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WASTEWATER TREATMENT PLANT AND QUALITY OF BIOLOGICAL TREATMENT PROCESS

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Abstract

The aim of this paperwas to evaluate the quality of water povided from the municipal wastewater treatment plantof Tecuci town. In order to perform this objective, we collected the water semples and analysed them into the Faculty lab. We tested the physicaly and chemicaly characteristics of wastewater and compared theobtained values with the limits values for disposal of wastewater registeredin national Normative (NTPA 001).We found that water samples are in compliace with technical normative; the wastewater is properly treated and it can be discharged into the emissary.

***Key words**: wastewater,enviroment, water analysis, secondary treatment*

INTRODUCTION

The objective of wastewater treatment plant is to produce a disposable effluent that will not harm the environment and thus, prevent pollution. The process consists of several steps, called preliminary, primary, secondary and tertiary treatment, see Figure 1.

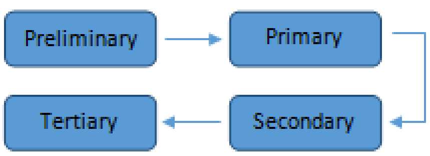

Figure 1. Conceptual scheme of the different steps in wastewater treatment plant

The principal objective of wastewater treatment is generally to allow human and all life form to live without danger to health or unacceptable damage to the natural environment. However some degree of treatment must normally be provided to municipal wastewater before it can discharge into natural receivers and be used.
The scope of this work was to evaluate the water quality before and after secondary and tertiary treatment process at wastewater treatment plant of Tecuci town, Galati county. The wastewater treatment plant was rehabilitated and extended, in september 2015 it was given in use so i decided to check the quality of water after the new treatment technology and process. Water samples were collected in sterile recipients before and after biological treatment step.
After analysis of water samples the physico-chemical indicator values were compared with technical standards for water quality provided in normative on the establishment of limits on charging industrial pollutants and urban sewage discharge into natural receivers (NTPA 001).
In this work were checked the next parameters: pH, TSS, NH4, NH4-N, NO3, NO3-N, NT, PT, CODCr.

MATERIALS AND METHODS

Determination of pH
The pH defines alkaline or acid water as having values from 0 to 14. Values between 0-6 characterize an acid pH, the 7 designates a neutral pH and alkalinity is between 8-14. Determination of pH was performed using pH sensor (Figure 2). Before taking readings, sensor calibration was performed in solutions of known pH (4, 7, and 9).

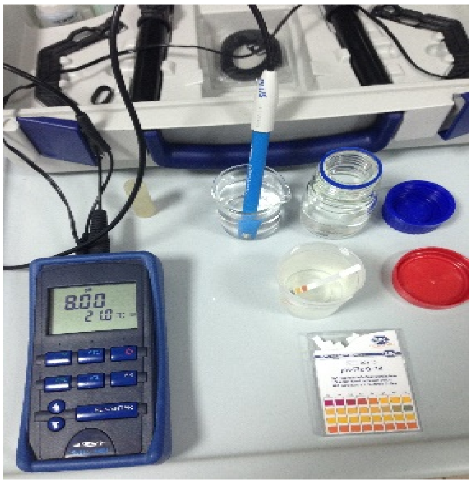

Figure 2. Determination of pH with pH sensor

Chemical oxygen demand (COD):

The organic matter, present in water sample is oxidized by potassium dichromate in the presence of sulphuric acid, silver sulfate and mercury sulfate to produce carbon dioxide ($CO2$) and water ($H2O$). The quantity of potassium dichromate used is calculated by the difference in volumes of ferrous ammonium sulfate consumed in blank and samle titrations. The quantity of potassium dichromate used in reactions is equivalent to the oxygen (O_2) used to exidize the organic matter of wastewater.

Test for Chemical Oxygen Demand:

1. Take 10 ml of sample into a round bottom reflex flask.
2. Add some glass beads to prevent the solution from bumping in flask while heating
3. Add 1 ml of Mercury sulfate ($HgSO4$) solution to the flask and mix by swirling the flask.
4. Add 5 ml of Potassium dichromate ($K2Cr2O7$) solution
5. Now add slowly and carefully 15 ml Silver sulfate – Sulfuric acid solution.
6. Connect the reflex condenser and digest the content using hot plate for 2 hours.
7. After digestion cool the flask and rinse the condenser with 25 ml of distilled water collecting in the same flask.
8. Add 2-4 drops of ferroin indicator to the flask and titrate with 0.025M ferrous ammonium sulfate solution to the end point.
9. Make the blank preparation in the same manner as sample using distilled water instead of the sample.

Calculate the chemical oxygen demand by follwing formula:

$$COD = \frac{8 \times 1000 \times DF \times M\ (Vb - Vs)}{\text{Volume of sample (in ml)}}$$

Where,
DF – Dilution Factor
M – Molarity of standardized Ferrous Ammonium Sulfate solution
Vb – volume consumed in titration with blank preparation
Vs – volume consumed in titration with sample preparation

Determination of Nitrogen/Nitrogen-N

Reagents

1. Solution of 50% NaOH.
 a. dissolve 100 g of NaOH in water, dilute to 200 mL
2. Buffer solution:
a. to a 1000 mL flask add 600 mL of water,
b. add 14.2g of Na_2HPO_4 or 17.8g of $Na_2HPO_4.2H_2O$ or 35.8g of $Na_2HPO_4.12H2O$ and dissolve
c. add 50g of K Na tartrate($C_4H_4KNaO_6.4H_2O$)
d. add 108 g of 50% NaOH
3. Salicylate/nitroprusside solution
a. in a 1000mL flask dissolve 150 g of Na Salicylate ($C_7H_5NaO_3$) and 0.30g of sodium nitroprusside ($Na_2[Fe(CN)5NO].2H_2O$) and make up to 1L
b. store in dark in brown bottle
4. Hypochlorite solution
a. dilute 6 mL of 5.25% sodium hypochlorite to 100 mL
b. prepare daily as it isn't stable
5. A "Diluent" solution
a. This contains the metal catalyst, or digestion solution, or the extraction solution.

Standards:

2. 100 mg/L NH_4-N
a. Dilute 10 mL of the 1000 mg/L solution to 100 mL using "diluent"
1. Series of NH_4 standards
 a. Dilute 0, 1, 2, 3, 4, 5, 6 of 100 mg/L to 100 mL with "diluent"
b. This series contains 0, 1, 2, 3, 4, 5, 6 mg/L of NH_4-N

Procedure

1. Turn on spectrophotometer and set `wavelength to 650 nm
2. Transfer 1mL of solution or standard to a test tube

3. Add 5.5 mL of buffer solution. Mix and agitate with vortex
4. add 4 mL of salicylate/nitroprusside solution and mix
5. add 2 mL of hypochlorite solution and mix
6. let rest for 45 min at 25C or 15 min at 37C
7. read absorbance at 650 nm within 2 hours.

Determination of total phosphotus
The phosphorus was determined by the method standardized by spectrometry.

RESULTS AND DISCUSSIONS

The seconday treatment (biological) is carried out using a sludge of active microorganism (bacteria, fungi, protozoa and algae) that transform different compounds found in wastewater. The process configuration for treating wastewater where microorganism are used for removal of polluants is called activted-sludge.
Most bacteria are heterotrophic, which means that they need an organic substance for the formation of cell tissue. They extract energy by an aerobic process where the organic matter is oxidized to carbon dioxide, water and oxygen is reduced. In the absence of oxygen there are autotrophic bacteria that can perform an anaerobic process where part of the organic matter is oxidized to carbon dioxide and water, while something other than oxygen, normally ammonia or sulphides, is reduce
At high pH values, over 8.0, nitrogen is mostly in the ammonia form (NH3) but when the wastewater is acidic or neutral (municipal wastewater is neutral), the majority of nitrogen is in the ammonium form (NH4+).

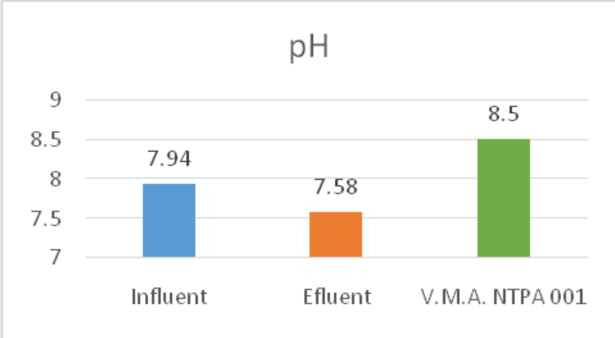

Figure 3. pH

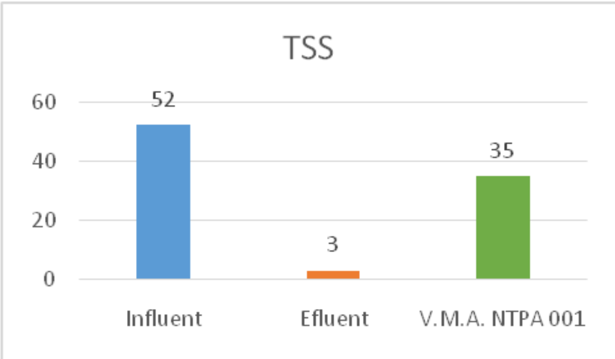

Figure 4. TSS

The removal of organic matter is important, because of the oxygen consuming reactions that pollute the recipient (Tchobangoglous and Burton, 1991). Removal of organic matter is the primary target for wastewater treatment. Equation (1) shows oxidation of organic matter and synthesis of cell tissue and equation (2) shows the endogenous respiration.

$$COHNS + O_2 + nutrients \xrightarrow{bacteria} CO_2 + NH_3 + C_5H_7NO_2 + other\ end\ products \quad (1)$$

$$C_5H_7NO_2 + 5O_2 \xrightarrow{bacteria} 5CO_2 + 2H_2O + NH_3 + energy \quad (2)$$

where,
COHNS = organic matter in wastewater (carbon, oxygen, hydrogen, nitrogen and sulphur)
$C_5H_7NO_2$ = cell tissue

The removal of organic matter is usually measured as BOD (Biological Oxygen Demand), TOC (Total Organic Carbon) or COD (Chemical Oxygen Demand).
COD test includes using a strong chemical oxidizing agent in an acidic medium and measuring the oxygen equivalent of the organic matter that can be oxidized. The COD can be determined in just two hours (Tchobangoglous and Burton, 1991). An advantage is that the test can be used to measure the organic matter in both industrial and municipal wastes that contain compounds that are toxic to biological life. In general, the COD test is higher than the BOD because more compounds can be oxidised chemically than biologically. Thus, the ratio between COD/BOD indicates the degree of biodegradability of wastewater. Matter that biodegrades relatively easily has low values, i.e. COD/BOD < 2 (Gillberg, et al., 2003) and a high value indicates that the organic matter will biodegrade slowly.

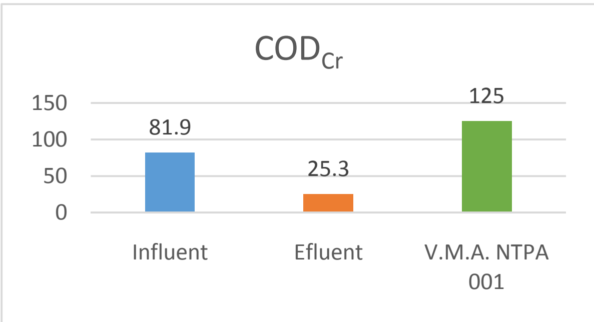

Figure 5. COD Cr

Treatment of nitrogen
Nitrogen is undesirable in wastewater effluent because of the environmental hazards. Free ammonia is toxic to fish and other aquatic organisms. It is also oxygen-consuming and depletes the dissolved oxygen in the receiving water. Nitrogen in all forms is a nutrient and therefore contributes to eutrophication.
The biological removal of nitrogen is a three-step process (US. EPA, 2008). First, organic carbon is converted to ammonium through hydrolysis and microbial activities according to equation (4), which is called ammonification. Then ammonia converts to nitrate, equation (5) and (6), under aerobic conditions with oxygen, the process is called nitrification. In equation (7) the nitrate then reacts with organic carbon to form nitrogen gas. This process is called denitrification and occurs under anoxic conditions, which means that there is no soluble oxygen present.
When wastewater enters the wastewater treatment plant, about 60 percent of the nitrogen is in organic form and 40 percent is in the ammonium form (Sedlak, 1991), i.e. equation (4) has already occurred. A build-up of nitrite is seldom seen, thus it is the ammonia to nitrate conversion rate that controls the rate of the overall reaction (Sedlak, 1991). The carbonic acid derived from equation (5) lowers pH and if pH goes below 7 (municipal wastewater often have a pH value of 7) the activity of nitrifying bacteria decrease butthe presence of denitrification, see equation (7), counteracts this reduction of pH. Optimal nitrification rates occur at pH values between 7.5 and 8.0 (Tchobanoglous et al., 2003). The effect on pH depends on the alkalinity of the wastewater. There is equilibrium, see equation (9), between the species of ammonia depending on pH value in the water. At pH below 9, a larger percentage is in $NH4^+$ form.

$$Organic\ nitrogen \xrightarrow{hydrolysis,bacteria} NH_4^+ \quad (4)$$

$$NH_4^+ + \frac{3}{2}O_2 + 2HCO_3^- \xrightarrow{bacteria} NO_2^- + 2H_2CO_3 + H_2O \quad (5)$$

$$NO_2^- + \frac{1}{2}O_2 \xrightarrow{bacteria} NO_3^- \quad (6)$$

$$NO_3^- + organic\ carbon \xrightarrow{bacteria} N_2(g) + CO_2(g) + H_2O + OH^- \quad (7)$$

where,
NH_4^+ = ammonium
HCO_3^- = bicarbonate
H_2CO_3 = carbonic acid
NO_2^- = nitrite
NO_3^- = nitrate

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$NH_4^+ \leftrightarrow NH_3 + H^+$ (9)

Total nitrogen (TN) is the sum of organic nitrogen, ammonia (NH4+/NH3) nitrogen, nitrite and nitrate. Another parameter is total nitrogen (TN), which is the total of organic nitrogen and ammonia nitrogen. Nitrifying bacteria fixate carbon dioxide which is highly energy demanding, this means they grow slowly. The generation time of nitrifying bacteria varies from eight hours to several days, this limits the process and requires quite long solids retention time (SRT) to maintain nitrification. About 10 – percent of influent nitrogen accumulates in sludge due the formation of cell tissue but the largest fraction will leave the system as harmless nitrogen gas (N_2).

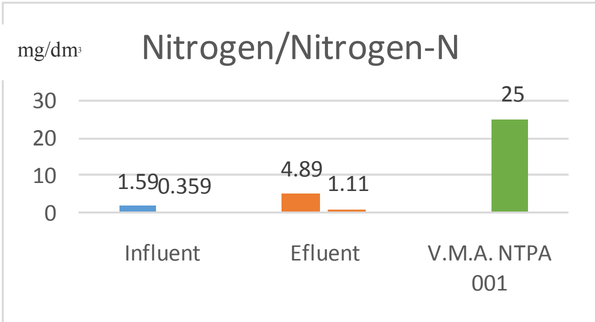

Figure 6. Nitrogen / Nitrogen-N

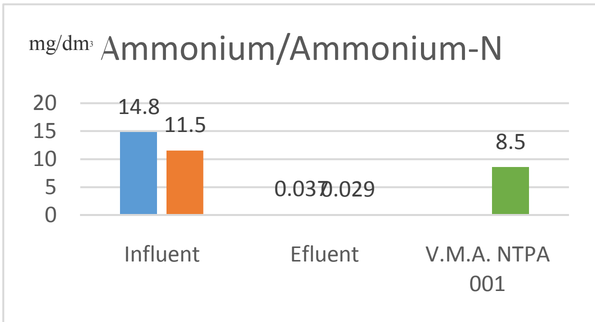

Figure 7. Ammonium / Ammonium-N

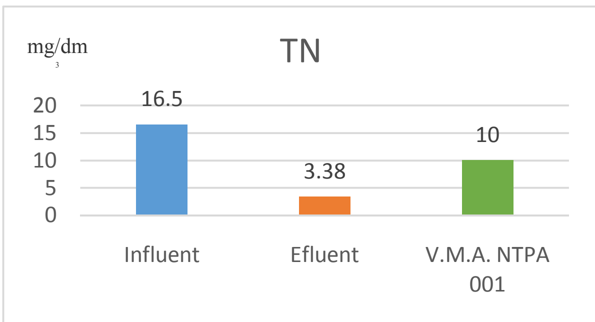

Figure 8. TN

Treatment of phosphorus

Phosphorus is normally removed through precipitation but in order to reduce the use of chemicals, which is costly, and reduce sludge production, biological removal in the secondary treatment is an alternative. Special bacteria, called phosphate-accumulating organisms (PAO) (US. EPA, 2008), assimilates short volatile fatty acids (VFA) and stores them in the cell. To release energy needed for the uptake, orthophosphate (OPO4) is cleaved, thus increasing the phosphorus concentration in the water. This occurs in an anaerobic environment. When the organisms reach an aerobic or anoxic environment, metabolism i.e. oxidation of organic matter releases energy and enables binding of phosphate to the bacteria cells. Due to disposal of stored phosphorus with the waste sludge the net effect will be a reduction of dissolved phosphorus in the water.

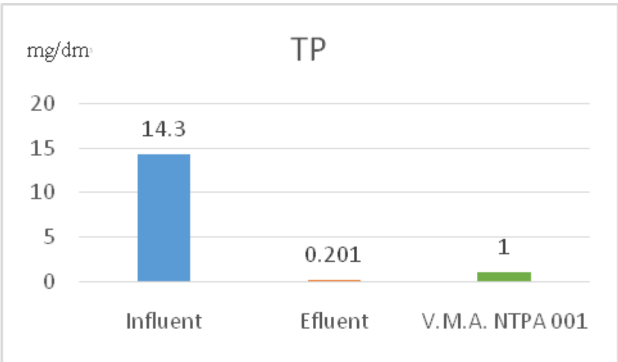

Figure 9. TP

CONCLUSIONS

Physico chemical analysis reflects the quality of treatment process in biological step. Concentrations of pollutants in water decresed, make it fits in the maximum value admitted in NTPA 001 which proves that water cand be deversed in natural receptors. Nitrification and denitrification process it is adapted according to quality of wastewater, concentration values may decrease or increase, the process being controlled by a quality monitoring system, automatic system – SCADA, or can be controlled manually.

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SECTION 04
CADASTRE