Study Regarding the Negative Effects of Industrial Wastewater Discharges

Studiu privind efectele negative ale deversărilor de ape uzate industriale

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Abstract. *The purpose of this article is to better comprehend the impact of industrial waste waters discharges on the water cycle, in order to better understand current trends and the magnitude of the environmental strain posed by industrial wastewaters. It also examines the various regulatory frameworks that restrict and influence industrial wastewater discharges. An assessment of industrial wastewater discharges in Cluj-Napoca, Romania is carried out, taking into account the types of monitored industrial units, the monitored quality indicators, and their compliance with the EU and Romanian environmental regulations.*

Key words: industrial wastewater, pollution, wastewater discharges monitoring.

1. Introduction

Insufficiently treated or untreated wastewater is one of the main causes of pollution and degradation of water bodies. Therefore, the main practical measure to protect the quality of surface water is wastewater treatment, which involves collecting the wastewater through sewage systems and transporting it to the treatment plant, from where it is usually discharged into a surface water body.

The composition of industrial wastewater and the concentration of pollution differ considerably depending on the type of activity of the industrial agent.

Also, the types of hazardous substances that can be found in industrial effluents differ depending on the existing industrial production process and the state of the treatment and production facilities.

Water abstraction for industrial purposes in European Union represents about 54% of the total uptake for human activities [1]. Thus, water discharges from industry create significant pressures on water bodies both quantitatively and qualitatively.

In most cases, these waters show a substantial deterioration of all quality properties and therefore cannot be discharged safely into a surface water without prior treatment.

Figure 1 shows an overview of the industrial water cycle, starting with the water uptake from a body of water - freshwater catchment – and presents three possible variants of discharging the industrial effluent (A, B and C) depending on the existing industrial production process: direct release, direct release without treatment, indirect release.

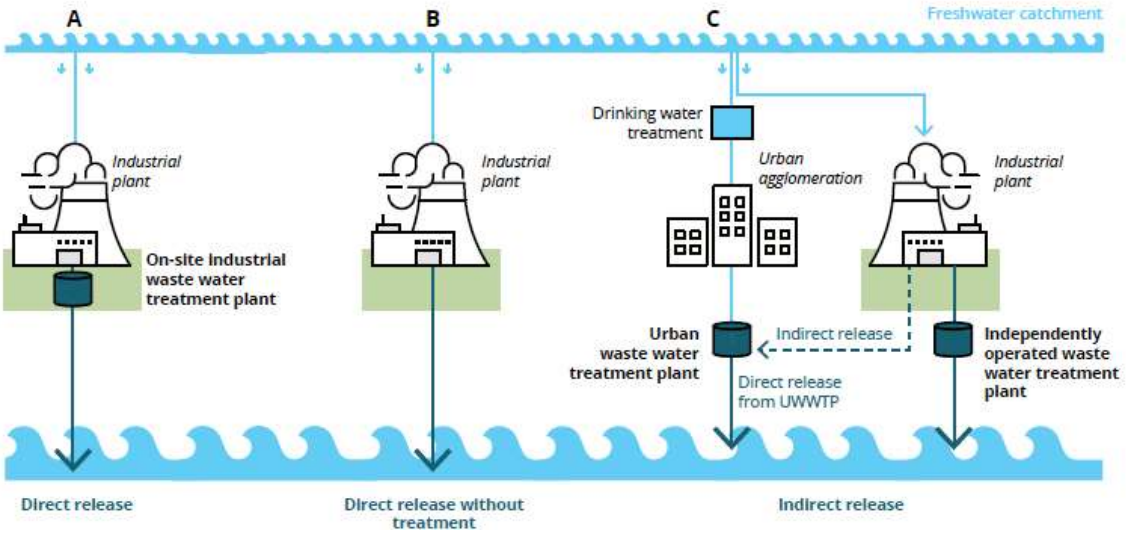

Fig. 1. Wastewater treatment cycle [1].

The first scenario, variant A, applies to the case of effluents from certain industrial processes which require a specific treatment, that is not usually available in the urban wastewater treatment plants, and thus need to be treated to meet the quality standards before being discharged back into a surface water.

In the next scenario (B) the wastewater has a low pollutant concentration and can be discharged directly into the surface water because it meets the quality standards, which are presented in the next section.

As seen in the last scenario (C), there are some industrial processes that release wastewater streams which cannot be discharged directly into the surface waters because they do not meet the quality standards, or the industrial operator does not have the necessary treatment facilities and chooses to discharge the effluent into a municipal sewer system to be subsequently treated in an urban wastewater treatment plant.

Wastewater treatment facilities of industrial or economic operators must be sufficiently effective to prevent dangerous effects on humans or the environment. This applies both to the direct release and indirect release of industrial effluent. In the latter case, a pretreatment at the industrial/ economic operator is still necessary and must be sufficiently efficient to prevent the harmful effects on the sewerage and the wastewater treatment plant.

2. European Policy Framework for industrial Wastewaters

To have an overview of the legislation in this field, we will present the European directives and the relevant Romanian legislation and other legislative elements regarding the prevention and combating of accidental pollution and restrictions regarding the evacuation in the municipal sewerage system.

The discharge of industrial wastewater is regulated in Europe both directly, through environmental legislation for industry, and indirectly through water regulations.

The most relevant directives are the Water Framework Directive (2000/60/EC), the Urban Waste Water Treatment Directive (91/271/EEC), the Groundwater Directive (2006/118/EC) and the Environmental Quality Standards Directive (2008/105/EC). These directives regulate aspects that will influence industrial wastewater generation and management.

The Water Framework Directive establishes a series of mechanisms for the protection of all water resources in the EU. It applies to rivers, lakes, groundwater, and transitional coastal waters and it aims to ensure that all aquatic ecosystems meet the ‘good ecological status' and the 'good chemical status' and it also sets deadlines for this objective. The first deadline was set to 2015, although a large proportion of the water bodies in Europe have failed to meet it, and the latest deadline is set to 2027.

The Urban Waste Water Treatment Directive represents the main instrument for regulating the operation of waste water treatment plants in the EU. Its main objective is to protect the water environment from the adverse effects of discharges of urban waste water and from certain industrial discharges.[4]

Directive 2010/75/EU, named the Industrial Emissions Directive represents the main instrument for regulating pollutant emissions from industrial operations [5]. By decreasing harmful industrial emissions across the EU, the IED strives to establish a high degree of protection for human health and the environment. In Europe, the IED currently oversees 31 industrial sectors and approximately 50 000 installations.

The IED distinguishes between "direct" and "indirect" environmental emissions, with the latter occurring after separate treatment. Permit limit values for direct releases of certain pollutants are typically more stringent than those for indirect releases. For some compounds, this may be done to guarantee that pollution levels in the effluent do not harm the sewer system or degrade the performance of the urban wastewater treatment plant.

In most cases, industrial wastewater discharged into surface water must be sufficiently treated to prevent adverse effects on surface water bodies. In the EU, the directives presented above provide a guide to industrial wastewater discharges into

surface water, using water quality standards, emission limit values and the concept of best available technology.

All the European directives mentioned above are already transposed into national Romanian regulations. Among the most important national legislative acts that regulate the discharge of industrial wastewater in Romania can be mentioned:

- Water Law no. 107 / 25.09.1996 with subsequent amendments and completions
- Decision no. 188 of February 28, 2002 - that comprises NTPA-001/2002, which establishes loading restrictions for contaminants in industrial and urban wastewater discharged into natural receptors and NTPA-002/2002 on the conditions of wastewater discharge in urban sewerage networks and directly in the treatment plants
- Decision no. 570 of August 10, 2016, Program for the phasing out of discharges, emissions and losses of priority hazardous substances and other measures for major pollutants
- O.M. no.161 / 16.02.2006 Norm on the classification of surface water quality in order to establish the ecological status of water bodies
- Decision no. 472 of June 9, 2000 - measures for the protection of the quality of water resources, with subsequent amendments and completions

3. Negative effects of industrial wastewater discharge

We will investigate the effects of these discharges on the ecosystem to have a better knowledge of the impact of industrial waste waters on the environment.

Industrial wastewater discharges into sewage systems must be managed to avoid the following:

- **Harmful effects on the health of operational employees and those exposed to wastewater and sludge.**

Humans may be exposed to hazardous substances during sewage system operation and maintenance, as well as throughout the treatment process. Exposure to hazardous or explosive volatile compounds is a potential concern. Discharges of potentially harmful compounds must be avoided or limited to a level that does not endanger the effluent being released into the sewage system.

- **Harmful effects on the sewage system**

The following are some of the consequences of industrial wastewater discharge on the sewerage system: corrosion, blockage, deposition of fine suspensions that obstruct the flow, and a foul odor. Sewer system corrosion is a well-known problem. Corrosion can be caused by acids, bases, chlorides, and sulfates in the system. Sulfate corrosion is usually linked to the transition of sulfates into sulfides, an anaerobic process that occurs in the sewer system. In the sewer system, disagreeable scents are primarily induced by hydrogen sulfide generation, but ammonia and other volatile organic compounds (mercaptan and metal sulfide, for example) can also cause unpleasant odors. Anaerobic conditions inside canals, sulphate concentrations, and easily biodegradable organic substances all contribute to sulfur formation.

- **Harmful effects on wastewater treatment facilities**

The effects of industrial wastewater on treatment facilities include inhibition of the biological treatment process, bad odors, corrosion of some treatment plant components. The biological treatment stage in wastewater treatment plants is mainly based on the concept of activated sludge. Activated sludge biodegrades or eliminates a wide spectrum of organic molecules, including potentially hazardous chemicals, under normal operating conditions. However, if non-biodegradable poisonous compounds are present in excessive concentrations, or if the concentration (loading) of toxic biodegradable compounds exceeds the removal ability of activated sludge, this biological activity may be adversely affected.

Within an activated sludge unit, the following biological processes occur water line, aerobic respiration (degradation of organic compounds under aerobic conditions), nitrification (aerobic oxidation of ammoniacal nitrogen in nitrites and nitrates), denitrification (anoxic reduction of nitrates to free nitrogen), biological phosphorus removal, sludge line, anaerobic sludge fermentation

The most sensitive process within the water line is nitrification, which is a key indicator for wastewater toxicity. Aerobic respiration inhibition is thought to be a less sensitive mechanism than nitrification. Inhibition of aerobic respiration, on the other hand, indicates the presence of hazardous substances. Inhibition of the sludge fermentation process within the sludge line could indicate the presence of hazardous chemicals for anaerobic fermentation. Anaerobic processes are more sensitive than aerobic processes in general. It is a well-known fact that unpleasant scents created by volatile organic and inorganic substances cause problems. Sulfides, mercaptan, and methyl sulfides are some of the substances that have been found in treatment plants and cause a disagreeable odor. Such issues may arise because of some industrial discharges of volatile compounds. Many of Europe's treatment plants have implemented procedures to limit the discharge of volatile chemicals into the atmosphere. Chemical dosing, covering areas of the station, and ventilation or treatment / purification of vented air are examples of these measures.

If the composition of wastewater (e.g. sulfate and chloride levels) encourages corrosion and concrete basins and/or equipment and pipes are not designed for a specific composition of wastewater, corrosion of concrete basins or specific equipment in treatment plants may occur.

- **Dangerous impacts on receiving surface waters**

The overall environmental impact of the effluent discharged from a wastewater treatment plant on the receiver body of water is determined by the effluent's qualities. Most small wastewater treatment plants treat solely household wastewater, but medium and large wastewater treatment plants treat both domestic and industrial wastewater.

The following compounds may reduce effluent quality:

• Toxic compounds for life in the aquatic environment
• Bioaccumulative substances
• Potentially toxic substances that biodegrade slowly in natural environment

Toxic compounds that are not readily biodegradable, such as substances that are not sufficiently biodegraded in the treatment plant or that are not significantly absorbed in the activated sludge, may cause ecotoxicity to the effluent.

4. Case study in Romania – assessment of industrial wastewater discharges in Cluj-Napoca

The primary economic sectors in the Cluj County area are industry, agriculture, trade, and construction and all of these are contributing to the wastewater outflow.

The following figure shows the percentage distribution of active local units operating in various national economy activities in Cluj County, according to the National Institute of Statistics [6].

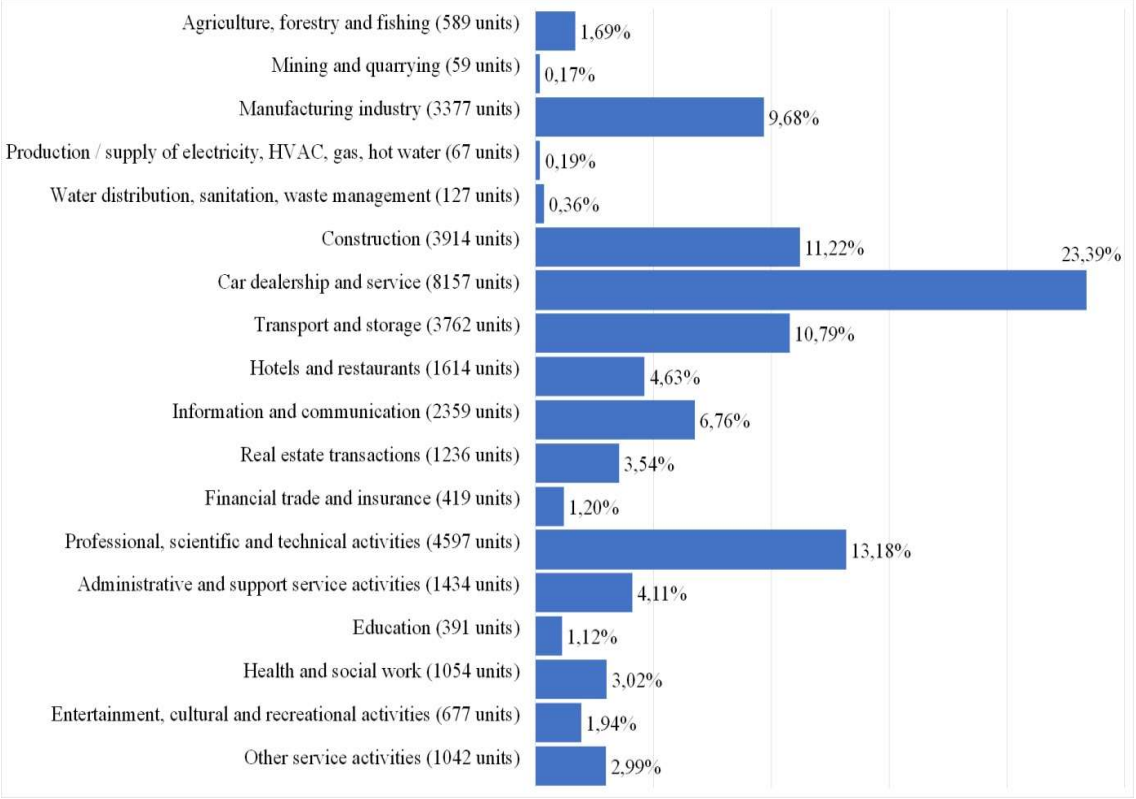

Fig. 2. Percentage distribution of active local units operating in various national economy activities in Cluj County.

All existing industries in Cluj-Napoca area can be connected to the municipal waste water treatment plant, provided they comply with the requirements defined by NTPA 002/2002. For most industries, connecting to the municipal sewerage network represents the most cost-effective option.

On the sewerage system, the amount of water collected from potential polluters' connections is monitored, especially for the economic agents who may have significant

impact on the quality of the wastewater collected in the system due to the large volumes of wastewater evacuated or the high pollutant concentrations (table 1).

Table 1

Pre-treatment facilities and monitored wastewater quality indicators depending on the activity profile of the economic agents in Cluj-Napoca

Activity profile	Number of monitored units	Treatment facilities	Monitored indicators
Tourism	20	Clarifiers and grease separator	pH, CCO-Cr, CB05, MTS, NH4+, SE, detergents
Fuel station	14	Clarifiers and separator of petroleum substances	pH, MTS, SE, CCO-Cr
Car wash	11	Grit removal, clarifier and hydrocarbon separators	pH, MTS, SE pH, CCO-Cr, CB05, MTS, NH4+, SE
Bakery	11	-	pH, CCO-Cr, CB05, MTS, NH4+, SE
Shop and supermarket	11	Clarifiers and oil separators and petroleum substances	pH, CCO-Cr, CB05, MTS, NH4+, SE, P, detergents
Car dealership and service	11	Clarifiers and separators of petroleum products	pH, CCO-Cr, MTS, SE
Heavy industry	5	Clarifiers	pH, MTS, SE, CCO-Cr, NH4+
Concrete station	5	Clarifiers	pH, MTS
Textile and footwear industry	4	Clarifier, neutralizing chamber	pH, CB05, MTS, NH4+, MTS, SE, detergents
Farms and butchery	3	Monobloc mechanical-biological pre-treatment plant, separator of petroleum substances and Clarifiers	pH, CCO-Cr, CB05, MTS, NH4+, SE, P, detergents
Mining processing	3	Clarifiers and separator of petroleum substances	pH, MTS, Al, NH4+
Restaurant	3	Clarifier and grease separator	pH, CCO-Cr, CB05, MTS, NH4+, SE, P, detergents
Meat processing	3	Clarifier	pH, CCO-Cr, CB05, MTS, NH4+, SE
Metal fabrications	2	Neutralizer, clarifiers	pH, MTS, SE, Ni, Zn
Industrial fittings	1	Clarifiers and separators of petroleum products	pH, CCO-Cr, CB05, MTS, SE
Seafood processing	1	Monobloc mechanical-Biological pre-treatment plant	CCO-Cr, CB05, NH4+, SE, P

Activity profile	Number of monitored units	Treatment facilities	Monitored indicators
Abrasive material	1	Clarifiers and separators of petroleum products	pH, CB05, MTS, NH4+, SE
Metal coatings	2	Neutralizer and Clarifiers	pH, SE, Ni, Zn
Beauty	2	Neutralizer, clarifiers and grease separators	CCO-Cr, CB05, MTS, NH4+, SE
Ceramics	2	Clarifiers	pH, MTS, SE
Research	2	Clarifiers and separators of petroleum products	pH, MTS, SE, NH4+
Industrial park with canteen	2	Grease separators	pH, CCO-Cr, CB05, MTS, NH4+, SE,P
Printing	2	Pre-treatment micro station	CCO-Cr, CB05, MTS, NH4+, SE
Chemical industry	1	Clarifiers and separators of petroleum products	pH, CCO-Cr, CB05, MTS, NH4+, SE
Industrial warehouse and park	1	Clarifiers and separators of petroleum products	pH, MTS
Building materials	1	-	pH, MTS, Al
Metal sintering	1	Clarifiers and separators of petroleum products	pH, MTS, SE, CCO-Cr
Cake shop	1	-	pH, CCO-Cr, CB05, MTS, NH4+, SE, P
Plastic material	1	-	pH, MTS, SE
Furniture	1	Clarifiers	pH, SE, CCO-Cr
Dairy industry	1	Mechanical-biological treatment plant	pH, CCO-Cr, CB05, MTS, NH4+, SE,P detergenți
Chemical laundry	1	Clarifiers	pH, SE, P, detergenți
Spirt industry	1	Storage tank, clarifiers, neutralizer	pH, CCO-Cr, CB05
Rolling stock repairs	1	Grit removal, clarifiers and hydrocarbon separators	pH, MTS, SE
Pharmaceutical packaging	1	-	pH, MTS, SE, CCO-Cr
Manufactured items	1	Clarifiers	pH, SE, Ni, Zn

According to the findings of the physico-chemical analyzes of the industrial wastewater discharged by the economic agents from the Cluj-Napoca area, some industrial units exceed the limits established by NTPA 002/2002 (figure 2). However, due to the reduced quantity of industrial wastewater discharged, respectively due the

effects of dilution in the sewerage network, there is no significant overall impact on the sewerage system and on the processes of the municipal wastewater treatment plant.

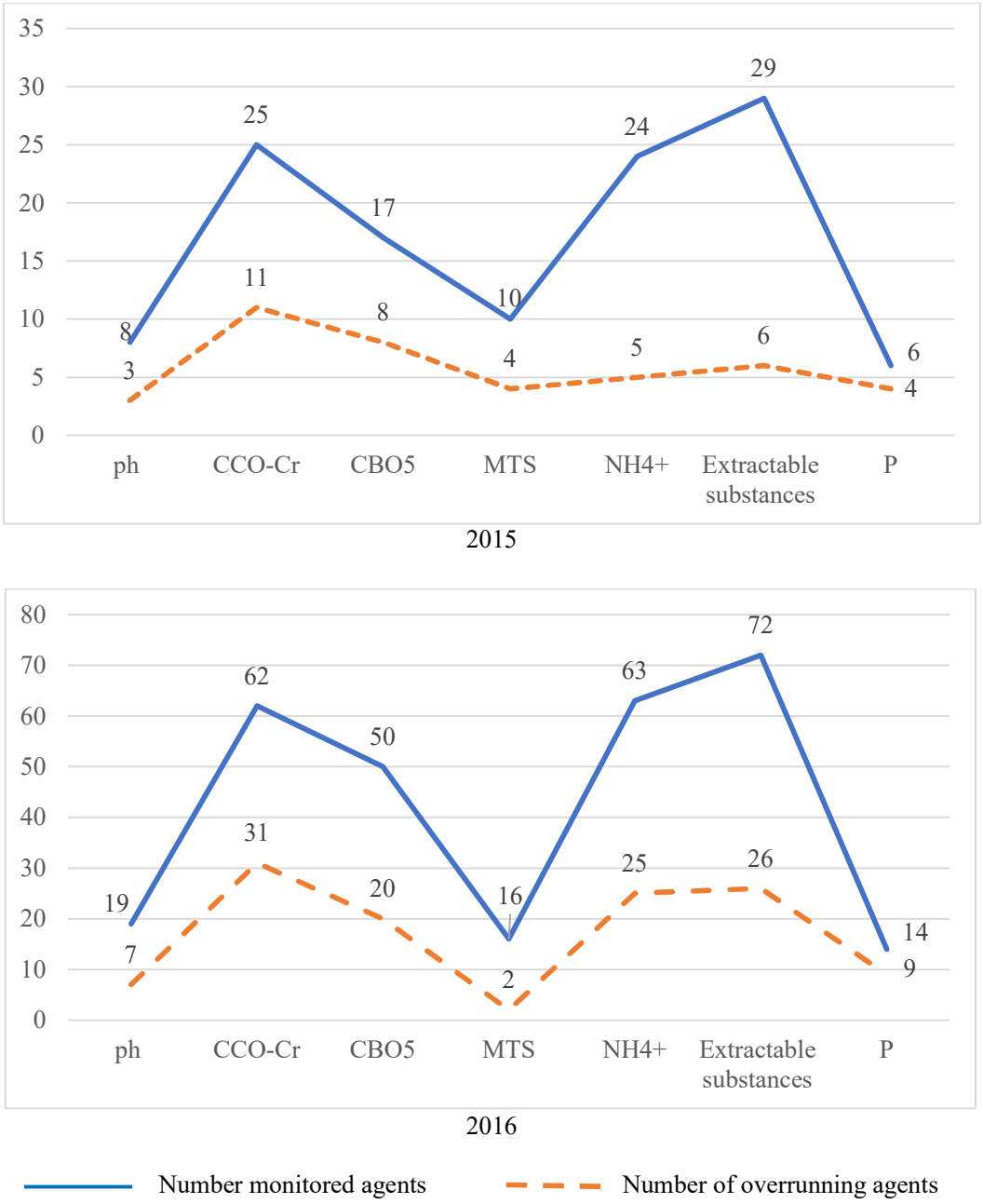

Fig. 2. The economic agents that registered exceedances for the monitored indicators

Based on the results of the economic agent monitoring and the impact on the wastewater treatment plant, it is considered that no adjustments in the wastewater treatment plant's technological flow or the construction of additional treatment plants are required. However, the economic operators who have consistently exceeded the

values imposed for different quality indicators should adopt wastewater pre-treatment solutions to fall within the limits of NTPA 002/2002.

5. Conclusions

In general, industrial wastewater discharged into surface water must be properly treated to prevent adverse effects on receptors. EU directives and national legislation provide a guide for the management of industrial wastewater discharges into surface waters, indicating limit values for pollutants and using the concept of the best available technology.

The results presented in this article show that the water discharged by economic agents into the municipal sewer is, with some exceptions, in accordance with the standards imposed by NTPA 002/2002, however, improvements are needed, both in terms of pretreatment facilities at economic agents, as well as regarding the monitoring program.

The problem that economic agents face is not due to a lack of legislation in this field, which has been in place for a long time, but rather to the fact that budgets for provision and maintenance of wastewater facilities have always been limited or unavailable.

In the case of wastewater treatment plants, their operators must take a set of measures to minimize the impact of industrial wastewater discharged into municipal sewerage networks.

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