UOT: 550.4
DOI: *https://doi.org/10.30546/2521-6317.2024.2.201*

ECOLOGICAL ANALYSIS OF ECOTOXIC INORGANIC VOLATILES IN INDUSTRIAL EFFLUENTS OF A RECYCLING STEEL SMELTING PLANT

Naila JAFAROVA, Sevinj HAJIYEVA, Giyas BAYRAMOV

Baku State University, Azerbaijan, Baku

ceferova-nailem@mail.ru

ARTICLE INFO

Article history
Received:2025-01-10
Received in revised form:2025-01-21
Accepted: 2025-04-10
Available online

Keywords: *recycled steel smelting, technological steel equipment, industrial flows, ecotoxicant, industrial streams*

ABSTRACT

As it is known, the recycled steel smelting industry is considered as one of the economically and ecologically very important fields. In this industry, the reprocessing of obsolete steel waste, which is dangerous for the environment, is of great economic importance as well as environmentally beneficial. the processes of ore extraction and its subsequent stages of processing save on the use of natural resources. steel smelting is important. During the research carried out by us, it was determined that a large amount of water is also used in the recycling processes of out-of-service steel technological equipment in the recycled steel smelting industry. The object of the study was the Baku Steel Smelting Enterprise. For the first time, in-depth environmental analyzes of the composition of the industrial streams-wastewater received during the technological process of that production were carried out by us. It was determined by us the emissions of ecotoxicant substances - H_2S, SO_2, NH_3, SO_3, NO_2 Cl_2, HCl, HCN, PH_3 which are contained in the industrial streams formed in the main production areas of that enterprise and evaporate in a short period of time.

INTRODUCTION

The following explanations can be given based on the information given in many technical literatures [1-13] and the results of scientific research conducted in scientific and technical journals:

- A significant amount of water is used in ore extraction production areas, which are the primary raw materials of the metal industry and large production areas. At this time, industrial streams are also formed in the same volume. During the extraction of ore, the metal compounds contained in the ore enter the environment in the form of complex dust-aerosol, mainly metal oxides and salts, along with the change of the land relief. At the same time, it can be noted that during the process of extracting ore from underground, grinding ore, enrichment and preparation of ores as commodity raw materials for smelting according to the required indicators, industrial streams containing a certain amount of heavy metal compounds are formed in the environment.

- Along with the preparation of the raw materials required for the metallurgical industry, industrial effluents - waste waters, which differ from each other and have very complex characteristics due to their composition, are constantly generated in the ferrous and non-ferrous metal smelting industrial enterprise for its purpose.

- Discharge of metal oxides, S, SO_3, dust, soot waste mixture into the atmosphere in the form of aerosols, combined with compounds with ecotoxic inorganic substances (H_2S, SO_2, NH_3, PH_3 etc.) is happening. At the same time, inorganic and organic ecotoxicant aldehydes, benzopyrene, etc., which are dissolved in the industrial effluents formed in the above-mentioned production area. evaporation of compounds also occurs. As a result of the generation of waste gases, industrial effluents, and also received solid wastes, both in the ore extraction industry and in the steel smelting industry, environmental pollution is caused. That is why we purposefully carried out an in-depth environmental monitoring research study at the "Baku Steel Company" enterprise, which is one of the recycling steel smelting industrial enterprises. During the research, it was determined that coke, limestone, ferromanganese, ferrosilicomanganese, as well as many inorganic substances contained in unusable steel equipment at high temperature (~15000C temperature) of the reagents used in the melting of recycled steel, ecotoxic substances obtained as a result of various chemical transformations are used in cooling goes into the composition of the waters.

- For the first time, we have also determined the concentrations of inorganic substances with ecotoxic properties that evaporate quickly in the waste water of the above-mentioned industrial enterprise. Environmental analyzes of all harmful substances in the form of gases and aerosols formed in that enterprise, as well as concentrations of ecotoxic substances in the air, were carried out with Drager Tubes LLG gas detector and UQ-2 gas analyzer special devices. At the same time, samples were taken to determine the in-depth analytical analysis of industrial streams and solid wastes formed in that industry and research work was carried out in laboratory conditions. For this purpose, samples were taken from the waste water received at the above-mentioned institution, and the composition of the samples was determined using known analytical methods shown in the literature [1-12].

EXPERIMENTAL PART

Baku Steel Company, which is located in the Nizami district of Baku city and is considered one of the main industries, is considered as one of the enterprises that use a large amount of water. During the research, it was determined that gaseous harmful substances, waste water and solid waste with different composition and characteristics are constantly formed during technological processes in the enterprise. By us, the distribution and composition of gas wastes actually formed in that enterprise was determined by means of special devices. As we mentioned earlier, one of the directions of the main research work was the determination of the composition of the industrial streams formed and received in that enterprise. For this purpose, water samples were taken by us from the industrial streams formed in the above-mentioned main production areas and directed to the treatment areas. Qualitative and quantitative analyzes of the composition of the water samples were carried out. The composition of samples taken from the inlet and outlet of the industrial effluents used before the cooling system of the Electric Arc Steel Melting Furnace (EASMF) of the main production area of the mentioned enterprise and discharged to the treatment area was determined by means of the ICP-OES GBC Quantima device. Table 1 shows the analysis results of the composition of water samples taken from the (EASMF) production area of the Baku Steel Smelting Enterprise.

Table 1. Analysis results of the composition of water samples

The Name of Components	Unit of Measure	Water re-entered into the cooling system of the EASMF	Recycled effluent water from the cooling system of EASMF
SO_4^{2-}	mg/l	28.6	228.8
Cl^-	mg/l	96.9	95.5
H_2S^-	mg/l	0.02	1.5
Cl	mg/l	0.02	2.0
SiO_2^-	mg/l	14.12	14.96
Na^+	mg/l	137.8	222.5
K^+	mg/l	3.2	3.1
Al^{3+}	mg/l	9.49	41.4
Fe	mg/l	79.5	225.2
Mn	mg/l	0.372	7.98
Cu	mg/l	54.4	93.6
Mo	mg/l	23.7	25.0
Zn	mg/l	0.525	1.8
Pb	mg/l	0.162	0.673
Ni	mg/l	2.08	2.1
Cr	mg/l	3.44	4.68
B	mg/l	0.241	0.245
As	mg/l	<4	<4
Ba	mg/l	<0.6	<0.6
Hg	mg/l	<0.002	<0.02
Se	mg/l	<0.1	<0.1

As can be seen from Table 1, there are dissolved ecotoxic substances in those water samples. During the research, it was determined that the ecologically analyzed water samples also contain volatile, quickly evaporating inorganic ecotoxic compounds. This, in turn, can be considered as one of the sources of atmospheric air pollution. The distribution of volatile ecotoxicant inorganic substances contained in the mentioned water samples in the atmosphere regardless of temperature and their actual concentrations in the air were determined using a mobile gas analyzer, Drager Tubes LLG gas detector detector and UQ-2 gas analyzer devices. Environmental analyzes of concentrations of ecotoxic substances released into the atmosphere in waste water treatment areas were also carried out with the same devices.

The industrial streams formed in the recycled steel smelting plant are precipitated and purified in several stages and repeatedly used in the cooling cooling system. During the cooling process of the hot steel alloys of those industrial streams, they are repeatedly used in the cooling process until their volume decreases. In the area where the samples of the industrial streams taken for the study are the sources, a mixture of gas and aerosol wastes of extremely different characteristics is created mainly in the air environment around the Electric Arc Steel Melting Furnace (EASMF). That is why it is not possible to accurately determine the concentrations of volatile substances emitted into the atmosphere from the sources that form industrial streams with gas analyzer devices. In this regard, 5-20 minutes of each of the above-mentioned ecotoxicant inorganic substances dissolved in the samples of industrial streams taken from the production area mentioned by us. In laboratory conditions, evaporation concentrations in air were determined using Drager Tubes LLG gas detector and UQ-2 gas analyzer devices. Table 2 shows the results of the study on the determination of the air dispersion concentrations of each of the inorganic toxic CO, H_2S, SO_2, SO_3, NO_x, PH_3, HCl, Cl_2 gases evaporated from water samples of industrial streams in laboratory conditions.

Table 2. Analysis results of recycled industrial streams and the final stage treatment area of the enterprise

The Name of Components	Unit of Measure	Examples of recycled industrial streams in EASMF	Samples of industrial effluents of the final stage treatment area of the enterprise
H_2S	ppm	6.5	4.2
SO_2	ppm	4.2	3.1
SO_3	ppm	3.5	2.6
CO	ppm	18.5	16.7
NH_3	ppm	4.5	3.4
HCN	ppm	1.0	0.8
PH_3	ppm	0.7	0.4
HCL	ppm	0.9	0.63
Cl_2	ppm	1.5	0.8

Note: As a result of the entry of other dirty waters into the cleaning area of the enterprise at the final stage, dilution of industrial streams containing ecotoxic inorganic compounds occurs.

As can be seen from Table 2, the concentrations of inorganic ecotoxic substances in the air that are contained in samples of industrial streams and quickly evaporate, decrease several times depending on the time and the distance from the source, that is, by diluting, they approach the sanitary norms. So, since the indicated production area is in a covered area, despite the use of artificial ventilation system with a very high power in that area, the dilution of harmful substances in the air does not occur in a short period of time. The concentration of inorganic ecotoxic substances in wastewater samples obtained from the use of reused, cooled, not fully purified industrial streams in the subsequent stages of cooling of the molten recycled steel alloy released from EASMF is high. Tables 2 and 3 show the results of the environmental analysis of volatile inorganic ecotoxicants in air concentrations of samples of industrial effluents taken from that production area and also from the final stage treatment area of the enterprise.

After the waste water formed in the mentioned enterprise is collected in the common treatment area, mechanical sedimentation is carried out. In that area, concentrations of ecotoxicant inorganic compounds contained in the cleaning of industrial streams and quickly evaporating were determined in the air at different distances (10, 50, 100, 200 m) in the territory of the enterprise and outside the territory. Meteorological conditions were taken into account during the measurements. The concentrations of each of the fast-evaporating inorganic ecotoxic compounds released into the atmosphere from the cleaning area of the enterprise separately in the air from a distance and 5 min. The results of the study on the determination of time dependence are given in Table 3.

Table 3. The results of the study on the determination of time dependence

The Name of Components	Unit of Measure	Initial concentrations of inorganic ecotoxic substances in the air from industrial effluents in the cleaning area of the enterprise	Concentrations of inorganic ecotoxic substances in the air depending on the distance		
			20 m	60 m	100 m
H_2S	ppm	4.2	2.1	1.0	0.5
SO_2	ppm	3.1	1.5	0.8	0.4
SO_3	ppm	2.5	1.7	1.0	0.3
CO	ppm	16.7	10.1	2.5	0.8
NH_3	ppm	3.4	1.8	0.7	0.2
HCN	ppm	0.8	0.3	0.1	-
PH_3	ppm	0.4	0.2	0.06	-
HCl	ppm	0.6	0.4	0.1	-
Cl_2	ppm	0.8	0.6	0.2	-

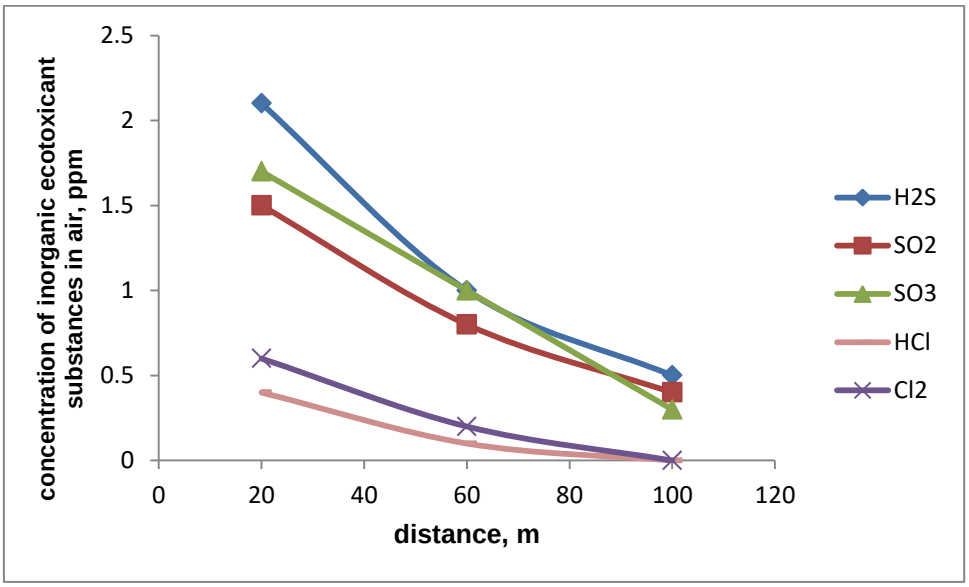

Figure 1. Graph of air concentrations of each of the inorganic ecotoxic substances in the treatment area for a period of 5 minutes depending on the distance.

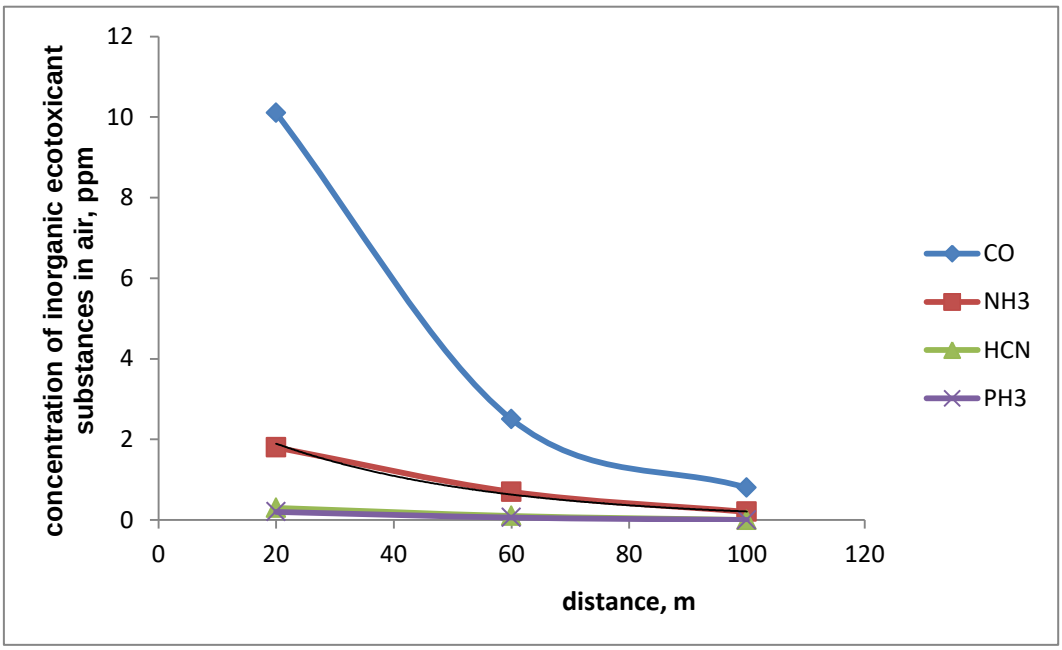

Figure 2. Graph of air concentrations of each of the inorganic ecotoxic substances in the cleaning area in a 5-minute period depending on the distance.

As can be seen from Figure 1-2 and Table 2-3, despite the fact that the concentrations of ecotoxic substances in the air that are dissolved and quickly evaporate in the industrial streams formed in the main production area of that enterprise are diluted close to sanitary norms depending on time and distance, each of them remains in the air for a long time. it is continuous. That is why it can be noted that ecotoxic substances that evaporate in solid and liquid waste formed in every industry are one of the factors that cause ecological pollution of the environment. At the same time, it can be considered reasonable to take into account the sources of atmospheric air pollution in the areas of storage and treatment of waste formed in the main production area of that enterprise.

Taking into account the above mentioned and the results of our environmental research, conducting scientific research in various directions on the development of new methods of deep cleaning, neutralization and purposeful disposal of all types of waste in the recycled steel smelting industry, as in other industries, can be considered as very important ecological issues of the time. At present, qualitative and quantitative analyzes of organic substances with ecotoxicity characteristics and quickly evaporating in the industrial effluents formed at the Baku Steel Company enterprise are being carried out. At the same time, environmental scientific research work is being carried out to determine the causes and composition of waste in the mentioned enterprise. A comprehensive scientific explanation of the causes of the formation of all harmful and ecotoxic substances in the wastes formed in the recycled steel smelting industry is also prepared based on the results of the research conducted by us.

During the research carried out by us, it was proven for the first time that the industrial flows formed in the above-mentioned enterprise lead to the pollution of the atmosphere with dangerous ecotoxic substances both in the working zone and outside the enterprise. At certain distances from those industrial streams, depending on the meteorological conditions, it was determined that the concentrations of these ecotoxic substances in the air are diluted and reach the permissible concentration limit.

In order to determine the concentrations of rapidly evaporating ecotoxicants contained in samples of industrial streams taken from the main production areas and purification facilities of Baku Steel Smelting Enterprise, those water samples were poured into special glass containers in laboratory conditions and the rate of evaporation of the samples was measured in the suction cabinet. During the research, it was determined that the rates of spreading of ecotoxic substances into the air environment in samples of industrial streams taken at different times are close to each other.

CONCLUSION

As can be seen in many technical literatures and the explanations given above, one of the most important issues is the collection of general information about the composition of raw materials and auxiliary reagents taken when carrying out environmental research work at an industrial enterprise, as well as the implementation of ecological analyzes about the composition, classification, characteristics of the products and all types of waste. is one. Therefore, along with the determination of the composition of the raw materials and auxiliary reagents used in the above-mentioned enterprise, we conducted an ecological research on the composition and characteristics of all types of waste received in the production process. A part of that research work was carried out on the determination of the causes, composition and characteristics of the negative impact on the environment of the industrial streams-wastewater formed at the Baku Steel Smelting Enterprise, which is considered one of the heavy industrial enterprises in Baku. As can be seen from the results of the conducted research, it was determined by us for the first time that one of the sources of atmospheric air pollution by the enterprise is the industrial flows formed in the production areas of that enterprise. The mentioned industrial streams and the directly mentioned industrial enterprise can be considered as one of the sources that pollute the atmosphere due to the evaporation, spreading, and change of concentrations in the air of the inorganic ecotoxic substances dissolved in those waters in a short period of time regardless of the temperature.

Despite the fact that each of the harmful substances given in the literature is within the permissible concentration limit in the working and sanitary zones, it causes the pollution of the biosphere in the end along with the pollution of all spheres. As a result, it was determined that it is possible to evaluate the environment as a source of negative environmental impact on human health. Taking into account the above results, it can be noted that the continuous determination of the composition of the industrial streams formed in the enterprise can be considered as an ecologically very important research work. As can be seen from the previous explanations, as a result of the use of auxiliary reagents with different composition and properties in the Baku Steel Smelting Enterprise, harmful and ecotoxic substances of various properties are released into the atmosphere. The industrial flows formed in that enterprise cause atmospheric pollution. That is why it can be considered reasonable that the cleaning of harmful substances with ecotoxic properties contained in industrial streams by the maximum possible physico-chemical method plays an important role in the fulfillment of environmental safety requirements in the modern era.

Thus, we consider it appropriate to conduct ecological studies on the application of a new purification technology for the purification of heavy metal compounds shown in table 1 along with the purification of volatile inorganic ecotoxic substances contained in the industrial streams formed in the enterprise where ecological research is conducted. In this regard, it can be noted that as one of the main results of the conducted ecological research work, the research work on the treatment of those waters is continued in order to reduce the possibility of the inorganic ecotoxic substances contained in the industrial streams having a negative effect on the health of the workers in the working zone and also in the sanitary protection zones of the enterprise. In this field, it can be considered scientifically based to evaluate the environmental research works in several directions as one of the ecological requirements of the time.

REFERENCE

1. Straus V., Meyerring S. Air pool pollution control. M., Science, 2009, 160 p.

2. Yusfin, Yu. C. Industry and surrounding environment / Yu. C. Yusfin, L. И. Leontiev, P. И. Chernousov. — M. : İKS "Academybook", 2002, 469 p.

3. Nisidzawa, C. Approach to environmental protection in ferrous metallurgy of Japan / C. Nisidzawa // Steel. 2003. No. 4. p. 71–75.

4. Impact of metallurgical enterprises on surrounding environment [Electronic resource]» URL: http://refleader.ru/jgeyfsyfsmeraty.html (date of access 13.04.2022)

6. Bolshina E.P. "Ecology of metallurgical production." Novotroitsk».: NF NİTU MİSİS, 2012, 155 p.

7. Rushnikov A.Yu, Recycling domestic and industrial waste water, Published in magazine SOK #1 | 2006 , p.102

8. Sehiselo Ndlow. Waste Production and Utilization in the Metal Extraction Industry / Waste Production and Utilization in the Metal Extraction Industry / CRC Press, 2017. 512 p.

9. Sehliselo Ndlovu, Geoffrey S. Simate, Elias Matinde, Waste Production and Utilization in the Metal Extraction Industry, eBook-Boca Raton : Taylor & Francis, CRC Press, 2017, p.501

10. Mukuldev Khunte, International Journal of Industrial and Manufacturing Systems Engineering 3(Vol 3, No 1), Process Waste Generation and Utilization in Steel Industry, May 11, 2018, p.1-5

11. Mukuldev Khunte, Process Waste Generation and Utilization in Steel Industry, International Journal of Industrial and Manufacturing Systems Engineering (Volume 3, Issue 1), May 11, 2018, p.432

12. G.I. Bayramov, A.A. Samadova, N.M. Jafarova "Methods of analysis of harmful substances in the industrial waste water produced in the oil industry", methodological manual, Baku-2019, p. 26

13. Vadim Romanov, R. Romanova, Emissions of harmful substances and their dangers for living organisms, LiteRes, July 23, 2020, p. 105

14. Luma A H Al-Kindi and Wadood K K Al-Ghabban, Reducing steel scrap in fabrication of steel storage tanks, IOP Conf. Series: Materials Science and Engineering 737 (2020), p.1-10

15. Branca, T.A., Colla, V., Algermissen, D., Granbom, H., Martini, U., Morillon, A., Pietruck, R., Rosendahl, S. Reuse and Recycling of By-Products in the Steel Sector: Recent Achievements Paving the Way to Circular Economy and Industrial Symbiosis in Europe. Metals 2020, 10, p.345.

16. Sankaran, K.J., Suman, S., Sahaw, A., Balaji, U., Sakthivel, R. Improved LPG sensing properties of nickel doped cobalt ferrites derived from metallurgical wastes. J. Magn. Magn. Mater. 2021, p.537.

17. Iluțiu-Varvara, D.A., Tintelecan, M., Aciu, J., Sas-Boca, I.M. Reuse of the Steel Mill Scale for Sustainable Industrial Applications. Proceedings 2020, 63, p. 14–17.

18. Gao, D., Wang, F.-P., Wang, Y.-T., Zeng, Y.-N. Sustainable Utilization of Steel Slag from Traditional Industry and Agriculture to Catalysis. Sustainability 2020, 12, 9295.

19. Brand, A.S.; Fanijo, E.O. A review of the influence of steel furnace slag type on the properties of cementitious composites. Appl. Sci. 2020, 10, 8210.

20. Chamling, P.K., Haldar, S., Patra, S. Physico-Chemical and Mechanical Characterization of Steel Slag as Railway Ballast. Indian Geotech. J. 2020, 50, p.267.

21. Herbelin, M., Bascou, J., Lavastre, V.;,Guillaume, D., Benbakkar, M., Peuble, S., Baron, J.-P. Steel Slag Characterization—Benefit of Coupling Chemical, Mineralogical and Magnetic Techniques. Minerals 2020, 10, p.705.

22. Habib, A., Bhatti, H.N., Iqbal, M. Metallurgical processing strategies for metals recovery from industrial slags. Zeitschrift für Physikalische Chemie 2020, 234, p.201–231.

Internet sources:

· European Commission. Recycling of Residues from Metallurgical Industry with the Arc Furnace Technology (Recarc). Available online: https://webgate.ec.europa.eu/life/publicWebsite/project/details/2089 (accessed on 22 February 2022).

· European Commission. Slag NO Waste: Innovative System for 100% Recycling of White Slag and for ZERO WASTE Electric Steel Production (SNOW-LIFE). Available online:https://webgate.ec.europa.eu/life/publicWebsite/index.cfm.fuseaction.search.dspPage&n_proj_id=5107 (accessed on 22 February 2022).