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# ENERGY CONSUMPTION ASSESSMENT IN THE WATER TREATMENT PROCESS, BACĂU CITY CASE STUDY

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## ABSTRACT

*In the national and international context, two general concerns revolve around water treatment processes. First of all, we talk about energy efficiency and environmental compatibility in the water treatment plants that should be continuously improved for rational energy use and renewable energy sources implementing [1]. Thus, the environmental objectives as reducing $CO_2$ emissions and improve energy efficiency are major concerns today. The purpose of this paper is to conduct a study on a water treatment plant and to develop solutions that will lead to the efficiency improvements of water treatment process in energy consumption terms.*

*By applying the Polyfactorial equation methodology, we can find out the environmental impact of the water treatment process. The total energy demand of water treatment plant Barati (WTP Barati) which treats the water of the city of Bacau was evaluated at 239.94 MW h/y and the highest energy consumption is registered by the technical building, which represent 40 % from total energy consumption. Another important aspect in case of Bacau water treatment plant is the raw water turbidity, which influences energy quantity used for treatment process.*

*The results analysis has highlighted two main conclusions of water treatment plant. The weakest point of the WTP Barati is the water distribution system. These are outdated and affect the treated water quality until it reaches the consumer. The biggest strong point is the raw water quality, which during the winter period reaches a very high level of quality, requiring only a simple chlorination in the treatment system.*

KEYWORDS: water treatment, energy consumption, carbon footprint, energy efficiency

## 1. Introduction

Considering everything that is happening worldwide, water has become the main element in all activities and life support on this planet. When we say the main element of all the activities we refer to population, food, industry, irrigation, cleaning. In their turn non-recoverable waste from these sectors of activity is often thrown into the water [2].

Finally, water potabilization means removing most of organic, inorganic and biological components. The water source of a city can be groundwater or surface water (rivers, lakes etc.).

The water source for drinking water in the town Bacau is Poiana Uzului Lake, the main purpose being water supply and electricity production. The dam is 84 m high, 507 m long and the lake has a length of 3.75 km, an area of 334 hectares and a volume of 98 million cubic meters. Maximum depth of the lake is 64.7 m. The lake is located at a distance of 60 Km SE form Bacau and is situated in Nemira Mountains (Figure 1); also, this lake is not affected by industrial pollution [3].

In general, each human being and everything that is happening on this earth have an impact on the environment, and also the most relevant impact on the environment in water treatment process is related to energy consumption, and if we want to speak about energy efficiency in water treatment process we need to consider the following factors: rational use of energy (mixing time, type of mixer), implementing renewable energy sources, the use of high efficiency machines, the use of advanced water treatment technologies (nanofiltration, reverse osmosis, granular activated carbon) [4]. This study aims at finding out the environmental impact of water treatment process regarding the energy consumption.

***Fig. 1.*** *Poiana Uzului Lake*

## 2. Evaluation method

Environmental impact of the water treatment process regarding the energy consumption can be analyzed through several methods, for example: Carbon Footprint methodology, Externalities of Energy, Polyfactorial equation methodology. In the present case study, we will use the Polyfactorial equation methodology, where we consider different factors [5]: the quantity of energy used for water treatment, working regime, type of flocculant, process and water treatment equipment, sedimentation time and, finally, we make different scenarios. For example, the following scenario: we have water treatment plant (WTP Bacau) and equipment from Bacau where we vary the quantity of energy and chemicals (Figure 2), working regime, type of flocculant and sedimentation time.

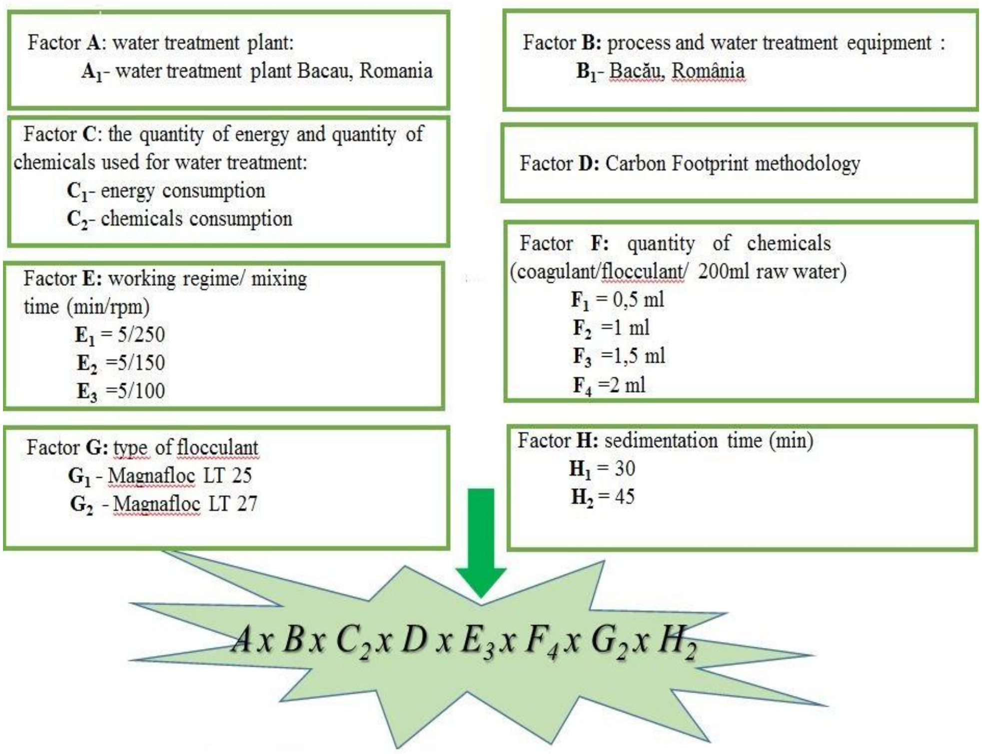


***Fig. 2.*** *Polyfactorial equation methodology*

Water Treatment Plant from Bacau is composed of the following units' components [3]:

- raw water intake and distribution chamber;
- rooms of flowmeters in the form of tanks made of reinforced concrete;
- fast mixing tanks, flocculation tanks and clarifiers lamellar;
- fast sand filters gravitational;
- chlorine contact tank;
- wash water tank;
- sedimentation tank dirty water from washing the filters;
- building support processes and control services
- chamber of sludge collection;
- chlorination building consisting of chlorine storage room, preparation chlorine concentration room, neutralization chamber;
- office building.

This unit components are grouped as shown in Table 1 [3]:

***Table 1.*** *Structure of Water Treatment Plant Bacau*

| Point | Description | Structure |
|---|---|---|
| **MCC 101** | Inlet Works and Clarifier | Pressure Switch for Recycling Pumps<br>Pressure Switch for Supernatant Pumps<br>Sludge Tank Ultrasonic Level Meter<br>Used B. Water Tank Ultrasonic Level Meter<br>Inlet Flowmeter<br>12 Pcs Sludge Pneumatic Valve<br>Turbidity Meter<br>3 Pcs Clarified Sample Water Solenoid Valves<br>PLC |
| **MCC 102** | Filtration | Pressure Switch for Backwash Pump (3 pieces) and Cl Driving Pump (2 pieces)<br>Pressure Switch for Booster Set<br>Air Compressor (2 pieces)<br>Overhead Crane<br>Fan Coil (Heating) (2 pieces)<br>Level Switch for Drainage Sump (2 pieces)<br>Wash Water Discharge Valve<br>Wash Water Discharge Flow Meter<br>Turbidity Meter (2 pieces)<br>Backwash Water Ultrasonic Level Meter<br>8 Pcs Filtered Sample Water Outlet Valves<br>PLC Panel<br>Lighting Panel LP-FB |
| **MCC 103** | Chlorination | Overhead Crane<br>Air Ventilation Fan Storage Room (2 pieces)<br>Air Ventilation Fan 1 Chlorinator Room<br>PLC Panel<br>Lighting Panel LP-CB |
| **MCC 104** | Chemicals | Alum Solution Discharge Flowmeter (4 pieces)<br>Al Dilution Water Solenoid Valve (4 pieces)<br>Level Switch Alum Tank (2 pieces) |

| | | |
|---|---|---|
| | | Pressure Switch for Lime Circulating Pump (2 pieces)<br>Lime Dosing Solenoid Valve (6 pieces)<br>Level Switch Lime Tank (2 pieces)<br>Pressure Switch for PAC Circulating Pump (2 pieces)<br>Solenoid Valve 1 (Pack Dosing) (3 pieces)<br>Level Switch PAC Tank (2 pieces)<br>Polymer Preparation & Dosing Unit<br>Polymer Solution Discharge Flowmeter (4 pieces)<br>Polymer Dilution Water Solenoid Valve (4 pieces)<br>Sampling Pump No (3 pieces)<br>Inlet Flowmeter Reservoir (3 pieces)<br>Outlet Flowmeter Reservoir (3 pieces)<br>Overhead Crane<br>Reservoir Ultrasonic Level Meter (3 pieces)<br>Lime Ventilator<br>Pac Ventilator<br>Lime Dosing Line Solenoid Valve (4 pieces)<br>Pac Dosing Line Solenoid Valve (4 pieces)<br>PLC panels<br>Lighting Panel LP-CH |
| **105** | Technical Building | Boiler<br>Circulation Pump (2 pieces)<br>Laboratory Equipment<br>pH & Conductivity Meter Water Analyzer Group 1<br>Conductivity Meter Analyzer Group 1<br>Residual Chlorine Meter Analyzer Group 1<br>pH & Conductivity Meter Water Analyzer Group 2<br>Conductivity Meter Analyzer Group 2<br>Residual Chlorine Meter Analyzer Group 2<br>Raw Water Sample Water Solenoid Valve<br>Chlorine Contact Tank Sample Water Solenoid Valve<br>Reservoir 1 Sample Water Solenoid Valve<br>Reservoir 2A Sample Water Solenoid Valve<br>Reservoir 2B Sample Water Solenoid Valve<br>PLC panels<br>Internal Lighting LP-TB<br>External Lighting Panel LP-OL |

*MCC - Motor Control Centers

## 3. Results and discussion

The scheme of water treatment plant of Bacau is structured according to the nature and characteristics of the raw water, as well as the qualitative conditions demanded by consumers' needs, following the most economical and safer operating solutions [6]. The water treatment plant Barati from our case study recorded, over the monitored period of the 12 months of 2015, an electrical energy consumption (Table 2) of about 239.94 MWh/year [7].

As can be seen (Figure 3) in the case of water treatment process in Bacau, the highest annual energy consumption is recorded in the filtration phase, representing more than 20 % of the total energy consumption.

The amount of energy consumed for groundwater extraction is unique to each water system, ranging from the low energy requirements of a gravity feed system to the high energy requirements of an inverse osmosis system pumped by sea [8].

***Table 2.*** *Structure of Water Treatment Plant Bacau* [7]

| Point | Description | MWh/year |
|---|---|---|
| MCC 101 | Inlet Works and Clarifier | 10.77 |
| MCC 102 | Filtration | 50.13 |
| MCC 103 | Chlorination | 33.39 |
| MCC 104 | Chemicals | 48.48 |
| 105 | Technical Building | 97.17 |
| **TOTAL POWER MW h/year** | | **239.94** |

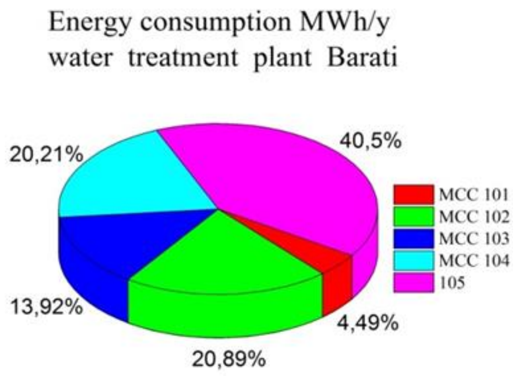


***Fig. 3.*** *Energy consumption for WTP Barati – 2015*

The connection of the equipment to the power supply from the water treatment plant Baraţi is made to the local network and the consumption depends on the turbidity of the raw water as can be seen in Table 3.

As far as energy efficiency and environmental compatibility are concerned, water treatment plants are continuously improved for rational use of energy and the implementation of renewable energy sources. Thus, environmental objectives such as reducing $CO_2$ emissions and optimizing energy efficiency are the main preoccupations. Using advanced efficiency machines, advanced water treatment technologies, it is possible to achieve additional synergies to reduce energy consumption [8].

***Table 3.*** *Energy consumption and water turbidity*

| **Electricity consumption** Process equipment | Average effective flow, $m^3/d$ (60 000 $m^3/d$) | Guaranteed unit electricity consumption, $kWh/m^3$ |
|---|---|---|
| Raw water NTU 1 - 10 | 30,000 | 0.02726 |
| Raw water NTU 10 - 20 | 21,000 | 0.02726 |
| Raw water NTU 20 - 70 | 9,000 | 0.02726 |

## 4. Conclusions

The case study in this research work is focused on the Baraţi water treatment plant located on the Barati hill of the commune Măgura, located at a distance of approx. 6 km from Bacau where the quality of raw water at the entrance in water treatment plant, the quality of the treated water at the exit of storage tank and the amount of energy consumed for water treatment were analyzed and monitored for 12 months (2015).

Analyses of water sources are carried out (surface waters / groundwater) if they are affected by industrial pollution or not, in order to distribute water to the population. Depending on the physico-chemical characteristics of the water, it will go through the water treatment process, which includes a series of stages determined by the level of water pollution.

The evolution of freshwater consumption confirms human evolution, so if at the beginning of the last century the average consumption reached only 240 cubic meters over the whole lifetime of an individual, in the last years it has tripled, according to modern living standards.

Certainly, the main cause, which determined the ascending curve of current water needs and consumption, is technical progress, so that industry and agriculture swallow most of the world's water consumption [9]. The crisis of fresh water resources and especially their efficient management has become among the most important issues of the contemporary world.

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