

A CURRENT MINIREVIEW ON THE AQUATIC ENVIRONMENT: IMPACT OF SOME IONS FROM THE FOOD AND METALLURGICAL INDUSTRIES

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ABSTRACT

Recent research has shown the high degree of pollution that the metallurgical and food industries can cause to the environment. In this minireview, the impact that various polluting ions, emitted as a result of technological processes specific to the metallurgical and food industries, can have on the aquatic environment was analysed. Our research also provides an assessment of the potential interactions and the most likely transformations of these chemical forms once they are released into the aquatic environment, as well as the likely impact on the ecosystem.

KEYWORDS: aquatic environment, ammonia, nitrogen oxides, carbon oxides, sulphur oxides

1. Introduction

A significant part of the atmospheric emissions and residues originating from the food and metallurgical industries ultimately end up in aquatic ecosystems.

Ammonia (NH₃), nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOCs), particulate matter (PM), etc. generated by various food, agricultural, and metallurgical processes, can be deposited through precipitation, transforming into soluble compounds that alter the chemistry of surface and groundwater. Other industries, such as pulp and paper, also have a significant contribution.

Thus, industrial processes can have a significant indirect contribution to the pollution of the aquatic environment.

This occurs not only through direct discharges (effluents), but also through atmospheric transport and the deposition of reactive species.

Agriculture also has a significant impact on the aquatic environment, polluting rivers, lakes and oceans by releasing nutrients.

In this context, while certain pollutants such as NO_x and SO_x have started to decrease in the last decade as a result of strict controls carried out by the authorities, there is currently increasing emphasis on optimizing technologies to reduce CO₂ emissions.

On the other hand, polluting oxides and the chemical compounds resulting from their

transformations, generated by various industrial processes, such as those in the food and metallurgical industries, affect the aquatic environment indirectly.

However, this impact is substantial, manifesting itself through significant changes in several environmental parameters, namely including eutrophication, acidification, increased biochemical oxygen demand (BOD), as well as the bioaccumulation of various metals [1-6].

Although there are studies [2, 7-10] that show how polluting oxides are formed and that monitor CO₂ emissions and Volatile Organic Compounds (VOCs) from the steel and food industries, we believe that there is still currently relatively little research on the evaluation of emissions of other gases, such as SO_x and NO_x.

This is in the context where the impact of these oxides on the aquatic environment is significant [2, 5].

In general, research on SO₂ and NO_x emissions focuses on the main production process, which is sintering. Various pollutants are generated during this process, with most SO₂ and NO_x emissions originating from the raw materials used in the sintering material. Nitrogen oxides originate from thermal reactions and sulphur dioxide from the sulphur content of the fuel [11].

The presence in the aquatic environment of nitrogen and sulphur compounds resulting from the transformation of oxides produced in technological processes, to which the agri-food sector has a major

contribution, is certainly a major cause of damage to aquatic ecosystems.

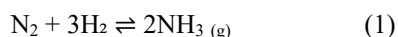
Through the novel elements provided by the specialized literature from the last decade, this minireview presents a perspective on the fundamental processes in which the main types of ions with a polluting character in aquatic systems are involved.

Particular attention is paid to the influence of these chemical species on the biota inhabiting the environments.

2. Bonded nitrogen technology – ammonia synthesis

The technology of bound nitrogen encompasses several fundamental sectors of basic inorganic chemical technology: the synthesis of ammonia, nitric acid and nitrogen fertilizers (simple and complex nitrates, urea, cyanamide, etc.).

Although agriculture is the main global source of NH_3 , industrial processes contribute significantly to the increase in the concentration of this chemical compound in industrialized areas. Ammonia production belongs to the basic chemical industry. In nitrogen fertilizer plants, ammonia is produced by the Haber–Bosch process. It is produced exclusively through the synthesis of its constituent elements according to the reaction:



This reaction appears as a strongly exothermic process with a large volume contraction, compounded by the chemical inertness of the nitrogen molecule.

According to the ammonia synthesis plant (Figure 1) the gases resulting from the technological process are recirculated, and after the accumulation of

about 5% CH_4 and noble gases in the recycle, purging into the atmosphere is performed [12].

During technological processes, NH_3 losses amounting to 0.5–2% of total production can occur through leaks from reactors, pipelines, tanks or during cooling and compression stages. They are released into the atmosphere as a gas. NH_3 can also occur as a by-product in nitrogen oxide reduction technologies in thermal power plants when coal or biomass is used.

Although less intuitive, the food industry contributes to NH_3 emissions through fermentation processes, food-wastewater treatment, and food-waste composting [13, 14]. The ammonia molecule plays a central role in the biogeochemical cycle of nitrogen and in the biology of organisms (Figure 2) [15].

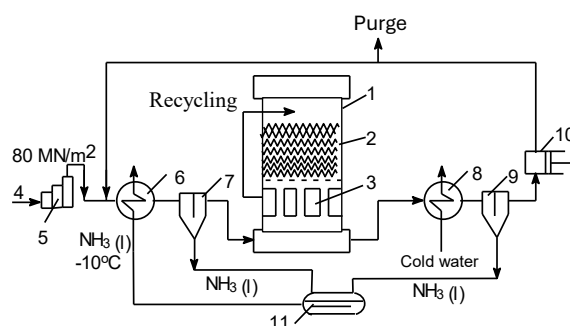


Fig. 1. Schematic diagram of the ammonia synthesis installation: (1) reactor with catalytic zone (2) and heat exchanger (3); (4) fresh gases; (5) - stage compressor; (6) and (8) NH_3 coolers and water, respectively; (7) and (9) - liquid ammonia separators; (10) – recirculation pump; (11) - NH_3 tank; (reproduction after [12])

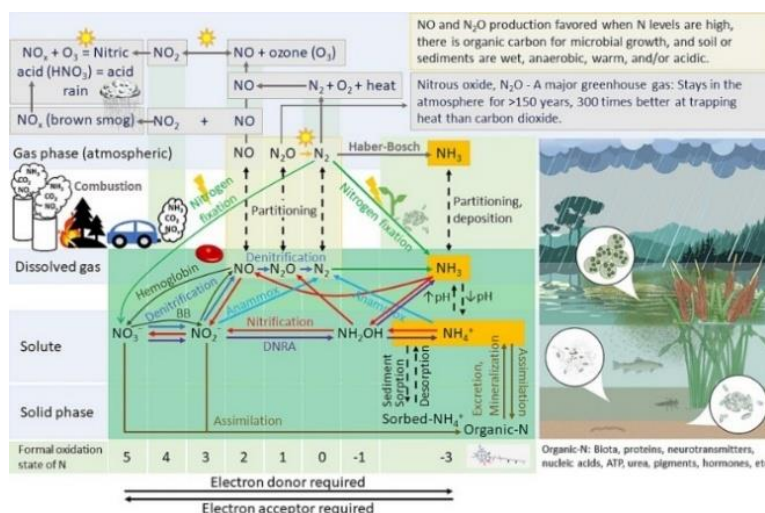
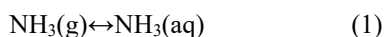


Fig. 2. The nitrogen (N) cycle (reproduction after [15])

Due to excess NH_3 from agricultural and industrial activities, the mechanism of transformation of atmospheric ammonia into ammonium ion (reactions 1 and 2) in aquatic environments becomes problematic.



In alkaline waters, the proportion of free NH_3 increases, thereby increasing its toxicity to aquatic organisms [16]. Atmospheric deposition of ammonia from processes specific to the metallurgical and food industries can lead to increased nitrate concentrations in the aquatic environment (Figure 3).

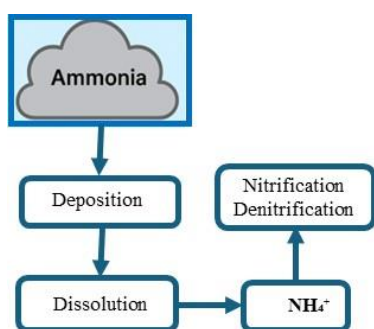
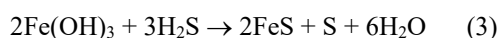
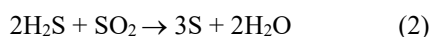
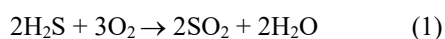


Fig. 3. Illustrative scheme regarding the atmospheric NH_3 transformation in the aquatic ecosystem

3. Processing of sulphur ores

Sulphur occurs in nature both in its native state and in minerals. Sulphur present in its native state is extracted after preliminary smelting, either by burning a small amount of sulphur or by injecting steam into the deposit.

A large part of elemental sulphur is recovered from natural gas, water gas, and coal synthesis gas, and from various fractions of crude oil distillation. In principle, in these processes, sulphur compounds are converted to H_2S , which is converted to S by combustion under controlled conditions or absorbed on $\text{Fe}(\text{OH})_3$.



In the manufacture of sulfuric acid, the first technological stage is the production of sulphurous gases (SO_2), which in the second stage are catalytically oxidized (contact process on a Pt or

V_2O_5 catalyst) to SO_3 , which in the final stage is absorbed in oleum and/or concentrated sulfuric acid (H_2SO_4 98%). According to the technology for obtaining sulfuric acid, its manufacture is based on a double oxidation process of sulphur or metal sulphides [12].

In the first stage, sulphur or metal sulphides, especially pyrite, are thermally oxidized, producing SO_2 ; in the second stage, SO_2 is oxidized to SO_3 . By absorbing and combining SO_3 with water, H_2SO_4 of different concentrations is obtained.

One of the important stages of the sulfuric acid manufacturing technology involves the purification, oxidation and absorption of sulphurous gases (Figure 4).

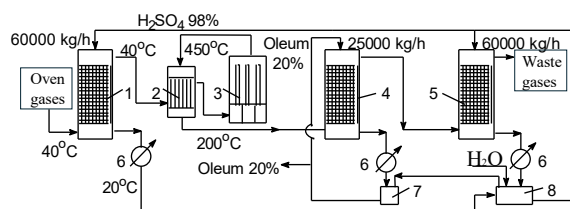


Fig. 4. Schematic diagram of the purification, oxidation and absorption installation for sulphurous gases in the H_2SO_4 production: 1 - drying tower; 2 - gas heater; 3 - contact stove; 4 - SO_3 absorption tower with 20% oleum; 5 - absorption tower with 98% H_2SO_4 ; 6 - coolers; 7 and 8 - oleum and 98% H_2SO_4 tanks, respectively. Flow rates of the acid solutions are indicated on the diagram (reproduction after [12])

On the other hand, while the steel industry remains a major source of air pollutants on a regional and global scale, the food industry generates a complex set of emissions: greenhouse gases (CO_2 , CH_4 , N_2O), NH_3 , NO_x and SO_x from combustion, VOCs particularly during cooking and frying, PM from thermal processes, etc.

The main sources of $\text{NO}_x/\text{SO}_x/\text{PM}$ in the food processing sector are steam and heat generation equipment (boilers/boilers) and incineration or auxiliary combustion; these emit NO_x , SO_x (depending on the sulphur content of the fuel) and particulate matter from combustion. In addition, frying, grilling, baking and deep-frying processes emit VOCs and PM [17].

4. Technological valorisation of phosphorus ores

Phosphate rocks: phosphorites, $\text{Ca}_3(\text{PO}_4)_2$, fluorapatites ($3\text{Ca}_3(\text{PO}_4)_2\text{CaF}_2$), chlorapatites and

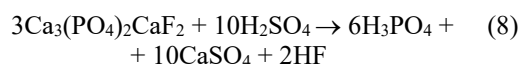
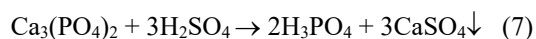
hydroxyapatites ($3\text{Ca}_3(\text{PO}_4)_2\text{Ca}(\text{OH})_2$, are technologically exploited for:

1. Production of phosphorus and phosphoric acid by the thermal method (dry process).
2. Production of phosphoric acid and phosphate fertilizers by the wet process.

The resulting phosphoric acid is purified by distillation and is used in the fertilizer industry, for the manufacture of phosphorus salts, as well as in the pharmaceutical and food industries [12].

Wet processes take place in aqueous solutions. On an industrial scale, the reaction of apatites and phosphorites with H_2SO_4 is used.

Treating phosphates with H_2SO_4 results in an impure phosphoric acid, with 20-40% P_2O_5 before purification and concentration, according to the reactions for the two ores (7, 8).



Among the types of emissions resulting from the phosphate fertilizer industry, we can list solid particles (CaHPO_4 , $\text{Ca}_3(\text{PO}_4)_2$, etc.) and acidic aerosols such as H_3PO_4 and HF .

On the other hand, in the process of smelting the ores, phosphorus (present as an impurity) is partially released by volatilization in the form of oxides (P_2O_5).

Phosphorus oxide subsequently reacts with water vapor, forming phosphoric acid.

The phosphate ion is also emitted from processes that take place in the food industry, such as the processing and preservation of food, from the combustion of food residues or from the treatment of food wastewater. The mineral aerosols are the dominant source of atmospheric total phosphorus (TP) on a global scale, with primary biogenic particles and combustion sources [18].

Although atmospheric phosphorus emissions are relatively small compared to nitrogen or sulphur, they have a significant ecological impact.

This is due to the fact that phosphate particles can be transported over long distances and subsequently deposited in soils and, implicitly, in waters, promoting secondary eutrophication.

5. Sodium chloride product technology

The production of sodium chloride products is mainly based on the chemical and electrochemical valorisation of salt deposits.

Salt is extracted from deposits by mining and drilling. Before technological use, the extracted product is purified by specific methods [12].

The main stages of treatment and technological valorisation of salt from deposits with the two main directions of chemical processing are presented in Figure 5.

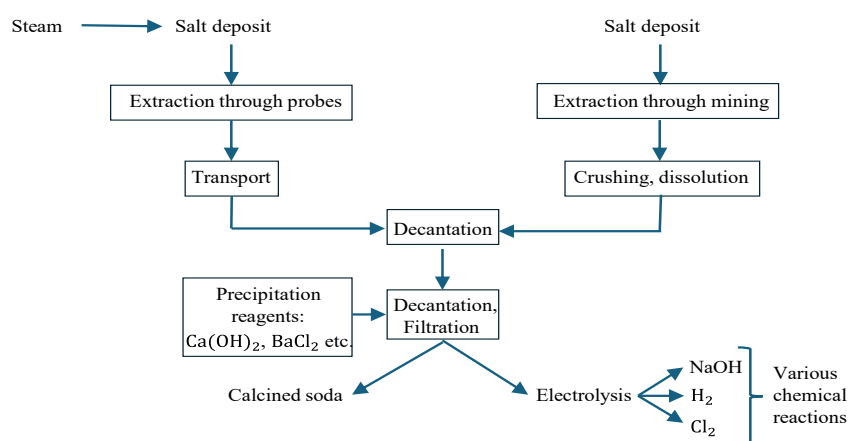


Fig. 5. Scheme of extraction, primary treatment and technological recovery of NaCl (reproduction after [12])

6. The implications of some ions on the aquatic environment

6.1. NO_2^-

Monitoring the presence of nitrites (NO_2^-) in river waters is vital, as they are very toxic to the

environment at certain concentrations. NO_2^- ions greatly affect water quality, posing a significant risk to the ecosystem and human health [19]. According to studies, high concentrations of nitrites have been noted in certain research regions. This is an important element concerning the toxicity of these oxides for the environment, given that their impact, from a

biochemical point of view, can have major effects, since nitrites easily pass into the blood of fish and other aquatic creatures, where they react with haemoglobin, forming methaemoglobin (MetHb). Thus, nitrites prevent erythrocytes from delivering oxygen to the cell (methemoglobinemia or brown blood disease), with sensitivity to nitrites varying by species [20].

Therefore, the high content of nitrites present in water samples analysed in certain geographical regions may be associated with an increased risk of developing methemoglobinemia in those people who consume affected fish or who eventually use this water for consumption. Depending on the level of MetHb, negative effects on the living organism may occur, such as cardiac arrhythmias and destructive effects on the central nervous system [21].

Analysing the data obtained through rigorous monitoring of the nitrite ion, a lower amount of nitrite can be noted in one research area compared to another, which may indicate a more intense oxidative process. Also, this higher amount of nitrite present in the other study area may come from the reduction of nitrates in the presence of a reducing flora, as well as a higher water temperature at the time of sampling.

6.2. NO_3^-

Nitrates, salts of major importance for protein synthesis, are the products most used by plants, being found in large quantities in surface waters. Therefore, the presence of nitrates in the aquatic environment is an indication of environmental stability with respect to nitrogen transformation. Nitrates can represent one of the most important factors for the development of algae and other aquatic plants. However, their presence above certain limits in the water of rivers and streams can lead to a harmful effect due to the fact that excessive nitrogen compounds can become toxic. Nitrates present in the analysed waters can have a toxic effect primarily through direct action on living organisms: through in vivo conversion into nitrites and through their ability to oxidize haemoglobin (Figure 2), transforming it into methaemoglobin, which cannot bind oxygen [22]. This process leads to haemoglobin inactivation. This toxicity of nitrates and, implicitly, nitrites, varies in aquatic organisms depending on a series of factors, among which their species and water salinity stand out. The degree of absorption of nitrites depends on the nitrite-chloride ratio present in the analysed water, the toxic effect of NO_2^- decreasing with increasing salinity levels [23, 24].

At the same time, nitrates can have an indirect effect by decreasing the resistance of living organisms to stress factors, thereby favouring the development of various diseases. Also, the presence

of high concentrations of nitrates in the aquatic environment can contribute to the uncontrolled development of some aquatic plants.

The analysis of experimental data obtained from analysing samples collected in the aquatic environment leads to the clarification of the implications of nitrates on the pollution of surface waters, deeper waters, and the sediments of the monitored region. In this context, the presence of nitrates determined in a location in higher quantities compared to another region subject to monitoring may be the result of the mineralization of protein-based organic pollutants, as well as fertilizers and pesticides with nitrogen content in the chemical composition. Thus, the higher concentration of nitrates present in the water samples analysed from the respective location may be due to the more abundant presence of bacteria, such as nitrifying bacteria. These oxidize nitrites to nitrates using molecular oxygen (electron acceptor) to produce energy and reducing power. Bacteria such as those belonging to the genera *Nitrobacter*, *Nitrococcus* and *Nitrospira* are present everywhere in freshwater [25-28].

On the other hand, the decrease in nitrate and nitrite concentrations in water samples taken from the aquatic environment is probably the result of the dissimilatory reduction of both ionic nitrogen oxides to gaseous oxides, such as NO and N_2O . Such oxides can be further reduced and eliminated as gaseous nitrogen in the atmosphere. Also, the lower concentration of nitrites/nitrates is probably due to the same biological process carried out exclusively by various bacteria. We consider such research to be especially important. The results obtained in the case of water samples taken from a region of interest may show that a major loss of nitrogen compounds for water and soil fertilization occurs in that location.

6.3. NH_4^+

A series of studies conducted on the aquatic environment several decades ago [29, 30] have shown that there are two forms of ammonium in water: non-ionized (NH_3) and ionized (NH_4^+) ammonia. According to in-depth studies [31] for many aquatic organisms, toxicity is primarily attributed to non-ionized species, with NH_4^+ being relatively less toxic. However, monitoring the NH_4^+ ion in this study is important because ammonium is easily transformed into toxic substances (nitrites, nitrates, etc.).

Increased concentrations of ammonia in water samples taken from a region of the aquatic environment may indicate the existence of an advanced degree of pollution due to the presence of organic substances. This may be due to the action of putrefactive bacteria on proteins present in the body

of dead hydrobionts. Such results show that, due to the presence of ammonia nitrogen in surface waters, there is, in the respective region, a high risk of toxicity for most animal organisms in aquatic ecosystems.

If comparative results indicate much lower concentrations of ammonia nitrogen in the region analysed, then this indicates that, following the various catabolic processes through which protein deamination occurs, hydrobionts eliminate products with lower toxicity in the respective region (urea, uric acid, ammonia salts, etc.).

6.4. Total nitrogen

The nitrogen fraction dosed by total nitrogen is given by the totality of nitrogen-containing compounds. In water, nitrogen exists as inorganic and organic species. Inorganic nitrogen is present in oxidized form (e.g., nitrites and nitrates) and reduced form (e.g., ammonia/ammonium and dinitrogen gas). Organic nitrogen is found in water either in colloidal form or in the form of amino acid molecules. These can originate from the corpses of aquatic organisms. Through their metabolic activity, organisms excrete nitrogen compounds, such as amino acids, polypeptides, urea, hydroxyl amines, etc. In the nitrogen fraction, proteins are dominant, constituting the protein fraction. The difference between total and protein nitrogen represents non-protein or amine nitrogen.

N pollution (total nitrogen represents the sum of all forms of nitrogen in a water sample) also causes eutrophication of water, which disrupts ecology and leads, among other effects, to oxygen depletion and loss of biodiversity [32].

Recent research shows that in some regions, excessive nitrogen inputs can lead to serious pollution problems in aquatic environments. Examples include eutrophication and degradation of water quality parameters that are directly associated with excess total nitrogen [33].

6.5. PO_4^{3-}

Phosphorus, the second most important nutrient for plants after nitrogen [34], is present in water in organic form bound to certain radicals, within complex substances, or in the form of salts of phosphoric acid. Mineral phosphorus is indispensable for biochemical processes, as it is the carrier of energy taken from the sun in photosynthesis and stored in macroergic phosphate groups. The main macroergic substances of metabolism are the organic phosphorus compounds ADP and ATP. Phosphorus also enters the structure of the body's skeleton and the

composition of nucleic acids [35]. Phosphorus oxides are toxic. Phosphates also become toxic in high concentrations. In elemental form, phosphorus is toxic and subject to bioaccumulation. For fish, white phosphorus is toxic.

Phosphates are major nutrients for plants, contributing to their growth and productivity. Phosphates enter watercourses from several sources: agricultural soil drainage, stormwater, industrial wastewater discharges, excretory products, variations in temperature and bacterial activity, etc. [36].

High phosphate concentrations determined in the aquatic environment at great depths indicate that in such a location, due to the greater depth of the water in the area where the samples were taken, dissolved oxygen is minimal and, therefore, these regions tend to accumulate higher concentrations of organic substances.

Phosphates, chemical compounds containing the phosphate ion (PO_4^{3-}), actively participate in many complex biochemical processes. At the same time, they are chemical compounds widely used in agricultural fertilizers.

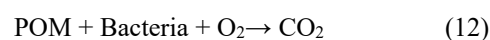
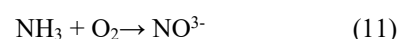
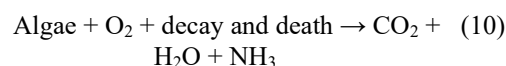
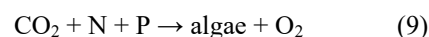
However, the influx of phosphates into aquatic ecosystems can have a significant impact on the aquatic environment.

Phosphate is an important factor affecting the growth rate of organisms, acting as a limiting nutrient for plant growth in freshwater environments [37].

An increase in the phosphate content in the aquatic environment above the permissible limits indicates that pollution processes are taking place in the respective location, likely caused by pesticides, fertilizers or detergents.

The results of our research show that the identification of high phosphate concentrations in certain regions of the aquatic environment is an indication that eutrophication of the aquatic environment is probably favoured in the presence of sunlight and nitrogen.

The sequence of chemical reactions that occur during water eutrophication [38] can be represented by equations (9-12).



where POM - particulate organic matter.

Consequently, the dissolution in water is reduced, which can cause the death or decomposition of animal organisms in aquatic ecosystems.

In addition, the concentrations of phosphates identified in this environment may stimulate the growth of plant species that are accidentally introduced into the ecosystem.

Therefore, we consider that this situation poses a risk of altering plant distribution patterns in these areas.

On the other hand, we can conclude that, in general, the total concentration of phosphorus (including phosphate) in aquatic samples reaches values of only a few ppm. This suggests that phosphate is unlikely to exert direct toxic effects in this region.

However, the excessive influx of phosphate identified in water samples collected from the aquatic environment has the potential to cause eutrophication in the respective ecosystems [39].

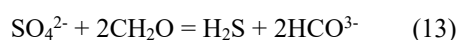
This potential of phosphates to stimulate plant overgrowth in freshwater environments may be attributed to the essential nutrient function of phosphate in plant metabolism.

Based on the N/P ratio, a good assessment of the chemical fertility of the water in the analysed areas can be made. Such a ratio is relatively constant in the aquatic environment. Any deviation from this ratio represents a direct indicator of the alteration of the normal metabolism of the ecosystem by various organic pollution phenomena or natural geochemical phenomena [40].

6.6. SO_4^{2-}

Sulphates are widely distributed in nature and can be present in freshwater environments, representing an important source of sulphur for plants and bacteria. Sulphates are typically found in low concentrations in most freshwater systems, although substantial concentrations can be found in areas where sulphate-containing minerals (including barite, epsomite, and gypsum) or anthropogenic activities exist [41].

Sulphates can have various adverse effects on the aquatic environment. Among the most important is their transformation. The process is known as bacterial sulphate reduction. In this process, the sulphate ion is converted to hydrogen sulphide [42] according to equation (13).



In addition to terrestrial plants, high concentrations of sulphur compounds are produced by marine algae. They accumulate high concentrations of sulphur compounds because the

habitats in which they live contain abundant sulphur (from various sources, such as underground volcanoes).

Once in the cells, sulphur is metabolized in various ways: it is incorporated either as organic sulphate or as a thiol group of cysteine. Such metabolites are involved in various cellular processes [42]. The high concentrations of inorganic sulphates identified in water samples taken from the aquatic environment may favour the formation of H_2S in the water (by their reduction under the action of sulphide-reducing bacteria), along with its formation following anaerobic degradation of organic sulphur compounds.

This can affect invertebrates in the aquatic environment, as well as fish eggs and fry. Furthermore, in certain situations conditioned by the pH of the water, sulphides may result.

The toxic nature of sulphides is determined predominantly by the undissociated form (H_2S) and to a lesser extent by the HS^- or S^{2-} ions, which are pH-dependent.

Therefore, from the analysis of water samples, a high concentration of sulphates can be noted, which can result in a major impact on the aquatic environment, as they are toxic to organisms. High concentrations of sulphates in such water samples can facilitate the formation of hydrogen sulphide, which is toxic to most aquatic organisms, lethal doses being very low. The toxic effect can be correlated with the mechanism of action on haemoglobin, forming sulphmethaemoglobin. In addition, poor water circulation can be an important factor that favours the formation of hydrogen sulphide.

On the other hand, if lower concentrations of sulphates are noted, these results can most likely be attributed to the formation of Ca^{2+} and SO_4^{2-} ion pairs which increase the total water hardness in the respective area of the aquatic environment.

6.7. Cl^-

In the case of the analysis of samples taken from the aquatic environment, an increase in the concentration of chlorine ions can be observed, which can directly lead, according to Wu *et al.*, to a reduction of water self-purification processes in the respective area. Such phenomena can make the detection of Cl^- in water very important [43].

In addition, these results are associated with a decrease in aquatic biodiversity [44] compared to the other regions analysed. Chlorine reacts with amino groups in proteins forming hydrochloric acid. Furthermore, the reaction of chlorine with water in tissues results in hydrochloric acid which can cause stomach hyperacidity, followed by ulceration.

When chloride, phosphate, and sulphate anions participate in the metabolic stages of aquatic plants in

high concentrations, they alter the acid-base balance. In this way, acidic conditions are created, a process that can lead to acidosis [45].

6.8. Chemical oxygen demand (COD)

An important indication of the presence of germs in water samples taken from the aquatic environment is the increase or sudden appearance of organic substances. Usually, organic substances are accompanied by such germs.

Therefore, those compounds that can be oxidized under the action of an oxidant constitute the oxidizable organic fraction in water. These are assessed by chemical oxygen demand (COD). However, according to Wojnárovits. *et al.* [46] in recent years, COD has been increasingly replaced by the total organic carbon (TOC) parameter. However, the results obtained regarding the COD parameter may indicate that in the region from which the samples subjected to subsequent analyses were taken, water pollution due to the content of organic substances is significant.

These results are probably due to high concentrations of autochthonous organic substances originating from the body of hydrobionts, such as proteins, cellulose, etc. or from the metabolic activity of hydrobionts, during which various ectocrine substances result. Once eliminated in the aquatic environment, exocrine substances can inhibit certain processes that occur in water. Also, such substances resulting from metabolism can inhibit or stimulate the metabolism of other species.

On the other hand, when the results obtained indicate that, through much lower COD values, the water samples taken are characterized by a lower degree of pollution, this is due to the presence of oxidizable organic substances in a lower percentage.

7. Conclusions

The metallurgical industry produces a wide range of polluting oxides, both non-metallic and metallic, with significant effects on the aquatic environment. The specialized literature of the last decade offers both the mapping of sources and the degree of pollution of the aquatic environment, as well as efficient technical solutions.

Our studies show that all the information accessed from the literature on chemical oxygen demand confirms that this parameter is of major importance for assessing the degree of pollution with organic compounds of the aquatic environment.

Where increases in the degree of pollution of the aquatic environment are identified as a result of technological processes in the metallurgical and food

industries, as well as in agriculture, the modernization of the respective technologies is required. This is necessary to achieve the water protection objectives established by directives of regulatory bodies on aquatic pollution. We believe that the results presented in this minireview are crucial for the development of new environmental policies by regulatory bodies.

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