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# Assessing the efficiency of industrial wastewater plant of Basra Gas Company

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**Abstract**

An important step in the avoidance of pollution was traditionally assuming the treatment of industrial effluent. As a result, it is crucial to regularly monitor and assess wastewater treatment facilities. This study examined the efficiency of an industrial wastewater treatment plant of a Gas Company in northern Rumelia. Several samples from the plant's outlet were collected for this purpose, and nine indicators (PH, EC, TDS, SO4, Turbidity, Total Hardness, Total Bacteria, BOD5, and COD) were tested. The results of these tests were compared to the guidelines established by Iraqi Health Ministry under Law No. 25 of 1967. Two samples were taken monthly from November through March 2022 for this study. The results showed that the majority of the indicators were above Iraqi standards, with values for PH ranging from (7-8.4), EC (1680-4060 mhos/cm), TDS (1206-2890 mg/l), SO4 (360-720 mg/l), turbidity (32-70 NTU), total hardness (655-779 mg/l), total number of bacteria (245-390 cell/ml), COD (110-227 mg/l), and BOD5 (57.9-119.5). The gas company's industrial wastewater treatment plant was unable to remove pollutants from the wastewater as a result. This is because there are no secondary or biological treatment components in the treatment plant; only primary treatment components are there.

**Keywords:** Basra Gas Company, Efficiency, Wastewater treatment, PH, Turbidity, Total Bacteria, BOD5, COD,
.

## 1. Introduction

Large amounts of associated gas were producing along with the extensive oil operations and significant growth in crude oil production in Iraq beginning in 2004, which were greatly enhancing after 2010 because of significant foreign investments in Iraqi oil sector within the framework of licensing rounds. The majority of this associated gas was burning resulting in wastewater. Given the absence of legal regulations that restrict environmental pollution in Iraq, very substantial oil and gas have greatly contributed to the degradation of the quality of life of Iraqis as well as the pollution of the environment. Due to oil and gas operations, which resulted in significant contamination of the environment's many elements, including water, mud, acids, and numerous chemicals that can leak or combine with other elements, the ecology in Iraq has suffered severely **[1]**.

Depending on the type of industry and commodities produced, the composition of industrial (including agro-industrial) effluent varies greatly. Some of this effluent may have very strong organic components, be quickly degradable, be primarily inorganic, or have inhibitory potential. As a result, the values of total suspended solid TSS, biological oxygen demand BOD5, and chemical oxygen demand COD may be in the tens of thousands of mg per liter **[2].**

A wastewater treatment plant typically has three sections: mechanical treatment, biological treatment, and sludge treatment. The wastewater contains a variety of pollutants and wastes, including nutrients, inorganic salts, pathogens, coarse particles, etc., that are extremely harmful to both humans and the environment. Different methods were exposing to eliminate these contaminants. There are specific chemical, physical, or biological procedures and unit operations used in wastewater treatment **[3].**

The possible health danger and environmental threat that industrial waste poses is one of the biggest issues that the community is now dealing with. Industrial effluent contains a wide range of poisonous and dangerous compounds **[4].**

Oil industries in developing nations were combining with industrial water. Even though wastewater treatment has advanced recently, it is still a major sustainability concern **[5].**

A fundamental indicator of wastewater treatment operation is the efficacy of wastewater treatment [6]. It is dependent on the quantity and makeup of wastewater, the kind and state of the sewage network, the producers, the used technical equipment, and environmental and other factors **[7].**

D.sobhi abdel sattar, Eng.sadiq hamid and Eng.ali awad provided the study that evaluated the efficacy of a wastewater treatment station associated with the Wasit General Company for Textile Industries over the period of 1/1/2016 to 31/12/2016 by measuring a number of environmental pollution limits from the station before draining it into the river. The station efficiency to remove (TSS) was at 76.77%, and the efficiency to produce (COD) and (BOD5) was at 59.58% and 81.9%, respectively. Additionally, the data demonstrate a decrease in (TDS) average concentration from 1415.5 mg/L prior to therapy to 1207 mg/L following that. Phosphate was roughly 0.3825, although the station is working in medium efficiency **[8].** Yusra m. Al-shaker and Amina B. Mohammed, concluded, the physical, chemical & biological tests carried out on monthly samples that collected for five months from November 2013- February 2014. The results showed that the station's pollutants removal was not efficient **[9].** Diana M. Byrnec , Jeremy S.guestd and Michal D. Shorthan., This paper presents a critical review of published LCAs ( Life Cycle Assessment System) related to municipal wastewater management. It aims to create systematic guidelines for researchers and practitioners to conduct LCA studies. The document walks the reader through the LCA approach step-by-step so they may decide on how best to implement it **[10].**

The purpose of this study is to assess the efficiency of Basra Gas Company's industrial wastewater treatment by examining the physical, chemical, and biological characteristics of samples taken from the inlet and outlet of the plant from November 2021 to March 2022 (two samples per month).

## 2. Study Area

Basra Gas Company is a great example of an Iraqi business. Iraqi government to address a problem in Iraq established it. Basra government's abundant natural gas output, which is currently being observed withering away but also blossoming into a vitality in the sphere of life for both the present and future generations, is the root cause of this issue. There is more than enough natural gas in Basra province to power the entire southern region of Iraq and beyond. Liquid gas was producing, storing, mixing, and compressing with the goal of transferring it via the pipeline network or another method to filling facilities or export outlets. Production and disposal of gas (natural gas). Building new and supplemental projects and manufacturing lines, as well as developing and expanding gas plants. Large amounts of waste were producing throughout the production processes by the company's operations, and this waste was then releasing into the environment. The performance of the treatment facility in this company should also be examine. This wastewater must therefore be evaluate, and its specifications must be compare to Iraqi standards. The company's headquarters are in Khor Al-Zubair, southwest of Basra Governorate. The plant has a straightforward treatment facility represented by a pipeline and sedimentation basin as shown in (figure 1) **[11].**

**Fig.1** Sedimentation tank and pipes in Gas Company

## 3. Methodology

In order to determine the physical, chemical, and biological properties at a temperature of 4 °C, samples from the industrial wastewater treatment were collected. For this purpose, nine indicators were choosing to assess the cleaning effectiveness of wastewater treatment plants for this purpose: PH, EC, TDS, SO4, Turbidity, Total Hardness, Total No Bacteria, BOD5, & COD. One liter of the sample was taking every 15 days for a period of four months (two samples/month) from November 2021 to March 2022. All indicators measured according to American Public Health Association (APHA 1998).

A pH meter used to measure PH. It should calibrated using the buffers (4, 7, and 9) before taking a reading. The glass electrode should also be made of hydrated silica gel, and the electrodes need to be soaked in water or a suitable buffer before being rinse in water. After use, electrode tips should cleaned by wiping with tissue paper to get rid of any sticking materials. The cap should removed during measurement to ensure that the potassium level in the calomel electrode is maintained.

A conductivity meter of the type LovibondSenso was using to measure the electrical conductivity (EC) of water samples, and the results were expressing in (mhos/cm). The electrical conductivity of a solution is determined by the amount of dissociated ions present. Both the temperature of the solution and its composition. The current will be impacted by these ions' concentration, between the two electrodes, flow the magnitude of this impact is closely related to the considering a constant temperature, the concentration of ions present. As a result, following calibration with using appropriate standards and a temperature probe to account for temperature variations the difference in EC of a solution between standards and samples can measured.
Total dissolved solids is a measurement of the dissolved substances in water that are still there after all the water

has evaporated. A known volume of well-mixed material was filtered using a standard glass-fiber filter, and the filtrate was then collected. In an oven maintained at 105 °C, the filtrate was evaporated to a constant weight. A dried sample's dissolved solid mass is calculated.

A spectrophotometer is a device to measuring sulfate concentration. It is necessary to prepare solutions with known sulfate concentrations in order to create a standard curve between known wavelengths and corresponding the sulfate concentration. Following that, color indicators were added to the sample to be studied. Using the wavelength as a guide, the device tests the sample and then, using the aforementioned curve, determines the corresponding concentration.

The amount of scattered light at a wavelength of 420 nanometers was measured using a spectrophotometer, and the sulfate ions (SO4) were approximated using the turbid metric method.

The cloudiness of a solution referred to technically as "turbidity," and it is a qualitative trait that is brought about by solid particles that prevent light from passing through a sample of water. The presence of suspended and dispersed particles, such as clay, organic matter, silt, alga, and other microorganisms, was frequently indicated by turbidity. Based on a comparison between the sample's intensity of light scattering under specific conditions and the intensity of light scattered by a standard reference suspension under the same circumstances, turbidity is determined. Thus, using a standard turbidity suspension as a reference, the amount of light scattered by the sample used to calculate its turbidity. The turbidity increases in direct proportion to the intensity of scattered light. Using a turbidity device and the Nephelometric Turbidity Unit as the unit of measurement, the turbidity of water samples was calculating using the Nephelometric method (N.T.U).

The total hardness was measuring using the titration method, and the findings were representing as mg/L in terms of calcium carbonate. Ammonia buffer is added to a sample to get the pH level to 10.0 before calculating total hardness. The ethylenediaminetetraacetic acid (EDTA) titrant is then used to titrate the sample to the equivalency point. When all of the calcium and magnesium have been complexes by the EDTA, a potentiometric change is produced by a calcium ion selective electrode (ISE), which is utilized as the titration indicator. The calcium ISE solves issues that are common with color indicators, such as the necessity for proper illumination to establish the endpoint during titration and endpoints that are not distinct and sharp **[12].**

The World Health Organization (WHO) determined the standard plate count method, which was using to calculate the total number of bacteria. That was by: take 0.1 ml from the sample and spread it on Petri- dish contain nutrient agar by using L-shape. Then incubate the plates into incubator at 37 0 C. After 24 -48 h of incubation read the results.

Calculate the bacterial growth by using :

$$G = (C / V) * 100$$

Where: G= Bacteria count
C= count of colony on Petri-dish.
V= mi of sample

The COD test is used to estimate how much oxygen an effluent will need and, by extension, how likely it is that the effluent will have an effect on the aquatic life in the receiving water channel. Three ranges can used to measure COD. LR (0–150 mg/l) is suitable for treated wastewater and final effluents. For measuring raw sewage, untreated wastewater, and partially treated waste water, use MR (0–1500 mg/l). It is appropriate to monitor trade effluents using HR (0–15000). The sample is heated to 150 degrees in the incubator for two hours to assess its value. After cooling the sample, the COD value is then determined. The results were obtained for the chemical need for oxygen demand (COD) using a calibration procedure using the Livibond device and in accordance with accepted practice.

The following mathematical connection was using to determine biological oxygen demand:

$$BOD5 = 6.1242 + 0.3142\,(COD) + 0.0008\,(COD)^2$$ **[13].**

## 4. Results & Discussion

The results of the laboratory testing indicated that the outlet industrial waste of the General Basra Gas Company's industrial wastewater plant has excessive levels of contaminants. Therefore, there is a significant environmental danger associated with releasing this industrial waste into the environment. The table below compares the results of laboratory testing with the Iraqi national wastewater limit standard to indicate how well wastewater treatment plants cleaned the nine indicators that were choosing: PH, EC, TDS, SO4, Turbidity, Total Hardness, Total No Bacteria, BOD5, & COD.

A. The acidity function (PH) : Potential hydrogen as shown in table 1

**Table 1** The acidity function values during [Nov.2021-Mar. 2022]

| Date | PH |
|---|---|
| 3-Nov | 8.2 |
| 16-Nov | 8 |
| 1-Dec | 7 |
| 15-Dec | 8.4 |
| 4-Jan | 7.5 |
| 18-Jan | 7.6 |
| 8-Mar | 7.3 |
| 15-Mar | 8.1 |
| average | 7.8 |
| Standard deviation | 0.5 |

| | |
|---|---|
| Limit | 6-9.5 |

Because of the breakdown of organic matter by microorganisms, the values varied as indicated in the table (1), with the lowest value occurring in March and the largest value occurring in November. This helps to balance the acidity function or the trend toward alkalinity. When creating bicarbonates, as the balance between CO gas, bicarbonate, and carbonate determines the value of the natural acidity function. According to the low value of standard deviation, so there is no significant difference in acidity function values during the study period.

B. Electrical Conductivity (EC) : cleared in table 2

**Table 2** Electrical conductivity values during [Nov.2021-Mar. 2022]

| Date | Ec (mhos\cm) |
|---|---|
| 3-Nov | 3572 |
| 16-Nov | 4060 |
| 1-Dec | 1680 |
| 15-Dec | 3820 |
| 4-Jan | 3660 |
| 18-Jan | 3560 |
| 8-Mar | 2890 |
| 15-Mar | 3942 |
| Average | 3398 |
| Standard deviation | 728.6 |
| Limit | 1600 |

According to table (2), the concentrations of dissolved salts and their ions decreased during the treatment process, with the average value about 3398 mhos/cm. The breakdown of organic components and the chemical reactions in water that because some of the compounds to dissolve may be to blame for the rise in electrical conductivity levels. Also high value of standard deviation refers to the depression of the electrical conductivity values.

C. Total Dissolved Solids(TDS): showed in table 3

**Table 3** Total dissolved solids values during [Nov.2021-Mar. 2022]

| Date | TDS ( Mg /L) |
|---|---|
| 3-Nov | 2162 |
| 16-Nov | 2543 |
| 1-Dec | 1206 |
| 15-Dec | 2249 |
| 4-Jan | 1926 |
| 18-Jan | 2460 |
| 8-Mar | 1845 |
| 15-Mar | 2890 |
| Average | 2160 |
| Standard deviation | 479.8 |
| Limit | 1500 |

The results presented in table (3) revealed that over the study's months, the value of T.D.S concentrations exceeded the limit value. The high concentrations caused by the presence of insoluble inorganic materials. This factor typically has a direct relationship with electrical conductivity, which evidenced by the average and high standard deviation values.

D. The Sulfates Concentration (SO4): cleared in table 4

**Table 4** The sulfate concentration values during [Nov.2021-Mar. 2022]

| Date | SO4 (mg/l) |
|---|---|
| 3-Nov | 468 |
| 16-Nov | 720 |
| 1-Dec | 360 |
| 15-Dec | 360 |
| 4-Jan | 497 |
| 18-Jan | 586 |
| 8-Mar | 370 |
| 15-Mar | 527 |
| Average | 486 |
| Standard deviation | 118.4 |
| Limit | <400 |

According to the findings depicted in table 4, the average sulfate concentrations value exceed the allowable limit value of it. The value of sulfate concentration was over limit value just on December and at 8-March. This growth caused by the gas company's high sulfur content, which is the principal impediment to any trend for industrial exploitation due to the high cost of the treatment process. As well as standard deviation, value refers to the important depression of sulfate concentration values during this period.

E. Turbidity (N.T.U.) : the values were denoted in table 5

**Table 5** Turbidity Values during [Nov.2021-Mar. 2022]

| Date | Turbidity (N.T.U) |
|---|---|
| 3-Nov | 32 |
| 16-Nov | 68 |
| 1-Dec | 30 |
| 15-Dec | 70 |
| 4-Jan | 50 |
| 18-Jan | 48 |
| 8-Mar | 55 |

| | |
|---|---|
| 15-Mar | 62 |
| Average | 51.9 |
| Standard deviation | 14.1 |
| Limit | 52 |

The table (5) depicts the turbidity values for the research period exceed the limit value for all recorded value accept for three of them. The average value was equal the limit value with standard deviation of 14.1 refers to little depression of the turbidity values. There are many particles and plankton in the water and it has been noted that there is a direct correlation between the level of turbidity and the activity of microorganisms, since plankton concentration directly affects how active and multiplying microorganisms are.

F. Total Hardness : its values were mentioned in table 6

**Table 6** Total Hardness Values during [Nov.2021-Mar. 2022]

| Date | Total Hardnes (mg/l) |
|---|---|
| 3-Nov | 690 |
| 16-Nov | 655 |
| 1-Dec | 760 |
| 15-Dec | 779 |
| 4-Jan | 702 |
| 18-Jan | 735 |
| 8-Mar | 700 |
| 15-Mar | 686 |
| Average | 716.4 |
| Standard deviation | 38.66 |
| Limit | 500 |

The total hardness values in the table (6), which varied from (779 mg/l) in December to (655 mg/l) in November. Clearly show that the difference in the rates may be cause by the nature of these various subtractions or by the processes of decomposition brought on by the presence of microorganisms on the organic matter and release $CO_2$, which, of course, will react with water. The average function showed exceeding the limit value with significant depression according to value of standard deviation.

G. Total number of bacteria: the results were in table 7

**Table 7** Total No. Of Bacteria values during [Nov.2021-Mar. 2022]

| Date | BOD5 (mg /l ) |
|---|---|
| 3-Nov | 118.5 |
| 16-Nov | 116 |
| 1-Dec | 50.4 |
| 15-Dec | 118.7 |
| 4-Jan | 50.7 |
| 18-Jan | 114.5 |
| 8-Mar | 49.7 |
| 15-Mar | 117.3 |
| Average | 91.975 |
| Standard deviation | 34.56467024 |
| Limit | <40 |

The results shown in table (7) revealed that the number of bacteria during the study's months ranged from (300-390) cells / ml, indicating that there is no actual treatment process and that the presence of organic and nutrient substances that promote the growth of bacteria and increase their numbers causes the number of bacteria to rise after treatment. It is clear that the average total number of bacteria was above the allowable value. A significant depression of the values according to effect of surrounding conditions.

H. Chemical Oxidation Demand (COD): the values mentioned in table 8

**Table 8** Chemical Oxidation Demand Values during [Nov.2021-Mar. 2022]

| Date | COD (mg/l) |
|---|---|
| 3-Nov | 226.7 |
| 16-Nov | 223 |
| 1-Dec | 110 |
| 15-Dec | 227 |
| 4-Jan | 110.7 |
| 18-Jan | 221 |
| 8-Mar | 108.6 |
| 15-Mar | 225 |
| Average | 181.5 |
| Standard deviation | 55,59 |
| Limit | <100 |

According to the table (8) the chemical oxygen demand rate in industrial wastewater reached its greatest excretion value (227 mg/l) on December and its lowest value (108.6 mg/l) on March. Due to the high levels of organic matter and reduced inorganic compounds, the chemical oxygen demand values are high. There is a considerable difference in comical oxygen demand values throughout the study due to high values of measures of dispersion.

I. Biological oxidation demand (BOD5): the results were in table 9

**Table 9** Biological oxidation demand values during [Nov.2021-Mar. 2022]

| Date | BOD5 (mg /l ) |
|---|---|
| 3-Nov | 118.5 |
| 16-Nov | 116 |
| 1-Dec | 50.4 |
| 15-Dec | 118.7 |
| 4-Jan | 50.7 |
| 18-Jan | 114.5 |
| 8-Mar | 49.7 |
| 15-Mar | 117.3 |
| Average | 91.97 |
| Standard deviation | 32.3 |
| Limit | <40 |

The average value of biological oxygen demand was exceeding the limit value. On the other hand, the values depressed during the study period. The biological need for oxygen in the wastewater peaked at (118.7 mg/l) on 15-December and peaked at its lowest at (49.7 mg/l) on 8-March. By dissolving the oxygen required to activate aerobic bacteria, which in turn feed on suspended and dissolved organic waste and convert it to carbon dioxide gas, the high values of BOD5 brought on by the high organic load and good ventilation work. One of the most significant barriers to biological therapy is the inability of bacteria to become weak, which highlights the need for chemical treatment in eliminating or reducing toxins to lessen their impact on germs.

J- The Efficiency

One important indicator of how successfully a wastewater treatment facility is performing is the efficiency of the wastewater treatment process. It based on the amount and composition of wastewater, the kind and condition of the sewage system, the producers, the age of the technical equipment, as well as environmental and other considerations.

The cleaning procedure's efficiency E [%] is calculated in accordance with standard ČSN 75 6401 by comparing the concentration of pollutants that have been eliminated to those that were initially present. The reduced efficiency of system component A is given by the following equation (Methodological Instruction ME) [13]:

$E\ \% = (C_{in} - C_{out} / C_{in})*100$ [14]

Where:

E: Efficiency

$C_{in}$: inter concentration .

$C_{out}$: outer concentration.

Table 10 showed the efficiency of a wastewater treatment plant in Basra Gas Company for removing the pollutants from industrial wastewater.

**Table 10** The Efficiency of Wastewater Treatment Plant in Basra Gas Company during [Nov.2021-Mar. 2022]

| Indicator | Input | Average output | Efficiency % | Limit |
|---|---|---|---|---|
| PH | 8 | 7.76 | 3 | 6-9.5 |
| EC(mhos\cm) | 3570 | 3398 | 4.8 | 1600 |
| TDS ( Mg /L) | 2890 | 2160.1 | 25.3 | 1500 |
| SO4 (mg/l) | 508 | 486 | 4.3 | <400 |
| Turbidity (N.T.U) | 62 | 51.9 | 16.3 | 52 |
| Total Hardness (mg/l) | 779 | 713.4 | 8.4 | 500 |
| Total No. of bacteria | 300 | 321.2 | -7.1 | 50 |
| COD (mg/l) | 170 | 181.5 | -6.8 | <100 |
| BOD5 (mg /l ) | 89.4 | 91.97 | -2.9 | <40 |

From Table 10, it is evident that the Basra Gas Company's industrial wastewater treatment facility is ineffective at removing pollutants, as the maximum value for efficiency in removing suspended solids was around 25%, which is also a low number. There is no biological or chemical treatment facility at this location, which would explain the high BOD5 and COD concentrations in the discharge.

## Conclusion

The industrial wastewater plant of the Basra Gas Company is not sufficiently handled by the industrial wastewater treatment. The Iraqi Health Ministry's restricting norms, established in accordance with Law No. 25 of 1967, were exceeded by all wastewater treatment indexes. All indicator readings have significantly decreased throughout the course of the study period at this plant because there is not a standard operating procedure there. It also introduces untreated industrial waste into the ecology of the community. The Gas Company asserts that they disposed of this industrial waste near residential areas.

## References

[1] Jawda, D. N. H., & Jaafar, H. N. (2018). “The Developmental Effects of Oil Industry in Iraq (Developmental of Oil Industry and Ist Reflection on Environment in Iraq)”. *Economic Sciences*, *13*(51).

[2] NG Wun Jern ,(2005). "Industrial Wastewater Treatment", *National University of Singapore*. Handbook 153.

[3] Kordrostami, S., & Rami Ismail, J. (2015). “Waste–water treatmant plant: Design”, *Westren Sydney University*. https://www.humanitarianlibrary.org/sites/default/files/2019/05/AWWT.pdf.

[4] Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., Von Gunten, U., & Wehrli, B. (2010). Global water pollution

and human health. *Annual review of environment and resources*, *35*(1), 109.

[5] Vicek V. Raude, Vinay M. Bhandar,(2014).‘‘ Industrial wastewater treatment recycling and reuse’’ *textbook copyright© Elsevier*.

[6] Kaindl, N., Tillman, U., & Möbius, C. H. (1999). Enhancement of capacity and efficiency of a biological waste water treatment plant. *Water science and technology*, *40*(11-12), 231.

[7] Dorussen, H. L., & Wassenberg, W. B. (1997). Feasibility of treatment of low polluted waste water in municipal waste water treatment plants. *Water science and technology*, *35*(10), 73

[8] Sobhi Abdel-Sattar Hassan, Sadeq Hamid Al-Ghanimawi, & Hussein Ali Awad Al-Zamili. (2017). "Evaluation of the efficiency of the industrial wastewater treatment plant in the Wasit State Company for Textile Industries". *Journal of College of Education/Wasit, 1(27).*

[9] AL-Shaker, Y. M., & Mohammed, A. B. (2019). Assessing the Environmental Situation for Excretion Management Stations in Al–Qayyarah Refinery. *Rafidain Journal of Science*, *28*(2), 8.

[10] Corominas, L., Byrne, D. M., Guest, J. S., Hospido, A., Roux, P., Shaw, A., & Short, M. D. (2020). The application of life cycle assessment (LCA) to wastewater treatment: A best practice guide and critical review. *Water Research*, *184*, 116058.

[11] The main site of Basra Gas Company.

[12] Worku, A., & Sahu, O. (2014). Reduction of heavy metal and hardness from ground water by algae. *J Appl Environ Microbiol*, *2*(3), 86-89KY-192.

[13] J Abdulla, H., K Bashar Al-Quraeshi, N., Nabeeh, F., & Al-Awadi, J. (2012). Study of chemical oxygen demand (COD) in relation to biochemical oxygen demand (BOD). *journal of kerbala university*, *8*(1), 40.

[14] Vítěz, T., Ševčíková, J., & Oppeltová, P. (2012). Evaluation of the efficiency of selected wastewater treatment plant. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *40*, 173