, based on the average values, the results of the analysis of these harmful substances are presented in Table 1.

Table 1: Analysis Results of Ecotoxicant Inorganic Substances Emitted into the Atmosphere from the EAF

Name of ecotoxicant characteristic inorganic substances	Their maximum allowable concentration (MAC) mg/m3	Concentrations determined in the EAF
H_2S	0.008	10 ppm (13.93 mq/m^3)
SO_2	0.05	5 ppm (13.01 mq/m^3)

As seen in Table 1, the one-time maximum concentration of H_2S was high. According to literature data, the one-time Maximum Allowable Concentration (MAC) of H_2S and SO_2 gases in the air should be ≤ 10 mg/m^3. However, in the initial state, the concentration of these harmful substances in the studied areas was significantly higher. Due to the rapid operation of the plant's ventilation system, the concentration of these substances decreases over short periods and reaches the Long-Term Allowable Concentration (LAC) at greater distances from the sources.In the working zone of the EAF area at the studied plant, the concentrations of ecotoxicant inorganic pollutants in the air were determined at distances of 50, 100, 150, and 200 meters, as well as in sanitary protection zones. The obtained results are presented in Table 2.

Table 2: Analysis Results of Ecotoxicant Inorganic Substances in the Atmospheric Air Outside the EAF

Name of ecotoxicant characteristic inorganic substances	Concentrations determined outside the EAF				
	50 m	100 m	150 m	200 m	Sanita mühafizə zonasında
H_2S	8 ppm	7 ppm	5 ppm	2.5 ppm	2 ppm
SO_2	4.1 ppm	2.2 ppm	1.7 ppm	1.0 ppm	1.5 ppm

The ecotoxicant substances emitted into the atmosphere from the Baku Steel Melting Industry Plant can spread not only up to 1 km but, depending on meteorological conditions, can actually disperse over distances of hundreds of kilometers [5-10].

In technical literature, particularly in the Secondary Steel Melting Industry, there are no scientific explanations provided for the causes of the formation of H_2S and SO_2 ecotoxicant compounds. Based on the results of long-term research conducted in the production areas and the information about the reagents used in those areas, the following scientific explanations can be provided:

1. In the Secondary Steel Melting Industry, the presence of up to 2% sulfur in petroleum coke leads to the release of sulfur in its free form at high temperatures (≤ 1500°C) during the steel melting process. At the same time, the decomposition of hydrocarbons in petroleum coke results in the release of hydrogen.

$H_2 + S \rightarrow H_2S$

At high temperatures, H_2S reacts with air to form:

H_2S + air → SO_2; likely SO_3; S; NxOy

This process results in the formation of harmful substances.

2. In the Secondary Steel Melting Industry, when the metal waste containing sulfur, which is no longer suitable for use, is melted, a certain amount of sulfur is released. This leads to the formation of H_2S and sulfur gas according to the reaction mechanism mentioned above.

At the Baku Steel Melting Plant, the analysis of construction reinforcement bars obtained after secondary steel melting is carried out regularly by the plant. The X-ray spectra and X-ray diffraction spectra of the solid slag waste formed at the plant have been studied using the S8 Tiger and Miniflex 600 devices. The obtained results are presented in Table 3.

Table 3: Chemical Composition, in %

Sample's conditional name	MgO	SiO_2	SO_3	P_2O_5	CaO	TiO_2	MnO	Fe_2O_3	Cr_2O_3
I furnace alkaline	3.19	21.60	0.24	0.66	31.43	0.58	6.07	28.81	2.10
II furnace alkaline	1.86	20.19	0.32	0.65	41.50	0.68	5.50	21.15	2.03

As seen from the tables, despite the high-temperature melting of metal waste, the composition still contains the metal oxides mentioned above, as well as sulfur compounds. Therefore, it can be stated that the ecological explanation provided for the formation of ecotoxicant sulfur compounds in the Secondary Steel Melting Plant is scientifically justified [11-13].

Result

As known from the literature, the primary objective of conducting any ecological scientific research in a plant is to determine the formation of waste with varying composition and quantity, depending on the raw material composition and the technological process used. It is important to note that, alongside the in-depth determination of the composition and environmental impact of each waste, the theoretical and practical explanation of the causes of waste generation is considered a key indicator of the research work.

The results of the conducted ecological scientific research and ecological study can be noted as follows:

1. The formation of H_2S and SO_2 gases in the Secondary Steel Melting Industry has been scientifically and theoretically justified.
2. The main reasons for the formation of H_2S and SO_2 compounds in the Secondary Steel Melting Industry are primarily due to the presence of sulfur in the petroleum coke used for steel melting. Additionally, the use of sulfur-iron compounds as raw materials in the Electric Arc Steel Melting Furnace (EAF) results in the formation of H_2S and SO_2 gases.
3. At the Baku Steel Melting Plant, due to the melting of various types of metal waste, including sulfur-containing non-ferrous and ferrous metals, a significant amount of H_2S and SO_2 compounds are formed.
4. It should also be noted that, during secondary steel melting in the EAF, the concentrations of ecotoxicant substances released into the air from the working zone are found to be many times higher than the Maximum Allowable Concentration (MAC) within an area of up to 10 km.

Therefore, considering the above, we propose that the final stage of the ventilation system should involve the neutralization or absorption of H_2S and SO_2 gases in a gas scrubber using special adsorbent solutions, such as NaOH or $Ca(OH)_2$. Based on this proposal, it would be possible to use large amounts of CaS and Na_2S salts in the production of sulfuric acid [14-16].

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