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# The Influence of Sugar-Processing Effects on Water in Treatment Plants

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**Abstract**

The present paper is a study regarding the influence of waters resulted from the production of sugar from sugar beet on waters in wastewater treatment plants. The objective of the paper is to prove that wastes, especially organic ones, resulted from the production of sugar from sugar beet (*Beta vulgaris L.*) may have a significant effect on the quality of water entering or leaving water treatment plants, unless appropriate measures are taken to pre-treat and/or treat wastewater. That is why the existence of norms, standards and/or instructions establishing the qualitative conditions of water, on different lines or technological flows, is particularly important for the policies regarding the economical use of water resources. The fact that the capacity of the wastewater treatment station in Ludus is below the designed level, the sometimes inadequate separation of vegetable wastes from sugar beet root before processing lead to the exceedance of the accepted value for some water quality indices (total suspensions, $CCO_{Cr}$), especially during the campaign periods.

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*Keywords:* pollution; water quality; quality indices; industrial wastewaters; water-treatment plant; admissible value; used water.

## 1. Introduction

Given the conditions of life-existence and specific human activities, water presents a double significance: the first as environmental factor, and ecological system generator and, second, the "raw material" for different uses, such as drinking water, industrial water, agriculture, fisheries, recreation, etc.

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The quality standards imposed to the various categories of water used in industry cover a very broad range, from natural water used in hydraulic transport in some industries (mining processing, coal, extractions, etc.), to high-purity water sought in the electronics industry.

Before the water is pumped into the distribution network, it should be subjected to purification in special plants in order to bring the water to standard quality or lower values. [7].

The existence of rules, standards and / or guidelines that determine water quality conditions on different lines or technological flows is particularly important in the policy of judicious management of water resources, because the areas of water use are very different and pollution threats are serious [1]. The effects of water pollution are complex and varied, depending on the nature and concentration of pollutants.

2. In recent decades, the range of pollutants is much diversified, primarily due to industrial activities [4]. The high degree of pollution with organic compounds leads to an imbalance of oxygen in water and is often accompanied by severe pathogenic contamination. The industrial wastewater can be discharged to the sewerage system or in the receiver, of course, where appropriate, after pre-treatment. Small flows of industrial wastewaters are discharged, most often in the urban sewerage system, their treatment being made with municipal wastewater. This solution can be applied only if the industrial wastewater does not present the risk of degradation or obstruction of the sewerage network and treatment [12]. Solving problems posed by water pollution is the application of treatments, thus ensuring the necessary conditions for consumption [3].

3. The problem of wastewater treatment has both an economic aspect (e.g. the recovery of different products from water, recycled water reuse by irrigation or other purposes) and a health aspect, in order to avoid contamination of the water which is discharged into the environment. Water purification is a complex process of retention and neutralization of harmful substances which are dissolved, in colloidal state or suspension state which are present in industrial wastewater. These waters are not accepted in the aquatic environment where treated water is discharged and they allow restoration of physicochemical properties of water before use. Wastewater treatment processes performed by specialized plants that use advanced technologies and modern, reliable and efficient equipment [17] contributes to achieving and maintaining water quality.

To ensure water quality conditions, which is a serious problem at national level (although there are other European countries facing the same problem) is necessary to comply with EU requirements imposed by European Directive 2000/60 / EC, which proposes a pollution control strategy by defining quality standards. Tracking water quality is needed to protect ecosystems and human health (2, 15, 9, 11,12, 14), not only because water must be present in significant quantities, but it must meet certain quality criteria [3,4].

4. Global Environmental Management Services (GEMS) is a United Nations-body which provides tracking water quality parameters in three categories [4,7] of basic parameters (temperature, pH, conductivity, dissolved oxygen, coccobacillus content), parameters indicating persistent pollution (cadmium, mercury, organo-halogenated compounds and mineral oils), optional parameters (total organic carbon, biochemical oxygen demand, anionic detergents, heavy metals, arsenic, chlorine, sodium cyanide, oil, total streptococci) [4,7].

Industrial wastewater can be discharged into the sewage system or in receivers, where appropriate, after pre-treatment or treatment.

Most cities take their industrial wastewater in sewage systems based on specific regulation, after sufficient research and based on a fee whose amount is determined by the amount and degree of contamination of these waters.

It is important for industrial wastewater channels not to have harmful properties which may affect the smooth functioning of the sewerage network and the treatment plant [17]. Sometimes the treatment of municipal wastewater and that of industrial water cannot be done simultaneously, because in some industrial water there are substances which inhibit the treatment processes. Therefore, the NTPA 002-2002 regulations regarding the conditions of wastewater discharge in the local sewerage networks and treatment plants, Annex 2 of the Governmental Resolution 188 of 28.02.2002, prohibits the discharge of suspended matter, whose quantity, size and nature is an erosive factor for sewers, causing deposits or impeding the normal flow of wastewater. There are industrial waters containing specific pollutants which cannot be removed by the three so-called conventional methods. This is the situation of wastewater containing biologically non-degradable soluble minerals and organic substances. In such circumstances advanced treatment techniques are applied [13], but such techniques are not applied in the sewage plant presented in the study.

## 2. Materials and method

In the study which we conducted, technological wastewaters entering the treatment plant are derived from sugar production and from population and economic agents from Luduş city.

We note that sugar beet processing is a complex extraction, consisting of a set of operation of physical, chemical and physico-chemical operations which aim to ensure the best technical conditions for sugar extraction and crystallization, with a yield as high as possible and a minimal cost. The largest amount of water used in sugar processing which enters the treatment plant is recorded in the washing stage and the hydraulic transport of beet. In literature (Water pollution and water remediation - Module II, page 89) the indicated water consumption required in the manufacture of sugar is between 76.0 and 95.0 ranging tons water / ton of product [18].

Since the theme of the paper refers to the influence of industrial water from the sugar factory SC Teresa Romania SA on the characteristics of water from the treatment plant, we consider it necessary to present the specific water consumption during beet processing (Table 1).

Table 1.Specific water consumption in Tereos RomaniaSA (during beet processing period)

| Specific industrial water consumption | TEREOS ROMÂNIA SA | | In accordance with BREF – FDM* | |
|---|---|---|---|---|
| | Fabrication norms | Achieved 2005 | Average value | Variation / Domain |
| *0* | *1* | *2* | *3* | *4* |
| Cubic meters water/ton of processed beet | 3,1 | 4,9<br>(5,7) b) | 0,3<br>7 | 0,23<br>0,50 b) |
| Cubic meters water/ton of sugar | 24,88 | 29,78 b) | 2,39 | 1,56 a)<br>3,21b) |

a) without cooling water consumption

b) including cooling water consumption

*) in accordance with BREF-FDM for sugar industry /2005 (year when the integrated environment authorization was approved)

The treatment plant takes waste industrial water from the Sugar plant and the sewage and industrial water in the city of Luduş. The wastewater treatment station was commissioned in 1986 and was dimensioned for a capacity of 240 l / s. The wastewater treatment station has a mechanical biological treatment technology using with natural dehydration of primary mud which is found in excess on dehydration platforms. The quality indicators for wastewater discharge into the sewage system must be within the limits set by the Government Resolution no. 188/2002 (NTPA002), with subsequent modifications and additions, but the values of pollutants shall not exceed the limits imposed by law; exceedance of the values set out in regulations lead to imposing penalties, according to EGO 798/2005.

During the factory campaign, the following waters enter the treatment plant: wastewater resulting from the beet transport and washing, accidental leaking from diffusion installations containing beet pulp, regeneration water, water resulting from softening filters in central heating stations, wastewater from washing floors, machinery, agricultural labs, waters from washing machines, cooling pumpsand water for household use. Daily water samples are taken to determine pH values, total suspensions, COD, BOD5, NH4 + and weekly to determine the nitrite content of industrial wastewater. At the beginning of each month, the unit transmits quality indicator values related to the previous month, to ABA Mures, SGA Mures. Measurements carried out in the laboratory institution are performed according to standardized methods of analysis (Table 2).

Table 2.Analysis methods for quality indicators

| Nr.crt. | Quality indicators | Analysis method |
|---|---|---|
| 1 | pH | STAS 8619/3-90 |
| 2 | Total suspensions (MTS) | STAS 6953/3-81 |
| 3 | CCOCr | STAS 9887-74 |
| 4 | $CBO_5$ | STAS 9887-74 |
| 5 | $NH_4^+$ | STAS 6954-82 |

## 3. Results and discussion

We shall present and discuss the annual average values of quality indicators (listed in Table 2) during overhauls (Table 3) and Campaign (Table 4), both when water enters the treatment plant and when it leaves the station. To get a clearer picture of the influence of wastewater from sugar beet processing (over waters in the WWTP), Table 5, Figure 1 and Figures 2-6 contain calculated values (and admissible values) of indicators for the waters.

Table 3.Average values of quality indicators for waters in treatment plants (January - august/overhaul-2012-2014)

| Year | Values of water quality indicators | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pH (units) | | Total suspensions (mg/l) | | $CCO_{Cr}$ (mg/l) | | $CBO_5$ (mg/l) | | $NH_4^+$ (mg/l) | |
| | In. * | Is.* | In.* | Is.* | In. * | Is.* | In.* | Is.* | In. * | Is.* |
| 2012 | 7.5 | 7.9 | 189.5 | 46.1 | 153.4 | 115.8 | 48.0 | 36.6 | 35.2 | 22.2 |
| 2013 | 7.8 | 8.0 | 184.5 | 40.9 | 167.6 | 121.9 | 51.8 | 37.1 | 33.3 | 15.4 |
| 2014 | 7.4 | 7.6 | 202.2 | 35.6 | 178.2 | 128.0 | 61.2 | 45.9 | 32.7 | 18.0 |
| **Admissible values when leaving the plant | 6.5-8.5 | | 60 | | 130 | | 50 | | 30 | |

*In. *- on entering plant; Is.*- on leaving plant.*

***Governmental resolution 188/2002 regarding the pollutant content limits, with subsequent modifications and additions.*

During overhaul and campaign periods, the treatment plant is supplied with water resulting from domestic and industrial water in the city of Luduş, including domestic and industrial water from the sugar plant. It is natural that the quality values of water entering the plant should indicate used water (table 3 and 4), but the objective of the treatment plant is to bring water values to / below normal before it is discharged in the environment, and the objective was fulfilled. Note the content of wastewater entering treatment plant in the period September – December in comparison with the period January – August.

The situation is primarily due to organic matters (vegetable wastes and soil) which remain after washing beet root; these influence the values of the other indicators: pH, $CCO_{Cr}$, $CBO_5$, $NH_4^+$, due to biochemical processes occurring during wastewater treatment. During overhaul periods, the recorded values were closed to admissible values when water leaves the treatment plant: for $CCO_{Cr}$ and $CBO_5$, in 2014 (128.0 mg/l compared to an admissible value of 130.0 mg/for $CCO_{Cr}$, and 45.9 mg/l $CBO_5$, which is 4,1mg/l below the legal value) (tables 3 and 4). Note that in 2013, during campaign period, $CCO_{Cr}$ exceeds the admissible value of 250.0 mg/l by 40 mg/l.

Used water (industrial and domestic) from the sugar plant exceed the admissible value for toal suspensions (200 mg/l) for all the three years of the study. In 2013, total suspensions exceeded 5.4 times the admissible value and, in comparison with the years 2012 and 2014, the exceedance was of 1.7 or, respectively, of 4.5 (table 5). The carbon content in organic compounds in water determined an increase of oxygen chemical and biochemical consumption (in 2013: 594.35 mg/l $CCO_{Cr}$ and 231.73 mg/l $CBO_5$) compared to the admissible value (250 mg/l $CCO_{Cr}$ and 200 mg/l $CBO_5$). The pH and $NH_4^+$ values did not exceed the legal limits (Table5).

Table 4. Average values of water quality indicators in treatment plant (September-December/beet processing campaign-2012-2014)

| Year | Values of water quality indicators | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pH (units) | | Total suspensions (mg/l) | | $CCO_{Cr}$ (mg/l) | | $CBO_5$ (mg/l) | | $NH_4^+$ (mg/l) | |
| | In. * | Is.* | In.* | Is.* | In. * | Is.* | In.* | Is.* | In. * | Is.* |
| 2012 | 7.0 | 7.3 | 424.8 | 85,2 | 263.2 | 186.1 | 131.4 | 111.9 | 30.5 | 13.7 |
| 2013 | 7.5 | 7.6 | 420.2 | 80,7 | 340.4 | 290,0 | 180.8 | 133.6 | 27.7 | 13.2 |
| 2014 | 7.2 | 7.2 | 345.7 | 81.0 | 315.7 | 234.3 | 171.2 | 142.9 | 35.3 | 16.4 |
| ** Admissible values when leaving the plant | 6,5-8,5 | | 200 | | 250 | | 200 | | 30 | |

*In. *- on entering plant;Is.*- on leaving plant.*

***Governmental resolution 188/2002 regarding the pollutant content limits, with subsequent modifications and additions.*

Table 5. Pollutant content of wastewater resulted from sugar processing activities (September- December-2012-2014)

| Year | Values of water quality indicators | | | | |
|---|---|---|---|---|---|
| | pH | Total suspensions (mg/l) | $CCO_{Cr}$ (mg/l) | $CBO_5$ (mg/l) | $NH_4^+$ (mg/l) |
| 2012 | 6.29 | 606.29 | 294.63 | 174.57 | 13.67 |
| 2013 | 7.87 | 1080.44 | 594.35 | 231.73 | 22.74 |
| 2014 | 6.93 | 239.35 | 131.89 | 39.17 | 24.47 |
| *Admissible values | 6.6-8.5 | 200 | 250 | 200 | 30 |

*Governmental resolution 188/2002 regarding the pollutant content limits, with subsequent modifications and additions.*

| Year | Values of water quality indicators | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | | | Total suspensions (mg/l) | | | | CCOCr (mg/l) | | | | CBO5 (mg/l) | | | | NH4⁺ (mg/l) | | | |
| | C* | R* | **Admissible values | C | **Admissible values (C) | R | **Admissible values (R) | C | **Admissible values (C) | R | **Admissible values (R) | C | **Admissible values (C) | R | **Admissible values (R) | C | **Admissible values (C) | R | **Admissible values (R) |
| 2012 | 7.3 | 7.9 | 8.5 | 85.2 | 200 | 46.1 | 60 | 186.1 | 250 | 115.8 | 130 | 111.9 | 200 | 36.6 | 50 | 13.7 | 30 | 22.2 | 30 |
| 2013 | 7.6 | 8 | 8.5 | 80.7 | 200 | 40.9 | 60 | 290 | 250 | 121.9 | 130 | 133.6 | 200 | 37.1 | 50 | 13.2 | 30 | 15.4 | 30 |
| 2014 | 7.2 | 7.6 | 8.5 | 81 | 200 | 35.6 | 60 | 234.3 | 250 | 128 | 130 | 142.9 | 200 | 45.9 | 50 | 16.4 | 30 | 18 | 30 |
| **Admissible values | 8.5 | 8.5 | | 200 | | 60 | | 250 | | 130 | | 200 | | 50 | | 30 | | 30 | |

Fig. 1- Pollutant content of wastewater resulted from sugar processing activities (September- December-2012-2014)

Fig. 2-6. present the comparative situation of pH, $CCO_{Cr}$, values, total suspensions, $CBO_5$, $NH_4^+$ when leaving treatment plant.

By analyzing Fig. 1-6, which present comparative values of treated water quality indices for the period of overhaul and campaign, we conclude:

- pH values indicate neutral water, except for the overhaul period of 2013 when water becomes slightly alkaline, with 8 pH units recorded in August (Figure 2);
- The value of $CCO_{Cr}$ in 2012 and 2014 fall within the legal values, but in 2013, during the campaign, the admissible value is exceeded by 40mg / l (Figure 4);
- The other indicators - total suspension (Figure 3), $CBO_5$ (Figure 5), $NH_4^+$ (Figure 6) are below the admissible limit.

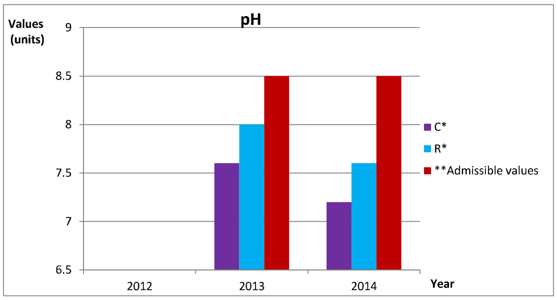


Fig.2. Values of water quality indicators

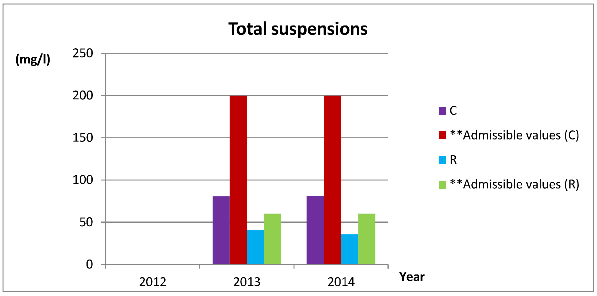


Fig.3. Values of water quality indicators- Total suspensions

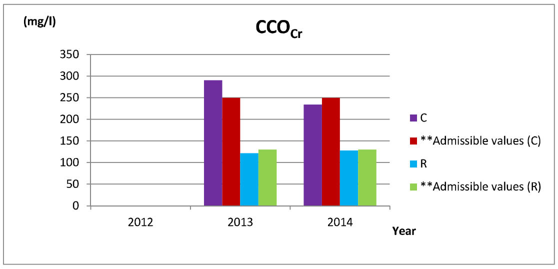


Fig.4. Values of water quality indicators- $CCO_{Cr}$

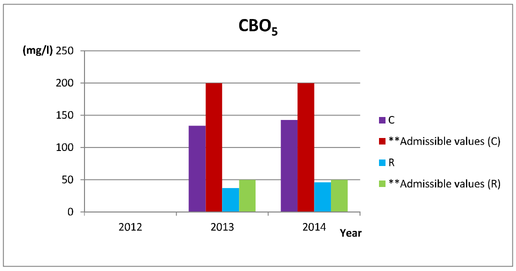


Fig.5. Values of water quality indicators- $CBO_5$

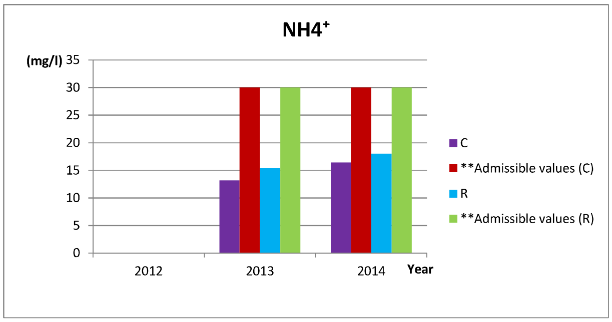


Fig.6. Values of water quality indicators- $NH_4^+$

## 4. Conclusion

The existence of regulations setting the qualitative conditions of water on various lines or technologic flows is particularly important in water resource management. The high level of organic element pollution leads to an imbalance of water oxygen, which is often accompanied by contamination with various pathogens. That is why it is necessary to sediment correctly suspension substances in wastewaters.

- In the years 2012-2014, during overhaul periods the admissible values of quality indicators of water leaving the treatment plant were not exceeded;
- During the 2013 campaign period we noted an exceedance of the admissible value for the indicator $CCO_{Cr}$ of 40 mg/l, due to the presence of organic nature in water, which were not sedimented enough during the two treatment stages;
- Technological water in the Ludus sugar plant records significant exceedance of total suspension values, during the three years of the study. This influences the presence and activity of oxygen in water, $CCO_{Cr}$ and $CBO_5$ values in 2013, being greater by 344,35 mg/l, respectively by 31,73 mg/l $CBO_5$;
- The treatment plant must be updated or replaced with a modern one including a tertiary treatment stage after the second treatment stage in order to increase the performance of classical treatment plants by lowering the concentrations of polluting elements in water below the legal limit that allows discharge of water into the environment.

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